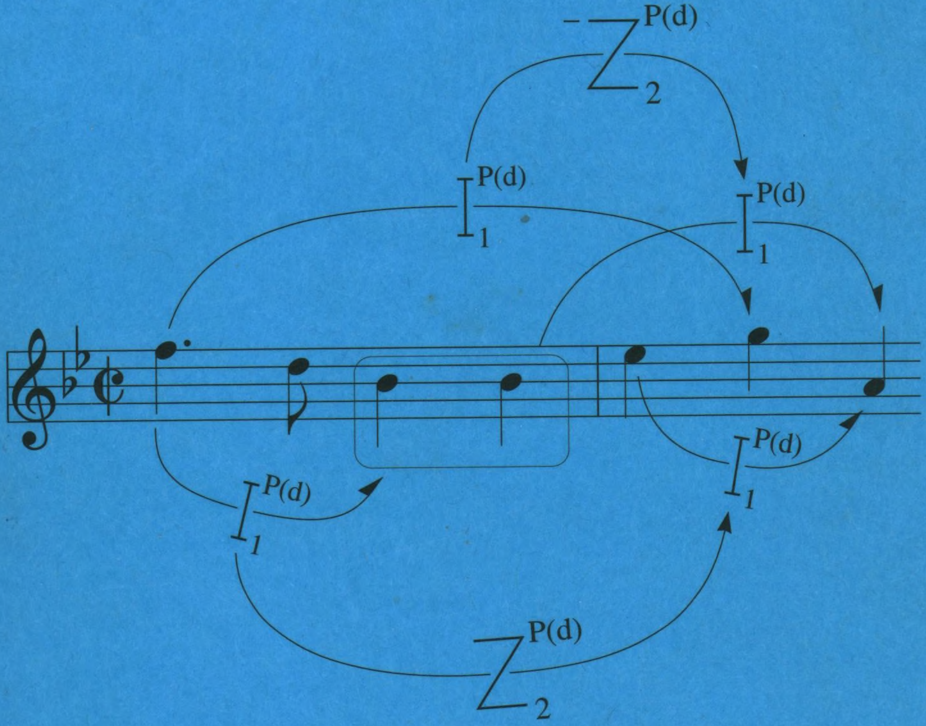
The Cognition of Order in Music



A Metacognitive Study

Adam Ockelford

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Preface

The production of *The Cognition of Order in Music* was initially stimulated by my interest in composition, where I felt the need to develop an adequate theoretical basis to support attempts at writing music that combined the time-honoured principles of canon with the twentieth century techniques of multiple serialism. However, it quickly became apparent that the new conceptual framework for which I was striving could be constructed only through retrospection: to see the way ahead it was necessary first to observe in detail the structures of extant pieces, and how the form of one related to that of another. Hence, music theory and analysis became necessary avenues of enquiry. The pursuit of these disciplines made me increasingly aware of their intimate relationship with music psychology. Moreover, questions of a philosphical nature were being raised: I felt the need to justify the systems of thought underlying the theoretical model that was taking shape, and to verify the propriety of the logic through which one proposition was leading to another. Inevitably, then, what follows is a multidisciplinary work, rooted in music theory, but embracing elements of musical analysis, psychology and philosophy too.

Music is considered as a system of perceived sonic variables. Some of these, such as duration, have a single axis of variability, while others, like timbre, are multidimensional in nature; some gauge qualities such as loudness, while others detail its perceived location in time or space; and some, like pitch, pertain to individual notes, while others, including tonality, are characteristic of a group. Each variable has many potential modes of existence, or 'values', whose range represents the freedom of choice available to composers. Conversely, each may be deemed 'ordered' to the extent that its value is thought to be subject to restriction. The causes of such constraint may lie beyond the composer's immediate control: the selection of timbre will be dictated by the availability of performers, for example, while a singer may be unable to reach a particular pitch. Although the influence of physical limitations such as these can be considerable, it is my contention that most perceived sonic restrictions in fact function intramusically, through the process of repetition: in short, a value may be thought to be ordered if it is reckoned to exist in imitation of another. Since the vast majority of listeners are quite unaware of this type of cognitive activity, clearly it need not operate at a conscious level. Yet we can surmise that it must be present, if only subliminally, otherwise an orderly sequence of sounds would prove no more effective a means of musical communication than a random one, which experience suggests is not the case. This hypothesis is examined in the light of numerous musical examples, representative of the widest diversity of styles.

Acknowledgements

I would like to offer my sincere thanks to the many people who have helped me, directly or indirectly, in writing and producing this book, including Harold Fiske, Michael Musgrave, Elizabeth Valentine, Graham Welch and Robert West.

Dedication

The Cognition of Order in Music is dedicated to the memory of my parents, Jenny and Norman, to my wife Sue, and to my children Felicity and Eloise.

Introduction

Music seeks to communicate. To succeed, communication must be intelligible, and a prerequisite of intelligibility is order (Arnheim, 1971, p. 1). This *sine qua non* of musical coherence expresses itself in every facet of the perceived sonic medium. In its absence there would be nothing but a haphazard succession of irregularly varying pitches which, differing widely in duration and time of attack, would describe wildly irregular rhythms, unpredictable in loudness, coloured by a bewildering confusion of timbres and proceeding indiscriminately from random locations potentially spaced the world apart. A statement of the obvious, perhaps, yet the vast majority of people have no overt cognisance of musical order. An intuitive grasp of the concept must be widespread, however, otherwise most of us would be unable to distinguish between organised sonic structures and the cacophonic conditions outlined above, and music would be incomprehensible.

Since it is possible to listen to music, to take part in performances and even to create new works perfectly satisfactorily without a conscious awareness of musical order, the question naturally arises of how one can justify its study. In my opinion, the enquiry is warranted since the notion of order in music lies at the heart of the vast body of theoretical literature that has grown up in cultures across the world. Occasionally, the issue appears on the surface: Meyer (1973, p. 4), for example, observes that

> A meaningful, a humanly viable world must be ordered and patterned into relationships of some sort. This is the case not only in everyday existence, but in the arts and sciences as well.

Let us reflect, then, on some of the forms of musical order that have evolved, beginning in the realm of pitch. This is subject to considerable precompositional restraint in, for example, Indian classical music. Pieces are improvised on a pitch framework or 'raga', which is a fusion of scalar and melodic elements (Jairazbhoy, 1971, p. 28). This means that a performer is not only restricted to certain standard arrangements of intervals (bearing in mind the considerable discrepancies in intonation that may go unnoticed in a musical context; Burns & Ward, 1978, p. 457), but constrained too in the way that these can be used, since only particular patterns of notes are permissible in, and characteristic of, a given raga (Jairazbhoy, op. cit., p. 38). Traditional Western music evinces a similar underlying order. For many years the ecclesiastical modes held sway, until their authority was eventually relinquished to the diatonic major and minor scales. These exerted a tight control over pitch structure that was extenuated only through the possibilities of chromatic inflexion and modulation. As in the East, scales here came to underlie music hand in hand with the evolution of conventions as to their use. Practices ranged from the persistent utilisation of a few cadential formulae to the overall tendency of pitches to appear only in certain juxtapositions. It would have been inconceivable for Haydn, for instance, to end a symphony other than with a perfect cadence. Equally, consider Simonton's (1984) study of the first five two-note transitions of over 15,000 Classical themes, in which he discovered that

> a relatively small number of pairs account for the vast majority of transitions, and certain pairs dominate melodic structure. (p. 5)

In fact, the four most commonly occurring pairs altogether make up over one fifth of all two-note transitions. Both the nature of melodic and harmonic stereotypes and the frequency with which individual pitches were juxtaposed varied from style to style. As the listeners of a given era became familiar with the ways in which pitches were typically associated, so the feeling grew that each fulfilled a particular function in relation to the others. Such aural images, fixed for us today in the concept of tonality, have variously coloured musical thought throughout the world. Note, however, that pitches can be ordered by other means too, as the serialist techniques employed by Schoenberg and his followers show. In conclusion, it must be stressed that scales, tonality and the other analytical constructs to be mentioned below merely aim to promote a fuller understanding of music;

their acquaintance is not necessary to experience pieces in a wholly satisfactory manner (Serafine, 1983, pp. 144ff). A great many people familiar with the song *Yesterday* (Lennon and McCartney, 1965), for example, although being quite unaware of the concept of modality, would doubtless notice something awry if it were played in a minor key. Clearly, this type of musical order can be understood on a purely intuitive level.

The temporal structure of music is usually highly organised too. The scores of many pieces, for instance, indicate events apparently occurring at precisely regular intervals of time. An expressive performance would demand that these be interpreted flexibly, however (Gabrielsson, 1982, p. 42). The most pronounced periodicity in music, to which we instinctively tap our foot or to which the conductor rather more deliberately waves his or her baton, is widely referred to as the 'beat'. Frequently beats are both subdivided, giving rise to a quicker pulse, and grouped (on the basis of accent, for example) to generate a slower cycle. The interaction of the two levels of organisation is termed the 'metre' (Yeston, 1976, p. 67). Western music etches a diversity of temporal designs, belying their utilisation of a small number of different metres, which generally comprise patterns of two, three or four beats. In this style, furthermore, one metre normally prevails throughout a piece or a movement. Hence the relative disposition of musical events in time is subject to stringent precompositional constraint. We have come to expect durations to be strictly controlled too; on paper, at least, a piece normally uses only a few different note-lengths, which are related to one another by simple ratios (Fraisse, 1978, p. 243). A sequence of durations may but need not bear metrical implications; conversely, a given metre more naturally harbours certain arrangements of note-lengths than others.

The combined effect of the onsets of notes, durations, and their relationship to metre may be referred to as 'rhythm' (although the term has been defined differently in the past—see, for example, Cooper and Meyer, 1960, and Brown, 1979). The degree to which rhythm is ordered varies stylistically. A number of cultures at some stage have made use of the concept of rhythmic 'modes'—units constructed from combinations of poetic feet. The idea is widely employed, for instance, in the classical Moslem world, where patterns range from a few beats in length to as many as fifty (Malm, 1977, p. 75). Similarly, Indians employ the concept of a periodic measure of time or 'tal', which sets out both the number of beats in a cycle and the distribution of stresses and accents within it (Jairazbhoy, op. cit., p. 29). A comparable method existed in mediaeval France, where, at the cathedral of Notre Dame, a system of modes in ternary metre was devised that formed the rhythmic basis of the organa, clausulae and motets of the 13th century (Apel, 1969, p. 535). From here, it was a small step to the isorhythmic motet, where a series of time-values or 'talea' was strictly reiterated in the tenor, whilst the rhythms of the upper parts were more freely governed by the same principle (Seay, 1965, pp. 133ff). In modern times, rhythmic practices have been expanded through the techniques of serialism. In Boulez's *Structure Ia* (1951–1952), for instance, all durations hail from ingeniously derived permutations of a twelve-term arithmetic sequence (Ligeti, 1958/1960, pp. 37ff). Here, it seems, the intellectual control of sound has overtaken considerations of perceptibility: such ordering may delight the sympathetic analyst's eye, but would surely escape the ear of the most discerning listener.

Traditionally, pitch and rhythm have together shouldered the burden of the compositional dialectic, which the other qualities of sound, such as loudness and timbre, have merely served to clarify (Boulez, 1963/1971, p. 37). Hence, the introductory brass fanfare from Tchaikovsky's 4th symphony, op. 36, would doubtless be recognised instantly if played *pianissimo* on a celesta, but with equal certainty would not spring to mind if the horn section were just to improvise at the appropriate dynamic level. We simply wouldn't consider it to be the same piece. That is not to say that loudness and timbre are not of immense musical importance (clearly, the heavenly tone of the celesta ill-befits the hammer blows of Fate), merely to concede that they qualify, rather than define, musical structure. This secondary role has ever been reinforced by the physical limitations of instruments, which admittedly were adroitly exploited by composers before the emancipation recently offered by electronically reproduced and synthesised sound. Naturally, similar restrictions affected pitch and rhythm too. The limited compass of the early pianoforte, for example, occasioned musically unwarranted octave transpositions in the recapitulations of some Classical sonatas, as in Mozart, K. 333, bars 43 and 139. Equally, it was only Érard's invention of the double escapement action, patented in 1821, that made the soft, rapid repetition of a note possible on the piano (Marcuse, 1975, p. 333). Still, in comparison, loudness and timbre were especially restricted. Only certain sounds can be produced on the violin, for instance, despite the historical expansion of resources demonstrated by such devices as harmonics (which appeared in the early 18th century), *sul ponticello, col legno,* the *Bartók pizzicato* and Penderecki's 'sonic' techniques (see, for example, his *Dies Irae* of 1967). In the same way, the oboe, for instance, exhibits only a comparatively narrow dynamic range (Clark and Luce, 1965, pp. 152ff), even in the hands of a virtuoso such as Holliger.

The availability of instruments has variously affected composers too: contrast Bach's meticulous writing for the known instrumental forces of the Margrave of Brandenburg, say, with the plight of Varèse, who refused to limit himself to sounds that had already been heard, and was thwarted technologically for over thirty years before being able to embark upon his initial essay in the electronic medium, *Déserts,* which was first performed in 1954. Differing styles have always favoured certain instruments and modes of performance at the expense of others, in ways that must ultimately reflect our changing cognitive predilections. There is a universal tendency to use set instrumental and vocal combinations, ranging from the string quartet to the Balinese gamelan, and from the rock group to the traditional church choir and organ.

Convention further dictates the layouts of such ensembles, whose relative importance varies according to circumstance. Hence a knowledgeable listener (unlike the conductor perhaps) may be a little stirred, though doubtless not seriously shaken, if the principal woodwinds in a symphony orchestra exchanged seats. A comparable substitution could wreak havoc, however, with the polychoral effects provided by G. Gabrieli for St. Mark's, Venice in the late 16th and early 17th centuries. A more general restriction on musical space is demanded by occasional pieces, such as National Anthems, which can be performed appropriately, moreover, only at particular times. In the twentieth century, some composers have sought to extend the organisational techniques previously associated with the 'secondary' aspects of sound. For example, Schoenberg, as early as 1909, advanced the expressive possibilities of timbre in the third of his *Five Orchestral Pieces,* Op. 16; Ives initiated spatial innovations in his 4th symphony (completed in 1916); and the control of loudness received fresh impetus from such works as Messiaen's *Mode de valeurs et d'intensités* (1949–1950). Finally, multiple serialism has taken musical order to the frontiers of what is perceptible and beyond.

The foregoing account should leave no doubt as to the high degree of order characteristic of each aspect of music, whether it be pitch, perceived time, timbre, loudness or space. Furthermore, although theory permits these elements to be discussed individually, in reality they are inseparable, and a coherent musical structure requires that their diverse modes of organisation be coordinated. Such coordination is essential if we are to cope with the sheer volume of aural information that any formation of sounds conveys in a relatively short space of time. Even so, consider the immense processing load imposed on listeners by a Mahler symphony, for example. Such stylistic complexity is feasible only since we are able to adopt appropriate strategies to ease the perceptual burden. One of these is our ability to encode the musical message in 'chunks' (to use the term coined by Miller, 1956, p. 92), whereby in traditional Western music, for example, individual notes are grouped to form motives, which in turn combine to make phrases, themselves constituting, for example, sentences, which are the building blocks of sections, and so on (Schoenberg, 1967).

As formal units such as these evolved, so means of manipulating them developed too. Since such manipulation characterises the vast majority of music, it would be impracticable to mention all the possibilities here. So, by way of example, we will take just one type of musical structure—imitation (whereby one part echoes another before the first is complete)—and consider, within this scheme, some of the procedures composers have seen fit to adopt. The simplest of these, direct repetition and transposition, find a place in the part-music of cultures across the world, from the native singing of Flores, which includes an elaborate combination of canon and double drone (Sachs, 1943, p. 51) to the head-hunting songs of the Naga, in the Congo, where the voices enter at relatively longer distances (Schneider, 1957, p. 21); from the canons of mediaeval times, such as the celebrated *Sumer is icumen in,* to the Renaissance Masses of, say, Palestrina; from the eighteenth century *Musical Offering* of Bach (BWV 1079) to the symphonies of Brahms written over one hundred years later; and, more recently, from the string quartets of Bartók to the micropolyphony of Lutoslawski. Instead of imitating its model directly, the part that follows may proceed by inversion. Dowling (1971, p. 348) notes from earlier research that this technique is prevalent both in Indonesia and Western Europe, where it appears as early as the fifteenth century in such works as the *Missa L'Homme Armé* by Obrecht, attains perhaps its ultimate expression in the mirror fugues that constitute *Contrapunctus XVI* and *Contrapunctus XVII* of Bach's *Art of Fugue* (1748–1749), frequently appears in nineteenth century development sections, for example, Bruckner's symphony no. 7 (1881–1883), and figures centrally in serialist thought, as Webern's *Symphony* (1928) lucidly demonstrates.

A process analogous to inversion, though somewhat less frequently encountered due, perhaps, to its relative perceptual obscurity (Dowling, 1972, p. 417), is retrogression. Even so, the Western tradition is sprinkled with renowned examples, including the pertinently titled *Ma fin est mon commencement* by Machaut, the minuet of Haydn's 47th symphony (1772) and *Der Mondfleck* from Schoenberg's *Pierrot Lunaire* (op. 21). Rarer still is the compound technique of retrograde inversion, which is generally cultivated only in theory books, although occasionally a specimen survives in the world of music outside, such as the postlude in Hindemith's *Ludus Tonalis* (1942), which is an inverse retrograde form of the prelude. Any of the methods of development described above may additionally incorporate augmentation or diminution, which modify durations while maintaining their proportions. Examples range from the *Missa Prolationem* by Ockeghem to the fantasias of Sweelinck, and from fugue 8 (bars 77–82) in volume 1 of Bach's *Well-Tempered Clavier* to the last movement of Beethoven's piano sonata, op. 110, bars 160ff. While transformations such as these may substantially alter a portion of music, none, in the examples given above, affects the internal structure of configurations. This need not, however, be the case, as many types of non-isomorphic change may be incorporated too. For instance, pitch and rhythm may be subject to inconsistent mutation, whereby different notes are altered to varying extents; some may even be repeated exactly while others are subject to substantial modification. Then, new material may be interjected between notes on a subsequent hearing; alternatively, items may be omitted. The possibilities are virtually boundless.

The preceding paragraph outlines some of the principal ways in which musical 'chunks' may be related one to another. When listening to music in an analytical way, we may envisage many such relationships, which accumulate during the course of a piece into a complex abstract network. In conjunction with other features such as tonality this noetic structure yields its own patterns to the mind striving for musical understanding, which are generally considered to comprise the 'form' of the work in question. Although the formal constitution of compositions is potentially as variable as their content, certain basic principles do recur time and again. The principle of 'return', for example, whereby two (or more) appearances of a given perceived sonic feature are separated by another or others (which may well be derived from the first) is found in many styles, from European folk music (see Nettl, 1965/1973, p. 92) to the choral songs of Central Australia (Ellis, 1965, p. 127); from the *togaku* pieces of the Japanese court (see Harich-Schneider, 1953, p. 56) to the *da capo* arias of the Western Baroque; and from Classical 'minuet and trio' to electronic works such as Stockhausen's *Studie II* (1954).

So much for the various manifestations of musical order. The diversity of these is to some extent matched by the widely differing explanations of order in music that have been sought (cf. Serafine, 1983, p. 135). In the West, over the last century alone, the question has been widely interpreted. Schenker (1935/1979, p. xxiii), for instance, reiterates the time-honoured view that order in music reflects the divinely governed proportions of the universe:

> All that is organic, every relatedness belongs to God ... even when man creates the work and perceives that it is organic.

In a rather more scientific vein, Schoenberg (1911/1978, p. 23) speculates that the major scale (and by implication, the pitch framework upon which the majority of pieces in the Western classical tradition are founded)[1]

> we can explain as having been found through imitation of nature. Intuition and inference assisted in translating the most important characteristic of the tone, the overtone series, from the vertical ... into the horizontal, into separate successive tones.

Other writers have adopted a mathematical approach, recently exemplified in certain analyses of serial music. Babbitt (1960, p. 246), for example, notes that

> the twelve-tone system, like any formal system whose abstract model is satisfactorily formulable, can be characterised completely by stating its elements, the stipulated relation or relations among these elements, and the defined operations on the so-related elements.

He goes on to define the twelve-tone system as a 'group' in the strict mathematical sense (op. cit., p. 249). In contrast, a sociological explanation of musical order is advanced by Ballantine (1984, p. 5):

> social structures crystallize in musical structures; ... in various ways and with various degrees of critical awareness, the musical microcosm replicates the social macrocosm.

[1]A view shared by a number of other writers, including Schenker (see, for example, 1906/1954, pp. 21ff).

These diverse notions at least share one thing in common: the order that each implies is not intrinsically musical. And while the elements of theology, physics, mathematics and sociology expressed above are undoubtedly germane to the issue of musical order, none of them addresses the central question of how music is actually heard. Yet nothing exists or is known to us except through perception (Ducasse, 1951/1976, p. 92). Therefore, if the foregoing ideas are to be relevant to music *per se*, they must be aurally justifiable.[2] Now it may be that certain people do hear music as modelling divine precepts, as deriving from acoustical phenomena, as exemplifying mathematical constructs or as mirroring the complexion of society. But such statements are of limited value without appropriate riders indicating who listens to which pieces of music in this way, and under what conditions. Clearly, information of this type is much too specific to play anything more than a subsidiary role in any theory of musical order that is generally applicable. For that we would need to know how the majority of people respond to the organisation inherent in a large number of pieces of music heard in a wide variety of situations. This is one topic engaged by psychologists working in the field of music cognition, whose general aim is to investigate the processing of musical information; that is, how we perceive, interpret, remember and react to aural stimuli (see, for example, Dowling and Harwood, 1986, p. ix; Hargreaves, 1986, p. 15). Hence it is largely in this discipline that the ideas of the present work are embedded.

My thesis is this: that the numerous and diverse manifestations of perceived sonic control, while for sure involving many different cognitive processes, rise from one essential source—namely, repetition. Admittedly, the importance of repetition in the structure of music has been widely recognised, although to my knowledge only Harris (1931) has devoted an entire article to it. Other writers have been content to comment in the course of wider discussion. Selincourt (1920/1958, p. 155), for example, notes that the

> foundation of musical expression is repetition. [It] begins with the bar, and continues in the melody and in every phrase or item into which we can resolve it.

[2]See, however, Bukofzer (1947, p. 369): "The distinction of audible form and inaudible order did not exist in baroque music. Music reached out from the audible into the inaudible world, it extended without a break from the world of the senses into that of the mind and the intellect."

Similarly, Zuckerlandl (1956, p. 213) writes:

> music can never have enough of saying over again what has already been said, not once or twice, but dozens of times; hardly does a section, which consists largely of repetitions, come to an end, before the whole story is happily told all over again.

See also Ruwet (1966/1987, p. 16), Abrahams and Foss (1968, p. 65), Apel (1969, p. 725) and Sloboda (1985, pp. 4, 55 and 56). Composers have themselves expressed the same view.[3] Stravinsky (1942, pp. 69 and 70), for instance, observes that

> we instinctively prefer coherence and its quiet strength to the restless powers of dispersion—that is, we prefer the realm of order to the realm of dissimilarity.

According to Chavéz (1961, pp. 38 and 41):

> repetition has been the decisive factor in giving shape to music ... the various devices used to integrate form are, again and again, nothing but methods of repetition.

Finally, consider Schoenberg's (1967, p. 20) characteristically unequivocal comment:

> Intelligibility in music seems to be impossible without repetition.

In my view, all these statements are limited, however, in that they are descriptive rather than analytical, for while they recognise the overriding importance of repetition to musical comprehensibility, none of them reveals just how the action of repeating sounds can contrive the illusion of order. It is an explanation of this process that forms the core of the present work, and, I believe, constitutes its chief claim to originality. In brief, it runs as follows.

Music is considered as a system of perceived sonic variables, including, for example, pitch, duration, loudness and timbre. Each has many potential modes of existence, or 'values', whose ranges represent the freedom of choice available to composers. Hence a note can be high or low, for instance, short or long, loud or soft, and strident or dulcet in tone. These

[3]It is instructive to read Eschman's critique of Hába, who had claimed to have written melodies in a style devoid of repetition (1945/1968, pp. 19ff).

considerations are the subject of the opening chapters, beginning with an investigation of just how sounds are perceived, and moving on, in chapter 2, to an exploration of the relationships we apprehend between them. In chapter 3, some of the individual qualities of perceived sound are discussed in detail. I believe that each may be deemed to be 'ordered' to the extent that its value is thought to be subject to restriction. The causes of such constraints may well lie beyond the composer's immediate control: only certain pitches will lie within a given singer's range, for example, whose ability to sustain notes will be limited too. Then, instruments such as the harpsichord conventionally have a predetermined dynamic level and one set tone colour or more. These are physical limitations, that have little to do with organisation of a purely musical nature, and although their influence is considerable, it is my contention that most perceived sonic restrictions in fact function intramusically, through the process of repetition: *a value may be thought to be ordered if it is reckoned to exist in imitation of another.* This theory is subject to detailed scrutiny in chapter 4, at the level of the shortest apprehensible fragments of perceived sound. Chapters 5 and 6 explore the hypothesis further in general terms, respectively in the contexts of sounds of palpable duration and groups of such sounds.

In the following chapters, specific issues are examined. Chapter 7 views the distinct forms of order inherent in the musical experiences of composers, performers and listeners. In chapter 8 the background order found in perceived reverberation, the disposition of the sound source or sources, loudness, timbre and number are investigated. In these and subsequent chapters, musical examples are drawn from the widest variety of styles,[4] with the hope of illustrating the universal applicability of the ideas that are presented. Indeed, extrapolation from the data presented enables possible future methods of structuring music to be mooted. Chapter 9 addresses the question of perceived temporal order, followed by a review of the organisation of pitch in chapter 10. Chapter 11 is devoted to an exploration of the co-ordinated order found between pitch and rhythm, followed, finally, in chapter 12 by an investigation of how different forms of organisation are combined in the formation of a piece (Mozart, K. 333, 1st movement). To conclude, we consider briefly how the current theory fits in with some of the established patterns of twentieth century musical thought.

[4]Inevitably, though, there is a preponderance of examples from the genre with which I am most familiar—pieces in the Western classical tradition.

1

Perceived sound and its constituents

Introduction

This chapter and the two following introduce the psychoacoustical concepts that underlie *The Cognition of Order in Music*. First we distinguish between our knowledge of events as they are perceived, and the external reality from which this consciousness derives (cf. Agmon, 1990, pp. 286ff). In particular, a distinction is drawn between 'physical' sound and its perceptual concomitant, a phenomenon that is subsequently anatomised by isolating and defining the attributes that characterise it at any instant. These qualities too are compared with the physical systems that instigate them. The conceptual resources gained through this piecemeal approach will fund the more extended analyses that follow.

Sound and perceived sound

Although it is not generally acknowledged, the word 'sound' has two distinct meanings. First, it refers to energy propagated from a resonant source through an elastic medium of transmission as a longitudinal wave describing successive compression and rarefaction. Second, it defines the mental image we produce in response to such a system (Olson, 1952/1967, p. 3). This semantic imprecision stems, I believe, from an underlying conceptual confusion incurred by the vivid nature of perception, whereby we are led to believe that our apprehension of 'sound' constitutes its physical reality. In fact, what we hear is merely the result of a neurological reaction to sound itself, the percept bearing no resemblance to its stimulus. In most day-to-day situations, this misconception is of little consequence, but in the present study, which is largely concerned with what we perceive, it would be intolerable. Accordingly, in an attempt to clarify the position, the term **perceived sound**[1] will be used to distinguish it from its physical counterpart. This expression has been used in the past—see, for example, Randall (1967, p. 124)—though not with the consistency that will be applied here.

Moments

Perceived sound is analysed in some detail, initially by isolating and describing its smallest indivisible components. This approach has been adopted in an attempt to make the theory that follows easier to understand. It is not intended to suggest that under normal circumstances people listen to music in this atomistic fashion.

The first step is to take 'slices' of perceived sound, each corresponding to the narrow interval of time we apprehend as the present.[2] Music

> comprises nothing more than a series of such events. (Davies, 1978, p. 48)

Each will be termed a **moment**,[3] a designation previously used by Boretz (1970, p. 105), Bregman and Pinker (1978, p. 24) and Rahn (1983, pp. 52ff).[4]

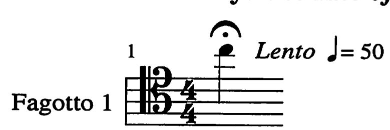
[1]This study presents a number of newly invented terms, as well as re-defining a number of words in common usage. There are two reasons for this. First, because new concepts are introduced whose subsequent reference demands they be labelled; and second, to promote brevity and clarity of expression: where a phrase is needed so frequently it would feel cumbersome, a single word is substituted. It will be appreciated that a fine judgement sometimes has had to be made between the benefits so gained and the disadvantage to the reader of having to learn a new word or definition before further inroads into the text can be undertaken. With this in mind, wherever possible, inventions and adaptations have been made with memorability as a prime concern. Key words are printed in bold on their first appearance and are listed in the index.

[2]Observe that this approach goes at least one stage 'further back' than traditional music analysis, which tends to regard notes as the fundamental, indivisible units of which music is made up. Indeed, Schoenberg (1967), for example, treats the motive as the 'smallest common multiple' of a piece (p. 8).

[3]Related adjective 'momentaneous'.

[4]See also Fraisse (1964, p. 100): "A brief stimulus can be perceived without appearing to be durable. Here we at the limit, which Piéron calls a 'point of time' by analogy with space (*La sensation guide de vie,* 3rd ed., 1955, p. 401)."

It is not possible to specify the length of a moment precisely. In part, this is because the information we obtain from differing perceived sounds may take different periods of time to resolve perceptually (cf. Gulick, 1971, p. 141; Cogan, 1984, p. 141). Also, a moment comprises a number of separate perceptual experiences which, in the related context of very short sounds, have been shown to have non-uniform processing times (Wang, 1983, p. 82). Subject to qualifications like these, it seems that the duration of a moment is approximately $^1/_{20}$ second (Davies, op. cit., p. 49). Not that the exact figure is important here; for present purposes, the definition proposed by Boretz (op. cit., p. 105) of the 'minimum discriminable time-span' is perfectly adequate. Some idea of how moments may be conceived in musical terms is shown below.

Stravinsky: *The Rite of Spring* (1913)

may be regarded as being made up of many individual moments of perceived sound thus:

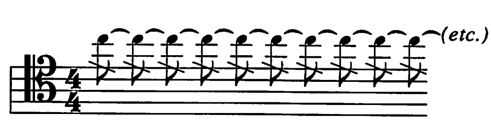


Figure 1.1 Representation of moments in standard notation.

Moments are not predetermined building blocks that always go to make up a perceived sound in the same way, but comprise samples of a continuous medium that can be taken at any instant. Hence the moments that pertain to a perceived sound may well differ from one occasion to another.

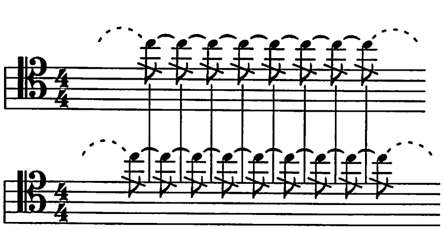


Figure 1.2 Moments differing from one occasion to another.

Perspects

A perceived sound has various perceived aspects, which will be referred to as **perspects**.[5,6] A moment has three perspects which concern its nature: **pitch, loudness** and **timbre**. Each moment has a perceived position in time, referred to as its **fix**.[7] Perceived sound has an apparent source, whose position with respect to the listener at any moment comprises three components which may be referred to as the 'perceived range', 'perceived elevation' and 'perceived azimuth'.

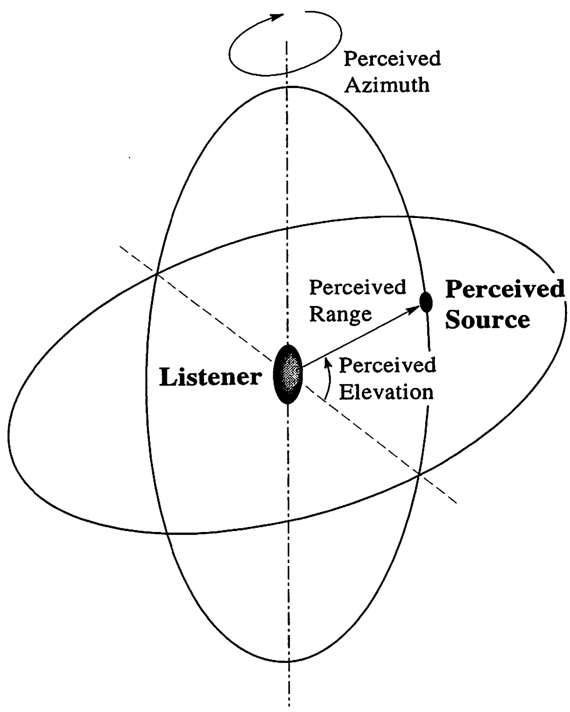


Figure 1.3 The three components of the apparent source of perceived sound.

[5]This term could equally well be applied to other sensory modalities; cf. Garner's (1978) discussion of *Aspects of a Stimulus.*

[6]Related adjective 'perspective'.

[7]This has the advantage of brevity over previous labels that otherwise fit the bill, such as 'time-point' used by Babbitt (1962, p. 63).

It is usually sufficient to consider the three perceived spatial dimensions together, in a combination that may be termed the 'perceived location' or **plot**.[8] Whilst the process of sound localisation has received considerable attention in the field of psychoacoustics (for example, Gulick, 1971, pp. 185ff; Moore, 1977, pp. 170ff), the question of the perceived source of sound has been aired only very occasionally in the realm of music theory. See, for instance, in Stockhausen (1959/1961, pp. 68ff).

These are the perspects that pertain to moments of perceived sound. However, with the exception of fix, they also apply to the 'unsliced' perceived sounds of which most music is actually made up—notes. These longer perceptual units exhibit a number of other characteristics too, and other attributes pertain to groups of perceived sounds considered together. Furthermore, the perceived sonic environment has features whose effects linger beyond the temporal confines of a moment, such as 'perceived reverberation'. All these perspects will be considered in due course (see, for example, pp. 118, 119, 155, 158, 161ff, 266ff, 380, 494, 595 and 613).

Perspective particles and perspective values

The fleeting appearance of each perceived aspect of a moment may be referred to as a **perspective particle** and represented as follows:

■

Figure 1.4 Representation of perspective particle.

Without its identity being compromised, a perspect can vary greatly in the way it sounds or, with regard to fix and plot, in its perceived location in time or space. However, a moment can by definition countenance no change, since this would imply it had a palpable duration. Consequently, each perspective particle is constrained to appear in any one state, termed a **perspective value**.

[8]It is possible to consider the perceived location of a sound source in another sense—relative to its environment. This would better reflect the constancy of plot that an immobile source of sound may be supposed to maintain, even when we, as listeners, move around it. However, the rather more limited definition given above is sufficient for present purposes.

To those oblivious of music-theoretical constructs, a perspective value represents nothing more than a particular qualitative experience. This subjective mode of listening, however, has been accorded an intellectual overlay by the musicians of certain cultures (including those working in the Western classical tradition). They have shown that the values of some perspects can be rendered objectively by a single numerical index or equivalent, such as an alphabetical string. Perspects with which this is possible, such as pitch, loudness and fix may be termed **simple**.

Other perspects, though, which are variable in a number of different ways, have a multidimensional character, and their values are correspondingly complex. Perspects of this type, which include timbre and plot, will be referred to as **compound**.

Parameters, and their relationship to perspects

In my opinion, the term 'parameter', which, according to Krenek (1960, p. 210) was introduced into music theory by the physicist Meyer-Eppler (who was influential in the development of electronic music in the late 1940s and early 1950s), and which has gained wide acceptance in contemporary music literature (see, for example, Narmour, 1990), should be reserved solely for the attributes of 'physical' sound such as frequency, intensity and waveform. This usage, in conjunction with the availability of the term 'perspect', offers a greater linguistic clarity than is currently obtainable. Moreover, such semantic precision may hopefully foster a conceptual rigour absent from some theoretical writing, such as that by Stockhausen (1962), in which connection Meyer (1967, p. 246) comments:

> it is an inexcusable error to equate acoustical phenomena with qualitative experiences. The former are abstract scientific concepts, the latter are psychological perceptions. One measures frequency [for instance], but one perceives pitch.

Admittedly, there is a close relationship between certain physical and perceived attributes of sound, so much so that a given perspect may be defined as the perception of a particular parameter. For example, loudness is said to be the perceptual correlate of intensity. However, it is not the case that

> any simple one-to-one relationship exists between an acoustical event and its concomitant perceptual experience: (Meyer, ibid.)

the way in which a perspect is apprehended will usually be affected by change in any parameter. Sometimes the interference is immediately obvious: consider, for example, how loudness diminishes with increasing distance from the source of sound. Other effects are less evident—scarcely, if at all, noticeable to the listener of traditional instrumental music (Dowling and Harwood, 1986, p. 50)—although they may have a bearing on the way listeners perceive certain electronically synthesised sounds. Pitches, for instance, are variously affected by alterations in intensity (Stevens, 1975, p. 88), and loudnesses are partly determined by frequency (Stevens and Davis, 1938, pp. 123 and 124), to cite two well-documented cases.[9] Furthermore, not every parameter has a perspective equivalent: 'phase', for example, although apparently influencing timbre slightly (Plomp and Steeneken, 1969), is essentially imperceptible. And while all perspects correspond to a particular parameter, the link between them can be tenuous indeed, since perceived sounds that are remembered have only an indirect physical analogue, and those that are imagined have no substantive parallel at all. Moreover, under certain conditions, the non-linearity of the auditory system produces perceived sounds, such as aural harmonics, combination tones and difference tones (Roederer, 1973, pp. 34ff), that are not present in the original stimulus. The brain will even supply a fundamental missing from an appropriate complex of harmonics (Schouten, Ritsma and Cardozo, 1962; Plomp, 1967, p. 1529).

Conclusion

It was proposed the term 'perceived sound' be used where appropriate, with the aim of promoting a distinction between this and its physical agent, 'sound'. The perception of sound was analysed in detail, initially by reducing it to thin temporal portions called 'moments', and then by showing that each of these is a composite experience comprising various perceived aspects or 'perspects'. The brief exposure of each perspect of a moment was termed a 'perspective particle', to which a particular 'value' may be

[9]See also, for example, Crowder and Neath (1994), who show that the pitch difference between notes defining the boundaries of a silent interval affects its perceived duration.

ascribed. Finally, the need to distinguish perspects from the physical qualities of sound, 'parameters', was expressed. It is fruitful to compare the ideas presented here with those put forward by West, Howell and Cross (1987, p. 14), in which they propose

> to quantise the time dimension and represent relevant facets of musical experience in each time slice.

The authors suggest that the notion of 'frames', a representational system currently used in the sphere of artificial intelligence, be adapted to these ends. They define a frame as comprising a number of percepts (likened to 'slots'), each having some value (the content of the slots). This concept enables

> experienced pitch values, timbral qualities, loudness and spatial location

to be captured at the most detailed level,

> as well as higher order pitch and rhythmic structures with their associated features such as depth of texture, tonality, idiom, tempo etc.

Moments are ultimately capable of sustaining this type of information too, as will become apparent in the chapters that follow.

2

Interperspective relationships

Introduction

The essence of music lies not in the vast number of isolated perspective values of which it ultimately consists, but in the complex of relationships that are perceived between them (cf. Krumhansl, 1990, p. 3). Since most listeners have no conscious knowledge of these abstract connections, it follows that as concepts they are largely irrelevant to the musical experience. As percepts, however, acting on a purely subconscious level, relationships carry the burden of the musical message. It is to relationships, in both their objective and subjective manifestations, that this chapter is devoted.

Primary interparticular relationships; interperspective relationships

We begin by considering how the values of two perspective particles of the same type are compared. In the normal course of events, this process is effected at a completely subconscious level; however, introspection permits a heightened awareness of the mental activity involved. The nature of the comparison depends partly on the relative temporal disposition of the particles. Initially, we examine the situation in which they occur at different times.

Imagine, then, that a perspective particle enters a listener's sphere of consciousness, and that he or she keeps its value in mind as a potential 'reference'. Next assume that a second value is registered, which is subsequently assessed relative to the first. This process is accomplished through a particular mental construct—a cognitive bridge—which spans the gap between the values of the particles. This may be referred to as a 'primary interparticular relationship'.

The term 'relationship' is taken to mean a perceived connection between any two perspective appearances, including values, many of which exist beyond the confines of particles. Here it is described as 'primary' since there are higher ranks of relationship (to be defined in due course), and 'interparticular' since it exists between particles. Compound labels such as this can be reduced as far as possible provided that ambiguity is not incurred. So, if it were clear that particles were the subject of attention, for example, the term 'primary relationship' would suffice.

A primary interparticular relationship is one type of 'interperspective relationship', that is, the medium through which two perspective appearances may be compared. This general term may substitute for others more specific. Hence the expression **primary interperspective relationship** would be acceptable in the appropriate context.

An interperspective relationship may be symbolised by an arrow, whose directionality is intended to show the supposed cognitive shift from reference to comparison value. Additionally, the letter 'I' may be superimposed as an abbreviation for 'interperspective'. Without modification, the same symbol can denote an 'interparticular' relationship, a meaning that would be apparent from the nature of the material being related (cf. Lewin, 1987, p. xi).

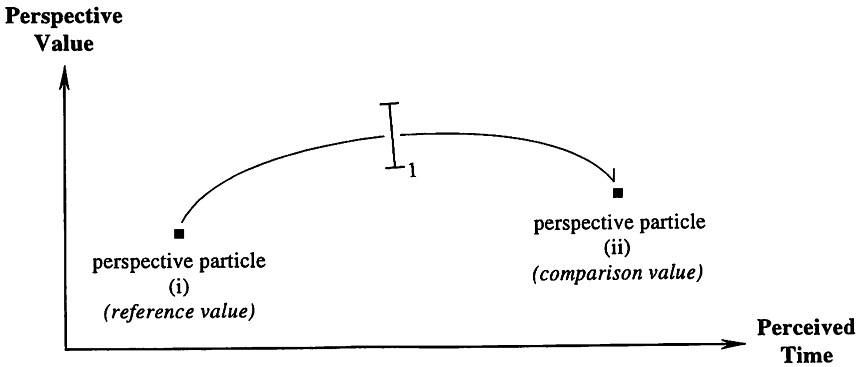


Figure 2.1 Primary interparticular relationship.

The suffix '1' indicates the primary status of the relationship. The style of arrowhead is used to show a connection between perspective values. Here, and in the diagrams that follow, a graphical layout is adopted in which time appears along the horizontal axis, and non-temporal perspective values are proportional to their vertical position on the page.[1] The propriety of representing perspects in this way is reviewed in chapter 3.

This model represents the usual state of affairs, in which the particles' order of appearance dictates the direction in which the relationship between them is felt to operate: that is, the first value acts as a standard against which the second is judged. However, there is no reason why the roles fulfilled by the values should not be reversed, and the second one serve as a reference against which the first is then measured. To achieve this, the cognitive process invoked to get from particle (i) to particle (ii), shown in figure 2.1, has to be replaced by a mental operation of the opposite effect.

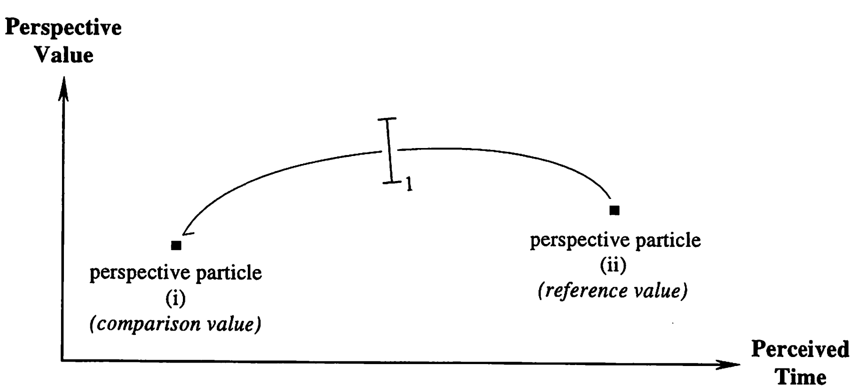


Figure 2.2 Relationship opposite in effect to that illustrated in figure 2.1.

Hence, just as memory and imagination free perspective particles from the temporal shackles of their correlates in the physical world, so, by the same token, relationships may be temporally independent too.

If two perspective particles appear simultaneously, then the value of each may function both as reference and comparison together, and the relationship that connects them effectively does so in both directions at once. Hence it is 'mutual' in operation. See figure 2.3.

[1]Cf. 'time-space notation', used by Brown, Berio and other composers.

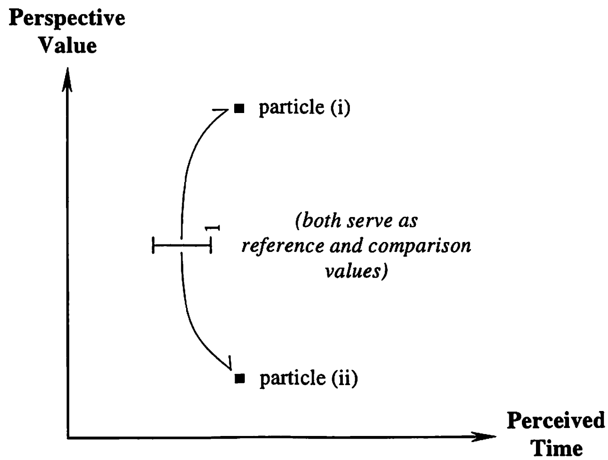


Figure 2.3 'Mutual' interparticular relationship.

There may be other grounds, however, for establishing the relative perceptual priority of the particles—for regarding one as the model against which the other is compared (see, for example, figure 4.14).

One perspective value may be related to any number of others, operating in the role either of reference or comparison or both.

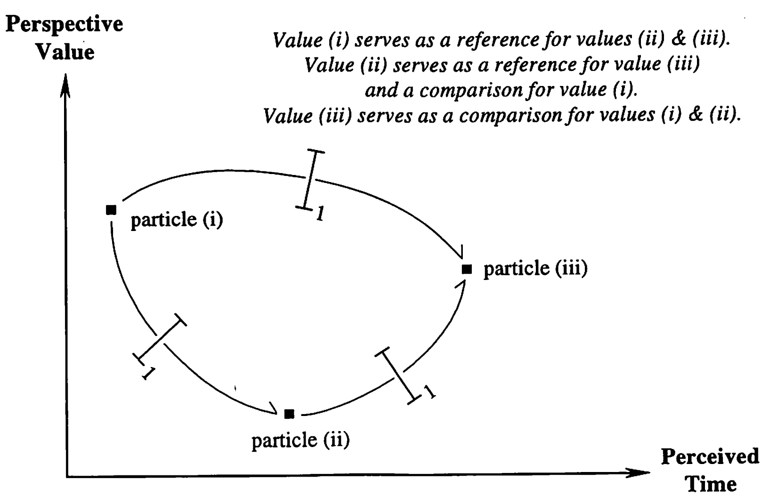


Figure 2.4 Perspective values related to more than one other.

A primary interparticular relationship requires the presence of two moments. This in turn implies the existence of other primary relationships between the remaining perspective particles. For example:

Berlioz: *Requiem*, Op. 5; No. 6, *Lacrymosa*

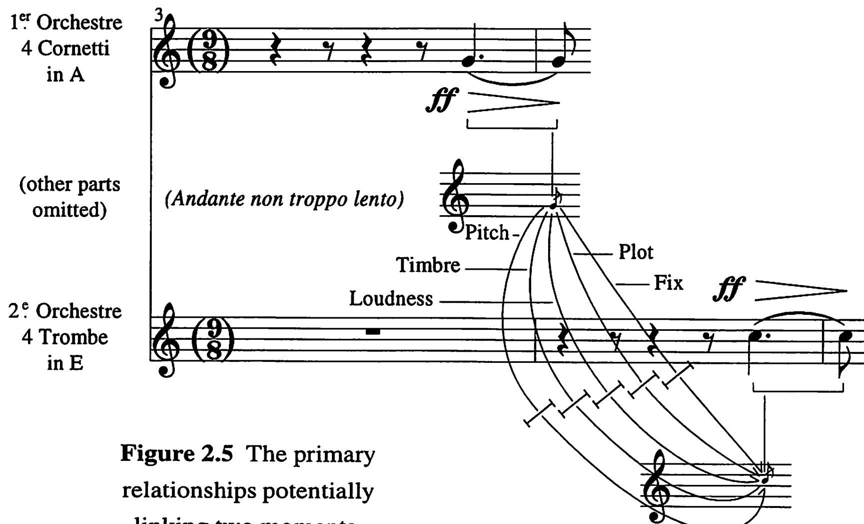


Figure 2.5 The primary relationships potentially linking two moments.

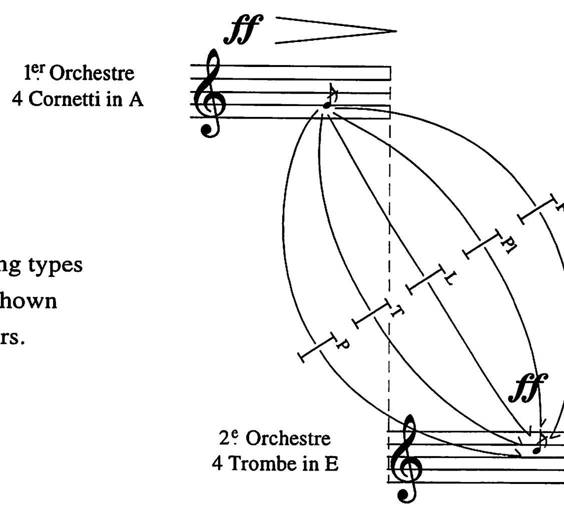


Figure 2.6 Differing types of relationship, shown by initial letters.

(Observe that the hypothetical derivation of moments is notated using grace notes which are allocated a separate stave.)

To make it clear which perspect a relationship refers to, its initial letter or letters may be appended in manner shown in figure 2.6.

Many of the diagrams that follow illustrate interperspective relationships in general terms. To show that these are not specific to any one perspect, the letter 'X' will be used:

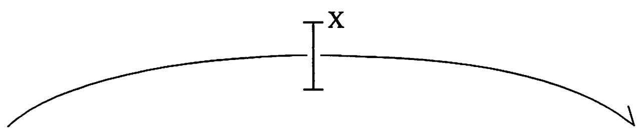


Figure 2.7 Interperspective relationship, non-specific as to perspect.

These primary interperspective relationships may be described as 'reactive' since they are a response to a stimulus. Consider, however, a composer or listener engaged in anticipating the future course of a piece. Starting from a given value, he or she imagines a second (which may but need not subsequently be realised in sound) through a relationship that operates 'proactively'.[2,3]

[2]Inevitably, the model proposed here is an oversimplification. For example, a listener having mentally created a second particle through the extension of a proactive relationship from one given may subsequently compare the two through a reactive relationship. This raises wider issues: for instance, if the relationship between two perspective appearances can be re-conceived at a later stage, how are we to understand the connection between the two relationships so imagined? Should we view them as different manifestations of the same thing, or two similar things generated separately from the same stimuli? Then, should a relationship to which we attend for more than an instant should be considered as many discrete entities or as a single cognitive creation extended in time? Unfortunately the confines of the present work do not permit further investigation here.

[3]Cf. Ockelford (1991, p. 134), where the terms 'passive' and 'active' are used. I am indebted to Ian Cross (personal communication, 1990) for pointing me in the direction of the present terminology.

Primary interparticular values; interperspective values

Interperspective relationships differ according to the type of perspect concerned. In the case of simple values, a relationship can gauge the difference between them. This is a kind of **primary interperspective value.** (In referring to particles, the term 'primary interparticular value' may be used.)

The operation of a primary interperspective relationship of difference is illustrated in figure 2.8, which shows the relative vertical position of two dots, each equivalent to a perspective value. (Observe that the value of the relationship is shown behind the arrowhead, a procedure adopted as standard.)[4] This analogy shows how interperspective relationships function in general terms. Specific examples are given in chapter 3.

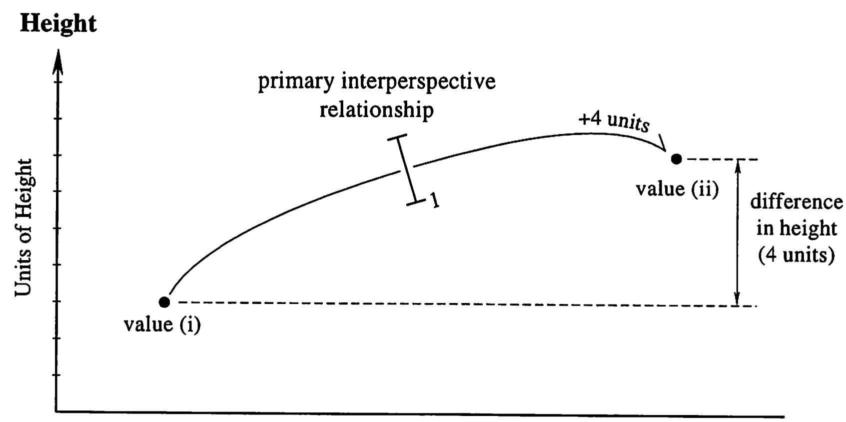


Figure 2.8 Primary interperspective relationship of difference.

In some cases, simple perspective values may be related by a ratio too. An analogy is presented in figure 2.9, where two columns are compared. Observe that ratios, unlike differences, are 'abstract', and exist independently of the perspects they relate.

[4]Such values may but need not be shown.

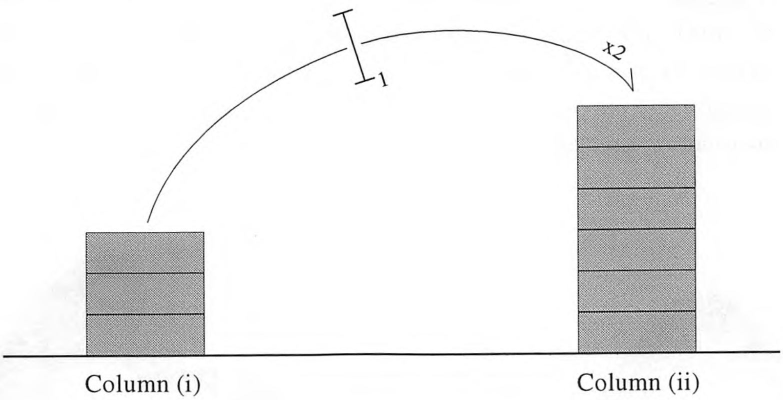


Figure 2.9 Primary interperspective relationship of ratio.

In the general illustrations of interperspective relationships that follow, it is necessary to have an arbitary unit, of which differences can be taken to be multiples or fractions. This will be shown as a lower case 'x':

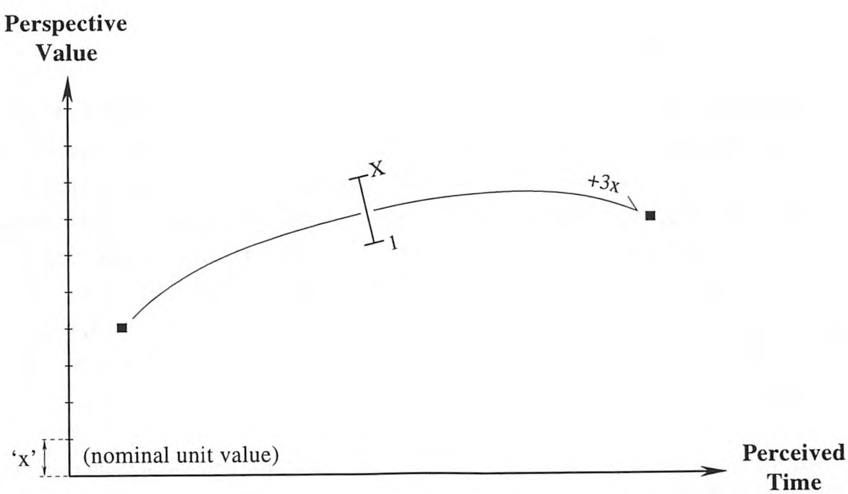


Figure 2.10 Non-specific interperspective relationship of difference expressed as an arbitary value.

Where perspective values are compound, that is, irreducible to a solitary figure, this is mirrored in their corresponding interperspective values, which may be referred to as 'complex'. This is shown in the analogy below, where the relationship between the shapes of two figures is no more reducible to a single quantity than are they.[5]

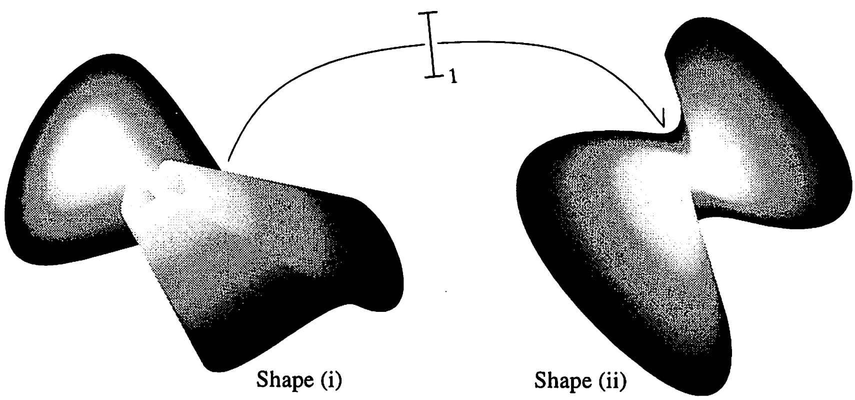


Figure 2.11 Complex interperspective relationship.

Interperspective relationships function like 'vectors' (to borrow a term from mathematics; cf. Dowling, 1972, p. 417), since they express a value that is effective in a given direction. The polarity of simple interperspective values may either be 'positive' or 'negative',[6] depending which perspective value is the reference and which the comparison. (Hence, switching the order in which the perspective values occur usually reverses their interperspective polarity as well.) For example, in figure 2.8 above, with respect to the first dot, the second is four units higher; with respect to the second, the first is four units lower.

[5]If the structures were isomorphic, however, the relationship between them could be described in simple terms.

[6] ... or 'neutral' if the value is 0.

Secondary interparticular and interperspective relationships

In the same way that the values of two particles may be compared or created through primary relationships, so two interparticular values of the same type may be matched, reactively or proactively, through a 'secondary interparticular relationship'. This may be symbolised as follows:

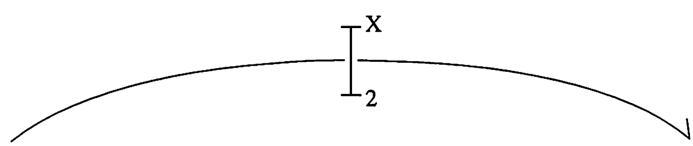


Figure 2.12 Secondary interparticular relationship.

(Observe that the number 2 stands for 'secondary'.) This is one type of **secondary interperspective relationship**, whose character will depend upon the nature of the primary interperspective values to which it pertains. Potentially, two differences can be compared through a further difference

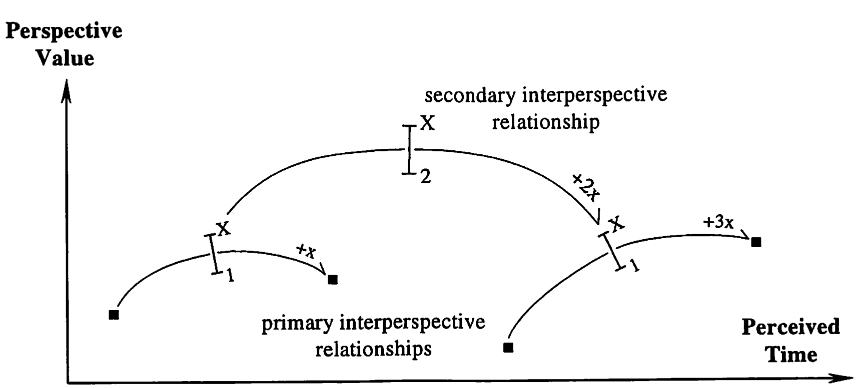


Figure 2.13 Secondary interperspective relationship of difference.

or a ratio (see figure 2.14).

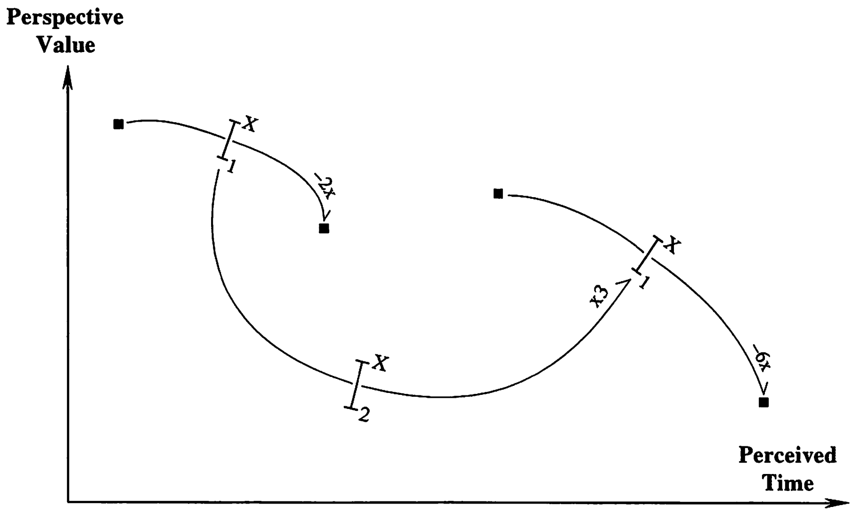


Figure 2.14 Secondary relationship of ratio.

These are examples of **secondary interperspective values**.

Theoretically, primary interperspective ratios may be related through any function. For example, one may be the square of another.[7] Similarly, two compound primary interperspective values may be linked through a complex secondary value. It seems that relationships such as these are cognitively too demanding for them to be of any musical consequence, however.

For the listener, perceived temporal precedence normally determines which primary interperspective value serves as a reference, against which the second is then compared. Establishing which relationship precedes and which follows may not be a straightforward matter, though. For example, relationships may overlap in time (figure 2.15) or one may be entirely contained within the span of another (figure 2.16). Other factors may influence the polarity of secondary interperspective relationships as well: a given context may highlight one primary interperspective value at the expense of another, thereby dictating the direction of a comparison between them.

[7] Cf. Lerdahl and Jackendoff, 1983, p. 342.

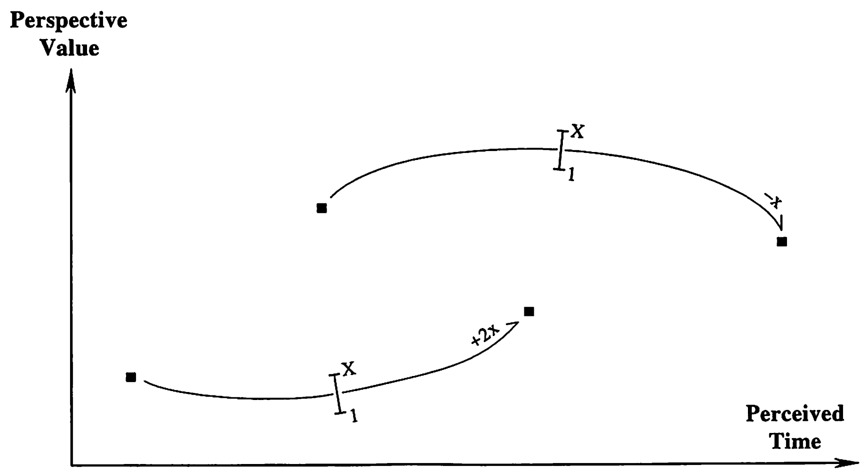


Figure 2.15 Overlapping relationships.

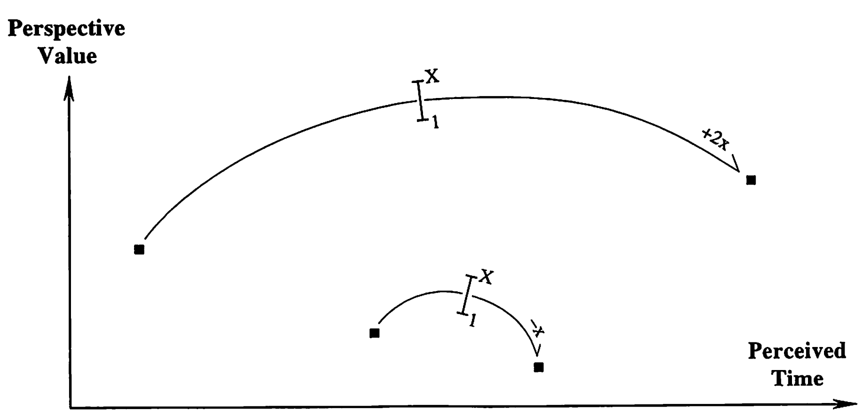


Figure 2.16 One relationship contained within the span of another.

Secondary interperspective relationships may function proactively too, employing any combination of given, remembered or imagined perspective values and primary interperspective relationships. Hence, a perspective value may be proposed on the basis of three given values (see figure 2.17).

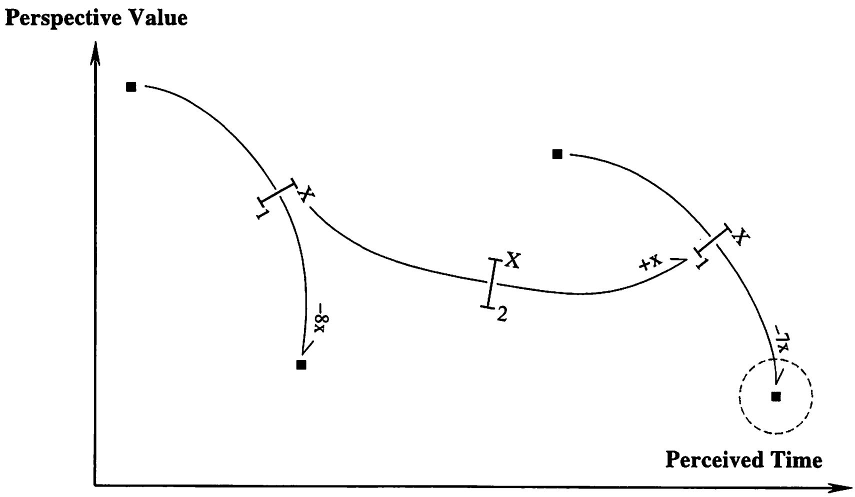


Figure 2.17 Final value proposed on the basis of the three preceding.

Alternatively, a further primary relationship may be derived from one presented.

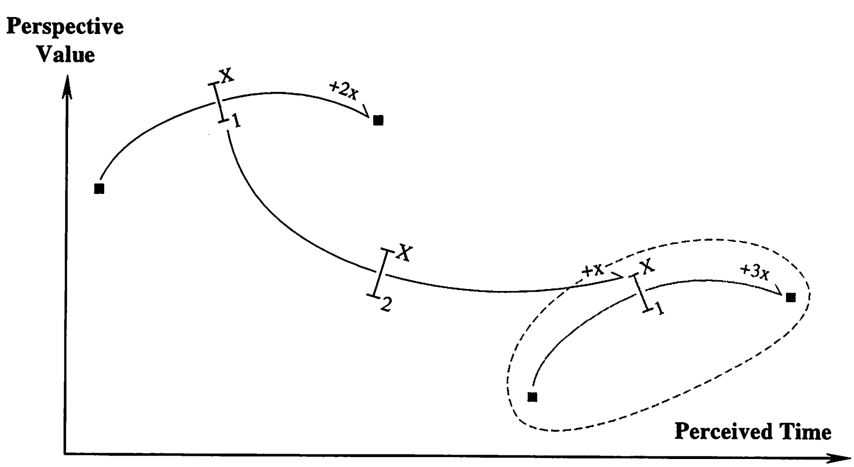
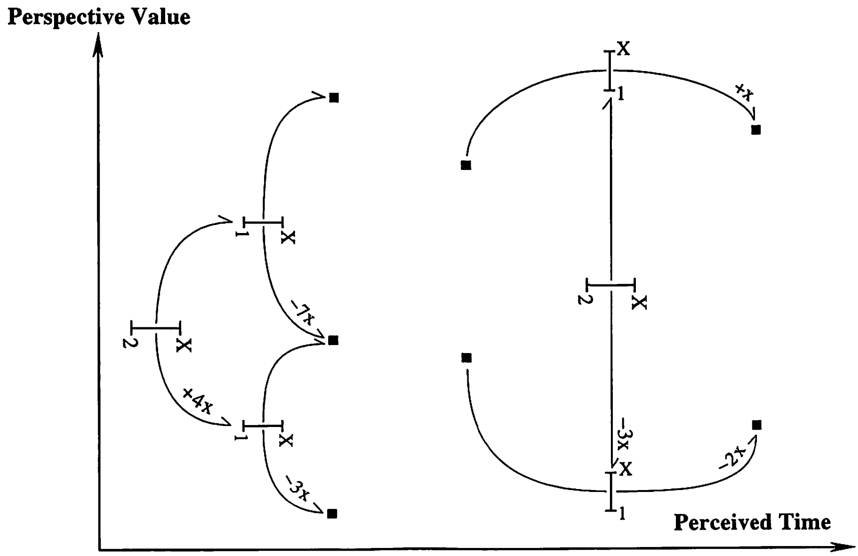


Figure 2.18 Second primary relationship proposed on the basis of the first.

Primary interperspective values may function as both reference and comparison. For example:



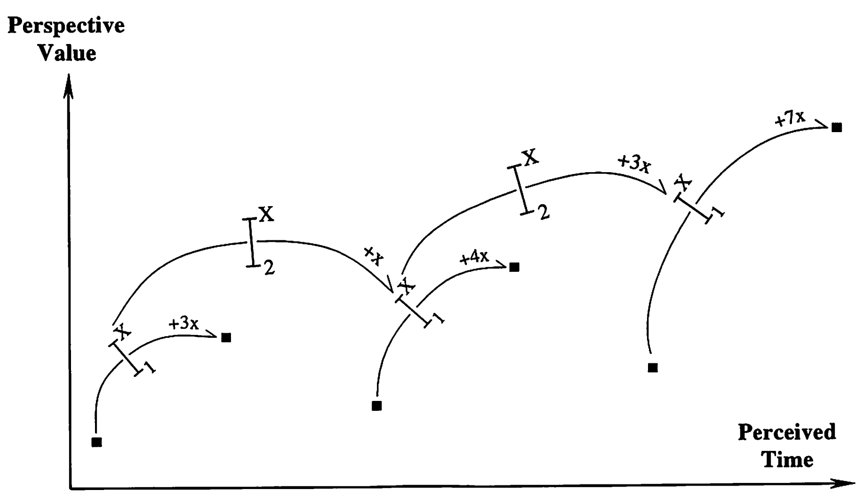


Figure 2.19 Primary value serving both as reference and comparison.

Higher ranks of interperspective relationship

Secondary interperspective values may themselves be compared or produced through **tertiary interperspective relationships**, which may be represented as follows:

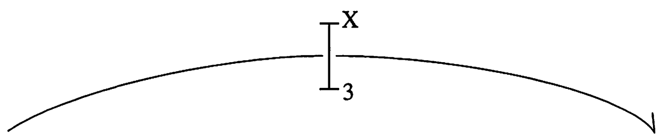


Figure 2.20 Tertiary interperspective relationship.

Such relationships have **tertiary interperspective values**, which may in turn be connected through **quaternary interperspective relationships** (see figure 2.21), and so the pattern may be continued indefinitely through higher ranks of relationship.

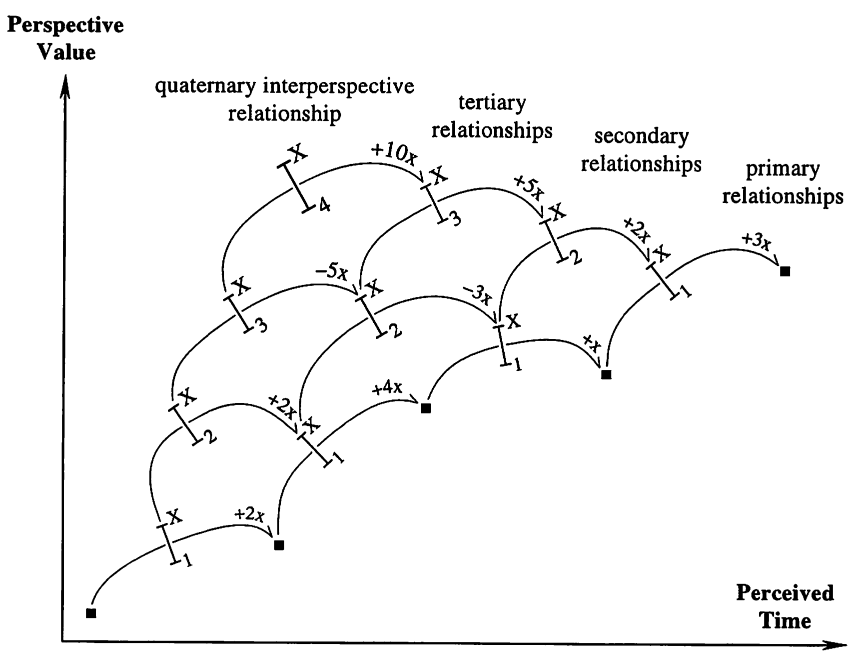


Figure 2.21 Primary, secondary, tertiary and quaternary relationships.

Such relationships are mentioned here only for the sake of completeness, however; their perceptual inaccessibility has prevented them finding any practical application to date. Observe also that the musical relevance of all higher ranks of interperspective relationship varies greatly from one perspect to another; specific comments follow in the next chapter.

Interperspective relationships of mixed rank

Interperspective relationships of different ranks which share values of the same type may be compared through higher relationships of **mixed rank**, a characteristic that may be defined precisely using a matrix. Consider, for example, the following mixed-rank relationship, which expresses the difference between a primary and a secondary interperspective value.

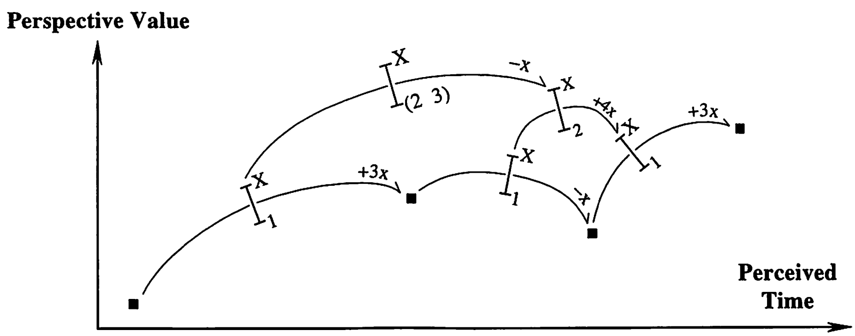


Figure 2.22 A (secondary tertiary) relationship of difference.

Cross-modal interperspective relationships

The relationships described up to this point have matched only perspective or interperspective values of the same type. However, *differing* aspects of perceived sound can be compared and contrasted too. Stevens (1975, p. 132), in summarising the results of many previous experiments, concludes that:

any two stimuli can be equated through the procedure of cross-modality matching, provided they have at least one aspect or attribute that varies in degree.

Such relationships may be termed **cross-perspective** or 'cross-modal' (after Stevens, op. cit.). If required, the nature of their cross-modality may be represented as a matrix. For example:

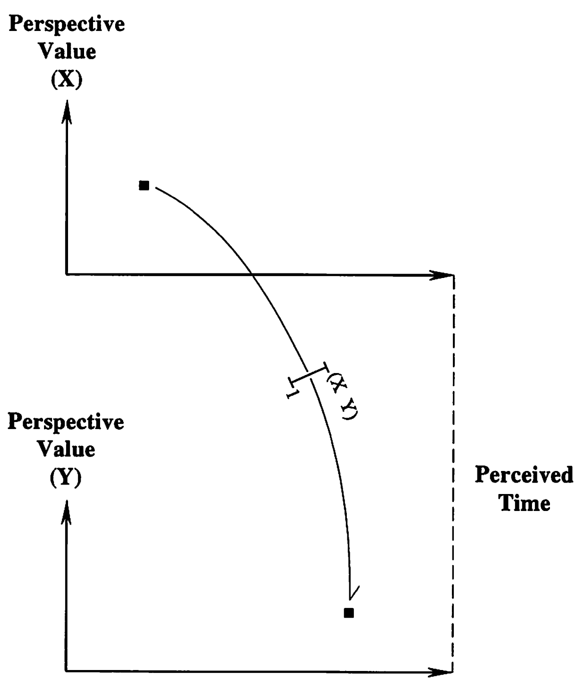


Figure 2.23 Cross-modal primary interperspective relationship.

(Here the second type of unspecified perspect is symbolised as 'Y', with nominal unit value 'y').

Observe that in comparing two such primary connections *between* the perspects X and Y, a secondary relationship *of* X and Y is implicated, which may be symbolised as follows:

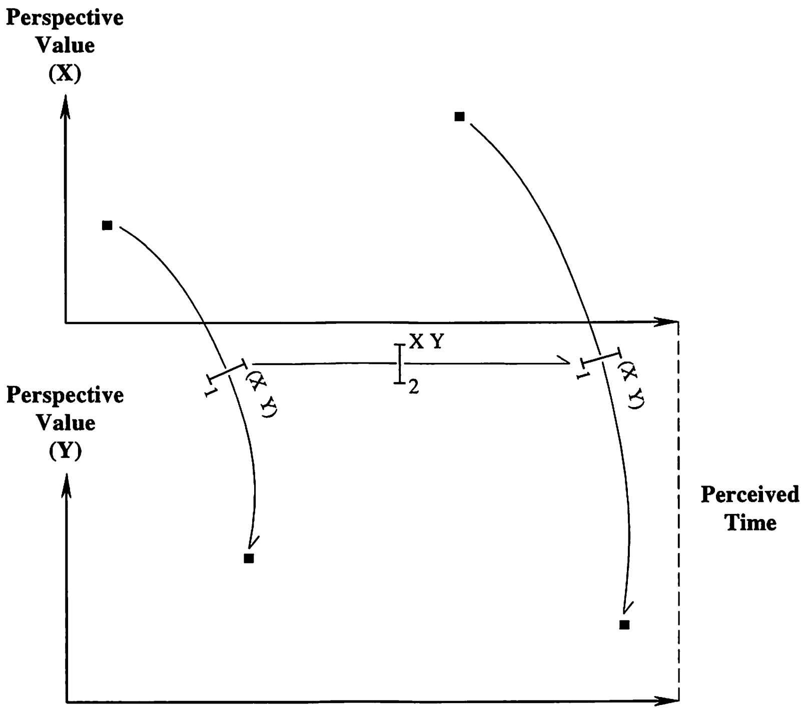


Figure 2.24 Secondary relationship between cross-modal primaries.

Another approach to linking perspects of different types is to be found in the use of secondary (or higher) relationships between interperspective ratios. Such a concept is implied in certain techniques of mutiple serialism, whose effectiveness, admittedly, is a matter of contention. Since ratios are 'pure numbers' that exist independently of the perspects to which they pertain, the legitimacy of relationships between fundamentally different qualities of sound, questioned, for example, by Meyer, 1967, p. 250, is in fact in no doubt. See, for example, figure 2.25 (and cf. figure 11.7).

Cross-modal relationships may be of mixed rank. See figure 2.26 (and cf. figures 9.57 and 9.74).

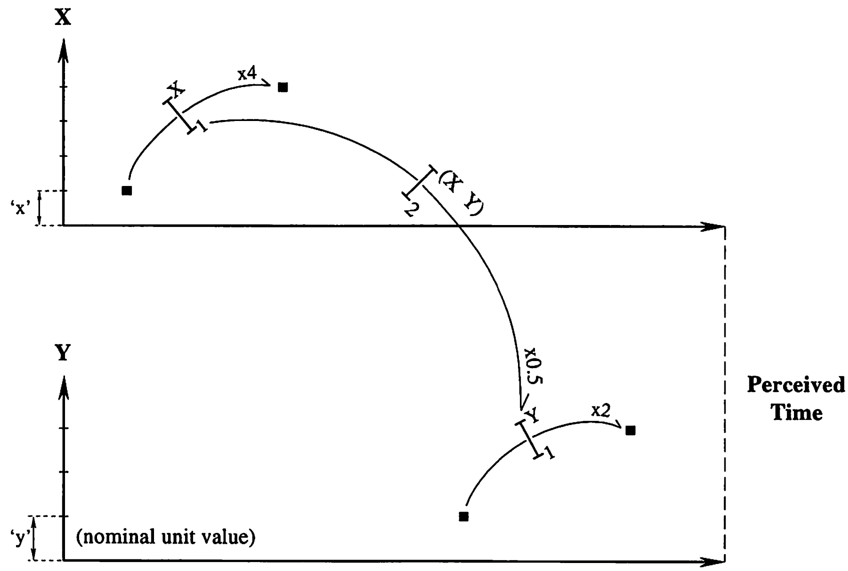


Figure 2.25 Cross-modal secondary relationship between primary ratios.

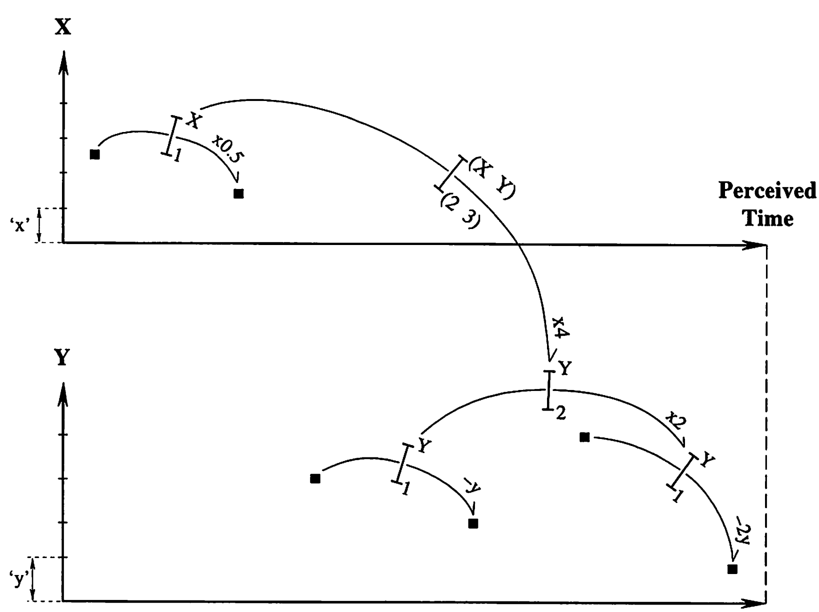


Figure 2.26 Cross-modal interperspective relationship of mixed rank.

Multivariate relationships

It is conceivable that three or more values may be linked through a 'multivariate' relationship—that is, one involving two or more variables. For example, the third value in the series below is '2x' greater than the first two added together. This may be symbolised as follows (cf. figures 9.20 and 9.21).

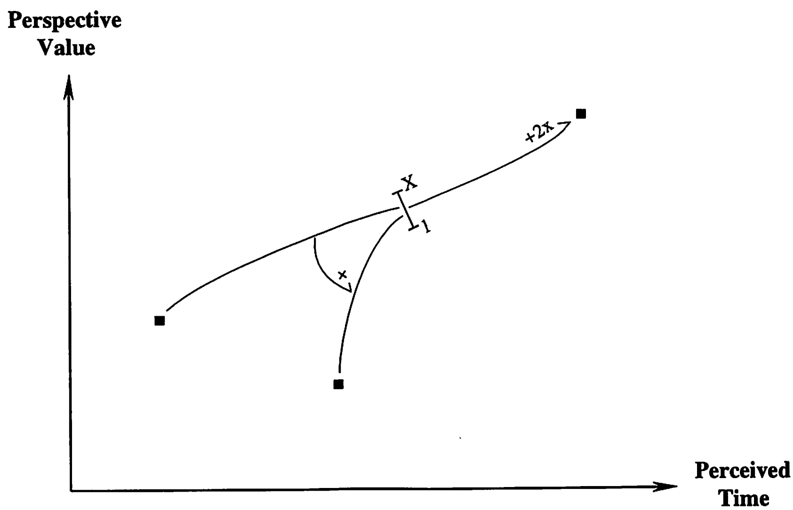


Figure 2.27 Multivariate relationship.

Conclusion

This chapter has sought to describe the relationships through which particular and interparticular values may be matched, either reactively or proactively. Moreover, as will become apparent, many of the observations that have been made apply beyond the realm of particles to perspective values generally. During the course of a piece of music, listeners are typically aware of relationships only subconsciously, passing by as a series of qualitative sensations. Introspection, however, enables us to quantify and conceptualise something of what we perceive. It is in this guise, as products of the intellect, that relationships underlie so much of music theory, including the present work.

3

Perspects

Introduction

This chapter describes in detail the five perspects identified in chapter 1: pitch, loudness, timbre, fix and plot. The survey is by no means exhaustive, covering only those areas that are relevant to the theory of perceived musical order presented in the chapters that follow. Pitch is the aspect of perceived sound that has been most thoroughly investigated by music psychologists and theorists, and so it provides a good starting point for our enquiry.

Pitch

Music theory takes a primary interperspective relationship of pitch to be a measure of difference, which it terms an 'interval'. Hence musicians speak of the interval between fourth octave *e* and the *f#* above it, for example, as being a 'tone' or a 'major second'. Such information may be appended to the symbol for an interperspective relationship. See figure 3.1.

Labelling intervals in this abstract way helps musicians to understand, classify and use them. To the practised ear, the notion of a 'major second', for instance, evokes a particular perceived sonic image. Equally, conscious aural analysis makes it possible to recognise intervals as they crop up during the course of a piece. However, music is not typically experienced in this way. In the discerning listener, at least, an intervallic progression induces successive subjective responses that defy reduction to a mere numerical sequence. This illustrates the distinction drawn in chapter 2 (p. 20) between

Bach: *Well-Tempered Clavier*, Part 1, Fugue 9, BWV 854

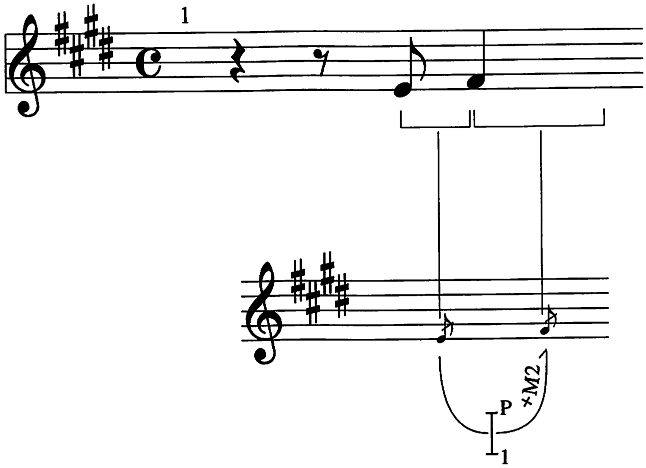


Figure 3.1 Primary interperspective difference of pitch.

the cerebral and affective components of a relationship. And although intervals are identified here by means of their traditional music-theoretical labels, these should be treated merely as mnemonics for an underlying experiential reality.

According to some psychoacoustical research, for example, Stevens and Volkman (1940), it appears that pitches may be related through ratios too. Whether a relationship of difference or ratio is perceived depends upon the disposition of the pitch values presented (since different patterns may emphasise one function or the other), upon the context in which they are heard, and upon the attitude of the listener, since expectation and experience can sway one's mode of perception (Krumhansl and Shepard, 1979, p. 580).

There are generally thought to be two ways of perceiving a relationship of pitch, determined largely by the period of time separating the values (Bachem, 1954). The first exploits our 'long term' pitch memory, through which a temporally remote value can be related indirectly with one of the immediate past or present. The second consists of a more direct relationship existing between two pitches occurring contemporaneously or approximately so. The capacity to make judgements like this is known as 'relative pitch'. These two perceptual mechanisms are now examined in turn.

Exposure to numerous different pitches from the earliest stages enables us to develop an 'internal pitch scale'. This is constantly being revitalised as new pitch values are assimilated, as well as providing each of us with a personal yardstick against which fresh material can be compared. Hence, with varying degrees of accuracy, a pitch can be assessed or a value reproduced in apparent isolation. Using our internal scale, we can, on average, assign pitches reliably to one of about five different categories (Pollack, 1952, p. 745) A tiny proportion of people, however, can manage a resolution a good deal finer than this: in excess of seventy categories of pitch are discriminable in certain cases (Ward, 1963, p. 38). Such fidelity of judgement is more than sufficient to allow the pitches used in the majority of music to be distinguished, labelled and, if necessary, reproduced without recourse to a known external standard. This ability, in either its reactive or, rather more infrequently occurring, proactive form (Révész, 1953, p. 96) is known by psychologists as 'absolute pitch' ('AP').[1]

'Relative pitch' requires the judgement of intervals in isolation, a facility which is more readily amenable to training (cf. Fyk, 1982, p. 41) and which people generally find much less problematic than the assessment of solitary values. According to Burns and Ward (1978, p. 456), musicians are able to categorise more than thirty different intervals without immediate reference to a standard. And although the majority of people have not learned to label intervals according to music-theoretical principles, by and large, relative pitch is sufficiently well developed to permit a familiar tune to be identified easily or sung recognisably at an arbitary pitch level.

Except in the case of simultaneous values, the resolution of relative judgements hinges upon the fidelity of memory. This is affected both by decay, which is related to the period that elapses between pitches, and interference, such as the interpolation of other musical material (Massaro, 1970; Deutsch, 1974). This implies that the degree of uncertainty attached to intervallic recognition and reproduction increases as the conditions for perception deteriorate. Given the highly favourable circumstances obtainable in psychoacoustical experiments, it is possible to obtain a measure of the smallest perceptible interval. In psychological terms, this is referred to as the 'just noticeable difference' or 'JND'. According to Stevens (1975, p. 169), the JND of pitch is subjectively constant, which means that whatever its value, the difference between a pitch and its nearest perceivable neighbour always seems to be the same. This relates to a change of the order of 0.3% standard frequency (Bachem, 1954, p. 752). The typical perceptual

[1]Musicians tend to use the term 'perfect pitch' (Ward, 1963, p. 14).

environment that obtains musically, however, in which large numbers of pitches are dispersed over extended periods of time, falls far short of the ideal which is approachable in the laboratory; and, despite the cognitive mitigation offered by the ordered disposition of musical material, it would be a contrived piece indeed that exploited the levels of relative pitch discrimination of which listeners are potentially capable.

We now consider pitch relationships of higher rank. Both secondary interperspective differences and ratios form an accepted part of traditional music theory: for example, statements to the effect that the difference between a major third and a minor third is a minor second (as in the following excerpt),

Bach: Violin Concerto in *E* major, BWV 1042

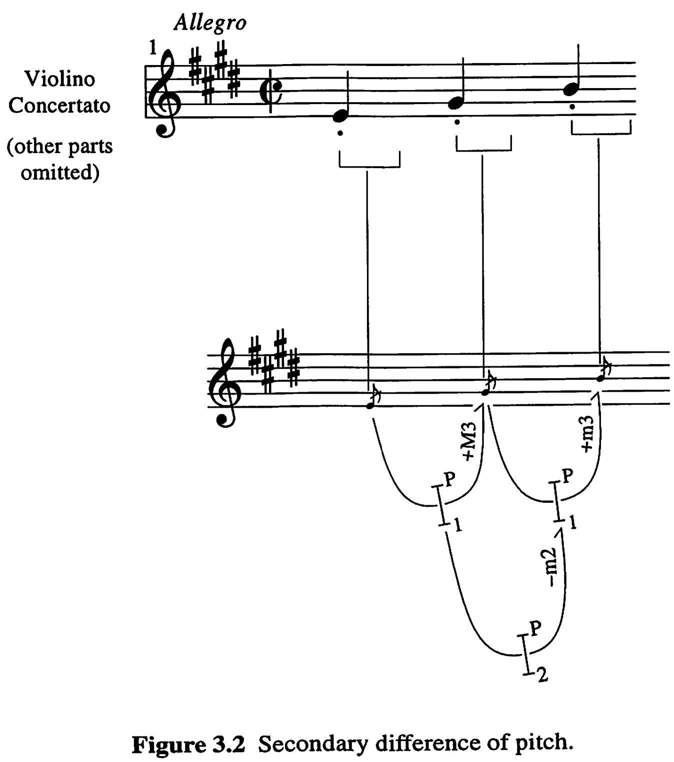


Figure 3.2 Secondary difference of pitch.

or that five semitones constitute a perfect fourth (cf. Meyer, 1973, p. 146) are commonplace; see figure 3.3. Similarly, tertiary interperspective relationships have relevance to the ear that is suitably primed. For instance,

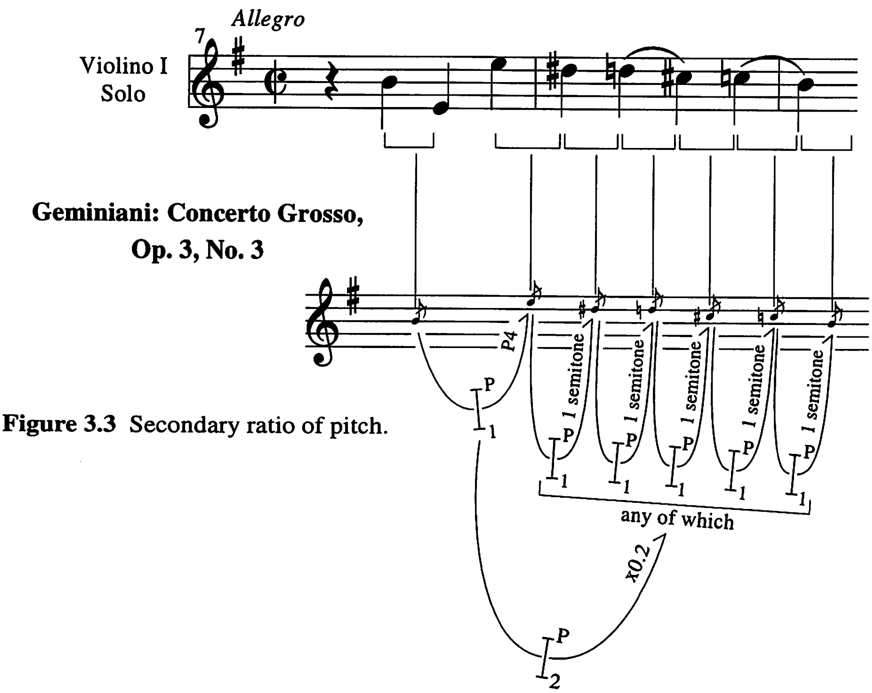


Figure 3.3 Secondary ratio of pitch.

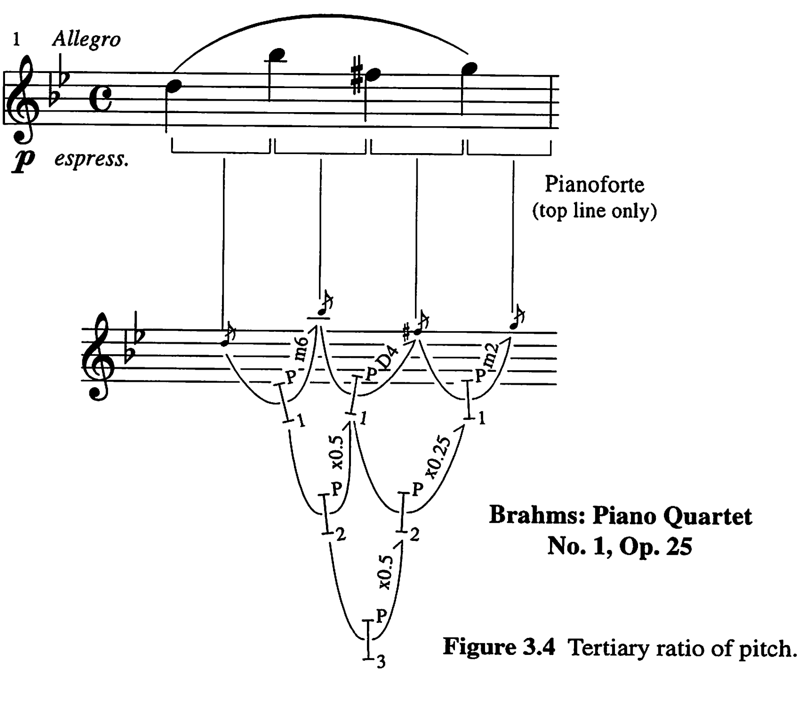


Figure 3.4 Tertiary ratio of pitch.

it is possible to hear that the ratio between a diminished fourth and a minor second (which is x0.25) is half that existing between a minor sixth and a diminished fourth (which is x0.5)—see figure 3.4. However, it is difficult to judge the part such relationships play in the subjective listening experience.

So much for the general principles underlying interperspective relationships of pitch. We now examine the relationships perceived between a wide range of specific values and use the information obtained to build up a model of pitch perception. This conceptual structure is intended to illustrate the way pitch is perceived in the context of traditional Western music; other situations may require different analogies. It will be displayed according to the conventions summarised by Krumhansl (1983, p. 34), whereby the perceived similarity of values is represented by the adjacency of points on the page: the more alike two pitches seem, the closer their depiction diagrammatically. (Identical values occupy the same space.) Hence the data are summarised in a form

> that by its geometric nature is visually accessible. (ibid.)

Imagine, then, a pitch of moderate value; the arbitary point of reference for our model:

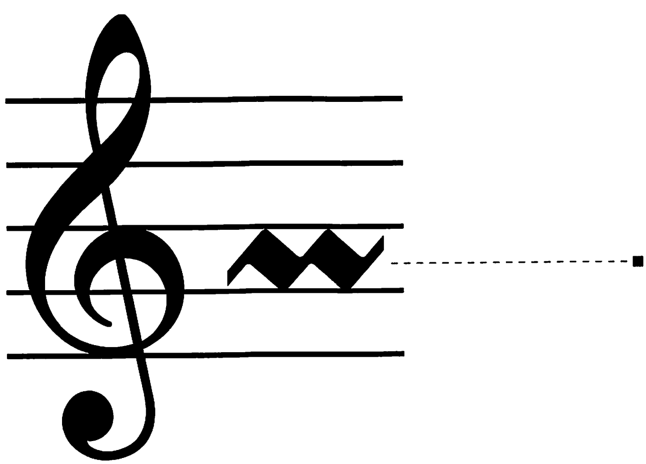


Figure 3.5 Arbitary reference pitch.

This value is separated from the ones nearest to it (either higher or lower) by the JND of pitch. Since there is no perceived discontinuity between the two values, the corresponding points are perfectly contiguous too. This is displayed vertically in figure 3.6.

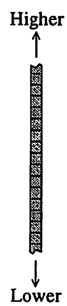


Figure 3.6 Contiguous values of pitch separated by their JNDs.

Figure 3.7 Portion of the domain of pitch represented as an unbroken line of uniform density.

The complete spectrum of pitches constitutes a **perspective domain**. This may be represented as a series of adjoining points, comprising one unbroken line in accordance with the continuous variation open to pitch. The fact that the JND of pitch is subjectively constant irrespective of its position within the domain is shown by the uniform density of line. (See figure 3.7.)

Pitch is a 'positional' quality of perceived sound; as a value changes, it seems to move within its domain through a process of substitution, whereby one apparent locus of excitation is replaced by another. Stevens (1975, pp. 12 and 13) terms continua of this type 'metathetic'.

The disposition of the domain of pitch is susceptible to considerable variation. Its extent, for instance, differs from one person to another, while the intensity of a sound influences both the width of the JND, and hence the total number of discriminable pitches, and their audible range (Stevens and Davis, 1938, p. 153). Still, it is useful to have an approximate idea of perceptual limits, and between the stimulus frequencies of 20Hz and 12,000Hz, at a moderate level of loudness, about 1,400 separate pitches are discriminable (Stevens and Davis, op. cit., p. 95).

'Traditional' Western values can be placed on the proposed representation of the pitch domain, although their locations are subject to a certain flexibility, due to the historical and geographical differences in pitch standards (Apel, 1969, p. 67) and tuning systems (Barbour, 1951). Furthermore, vocal and many instrumental performances are prone to a high degree of pitch variability (Seashore, 1938, pp. 218ff). However, experienced listeners tend to compensate for discrepancies in intonation by unwittingly 'categorising' intervals heard in a musical context (Siegel and Siegel, 1977; Burns and Ward, 1978). This mechanism allows mistunings that would be picked up instantly in less distracting circumstances to pass by unnoticed, as wayward interperspective differences are subconsciously assimilated into their nearest orthodox intervallic classes. In learning to perceive intervals categorically, listeners effectively carve a series of discrete steps out of the smooth slope of continuous pitch perception with which they are naturally endowed.

We are now in a position to ascertain what form the perspective domain takes, which is equivalent to determining the course followed by the line of the analogy presented in figure 3.7. First, consider that as an interval increases in size, there is felt to be a proportionate decrease in pitch similarity (Kallman, 1982, pp. 39ff). This simply implies that the line be straight. See figure 3.8.

But there is another aspect of pitch perception whereby, in an appropriate context, musically experienced listeners credit values an octave apart with a special equivalence, quite distinct from the intervallic difference that divides them (see, for example, Allen, 1967). To accommodate this phenomenon, the straight line of figure 3.8 must be coiled into a helix, in such a way that the octave multiples of pitches, which are said to share a distinct 'chroma', are brought into a vertical alignment that acknowledges their privileged perceptual status (Révész, 1953, p. 67). See figure 3.9. Hence pitch can be perceived cyclically as well as linearly.

Observe that the effect of octave similarity applies interperspectively too: primary values linking pitches that share the same chroma are likewise felt to have a special affinity. This is reflected in music-theoretical terms, whereby intervals of a minor ninth or more are sometimes referred to as 'compound' versions of those an octave smaller, while the intervals between

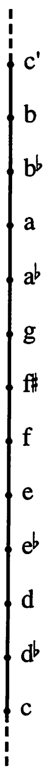


Figure 3.8 Portion of the domain of pitch, featuring the harmonic chromatic scale of *c*.

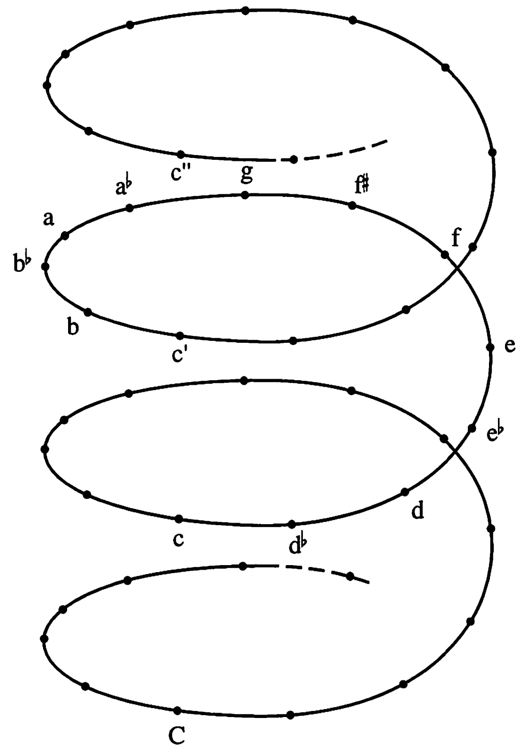


Figure 3.9 Pitch domain represented as a helix.

two pairs of pitches with the same letter names but with opposite polarity are known as one another's 'octave complement'.[2]

[2]The term 'inversion' is also widely used in this sense (see, for example, the *Rudiments and Theory of Music,* published by The Associated Board of the Royal Schools of Music, 1958, p. 61), though, as Browne (1974, p. 415) points out, it is probably better restricted to mean the relationship between two intervals of equal magnitude and opposite polarity. Hence the inversion of a major third ascending is a major third descending, whereas its octave complement is a minor sixth. An alternative is found in Apel (1969, pp. 422 and 423), who labels the two transformations 'melodic inversion' and 'harmonic inversion' respectively.

According to Shepard (1982), values separated by fifths have augmented perceptual proximities too, and to illustrate this, he expands the representation of pitch shown in figure 3.9 into a five dimensional model comprising a double helix wrapped around a helical cylinder. He claims (p. 370) that a portrayal of this type is necessary to show the different paths in 'pitch space' which a variable value can be made to traverse;

> paths corresponding, for example, to a shift through height, a shift through chroma, or a shift through the circle of fifths.

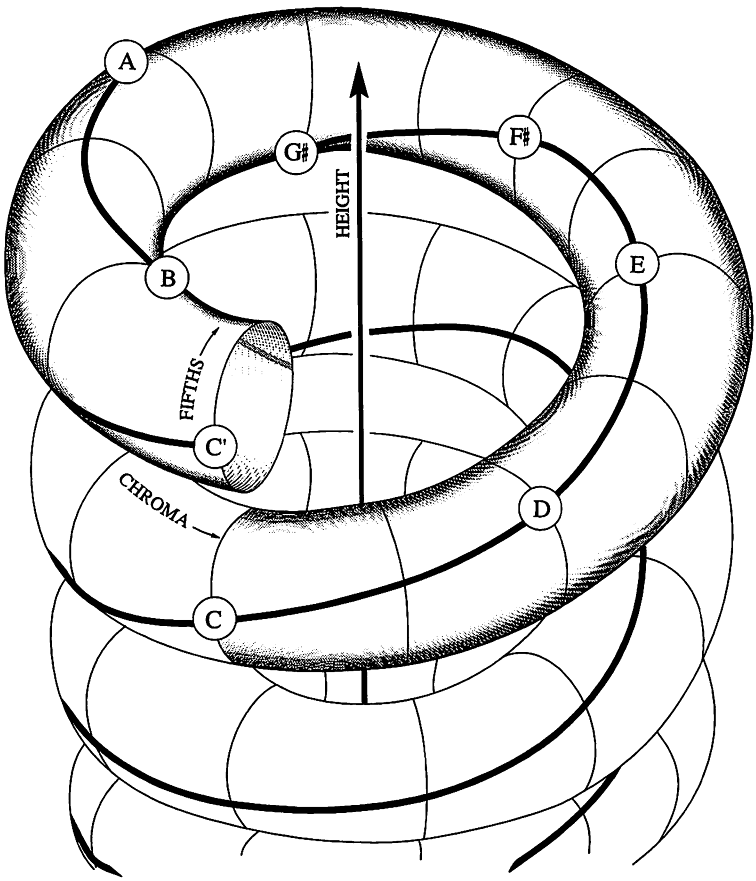


Figure 3.10 Representation of the domain of pitch as a five-dimensional helix (after Shepard, 1982, p. 364).

This helical configuration has been criticised on a number of counts. Krumhansl (1979, p. 360), for instance, observes that

> the structure does not represent in any way the special status of the third.

She contends, moreover, that the model depicts only certain relationships of pitch that are invariant across different tonal systems, and that modifications would be needed to account for interperspective values gauged in the context of specific tonalities. This is demonstrated by the fact that listeners give different similarity ratings to the same interval heard in varying tonal circumstances. Hence, although the differences between *c* and *g*, and *c#* and *g#* both constitute a perfect fifth, this does not guarantee their equivalence in musical terms. Tonality further implies that the perceived affinity between pitches will be affected by the order in which they are presented (op. cit., p. 361). These findings lead Krumhansl and Kessler (1982, p. 337) to the conclusion that

> some systematic transformation must intervene between geometrically regular representations of pitch structure,

in which all intervals of a given size correspond to a fixed interpoint distance,

> and the pitch relations as they are perceived in a tonal context.

This applies with equal force to the helical models shown above and to such two-dimensional arrays as that proposed by Longuet-Higgins (1978), which is based on major thirds and perfect fifths, and the one put forward by Balzano (1982, p. 337), founded on a network of major and minor thirds. Krumhansl's own similarity scaling of pitches in explicitly musical conditions shows the members of the tonic triad to be most alike, followed by the remaining diatonic degrees, with the chromatic values showing least mutual resemblance. She represents this diagrammatically by a conical configuration (1979, p. 357).[3]

[3]The nature of pitch perception in a tonal context is investigated in more detail in chapter 10.

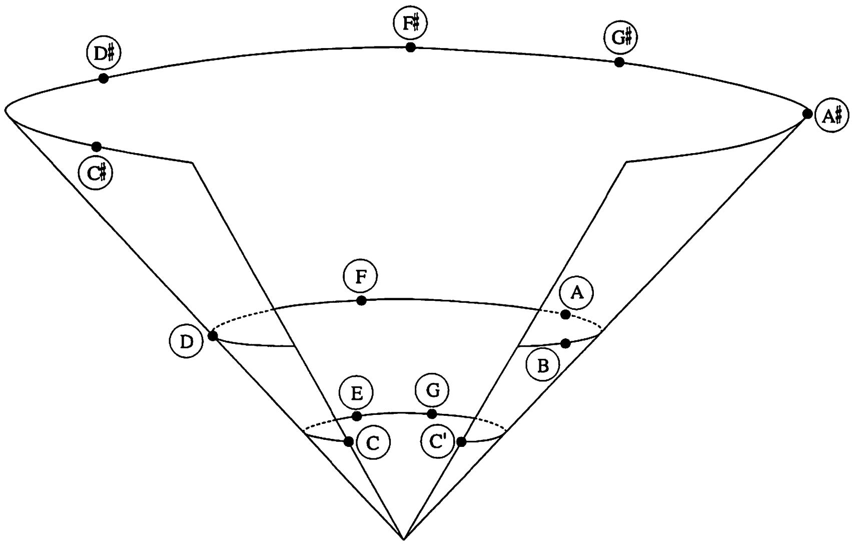


Figure 3.11 Conical representation of a portion of the domain of pitch (after Krumhansl).

The main issues arising from this brief review of pitch perception may be summarised as follows. Usually, in listening to a piece of music, listeners are only subconsciously aware of its constituent primary interperspective relationships of pitch, which slip by as a series of qualitative experiences. However, introspection of the type demanded by music theory enables these to be quantified as differences, and psychoacoustical investigation has shown that they can be reckoned in terms of ratios as well. In a spatial representation of pitch, it is generally acknowledged that such relationships operate in a dimension corresponding to 'height'. To the appropriately trained ear, pitches share affinities along other axes too. For example, values separated by an octave are said to share the same 'chroma', a correspondence which Western theoretical thought recognises by according them the same letter-name. Moreover, pitches separated by other intervals such as the perfect fifth and the major third apparently enjoy a comparable, though weaker, perceptual kinship. The nature of an interperspective relationship between two pitches depends heavily upon the context in which the values are heard, upon the aural propensities and musical background of the listener, and upon the set of attitudes that he or she brings to bear.

Loudness

Loudness is generally held to be of less musical consequence than pitch; it is scarcely mentioned by music theorists. Its perception is well documented in the psychoacoustical literature, however, and attempts to scale loudness have led some researchers to the conclusion that it is feasible to perceive both interperspective differences and ratios with consistent accuracy (Stevens and Davis, 1938, p. 122). This belief has been questioned in other quarters, however, since the experimental evidence on which it is based is demonstrably prone to contextual variation (Garner, 1954) and shows wide discrepancies from one listener to another (Moore, 1977, p. 63).

As far as musicians are concerned, there has been no attempt to evaluate interperspective relationships of loudness in terms of numerically accountable differences or ratios. Hence, a conductor may simply ask that a passage be performed "more quietly", for example, and even so specific-sounding a request as "half as loud" would probably be interpreted rather freely. Then consider the labels traditionally assigned to loudnesses in the West: *pp, p, mp, mf, f, ff* and so forth. It is difficult to judge, and music theory offers no clues, precisely how one item on the list is felt to relate to another. Whatever the comparative process involved, it is not adopted with any consistency: performers are under no obligation to maintain a uniform margin between equivalent pairs of loudness categories. So the interperspective value distinguishing *pp* from *p* need not be the same as that between *f* and *ff*, for instance. Indeed, a relationship between given degrees may differ greatly on separate occasions, making each designation of loudness open to a broad range of interpretation too.

Higher ranks of interperspective relationship are inevitably beset by a similar haziness. For example, a teacher may entreat a pupil to make "a greater dynamic contrast", thereby implying a secondary interperspective relationship, while stipulating neither its type nor value.

The qualitative approach to loudness adopted by musicians (standing in marked contrast to the meticulous quantification to which pitch is subject) must be represented faithfully in the symbolisation of interperspective relationships. Often, this will involve displaying the two related loudness levels in the following manner:

Elgar: *Enigma* Variations, Op. 36; IX, *Nimrod*

Violino I (other parts omitted)

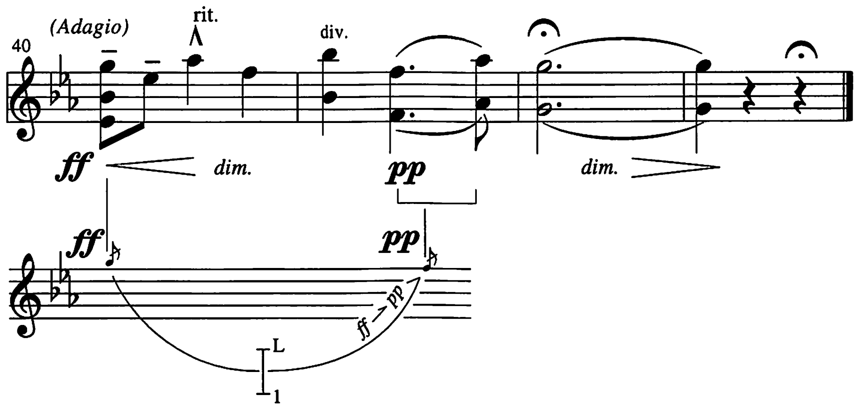


Figure 3.12 Primary relationship between two different levels of loudness.

A general model of loudness perception is now proposed using material culled from psychoacoustical research, and an attempt is made to illustrate this schematically.

Values of loudness extend from the 'threshold of hearing' (the quietest level that can be perceived) to the 'threshold of pain' (above which permanent damage is inflicted on the ear). This corresponds to a 100,000,000,000,000-fold rise in intensity (Moore, 1977, p. 53). Levels presented randomly across this range may be securely assigned, like those of pitch, to one of only about five categories (Garner, 1953, p. 380). However, by moving upwards in just-noticeable increments, Stevens and Davis (1938, p. 52) ascertained that over three-hundred values of loudness are actually distinguishable.

These may be represented by a series of adjacent points (appearing as a continuous line) in accordance with the diagrammatic conventions used in the previous section in connection with pitch. However, loudness and pitch constitute fundamentally different types of psychological measure. Whilst pitch can be thought of as a 'positional' quality of perceived sound, each level of loudness seems to possess a certain 'magnitude', which varies along the length of the perspective domain. Stevens (1975, pp. 12 and 13) coins the term 'prothetic' to describe continua of this sort.

The JND of loudness is not constant (unlike that of pitch), but grows subjectively larger with the level at which it is gauged. This is shown by matching the size of the JND with the density of the line representing perspective values in such a way that heavier print corresponds to a larger limen of difference.

Values of loudness exhibit a monotonic decrease in similarity as the difference or ratio between them is expanded. Since the degree of perceptual affinity is depicted in terms of adjacency, this implies that the line symbolising perspective values be straight.

Taking these observations into account, the perspective domain of loudness may be illustrated as follows (figure 3.13).

The labels *pp...ff* are not attached to specific points on the domain. Indeed, it is possible that the same level may be differently labelled on different occasions. This means that a value once referred to as *forte* may later be described as *mezzo forte*, and so on. Moreover, the interpretation of loudness markers may differ from one instrument to another in response to their varying dynamic ranges: *fortissimo* on the trumpet is likely to drown the most strenuous efforts of an oboist to play very loudly, for example (Clark and Luce, 1965). Finally, consider the diverse loudness levels that may be experienced by individual listeners of the same performance. The *ff* prescribed for the tutti chord concluding the first movement of Bartók's *Concerto for Orchestra* (1943), for instance, may appear to be rather quieter than this at the back of the concert hall, and in a broadcast version, the loudness of the music emanating from the receiver is variable over a vast range, depending on the setting of the gain control.

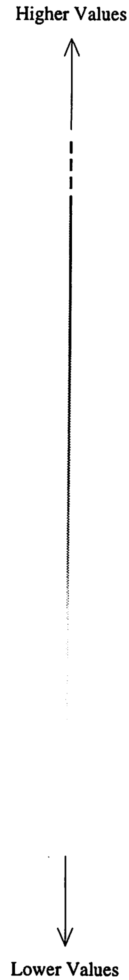


Figure 3.13 Representation of the perspective domain of loudness.

It is quite conceivable that a member of the radio audience (particularly one with score in hand) may rate the final notes of the Bartók as *fortissimo*, when the level at which they are hearing the piece would scarcely class as *pianissimo* in the auditorium where the sounds originated.[4]

In summary, loudness is perceived subjectively by musicians and non-musicians alike. Its musical significance lies less in the absolute levels of succeeding values than in the effect they engender in relative terms, which is greatly conditioned both by the context in which they occur and by the expectations of the listener.

Timbre

In referring to tone quality, musicians typically use what they feel to be appropriate epithets, often borrowed from other sensory modalities. For instance, they may say that a certain violinist produces a 'sweet' sound, or that the tone of the oboe is 'pungent', while in the realm of vocal music, the notes of a tenor, for example, may be said to range from 'velvety' to 'strident'. As a result, no doubt, of timbre's many-faceted nature, labels such as these frequently appear in combination. Hence we find Apel, for instance, speaking of the sound of the clarinet as 'rich and mellow' (1969, p. 856).

A number of workers in the field of music psychology have isolated what they believe to be the chief attributes of timbre with varying degrees of success. For example, Wedin and Goude (1972) propose that the perceptual similarity of the timbres of some of the most common symphonic instruments may be explained in terms of a three-dimensional model. Bismarck (1974, p. 146), in attempting to

> extract from the timbre percept those independent features that can be described in terms of verbal attributes,

finds (p. 157) that 90% of the timbral variance of 35 selected sounds can be described when rated on four scales, whose endpoints are characterised by pairs of opposite attributes: dull-sharp, compact-scattered, full-empty and

[4]Also relevant in this regard is Vernon's observation that "Whatever the actual energies of the various stimuli, definite, attentive listening to any one figure seems to increase its apparent intensity relative to the rest" (1934, p. 131).

colourful-colourless. Of these, the first accounts for 44% of the variance. The remaining continua, which account for rather lower percentages, exhibit a relatively large scatter of ratings between individuals and, Bismarck believes, reflect special properties of the sound sample.

Slawson (1985), in an analysis of what he terms 'sound color', proposes four dimensions which are based on vowel sounds: openness, acuteness, laxness and smallness. The scope of his work extends beyond psychoacoustics, however, into the province of music theory, and, by demonstrating the transposition, inversion and serial manipulation of 'color', Slawson shows how his model can be used as a structural basis for composition.

It is unimportant, from the point of view of the present theory, which timbral representation one opts for, although it seems reasonable to assume that different auditory contexts would highlight one or the other. We need only take into account that values of timbre can be considered to form a compound perspective domain, which is metathetic.

Within this domain, the natural variation to which instrumental colours are subject means that each can be considered to occupy a region, whose boundaries are not distinct, but which contrasts, nevertheless, with other comparable timbral zones. People's ability to distinguish a single instrument (or voice) from the variety of different sounds it may produce is discussed, for example, by Erickson (1975, pp. 11 and 12). An extension of this concept is that of instrumental 'families', such as the strings, brass and double-reeds, for which Clark, Robertson and Luce (1964) present experimental perceptual evidence. As well as listing these in decreasing order of 'tightness', the authors also identify 'very tight' subfamilies.

It seems that isolated timbral values are rather easier to identify than are those of pitch or loudness. Consider, for example, how many different vowel sounds can be recognised in isolation, or think of the ease with which musicians can name any of the wide range of instruments with which they may be familiar: in either case, the number far exceeds the five or so categories of pitch or loudness that are internalised by most people. It seems reasonable to suppose that this greater facility may be attributed to the multidimensional make-up of timbre.

The fact that individual timbres are readily identifiable, combined with the great intricacy of many inter-timbral relationships, means that these connections are not, on the whole, as musically significant as interperspective comparisons of pitch and loudness. Relationships between timbres can be conceptualised only when they are of minimal complexity: suitably direct links may be supposed to exist between separate appearances of the same timbre or at least between timbral values that display an affinity. Hence one may speak, for instance, of a student in the early stages of learning the cello producing a 'coarser' tone than would a professional; or one may suppose the viola to produce a 'darker' sound than the violin. Inevitably, such comparisons are as subjective as the values they compare. A relationship may view a plurality of timbral aspects simultaneously; hence one tone may be described as being both 'fuller' and 'sweeter' than another at the same time. In notating interperspective values of timbre, it may be sufficient simply to specify the two tone qualities that are related. For example:

Franck: Sonata for Violin and Piano (1886); 4th movement

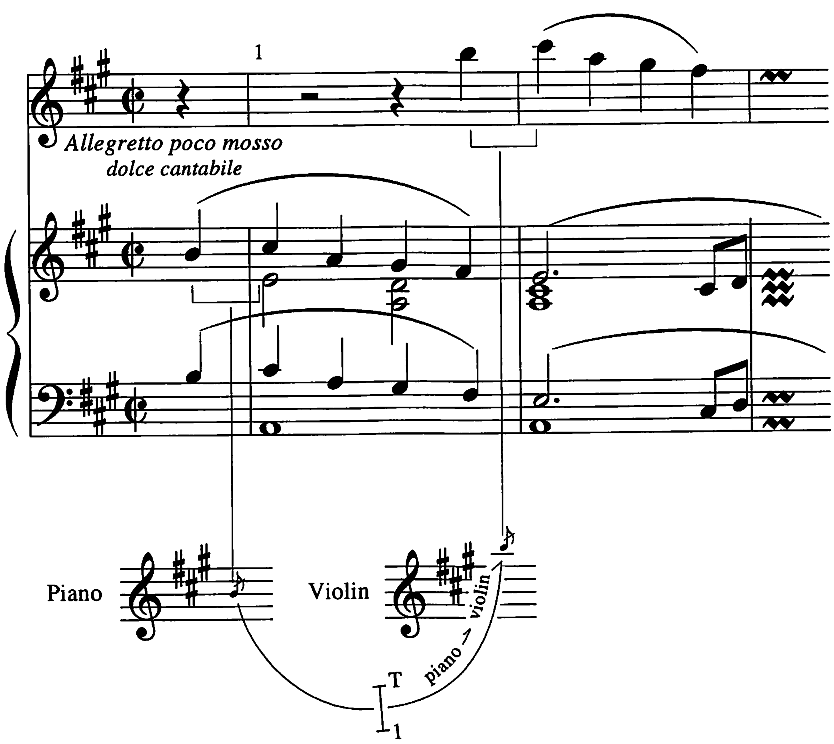


Figure 3.14 Interperspective value of timbre described in terms of two perspective values.

However, where it is appropriate an attempt to define the inter-timbral value itself may be made. For instance:

Vaughan Williams: 5th Symphony; 3rd Movement, *Romanza*

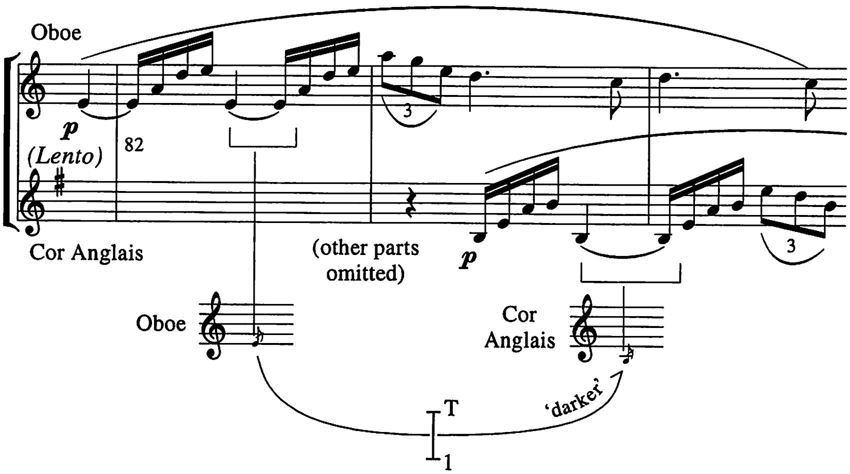


Figure 3.15 Interperspective value of timbre defined in its own right.

Fix

Although, at this stage, it is convenient from a theoretical standpoint to examine fix in isolation, it is not an approach that accords with standard musical practice, in which the perceived temporal dimensions of sound are structurally coordinated. As a consequence, some of the observations made here can only be preliminary in nature, and these will be developed in the course of chapter 9.

Since it is impossible ever to repeat particles of fix (although time may be reckoned cyclically), in examining the fidelity with which they are perceived, there is only one issue to consider: the accuracy with which simultaneous events can be performed and perceived. Rasch (1979, p. 121) notes that although a polyphonic score often prescribes that different parts or voices should begin at the same moment in time,

In actual performances perfect synchronization is never realized... .

His measurements show that

> Asynchronization values fall largely within the range of 30 to 50ms. ... The recorder ensemble shows a relatively small asynchronization (about 30ms). Two samples of the wind trio have different amounts of asynchronization, 27 and 37ms respectively. Largest asynchronization is found in the string trio samples (37 and 49ms). (p. 128)

However, when listening to music, Rasch observes, these discrepancies for the most part go unnoticed, and

> the performances of professional ensembles give the impression of perfect synchronization. (p. 130)

A perceived point in time has meaning only in relation to another. Hence perspective values of fix as such cannot be ascribed, and it is through primary interperspective relationships (which are always expressions of difference) that musical time is defined. This process is usually undertaken with respect to the framework of regular **beats** that is characteristic of so many styles: each acts as a potential temporal reference, in relation to which other sounds are organised (Sloboda, 1985, p. 257). The distance between beats (which may be prescribed metronomically or defined in rather more subjective terms) typically ranges from about 0.25 second to 1.5 seconds (Povel, 1981, p. 4). Longer time spans extend beyond the 'perceived present', outside which successive perceived sonic events tend to be regarded as separate entities rather than members of a coherent series (Fraisse, 1978); whilst aural stimuli occurring at intervals shorter than 0.25 second tend to be heard as subdivisions of a slower pulse. The hierarchical grouping of beats produces the effect of **metre**, which is reflected in the Western notational system of bars.

The beginning of a movement or section serves as a 'data zero' from which values of fix can be judged interperspectively, although, within the context of the piece to which they pertain, they function like perspective values, and it is easy to conceive of them as such. Consider, for example, the observation that "in the first movement of Brahms' Violin Concerto, the soloist enters on the first beat of bar 90". However, there is no qualitative difference between this statement and another that says: "at the start of movement II of Bartók's third piano concerto, the second violins enter one bar after the firsts"; it is just that here the relativity is more apparent.

Bartók: Piano Concerto No. 3 (1945); 2nd Movement

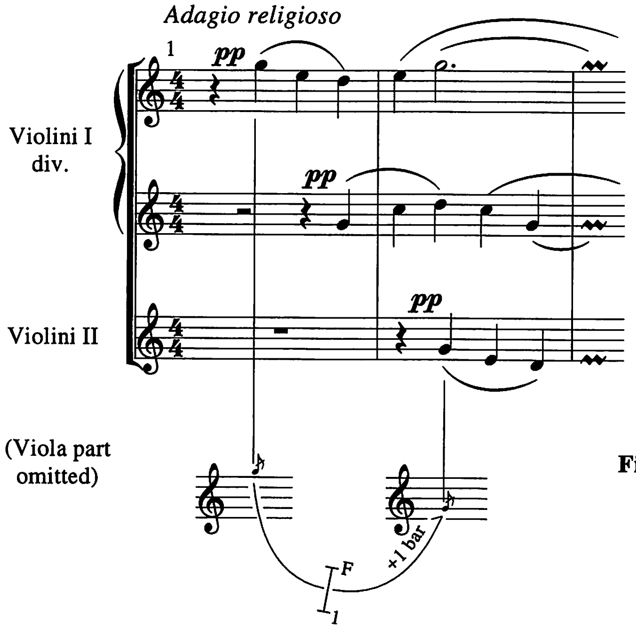


Figure 3.16 Primary interperspective relationship of fix.

In some contemporary scores, the designation of interperspective values of fix takes other forms; the perceived temporal conformation of *Sequenza VII*, by Berio, for instance, is reckoned in seconds.

Berio: *Sequenza VII* (1969)

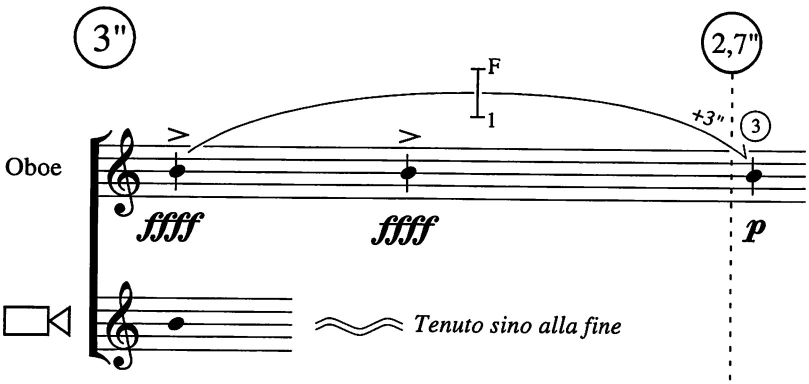


Figure 3.17 Primary interperspective value of fix expressed in seconds.

(Observe the close similarity between Berio's '♪'—a note to be played as quickly as possible—and the notion of a 'moment'.)

Observe that although time is physically irreversible, cognitively this restriction does not apply, and it is commonplace to say, for example, as in the first movement of Mozart's 22nd string quartet, K. 589, that the viola's initial entry is four bars before that of the 'cello.

Mozart: String Quartet No. 22, K. 589; 1st Movement

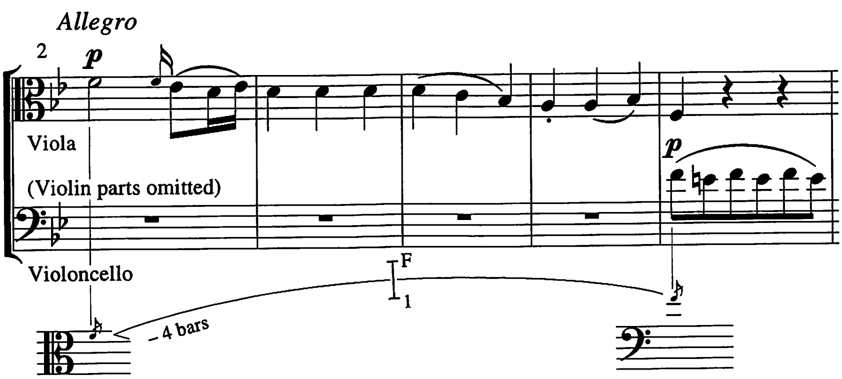


Figure 3.18 Retroactive primary relationship of fix.

An internalised scale of primary interperspective values of fix enable listeners to judge lengths of time in isolation. According to Murphy (1966), who investigated this phenomenon using informational analysis, in the 0.1 to 1.0 second range, 4 to 5 different durations can be categorised, whereas from 0.5 to 5.0 seconds, 6 to 7 categories are available (p. 260). He postulates (p. 263) that a higher number of lengths of time are classifiable within a longer period since here subjects are able to use some form of time-marking to help them. It seems reasonable to assume that over even more extended spells, the number of identifiable temporal intervals would rise still further. However, this position is complicated by the fact that

> the perception of duration is a function of our attitude, of which the most important element seems to be the attention paid to perceived time. The greater this attention, the longer the interval seems. But, all things being equal as regards attitude, the perception of duration depends on the nature of the changes perceived. (Fraisse, 1964, p. 147)

The manner in which many pieces are structured with regard to perceived time reflects the ease with which primary interperspective values of fix can be compared: secondary relationships play a large part in the perception of music. These may express a difference—observations to the effect that one note is a crotchet longer than another, for example, are commonplace—although ratios are encountered far more frequently. This preference may be attributed to the fact that primary values of fix tend to be regarded either as multiples or fractions of an underlying beat (Povel, 1981, p. 13). A rhythm is normally encoded as a series of perceived temporal proportions, and, provided these are kept intact, the tempo may be altered without destroying its essential design. Uniform change, on the other hand (for instance, adding a quaver to every note of a melody), would substantially alter the nature of a rhythm incorporating different note-lengths.

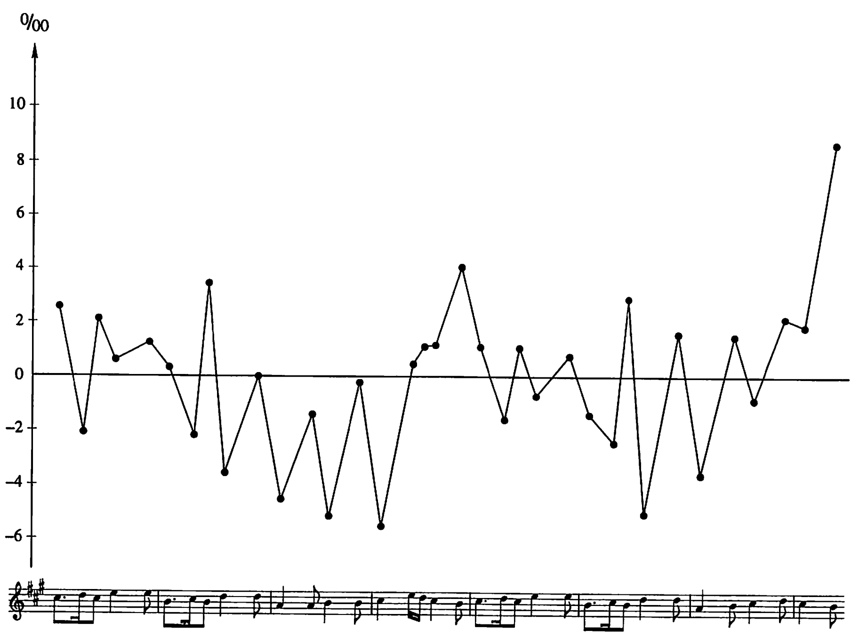


Figure 3.19 Deviations from mechanical performance in the pianist Ingrid Haebler's performance of the beginning of Mozart's Piano Sonata in *A* Major (K. 331). The deviations are expressed in per mille of the total duration (until the last one); one per mille corresponds to approximately 23 ms. (After Gabrielsson, 1988, p. 45.)

Although traditional systems of notation and music theory together foster the belief that the ratios used in music are on the whole simple—2:1, 3:1 *et cetera*—work in the field of music psychology suggests that this is far from being the case. Gabrielsson (1988, p. 45), for example, charts the deviations in one performance from the mechanical ideal; considerable discrepancies that any metronome-bound piano teacher would surely find rather alarming. (See figure 3.19.) Clearly, a form of categorical perception is in operation.

Finally we consider how the perspective domain of fix may be illustrated. Only a small portion of it can ever be shown at once, since values continue indefinitely in either direction, a characteristic indicated with the use of broken lines. An arrow points the direction in which time appears to be moving. The JND of fix is subjectively constant, so the line is of uniform density. The continuum is drawn horizontally in accordance with the graphical conventions adopted earlier. It is metathetic.

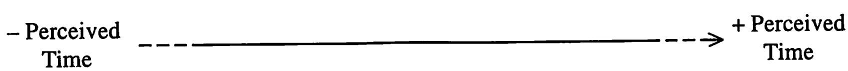


Figure 3.20 Representation of the perspective domain of fix.

Plot

Matters concerning the perceived location of the sound source are scarcely acknowledged by traditional music theory, a state of affairs that reflects the low regard in which composers have generally held this aspect of perceived sound. Berlioz (1855/1858) is one of the few to have broached the subject; hardly surprising, perhaps, with works such as the spatially conceived *Requiem* to his name. He writes (p. 242):

> There occurs here an opportunity to remark upon the importance of the various points of procedure for the sounds. Certain parts of an orchestra are intended by the composer to interrogate and answer each other; now, this intention can only be made manifest and of fine effect, by causing the groups between which the dialogue occurs to be placed at sufficient mutual distance. The composer should, therefore, in his score, appoint for them severally the disposal which he judges proper.

Nevertheless, as the use of electronically reproduced and synthesised sounds shows, the structural potential of plot is without doubt enormous, although its expressive possibilities are yet to be clearly defined (see chapter 8, pp. 270ff).

Composers may encounter difficulties in handling plot that are not to be found in the manipulation of pitch, loudness, timbre and fix. For around these perspects fields of expertise have been cultivated by countless generations of musicians. In comparison, the latent musical wealth of plot has barely begun to be explored, and in preference to composers investigating its little-known depths unguided, it would seem more satisfactory for them to heed the findings of the psychoacoustical research that has been undertaken in this area.

It would be futile, for example, to prescribe separate locations for two perceived sounds if these proved indiscriminable. Hence composers would do well to temper Stockhausen's notion of a sound source situated on every point of a circle surrounding the listener (1959/1961, p. 81) with the disclosures of Stevens and Newman (1936, p. 305), which reveal that

> The error of localization is smallest for tones located near the median plane and increases as the tone is moved toward the side of the *O*.

Moreover,

> confusion of positions lying in the quadrant in front of the *O* with those in the quadrant behind him is very frequent.

Finally, the authors present the now well-established hypothesis

> that the localization of low tones is made on the basis of phase-differences at the two ears, and that the localization of high tones is made on the basis of intensitive differences. There is a band of intermediate frequencies near 3000 cycles in which neither phase nor intensity is very effective and in which localization is poorest.

Naturally, one could argue that listening to a piece of music in which the control of plot figures prominently only slightly resembles psychoacoustical experiments of the type conducted by Stevens and Newman. For example, the members of a concert audience are free to move their heads, thereby providing themselves with an effective means of resolving ambiguities in location (Wallach, 1940; Moore, 1977, p. 178). The visual element may offer valuable assistance too, although, particularly when sound emanates from loudspeakers, its physical and perceived sources may be utterly at odds (consider the impact of a stereophonic music system, for example).

The way in which the distance of a sound source from the listener is perceived has been scrutinised by psychologists too. Moore (op. cit., p. 204) observes that listeners use a multiplicity of clues in making distance judgements: the curvature of the wavefront is important, as are the effects of any reflection that may be present; more obviously, perhaps, loudness can act as a crude measure of the perceived range of a sound, and over moderate distances, the spectral change which occurs due to the absorption properties of the air (implying a mutation of timbre) can be of assistance as well. The operation of the last two factors is dependent on familiarity, though, and errors of 20% are not uncommon in judging how near the sources of unfamiliar perceived sounds are. Because of this, Stockhausen (op. cit., p. 77) argues that only under very limited conditions would it be advisable to treat the perceived remoteness of a sound as an individual perspect; for example, timbres would have to be used with which the listener was either already acquainted, or had become so during the course of the piece.

Whether plot is regarded as one compound perspect, or in terms of the three components identified in chapter 1, an interperspective relationship between two values unfailingly expresses a difference in a given orientation. If distances are judged from the listener, however, who may therefore be used as a 'data zero', ratios are feasible too. Hence listeners may perceive one sound as coming from twice as far away as another.

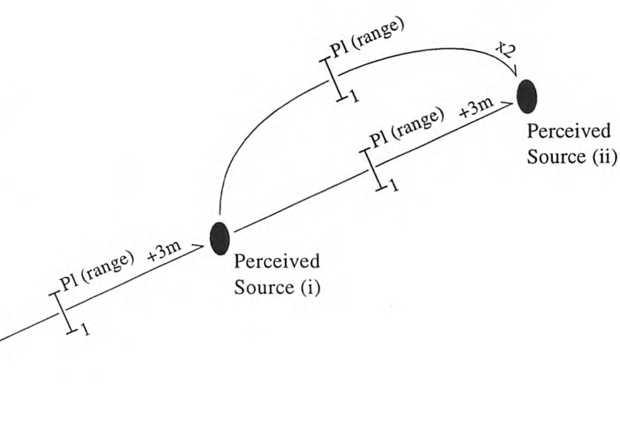


Figure 3.21 Primary interperspective relationships of plot.

Theoretically, secondary relationships, and those of higher ranks, can constitute differences, ratios or any other function. Although, as far as I am aware, possibilities such as these have not been seriously exploited by composers, their existence is at least partly acknowledged: Stockhausen (op. cit., p. 78), for instance, postulates that distance in space may be subject to a ratio in the same way as durations.

The complete perspective domain of plot, which functions metathetically, may be represented as a solid sphere, which extends indefinitely from the listener situated at its centre.

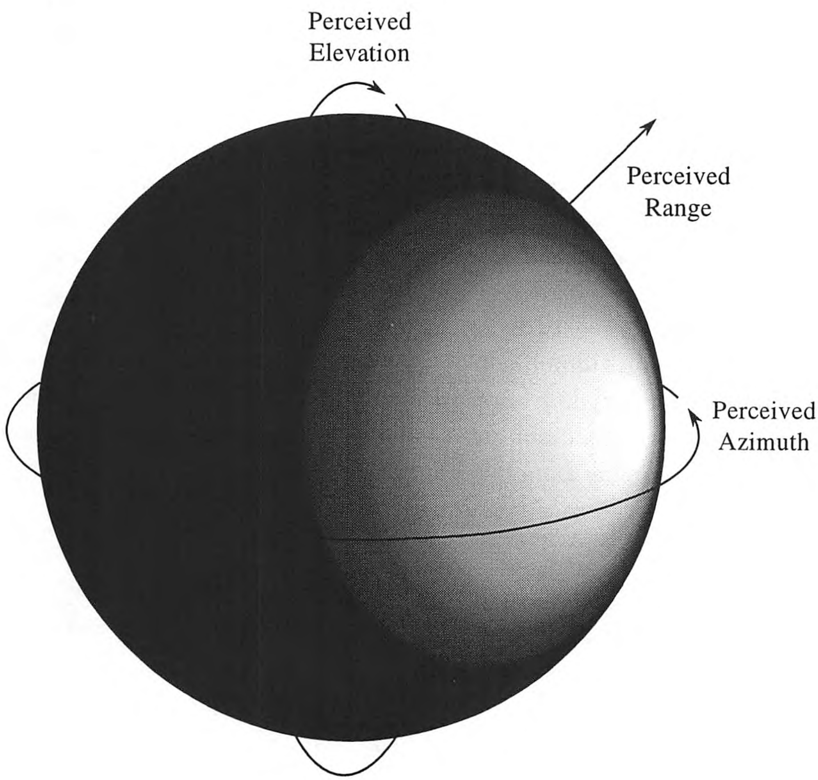


Figure 3.22 Representation of the domain of plot.

Conclusion

A striking feature of this chapter is the diversity of the five perspects examined. Each is unique, for example, in the way its values are perceived, and in the extent to which the relationships reckoned to exist between them have won the acceptance of musicians. Of overriding importance to the present theory, however, is the fact that every perspect is similar in having a continuous domain of potential values. The fact that these domains differ from one perspect to another can, for the present, be discounted, and, in the chapters that follow, non-specific perspective ranges will continue to be represented as straight lines along which values can be supposed to vary unidimensionally. This practice is adopted merely for diagrammatic convenience, however, and it does not affect the general validity of the conclusions that are drawn.

4

The cognition of order in music

Introduction

This chapter introduces the theory concerning the cognition of order in music that lies at the heart of the current work. The hypothesis presented rests upon the presence of certain mental processes, whose existence and nature were deduced from introspection. Since an awareness of cognitive operations like these is extremely rare, it follows that, on a conscious level, they can form neither a typical nor necessary part of the musical experience. However, we can surmise that intellectual procedures of the kind proposed must be present subconsciously, otherwise people would find music—the art of organised sound—incomprehensible. The question of musical order will be considered first with respect to the fundamental constituents of the perceived sonic medium: perspective particles.

Order and freedom; restricting perspective values

A perspect has a certain hypothetical 'freedom', since it has many potential modes of existence, determined by the values available within the perspective domain (see figure 4.1). Conversely, it is feasible to perceive a perspect as 'ordered' if its value is thought to be restricted in some way (see figure 4.2). This ties in with the definition given by Weiss (1968, p. 18):

> To order is ... to restrict entities in a definite way.

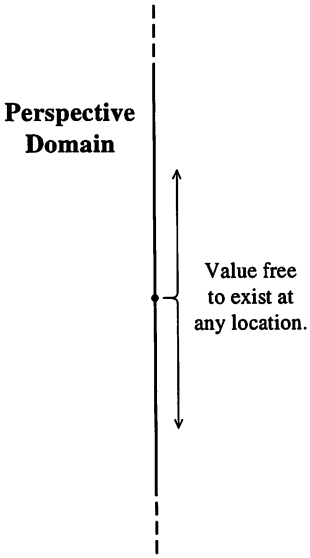


Figure 4.1 The freedom of a perspect to appear as one of many potential values.

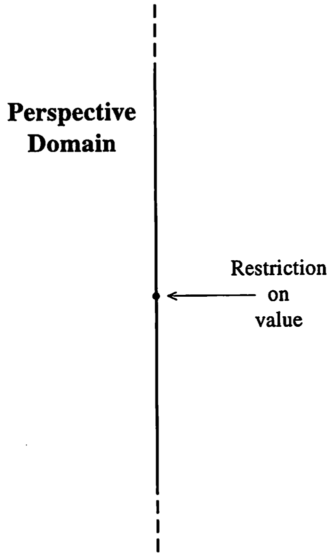


Figure 4.2 Perceived ordering through the restriction of perspective value.

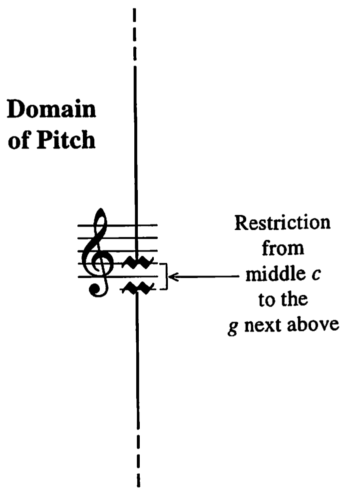


Figure 4.3 'Partial' ordering of pitch.

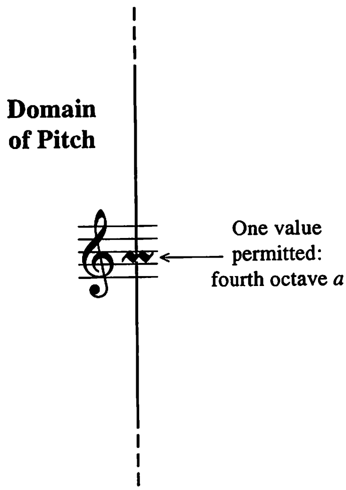


Figure 4.4 Complete restriction resulting in 'total' ordering.

The degree of order varies according to the extent of the restriction that is thought to obtain. For example, a pitch that can occur only over the range extending from middle *c* to the *g* a perfect fifth above may be deemed to be 'partially' ordered (see figure 4.3), whereas if only one value is permitted, for instance, *a* in the fourth octave (see figure 4.4), then this is in effect 'totally' ordered.

Imitation, repetition and the cognition of order

We now consider how composers convey the impression of order in the pieces they create. In 'pure' music (devoid of text or accompanying action), any order that listeners discern must stem from the musical medium itself, that is, from perceived sound. It is my contention that this process occurs through imitation: if one perspective particle is thought to echo another, then its value is restricted, and ordering may be inferred. Since imitating something implies that it is repeated (cf. Chavéz, 1961, p. 38), we can further postulate that the source of perceived musical order lies in repetition.

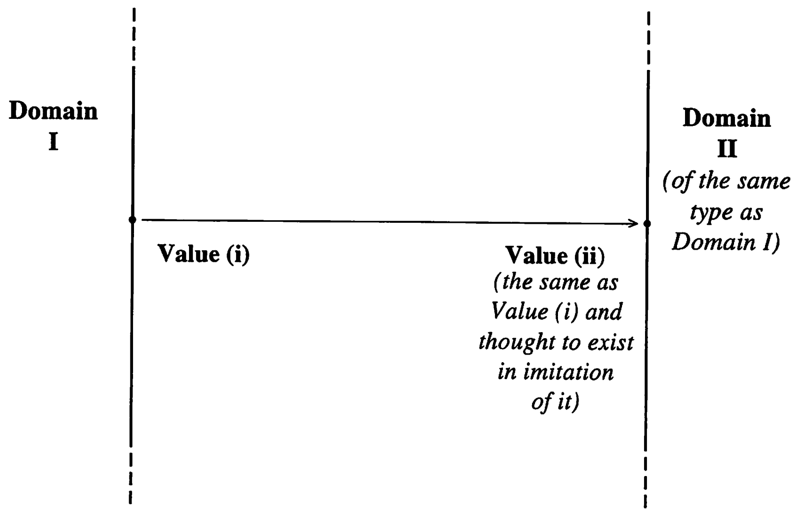


Figure 4.5 Ordering through imitation.

Hence a key prediction of the present theory is that the intuitive search for repetition is central to the process of listening to music.

The degree of ordering perceived is proportional to the fidelity with which the second value duplicates the first. An exact resemblance produces the effect of total ordering, as it entails the reproduction of just one particular value. With successively freer imitation, the impression of order weakens.

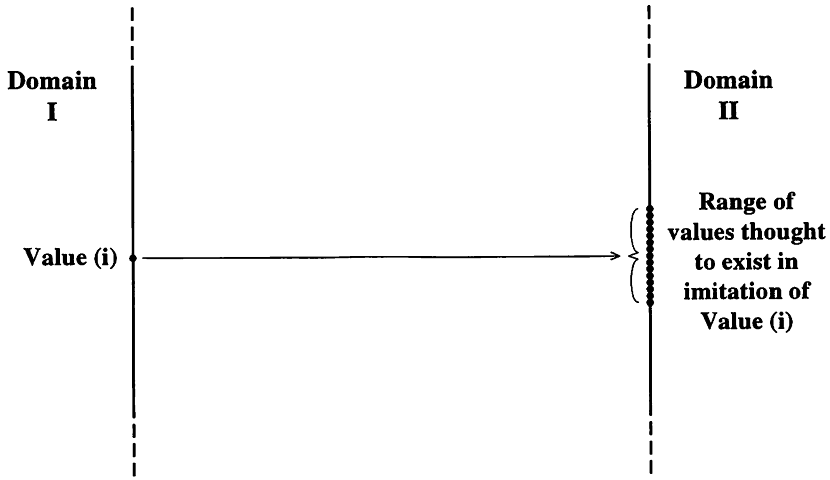


Figure 4.6 Partial ordering through approximate imitation.

In later chapters, corroboration of the hypothesis presented here will be sought in the analysis of a wide range of music, with a view to exposing the organisational procedures adopted compositionally, and whose detection, albeit at a subconscious level, can be assumed by discerning listeners. Here, indirect evidence is amassed from the works of other theorists. For instance, it was established in the introduction (pp. 9 and 10) that a number of writers, including Stravinsky and Schoenberg, have acknowledged the importance of repetition in music. The fact that it is necessary to repeat things since music is a 'self-contained' art-form, is recognised rather less frequently. Selincourt (1920/1958, p. 156), for instance, states that:

> The value of repetition in music belongs of course to the peculiar inwardness of the art. A musical composition must be content to be itself. The reference and relations into which analysis resolves its life-current need point to no object, no event; they take the form of the creative impulse which is their unity and they repeat one another because iteration is the only outward sign of identity which is available to them.

Similarly, in an expansion of the ideas put forward by Schenker (1906/1954, pp. 4–6 and 1935/1979, p. 93), Rothgeb (1983, p. 39) comments:

> Music, lacking access to the kinds of direct association with the phenomenal world central to most other art forms, was able to satisfy the universal requirement of association only through "the likeness of itself"—through self-repetition.

Sessions (1950, p. 63) reaches the same conclusion:

> Where there is nothing of a not strictly musical nature to contribute this element of association, it must be supplied from within the music itself. The music must, to state it cautiously, supply some element of repetition.

To find the concepts of repetition and order linked, one must look to the realms of psychology and philosophy. Sickles and Hartmann (1942, p. 408), for example, find that

> On inspection, it will be found that *order depends on the even repetition of a unit* ... one of the basic elements in the orderly whole is repetition.

Related ideas are expressed by Feibleman, (1968, pp. 3 and 4):

> Intuitively, order has always been understood in terms of law, a law that consists in a similarity among disparate elements ... Order, then, can be identified with similarity and disorder with differences.

Jenkins (1968, p. 429) holds the view that

> order embodies our discovery of pattern and regularity in the world. It announces the similarities that hold among things and the sequences that run among events; it summarizes the fact that we find threads of uniformity and connectedness that bind together discrete objects and occurrences.

In conclusion, consider the following notion propounded by Cone (1987, p. 237), concerning the derivation of musical material, which entirely accords with the hypothesis presented above:

> y is derived from x (y ← x), or, to use the active voice, x generates y (x → y), if y resembles x and y follows x. By 'resembles', I mean 'sounds like' ...

Primary zygons

The interperspective relationships defined in chapter 2, whether reactively gauging the connection between extant values or proactively anticipating how they may be linked in the future, were essentially descriptive in nature. However, the theory of perceived musical order presented here, in assuming that one value is chosen to imitate another, supposes a functionally different type of relationship, which is felt to act implicatively.[1]

The relationship through which one perspective value is implied by another the same may be termed a **primary zygon,**[2,3] which may be symbolised as follows:

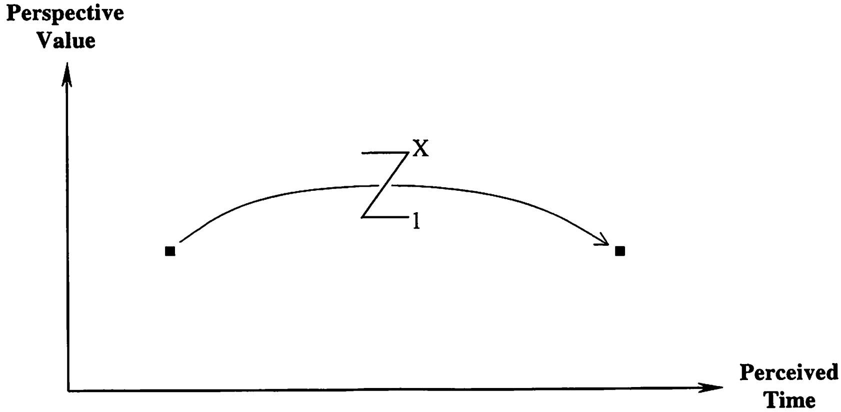


Figure 4.7 Primary zygon.

Observe that the 'z' stands for 'zygon'. The full style of arrowhead indicates a relationship between two perspective values the same.

[1]The notion of implication replaces that of causation found in earlier versions of this passage (see Ockelford, 1991), a change that was influenced by Meyer's discussion of the two concepts (1989, pp. 84ff). I would now say that the *cause* of a perspective value was the composer's decision to take up the *implication* inherent in a previous one.

[2]'Zygon' derives from the Greek term for 'yoke', and implies the union of two similar things. The adjectival and adverbial forms 'zygonic' and 'zygonically' will be employed where appropriate.

[3]The general term **zygonic relationship** refers to any relationship with a zygonic component.

The arrow shows the direction of the ordering effect, which tends to be chronological. However, reversals may be incurred when the second of two identical values takes structural priority over the first. Consider, for example, two pitches the same, one occurring on a downbeat and the other on its anacrusis. Cone (1987, pp. 249ff) cites cases on a rather larger scale, such as the introduction to a chorale prelude, anteceding yet deriving from a cantus firmus; and the potpourri overture, which, by convention, draws on themes heard subsequently. Although these echoes of sounds to be are the exception rather than the rule, all zygonic relationships exert a certain retrospective influence. The musical significance first accorded a perspective value may well change if later it is found to imitate, or to exist in imitation of, another; it would acquire an 'evident meaning' (Meyer, 1956, p. 37).

Like other interperspective relationships, zygons can be reactive or proactive in operation. Either type may arise from the action of the subconscious or may be conceived knowingly. Whatever the case, primary zygons functioning proactively enable composers to prescribe or listeners anticipate future values, derived from those that are presented. Reactive zygons are the mechanism through which extant organisation is acknowledged cognitively.

In music analysis that uses the theory of zygonic relationships, it would seem advisable to be explicit about which mode of cognition is being modelled. Is the aim to conceptualise the intuitions of the typical listener, for example, or to retrace the process of composition? The two are not the same: while some order, planned by composers, may go unnoticed, other organisation may subsequently be discovered where none was conceived (cf. Nattiez, 1990, p. 17). As Sloboda (1985, p. 102) remarks:

> It is ... possible that certain features of a composition highlighted by critical analysis were no part of the composer's intention, conscious or otherwise. In a system of inter-related sounds as large as, say, a symphony, there are bound to be some relationships discoverable by analysis which were neither noticed nor designed by the composer.

Moreover, listeners' perception of musical organisation may be swayed by differing interpretations of the same piece: one performance may stress what is felt to be an implicative connection, whereas in a second, the same link may be played down.

It is possible that *no* ordering is perceived betwen two values the same. In analytical terms, the lack of zygonic influence may be expressed through a ***non-zygonic* relationship**, indicated by cancelling the 'z' for zygon:

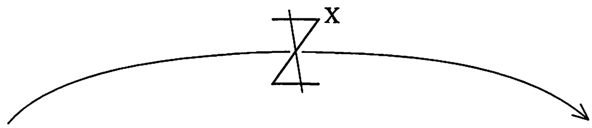


Figure 4.8 Non-zygonic relationship.

It may be unclear whether a relationship is zygonic or not, in which case values may be deemed to be connected through an interperspective relationship expressing a difference of 0 (or a ratio of 1). This may be symbolised as follows:

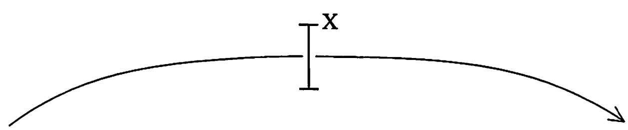


Figure 4.9 Relationship between identical perspective or interperspective values—zygonic status undefined.[4]

The criteria for inferring implicative intramusical connections are a major concern of the present work. This complex issue has preoccupied a number of analysts and engendered considerable controversy among them—see, for example, Meyer's damning critique (1973, pp. 59ff) of Reti's (1951) hypothesis. One hope of the theory offered here is that it may serve as an analytical tool, through which the issues that form the substance of this debate may be worked with a new precision.

[4]The notion that a relationship of this type conceptually embraces other forms of interperspective connection, whether zygonic or non-zygonic, represents an advance on earlier thinking (see Ockelford, 1993, p. 99).

The canonic concept

Two zygonically related perspective values may be said to form a **canon**, since the second may be considered to exist 'according to the rule' of the first. This represents a substantial expansion of the conventional use of the term:

> A contrapuntal device whereby an extended melody, stated in one part, is imitated strictly and in its entirety in one or more other parts. (Apel, 1969, p. 124)

However, the interpretation presented here is not unprecedented: Lewin (1977, p. 195) uses the expression 'canonical transformation' to mean

> an operation on pc's which is understood, in a given theoretical context, to transform (the total content of) any pcset into a pcset which is accepted as "similar" in that context.

As it is defined here, a canon can entail the ordering of perspects of any type. The one concept, therefore, bequeaths a vast perceptual legacy, encompassing a broad range of musical effects. These are examined in chapters 7–12.

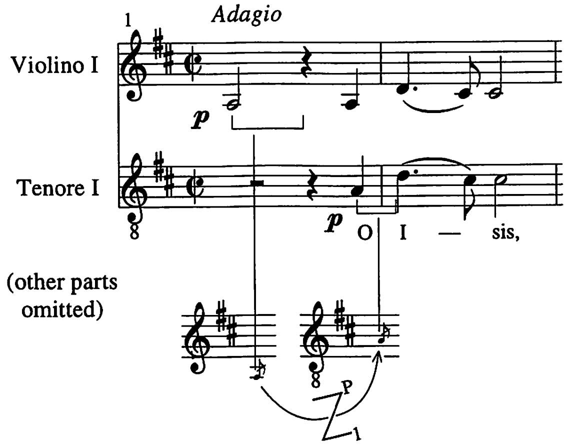
Variation

Since a canon may arise from a zygonic relationship between any pair of perspective values of the same type, in diagrams, to avoid ambiguity, it is necessary to append the pertinent initial letter or letters in the manner adopted previously (see p. 24); figure 4.10.

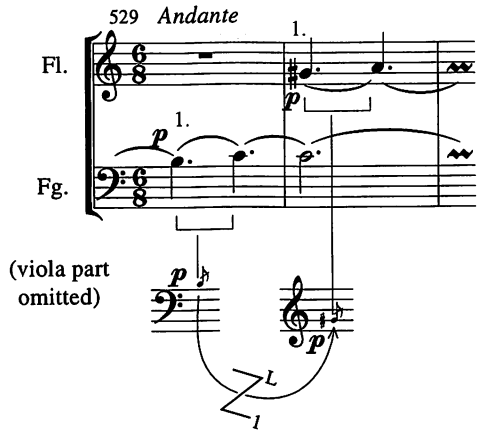
A moment may be ordered through two or more zygons. Where a number of similar zygonic relationships co-exist, these may be symbolised in the simplified way shown in figure 4.11.

The more zygons that operate together in this way, the stronger the ordering effect. The extreme case, in which all the relationships linking two moments are zygonic, implies the existence of two identical fragments of

Mozart: *The Magic Flute*, K. 620; No. 18, *Chor der Priester*



Mendelssohn: Violin Concerto, Op. 64; 2nd Movement



Dvorák: Symphony No. 5, Op. 95; 2nd Movement

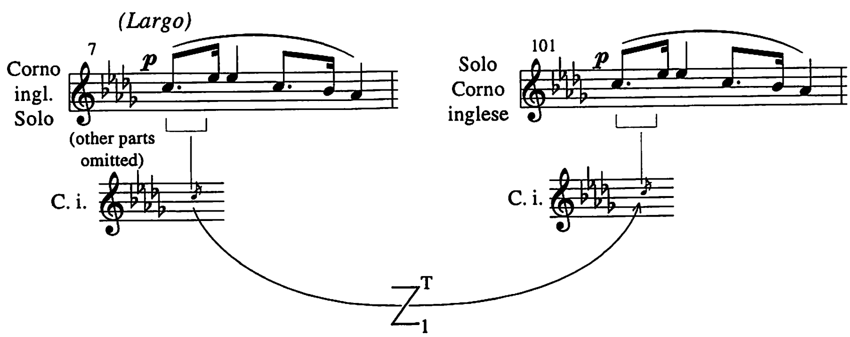


Figure 4.10 Zygons of pitch, loudness and timbre.

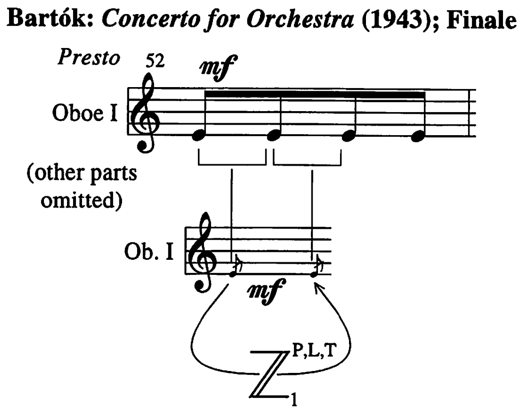


Figure 4.11 Co-existent zygonic relationships.

perceived sound, in effect forming one perceptual unit, whose intrinsic duality can be implied only through the operation of external ordering.[5,6]

[5]That is to say, as well as the need for order, a further fundamental requirement of music is a certain amount of disorder, for perfect resemblance (which may be interpreted as total organisation) would mean a piece reduced theoretically to an infinitesimal dot—all sounds being sucked, as it were, into the black hole of complete identity. As Arnheim (1971, pp. 48 and 49) observes: "orderliness by itself is not sufficient to account for the nature of organized systems in general or for those created by man in particular. Mere orderliness leads to increasing impoverishment ..."

[6]For example, the two faces of the final *f* below are apparent only in the light of the preceding part movement, and are thereby inferable through zygons of higher ranks:

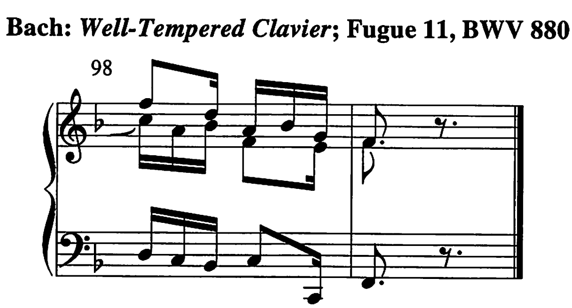


Figure 4.12 The occurrence of identical moments of perceived sound.

Inevitably, then, zygonic and other interperspective relationships frequently operate together, creating the effect of **variation**. For example:

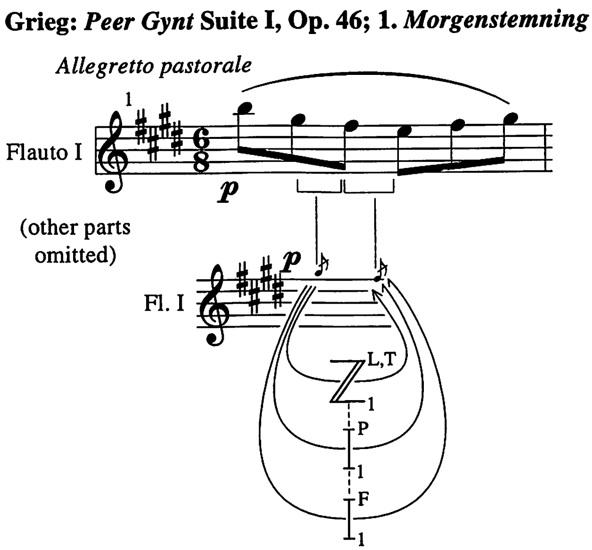


Figure 4.13 Co-extensive zygonic and other interperspective relationships together creating the effect of variation.

(Observe that relationships operating in parallel between the same two perceived sonic events may be connected transversely with a dotted line, as here, to show their mutual association.)

This accords with the traditional use of the term. See, for example, Schoenberg (1967, p. 9):

> Variation ... is repetition in which some features are changed and the rest preserved.

Bernstein's definition (1976, p. 162) is also particularly pertinent in the present context. He considers variation to be the:

> Violation of Expectation. What is expected is, of course, repetition ... and when those expectations are violated, you've got a variation. The violation is the variation.

In other words, variation cannot exist without the previously assumed idea of repetition.[7]

Variation may also occur if one value is thought to imitate another approximately. This is considered below (pp. 91ff). Differing musical applications of variation are scrutinised in some detail in chapters 7–12.

Canons of fix; mutual zygons

A canon of fix implies simultaneity. Hence there is no perceived temporal basis for deciding which value is the model and which the imitation. The ordering effect can be given a specific bias only through appropriate contextual implication. This may involve a further zygonic relationship. For example:

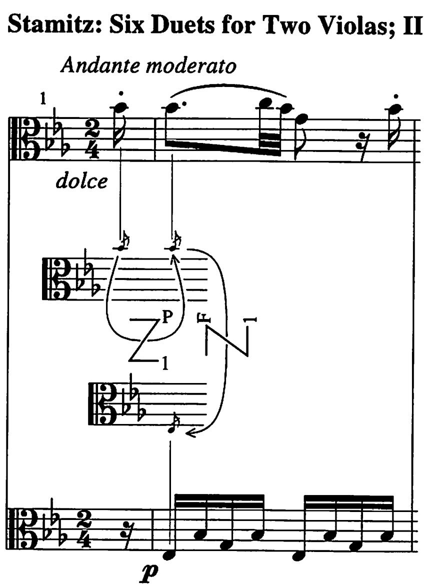


Figure 4.14 Zygon of fix polarised through zygon of pitch.

[7]See also Kubler (1962, p. 67): "It is in the nature of being that no event ever repeats, but it is in the nature of thought that we understand events only by the identities we imagine among them".

In the absence of a connection such as this, a primary zygonic relationship may be **mutual** in operation: each value perceived to exist in imitation of the other. For instance:

Beethoven: Symphony No. 9; 1st Movement

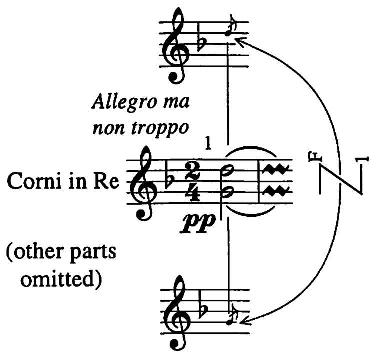


Figure 4.15 Mutual primary zygon.

Zygonic relationships connecting perspective particles of other types may function mutually too. For example:

Beethoven: Symphony No. 9; 1st Movement

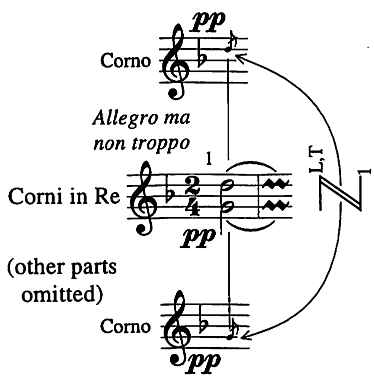


Figure 4.16 Co-existent mutual zygonic relationships.

Indirect zygons

Two values may imitate the same model, while neither emulates the other directly:

> x and y may both be derived from some common source (a previous w such that w → x and w → y), in which case y is not necessarily also derived from x. (Cone, 1987, p. 240)

Their common descent is reflected in the kind of relationship perceived to exist between them, which may be termed a **parallel indirect zygon**. See figure 4.17. A further possibility is for one value to be echoed by a second which in turn is imitated by a third, with no direct link between values one and three. Here the connection involved may be described as a **serial indirect zygon**, shown in figure 4.18. (Here the underlying relationships are shown in light type).

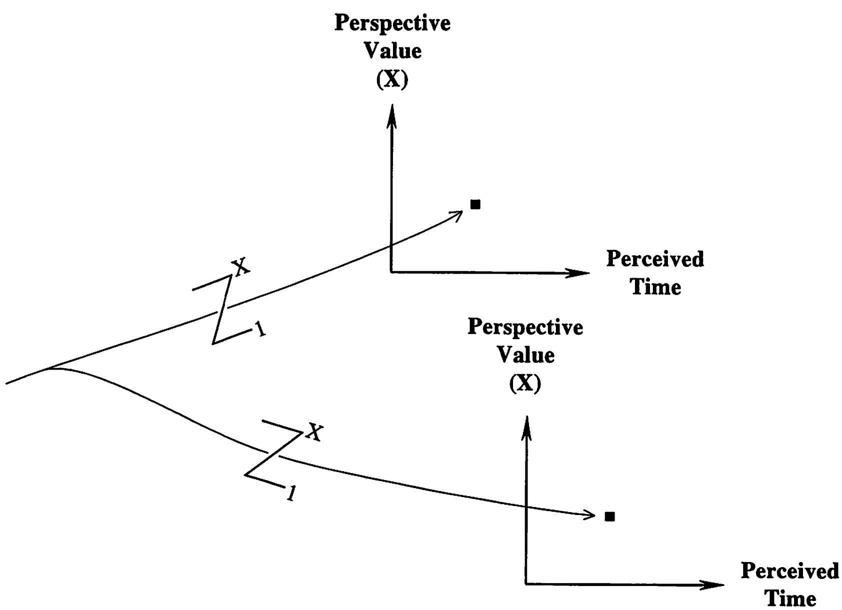


Figure 4.17 Parallel indirect zygon.

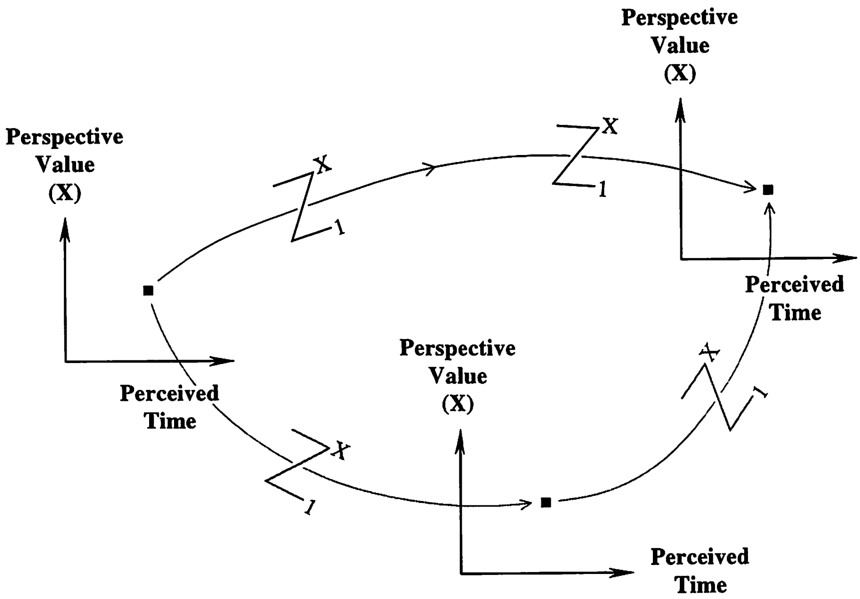


Figure 4.18 Serial indirect zygon.

Secondary zygonic relationships

Following earlier reasoning (pp. 68–72), it is possible to consider a primary interperspective relationship (which may itself be zygonic) to be ordered if a restriction is thought to be placed on its value. This impression of order may be created through imitation, implying the presence of a secondary interperspective relationship between two primary values the same, through which one is felt to imply the other. This may be referred to as a **secondary zygon**, symbolised as follows:

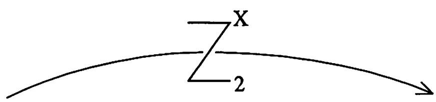


Figure 4.19 Secondary zygon.

A secondary zygon functioning proactively may lead to one new perspective value (figure 4.20) or two more (figure 4.21).

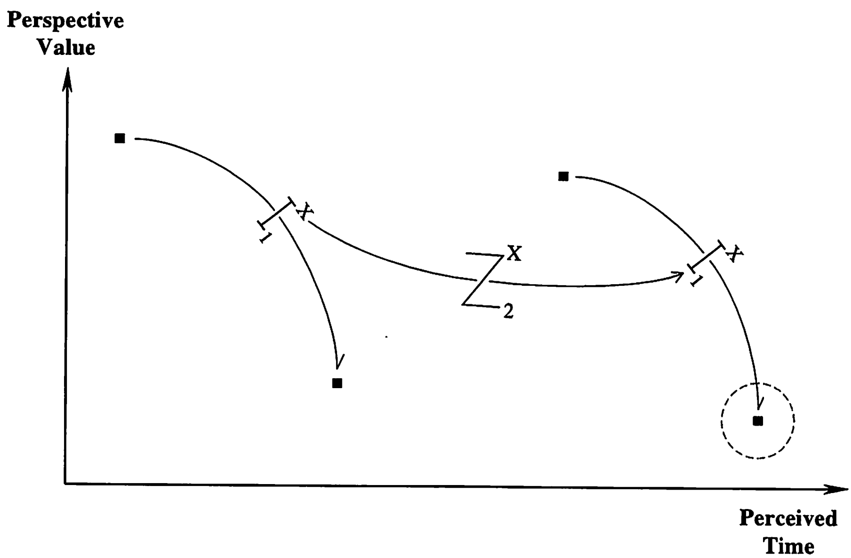


Figure 4.20 Secondary zygon responsible for the conception of one more perspective value.

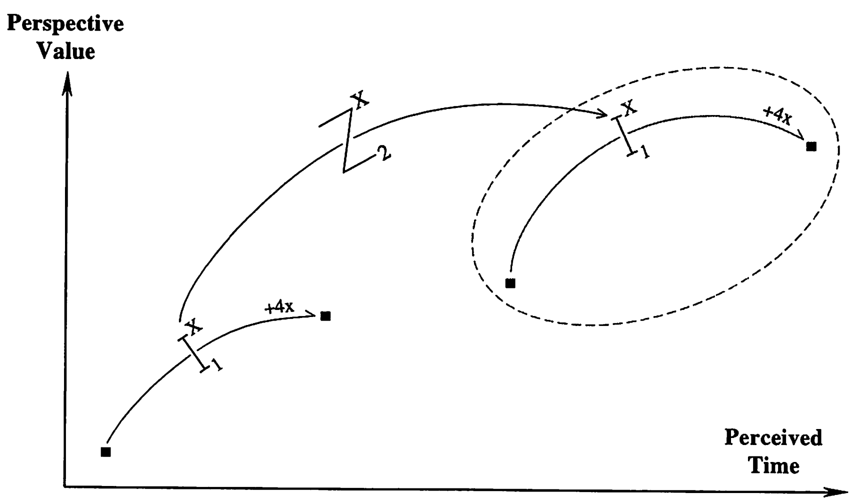


Figure 4.21 Two perspective values conceived through a secondary zygon.

Non-zygonic secondary relationships, and relationships whose zygonic status is undefined are also conceivable, and may be symbolised as follows:

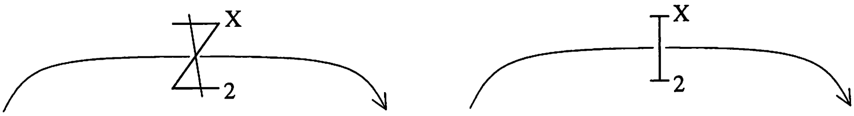


Figure 4.22 Non-zygonic secondary relationship and secondary relationship, difference 0, zygonic status undefined.

Mutual secondary zygons are possible between primary relationships that exist simultaneously, and where neither takes perceptual priority for other reasons.

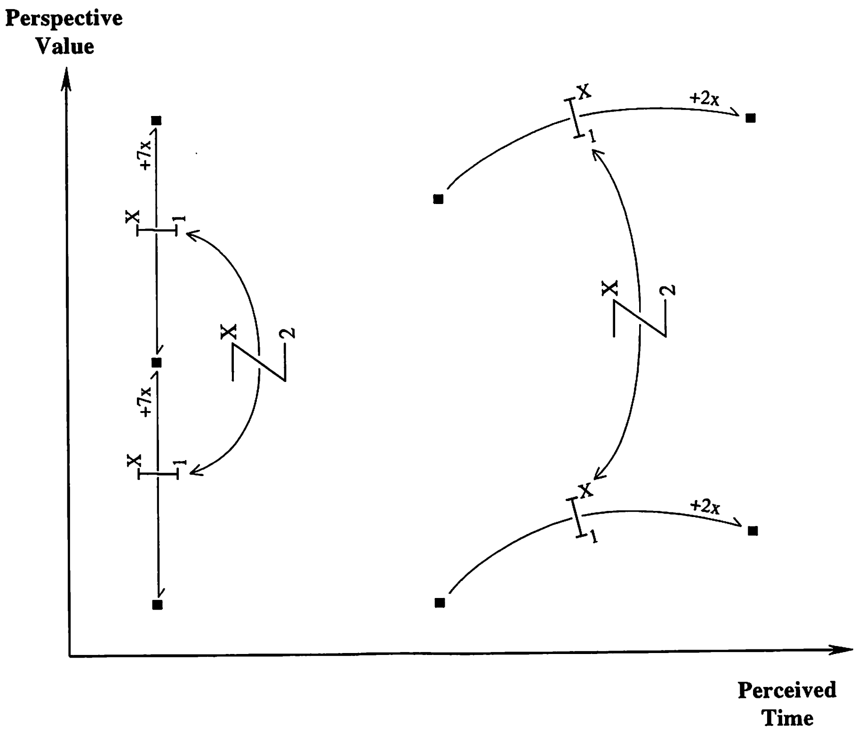


Figure 4.23 Mutual secondary zygons.

The perspective values that are ultimately linked by a secondary zygon (through two primary relationships) may be said to form a canon, since one value—usually that occurring last—may be derived 'according to the rule' of the other three.

Finally, it is of interest to note that the theoretical stance adopted here accords precisely with that taken by Sickles and Hartmann (1942), which they illustrate with a geometrical model:

> Consider our straight line again, drawn between *three* objectively given positions and allowing two [successive] intervals. We still have disorder if the points are not equidistant, *i.e.*, if the intervals are not the same. However, if we take this disorderly unit of two unequal intervals and add directly beneath it another pattern of identical configuration we have order. Though all four intervals are not equal, we do have two units of order, each composed of two *orderly* intervals. (p. 410)

Zygonic relationships of higher ranks

A secondary interperspective relationship (whether zygonic or not) may be perceived as being ordered through a **tertiary zygon**—see figure 4.24. We can further suppose that a tertiary interperspective relationship may itself be ordered through the operation of a **quaternary zygon**, which is responsible for a canon comprising at least five perspective values; see figure 4.25.[8] Similarly, non-zygonic tertiary and quaternary relationships are possible, and tertiary and quaternary relationships whose zygonic status is undefined.

Whilst logic dictates that the series of relationships outlined here is capable of being extended indefinitely, perceptual limitations curtail its musical applicability almost immediately: even a quaternary zygonic relation-

[8]A canon founded on a quaternary zygon could incorporate up to sixteen different perspective values. Since, in such cirumstances, the effect of the ordering force depicted in figure 4.25 would be spread much wider, so the degree of control pertaining to any one perspective value would be less. Theoretically it would be possible to derive a measure of the canonic intensity (or 'canonicity') of a passage by setting the minimum number of perspective values demanded by the zygon in question against the number of values actually taken up. Through such means, the canonicity of the group of values illustrated in figure 4.25 can be calculated to be $^5/_5 = 1$, whereas a quaternary zygon that involved sixteen perspective values would yield a correspondingly lower value of $^5/_{16} = 0.3125$.

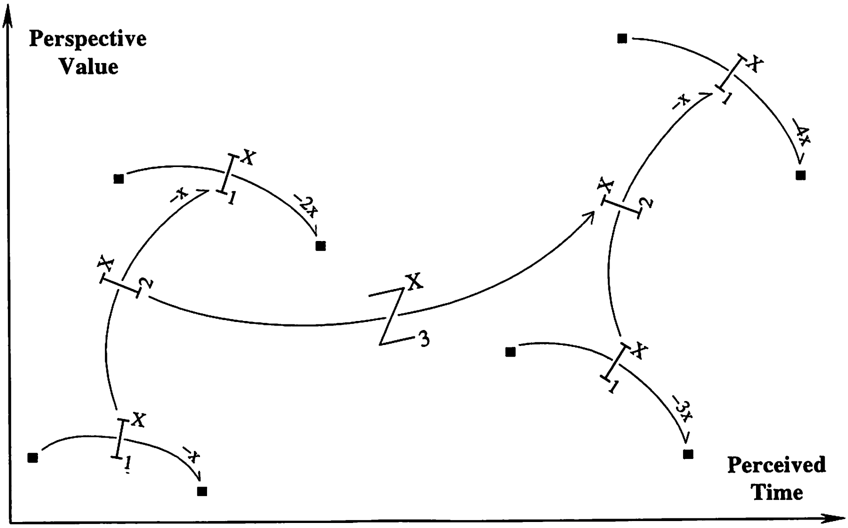


Figure 4.24 Tertiary zygon.

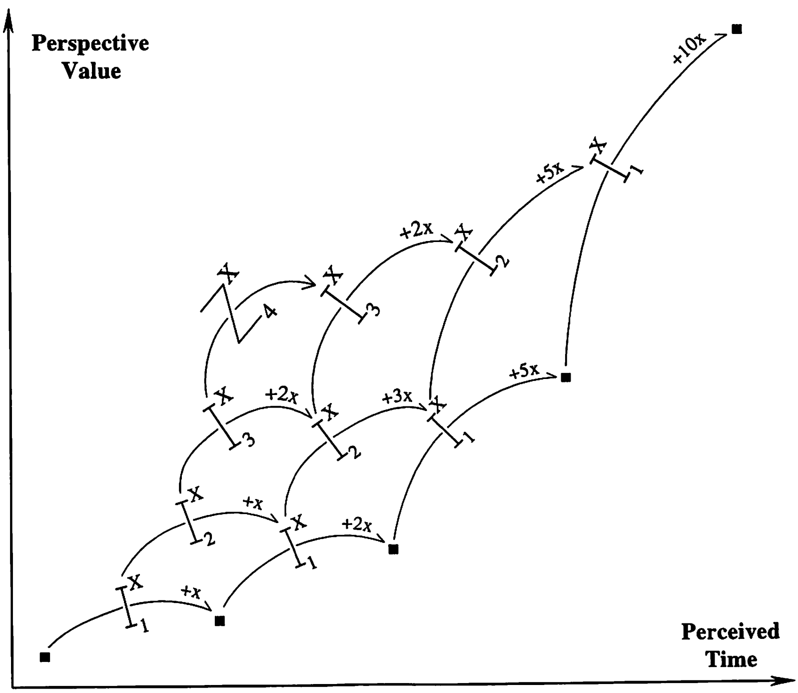


Figure 4.25 Quaternary zygon.

ship is just too intangible, it seems, to have found a place in musical organisation to date. That is not to say, though, that in the future composers may not effectively exploit relationships of this degree of abstraction. In any case, as potential avenues of ordering, their presence should at least be acknowledged on the theoretical map.

Mixed-rank zygons, zygons of cross-modality; zygonic multivariate relationships

Interperspective relationships of mixed rank may function zygonically. For example:

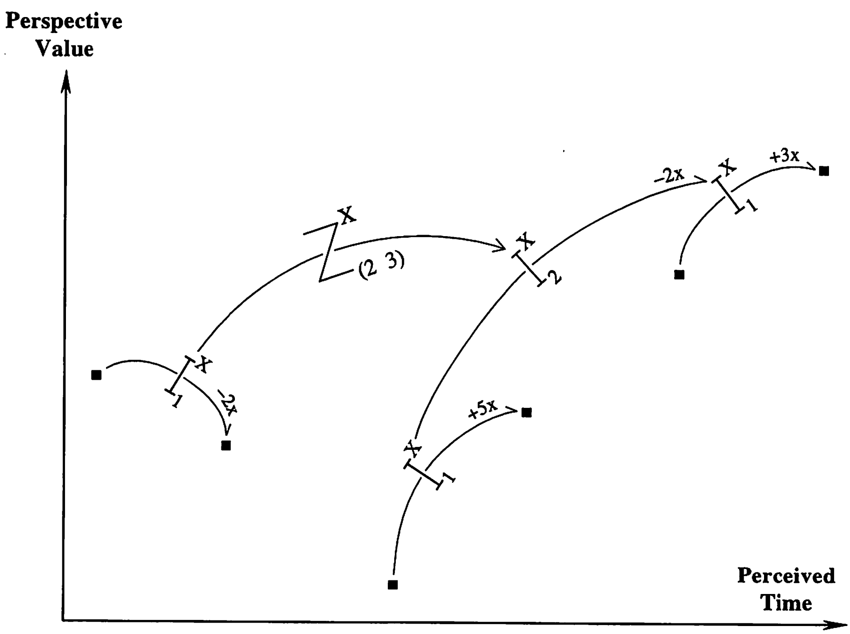


Figure 4.26 Zygon of mixed rank.

Similarly, cross-modal zygons are possible. For instance:

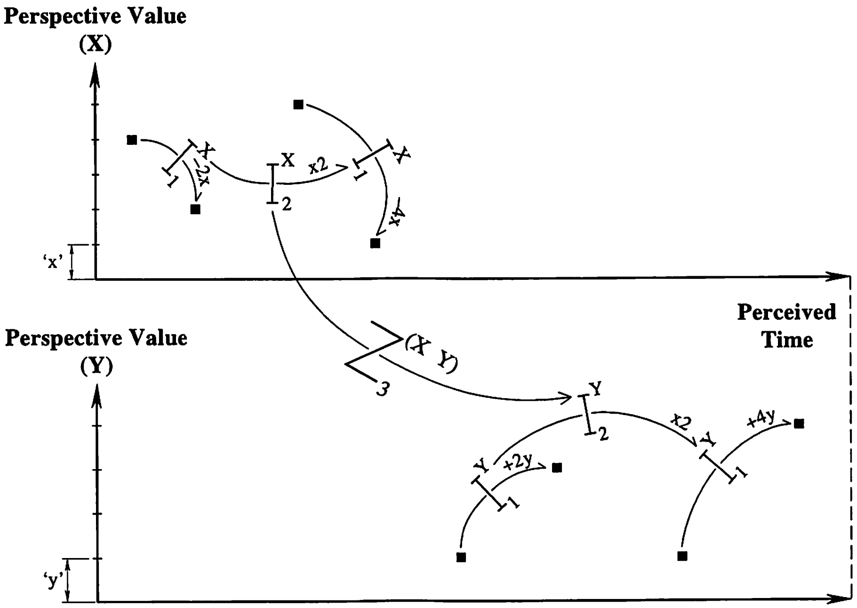


Figure 4.27 Cross-modal zygon (cf. figure 2.25).

The two types may appear in combination (see figures 9.60ff).
Multivariate relationships may be ordered through imitation. For example:

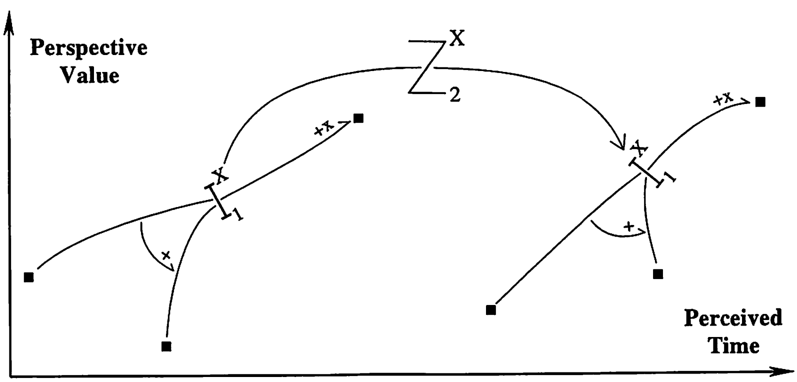


Figure 4.28 Secondary zygon linkng primary multivariate relationships.

Multivariate relationships may themselves be zygonic. For instance:

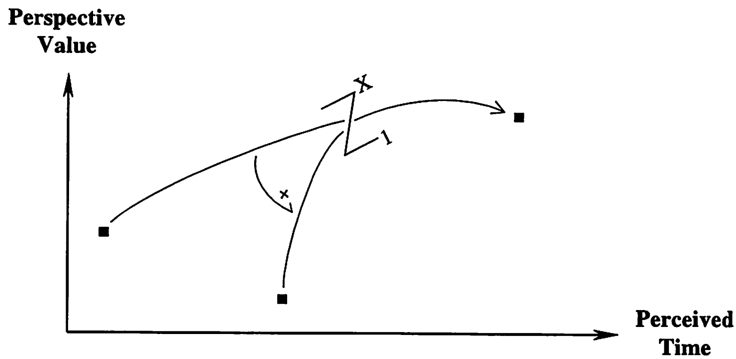


Figure 4.29 Zygonic multivariate relationship (cf. figure 9.20).

Inverse zygonic relationships

It is possible to consider one relationship as being ordered in imitation of another where the second interperspective value is quantitatively the same as the first, but its polarity is reversed. Zygons which order values in this way, which may be secondary or of higher rank, may be termed **inverse**, and symbolised as follows:

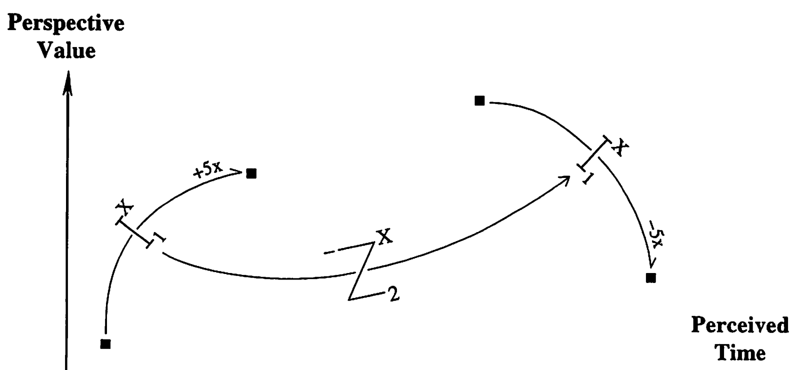


Figure 4.30 Inverse secondary zygon (cf. figure 10.33).

Similarly, inverse secondary interperspective relationships of difference 0 or ratio 1 whose zygonic status is undefined may be shown thus:

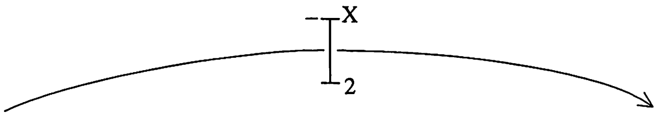


Figure 4.31 Inverse secondary interperspective relationship of difference 0 or ratio 1.

Inverse zygons have a somewhat weaker ordering effect than those than those that maintain polarity too.

Imperfect zygons and imperfect canons

One value may derive from another, although noticeably differing from it. The primary interperspective relationship through which such partial ordering occurs may be termed an ***imperfect* primary zygon**, symbolised as follows:

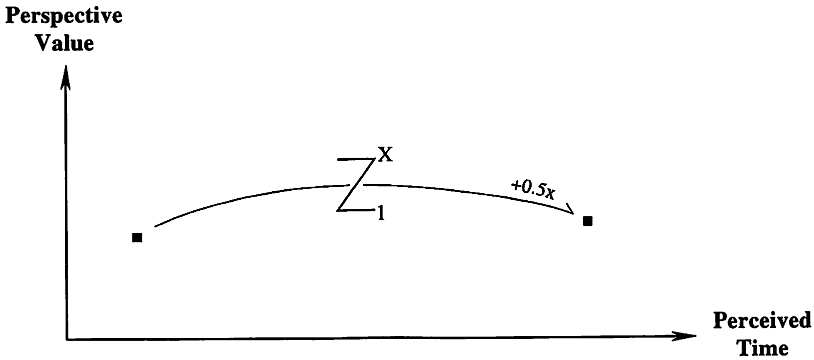


Figure 4.32 Imperfect primary zygon.

The degree of imperfection, here expressed as a difference, could also take the form of a ratio. Neither need be indicated.

The values together form an ***imperfect* canon,** which constitutes a type of variation.[9]

Imperfect relationships may also be of secondary rank or higher. For instance:

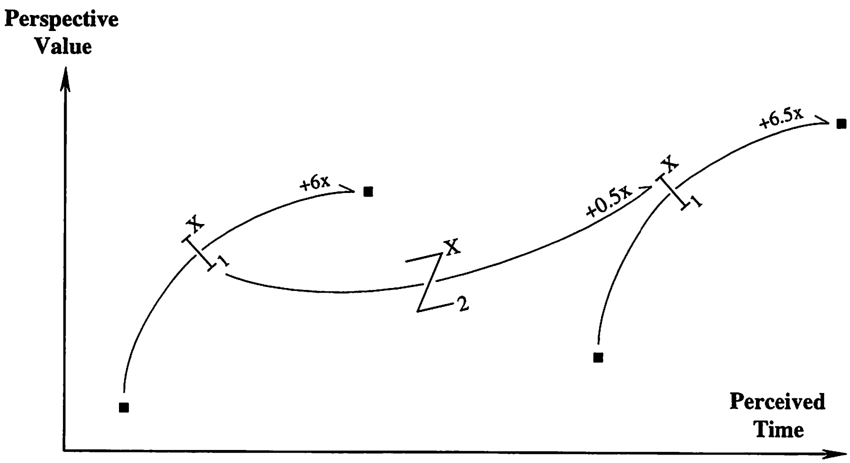


Figure 4.33 Imperfect secondary zygon.

The strictest form of imperfect ordering occurs when two zygonically related perspective or interperspective values are separated by their JND (just noticeable difference). Enlarging this difference progressively frees one value from the other, as the bond between them grows increasingly tenuous. Accordingly, the freer the imitation, the more strongly must its presence be implied in the music if it is to be recognised. This may be achieved, for example, through the gradual expansion of a pattern, through which a listener's expectations of order are continually strengthened, and the illusion of reasoned effect is conveyed by ever wider interperspective differences—stretching by degrees, as it were, his or her willing suspension of disbelief (cf. figure 10.70). With sudden change, on the other hand, the

[9]This is the only type of variation open to individual values. Where two or more values are considered together, variation may occur either through the maintenance of one or more while the remainder are changed, or through the approximate imitation of some or all of them. The underlying issue of similarity versus dissimilarity is considered by writers such as Attneave, who states (1950, p. 519) that "The characteristics with respect to which objects are similar may be conceptualized either as more or less discrete and common elements or as dimensions on which the objects have some degree of proximity".

sense of coherence may well be lost, and the zygonic impression no longer conveyed from one relationship to another.

Imperfect zygonic relationships of secondary rank and above are conceivable through which polarity only is imitated.

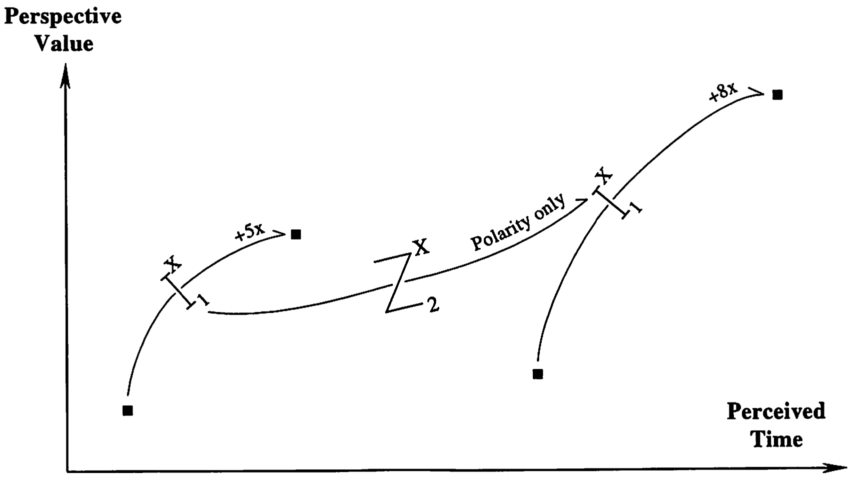


Figure 4.34 The imitation of polarity alone (cf. figure 9.73).

The perceived temporal control of relationships; sequence

Even a short passage of music comprises an abundance of perspective values, which are potentially linked by a prodigious number of inter-perspective relationships, any of which may be zygonic. This means that if the musical organisation devised by composers is to be perceived by listeners, the relative disposition of the zygons involved must be carefully planned, otherwise the ear, burdened with an intolerable processing load, would find the search for order futile, and the general effect, irrespective of the patterning theoretically present, would be tantamount to chaos. That is to say, any control of perceived sound in terms of pitch, loudness, timbre, plot and other non-temporal perspects would be ineffective without the parallel ordering of the perceived temporal dimensions.[10]

[10]Cf. Simon and Sumner (1968, p. 228): "Patterns involve *periodicity*—repetition (in a generalized sense) at intervals that occur periodically (in a generalized sense)"—and Jones (1981, pp. 37ff).

In its most precise form, structuring of this type involves zygons of fix. These may operate side by side with the zygonic relationships that do not pertain to perceived time—whose organisational force they permit to be discerned. For example, secondary zygons of pitch and fix may exist together.

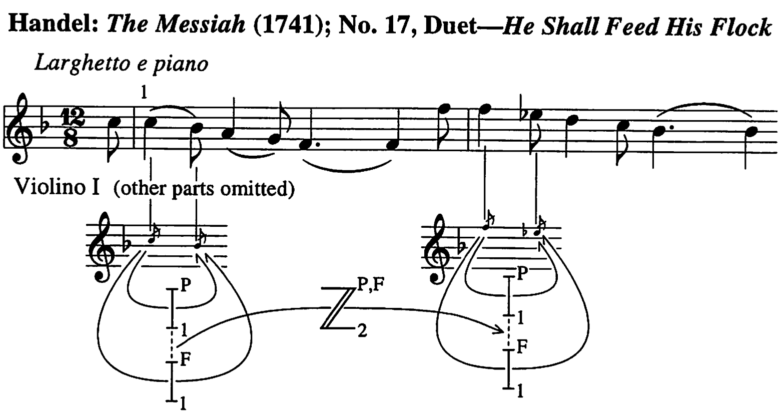


Figure 4.35 Co-existent secondary zygons of pitch and fix.

Here, not only is the final value of the four derivable from the other three considered together, but also its point of occurrence. Alternatively, the perceived temporal and non-temporal zygons need not coincide. See, for instance, figure 4.36.

Zygonic combinations such as these are fundamental to virtually all music, and are the subject of detailed discussion in chapter 11.

Non-temporal perspective ordering may also be combined with imperfect zygons of fix. Here, the chances of the intended organisation being missed or mistaken by the listener inevitably tend to be greater. The potential confusion is minimised, however, if the order in which events occur, at least, is recognisably structured.

Consider a number of particles of fix. As reflected by their values, these have a certain order of occurrence, or **sequence**. Within a sequence, each particle of fix occupies a position relative to the others which may be termed its **sequential location**, expressible as an ordinal number. Through this process, the first member of a sequence may nominally be assigned the figure '1', and each thereafter by a successively higher integer (figure 4.37).

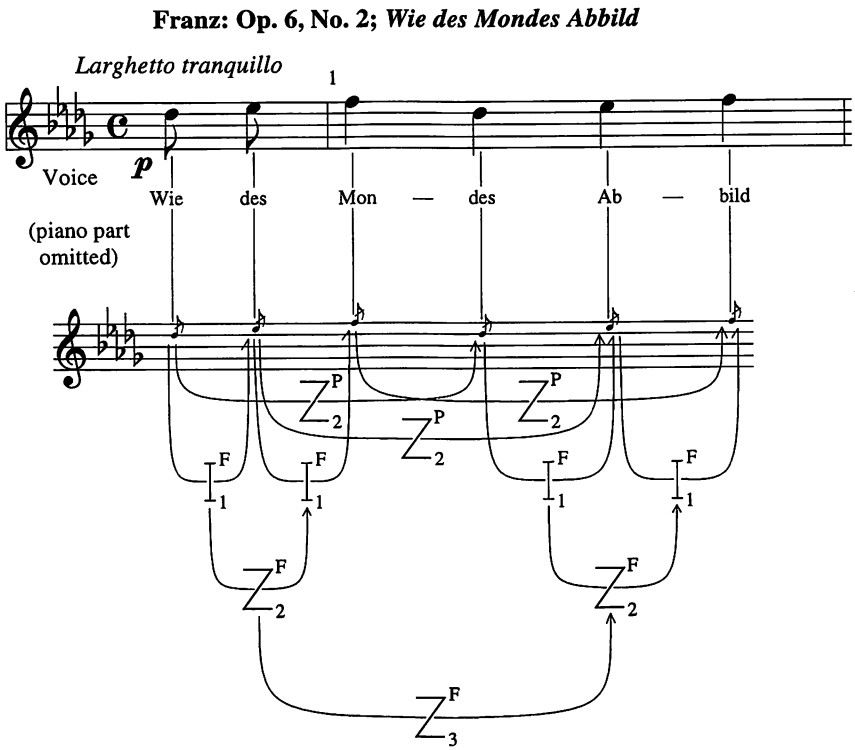


Figure 4.36 Non-coincident zygons of pitch and fix controlling the same particles of perceived sound.

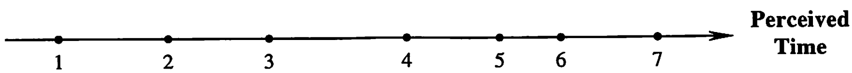


Figure 4.37 Ordinal numbers of fix expressing the sequential locations of particles of fix.

In the same way that the values of two particles can be linked through an interperspective relationship, so two ordinal numbers of fix may be compared through a **primary *intersequential* relationship**. Relationships of this type can exist equally within the internal sequence of one group of particles, or between two such groups.

An intersequential relationship be symbolised as follows; the manner in which the first ordinal number is mapped onto the second being expressed as a mathematical function, placed directly after the 's'.

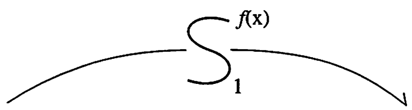


Figure 4.38 Primary intersequential relationship.

Commonly, a primary intersequential relationship may constitute a difference, as the following:

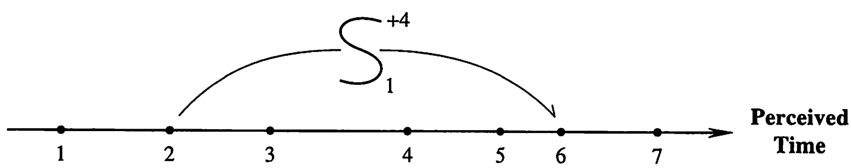


Figure 4.39 Primary intersequential relationship of difference.

A primary intersequential relationship which matches identical ordinal numbers of fix may be represented just by an 's' standing alone in conjunction with a double arrowhead. (The possibility of sequential ordering is discussed later in this chapter—see pp. 99ff)

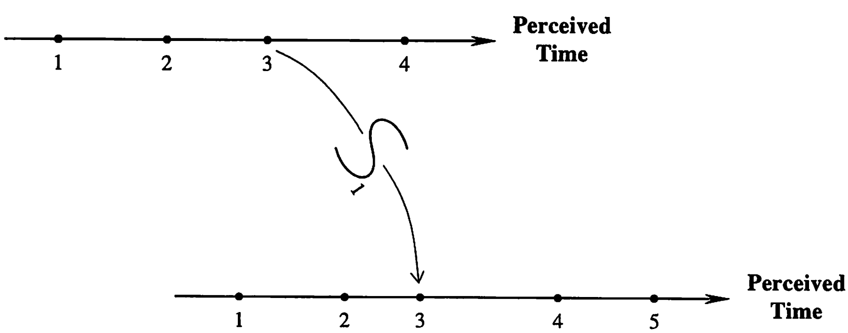


Figure 4.40 Primary relationship of sequence matching particles of fix with identical ordinal numbers.

The similarity of two primary intersequential relationships may be gauged through a 'secondary intersequential relationship'.

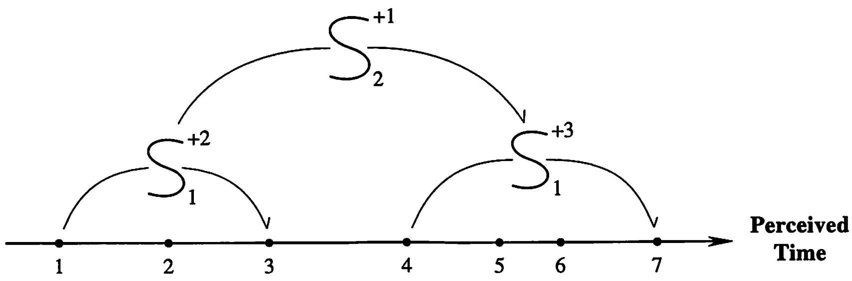


Figure 4.41 Secondary intersequential relationship.

Two of these may in turn be compared through a 'tertiary intersequential relationship', and so on, in a theoretically limitless, though perceptually highly restricted, hierarchy.

Although it has proved convenient to consider them as such, particles of fix are not really entities in their own right, that can be manipulated apart from other perspects; each is merely the quantitative evaluation of the temporal disposition of a fragment of perceived sound. Similarly, although sequential location is a measure of the dimension of time, its effects pertain to moments in their entirety, and so to all types of perspective particle. Hence it seems appropriate to refer directly to the sequential location of a particle of pitch, loudness, timbre or plot.

In the same way, it will often be appropriate to consider relationships of sequence not in isolation, but as additional strands of qualification running through interperspective relationships (which may be zygonic). Such combinations may be symbolised by inserting an 's' (for 'sequence') into the 'I' (for 'interperspective') or the 'Z' (for 'zygonic'). Indices may be appended in the usual way, although as far as primary connections are concerned, it is not necessary to indicate the rank of the sequential strand, since this may be deduced from its host interperspective relationship. See, for example, figure 4.42.

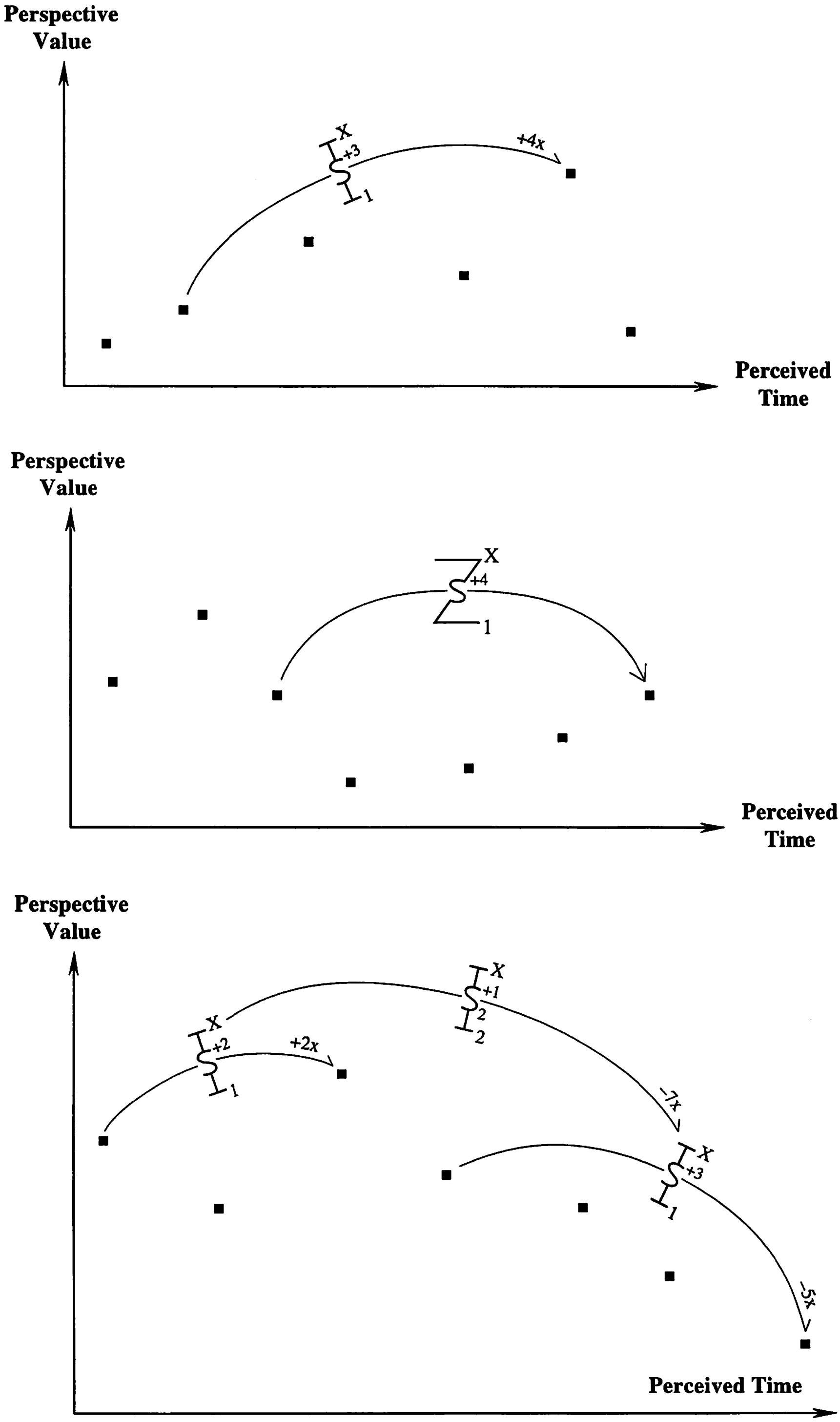


Figure 4.42 Combinations of intersequential and interperspective relationships.

The sequentiality of multivariate relationships may be shown as follows:

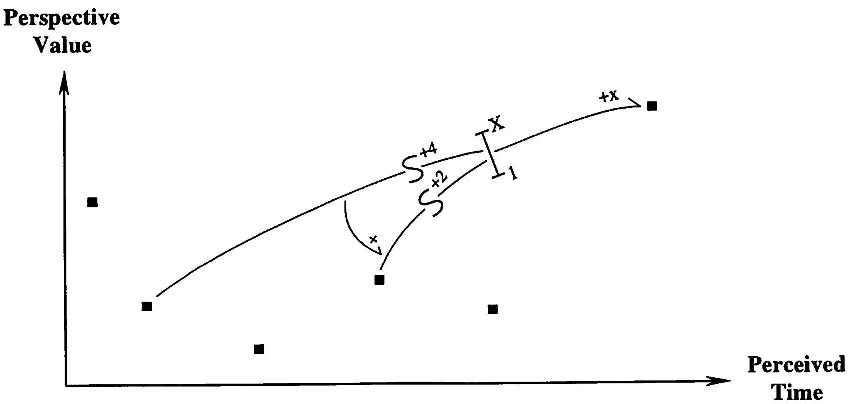


Figure 4.43 Representing the sequentiality of multivariate relationships.

The sequential ordering of perspective particles

The sequential location of a particle can be ordered through imitation. Hence a 'primary zygonic intersequential relationship' may be considered to exist, for example, as in figure 4.44. (Observe the zygonic status of the relationship is indicated with a 'z'.) On its own, however, the effect of such ordering is too weak to be of any musical consequence; imitative control functions purposefully in the realm of sequence when it is used to enhance the strength of an interperspective zygonic connection.

A primary zygon that links particles whose sequential locations are also zygonically related forms a dual bond which may be termed in full a **primary zygosequential zygon**. The term 'zygosequential' implies that the sequential component of the relationship is zygonic, a feature indicated diagrammatically by inserting a smaller 'z' into the larger one that stands for 'zygon'. See, for instance, figure 4.45. A zygosequential primary zygon is one of a group of similar relationships, which are all defined using the same format:

[level and type of perceived temporal control]:[nature of relationship].

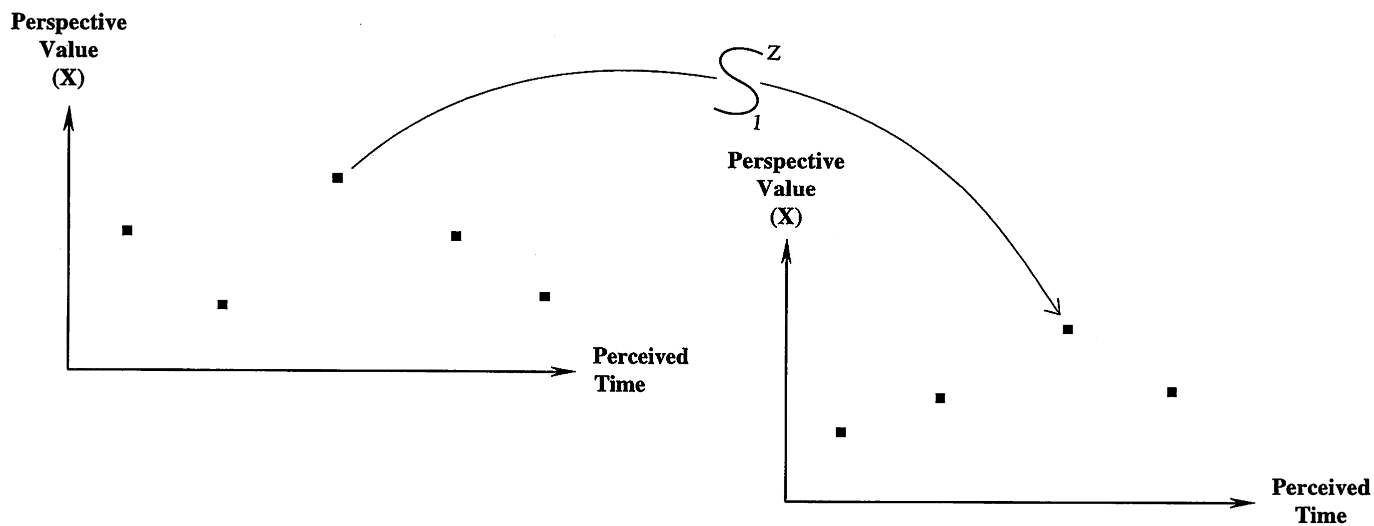


Figure 4.44 Primary zygonic intersequential relationship.

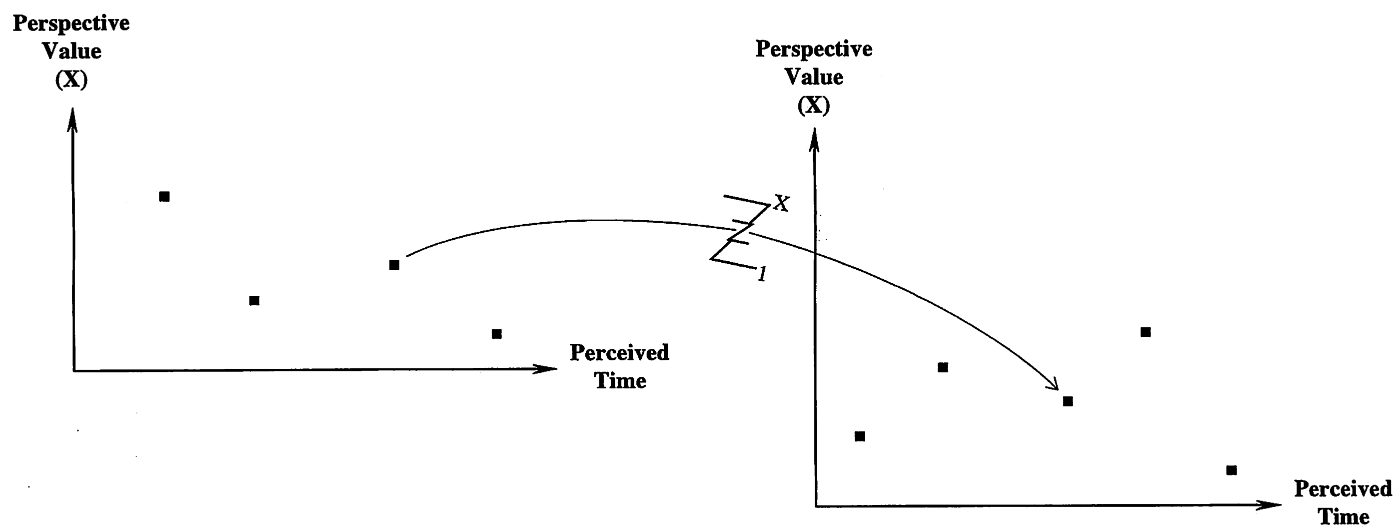


Figure 4.45 Primary zygosequential zygon.

A particle controlled by a zygosequential relationship is deemed to be **sequentially ordered**. The term 'sequentially free' may be used in contradistinction.

Higher order intersequential relationships exist too. For example, a **secondary zygosequential zygon** may be perceived as ordering one primary interperspective relationship, including its sequentiality, through imitation. See figure 4.46. Similarly, a **tertiary zygosequential zygon** may function as shown in figure 4.47, and higher ranks of zygosequential zygon are theoretically possible.

Finally, consider that a certain sequential equivalence is shared by two values that have the same relative ordinal number, one measured forwards from the beginning of a series of values, and the other gauged backwards from the end. For example, the location of the first may be 'a+2' (gauged from the beginning of the series), and that of the second 'b–2' (judged from the end). In the realm of perceived time, equality of magnitude in conjunction with opposing polarity yields **retrogression**. So, if two values are linked on a primary zygonic basis, and the sequential location of one is believed to exist in imitation of the retrograde equivalent of the other, then the two values may be considered to be related through a **retrograde primary zygon**. See, for example, figure 4.48.

It is also possible for the perceived temporal polarity of a relationship to be reversed on a subsequent appearance through the operation of a **retrograde secondary zygon** (figure 4.49). Observe that this secondary relationship takes no account of the primary sequential locations it connects, an aspect of retrogression that is considered below (see figure 6.62).

The sequential ordering of interperspective relationships

A primary interparticular relationship itself has a sequential location, based on the relative positions of the two particles that it links. This may be expressed as a matrix, whereby relationships existing *within* a group are expressed horizontally, and those *between* groups vertically. The sequential matrix appears above the letter denoting the type of relationship—see, for example, figure 4.50.

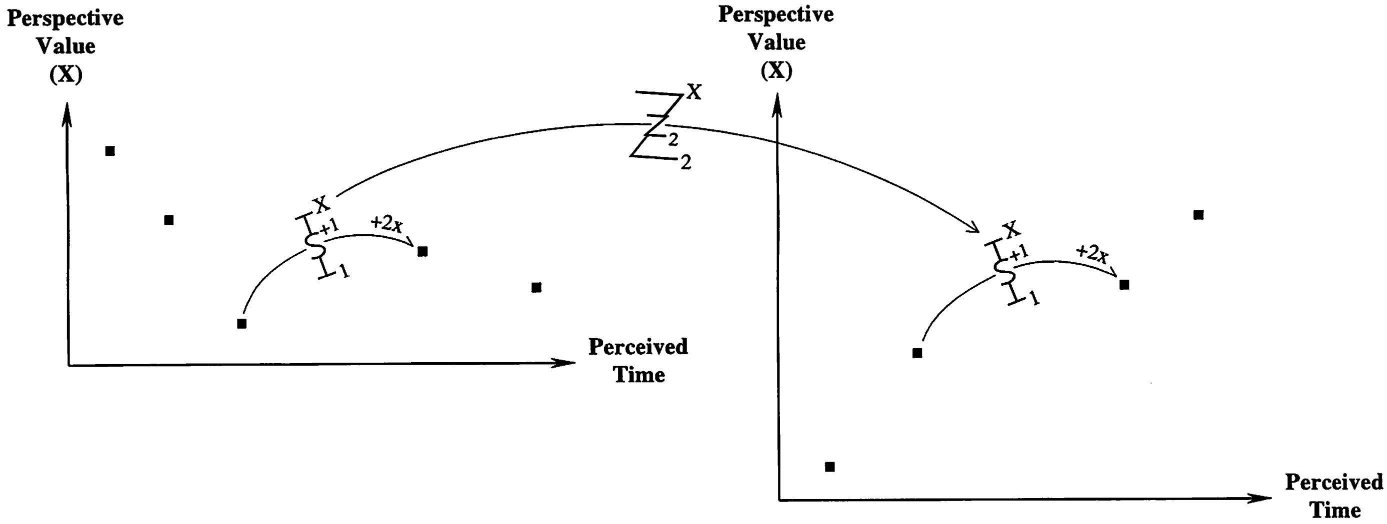


Figure 4.46 Secondary zygosequential zygon.

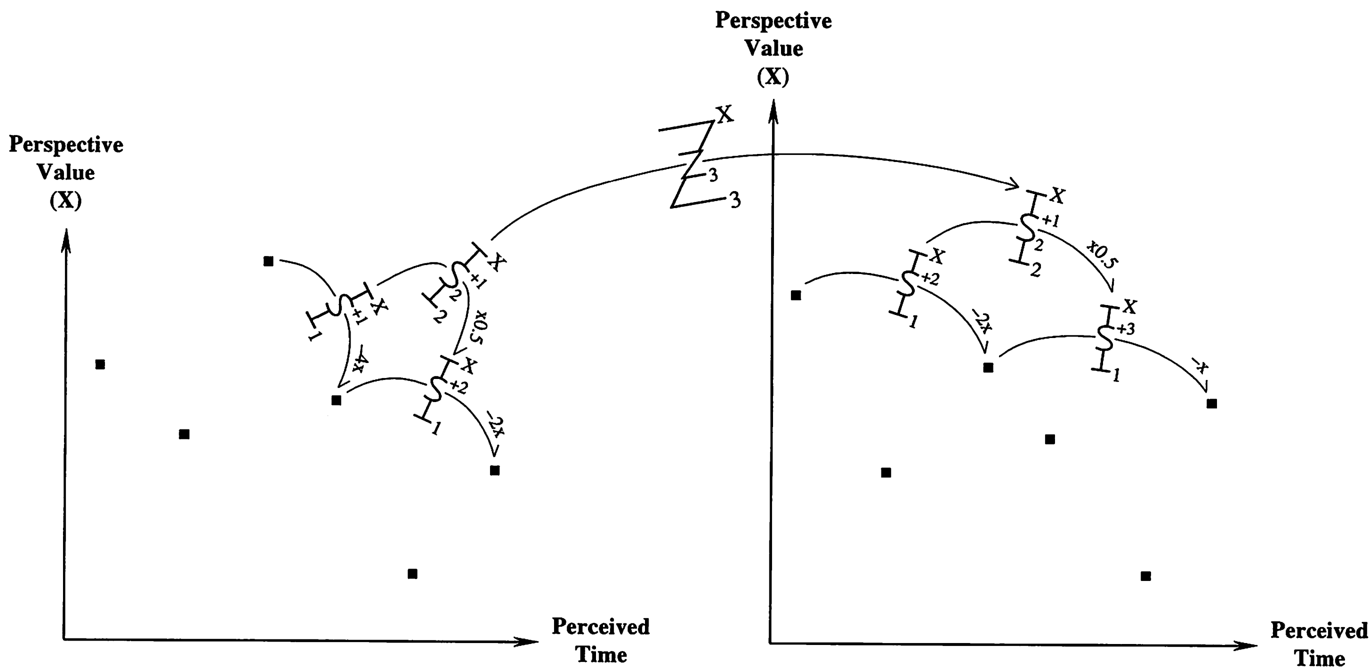


Figure 4.47 Tertiary zygosequential zygon.

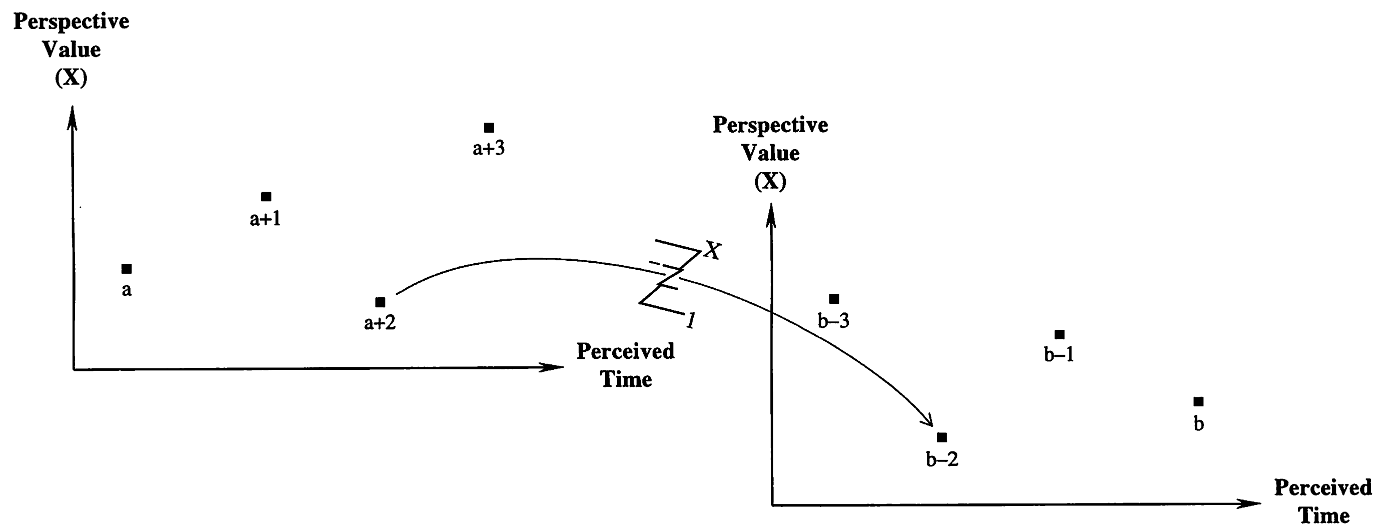


Figure 4.48 Retrograde primary zygon.

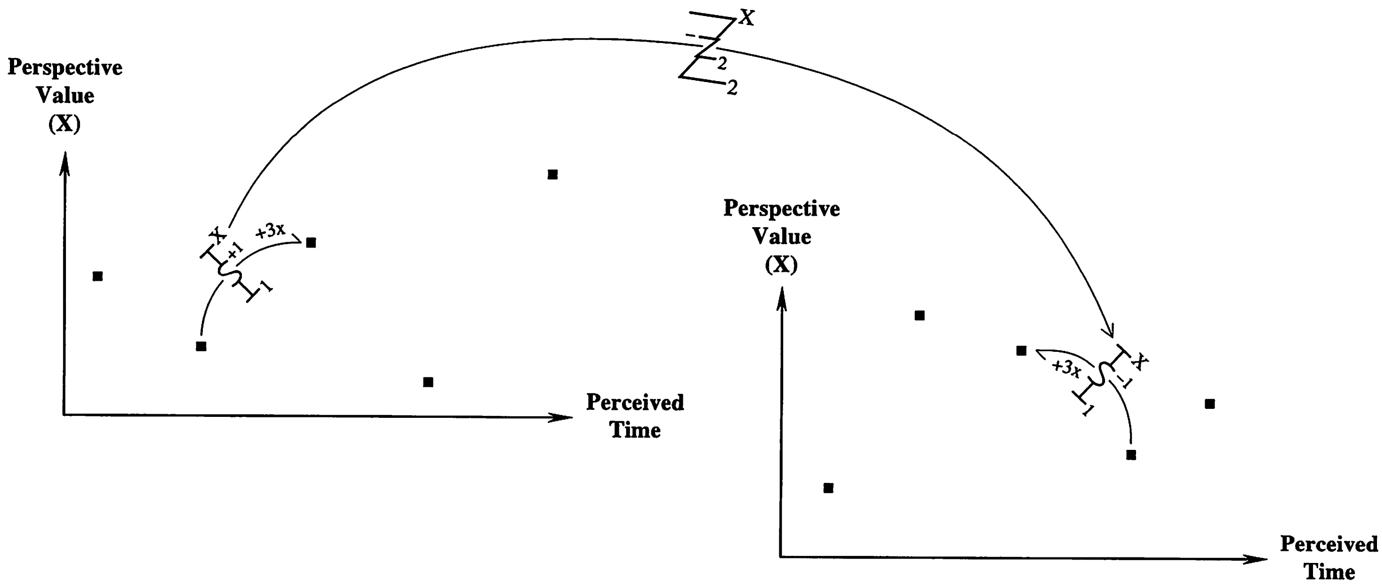


Figure 4.49 Retrograde secondary zygon.

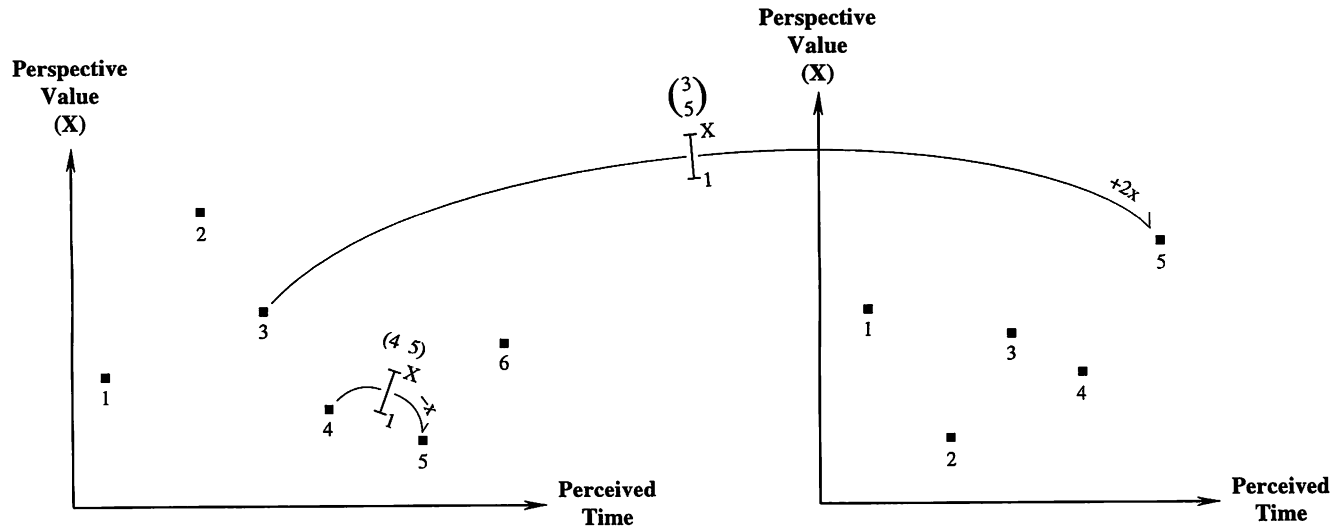


Figure 4.50 Matrices used to indicate the sequential locations of primary relationships.

The sequential location of an interperspective relationship, of any rank, may be related to that of another similar through a primary intersequential relationship. Moving from one location to another may affect an entire matrix consistently (if both primary relationships share the same sequential difference), or individual members may undergo separate transformations. For instance:

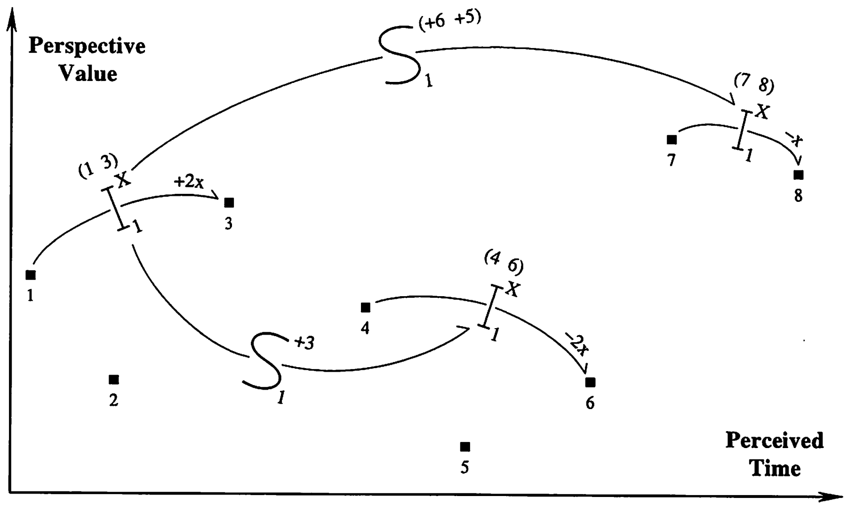


Figure 4.51 Primary relationship of sequence linking the sequential locations of primary interperspective relationships.

Sequential ordering results when the sequential location of one relationship is felt to imitate that of another. This is most likely to occur through the co-agency of a secondary zygon, forming a combination which may be termed a **primary zygosequential secondary zygon** (see figure 4.52).

Conceivably, the location of a relationship within a series of values may be reversed. If this is deemed to occur through imitation, then the operation of a **retrograde primary zygosequential secondary zygon** is implied, which may be symbolised in the manner shown in figure 4.53.

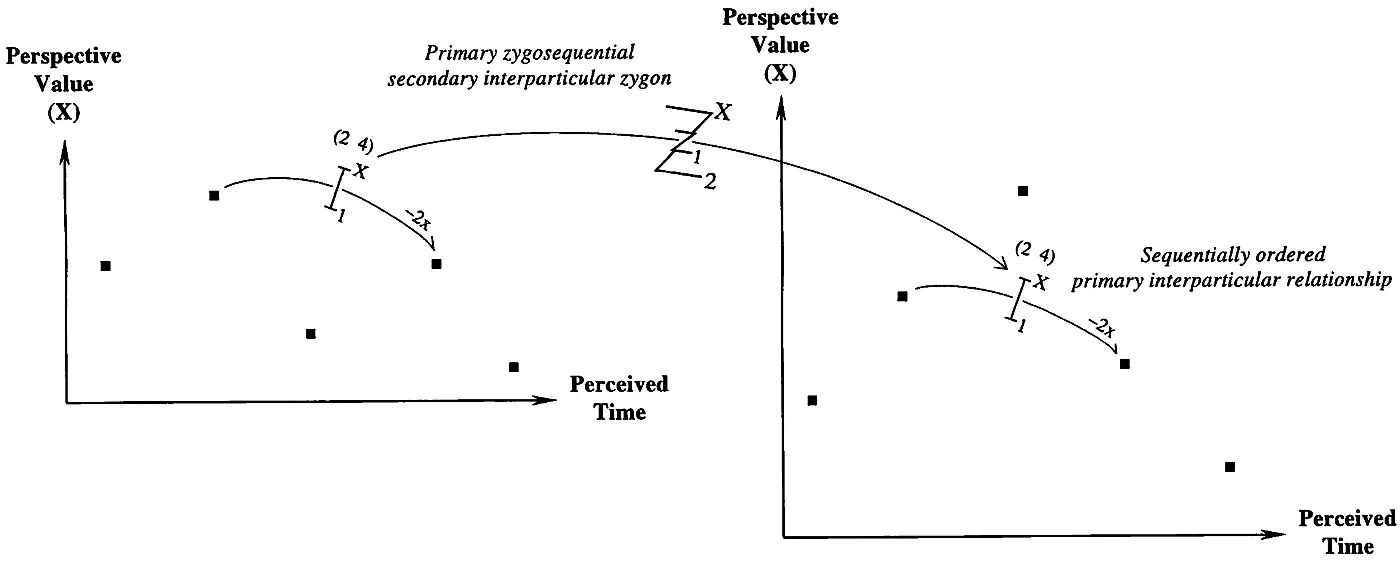


Figure 4.52 Primary zygosequential secondary zygon.

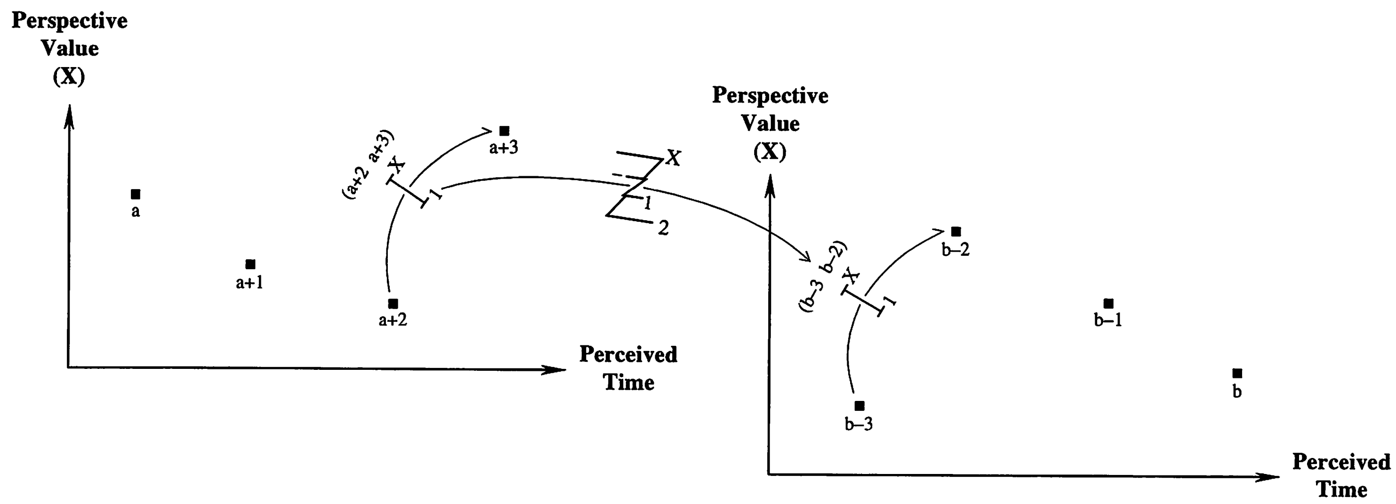


Figure 4.53 Retrograde primary zygosequential secondary zygon.

One primary interperspective relationship may differ from another, both quantitatively and with regard to relative position. The two may be compared through an asequential secondary interparticular relationship.

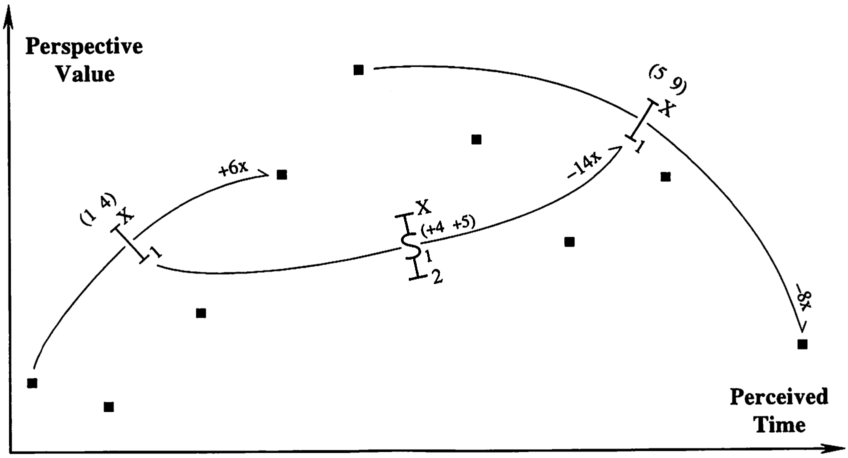


Figure 4.54 Asequential secondary interparticular relationship.

Sequential ordering may occur if two identical relationships of this kind exist, and one is imagined to imitate the other through a **secondary zygosequential tertiary zygon**. See figure 4.55. Similar principles theoretically apply to relationships of higher ranks.

To conclude, it should be recognised that many of the observations concerning sequence made here apply not only to particles, but also to more substantial chunks of perceived sound, and to groups of perceived sounds considered together, for which they have greater musical relevance. It is a matter of theoretical convenience that sequence is discussed at this stage.

Order deriving extramusically

Ordering may occur through the imitation of perceived sounds outside music, and through the representation of other external events. For instance, the view is held by some that repetition in music is itself an imitation of recurrence in nature, that:

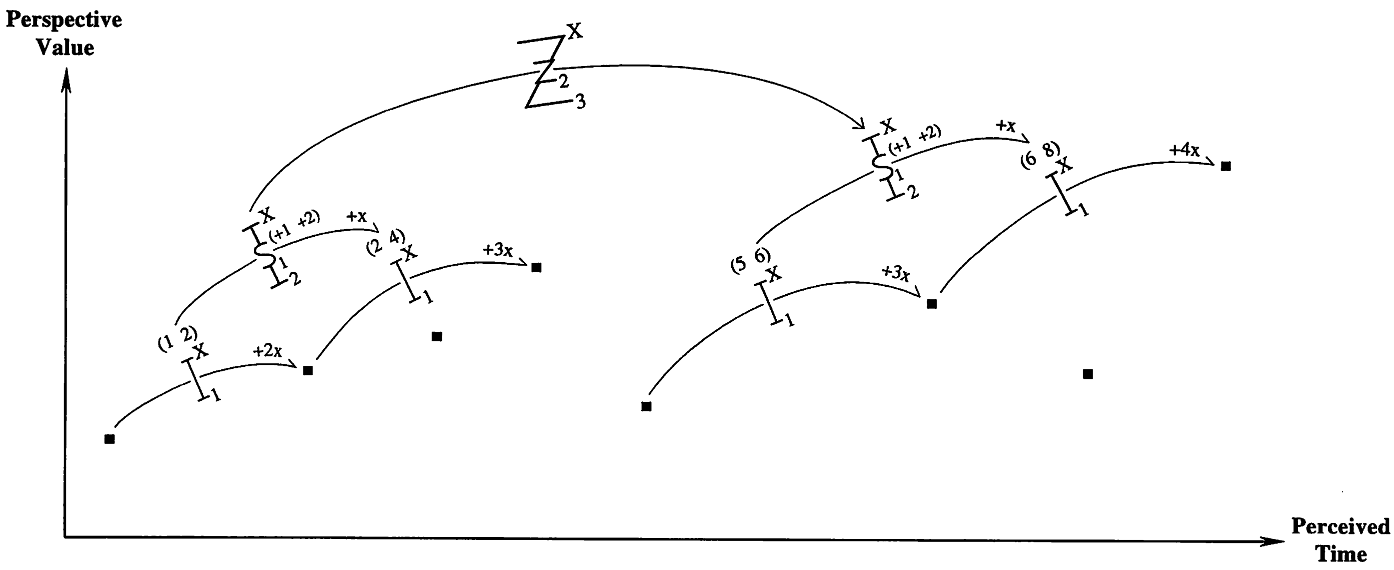


Figure 4.55 Secondary zygosequential tertiary zygon.

> Man's striving for order, of which art is but one manifestation, derives from a similar universal tendency throughout the organic world (Arnheim, 1971, p. 48).

Schenker (1906/1954, p. 6) states that

> Man repeats himself in man; tree in tree. In other words, any creature repeats itself in its own kind ...; and by this repetition the concept "man" or the concept "tree" is formed. Thus a series of tones becomes an individual in the world of music only by repeating itself in its own kind; and, as in nature in general, so music manifests a procreative urge, which initiates this process of repetition.

This opinion is shared by Chavéz (1961, p. 44):

> Nature itself ... teaches us by repetition. Repetition reigns over all basic phenomena in the physical world, and we imitate Nature in its repetitional procedures.

In terms of the present theory this means that the effect of a natural entity reproducing in its own likeness may be transferred to music via a secondary zygonic relationship:

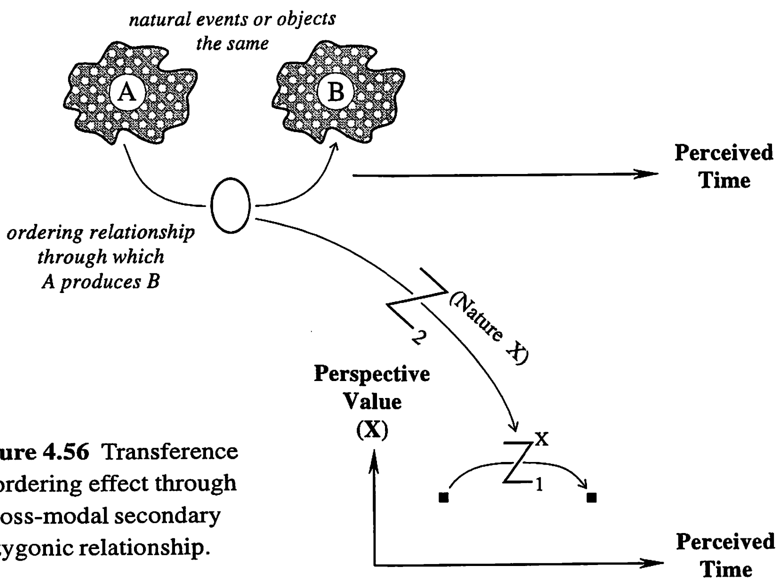


Figure 4.56 Transference of ordering effect through cross-modal secondary zygonic relationship.

Conclusion

This chapter has presented a theory concerning the cognition of order in music, which states that the value of a variable will be perceived to be ordered if it is thought (consciously or subconsciously) to exist in imitation of another. The relationship between two such values is termed a 'zygon'; together they are said to form a 'canon'. It is further hypothesised that for canonic organisation to be discerned, perceived temporal control must be present; order is of no consequence if listeners are unable to predict when it is going to occur. These principles are introduced through descriptions of their general application to perspective and interperspective values. Chapters 5 and 6 build on this theoretical base to examine more extended aspects of musical structure.

The theory presented has relevance to other art-forms too: many paintings, for example, are ordered through the imitation of external objects or events, thereby implying the presence of zygons between the world as it is perceived and the work of art. Moreover, in transforming what is seen, pictures normally display an inner coherence that ultimately derives from the repetition of one or more of its perceived aspects, such as colour, size, shape or texture. An abstract drawing that lacked duplication of any feature—that showed no evidence of symmetry, uniformity or regular change—would be the visual equivalent of random bursts of white noise. These concepts pertain to the products of other media as well: it is difficult to envisage a truly random sculpture, in which imitation played no part, and a bewildering variety of substances was distributed chaotically within an undefined three-dimensional region; in the field of architecture, the building which differs in every feature has yet to be erected (see Harris, 1931, p. 306); and the ballet whose movements were irregular in space and time would be unperformable.

With regard to the verbal arts, repetition is both the heart of language and its soul: a code whose symbols could be used only once, and so had constantly to be invented afresh, would be indecipherable; while in poetry, forms of imitation abound that are strikingly similar to those used in music. Apart from the question of metre, rhyme, assonance and alliteration are nothing more than types of timbral repetition (see Chavéz, 1961, pp. 39 and 40; Bernstein, 1976, pp. 147 and 148).

5

Protractions, and their ordering

Introduction

In the previous chapter, attention focused largely on individual zygonic relationships. This chapter and the one following examine *networks* of such relationships. We begin by considering the many separate perceived sounds which the Western analytical tradition typically regards music as comprising: 'notes'.[1]

Notes, elements and protractions; constants and variables

A **note** is customarily taken to be a portion of perceived sound that is constant in pitch. To the analytical ear, however, the notes of many instrumental and vocal performances exhibit considerable pitch variation, partly induced through the use of ornamental devices such as vibrato (Seashore, 1938, p. 266). Given the less critical stance normally adopted by listeners, though, such expressive deviations tend to be disregarded, giving the impression of perspective uniformity (Seashore, 1936, p. 48).

[1]'Tones' in USA (Apel, 1969, p. 856). The relative importance of pitch and the temporal perspects is shown by the fact that the term 'note' or 'tone', as well as meaning an entire blob of perceived sound, actually refers to its pitch, duration or both. Hence to the question: "What note is that?", appropriate answers may be: "*c♯*"; "a minim"; or "*c♯* minim".

A change in pitch, therefore, signals the end of one note and the beginning of the next, a boundary that may also be articulated by silence, a fresh attack, or a sudden modification in loudness, timbre or plot. In general terms:

> the note, as a stimulation homogeneous during a certain interval of time, is segregated from the other notes and unified within itself, by its homogeneity and its difference from the other notes.[2] (Koffka, 1935, p. 434)

Not all music, however, is divisible according to criteria like these, and there is no reason to suppose that notes will constitute the unquestioned quantum of certain future styles, particularly those incorporating electronically synthesised sounds. Therefore, in the present context, it is appropriate to introduce the broader concept of **elements**,[3] which may be defined as any complete units of perceived sound into which music can reasonably be divided. Accordingly, elements may vary in pitch or any other perspect.

Just as a moment comprises the fleeting appearance of several perspects of perceived sound, each termed a 'particle', so an element constitutes temporally extended manifestations of these perspective apperances, which may be referred to as **protractions**. Protractions fall into two main categories: those that are perceived to be **constant** and those that are **variable** (see figures 5.1 and 5.2).[4] The distinction between the two may not be clear cut, however. For example, portions of a variable may be constant. Although oversimplification is an inevitable feature of any system of classification such as this, its effects can at least be assuaged at a later stage, when borderline cases can be tested against the newly-secured conceptual framework.

[2]Rahn (1983, pp. 27 and 28) "raises the question of the definability of *notes*. Notes are generally distinguished by attacks or changes in pitch. But the distinction between a sustained note and a tone with an attack is not always clear. String tremolos in Western music, and pulsations in native North American music are but two illustrations of ambiguity in this regard. And pitch changes cannot be defined without recourse to interpretive criteria. For example, there is no objective, measurable difference between a wide vibrato and a narrow trill exclusive of other features of the musical structure."

[3]Adjectival form: 'elemental'.

[4]These terms may be used as nouns too: hence the expressions 'protractive constant' and 'protractive variable'.

Figure 5.1 Constant protraction.

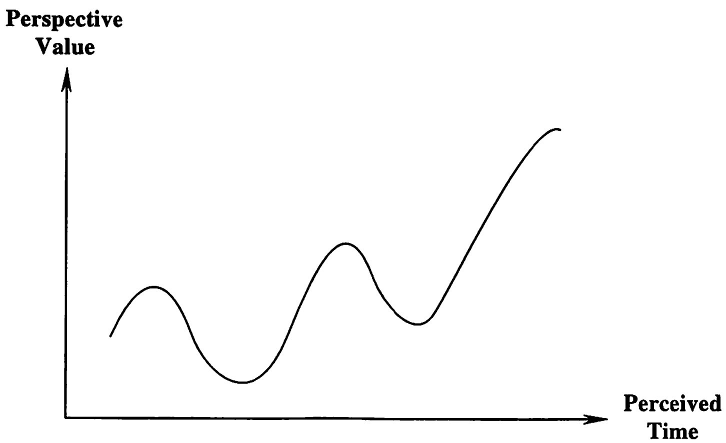


Figure 5.2 Variable protraction.

Constants may be **perfect**, if they perceived to be absolutely unvarying, or **imperfect** if virtually no change is perceptible. This distinction is drawn here for the sake of theoretical completeness—it is of far greater musical significance at the level of associations (see chapter 6).

An element can be regarded as comprising many moments (cf. Boretz, 1970, p. 84; Komar, 1971, p. 36). These should be thought of not as fixed portions of perceived sound which always go to make up an element in the same way, but as imaginary slices, each of which conceivably occuring at any point, and therefore almost certainly, though imperceptibly, differing from one hearing to another (cf. p. 14). The same is true of the numerous particles that hypothetically constitute a protraction: each the briefest imaginable sample of a perspect, taken with a resolution as fine as perception will allow.

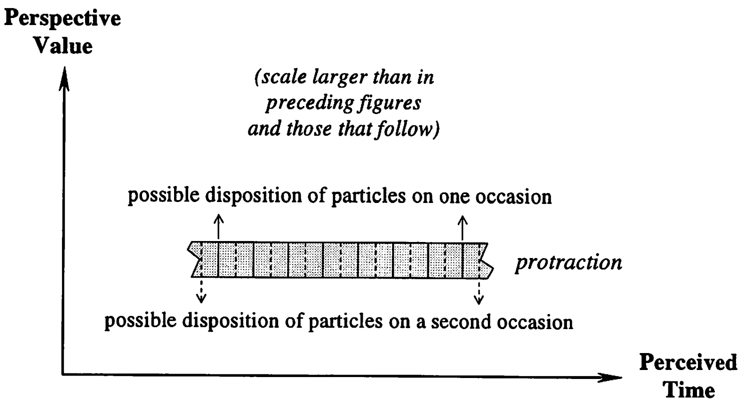


Figure 5.3 Particles differing from one occasion to another (cf. figure 1.2).

The perceived temporal dimensions of elements: prefix, suffix and duration

Values of fix vary widely in perceptual significance according to their relative position within a protraction. The initial particle is normally the most important: the perceived onset of an element is a prime concern of composers, performers and listeners alike. This may be termed the **prefix** (abbreviated to 'pF' when symbolising relationships). Next in order of priority is the fix at the end of an element, which may be termed the **suffix** (whose corresponding abbreviation is 'sF'). These terms are not entirely without precedent: the labels 'prefix' and 'suffix' appear in Erickson (1975, p. 6), for instance, although there they are attached to the objective correlates of the perceived 'attack' and 'final sound'.

Just as the prefix is perceptually the most significant temporal particle of an element, so the most important primary interperspective relationship of fix linking two elements is that between their prefixes. This view is confirmed by Clarke (1985), who, in referring to the 'inter onset interval', states:[5]

[5]Yeston (1976, p. 39) refers to this as the 'attack-point interval'.

> This is the most significant measure as far as the rhythmic function of the note is concerned. (p. 212)

Connections involving the suffixes of elements

> refer mainly to the articulation properties of the note. (ibid.)

The numerous fixes of an element together constitute a variable, since succeeding values differ as they register the passing of time. This Komar (1971, p. 36), after Boretz (1970, p. 84), refers to as a 'time-span', whose range is equivalent to the perceived elemental length or **duration**[6,7] (which may be shortened to 'D' in the representation of relationships).

Although the perception of duration shares much in common with the apprehension of interperspective relationships of fix (cf. pp. 58ff), a few additional comments are pertinent here. Duration is a simple perspect, whose values show a monotonic decrease in similarity as the difference between them is increased. The work, for example, of Kinchla (1972) supports the commonsense assumption that the JND grows as durations lengthen. Hence the perspective domain, which is metathetic, may be represented as follows:

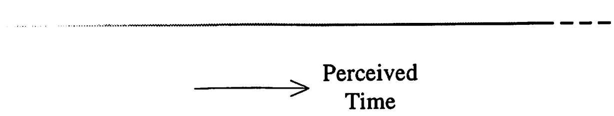


Figure 5.4 Representation of the perspective domain of duration.

[6]Dowling and Harwood (1986, p. 185) offer a similar definition of duration, as the 'psychological correlate of time'. The term 'physical duration' may be used where such a distinction needs to be drawn. Observe that this represents a slight departure from traditional usage.

[7]It is interesting to note that duration is the one feature of silence that is controllable— cf. Griffiths, 1986, p. 166. See, for example, Messiaen's *Turangalîla-Symphonie*, movement VI.

Constant protractions i: primary intraprotractive constant systems

An element comprises protractions of fix, pitch, loudness, timbre and plot, which, with the exception of fix, may form perspective constants. Although the observations made here are couched only in general terms, it is appropriate to reiterate the point made earlier with respect to pitch (p. 115), that what appears to be uniform on one perceptual level may in fact reveal fluctuations to the ear that is suitably attuned. Comparable observations apply to other perspects too. Most perceived sounds produced vocally or instrumentally—particularly those that are struck or plucked—are not constant in loudness, for instance, although the variation associated with each note often goes unrecognised. Take the following excerpt from Beethoven's piano sonata in *E* major, op. 10, no. 3:

Beethoven: Piano Sonata, Op. 10, No. 3; 1st Movement

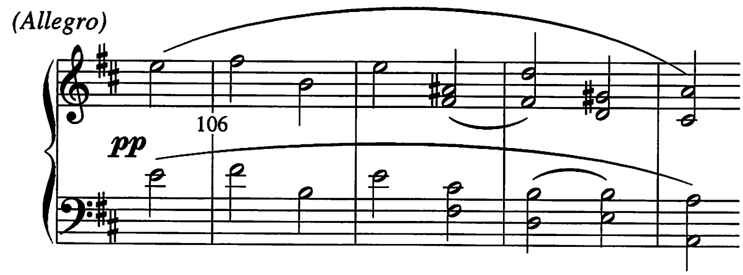



Figure 5.5 Varying levels of loudness heard as a constant association.

This would normally be regarded as existing on just one dynamic level (*pp*), although with a listener's attention suitably engaged, it could be heard as a series of diminuendi (say, *pp* down to *ppp* on each minim). Yet later in the same piece, Beethoven expressly asks that performers pay heed to the decreasing level of loudness inherent in the piano tone (see figure 5.6).[8]

[8]Indeed, listeners may even be required to hear the diminishing dynamics of the piano as a *crescendo*: take, for example, bar 62 of the last movement of the sonata op. 7 (see Brendel, 1976, p. 147).

Beethoven: Piano Sonata, Op. 14, No. 1; 2nd Movement

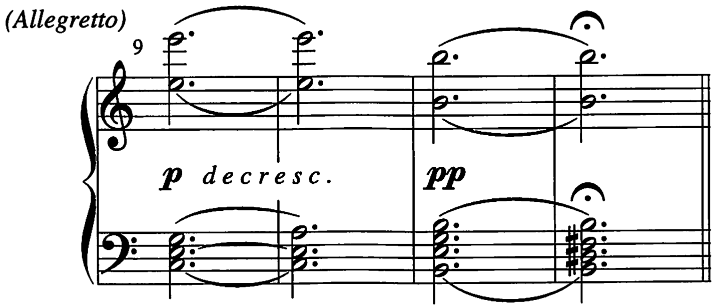


Figure 5.6 Diminishing loudness of piano tone intended to be heard as a *decrescendo.*

Similarly, in a musical context, listeners would normally consider most perceived sounds to have single timbres, although the characteristic qualities of instruments and voices actually depend on variation.

In using the designation 'constant', the aim is merely to reflect what may be taken to be the customary mode of listening, with the understanding that this will depend on how the element is projected stylistically, and may vary from one individual to another and on different occasions.

The theory presented in chapter 4 suggests that the value of every particle in a constant protraction (following the first) may be perceived as being ordered through the imitation of those preceding it. This implies a network of latent zygonic relationships (see figure 5.7), which may be represented rather more simply in the manner shown in figure 5.8, and which may be termed in full a **primary intraprotractive zygonic constant system**.[9]

'Intraprotractive' means 'within a protraction'—information that can normally be omitted since it is contextually self-evident. The term 'system' is defined here as a network of relationships operating within a group of perceived sonic events, through which every member is conceivably related to every other. The qualification 'constant' indicates that these are all identical.

[9]Observe that, since the manner in which a constant protraction is perceptually 'broken down' into particles is liable to differ from one occasion to another, so is the precise form of this hypothetical complex of relationships.

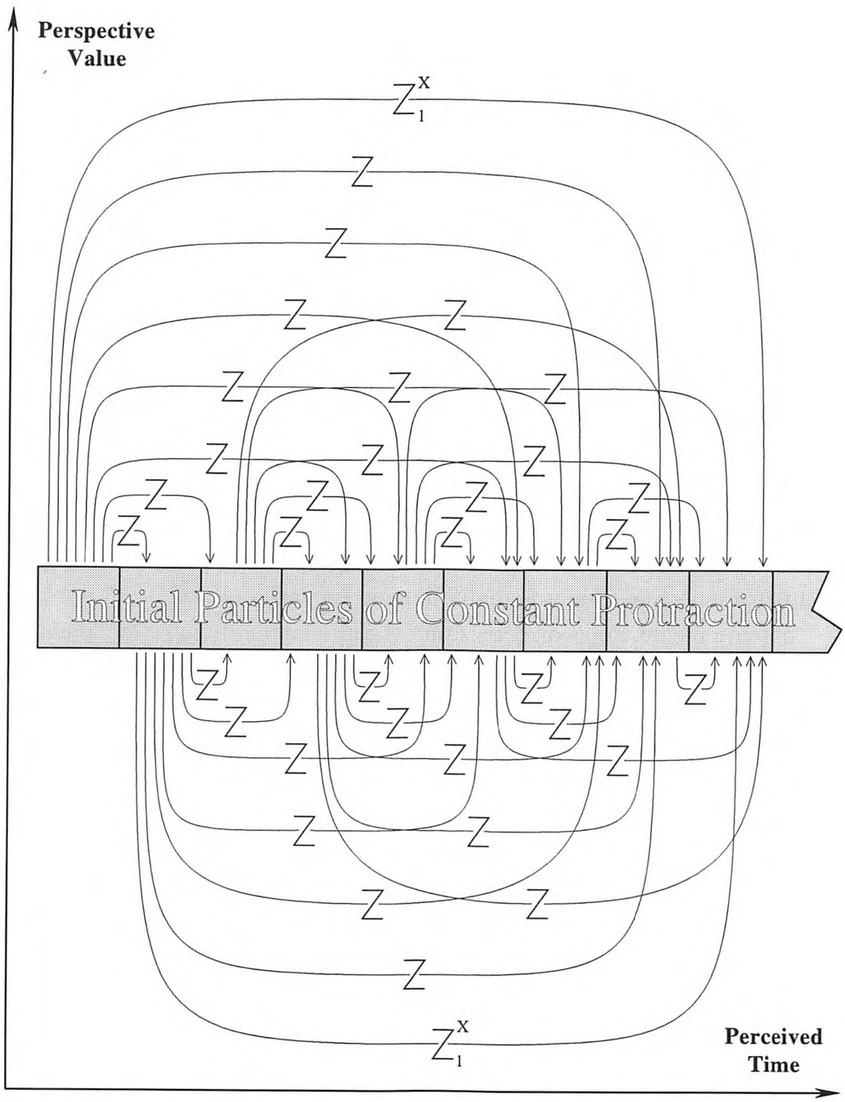


Figure 5.7 Hypothetical network of interparticular zygonic relationships through which the opening of a constant protraction is perceived to be ordered (cf. Husserl, 1964; Miller, 1984, pp. 117ff; Lewin, 1986, p. 329).

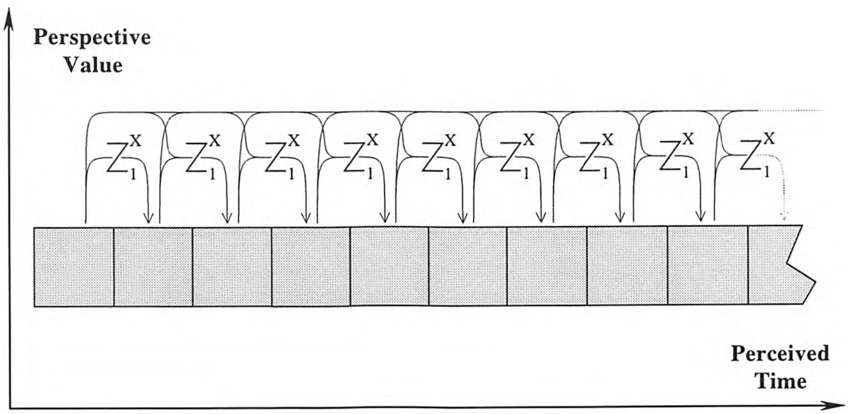


Figure 5.8 Simplified representation of the network illustrated in figure 5.7.

This model shows *potential* relationships, not all of which could possibly be realised cognitively. However, a proportion of them must be activated on any given occasion, since the interposition of particles of random value in an otherwise constant protraction would be perceived immediately and would create an impression of disorder. Moreover, research has shown that if a portion of a pitch constant is interrupted with a burst of noise sufficient to mask it, then the steady sound continues unabated in the listener's imagination (see, for example, Bregman, 1978, pp. 70 and 71), a process which indicates the operation of proactive primary zygons.

In most analyses, it would be unnecessary and impracticable to acknowledge the relationships that underlie the perception of every constant protraction; their existence can be assumed. Occasionally, though, by dint of particular musical prominence (gained, perhaps, by virtue of an unusually long duration), protractive constancy may be deemed worthy of especial analytical attention. On occasions such as these, symbolism along the following lines may be used (see figure 5.9).

The 'filled' arrowhead of the primary zygon indicates a plurality of relationships the same—here a constant system.[10] The primary zygons that constitute this system are associated with interperspective relationships of fix whose values may vary. This variability is shown by the 'open' arrowhead.

[10]This is a form of 'substitution', whereby a single sign is made to stand for two or more others. This principle is used extensively in the current work—without it many of the diagrams would be choked in a forest of unnecessary detail.

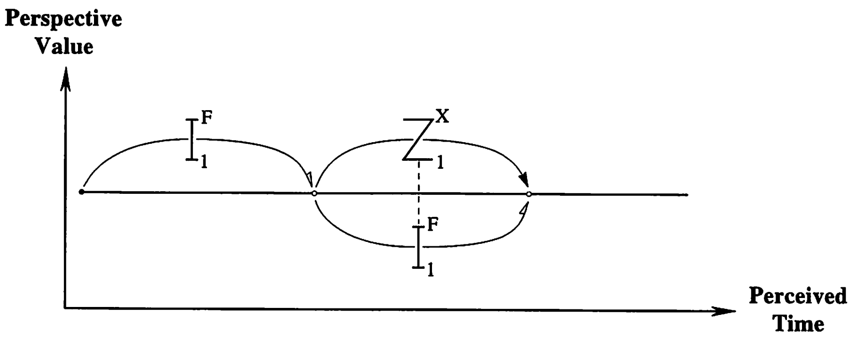


Figure 5.9 Symbolism of primary intraprotractive zygonic constant system.

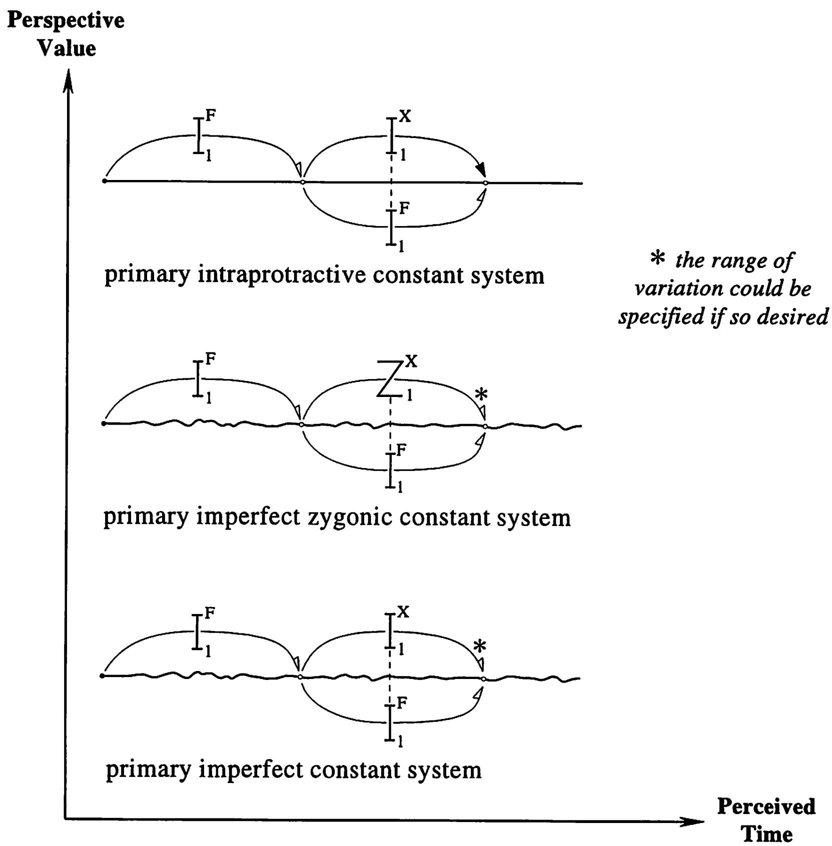


Figure 5.10 Symbolism of other intraprotractive constant systems.

The fact that the primary zygons can occur at any point during the constant is also shown with an interperspective relationship of fix bearing an open arrowhead, anchored at the beginning of the protraction with a filled dot. Open dots show the perceived temporal freedom of the remaining relationships. Comparable symbolism may be used for constant systems whose zygonic status is undetermined, and for imperfect constant systems (see figure 5.10).

Constant systems may be represented even more simply along the following lines (cf. figures 8.10, 8.29 and 10.1):

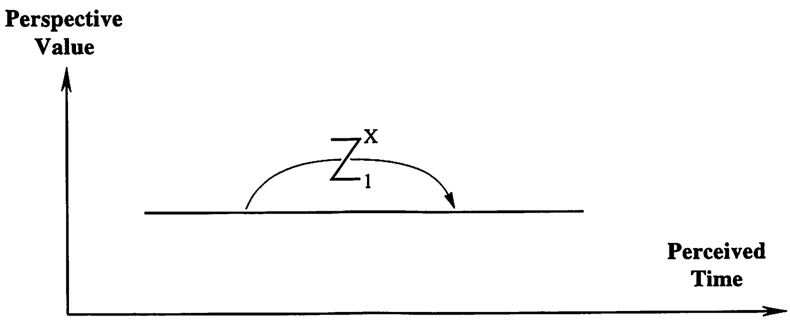


Figure 5.11 Simplified representation of constant systems.

Constant protractions ii: primary interprotractive constants; related secondary constant systems

The value of each perspective particle in one constant may be related to the value of every particle in a second. Between two constants, therefore, a network of identical primary interparticular relationships potentially exists. See figure 5.12. A simpler form of representation is shown in figure 5.13. This may be termed a **primary interprotractive constant**, symbolised as shown in figure 5.14.[11]

[11]Note that the term 'relationship', in the generic sense, may be used in referring to constants, invariants (cf. figure 7.2) and other connections made up of multiple strands.

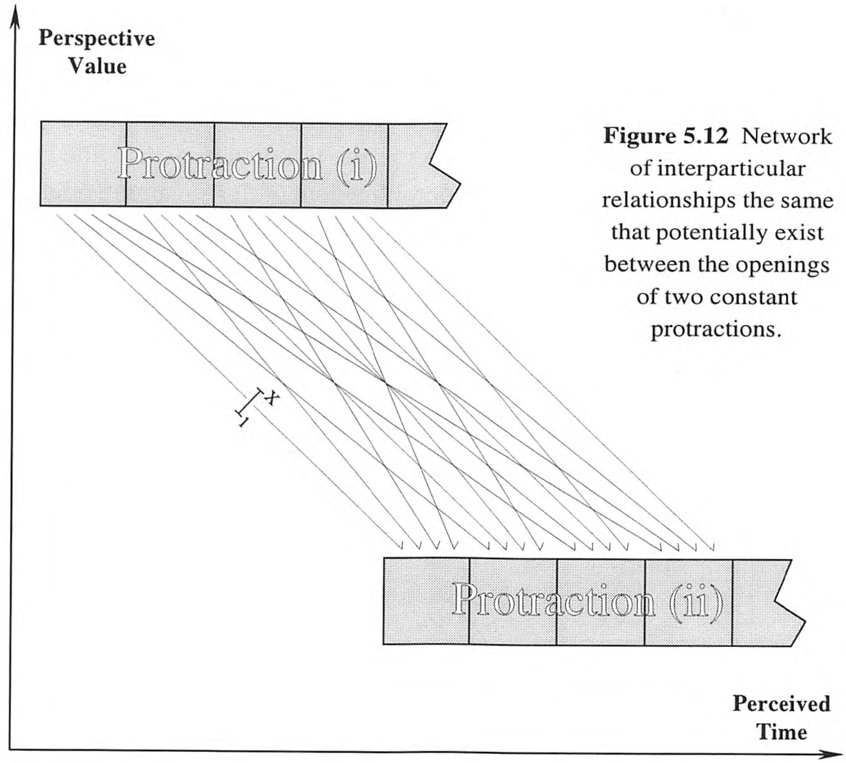


Figure 5.12 Network of interparticular relationships the same that potentially exist between the openings of two constant protractions.

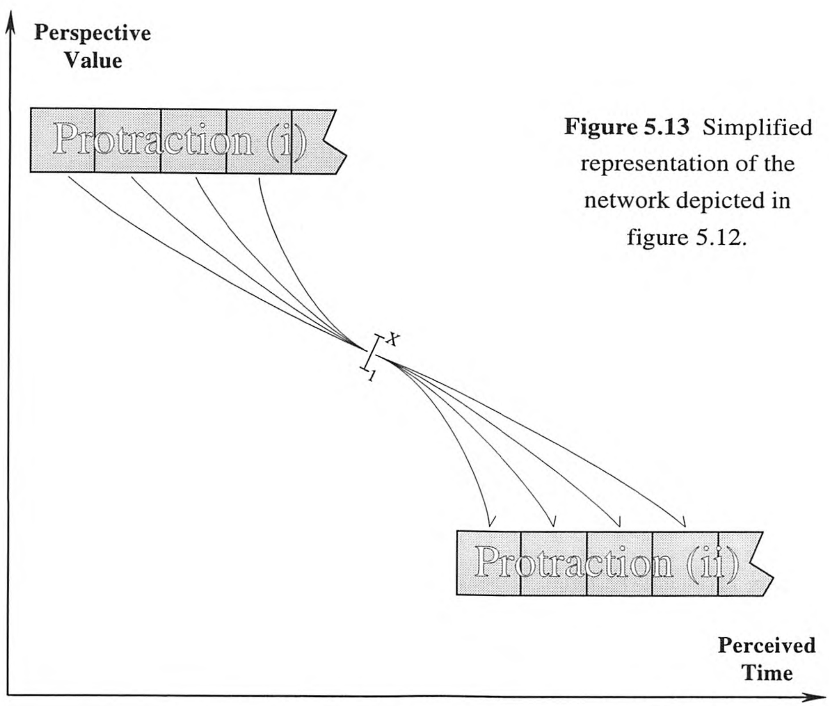


Figure 5.13 Simplified representation of the network depicted in figure 5.12.

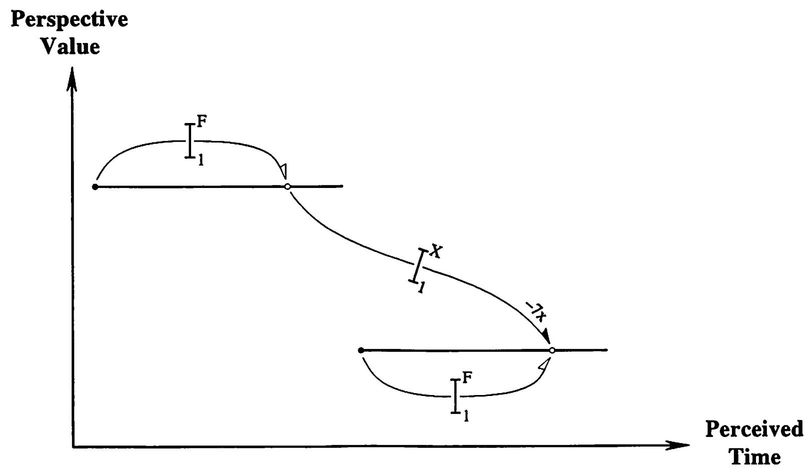


Figure 5.14 Primary interprotractive constant.

The fact that the symbol representing the primary interprotractive constant stands for relationships that can exist anywhere along the length of the two protractions is shown by the two signs indicating free interperspective differences of fix. Again, these perceived temporal indications may be omitted as standard practice. For example:

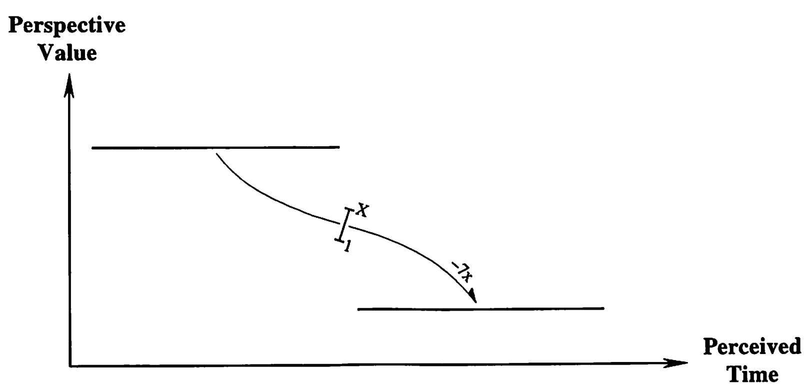


Figure 5.15 Simplified symbolism of primary interprotractive constant.

It is possible to consider that any of the interparticular relationships that make up a primary interprotractive constant (except the first) exist in imitation of one or more of those occuring earlier. A network of secondary interparticular zygons is thereby implied, which may be termed a **secondary zygonic constant system**, and represented as follows:

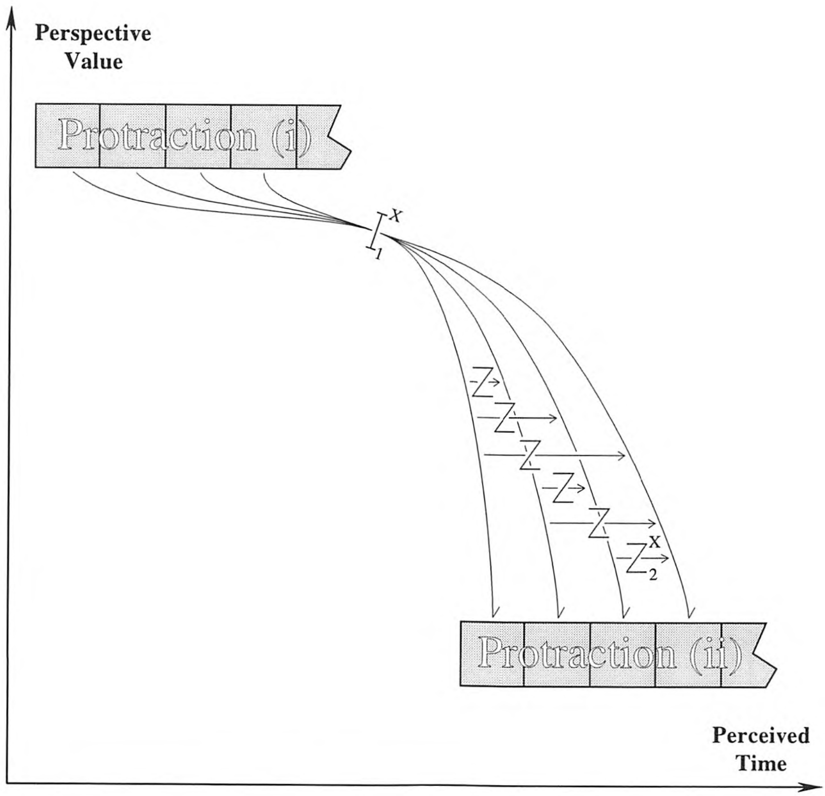


Figure 5.14 Secondary zygonic constant system between primary interprotractive constants.

A simpler form of symbolism is presented in figure 5.15. Here, the interprotractive constant is illustrated using two symbols connected with a solid line to enable the secondary constant system to be shown (cf. figure 6.30).

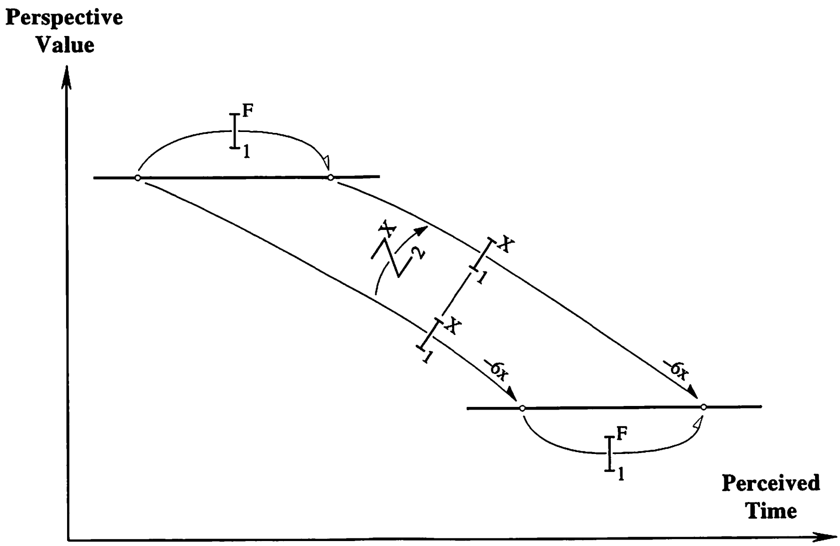


Figure 5.15 Proposed symbolism of secondary zygonic constant system between primary interprotractive constants.

The second of two constant protractions the same, which is held to exist in imitation of the first, may be considered to be related through a **primary interprotractive zygonic constant**, symbolised as follows.

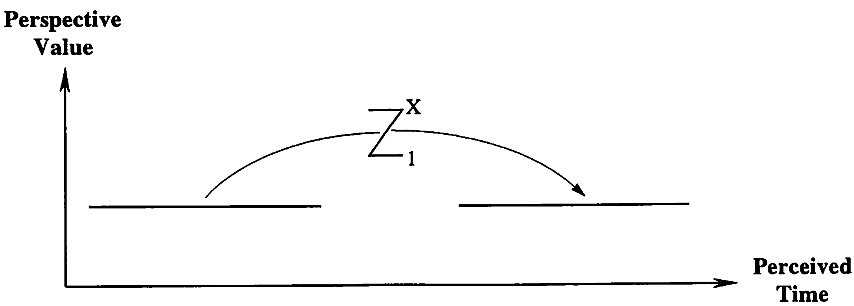


Figure 5.16 Primary interprotractive zygonic constant (cf. figures 8.11 and 10.4).

Primary interprotractive zygonic constants may be imperfect in two ways. First, two perfect constants may differ slightly. The relationship between them may be termed an ***imperfect*** **primary zygonic constant,** symbolised as follows (cf. figure 10.6):

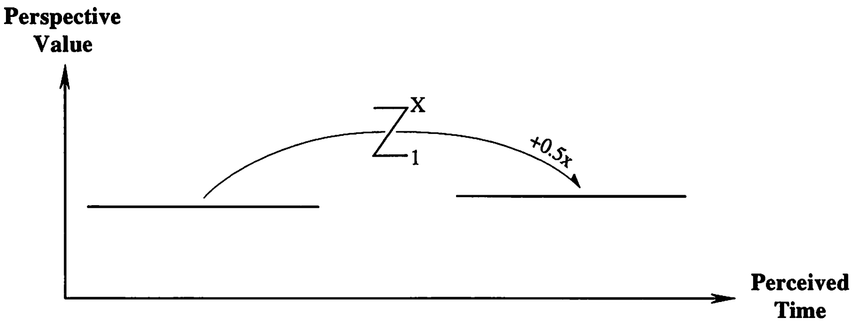


Figure 5.17 Imperfect primary interprotractive zygonic constant.

Observe the use of a filled arrowhead and the optional notation of the degree of imperfection involved.

Conversely, either or both of the constant protractions may themselves be imperfect, while being centred on essentially the same perspective value. In these circumstances, the relationship between them may be termed a **primary** ***imperfect*** **zygonic constant.** Constants of this type are shown using open arrowheads (cf. figure 6.33).

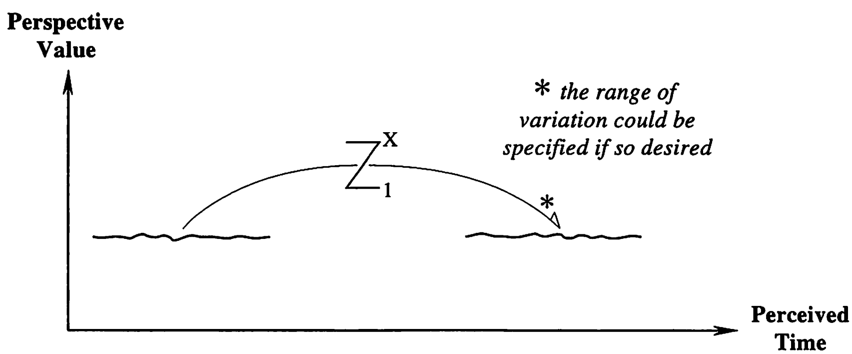


Figure 5.18 Primary interprotractive imperfect zygonic constant.

Imperfect primary constants of this type need not be zygonic. For example:

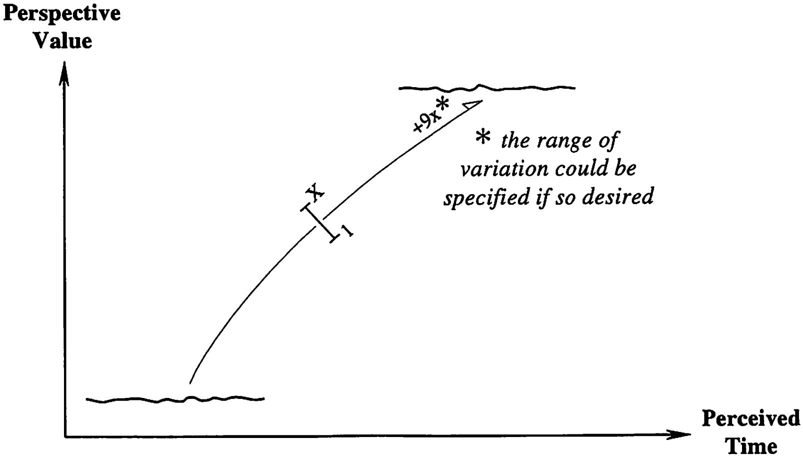


Figure 5.19 Primary imperfect constant (cf. figure 6.29).[12]

Constant protractions iii: higher ranks of interprotractive constant

Potentially, two primary interprotractive constants may be related through a vast array of secondary interparticular relationships (see figure 5.20). This may be termed a **secondary interprotractive constant**. See figure 5.21.

When one primary constant is perceived to exist in imitation of another the same, they may be deemed to be related through a **secondary interprotractive zygonic constant**, as shown in figure 5.22 (cf. figure 10.115). An **inverse secondary zygonic constant**—(cf. figure 10.85)—is a further possibility (figure 5.23).

By extension, **tertiary interprotractive constants**, which may but need not be zygonic, can be thought to relate secondaries; see figure 5.24 and cf. figure 10.15. The musical application of interprotractive constants varies greatly from perspect to perspect, as will become apparent in chapters 8–10.

[12]Note that such a constant differs from an invariant (defined later in this chapter) in its lack of sequential restriction.

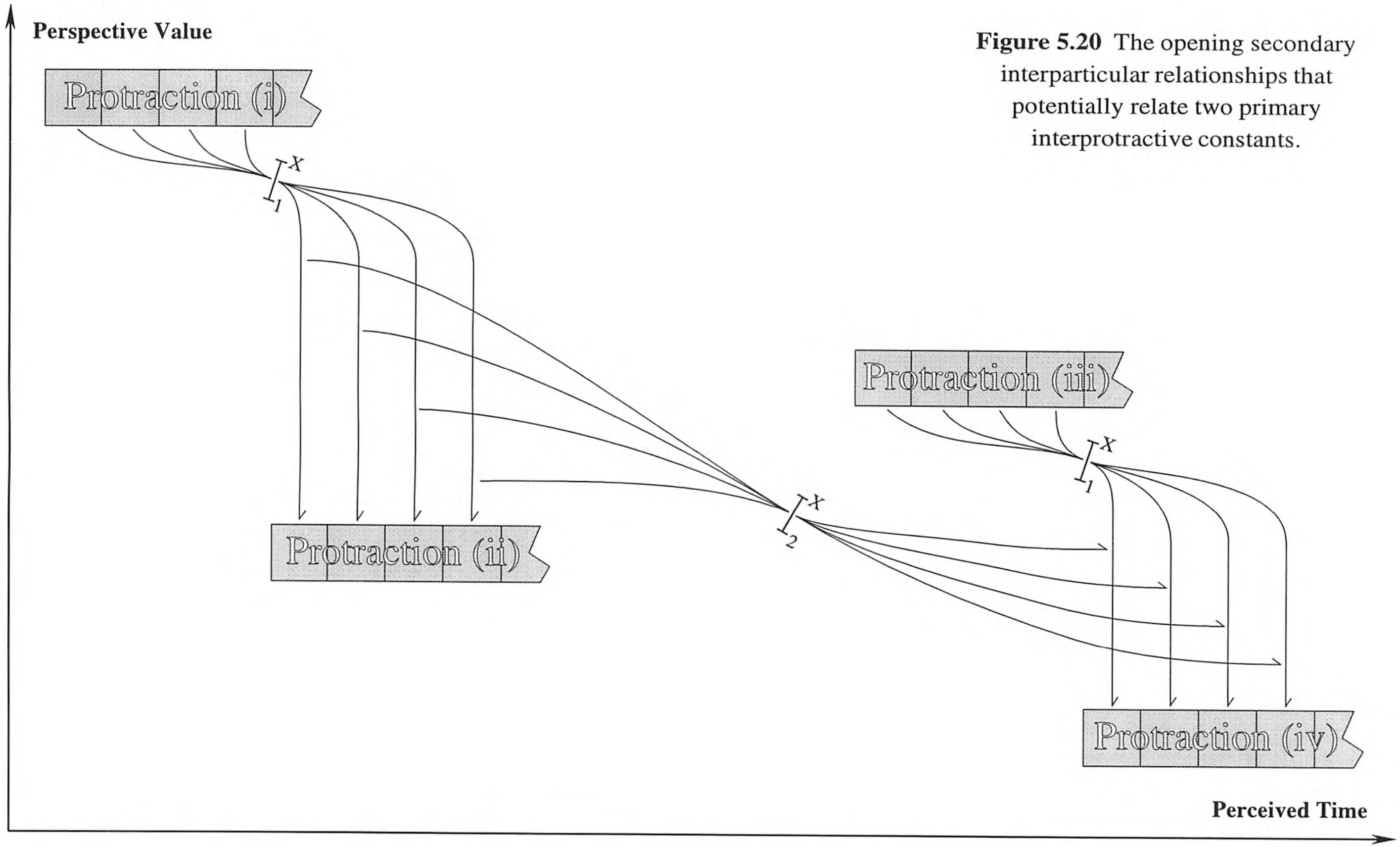


Figure 5.20 The opening secondary interparticular relationships that potentially relate two primary interprotractive constants.

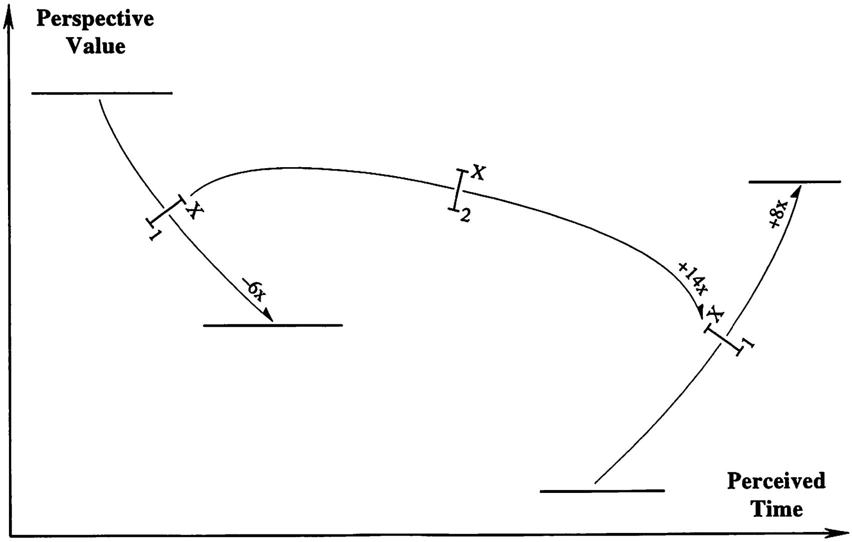


Figure 5.21 Secondary interprotractive constant.

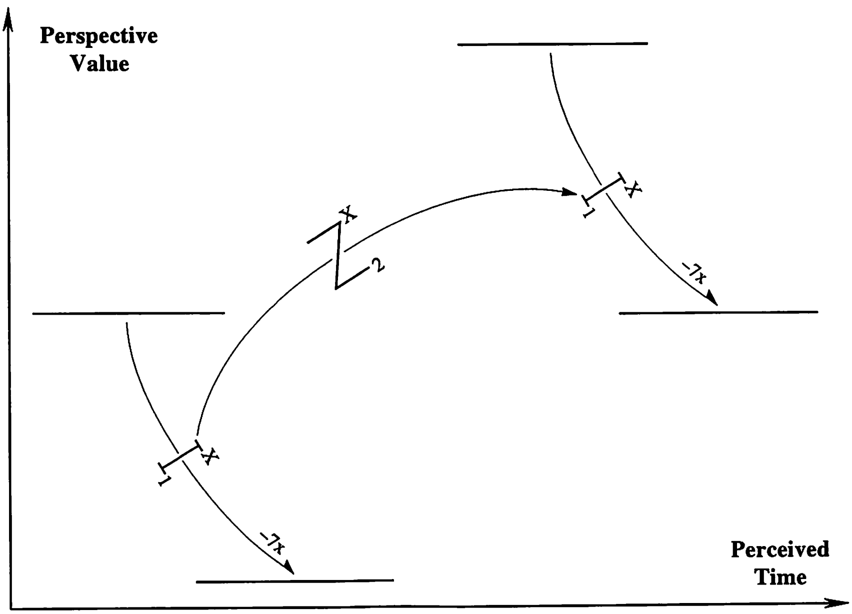


Figure 5.22 Secondary interprotractive zygonic constant.

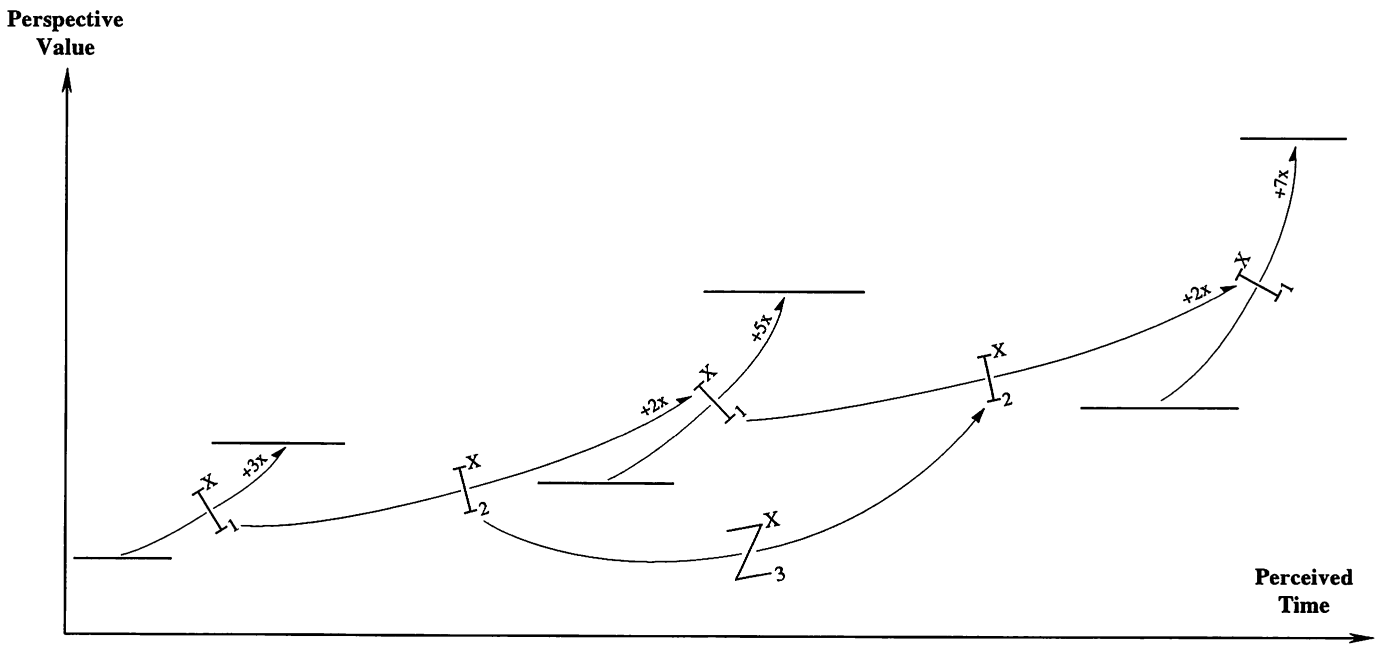


Figure 5.24 Tertiary zygonic constant.

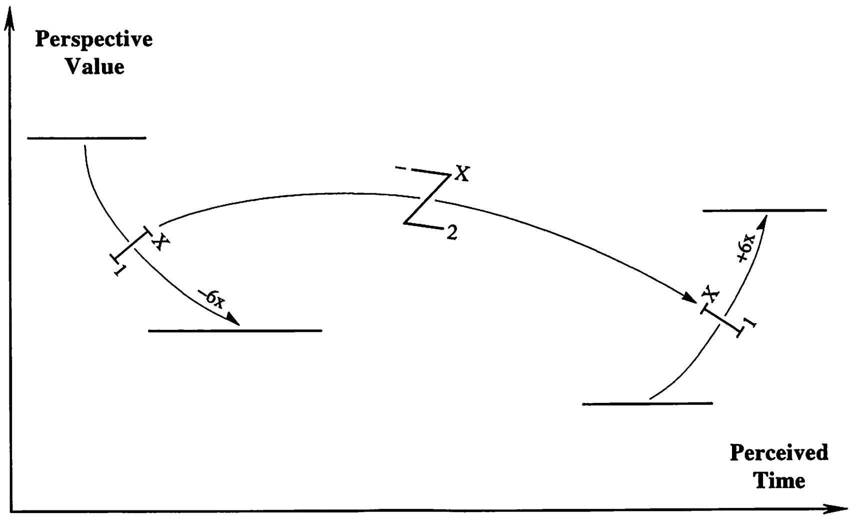


Figure 5.23 Inverse secondary zygonic constant.

Constant protractions iv: secondary constants between primary intraprotractive constant systems

A listener may hear the very uniformity of one constant as corresponding to that of another. This mode of perception may be interpreted in terms of a network of interparticular relationships—a secondary constant—through which each member of the primary constant system associated with one protraction is potentially linked to every primary relationship pertaining to a second. See figure 5.25. Which of these potential relationships are in fact realised is dependent on a range of perceptual and contextual factors. A secondary constant operating between primary intraprotractive constant systems may be symbolised as shown in figure 5.26.

Where order through imitation is perceived to be present (see figure 5.27) a secondary zygonic constant is inferred. Musical examples appear in chapters 8 and 10 (cf. figures 8.11, 8.30 and 10.2).

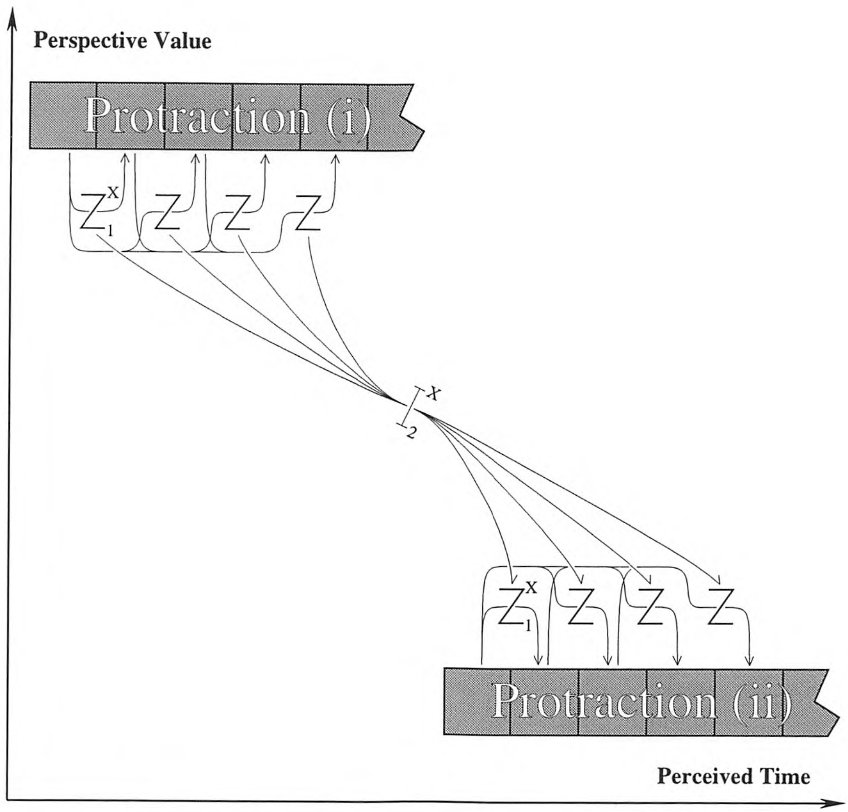


Figure 5.25 Opening relationships that potentially constitute a secondary constant between primary intraprotractive constant systems.

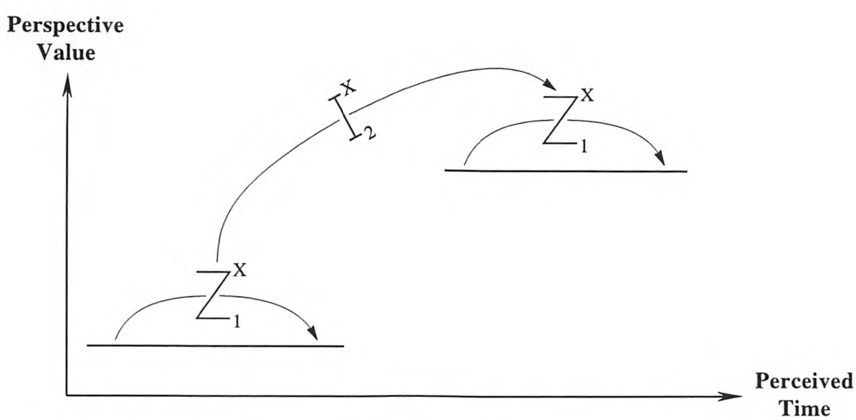


Figure 5.26 Simplified representation of figure 5.25.

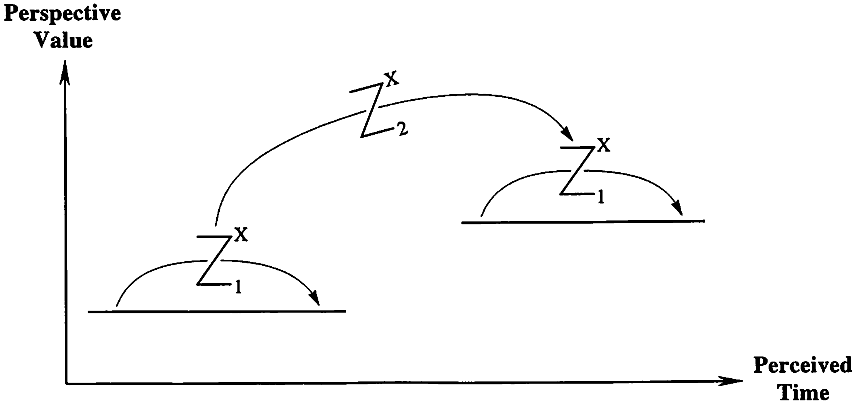


Figure 5.27 Secondary zygonic constant between primary constant systems.

Variable protractions i: uniform primary intraprotractive invariant systems; secondary intraprotractive constant systems

This section and the one that follows examine the interparticular relationships that pertain to variable protractions. We begin by examining the internal ordering of protractions that feature regular change. This occurs, for example, when a given primary interperspective value of fix is habitually associated with the same interparticular difference (see figure 5.28). Paired relationships like these potentially exist in great profusion. Grouping them in identical sets offers a certain conceptual clarification. Each set forms a **uniform primary intraprotractive invariant system of difference**.

The term 'uniform' recognises that each relationship expresses the same interperspective value of fix. In the present work, 'invariant' is used to label groups of identical relationships that link pairs of perspective values within or between variables. Contrast this with the term 'constant', which is reserved for combinations of relationships the same that potentially connect all the members of a group of equal values—internally, or to another similar group. Hence a constant implies a far greater proportion of relationships to values than does an invariant. A uniform primary invariant system may be symbolised in the manner shown in figure 5.29.

Invariant systems of any type may be imperfect.

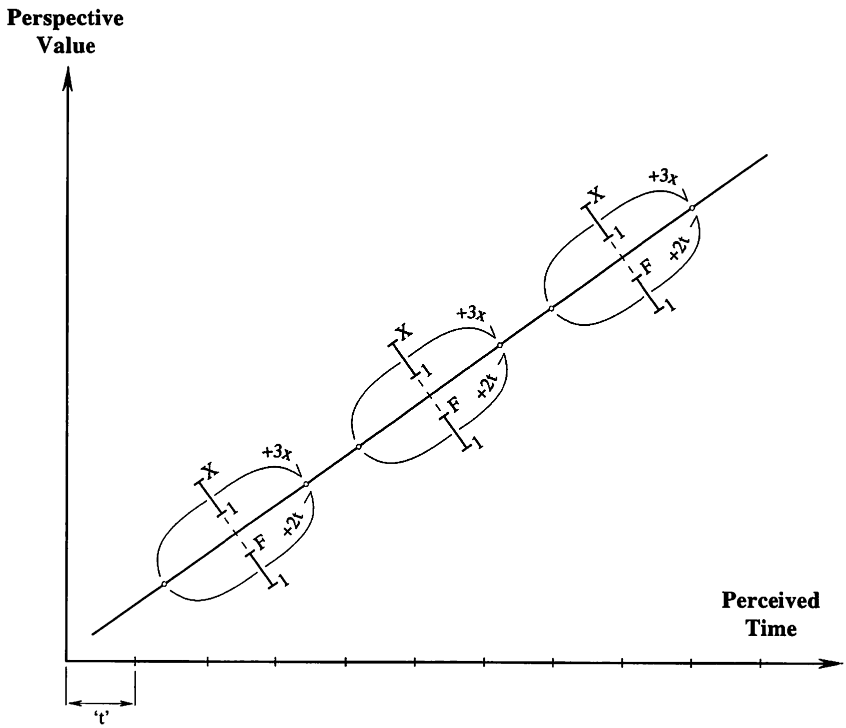


Figure 5.28 Regular variable protraction.

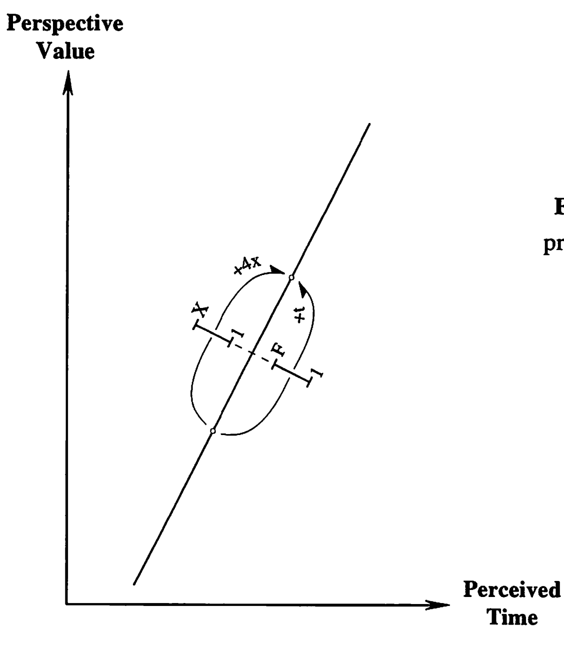


Figure 5.39 Uniform primary intraprotractive invariant system of difference.

The presence of one invariant system implies the existence of others.

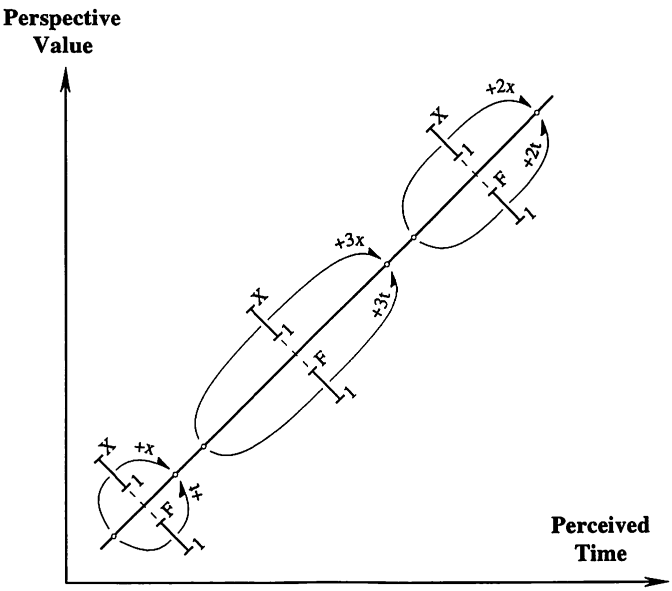


Figure 5.30 Implied further invariant systems (cf. figure 10.12).

Since the relationships that comprise a primary invariant system are all identical, it is possible to regard those following the first to be ordered through the imitation of others occurring earlier, implying the presence of a **uniform secondary zygonic constant system.** See, for instance, figure 5.31. In this diagram, the primary invariant system is represented by the two pairs of primary relationships, connected with unbroken lines. The fact that the perceived temporal interval that separates them is variable is shown by the interperspective relationship of fix with an open arrowhead linking their onsets. These separate strands are tied together through the uniform secondary zygonic constant system, which operates in two domains: perceived time and, in this case, the perspect 'X'. Each ordering effect relies on the other for its existence—here, the zygons of fix qualifying those of 'X'.

The system illustrated in figure 5.31 is part of a one much larger comprising secondary zygons that connect members of the other primary invariant systems potentially associated with the variable. The complete network of interperspective connections may be symbolised as shown in figure 5.32 (cf. figures 8.19, 8.36 and 9.26).

Compelling evidence that listeners build up internal models such as those

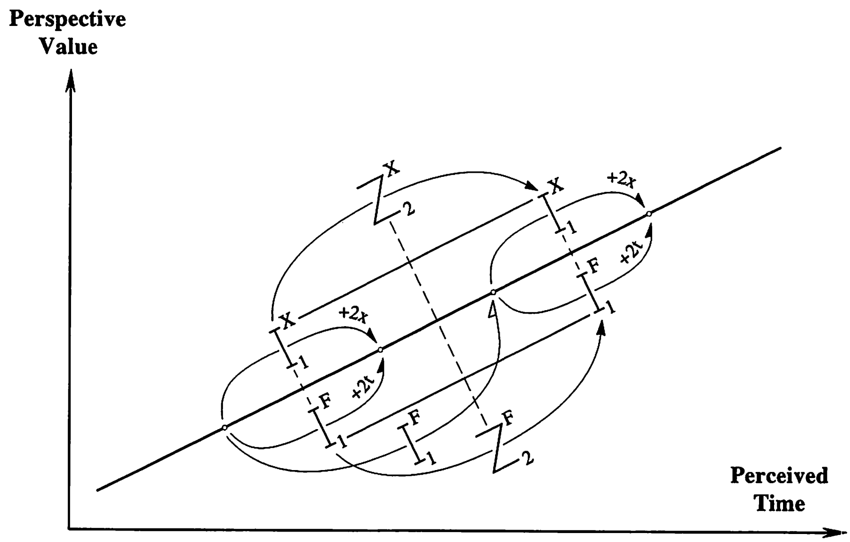


Figure 5.31 Uniform secondary zygonic constant system.

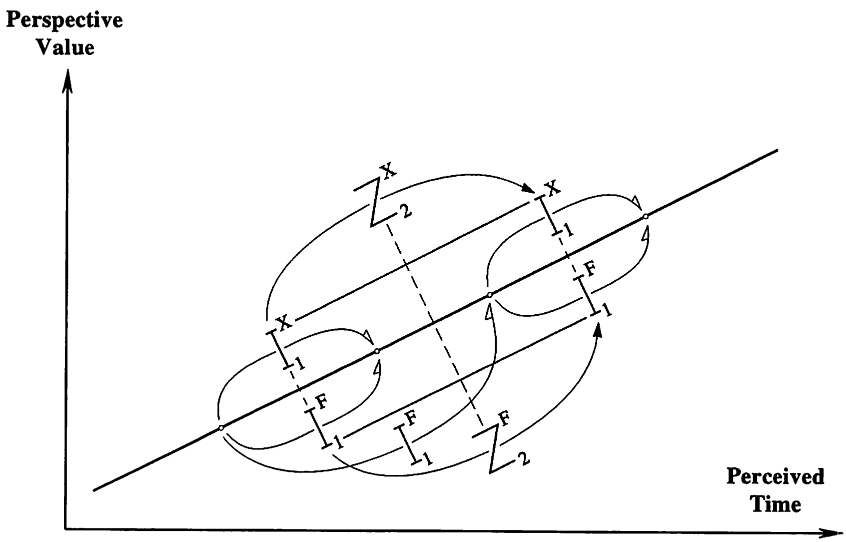


Figure 5.32 Representation of all the uniform secondary constant systems associated with a regular variable.

described here is offered by the work of Dannenbring (1976), in which it was demonstrated that listeners will mentally reinstate portions of regular pitch glides that are omitted. From this, the proactive projection of interparticular relationships based on the pattern of those that precede may be inferred.

Characteristic of all protractions is a regular variable of fix. This implies that a given protraction potentially supports many different sequentially ordered invariant systems of fix, each based on a differing interperspective difference, and each conceivably ordered through the operation of a secondary constant zygonic system. Perhaps the most significant of these is the system controlling the primary relationships linking successive particles; here, the order stems from the very continuity of an element of perceived sound.

Observe that there is also a sense in which an invariant system can be thought to act imperfect-zygonically, since each particle following the first may be perceived as being ordered through approximate imitation of those preceding—the more direct their adjacency, the greater degree of perfection involved. The sum of such relationships working within a protraction constitutes a **uniform primary zygonic invariant system** (cf. figure 8.24).

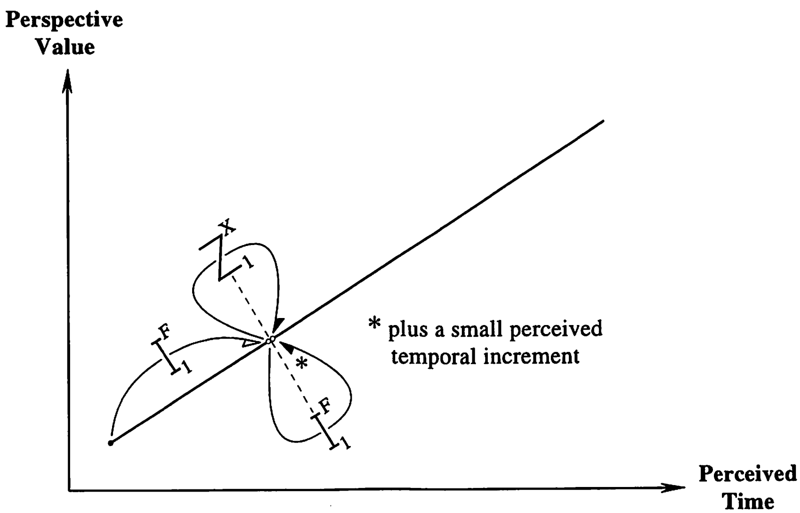


Figure 5.33 Uniform primary zygonic invariant system.

Theoretically, invariant systems may be based on ratios. For example, the value of the following variable doubles for every nominal unit of time that passes (figure 5.34).

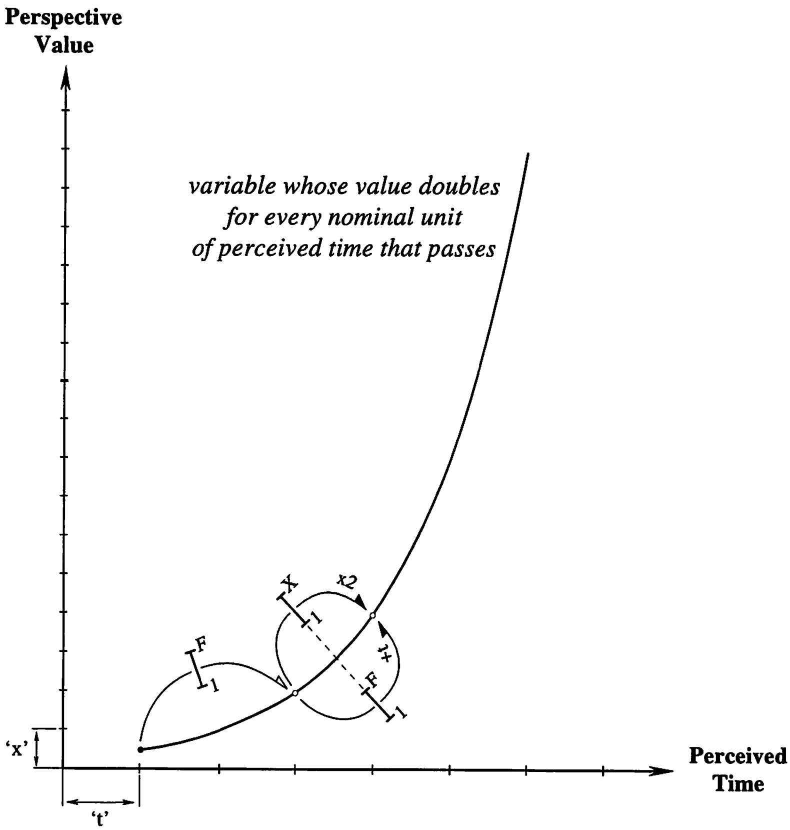


Figure 5.34 Uniform invariant system of ratio.

In practice, however, although listeners may be able to ascribe such precise functions to sounds perceived under the contrived conditions feasible in the laboratory, it is doubtful whether it would be possible to distinguish an invariant of ratio from the many other similar patterns of change that are possible, especially in the rich and distracting aural environment that music typically offers. Indeed, alternative interpretations of the same variable are possible. For example, the rising pitch illustrated in figure 5.35 could be heard either as a uniform invariant of ratio, linking a series of widening intervals which occur at regular points in time, or as an invariant of difference, in which a series of equal intervals occupy successively shorter time-spans.

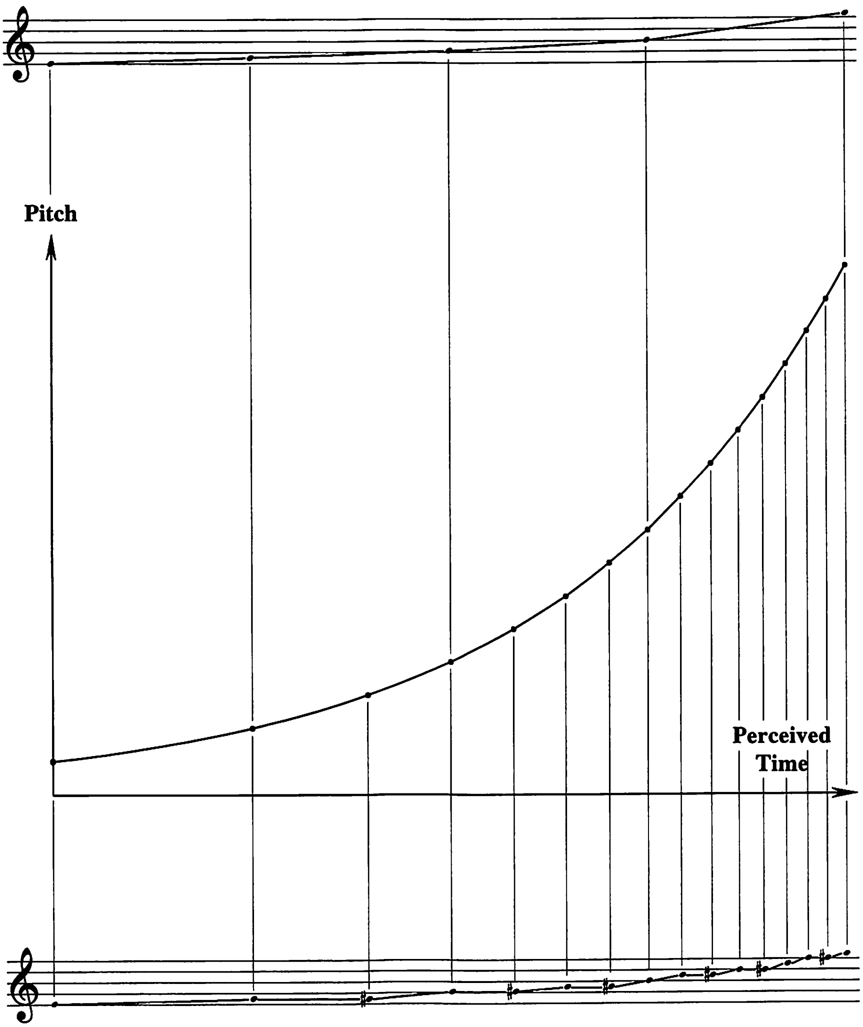


Figure 5.35 Alternative interpretations of accelerating change in pitch.

Variable protractions ii: uniform primary interprotractive invariants; secondary and tertiary zygonic constants

This section examines the networks of interparticular relationships that may exist between variables. We begin by considering two variables that exhibit identical patterns of change and between which there is a constant difference. They may be related through a web of differing interparticular relationships, whose combined effect would be cognitively overwhelming. However, attention may naturally focus on the run of parallel identical relationships linking particles with the equivalent perceived temporal location in their respective protractions, each existing side by side therefore with a secondary zygonic relationship of fix. This network may be termed a **uniform primary invariant of difference**, and symbolised as follows:

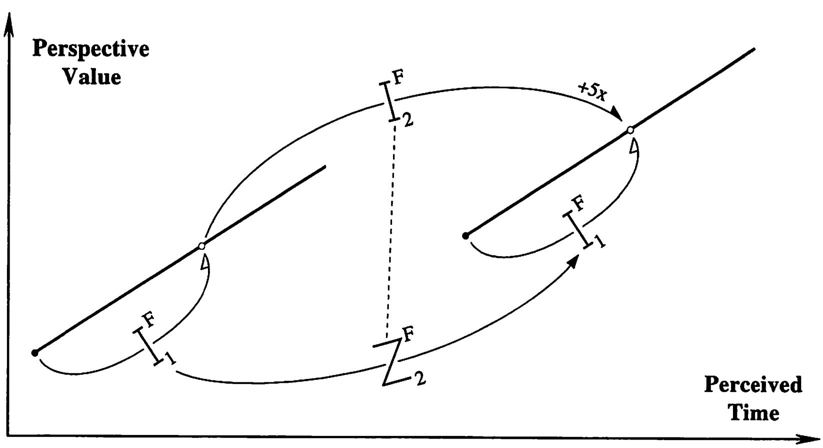


Figure 5.36 Uniform primary invariant of difference.

If two the variables are identical, and one is perceived as a repetition of the other, the relationship between them may take the form of a **uniform primary zygonic invariant**. See, for instance, figure 5.37 (and cf. figure 10.13).

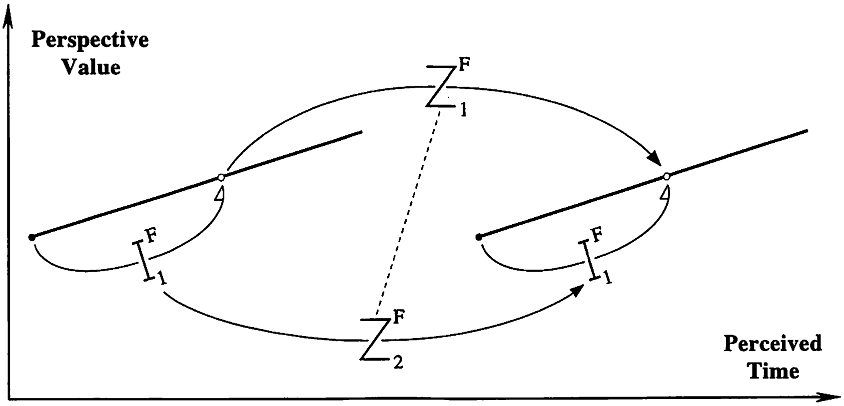


Figure 5.37 Uniform primary zygonic invariant.

The pattern of change in one variable may be perceived as imitating that in another through the operation of a secondary zygonic constant between primary invariant systems. For example:

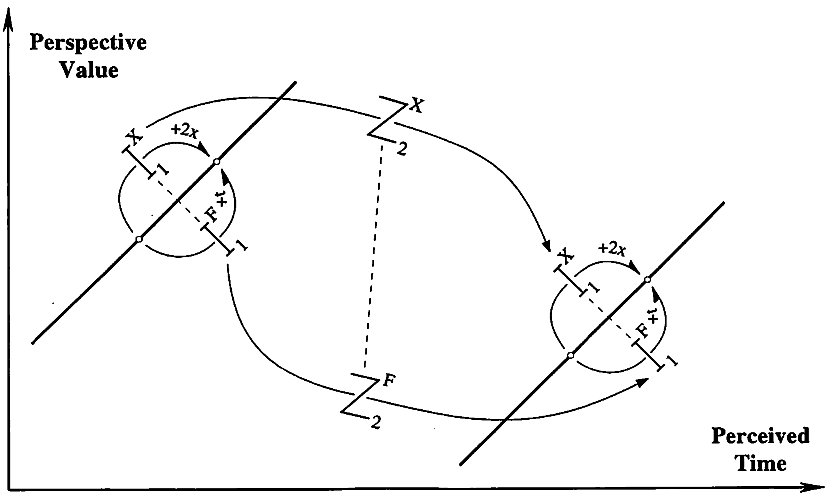


Figure 5.38 Secondary zygonic constant linking primary invariant systems (cf. figure 8.7).

Here, a set of intraprotractive relationships with a certain perceived temporal span pertaining to one protraction are reckoned to order a comparable set of relationships in a second protraction. This principle can be generalised to all other primary intraprotractive invariants pertaining to the variables, regardless of the perceived temporal interval on which they are founded (cf. figure 8.21).

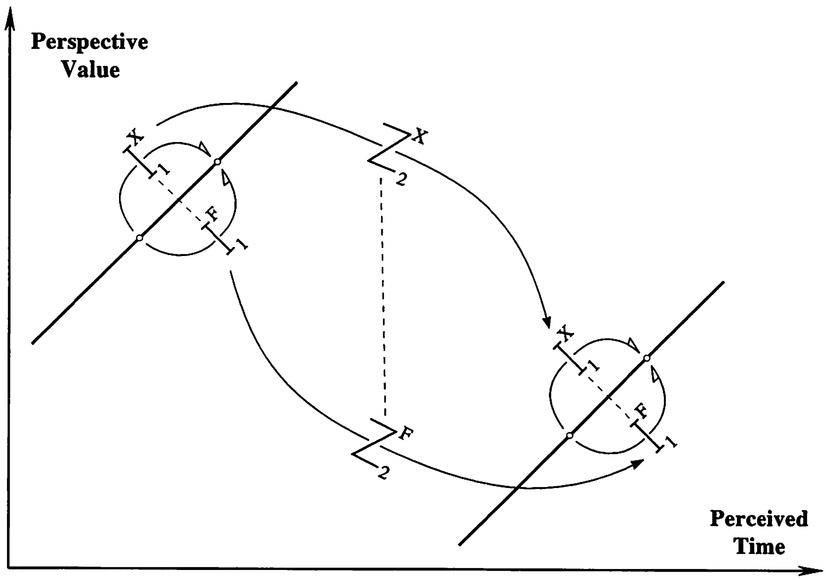


Figure 5.39 Representation of uniform secondary zygonic constants involving all invariants.

One protraction may display a pattern of regular change that differs consistently with that of another. The relationship perceived between them may constitute a uniform secondary constant (see figure 5.40). In this case, the interparticular relationships associated with a given interperspective value of fix in one protraction are related by a constant difference (–x) to those of similar perceived temporal disposition in another. One uniform secondary constant may be heard as existing in imitation of the other through the operation of a tertiary zygonic constant. See, for instance, figure 5.41 (and cf. figure 10.14).

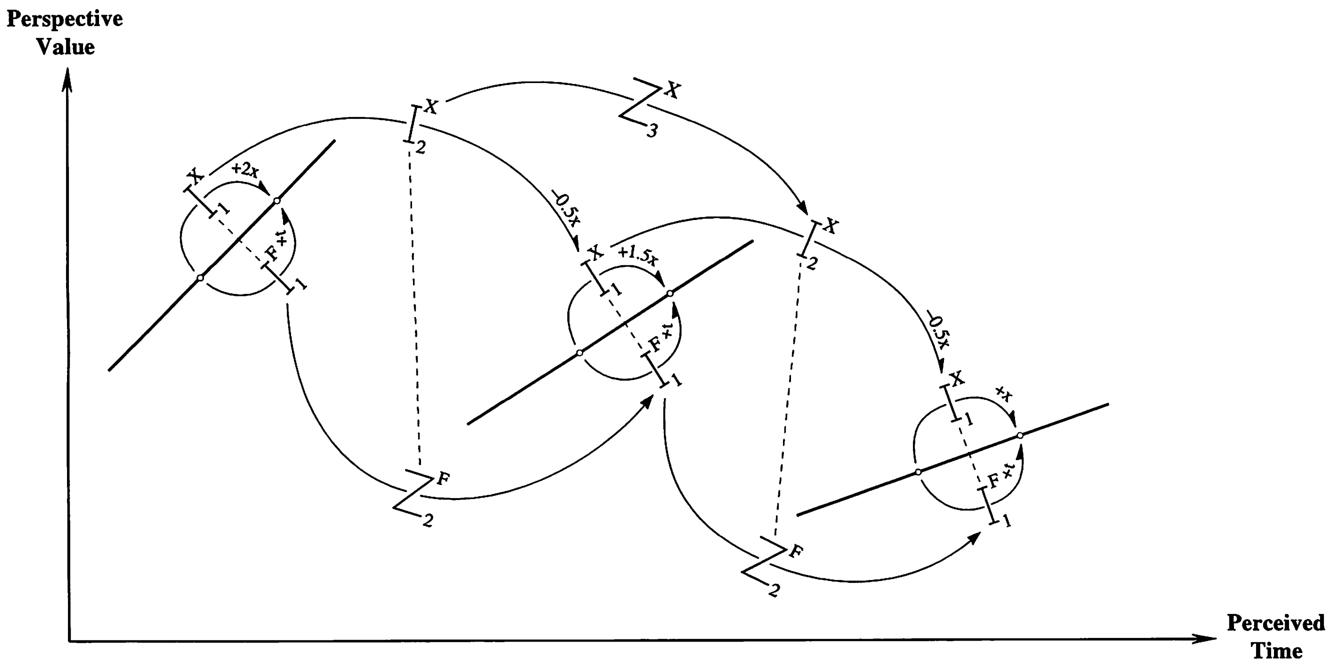


Figure 5.41 Tertiary zygonic constant ordering uniform secondary constants.

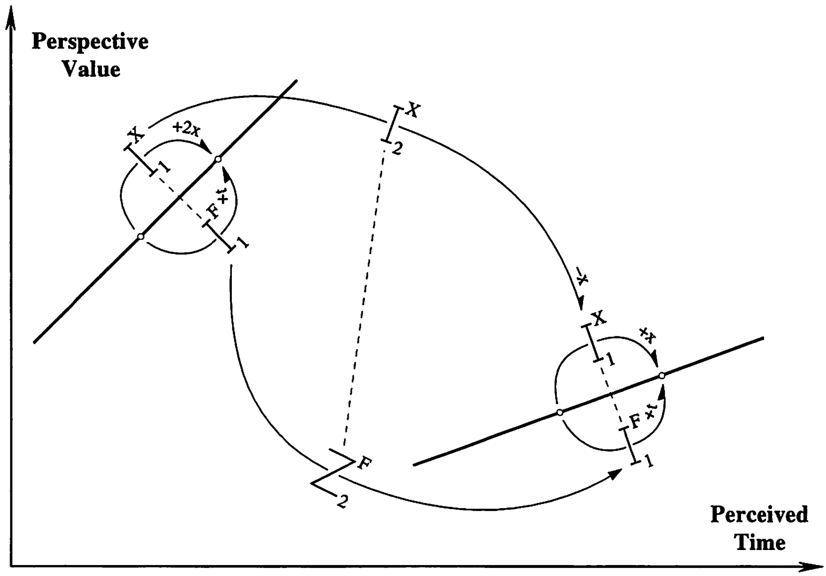


Figure 5.40 Uniform secondary constant.

Conclusion

This chapter has examined the organisation of 'protractions', which exist either as 'constants' or 'variables', by investigating the 'intraprotractive' and 'interprotractive' networks of relationships that potentially exist within and between them. These networks may form 'constants' or 'invariants'. Those identified above are summarised in the following charts (see figure 5.42), the first referring to constant protractions and the second to variables. A different horizontal level is reserved for each intraprotractive or interprotractive rank. The connecting lines mean "may be related by" (moving down the page), and "may relate" (moving up). Lines that move down to the left lead to networks of relationships that operate *within* groups—'systems'; those that move down to the right locate interperspective connections that function *between* groups. Both charts show only a small portion of what are extensive families of relationships.

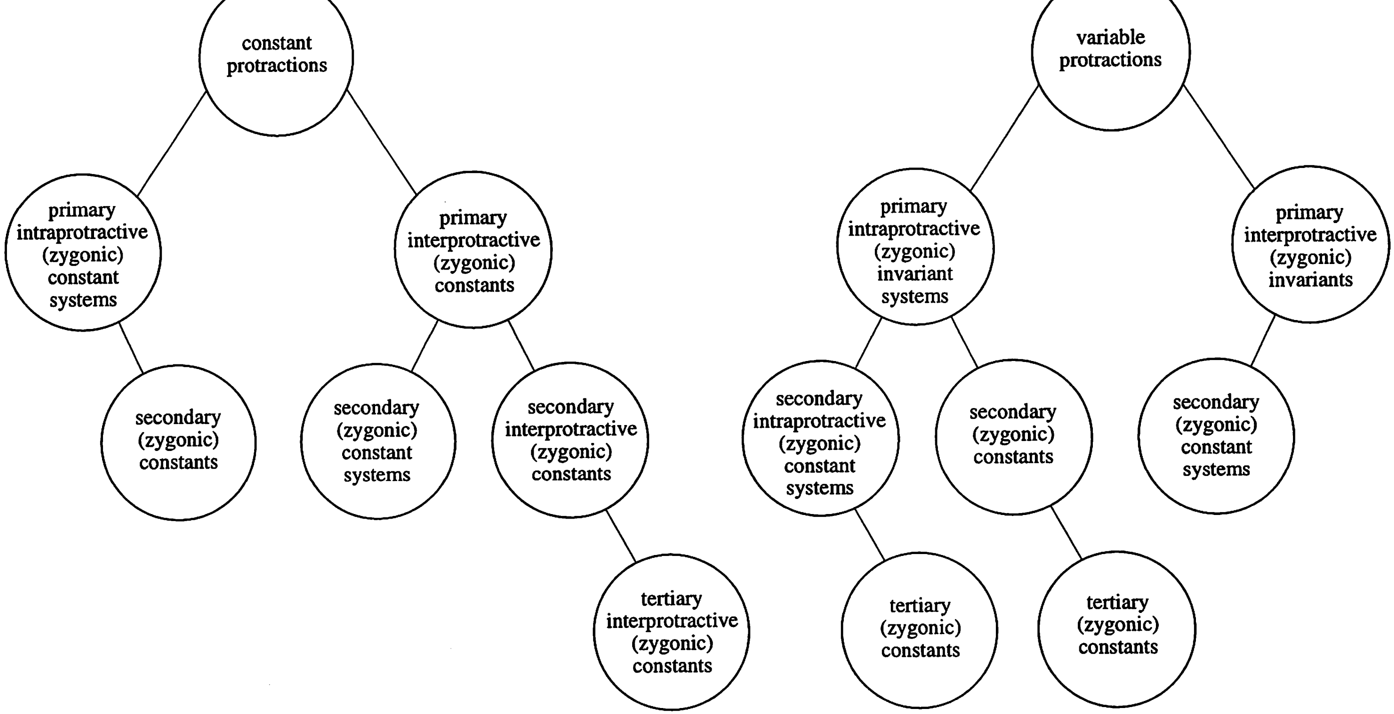


Figure 5.42 Some of the constants, constant systems, invariants and invariant systems of lower ranks that may be perceived operating within and between constant and variable protractions.

6

Associations, and their ordering

Introduction

This chapter examines the principles underlying the ordering that occurs within and between groups of elements. The section that follows offers some preliminary definitions.

Complements, configurations, associations and continua

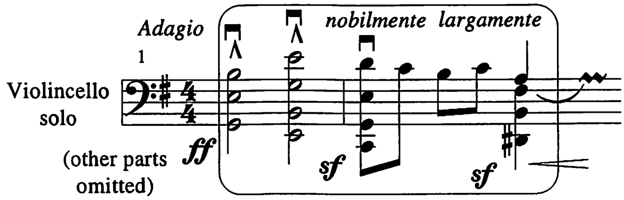
Two or more elements together constitute what may be termed a **complement.**[1] While there are no theoretical constraints on how elements may be grouped, in practice, music divides itself more naturally into some complements than others. Listeners' preferred groupings, and the cognitive mechanisms that determine them, are a concern of *Gestalt* psychology, discussed later in this chapter (see pp. 224ff).

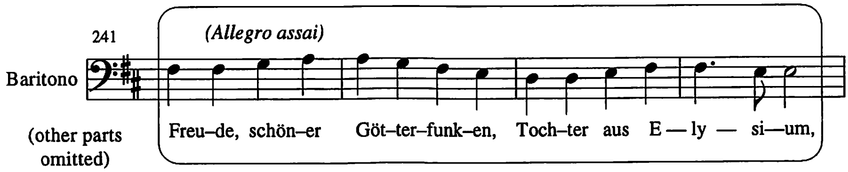
The members of a complement (unlike those of an element) may occur in any perceived temporal combination, ranging from simultaneity to isolation, which may involve the interposition of other material. Diagrammatically, the boundaries of a complement are shown with a continuous line. See, for example, figure 6.1.

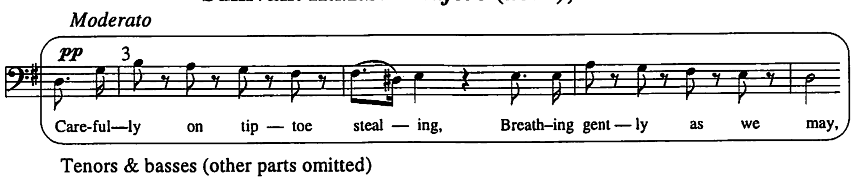
In certain cases, even a single element may be perceived as a complement; for example, if it is:

[1]Related terms: 'complementary', 'intracomplementary', 'intercomplementary', *etc.*

Elgar: 'Cello Concerto, Op. 85; 1st Movement



Beethoven: Symphony No. 9, Op. 125; 4th Movement

Sullivan: *H.M.S. Pinafore* (1878); No. 18



Chopin: Étude, Op. 25, No. 1

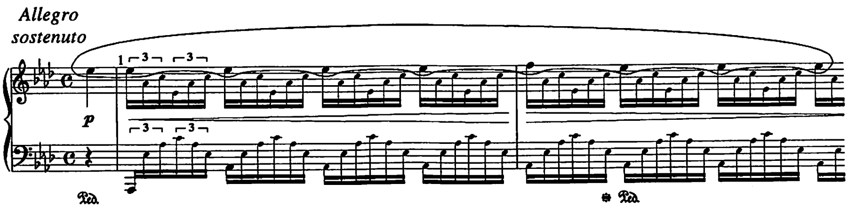


Figure 6.1 Examples of complements involving simultaneity, contiguity, isolation, and the interposition of other material.

Bach: Mass in *B* minor (BWV 232); *Symbolum Nicenum*, No. 3

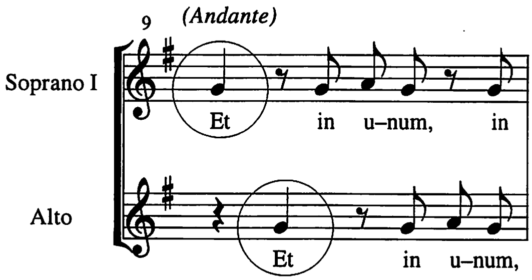


Figure 6.2 Single elements perceived as complements.

Beethoven: Piano Sonata, Op. 31, No. 3

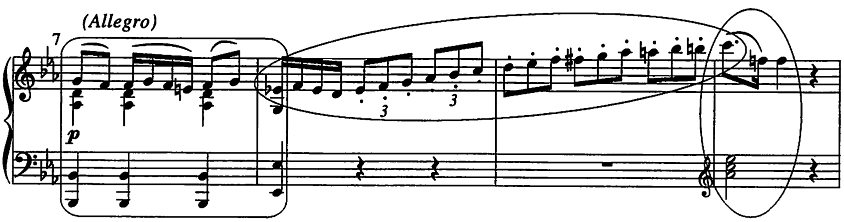


Figure 6.3 Single elements featuring in two complements.

Morley: Ballett, *My Bonny Lass* (1598)

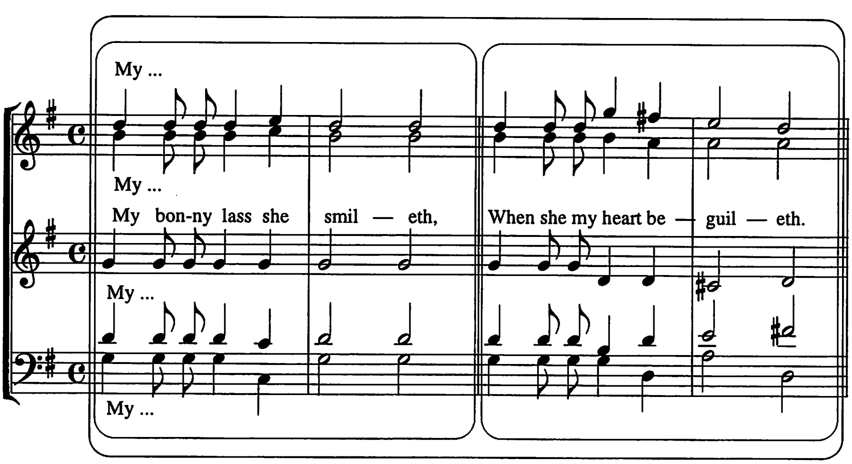


Figure 6.4 Two complements contained within another.

> strongly isolated from ... adjacent events, or if it for some reason functions motivically all by itself. (Lerdahl and Jackendoff, 1983, p. 43)

See, for instance, figure 6.2. At the other extreme, a complement may comprise a complete cycle of pieces. One element may feature in a plurality of complements, which may therefore overlap or 'intersect'. See figure 6.3. Equally, one complement may be contained within another—as, for example, in figure 6.4.

The individual perspective strands that make up a complement may each be termed an **association**,[2] and the combined contribution of pitch and the temporal perspects, a **configuration**.[3] Both are defined in diagrams with an encircling line. See, for instance, figures 6.5 and 6.6.

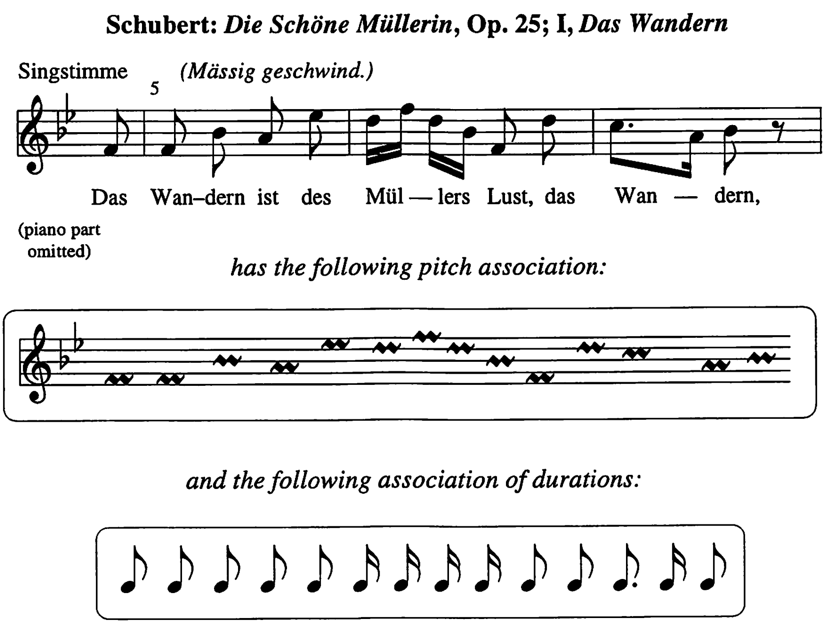



Figure 6.5 Associations of pitch and duration.

[2]Related terms: 'associative', 'intrasociative', 'intersociative', *etc.*
[3]Related terms: 'configurative', 'intrafigurative', 'interfigurative', *etc.*

In abstract terms, an association may be represented as follows:

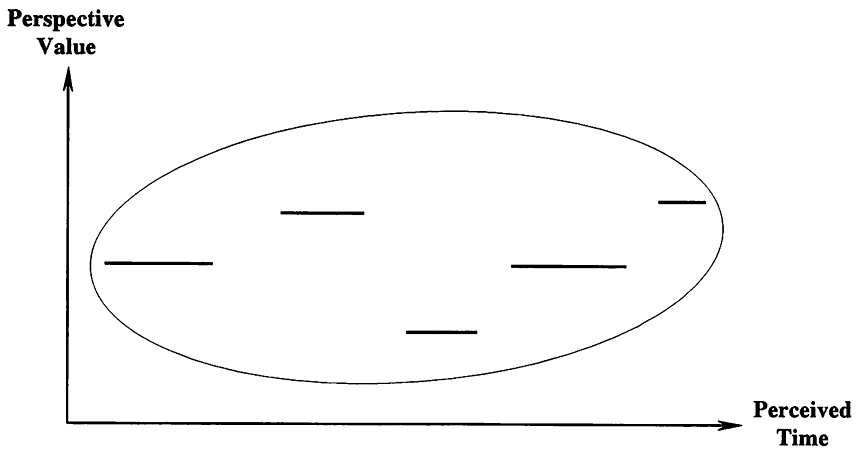


Figure 6.6 Representation of an abstract association.

Discrete units in one perspective domain may be combined with continuous change in another. For example:

Mahler: ***Kindertotenlieder*** **(1901–1904); 1.** ***Nun will die Sonn' so hell aufgeh'n!***

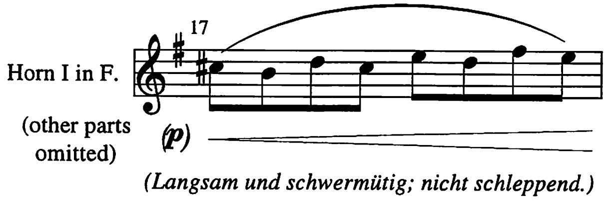



Figure 6.7 The combination of discrete and continuous perspective change.

Here, loudness forms a **continuum**,[4] which may be defined as a period of indivisible perspective constancy or change. Hence there is no necessary distinction between a continuum and a variable protraction; both function in the same way as far as the present theory of musical order is concerned. The choice of label on a given occasion is purely a matter of analytical propriety.

[4]Related terms: 'continuous', 'intracontinuous', 'intercontinuous', *etc.*

The perspects of complements, configurations, associations and continua

Certain perspects pertain to complements, configurations, associations and continua as a whole: prefix, suffix and duration, for example.[5] Other attributes include the **number** of elements or protractions featured, and the **range** over which they operate. For instance:

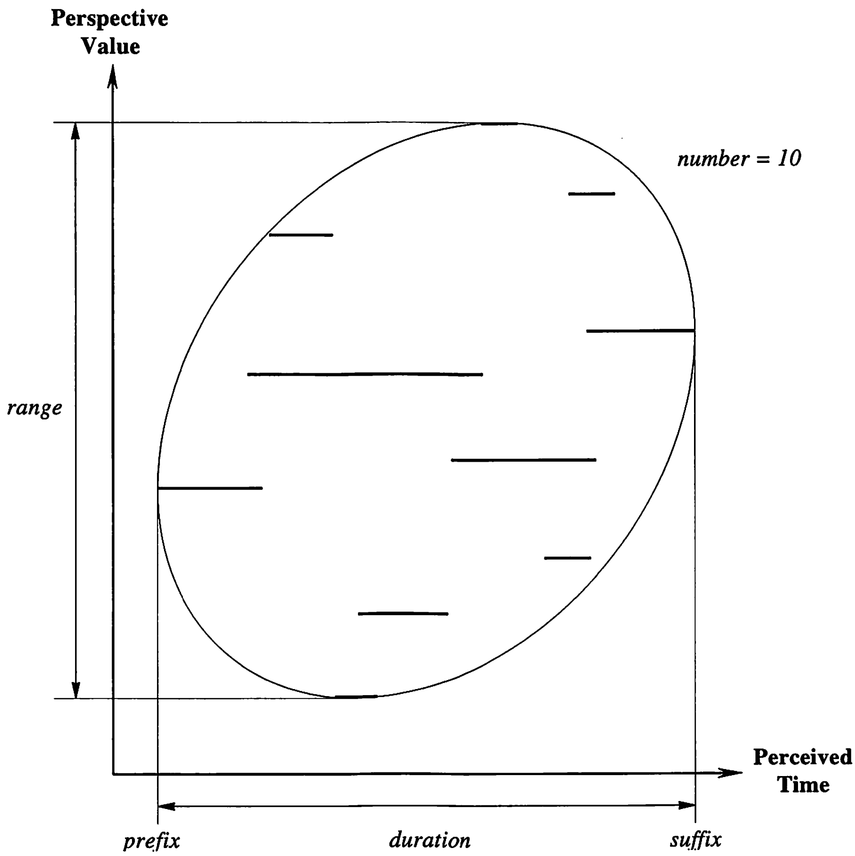


Figure 6.8 Perspects of an association.

[5]Where it is necessary to avoid ambiguity, these and subsequent perspects may be prefaced with the term 'complement', 'configuration', 'association' or 'continuum' (abbreviated to 'Cm', 'Cf', 'A' and 'Ct' respectively in the depiction of relationships).

The frequency of occurrence of values within an association may be considered as a perspect. The 'weighted scale' used by ethnomusicologists, in which the number of appearances of a pitch is represented by a duration (as in Malm, 1977, p. 6), is an extension of this principle.

Different appearances of the perspects described here may be linked through interperspective relationships. See, for instance, figures 6.9 and 6.10. Such relationships may be zygonic if ordering through imitation is reckoned to be present. See figures 6.11 and 6.12.

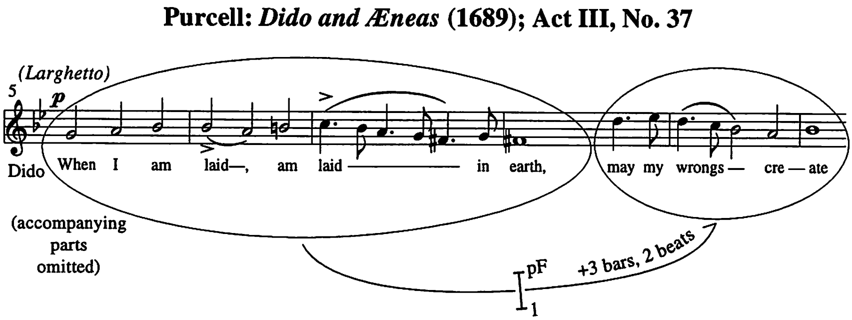


Figure 6.9 Relationship of complement prefix.

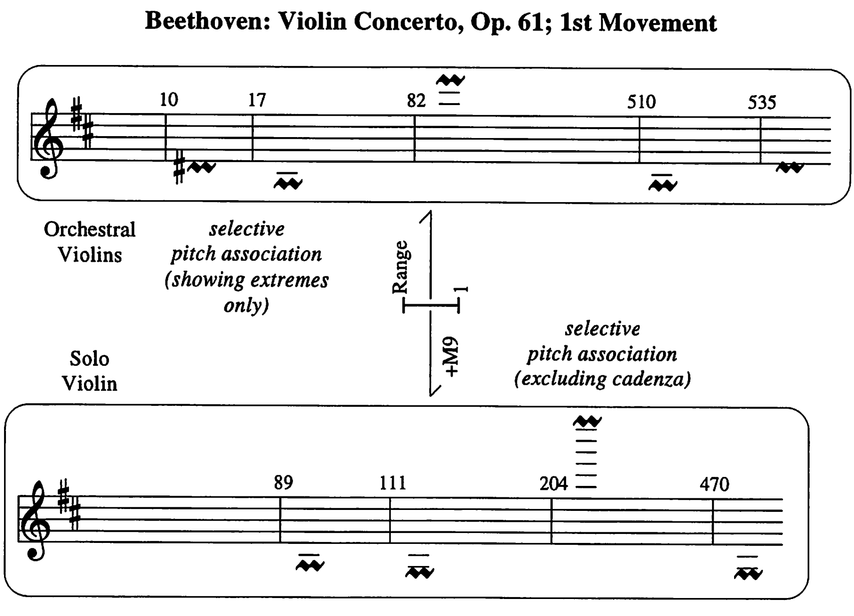


Figure 6.10 Relationship of pitch range.

Mozart: Symphony No. 41, K. 551; 4th Movement

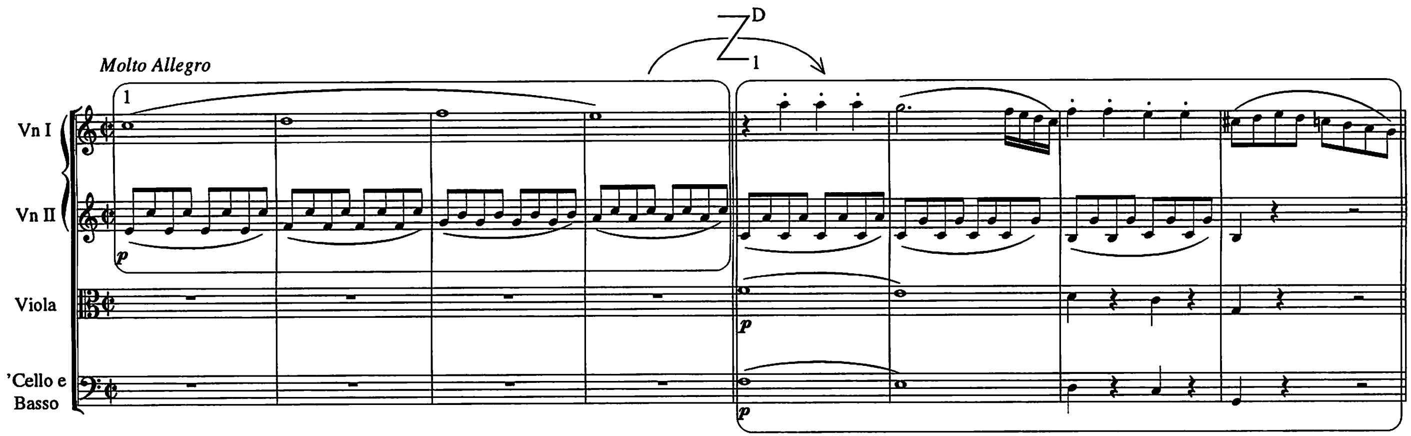


Figure 6.11 Canon of complement duration.

Beethoven, Piano Sonata, Op. 49, No.2; 2nd Movement

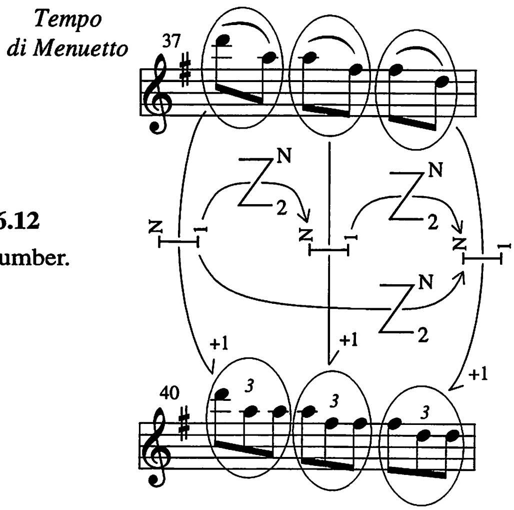


Figure 6.12
Canon of number.

Implied perspects; sequence

Each appearance of a perspect within a complement, configuration or association, whether as a single value or as a protraction, has qualities that reflect its standing relative to the other elements or protractions. Such attributes are said to be **implied**. For example, the number which each perspective appearance may be ascribed indicating its position relative to the other members of the association, is a type of implied perspect (see figure 6.13). There is no ambiguity as to the comparative position of values and constants. In the case of variables, however, the situation is considerably more complex. It can be difficult to assign a relative standing even to protractions displaying uniform change, as will become apparent.

The ordinal numbers pertaining to the fixes of elements register the sequence in which they occur. Although, generally speaking

> music-syntactical systems create references for only *order of initiation* and *sonority content* at any given time (Boretz, 1970, p. 105)

(a division corresponding to the distinction between 'melody' and 'harmony'), since the fixes of elements form variables, types of overlapping may result

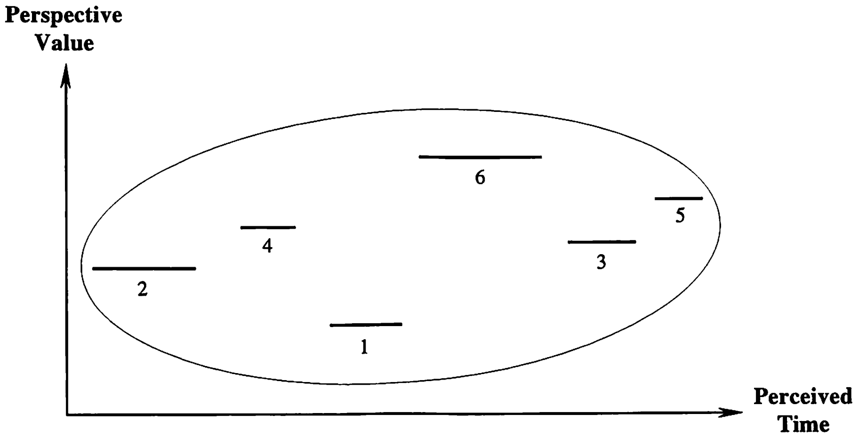


Figure 6.13 Ordinal numbers indicating the relative standing of perspective appearances within an association.

that muddy the issues of precedence and succession. Work in the field of multiple serialism has sought to define the position more precisely. Babbitt (1962, pp. 52 and 53), for example, identifies eleven discrete states in which one duration can exist in temporal relation to another. In this, however, he fails to differentiate between elements that succeed each other directly (without a perceived break in sound) and those that partially coincide. This omission is made good by Boretz (ibid.), who catalogues the full thirteen arrangements that are possible. These are illustrated in figure 6.14 with suggested designations.

Isolation is the state in which one element ends before another begins. With **contiguity**, elements follow each other directly, with neither cessation of perceived sound nor overlapping. **Imbrication** exists where one element overlaps another.[6] The situation in which one element surrounds another is termed **enclosure.** Two elements that begin together but end at different times are sequentially related through **prefixture**. Conversely, with **suffixal**, elements are initiated separately, but terminate at the same time. These states are reversible, yielding two potential modes of existence in each case. The perceived temporal symmetry of **simultaneity**, however (which is only available only to elements of identical duration) leaves sequence unaffected by the exchange of values.

[6]Rahn (1983, p. 59) includes a state termed 'tangential' between contiguity and imbrication. This is merely the shortest form of imbrication, however.

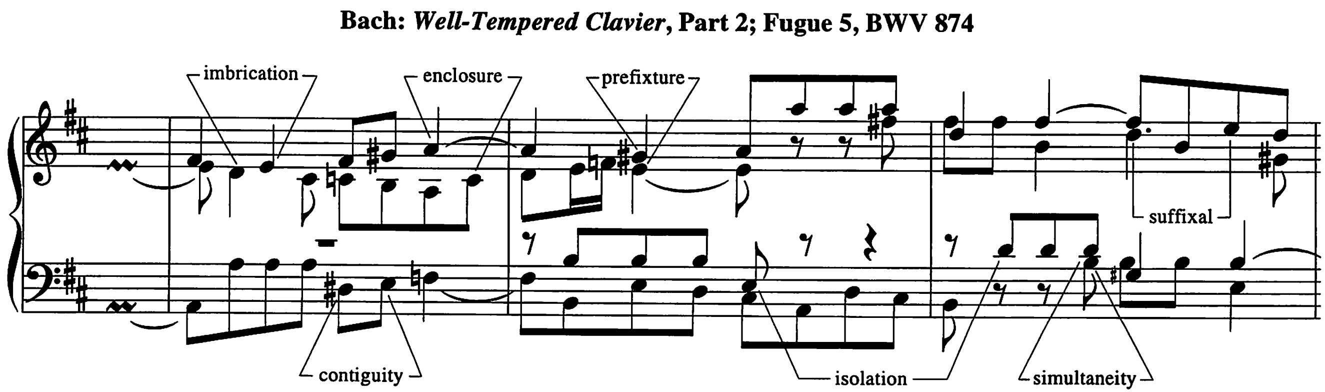


Figure 6.14 The sequential possibilities of two elements.

Chords

Groups of simultaneous elements are said to form **chords**.[7] These are a type of complement. A fundamental property of chords is the number of elements they comprise, a perspect sometimes referred to as **density** in the music-theoretical literature (see, for example, Yeston, 1976, p. 47). Berry (1976/1987, p. 184) concurs with this definition, but believes that density should also be used to mean

> the degree of "compression" of events within a given intervallic space.

In traditional parlance, chordal pitch density is known as 'spacing', which may be 'open' or 'close'.

Within chords, protractions other than those of fix may be assigned ordinal numbers according to their relative values. As Boretz (1970, p. 83) states:

> the components of a "single attack" might be regarded as an *ordered succession* in some other dimension than time, and hence as a "musical structure". Such order relations might be determined by registral, dynamic, or timbral characteristics.

Pitch is the perspect most commonly ascribed an ordinal number. See, for example, figure 6.15.

Perspects like these require that the elements comprising chords be heard separately, even if the results are subsequently integrated at a higher cognitive level. This approach does not reflect the way that chords tend to be heard, though: typically, their constituent elements are perceptually fused. The critical issue seems to be

> whether and how two events may be superimposed and retain their identities intact, or whether and under what conditions they form a new whole which is perceived as an integrated event. (Serafine, 1983, p. 170)

However, there is no hard-and-fast rule for determining whether a chord will be experienced as one thing or more than one; so much depends on its

[7]In fact, musicians often use the term just to refer to an assemblage of simultaneous pitches. Hence the same 'chord' (vertical group of pitches) may be played a second time shorter or louder than the first, or with a different timbre.

Rimsky-Korsakov: *Christmas Eve* (1894–1895); Scene 6, *Prelude*

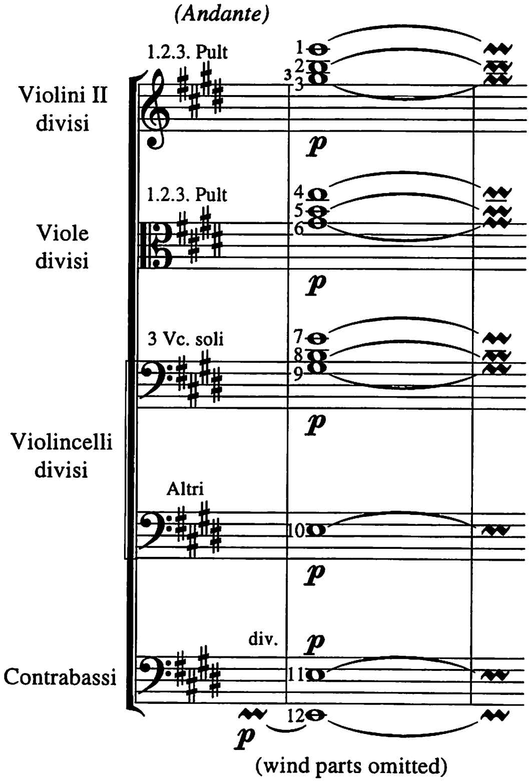


Figure 6.15 The ascription of ordinal numbers to the pitches in a chord.

musical context (see, for example, Bregman and Pinker, 1978); on the manner of performance, since, as Rasch (1978) has shown,

> if enough temporal differentiation is present in the stimulus ... [the] primary characteristics of the notes [pitch, loudness and timbre] are rather well preserved in perception (p. 33);

and on the disposition of the listener, whose concentration may even vacillate between the two modes of perception. All that one can say for sure is that certain combinations of elements, in particular conditions, are more inclined to merge than others.

If such a conflation does occur, the perceived properties of a chord differ from those that would otherwise have existed. For instance, the perception of two or more separate values of loudness is supplanted by one general effect which may be termed (in full) **chordal loudness**. Similarly, the place of individual timbres is taken by one **chordal timbre**. In fact, as Erickson (1975, p. 20) shows, there is no necessary distinction between a pitch with timbre and a chord, for by listening attentively, it is possible to hear any of the lower harmonics that may be present in a single sound. Conversely, it is conceivable, through the ascription of appropriate pitches and dynamic levels, for separate tones to coalesce into one note rich in harmonics (op. cit., pp. 31–33).

The effects of the pitches in a chord may combine, giving the impression of **harmony**. This may be perceived absolutely or in relative terms. Although the term 'harmony' tends to be associated only with a limited group of chords (a few well-worn diatonic and chromatic combinations), this restriction does not apply in the present work. Here, 'harmony' refers to the integrated pitch effect obtaining to any set of simultaneous perceived sounds.

An interperspective relationship may link two appearances of any of these perspects. Such a relationship may be zygonic, and result in a canon. For example:

Ives: First Sonata (1902–1909); 5th Movement

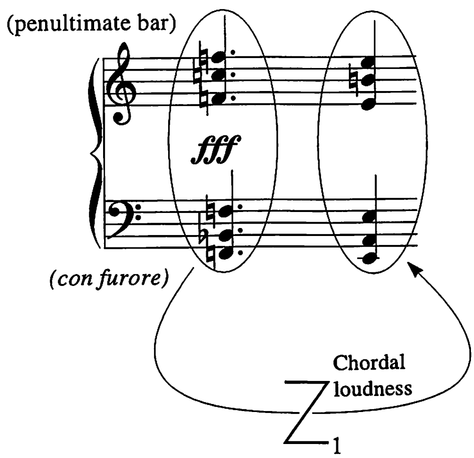


Figure 6.16 Canon of chordal loudness.

Constant associations i; primary intrasociative constant systems

This section and those that follow examine the groups of interprotractive relationships that potentially exist within and between associations. First we investigate associations whose members—whether single values, constants or variables—are all the same. Each may be termed a **constant association**. Observe that the uniformity of such associations, unlike that of constant protractions, does not necessarily exist as a function of time: chords, for example, can form constant associations of timbre.

Where it is perceived that members of a constant assocation owe their similarity to imitation, the operation of a **primary intrasociative zygonic constant system** is implied, which may comprise zygons, zygonic constants or zygonic invariants. A primary intrasociative zygonic constant system of zygons may be symbolised as follows (cf. figures 9.32 and 9.85):

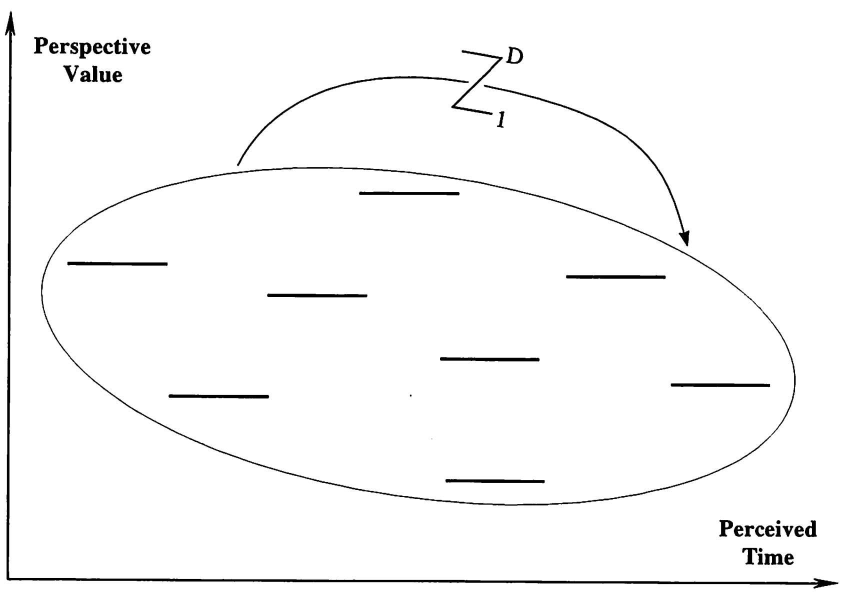


Figure 6.17 Primary intrasociative zygonic constant system of zygons.

Symbolising primary intrasociative zygonic constant systems of zygonic constants is rather more complicated, however. Full representation requires two arrowheads, the first showing that it is interprotractive zygonic constants that are involved, and the second indicating that together they comprise an intrasociative zygonic constant system.

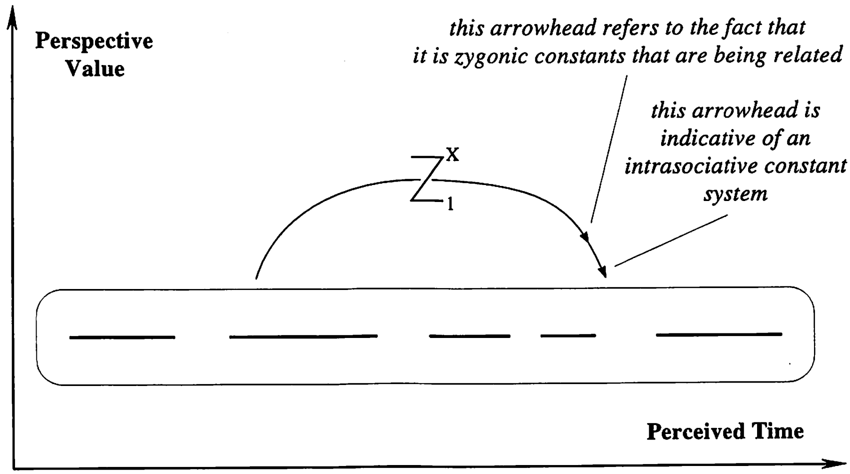


Figure 6.18 Primary intrasociative zygonic constant system of zygonic constants.

However, the arrowhead that indicates the presence of interprotractive zygonic constants may be omitted, provided that ambiguity does not arise:

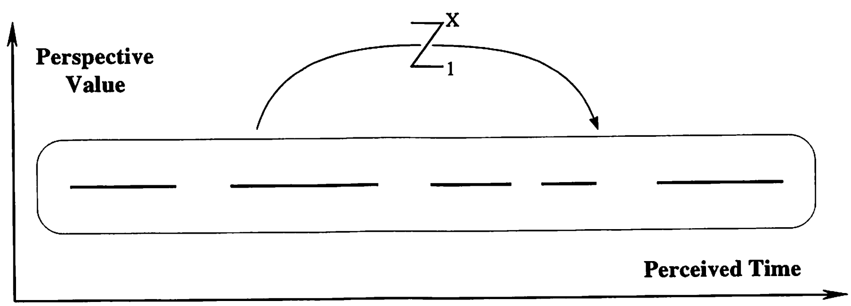


Figure 6.19 Simplified depiction of constant system of zygonic constants (cf. figure 10.122).

Illustrating primary intrasociative constant systems of zygonic invariants is potentially a complex matter too, and here perceptual processes will be modelled using a system of substitution, whereby a defined network of relationships can be represented by a single strand, characterised by a chosen letter. For example, if the primary interprotractive zygonic invariant in figure 6.20 is depicted as in figure 6.21, then a primary intrasociative constant system of zygonic invariants can be shown as in figure 6.22.

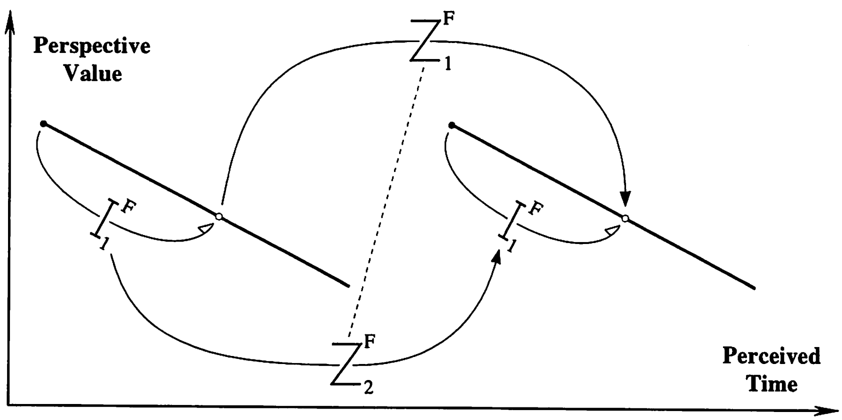


Figure 6.20 Primary interprotractive zygonic invariant.

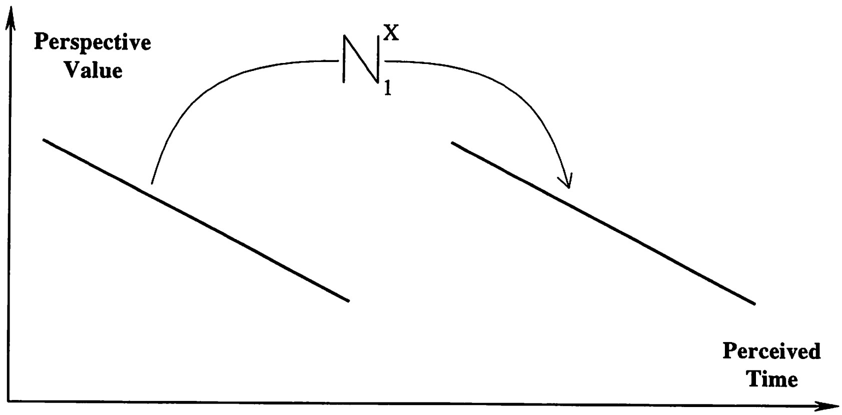


Figure 6.21 Simplified depiction of primary interprotractive zygonic invariant.

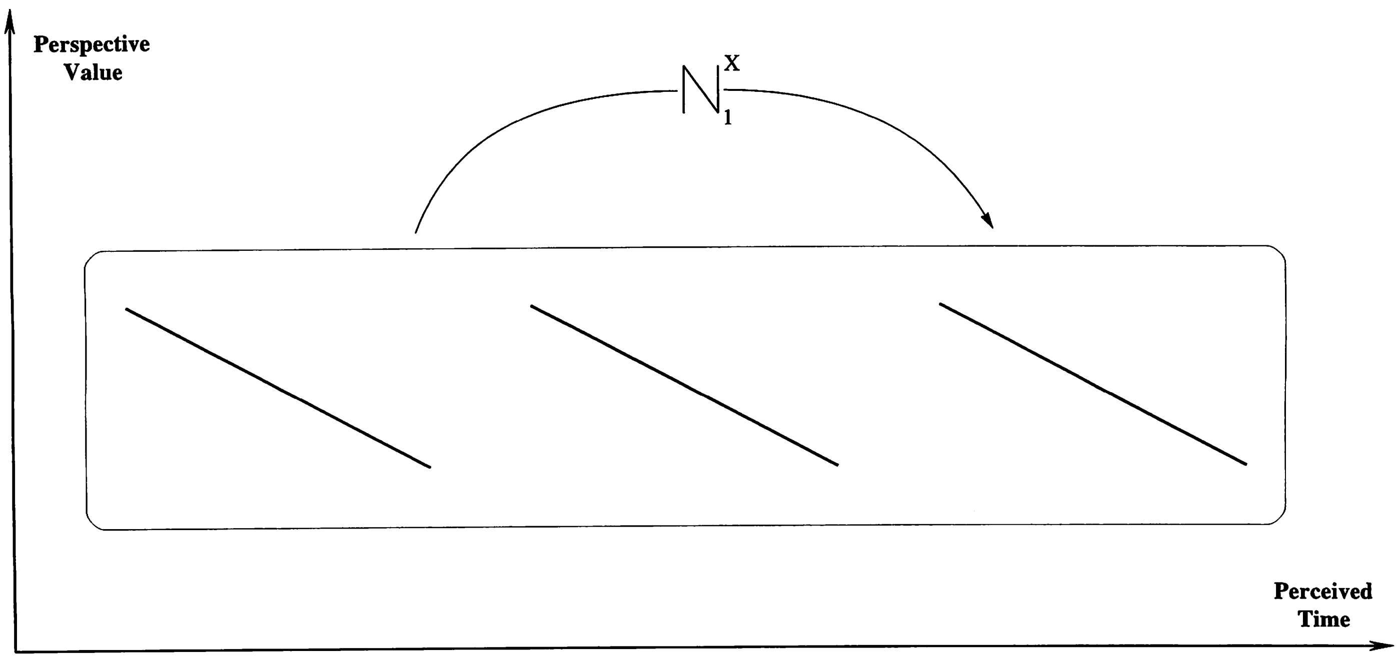


Figure 6.22 Symbolism of primary intrasociative constant system of zygonic invariants (cf. figure 10.129).

An ***imperfect* constant association** has members which differ slightly from one another. See, for example, figure 6.23. An imperfect constant association may be perceived to be ordered through the agency of a **primary intrasociative imperfect zygonic constant system** (figure 6.24).

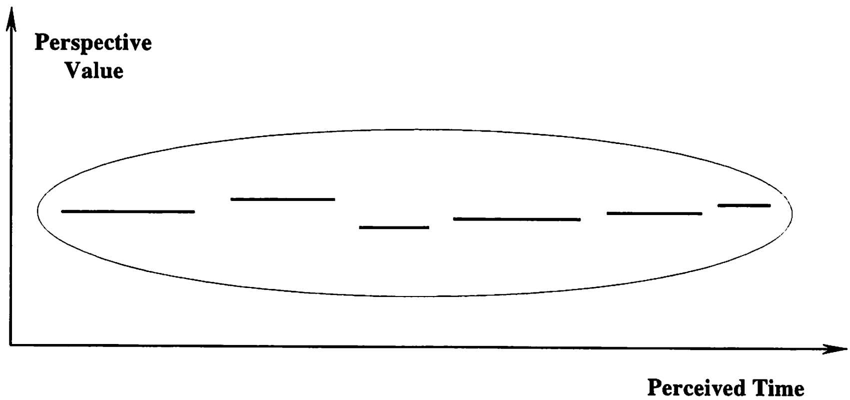


Figure 6.23 Imperfect constant association.

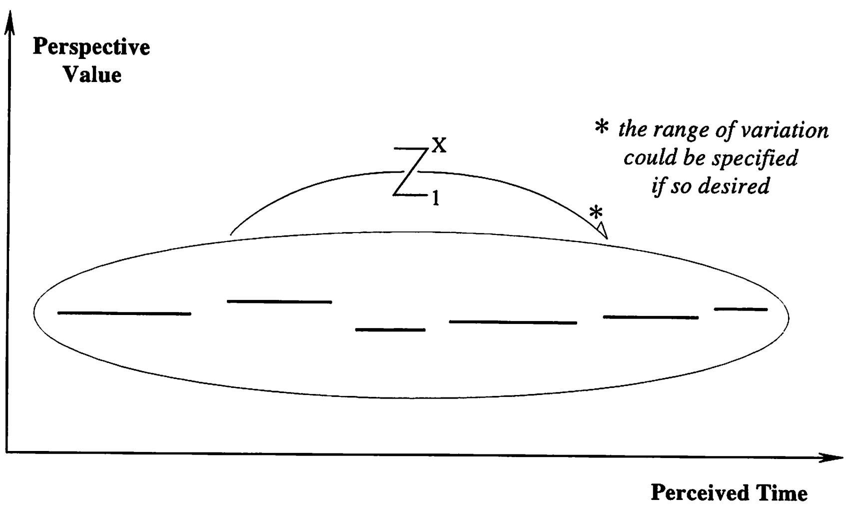


Figure 6.24 Primary intrasociative imperfect zygonic system (cf. figures 8.40 and 9.22).

In these examples it is assumed that the first member of each association acts as the model that is subsequently imitated. However, this need not be the case: any member of an association, irrespective of its relative perceived temporal location, may be felt to have the structural ascendancy necessary to be perceived as the source of zygonic ordering. For example:

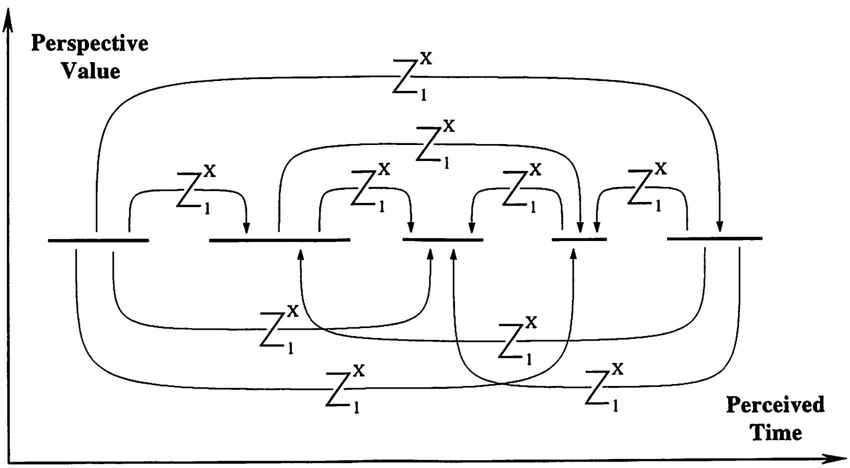


Figure 6.25 Primary zygonic constant system of mixed polarity.

Zygonic constants such as this may be symbolised thus (cf. figure 8.41):

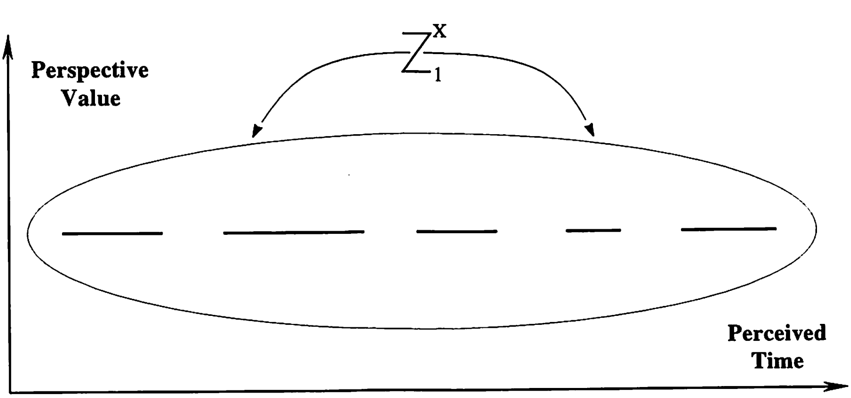


Figure 6.26 Symbolism of primary zygonic constant of mixed polarity.

Constant associations ii: intersociative constants; secondary constant systems linking intersociative constants; secondary constants relating intrasociative constant systems

Each member of one constant association may potentially be linked to each member of a second by the same primary interprotractive relationship:

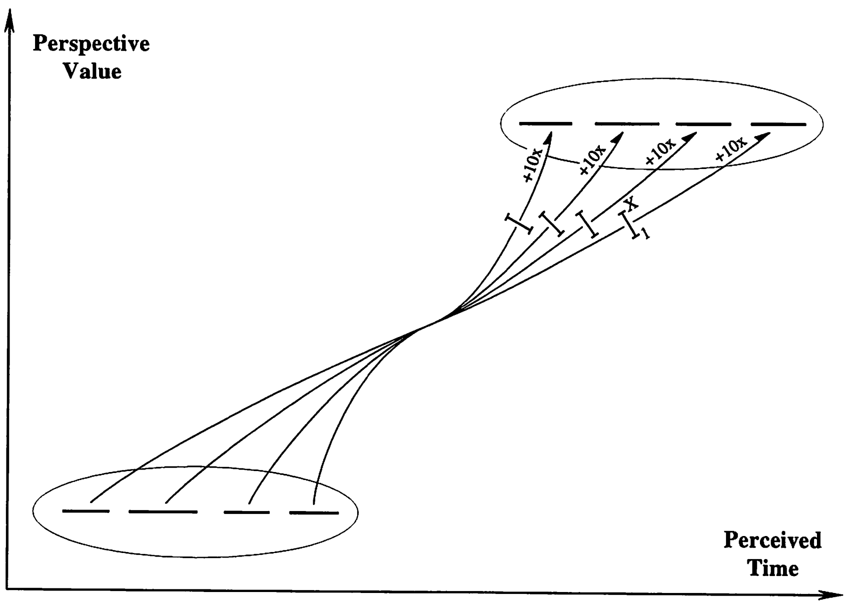


Figure 6.27 The network of relationships linking two constant associations.

This network may be termed a **primary intersociative constant**, whose symbolism reflects the nature of its component relationships (figure 6.28). Primary intersociative constants may be imperfect; see, for example, figure 6.29. Internal ordering through imitation may be deemed to occur through secondary zygonic constant systems. For example, figure 6.30 shows a secondary zygonic constant system operating mutually, between the durations of the elements that make up two chords (cf. figure 9.49).

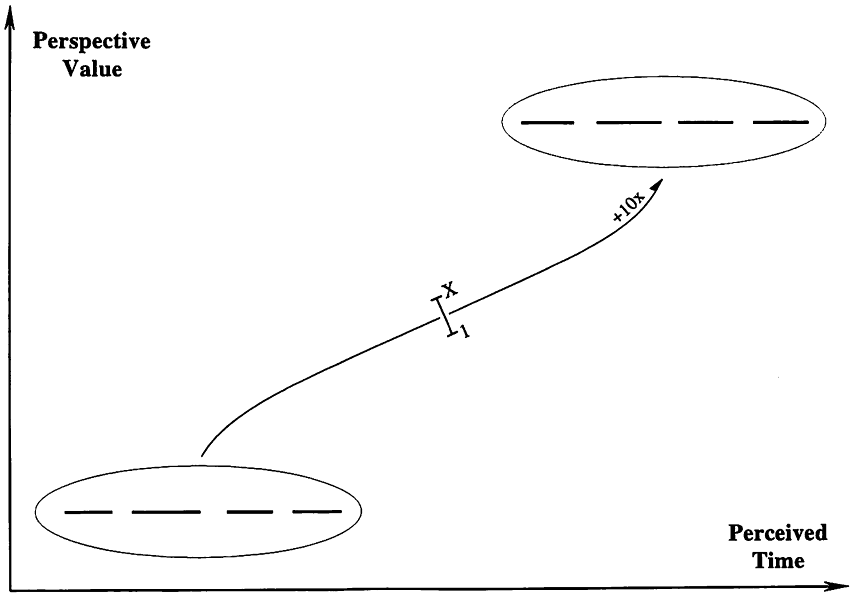


Figure 6.28 Primary intersociative constant of interprotractive constants.

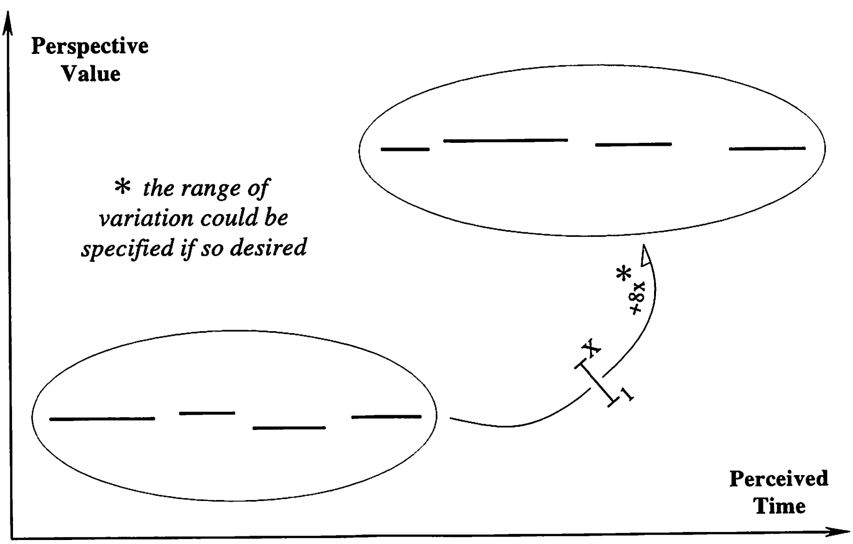


Figure 6.29 Primary intersociative imperfect constant.

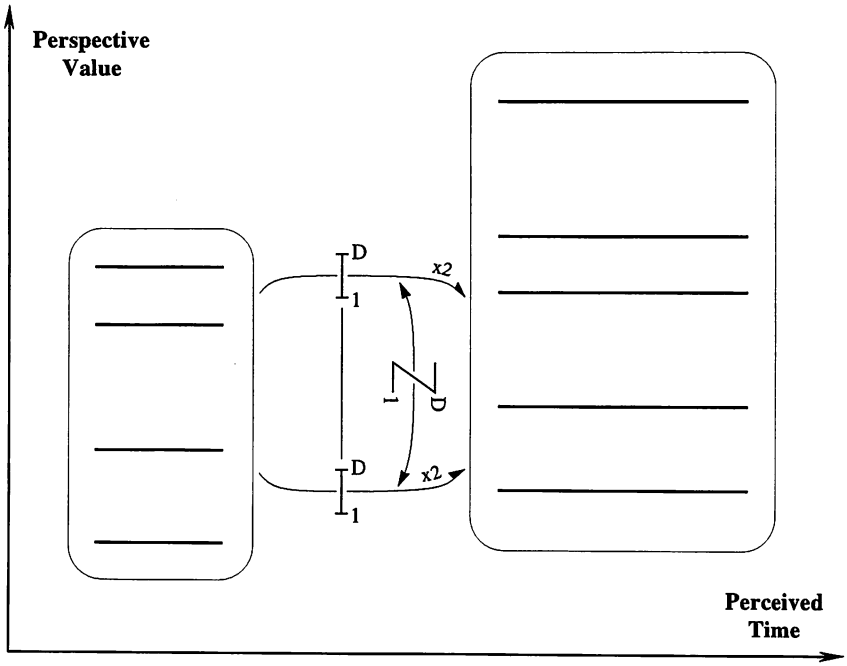


Figure 6.30 Secondary zygonic constant system governing primary intersociative constants.

One constant association may be perceived as existing in imitation of another the same, implying the operation of a **primary intersociative zygonic constant**. See, for instance, figure 6.31.

A primary zygonic constant may be imperfect if the constant associations it links differ slightly in a consistent way. In these circumstances, its component relationships will share the same imperfection, together constituting an imperfect primary zygonic constant (see figure 6.32).

If two constant associations both approximate to the same value, then the individual interprotractive relationships between them will differ in their imperfection, forming a primary imperfect zygonic constant (cf. p. 130)—see figure 6.33.

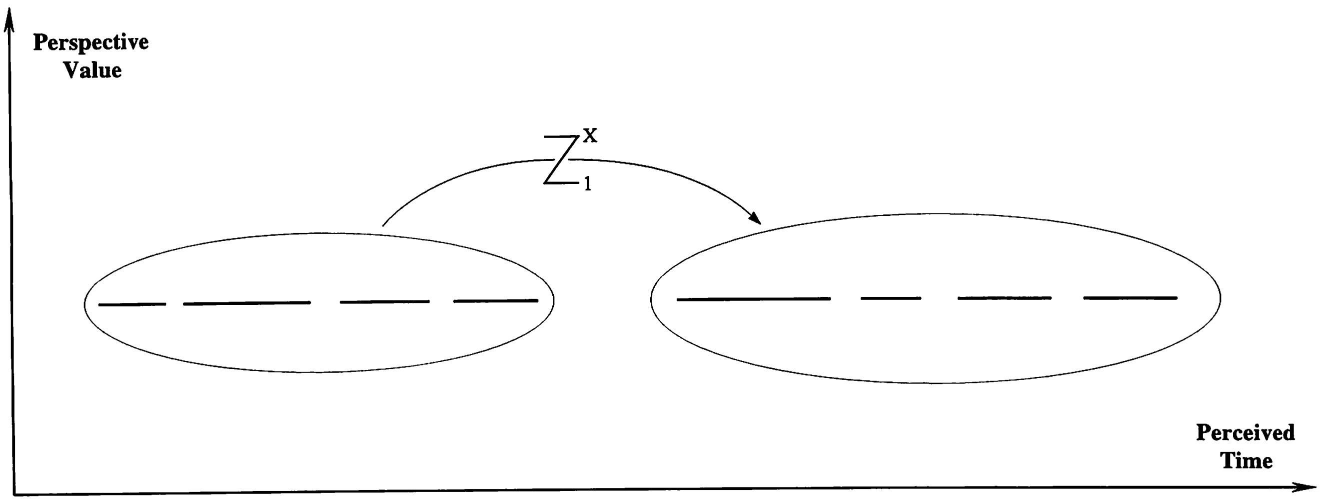


Figure 6.31 Primary intersociative zygonic constant (cf. figures 8.16, 8.33 and 10.54).

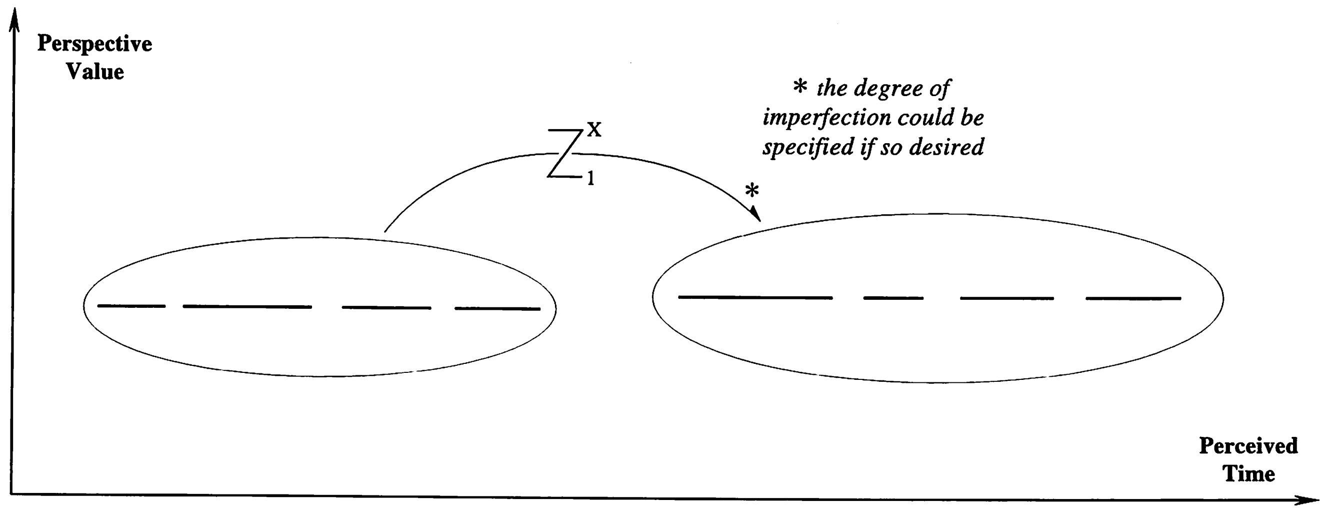


Figure 6.32 Imperfect primary intersociative zygonic constant (cf. figure 8.34).

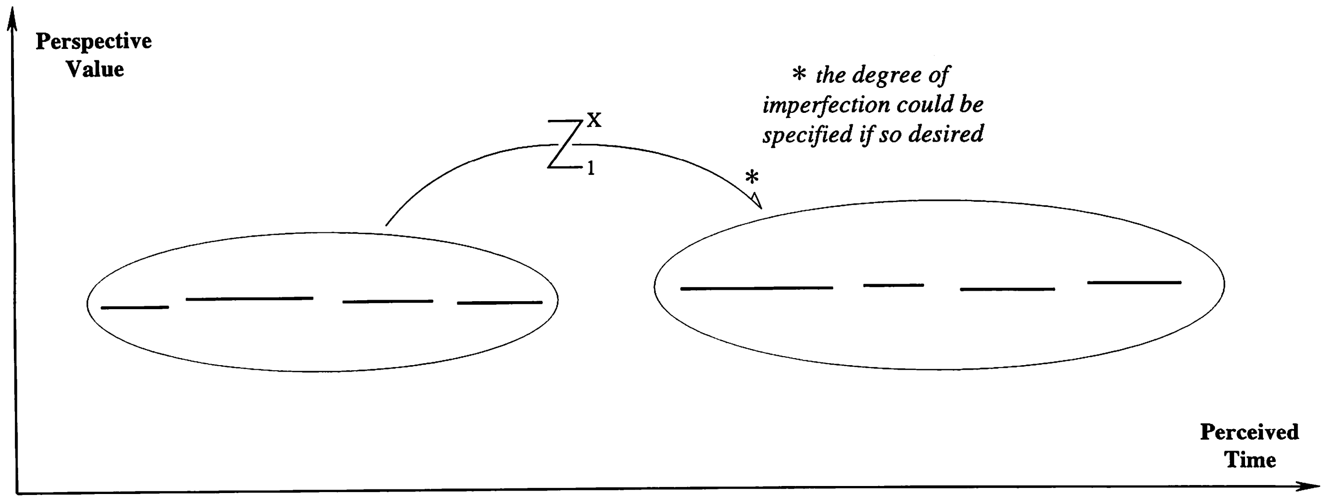


Figure 6.33 Primary intersociative imperfect zygonic constant (cf. figure 8.9).

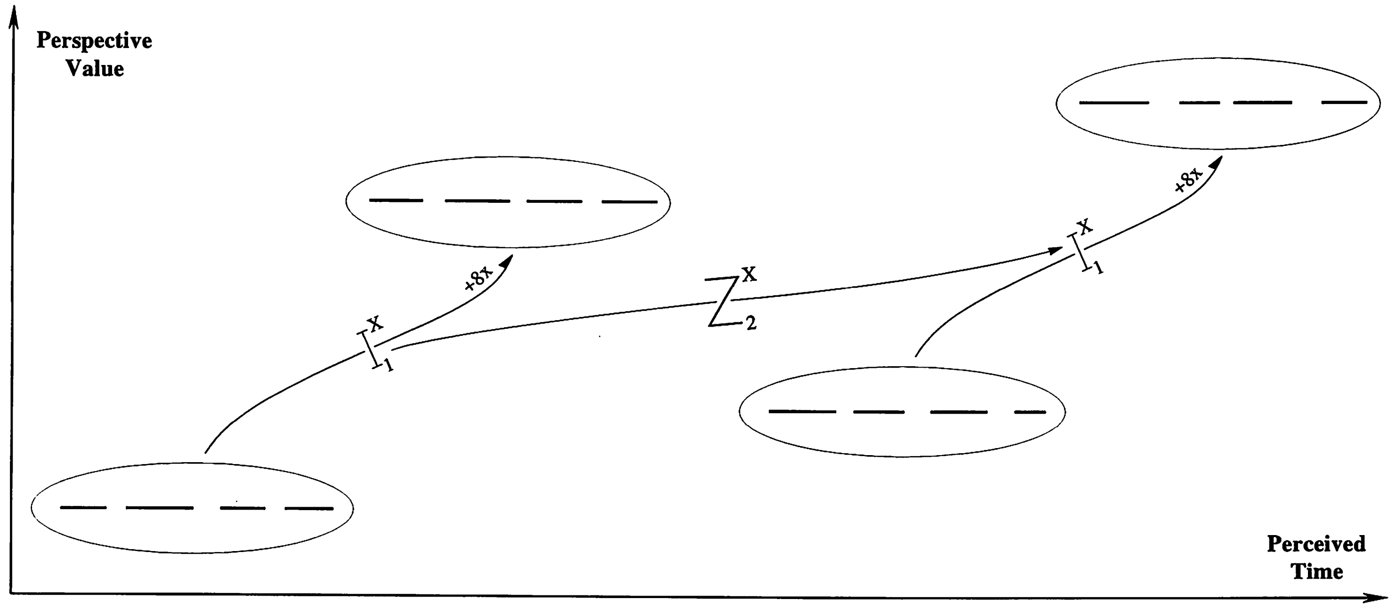


Figure 6.34 Secondary intersociative zygonic constant (cf. figure 8.35).

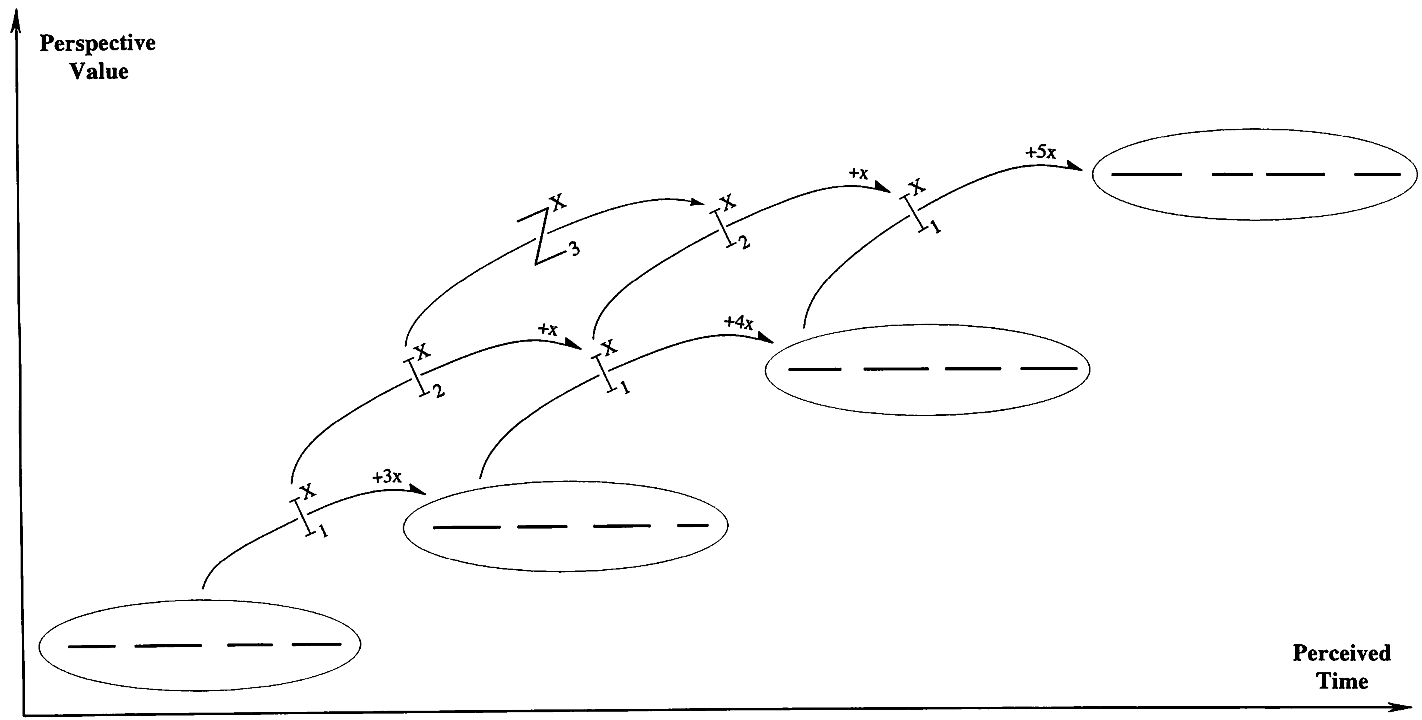


Figure 6.35 Tertiary zygonic constant (cf. figure 9.78).

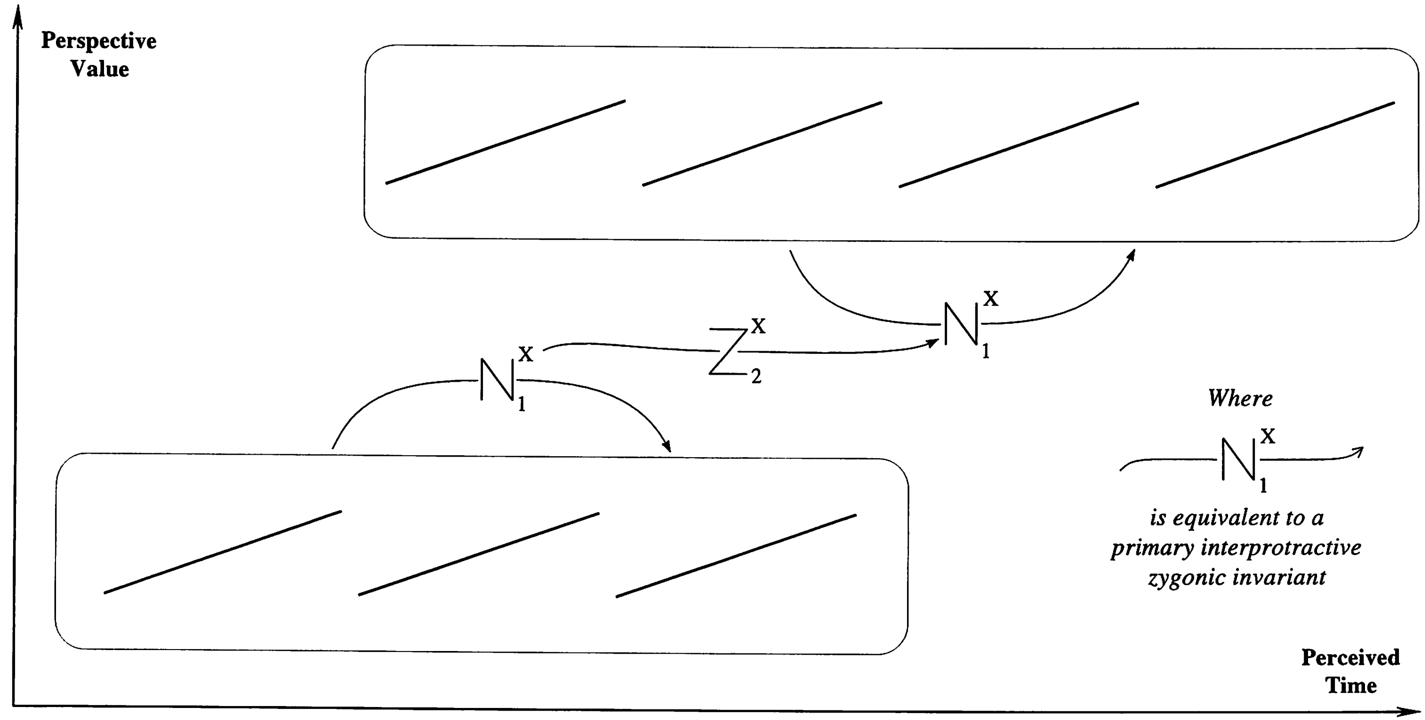


Figure 6.36 Secondary zygonic constant linking primary intrasociative constants (cf. figures 8.15 and 8.32).

Intersociative constants of higher ranks are feasible. These may be zygonic. Hence, two primary constants may be related through a **secondary constant** or a **secondary zygonic constant**, such as that illustrated in figure 6.34. A **tertiary zygonic constant** is shown in figure 6.35.

It may be felt that the uniformity of one constant association derives from the uniformity of a second. This interpretation implies a network of secondary zygonic relationships potentially ordering the members of one primary intrasociative constant system through the imitation of those pertaining to another. See, for example, figure 6.36.

Variable associations i: intrasociative invariant systems and constant systems

A group of perspective values, constants or variables which differ from one another quantitatively form a **variable association**. This section and the one that follows investigate the patterns of interprotractive relationships through which, according to the present theory, the perception of variable associations occurs.

We begin by examining variable associations whose members, considered sequentially, are separated by a common difference. See, for example, figure 6.37. This chain of relationships may be symbolised as shown in figure 6.38. Ordering through imitation may occur through the operation of a ***secondary zygosequential*** **zygonic constant system**,which controls a ***sequentially ordered*** **primary invariant system** (see figure 6.39). This may be symbolised in the following way—see figure 6.40 (cf. figures 10.26 and 10.49).

Invariant systems may comprise relationships equal in magnitude but of opposing polarities. See, for instance, figure 6.41. Systems of mixed polarity such as this may symbolised using the method shown in figure 6.42 (cf. figure 10.51). Where invariant systems exist between simultaneous protractions, sequentiality can be gauged with respect to the perspect of the interprotractive relationships concerned. To make it clear that sequence is not being judged in perceived temporal terms, the initial letter or letters of the perspect involved may be shown in brackets following the 's' or 'z' sequence signs. See, for example, figure 6.43 (cf. figure 10.107).

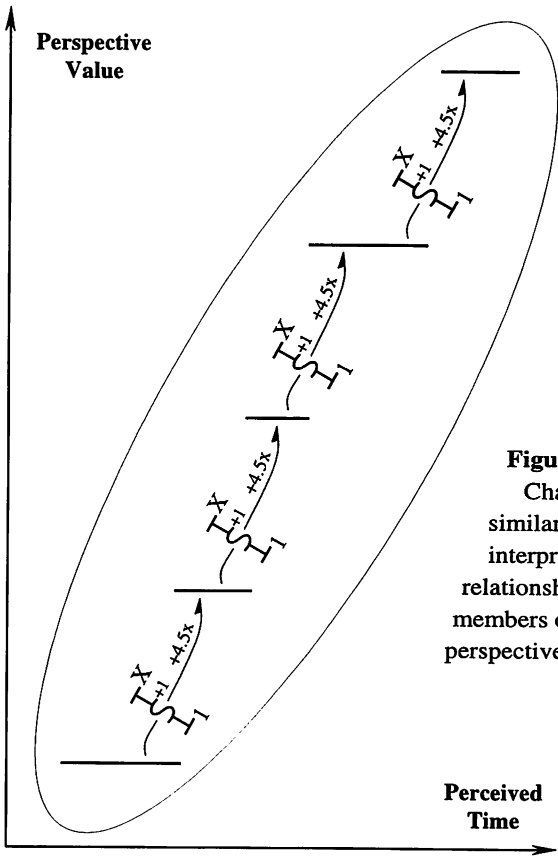


Figure 6.37
Chain of
similar primary
interprotractive
relationships linking
members of a variable
perspective association.

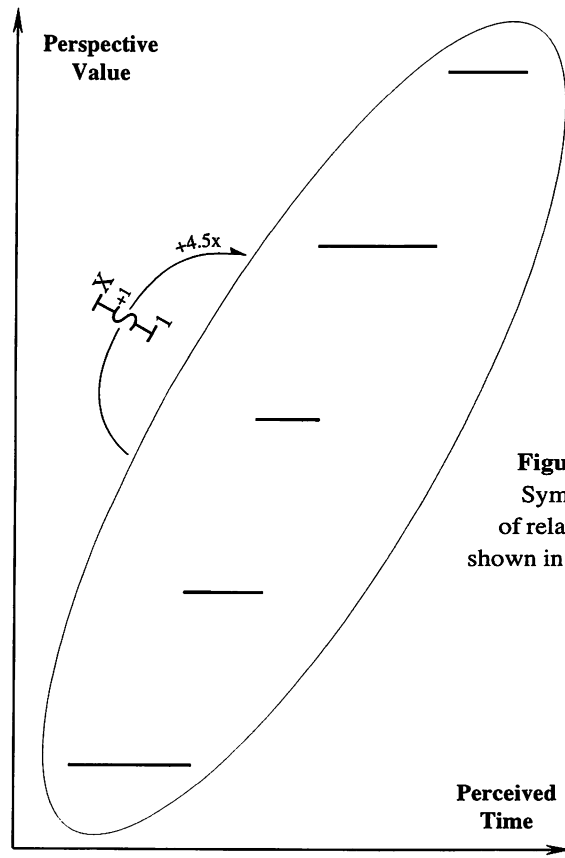


Figure 6.38
Symbolism
of relationships
shown in figure 6.38.

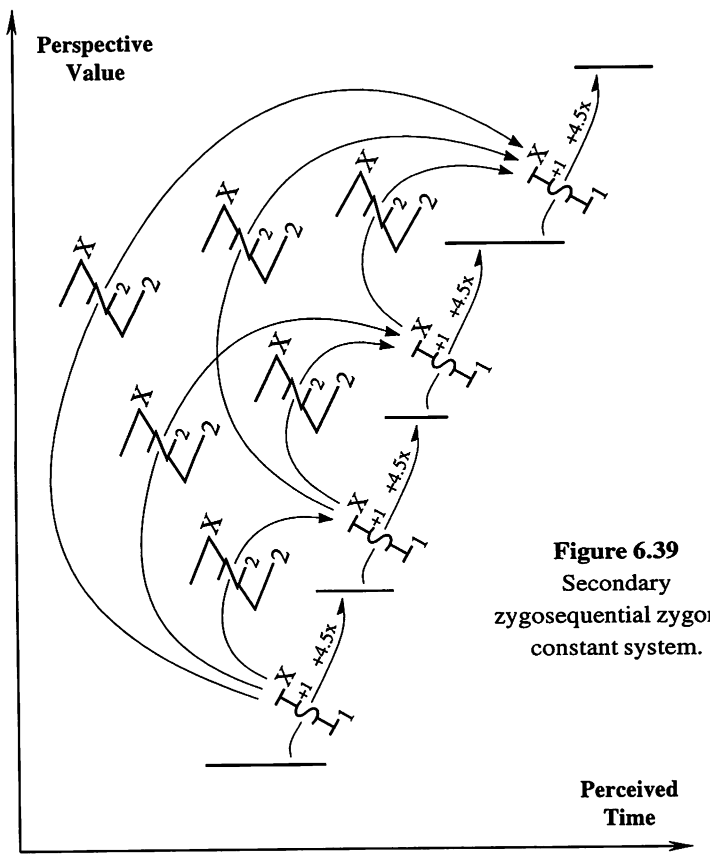


Figure 6.39
Secondary
zygosequential zygonic
constant system.

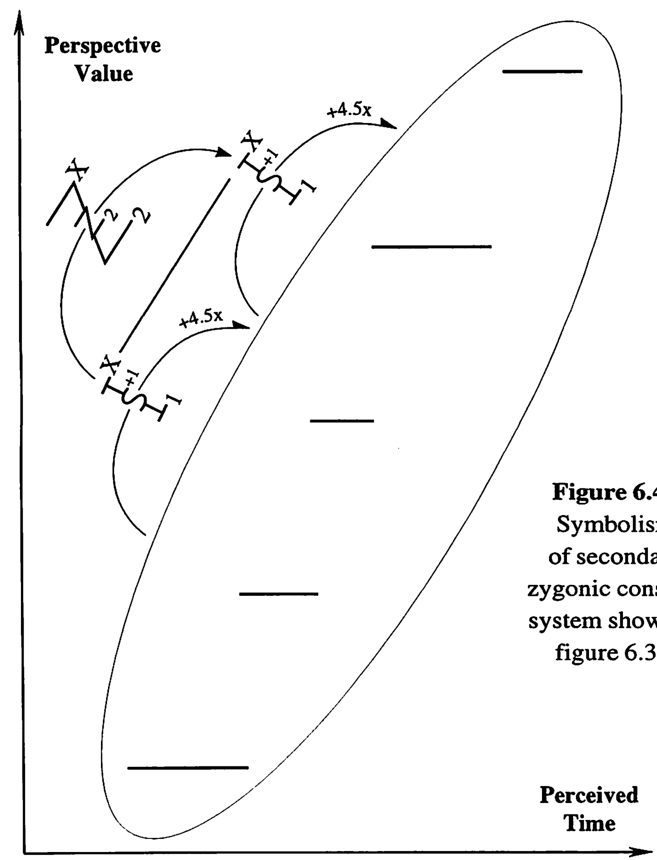


Figure 6.40
Symbolism
of secondary
zygonic constant
system shown in
figure 6.39.

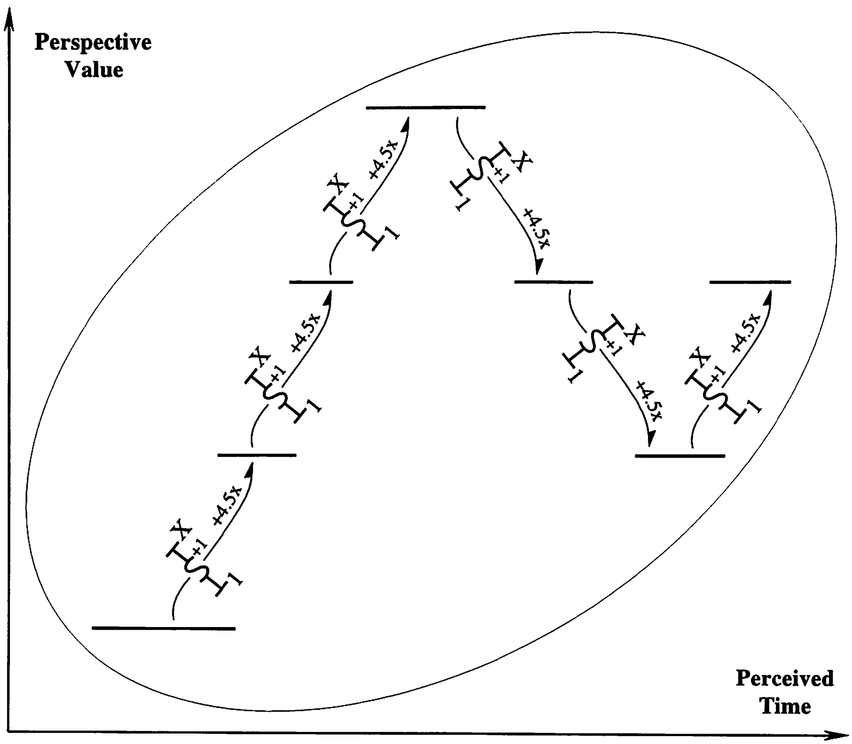


Figure 6.41 Invariant system comprising relationships of opposing polarities.

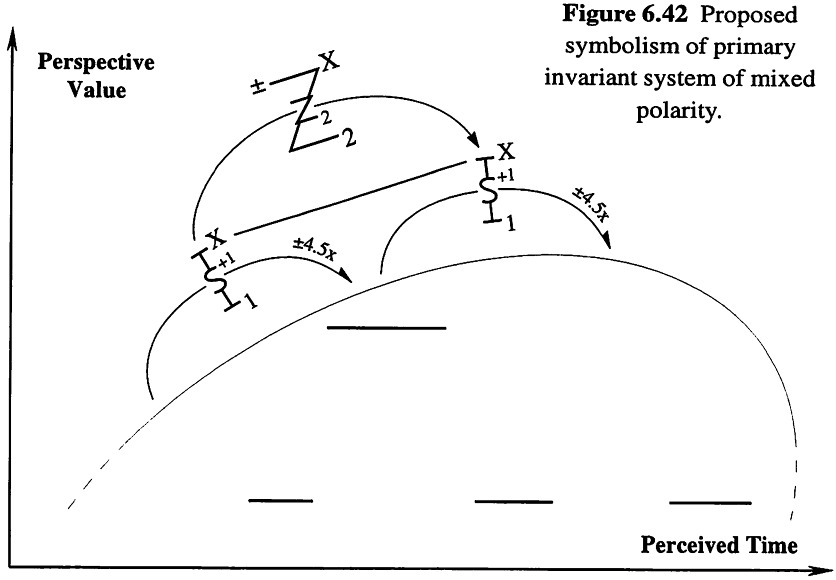


Figure 6.42 Proposed symbolism of primary invariant system of mixed polarity.

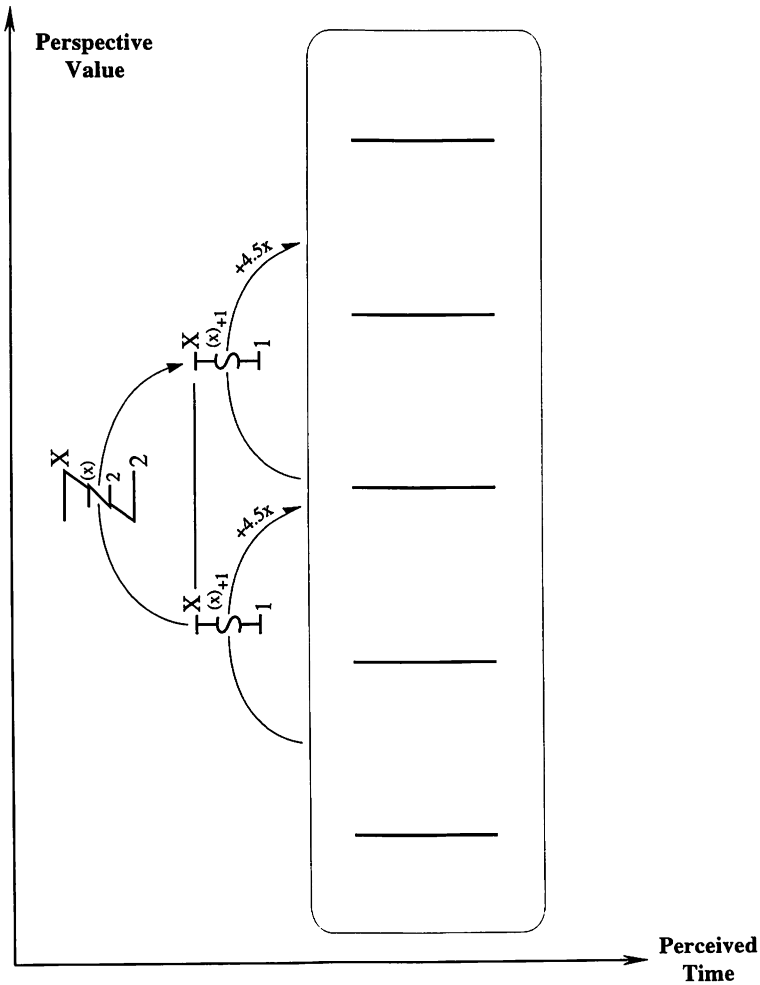


Figure 6.43 Secondary zygosequential intrasociative zygonic constant system; sequential with respect to X.

Primary invariant systems and the zygonic constant systems that order them may be imperfect. For example:

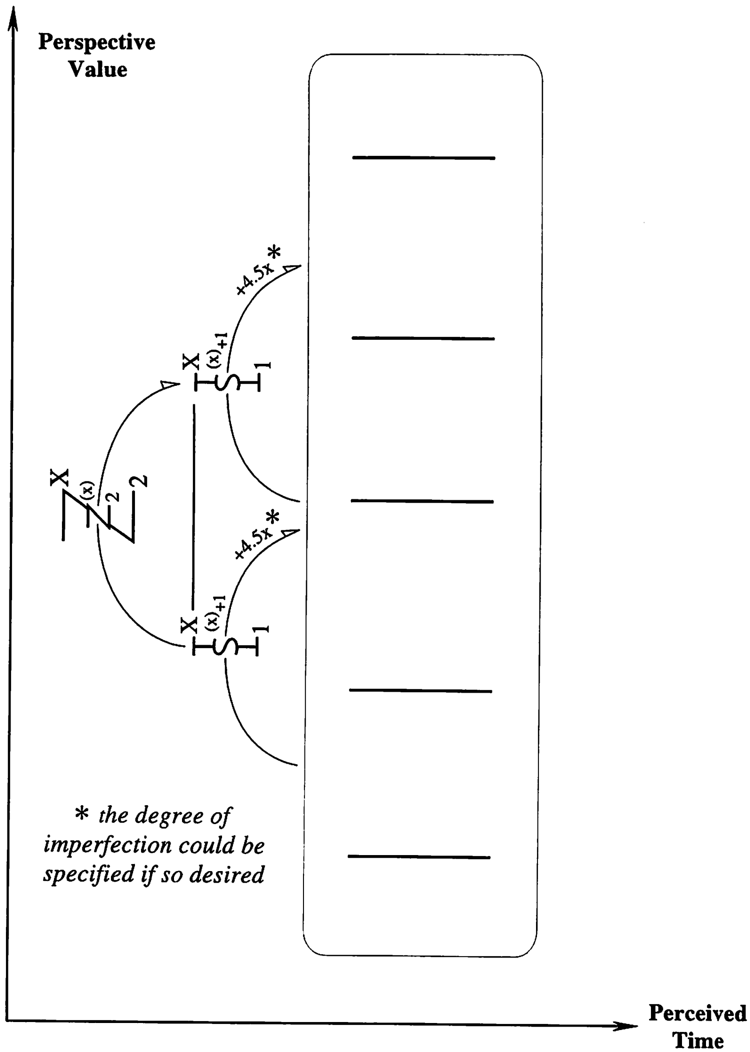


Figure 6.44 Imperfect secondary zygonic constant system (cf. figure 10.51).

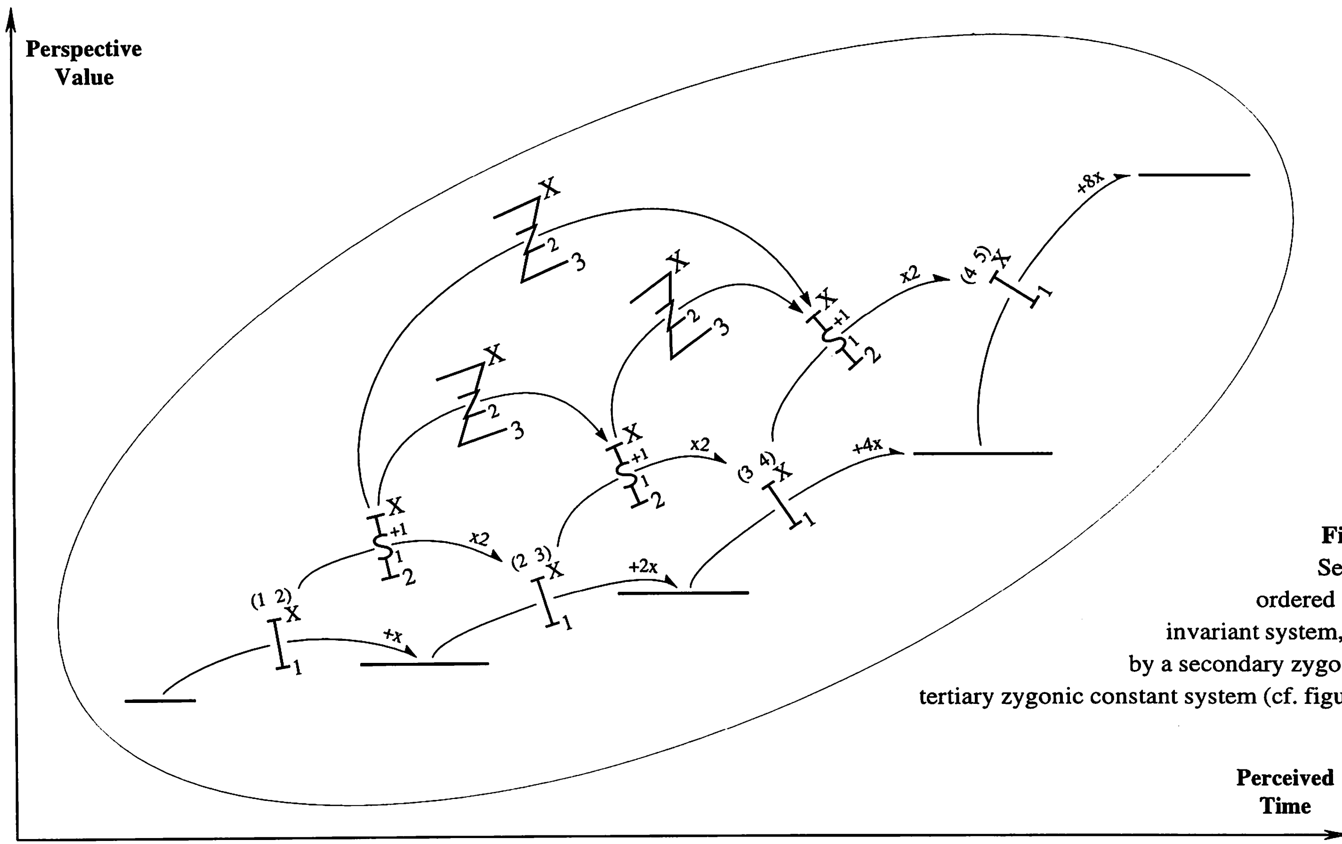


Figure 6.45
Sequentially
ordered secondary
invariant system, governed
by a secondary zygosequential
tertiary zygonic constant system (cf. figure 10.52).

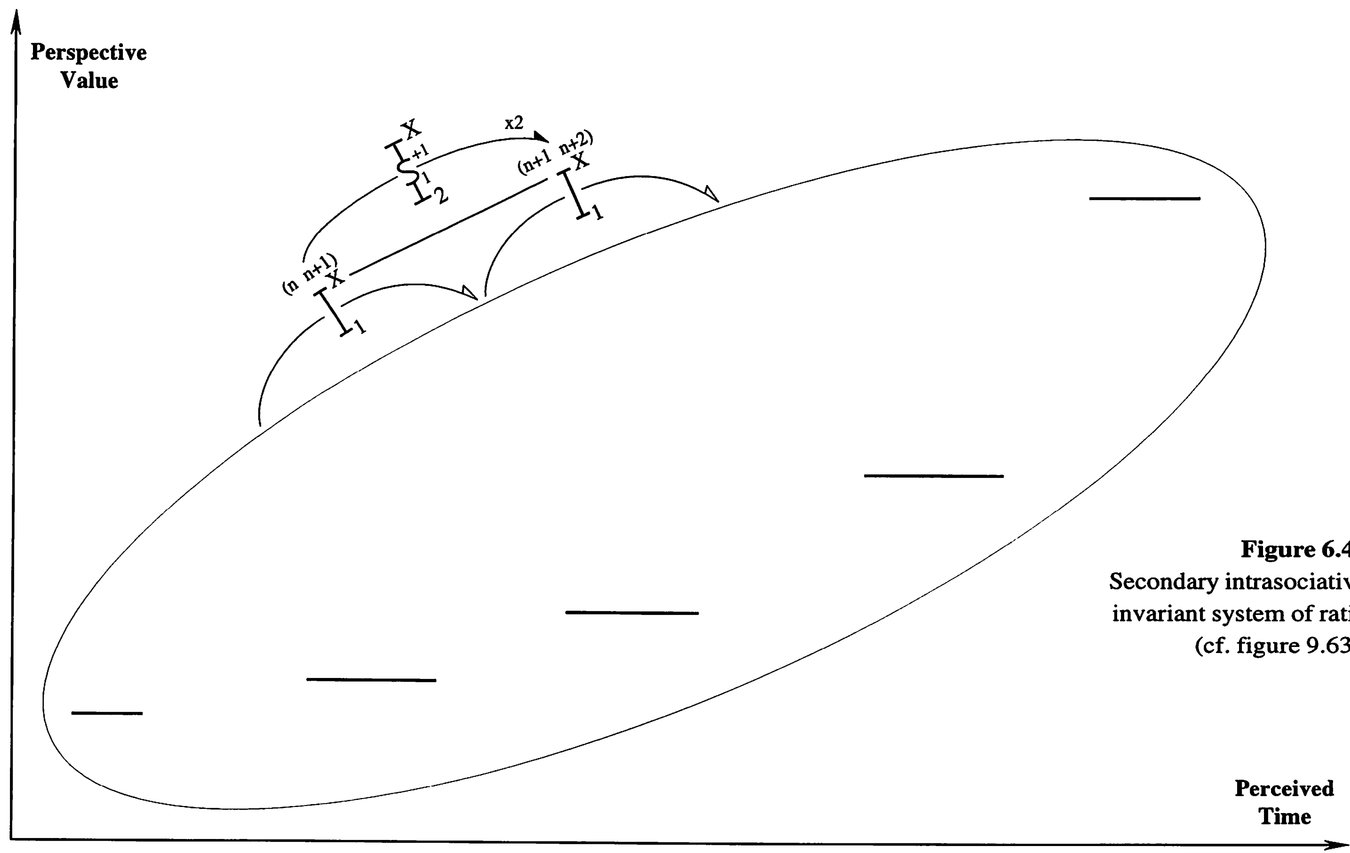


Figure 6.46
Secondary intrasociative invariant system of ratio (cf. figure 9.63).

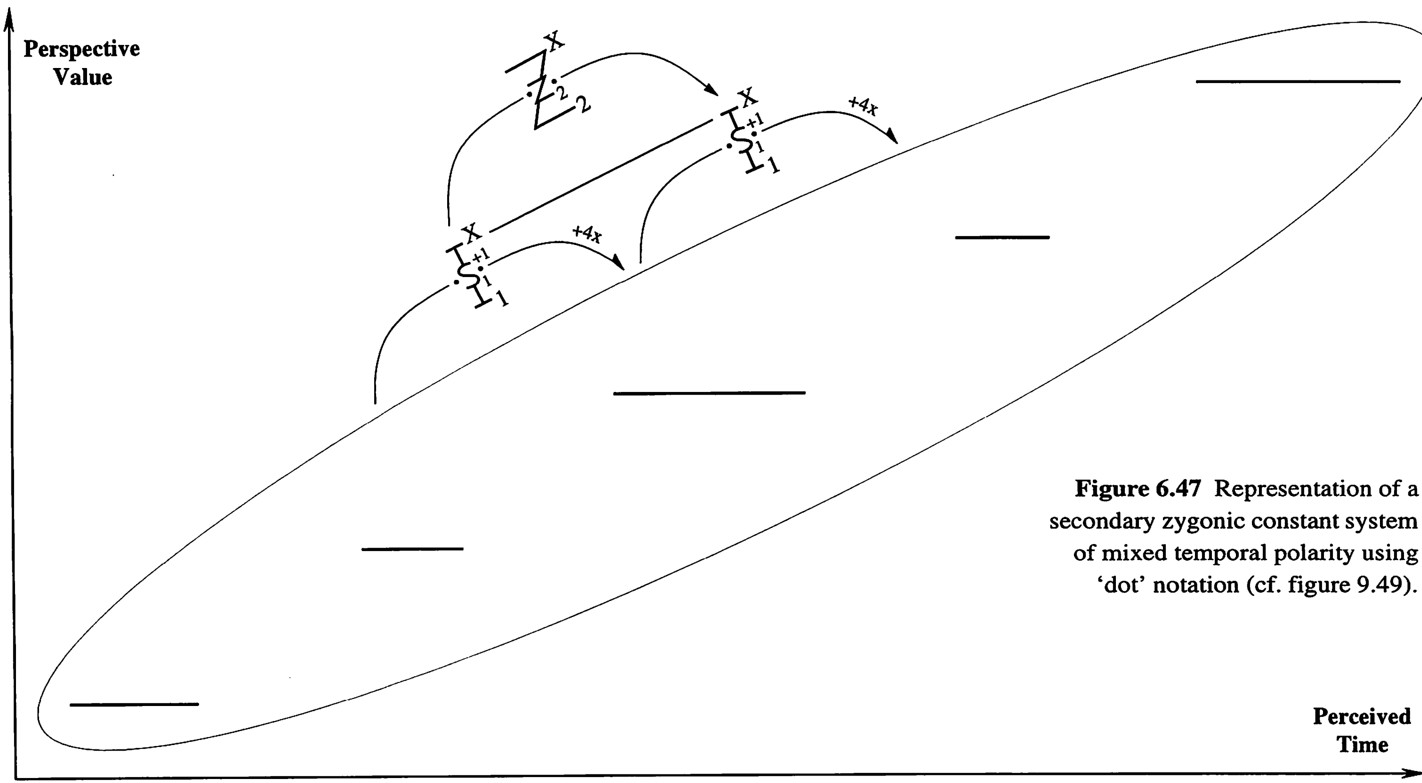


Figure 6.47 Representation of a secondary zygonic constant system of mixed temporal polarity using 'dot' notation (cf. figure 9.49).

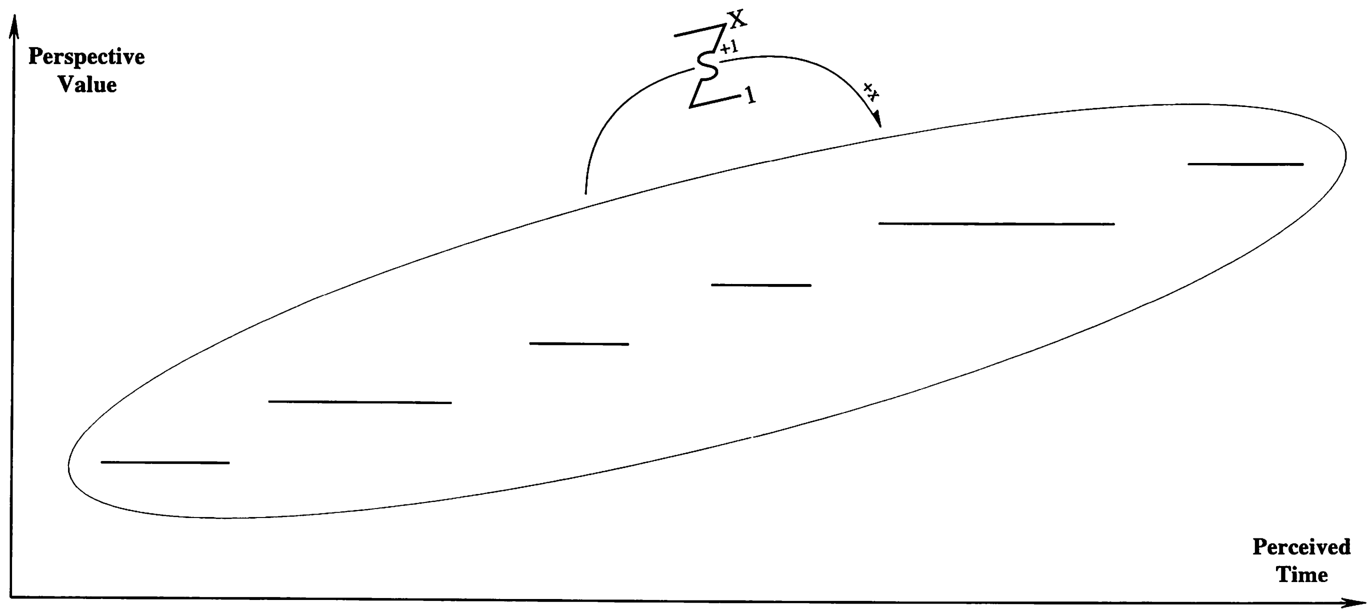


Figure 6.48 Primary zygonic invariant system (cf. figure 10.10).

Sequential control may feature in higher ranks of invariant system too. For example, a ***secondary zygosequential*** **tertiary zygonic constant system** may control a ***sequentially ordered*** **secondary invariant system** (see figure 6.45). The invariant system may be symbolised as shown in figure 6.46. Here, the expression 'n' is used as a non-specific indication of sequential location. The matrices (n n + 1) and (n + 1 n + 2) indicate that the two primary relationships, which are themselves successive, in each case link successive protractions.

The examples that have been presented in this section are based on the assumption that the first member of an association acts as the model from which subsequent components are derived. This need not be the case, however, implying the operation of primary invariants and secondary constants of mixed temporal polarity. These may be illustrated using the system of 'dot' notation shown in figure 6.47.

To conclude this section, consider the possibility of a **primary zygonic invariant system**—see figure 6.48—through which each member of an association (following the first) is felt to exist in approximate imitation of its immediate predecessor.

Variable associations ii: primary intersociative invariants; secondary constants, invariants and constant systems; tertiary constants

This section analyses the groups of interprotractive relationships that may exist between variable associations. We commence by considering two variable associations so disposed that each member of the first can be related to a member of the second via the same zygosequential primary interprotractive relationship (see figure 6.49). This network may be termed a **primary zygosequential intersociative invariant**, and symbolised as shown in figure 6.50. A **primary zygosequential intersociative zygonic invariant** may exist between identical associations, where one is thought to imitate the other (see figure 6.51). A ***retrograde*** **primary intersociative invariant** is a further possibility. See figure 6.52.

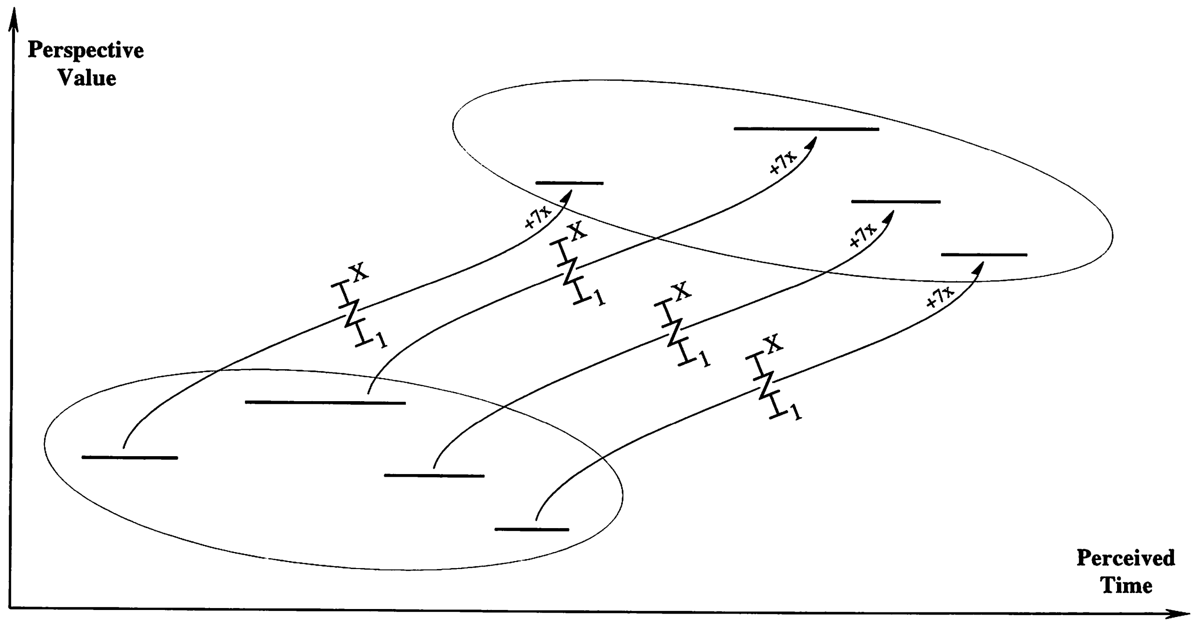


Figure 6.49 Succession of relationships the same between two associations.

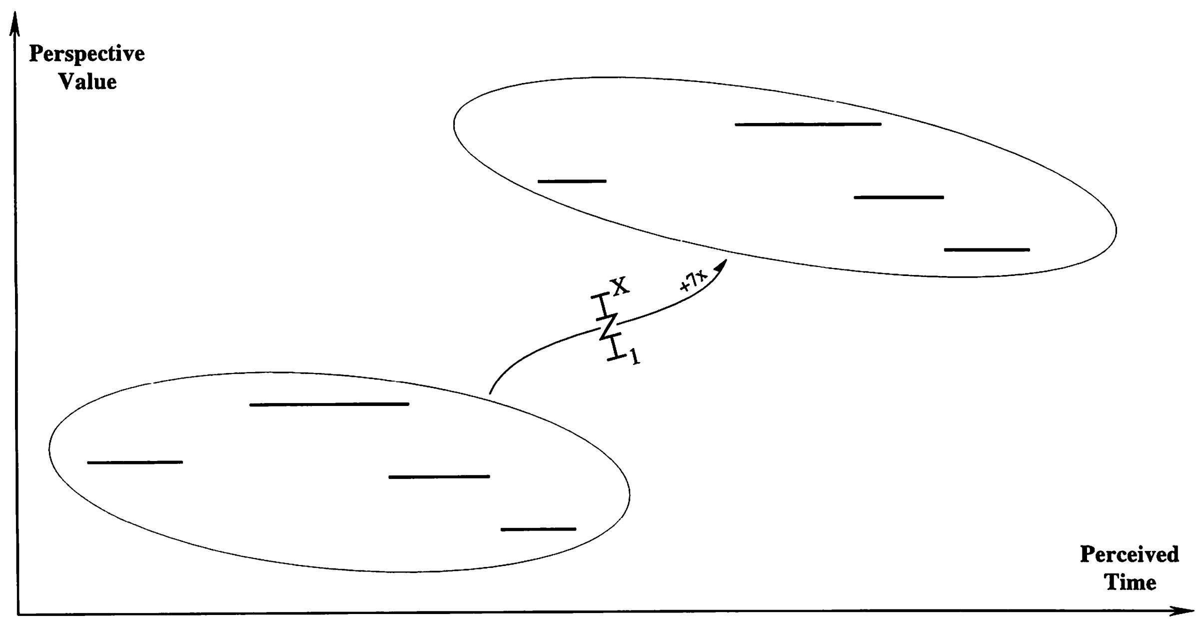


Figure 6.50 Primary zygosequential invariant (cf. figure 10.36).

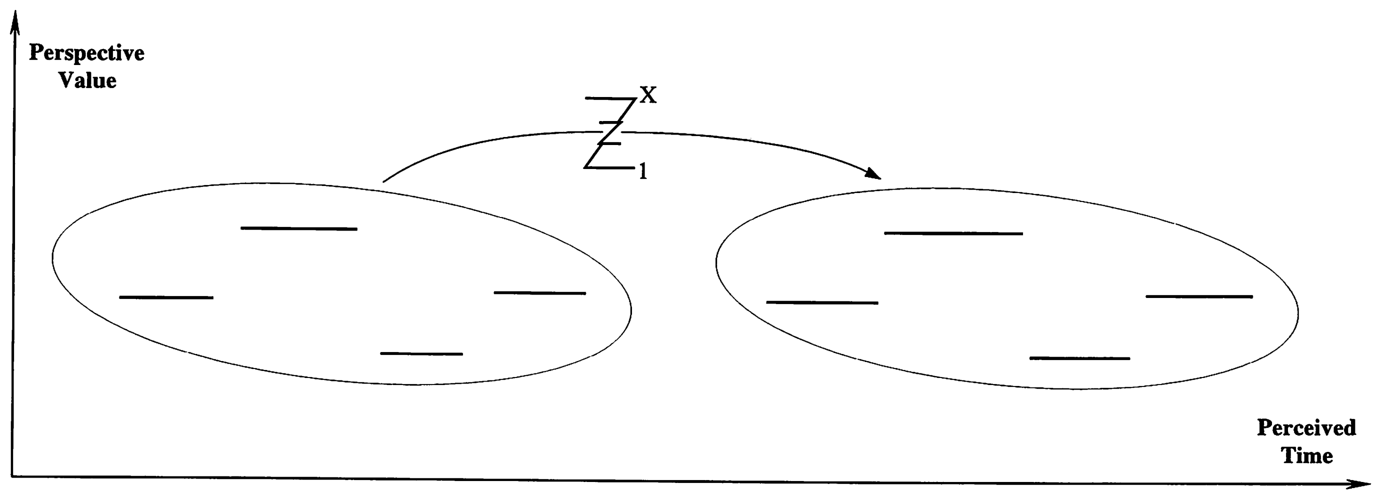


Figure 6.51 Primary zygosequential zygonic invariant (cf. figure 10.55).

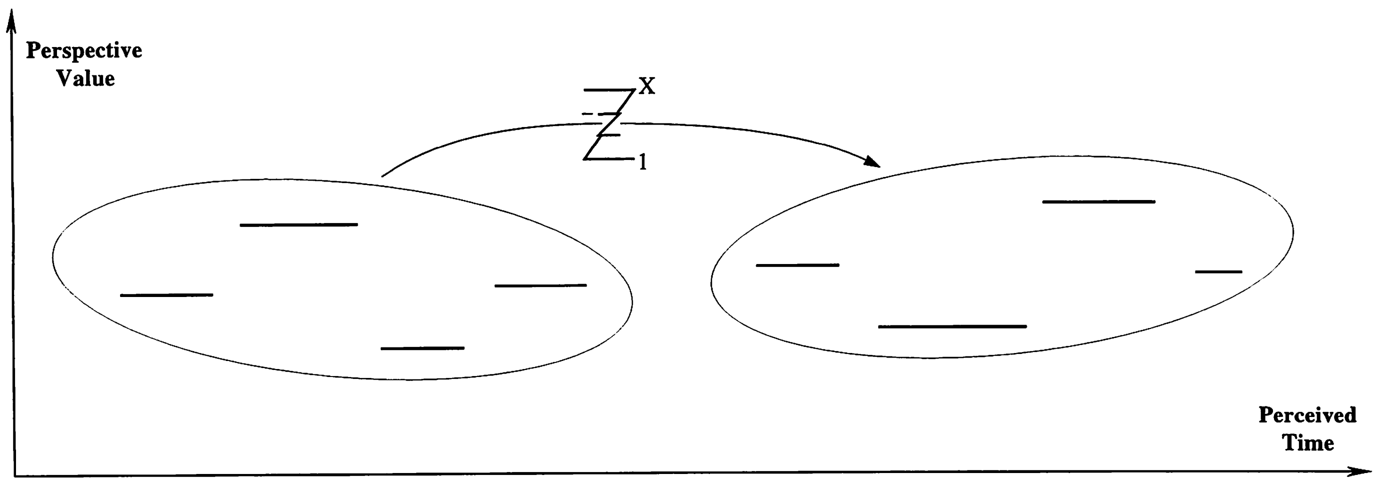


Figure 6.52 Retrograde primary invariant (cf. figure 8.17).

Invariants may be function imperfectly through slight differences in their component relationships: see, for example, figure 6.53. It is also conceivable that the constituent strands of zygonic invariants may each feature the same degree of imperfection; see figure 6.54. The two types of imperfection may appear in combination, symbolised through the use of a split arrowhead, half filled and half open—figure 6.55.

Zygosequential primary invariants may be related through **secondary zygosequential zygonic constants**; see figure 6.56. If the constituent interprotractive relationships that make up a primary intersociative invariant are deemed to be ordered through internal imitation, then the presence of a secondary zygosequential zygonic constant system is implied (figure 6.57).

The relationships that make up an invariant may each express the same sequential difference. This procedure depends on ordinal numbers of fix being treated like the figures on a clock face, whereby the highest number in the sequence succeeds the lowest without a break. See figure 6.58. Such a network may be symbolised as in figure 6.59.

A **primary zygosequential secondary zygonic invariant** registers the similarity between the internal interprotractive relationships pertaining to two associations, and attributes the existence of one group to the imitation of the other—figure 6.60. The fact that the intrasociative relationships concerned can be of any sequential disposition is shown by the (n n+y) brackets. By extension, a **primary zygosequential *inverse* secondary zygonic invariant** is a possibility (figure 6.61), and a **primary *retrograde* secondary zygonic invariant** is feasible too; see figure 6.62. Here, 'ñ' is taken to be the retrograde equivalent of 'n'. Hence if 'n' refers to the second protraction from the beginning of an association, for example, then 'ñ' will denote the second from the end. Here, the primary relationships pertaining to one association are reversed with respect to those of the other—a consequence of all intrasociative links being regressed with regard to sequential location. Retrogression and inversion may function together.

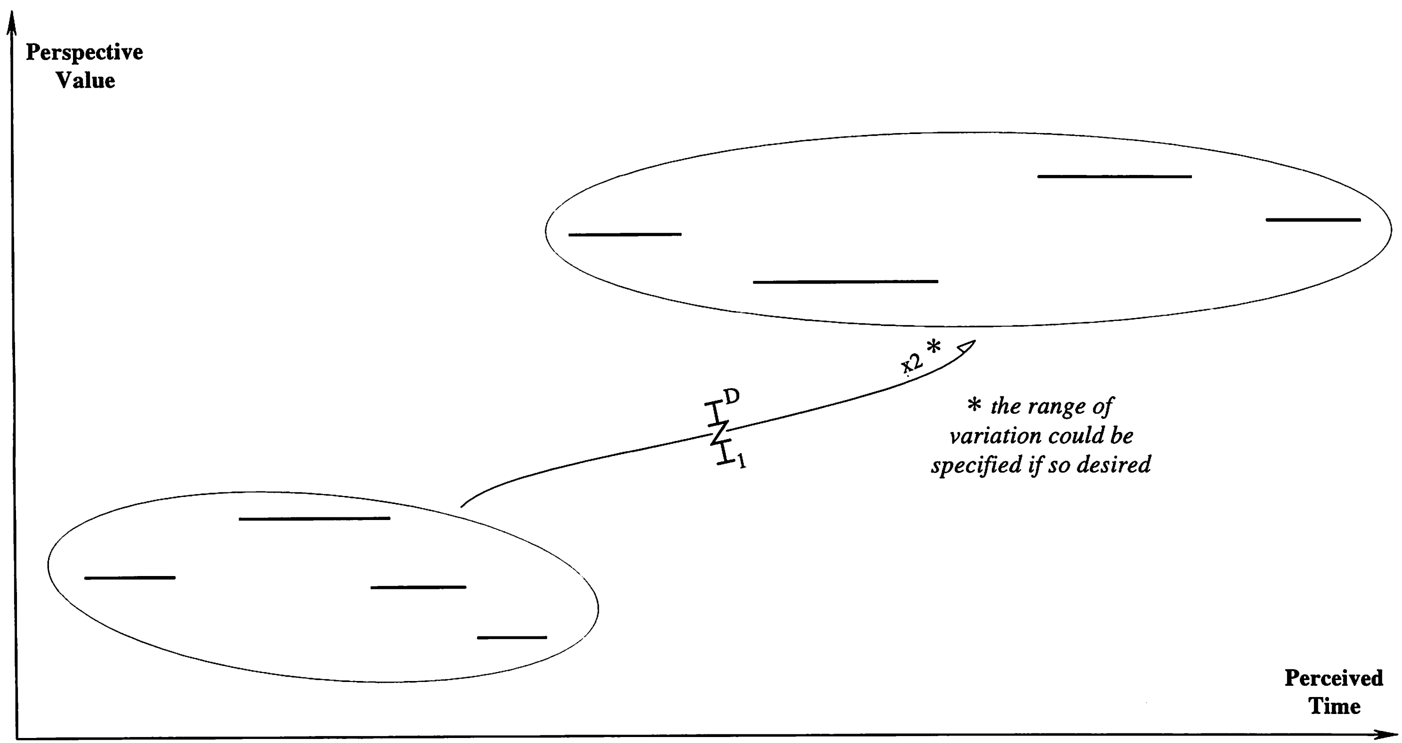


Figure 6.53 Primary zygosequential imperfect invariant.

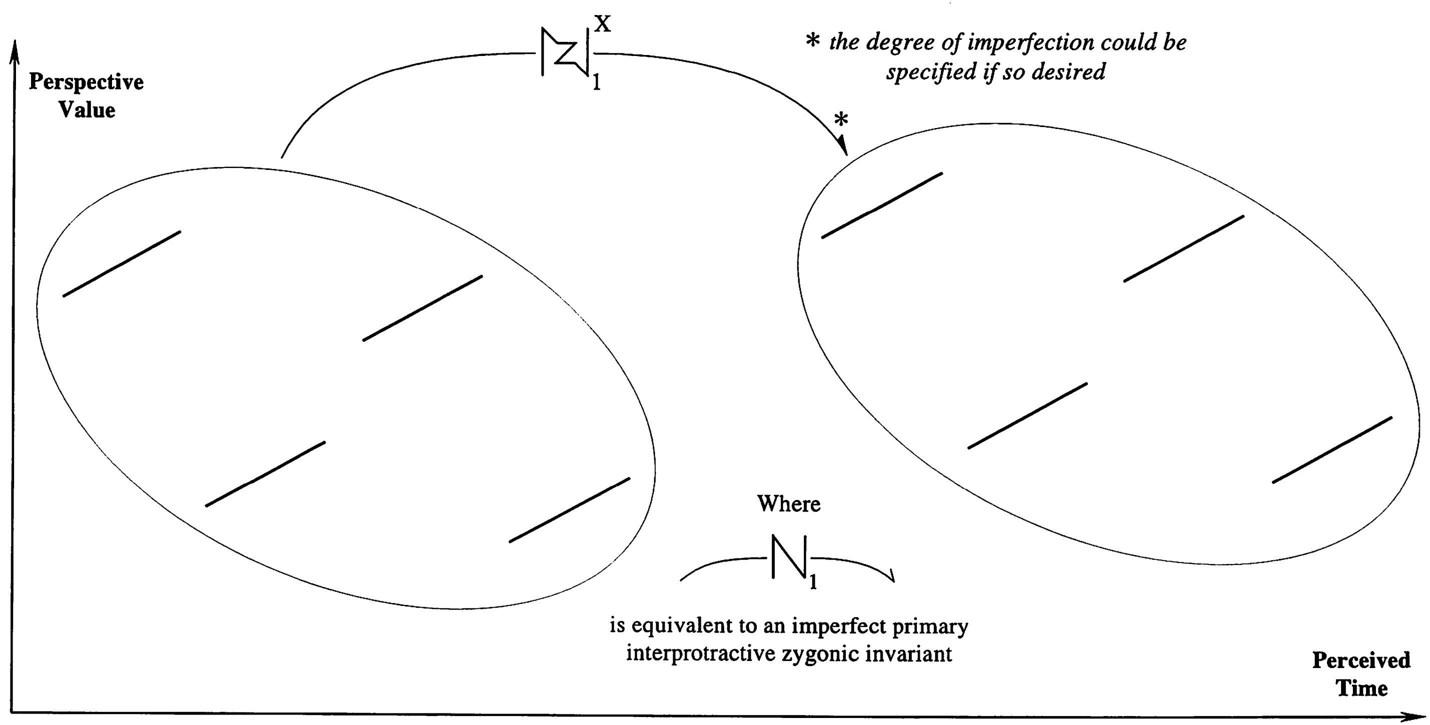


Figure 6.54 Primary zygosequential imperfect zygonic invariant.

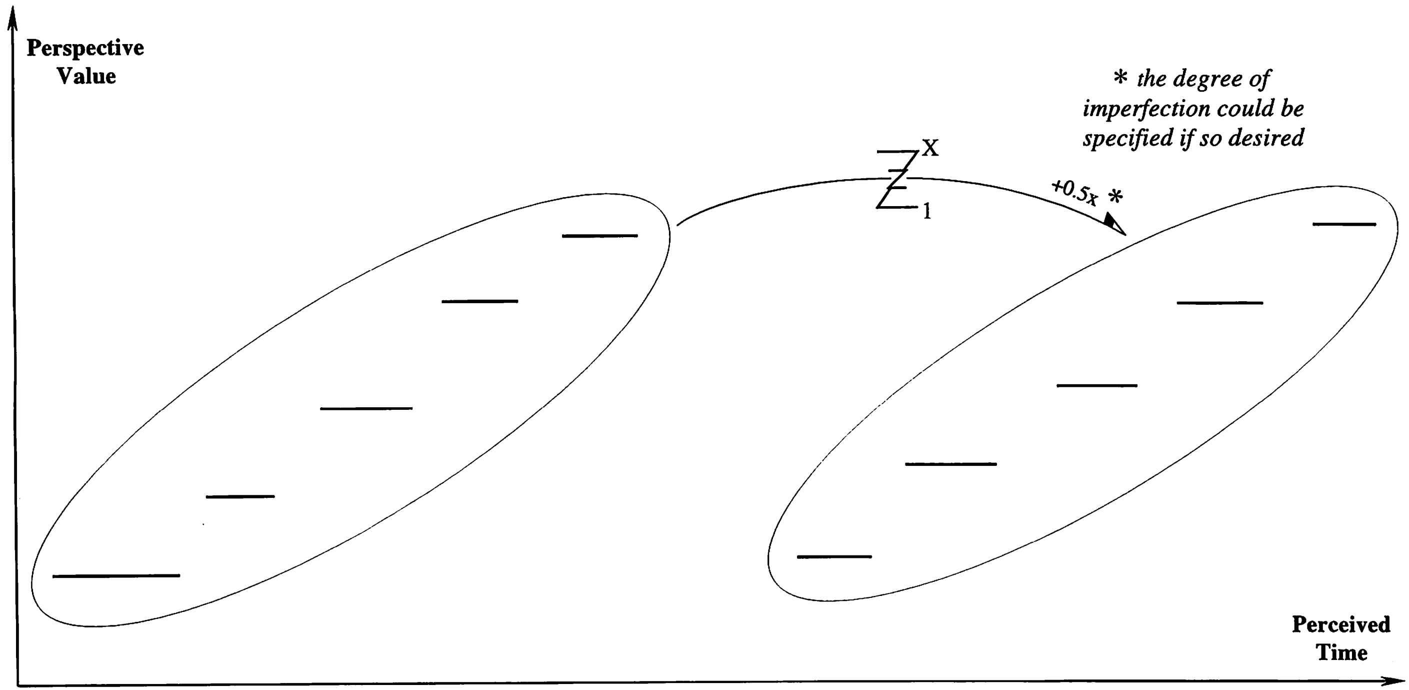


Figure 6.55 Imperfect primary zygosequential imperfect zygonic invariant (cf. figure 9.46).

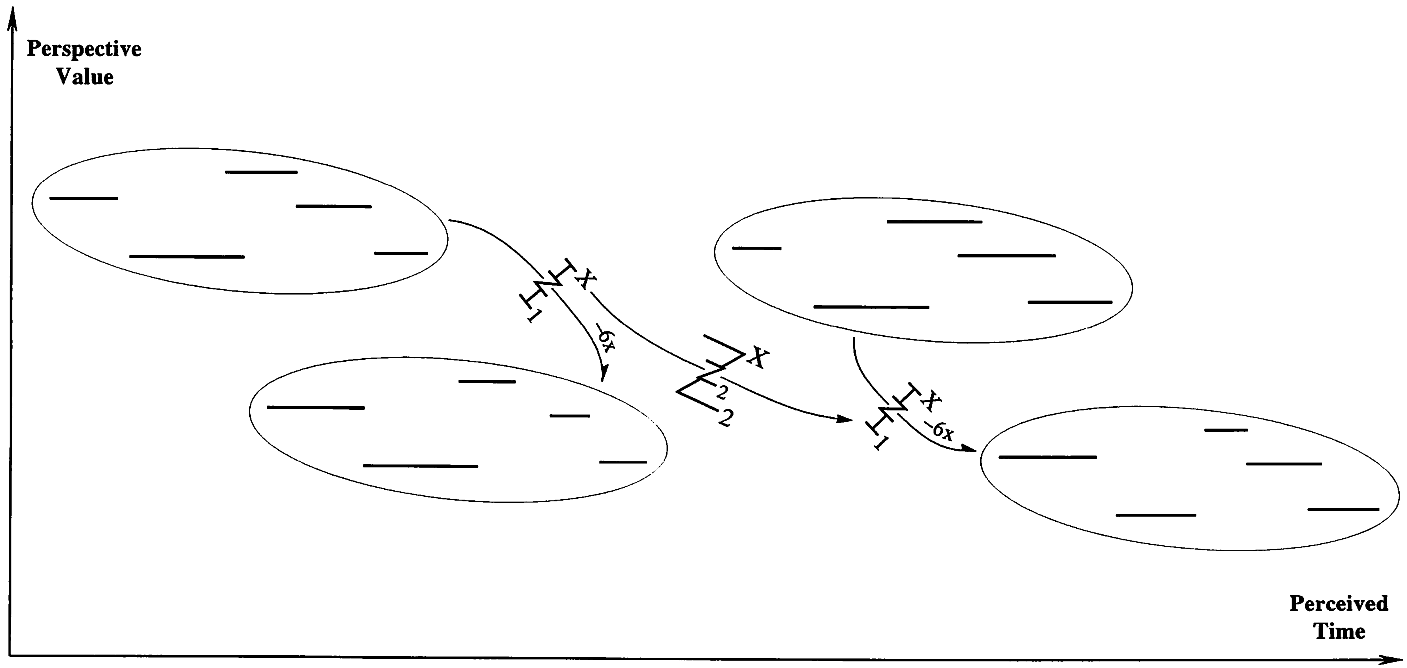


Figure 6.56 Secondary zygosequential zygonic constant.

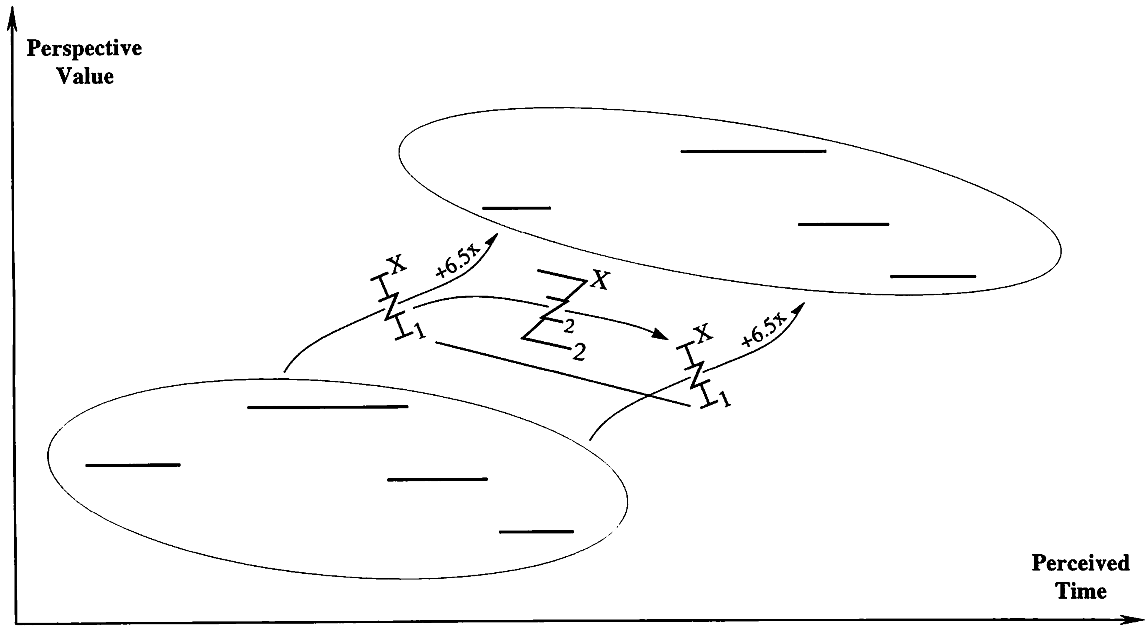


Figure 6.57 Secondary zygosequential zygonic constant system linking primary intersociative invariants (cf. figures 9.88 and 9.92).

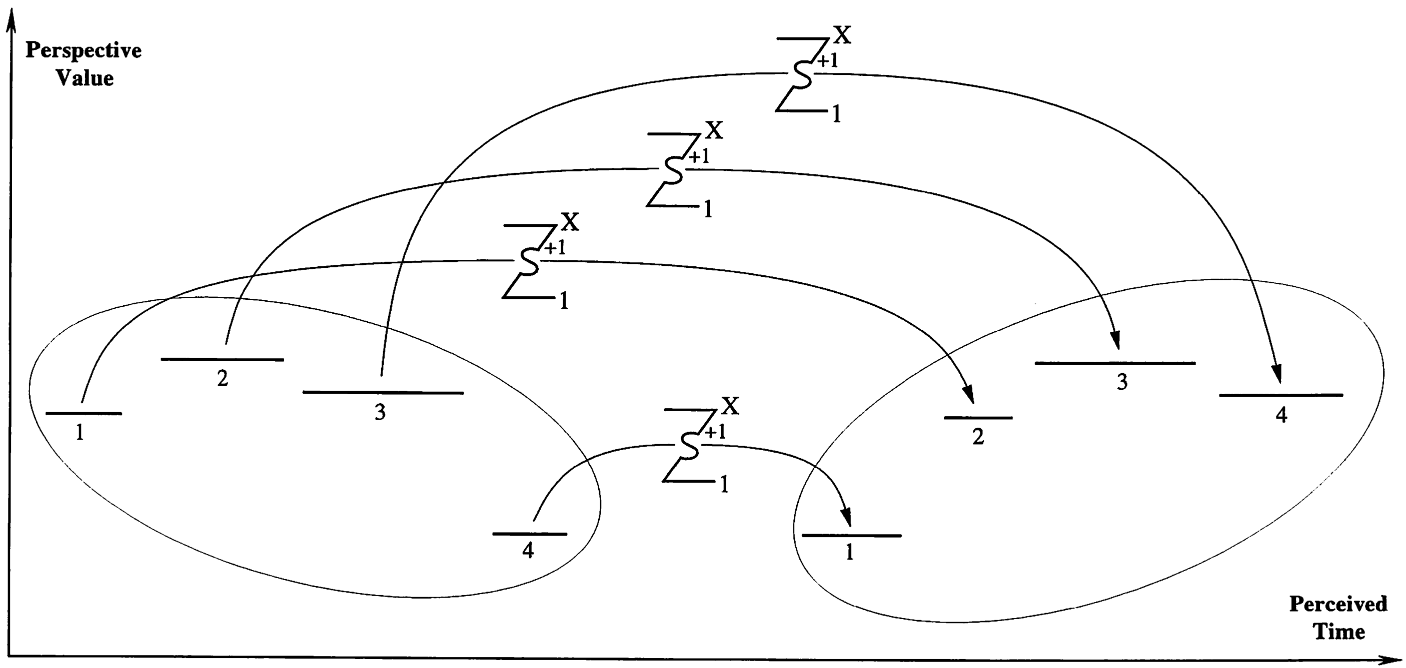


Figure 6.58 Two associations linked by a series of relationships sharing the same sequential difference.

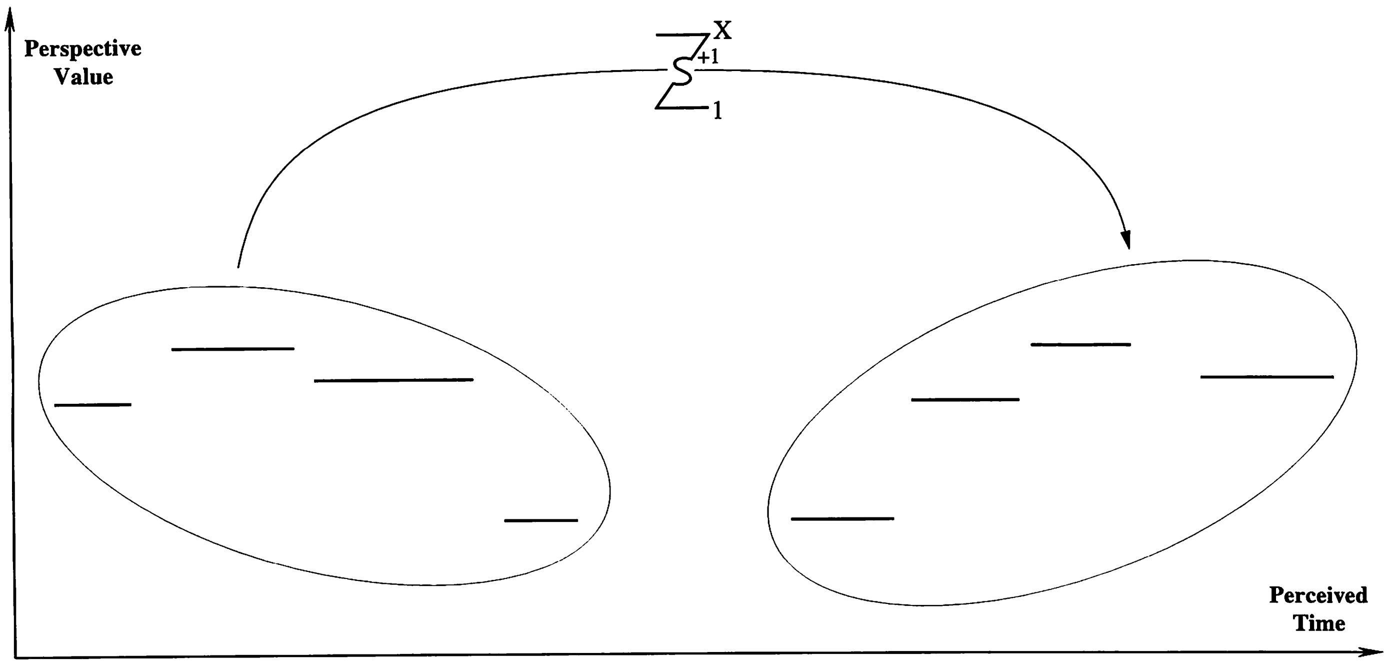


Figure 6.59 Symbolism of primary invariant shown in figure 6.58 (cf. figure 10.72).

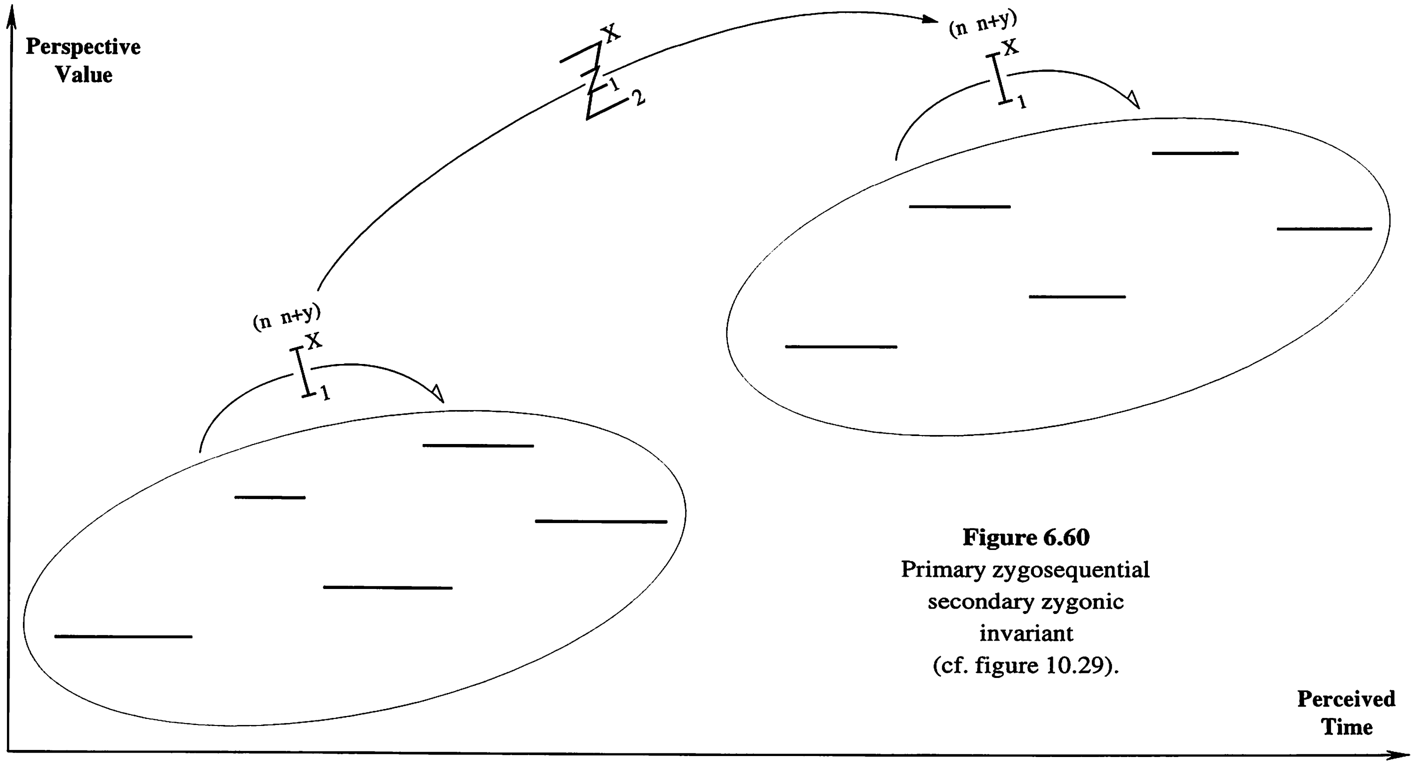


Figure 6.60
Primary zygosequential
secondary zygonic
invariant
(cf. figure 10.29).

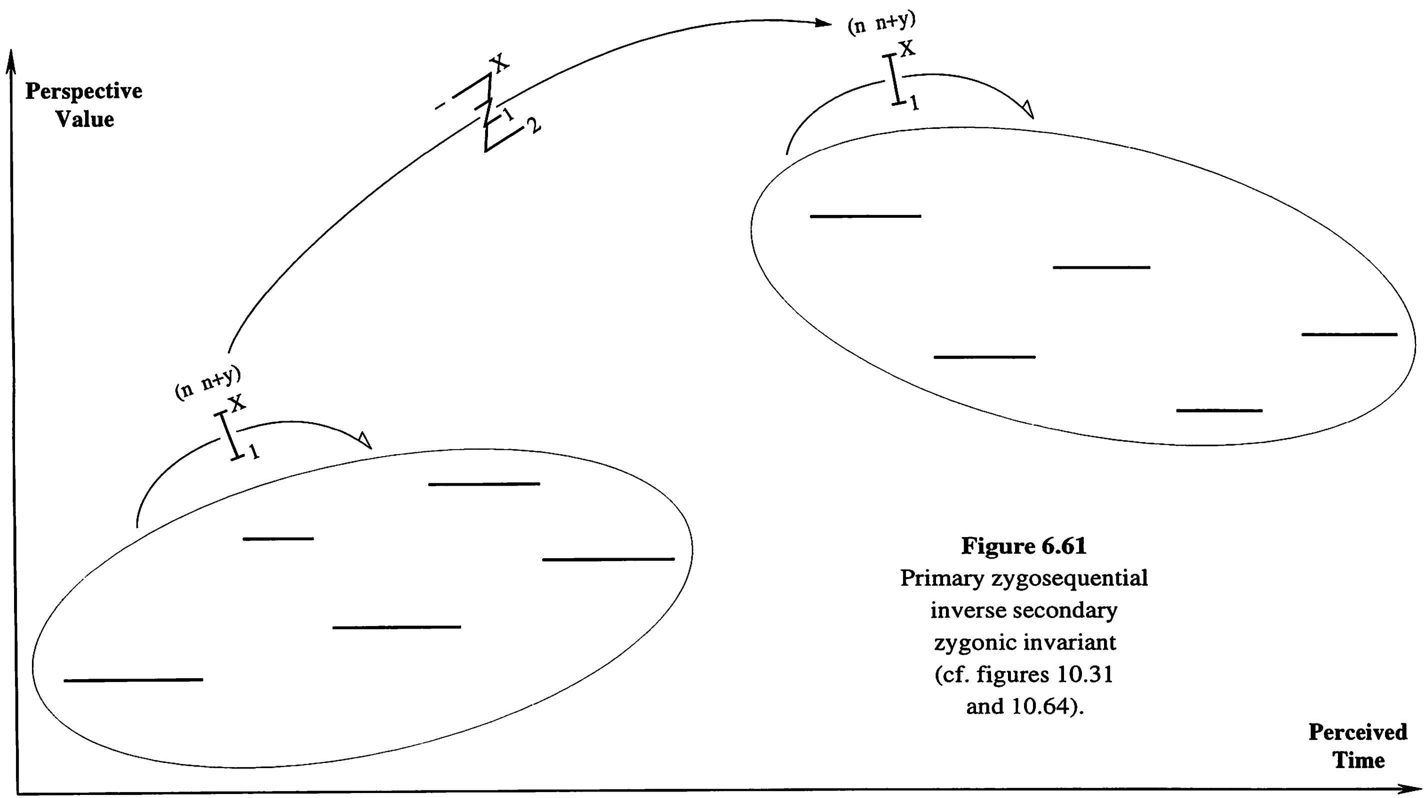


Figure 6.61
Primary zygosequential
inverse secondary
zygonic invariant
(cf. figures 10.31
and 10.64).

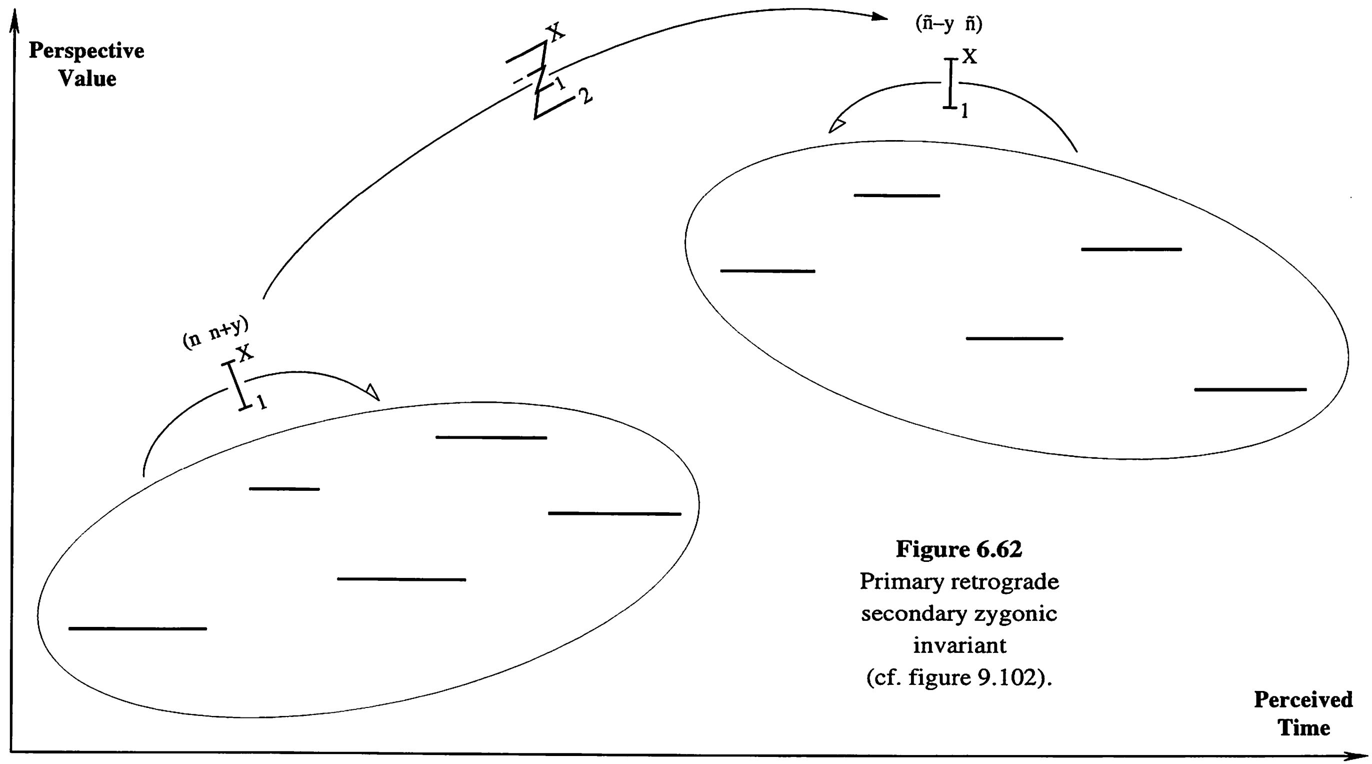


Figure 6.62
Primary retrograde
secondary zygonic
invariant
(cf. figure 9.102).

Two associations may be structured through the agency of similar sequentially ordered primary invariant systems. Listeners may perceive them to be related through a **secondary zygosequential secondary zygonic constant**. For example:

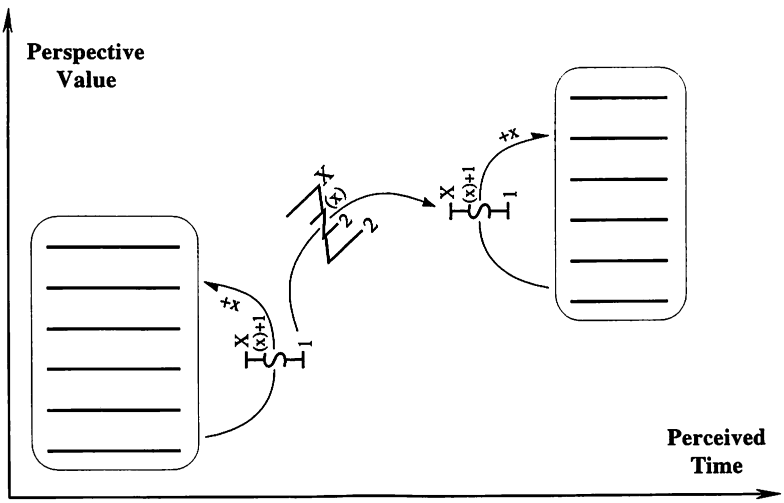


Figure 6.63 Secondary zygosequential zygonic constant linking primary invariant systems (cf. figure 10.11).

One association may feature a pattern of regular change that differs consistently with that of another. The perceived connection between two such variables may take the form of a secondary zygosequential constant; see figure 6.64. One constant of this type may be deemed to exist in imitation of another through the operation of a **tertiary zygosequential zygonic constant**. See, for instance, figure 6.65.

A variable association may be organised on the basis of a sequentially ordered secondary intrasociative invariant system in assumed imitation of another through the agency of a **secondary zygosequential tertiary zygonic constant** (figure 6.66).

Finally, consistent change in one association may imitate that found in another through a **tertiary zygosequential zygonic constant system**—see figure 6.67.

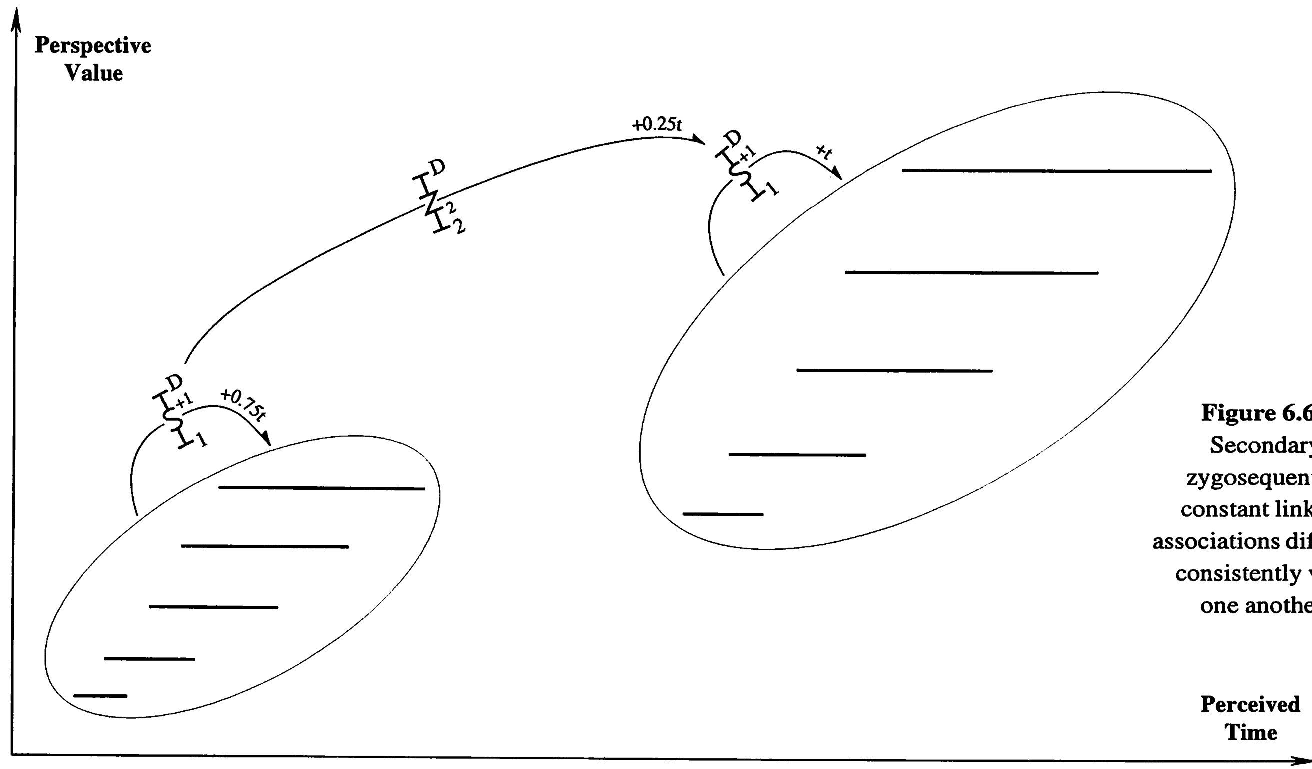


Figure 6.64
Secondary zygosequential constant linking associations differing consistently with one another.

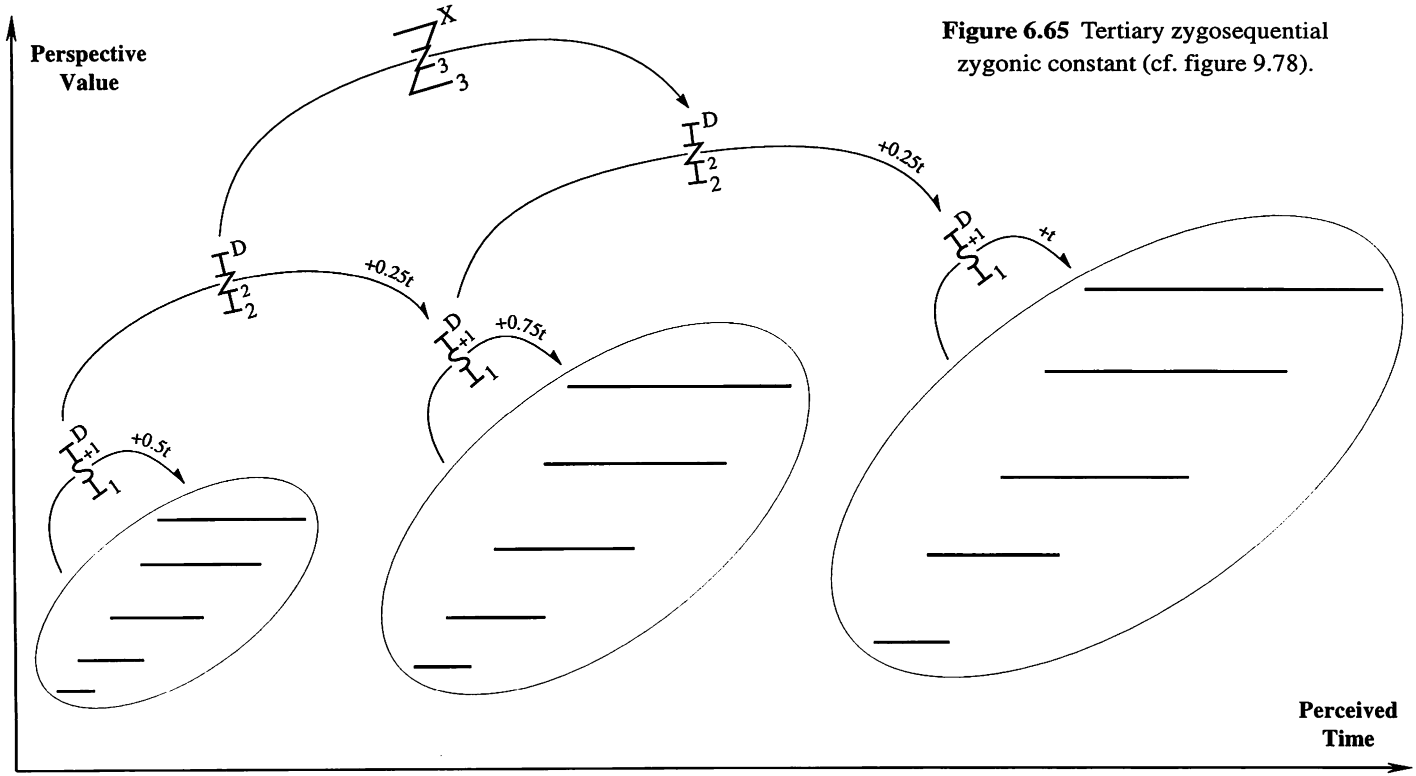


Figure 6.65 Tertiary zygosequential zygonic constant (cf. figure 9.78).

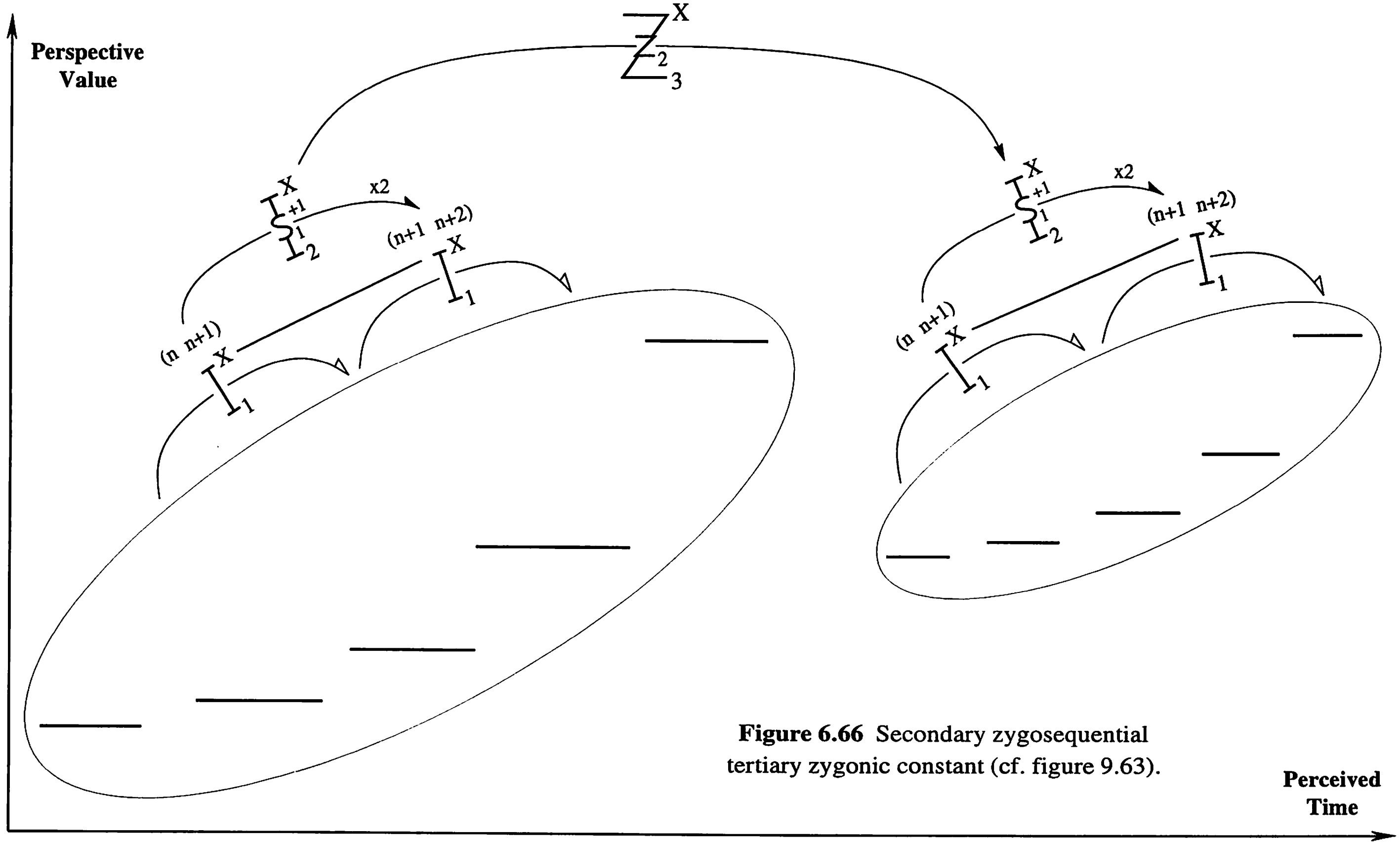


Figure 6.66 Secondary zygosequential tertiary zygonic constant (cf. figure 9.63).

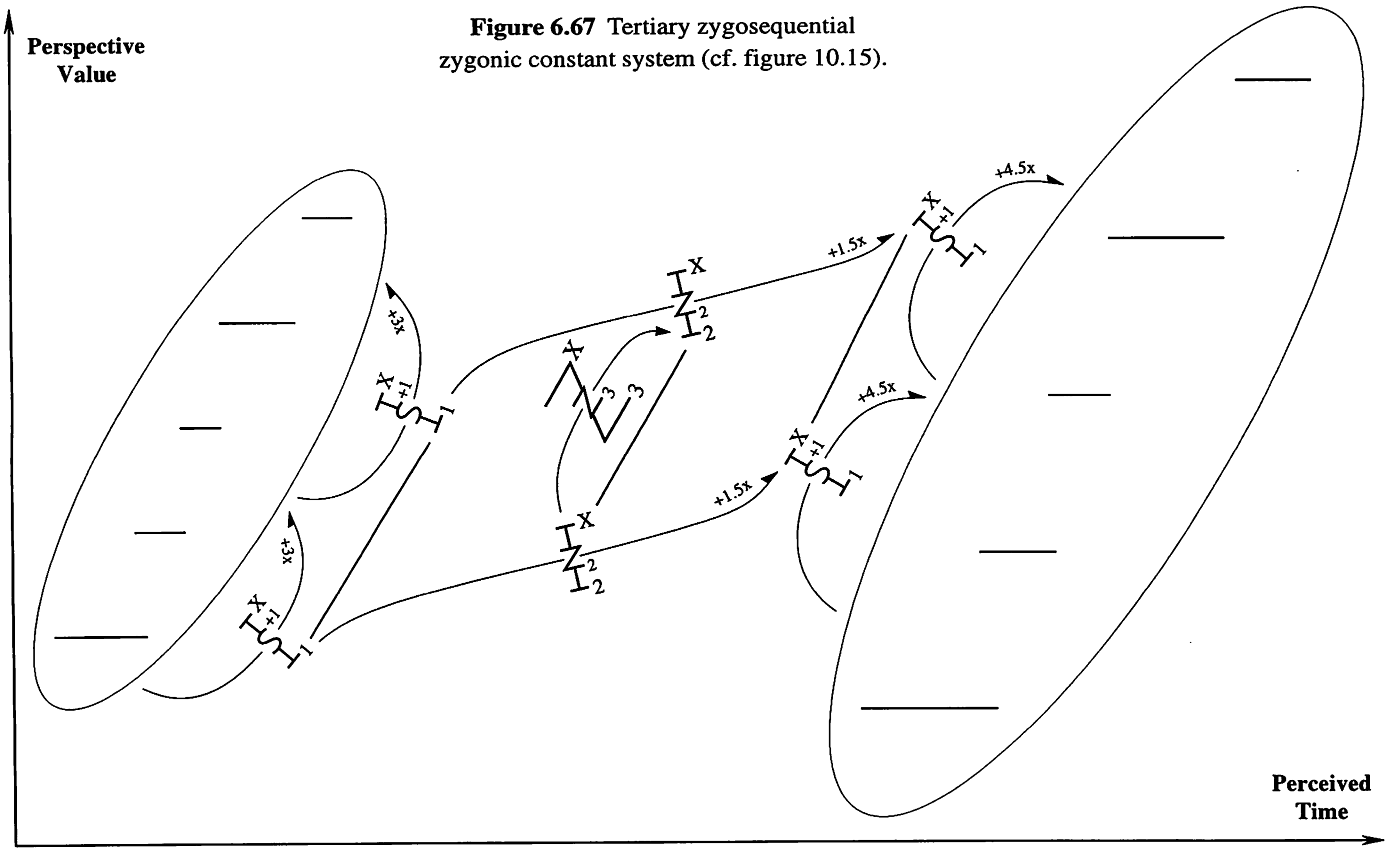


Figure 6.67 Tertiary zygosequential zygonic constant system (cf. figure 10.15).

Organic structures: complements, configurations and associations of higher orders

Since one complement may be contained within another (pp. 152 and 153), 'complements of complements' are possible, and 'complements of complements of complements', *et cetera*, in a manner that is finally limited only by the boundaries of compositions. The same principle applies to configurations. Structures such as these, in which parts are systematically coordinated to produce integrated wholes, may be termed **organic**. Within an organic structure, the smallest components that are under consideration at any given time are deemed to be of **order i**, followed by **order ii** , **order iii**, and so on. For example:

Tallis: *Tallis's Ordinal* (1567)

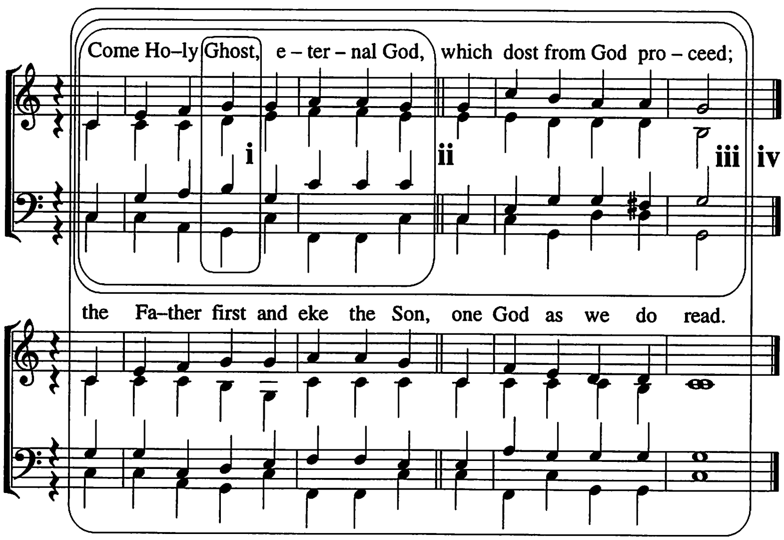


Figure 6.68 Configurations of orders i, ii, iii and iv.

Designations such as these are liable to vary according to the analytical needs of the occasion. For instance, the disposition of the configurations that make up *Tallis' Ordinal* may be reinterpreted as follows:

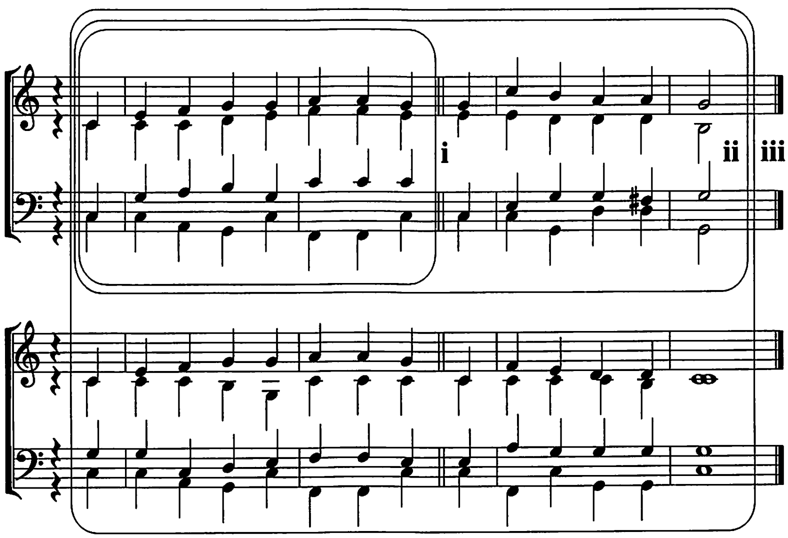


Figure 6.69 Reinterpretation of the configurative structure of *Tallis' Ordinal.*

Organic structures can be identified within the domains of individual perspects too, and so the terminology proposed here can also be applied to perspective associations. See, for instance, figure 6.70.

On p. 164, it was noted that primary intrasociative zygonic constant systems (order i) can consist of zygons, zygonic constants or zygonic invariants. This principle may be extended to include associations of higher orders. For example, a

'primary intrasociative zygonic constant system order ii
of
primary intersociative zygonic constants order i
of
primary interprotractive zygonic constants'

is conceivable. To represent this concept in full would require the sign for a zygonic relationship bearing three arrowheads, the first showing that it is interprotractive zygonic constants that are being related, the second indicating that these are combined to form intersociative zygonic constants order i, and the third revealing that these in turn constitute a second-order primary intrasociative zygonic constant system (figure 6.71).

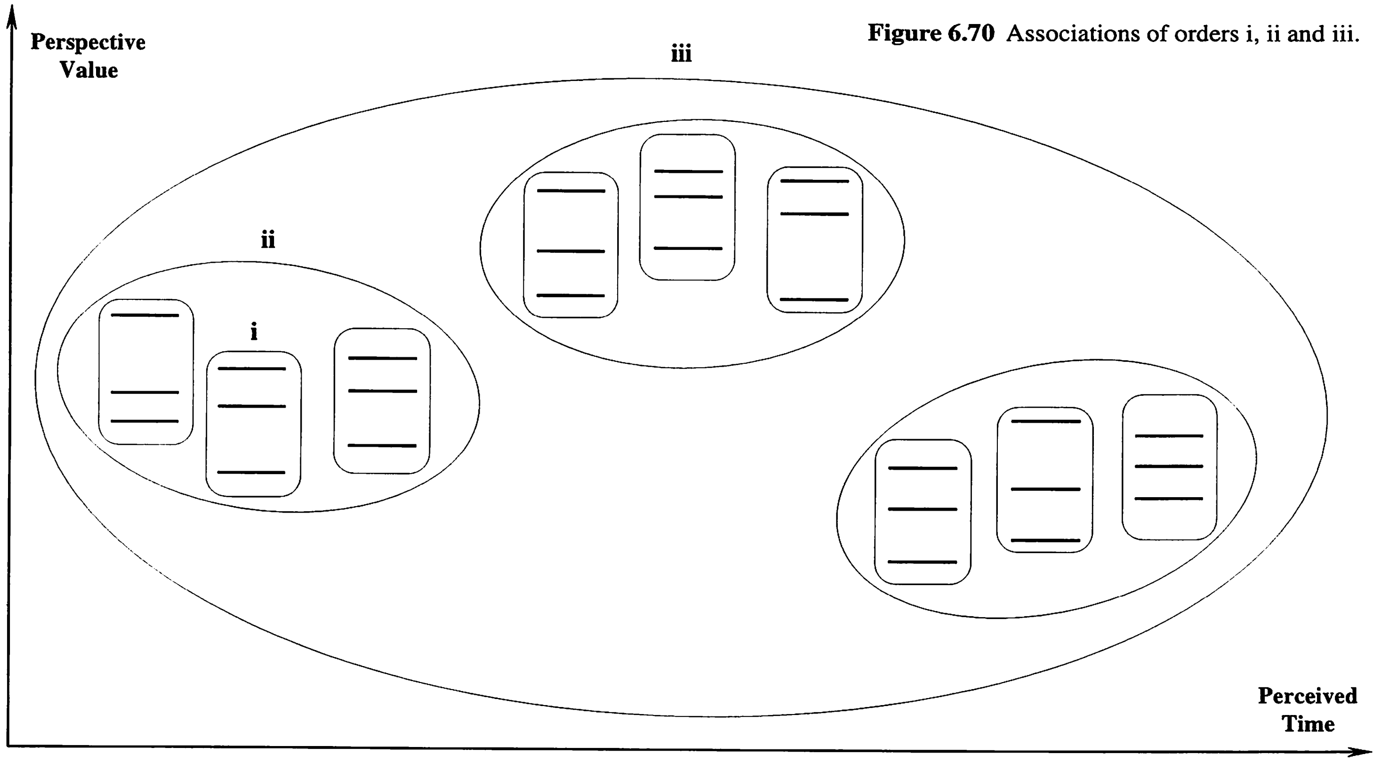


Figure 6.70 Associations of orders i, ii and iii.

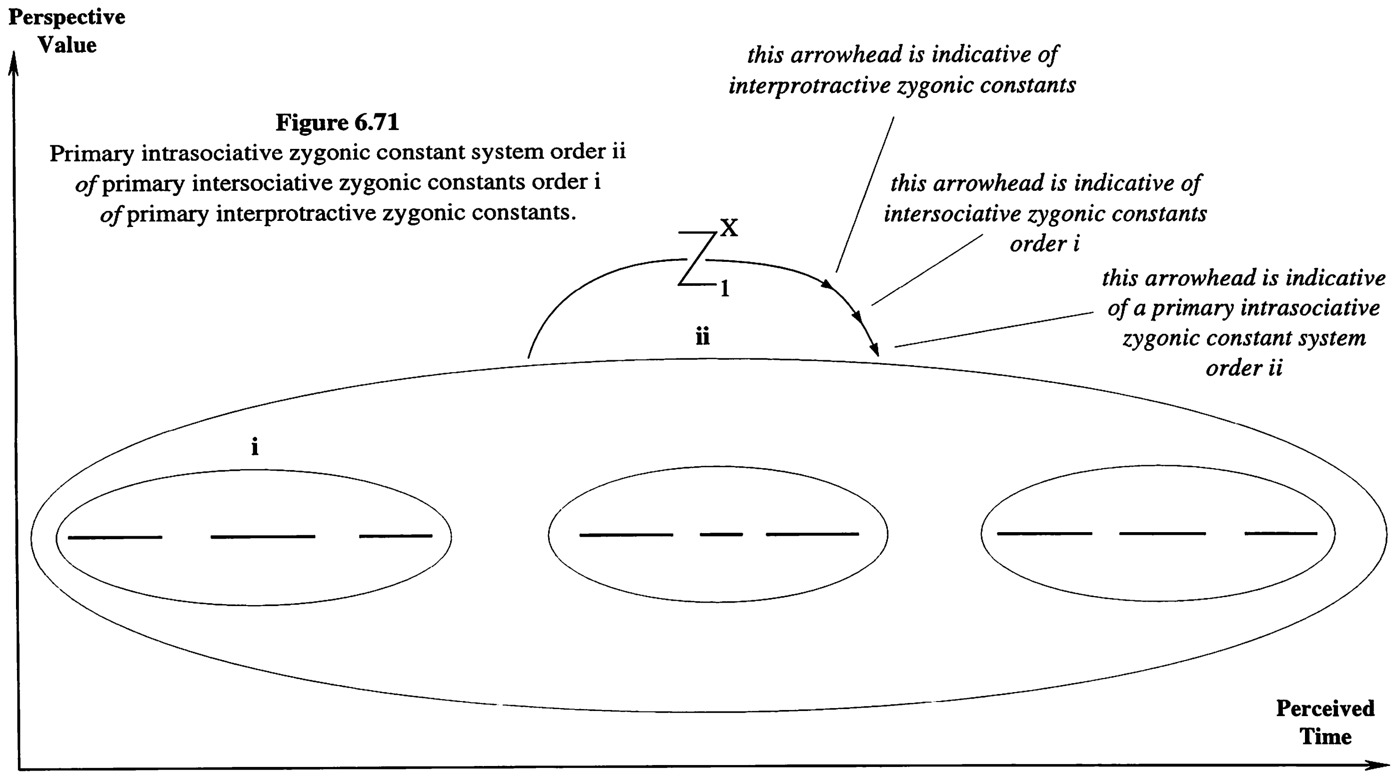


Figure 6.71
Primary intrasociative zygonic constant system order ii
of primary intersociative zygonic constants order i
of primary interprotractive zygonic constants.

However, in the interests of clarity, relationships such as this may be described solely in terms of the function they fulfil in relation to the highest order association present. Hence, in most circumstances, the compound pictured in figure 6.71 may be referred to simply as a 'primary zygonic constant system order ii', represented with a symbol using just one arrowhead. If necessary, the designation 'order ii' can be shown as a subscript to the left of the letter indicating the type of relationship (see figure 6.72).

Relationships between associations of order ii or above may well differ from the interperspective connections of which they are made up. For instance, an intersociative constant order ii may comprise first-order invariants. This may be shown through a system of substitution. Consider, for example, the

'sequentially ordered primary intrasociative invariant system, order ii
of
zygosequential primary intersociative invariants, order i'

shown in figure 6.73. Here, the invariants order i are represented by an 'X'.

Some types of interperspective relationship can exist only between associations of order ii and above. See figure 6.74, where 'association number' is controlled through a primary zygonic constant system order ii.

Relationships may be of 'mixed order', a characteristic which can be shown using a appropriate matrix—see figure 6.75. Similarly, protractions and associations may be related directly to one another. For example:

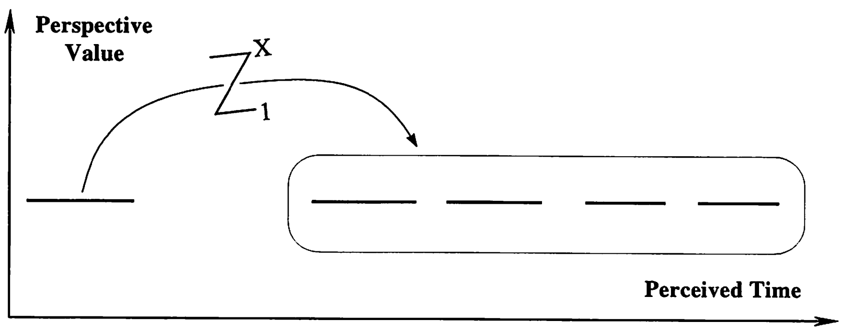


Figure 6.76 Zygonic constant linking protraction and association (cf. figure 9.81).

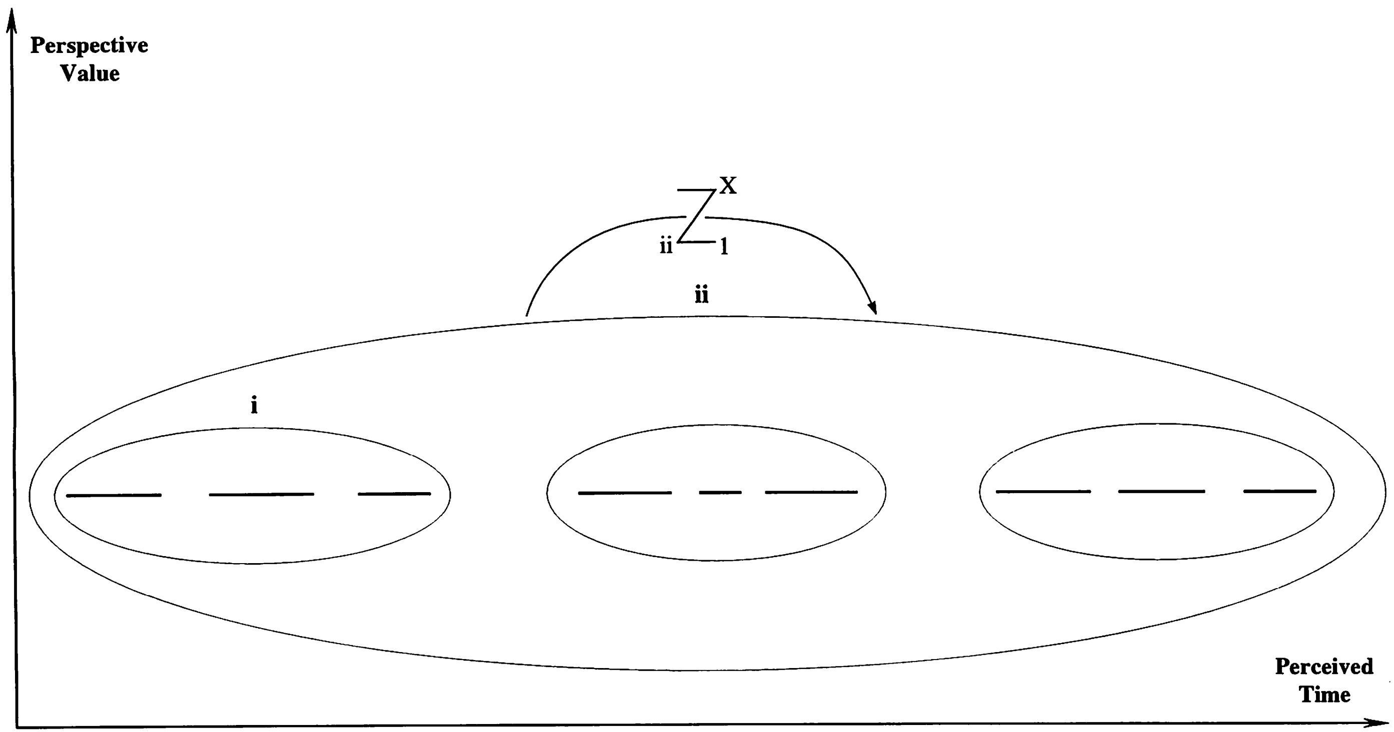


Figure 6.72 Primary zygonic constant system, order ii (cf. figure 9.6).

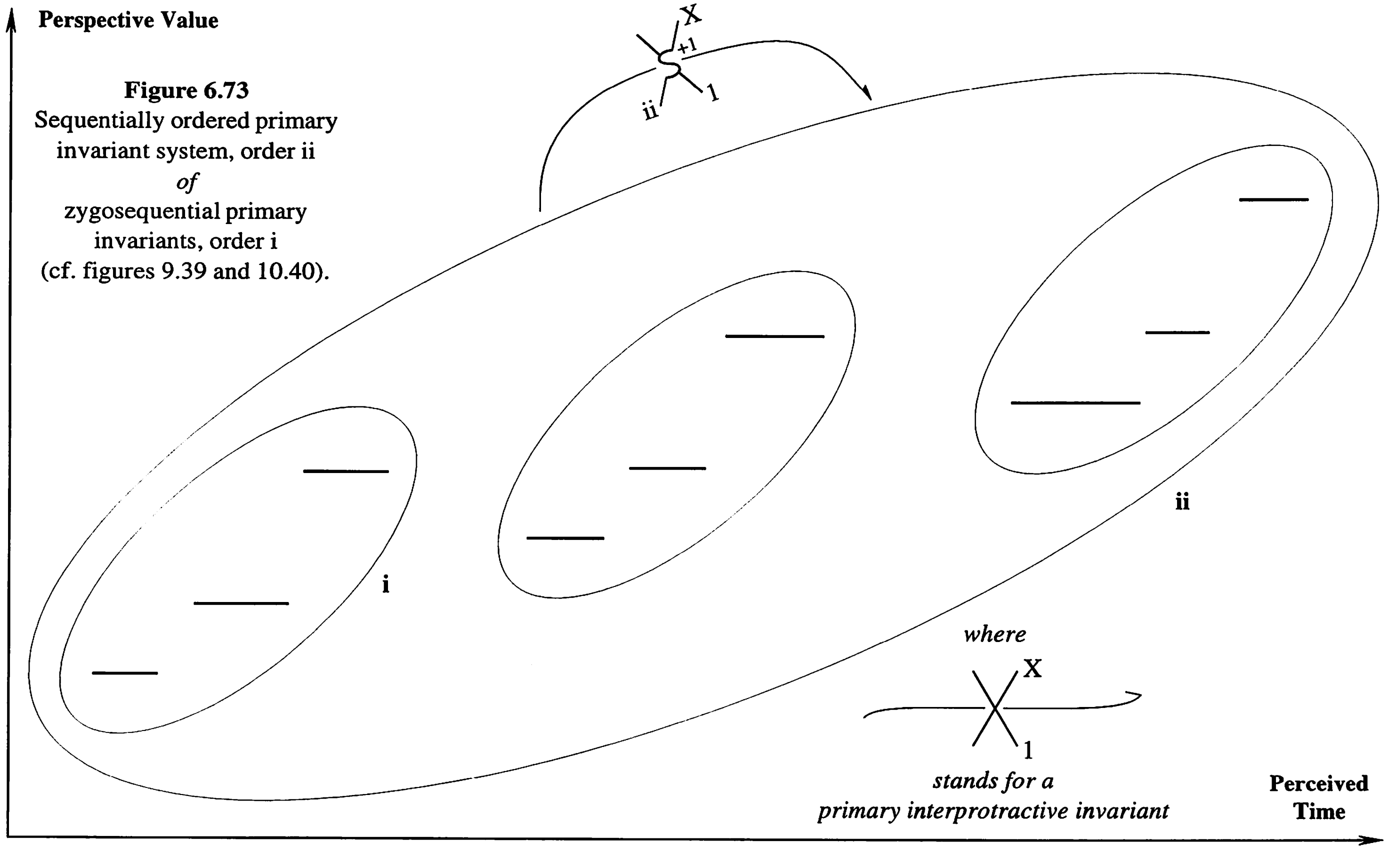


Figure 6.73
Sequentially ordered primary invariant system, order ii
of
zygosequential primary invariants, order i
(cf. figures 9.39 and 10.40).

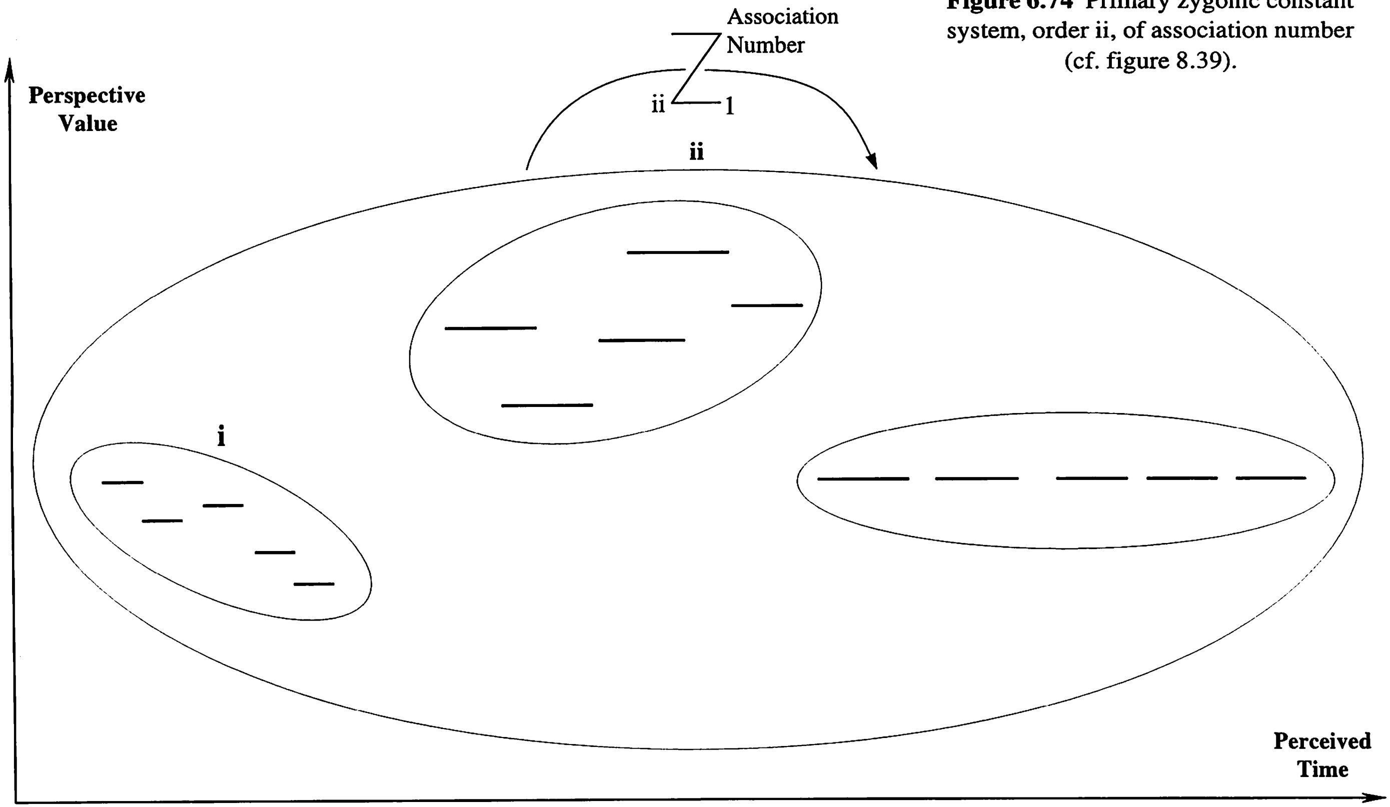


Figure 6.74 Primary zygonic constant system, order ii, of association number (cf. figure 8.39).

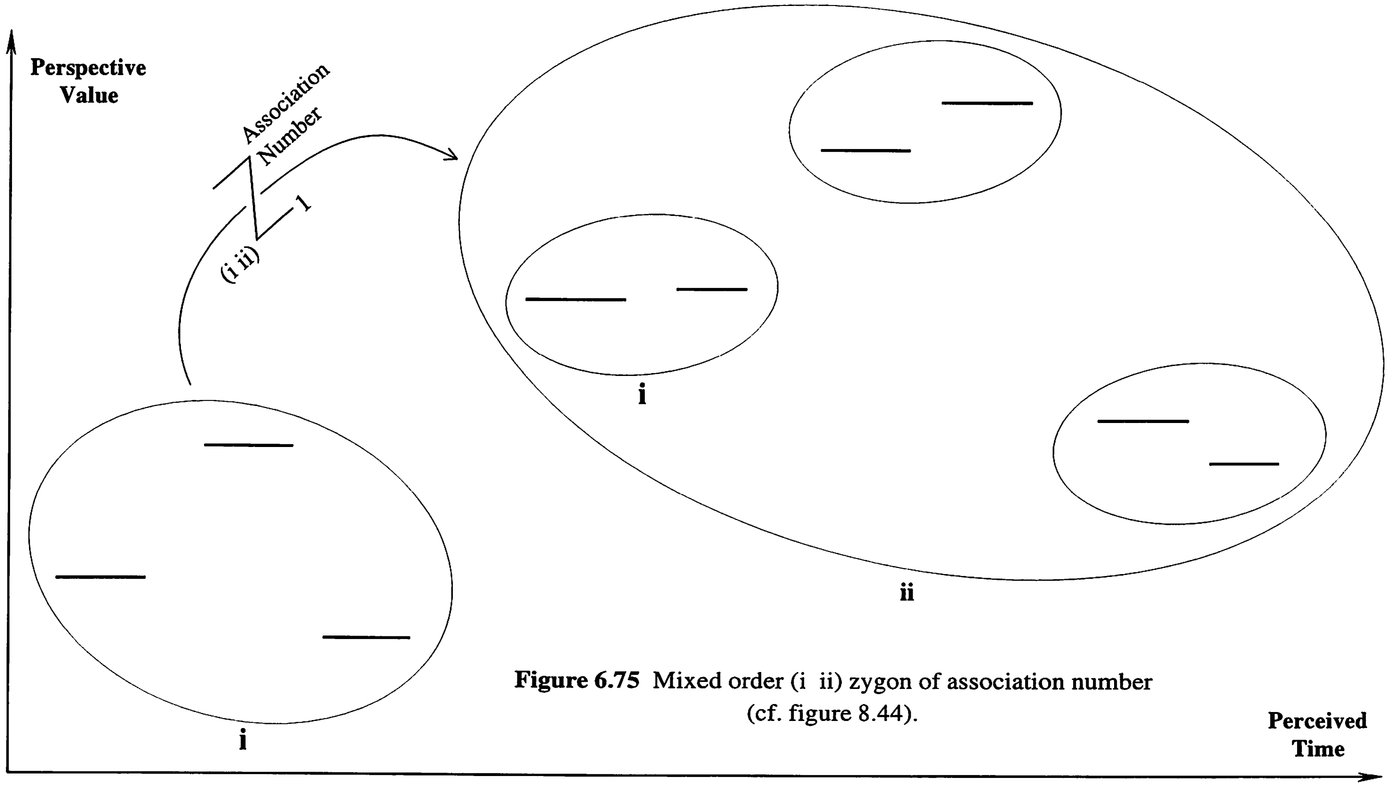


Figure 6.75 Mixed order (i ii) zygon of association number (cf. figure 8.44).

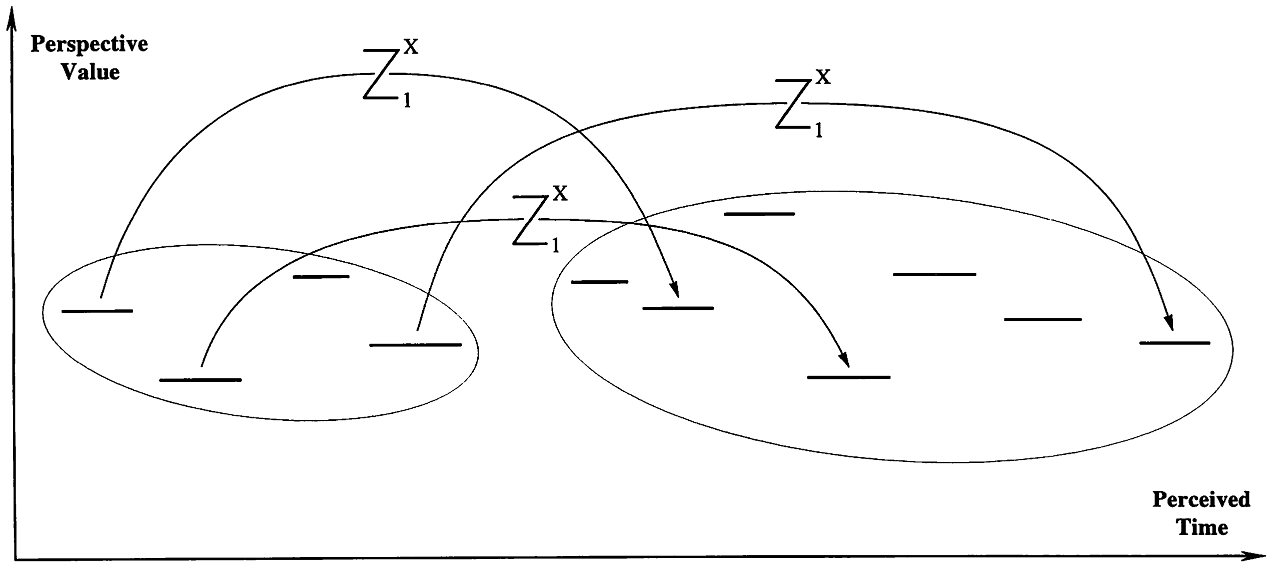


Figure 6.77 One association related to another through a primary zygonic invariant, with the addition of other material (cf. figures 10.74ff).

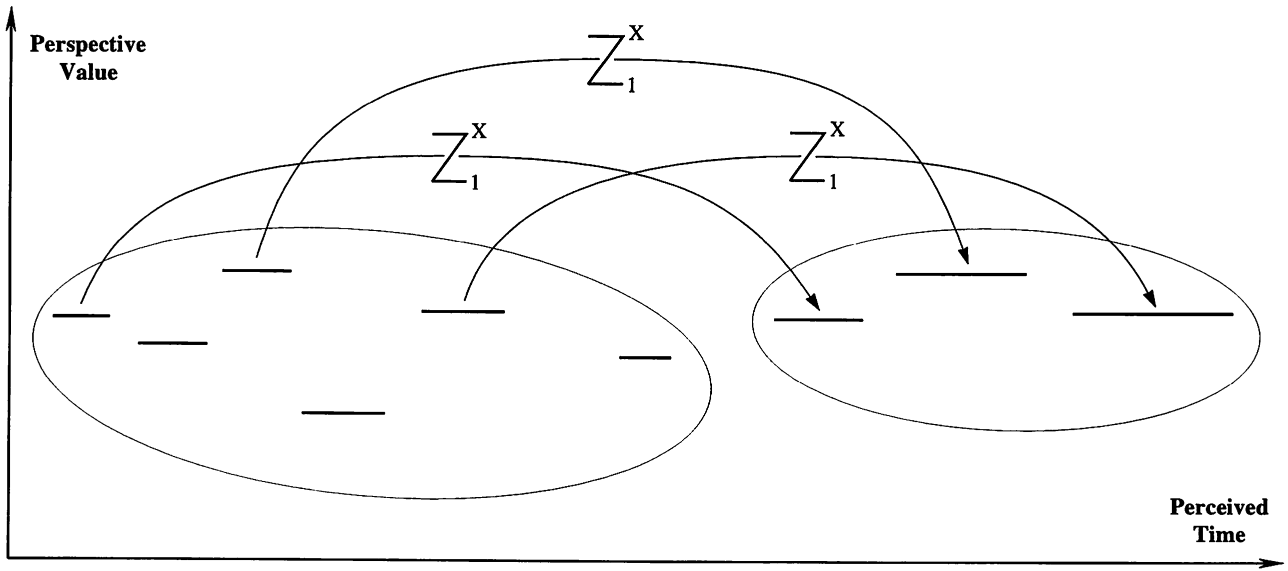


Figure 6.78 Associations related with the omission of material (cf. figure 9.123 and 10.80).

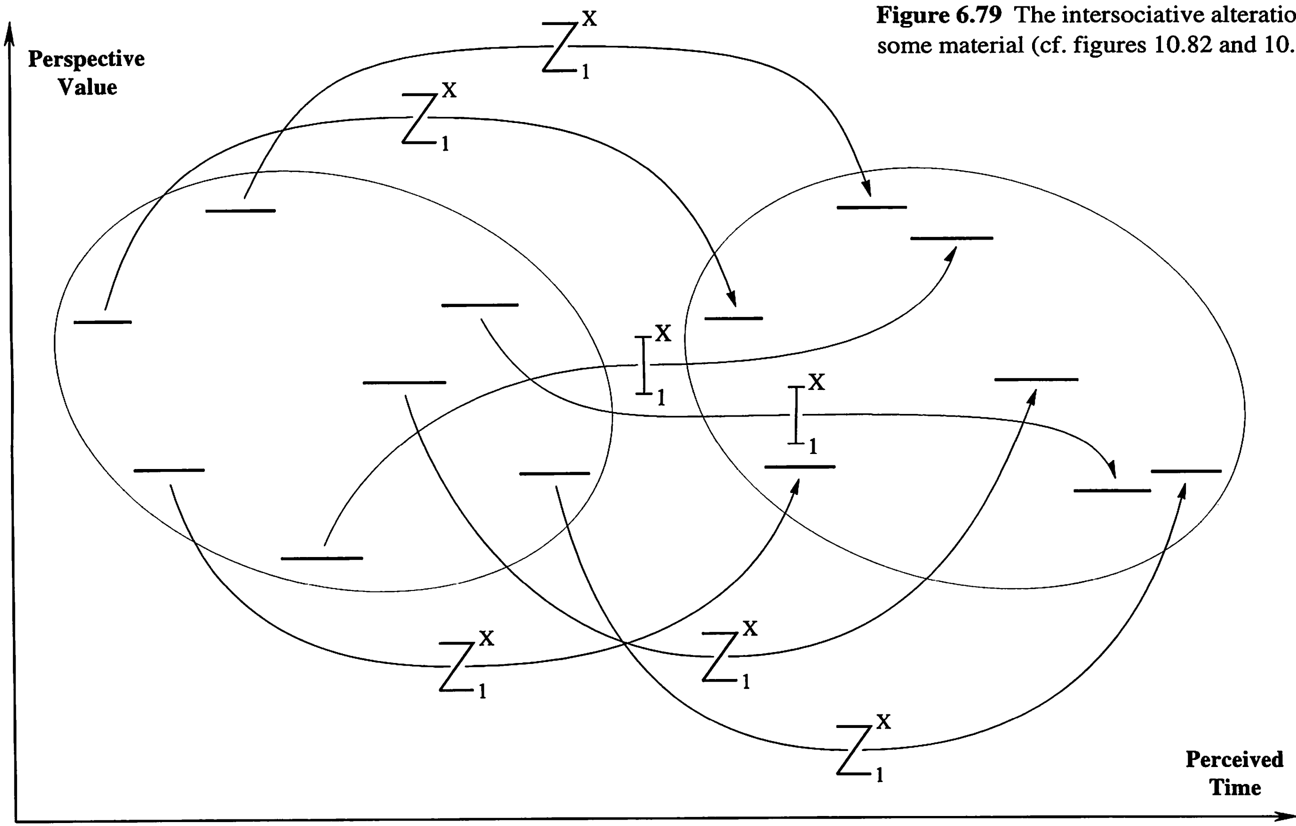


Figure 6.79 The intersociative alteration of some material (cf. figures 10.82 and 10.83).

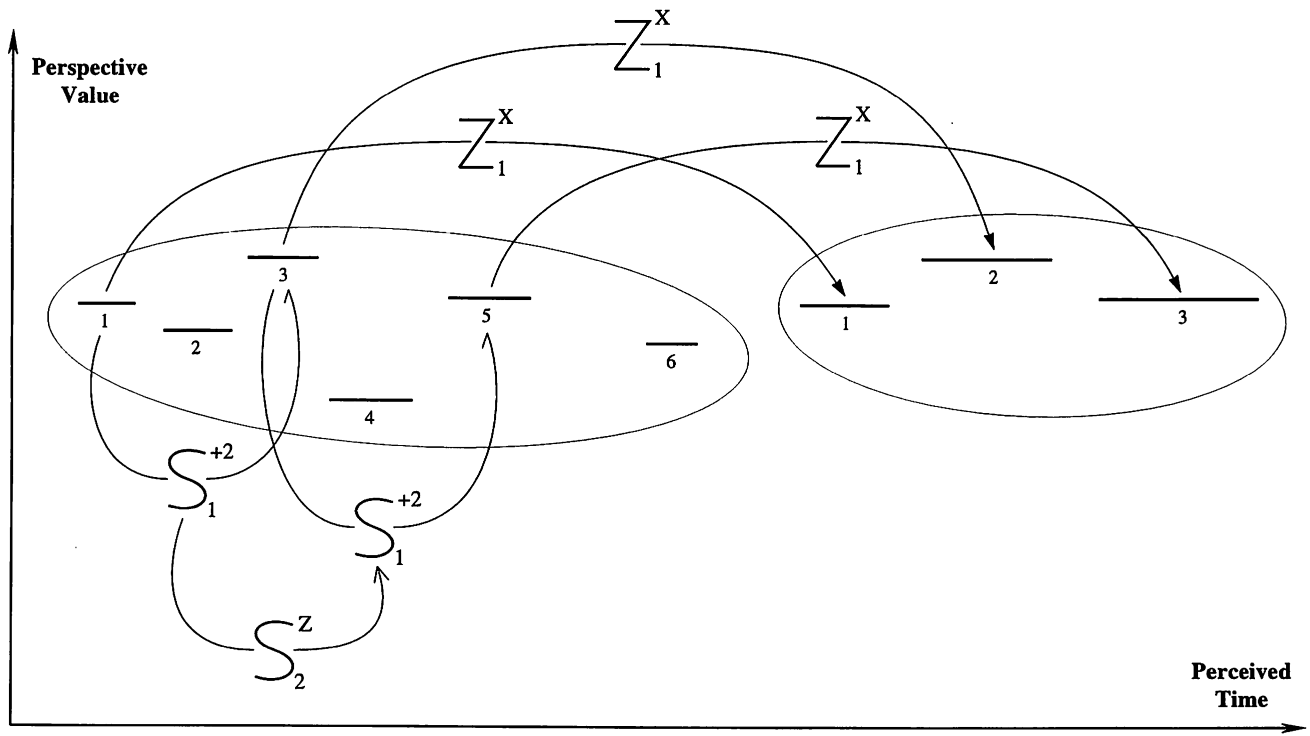


Figure 6.80 The orderly omission of material shown through relationships of sequence (cf. figure 10.81).

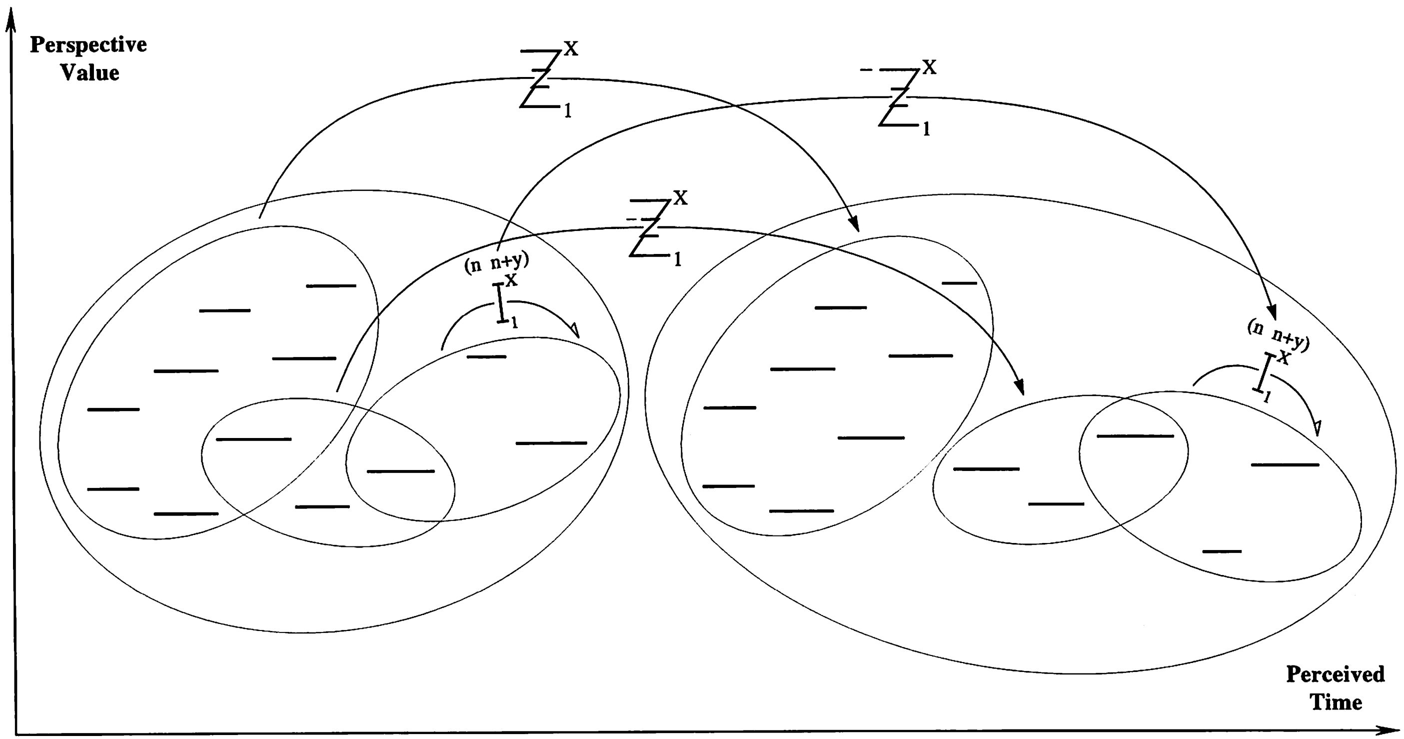


Figure 6.81 Compound intersociative connection involving repetition, retrogression and inversion (cf. figure 10.84).

The addition, omission and alteration of material; compound intersociative relationships

The relationship between one association and another may be partially ordered and partially free if either contains some material for which no correspondence can be found in the other. There are principally three ways in which this can occur (cf. Repp, 1996): through

(i) the *addition* of material (see figure 6.76),
(ii) the *omission* of material (see figure 6.77), and
(iii) the *alteration* of material (see figure 6.78).

The addition or omission of perceived sonic material from associations may be orderly with respect to sequence. See, for example, figure 6.79.

The relationship between one association and another may be wholly orderly, but in different ways. For instance, an intersociative link may involve repetition, retrogression and inversion (figure 6.80). Many other forms of compound intersociative relationship are, of course, possible.

Canonic organisation and *Gestalt* grouping principles

This chapter has examined ways in which groups of perceived sounds may be ordered through repetition. Here, we consider the connection between canonic organisation and the principles of *Gestalt* perception.

The 'chunking' of information (Miller, 1956) is a general feature of music cognition (see, for example, Harwood, 1976, p. 531; Deutsch, 1980, p. 381; Lerdahl and Jackendoff, 1983, p. 13; Serafine, 1983, p. 171; Sloboda, 1985, pp. 154ff). As Cooper and Meyer (1960, p. 2) put it:

> just as letters are combined into words, words into sentences, sentences into paragraphs, and so on, so in music individual tones are grouped into motives, motives into phrases, phrases into periods, etc.

Here, the term **holon** will be used in referring to refer to any complement, configuration or association that is felt to form a discrete event—a more or less separable perceptual entity—in its own right (see Meyer, 1973, p. 13).[8] Since elements and protractions constitute individual perceived sonic items too, they can also be regarded as holons, and many of the comments that follow applicable to them.

It has been shown that much of the perceived grouping of sounds can be explained in terms of *Gestalt* organisation, through features such as 'proximity', 'similarity', 'good continuation' and 'common fate' (see, for instance, Vernon, 1934; Deutsch, 1982, pp. 100 and 101; West, Howell and Cross, 1985, pp. 47 and 48). It can be argued that percepts such as these are underpinned by the cognitive acknowledgement of repetition, albeit at a subconscious level. Consider, for example, that to belong to a group members must share a characteristic that is not possessed by non-members—hence the implication of repetition. Group membership may be defined internally or externally (respectively through intrasociative and intersociative relationships). We being by examining internal grouping.

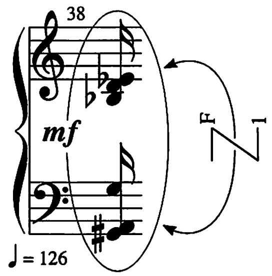
This may occur if a number of elements are identical in at least one perspective domain, the common value or values they possess being the shared feature that is needed to form a group. The presence of a primary intrasociative constant system (see pp. 164ff) is therefore implied. A holon may be determined less precisely if a restricted range of values is permitted, suggesting the operation of an imperfect intrasociative constant system. Non-membership is defined by a marked departure from this close alignment. Perceived sonic events may also form a group if adjacent values are related in the same way, implying the presence of a sequentially ordered primary intrasociative invariant system (see pp. 179ff). Grouping may occur too on the basis of consecutive secondary relationships being identical, that is, through a sequentially ordered secondary invariant system (see p. 183ff).

The boundaries of holons exist in essentially two dimensions: perceived time, and a perspective domain other than that of fix. With regard to the perceived temporal dimension, grouping through a constant system of fix forms a chord. See, for example, figure 6.81.

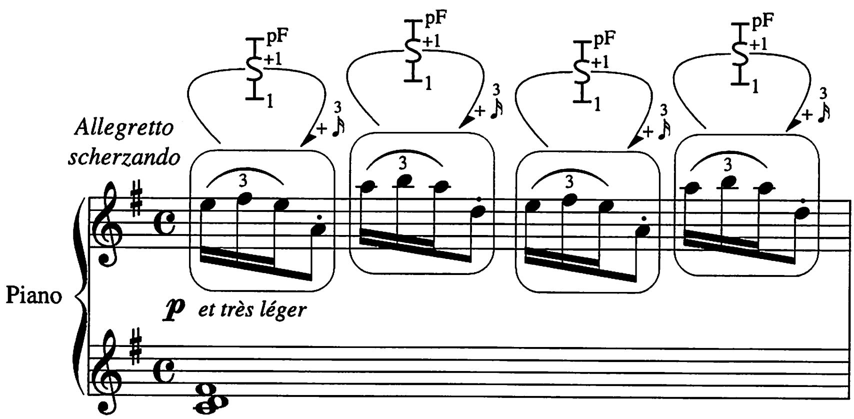
8Observe that while phrases, periods, sentences and sections form holons, motives need not. For example, 'an ascending fourth' constitutes a motive which is not necessarily holistic. The term 'figure' can be used to mean a motivic holon (cf. *Chambers 20th Century Dictionary* (1983) definition: "a group of notes felt as a unit").

Babbitt:
***Three Compositions for Piano* (1947);**
I

Figure 6.81 Grouping through a constant system of fix; a chord.



An invariant system produces a coherently spaced succession of perceived sonic events.[9] For example:



Debussy:
***Deux Arabesques* (1888);**
II

Figure 6.82 Grouping through invariant systems of prefix.

[9]At the level of elements, such a succession results in their characteristic continuity of perceived sound, whose cessation produces a group boundary. For example:

Machaut (c.1300—c.1377):
Le Lay de Confort

* plus the smallest discriminable perceived temporal increment

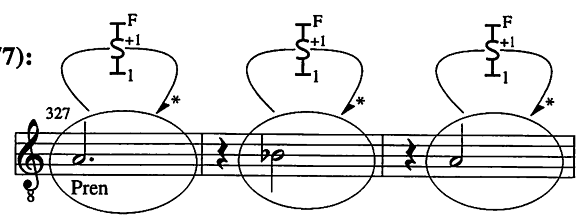


Figure 6.83 Grouping by proximity at the level of elements.

In *Gestalt* terms, groups such as these accord with the concept of proximity (see, for example, Lerdahl and Jackendoff, 1983, p. 45). Groups of non-temporal perspective appearances governed by a constant system (perfect or imperfect) follow the same *Gestalt* principle.[10] For instance:

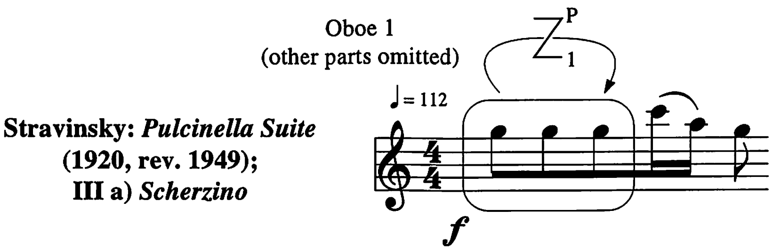


Figure 6.84 Grouping through a constant system of pitch.

An invariant system produces the effect of grouping by good continuation (cf. Deutsch and Feroe, 1981, p. 516). For example:

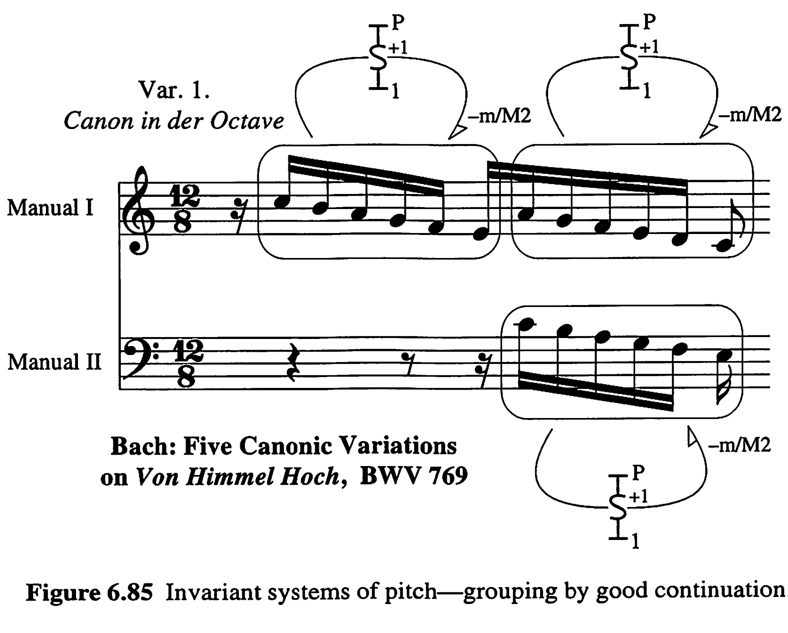
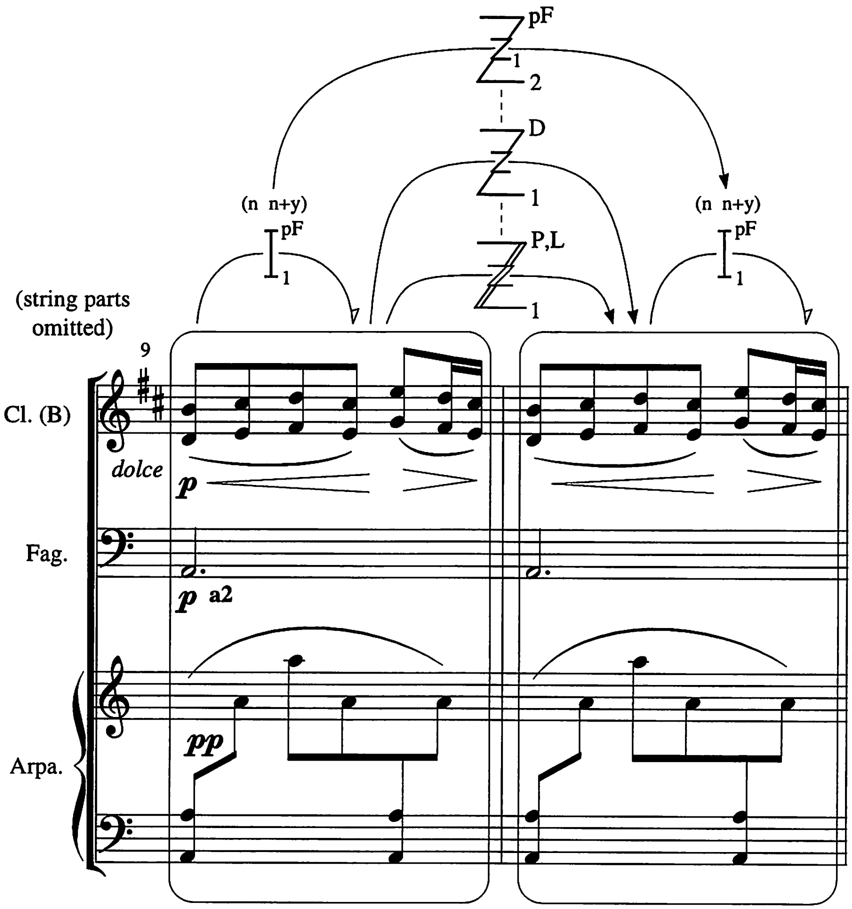


Figure 6.85 Invariant systems of pitch—grouping by good continuation.

[10]At least in the case of metathetic perspects, such as pitch, illustrated in figure 6.84. For prothetic perspects, however, such as loudness, 'similarity' may provide a more apt description of the attribute by which perspective apperances may be grouped.

Externally, grouping may be indicated if a number of perspective appearances share a common relationship or relationships with others elsewhere. For example:



Janáček: *Lachian Dances* (1889); I, *Starodávný* (I.)

Figure 6.86 Grouping induced through the operation of parallel intersociative zygonic invariants of prefix, duration, pitch and loudness.[11]

Ordering of this type produces the *Gestalt* effect of organisation through a common fate (West, Howell and Cross, 1985, p. 48).

[11]Coordinated ordering such as this is given detailed consideration in chapter 11.

It is not necessary for an entire group to be repeated for boundaries to be established. For instance, a complement may end quite unambiguously through the principle of proximity (with the termination of an invariant system of fix), and the way in which it concludes in a given perceived non-temporal perspective realm may be adopted by subsequent configurations, whose fixes alone offer no indication of group structure. The classic example of this technique is use of the cadence,

> a culturally established way of indicating the closure of a group. (West, Howell and Cross, ibid.)

Conclusion

The relationships presented in this chapter pertaining to constant associations may be classified as follows (cf. figure 5.96):

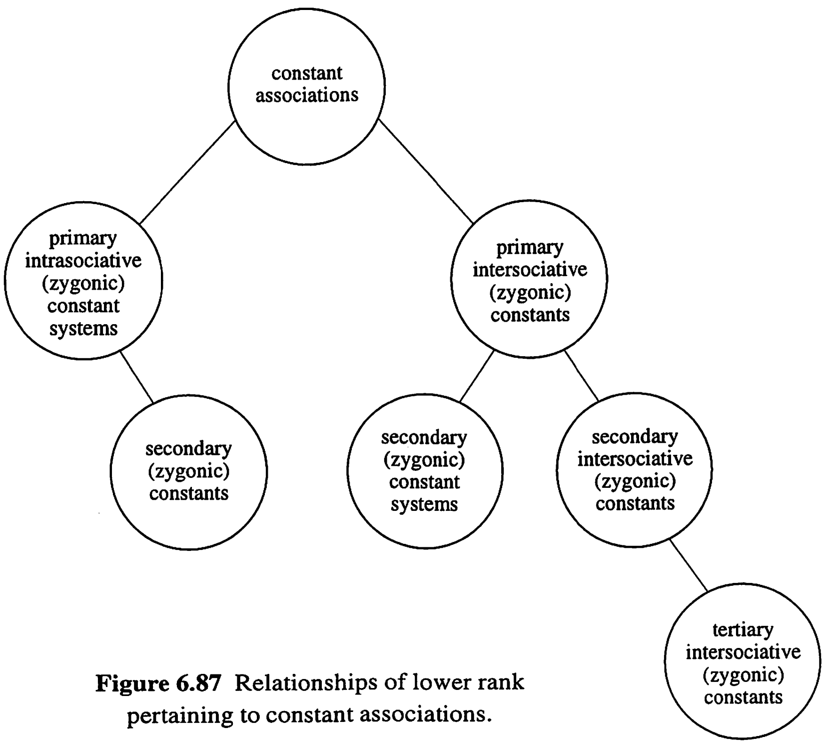
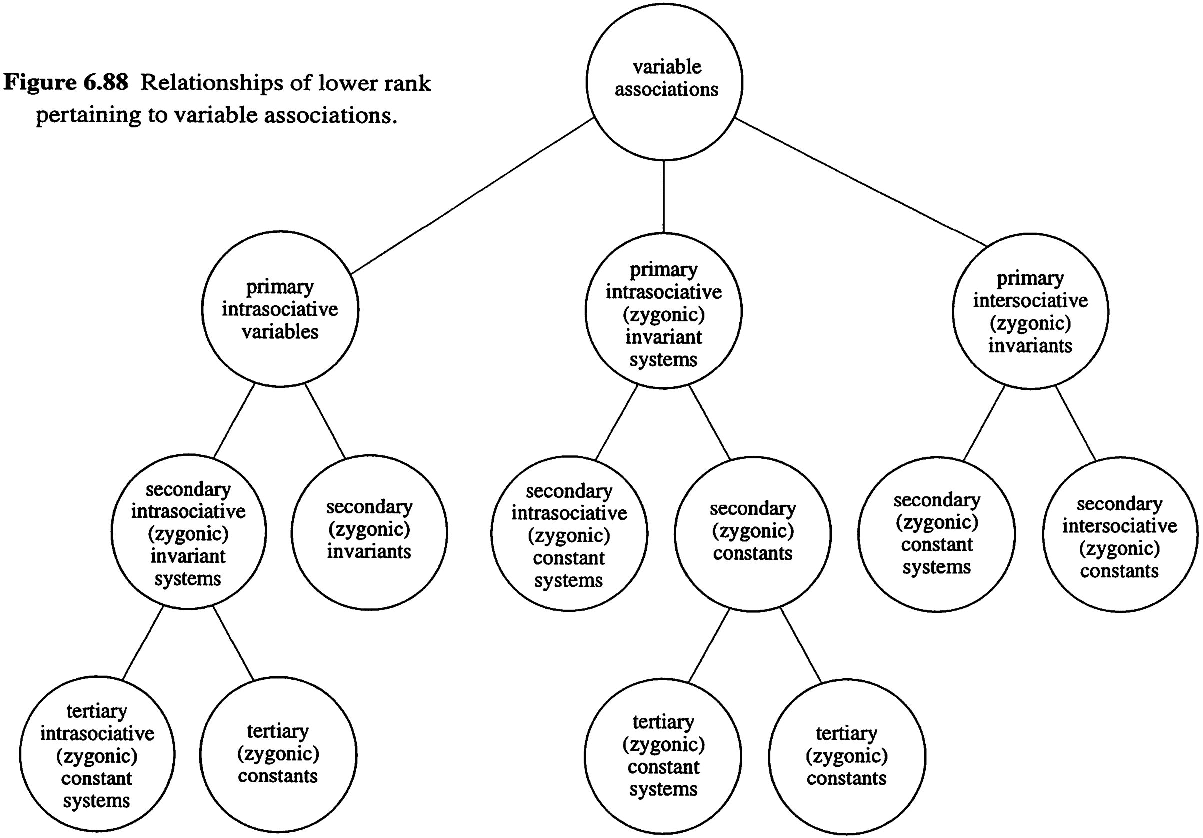


Figure 6.87 Relationships of lower rank pertaining to constant associations.

Figure 6.88 Relationships of lower rank pertaining to variable associations.



The relationships pertaining to variable associations that have been described are shown in figure 6.88.

Finally, it is appropriate at his stage to set out the divisions of perceived sound that have been proposed to date:

'horizontal' component

'vertical' component

	smallest imaginable instant	normal unit	group
perceived sound complete	**moment**	**element**	**complement**
pitch and the temporal perspects			**configuration**
individual perspects	**particle**	**protraction**	**association** - - - - - - - - **continuum**

Figure 6.89 Proposed divisions of perceived sound.

With the conclusion of this chapter, the 'theoretical' section of the book is complete. The chapters that follow investigate how the theory that has been postulated applies to music in practical terms.

7

The order pertaining to composing, performing and listening

Introduction

This chapter equates the model of perceived sonic ordering presented in chapters 4–6 with the three fundamental stages in the process of musical communication: composing, performing and listening.

The order pertaining to composition

Various non-canonic influences constrains composer in the creative act. Among these, perceptual thresholds are fundamental: there would be no musical virtue in decreeing a level of loudness too quiet to be heard, for example, or in prescribing two separate pitches that were so similar as to be indistinguishable. Then, with the feasibility of performance in mind, composers must take due account of the availability of instruments, players and singers, whose technical limitations have to be respected as well (see, for example, Carter, 1960, pp. 196ff). Moreover, it may be necessary to comply with the demands of a commission, or at least to conform to certain societal expectations;[1] consider, for instance, Shostakovich's fifth symphony (1937), which its composer dubbed a:

[1]In fact, just as all artists, whatever their fields of endeavour, are products of society, so ultimately are the works they produce: the influence of a culture on pieces written within it is fundamental (see, for example, Lomax, 1968, pp. 6ff).

"creative reply to just criticism". (Schwarz, 1972, p. 130)

Factors such as these, which considerably curtail the freedom of composers while lying, for the most part, beyond their control, inevitably restrict the ordering that they may choose to impose.[2]

Composers may opt to order some aspects of their music through extra-musical canons (see Kivy, 1984). The most straightforward of these entail the imitation of perceived sounds from outside music, with varying degrees of approximation. Examples in the Western literature range from the mimicry of bird-song, such as that found in the opening of the second movement of Beethoven's *Pastoral Symphony*, Op. 68, to Mossolov's evocation of *The Iron Foundry* (1928). At a less immediate level, the structure of external objects and events may be represented musically. Instances of this technique range from Handel's use of fugal imitation in Part I of *Israel in Egypt* (1739), which illustrates Moses leading his followers, to Smetana's depiction of the river *Vltava*, as it flows from its source to Prague (*Má Vlast*, II, 1874). As Cage has shown, it is even possible for music to reflect an apparent lack of order. In *Music of Changes* (1951), for example, the note-to-note procedures and to an extent the structure were determined by tossing coins (Cage, 1952/1961, pp. 57ff). Finally, it is worth remembering that Western composers have long adapted abstract notions from other systems of thought (Kirchmeyer, 1962/1968). The cantus firmus of Josquin's *Missa Hercules Dux Ferrariae* (printed 1505), for instance, is derived from the vowels of its dedicatee's title, suitably transformed by using the solmisation syllables of the Guidonian hexachord (Reese, 1954, p. 236). Later examples in similar vein include the theme of Schumann's *'Abegg' Variations*, Op. 1, and the numerous settings of the word 'Bach', including the one by Johann Sebastian himself in bars 235–237 of *Contrapunctus XIX* (BWV 1080)—see figure 7.1.

We now consider the place of canonic control in the process of composition. It seems inconceivable that, when devising a new piece, a composer would not bring his or her knowledge of other music to bear and, whether consciously or otherwise, model aspects of the latest work on those of compositions already in existence. This implies the operation of various types of proactive zygonic relationship between pieces, which may be

[2]Cohen (1962, p. 141), while recognising the power of restrictions of this type, makes the point that the composer is nevertheless presented with "a plethora of musical materials" from which to select and "to impose some sort of 'order'".

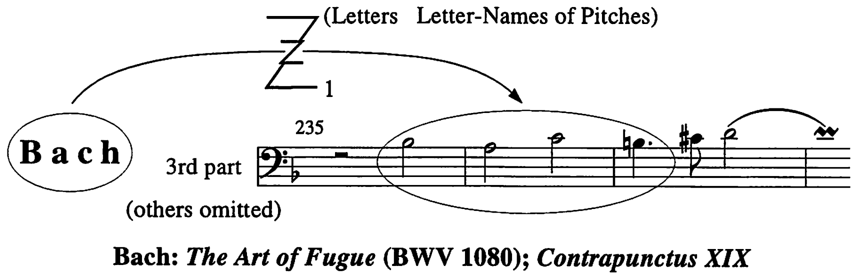


Figure 7.1 Pitches derived from the letters 'B–a–c–h'.

referred to as **interoperative.**[3] Such relationships are used in a variety of ways.

Apart from arrangements and adaptations, it rarely happens that a composer imitates a feature that was previously unique to one other work (or that is found, perhaps, in just two or three more), although examples do exist, such as the direct quotation of a theme (see figure 11.85). This implies the proactive utilisation of a single interoperative zygonic relationship.

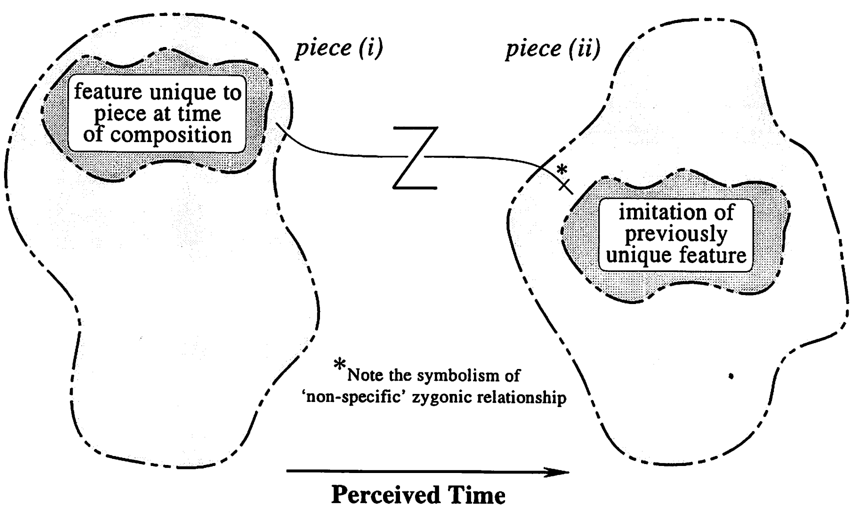


Figure 7.2 Imitation of a feature, previously unique to one piece, in another.

[3]I.e., an adjectival form of 'inter' (between) + 'opera' (works). The term 'operative' is used to refer to relationships pertaining to works in general.

Usually, the ideas that are borrowed lack the individuality of complete melodies: unobtrusively they find a place in many pieces, forming part of the vocabulary of a particular style. Every culture, it seems, subscribes to interoperative organisation of this type; indeed, the musical fragments that are used, and their manner of application, often become fixed in theoretical codes of practice. Consider, for example, the 'gusheh-ha' of classical Iranian music, which are used as models for improvised composition, providing the

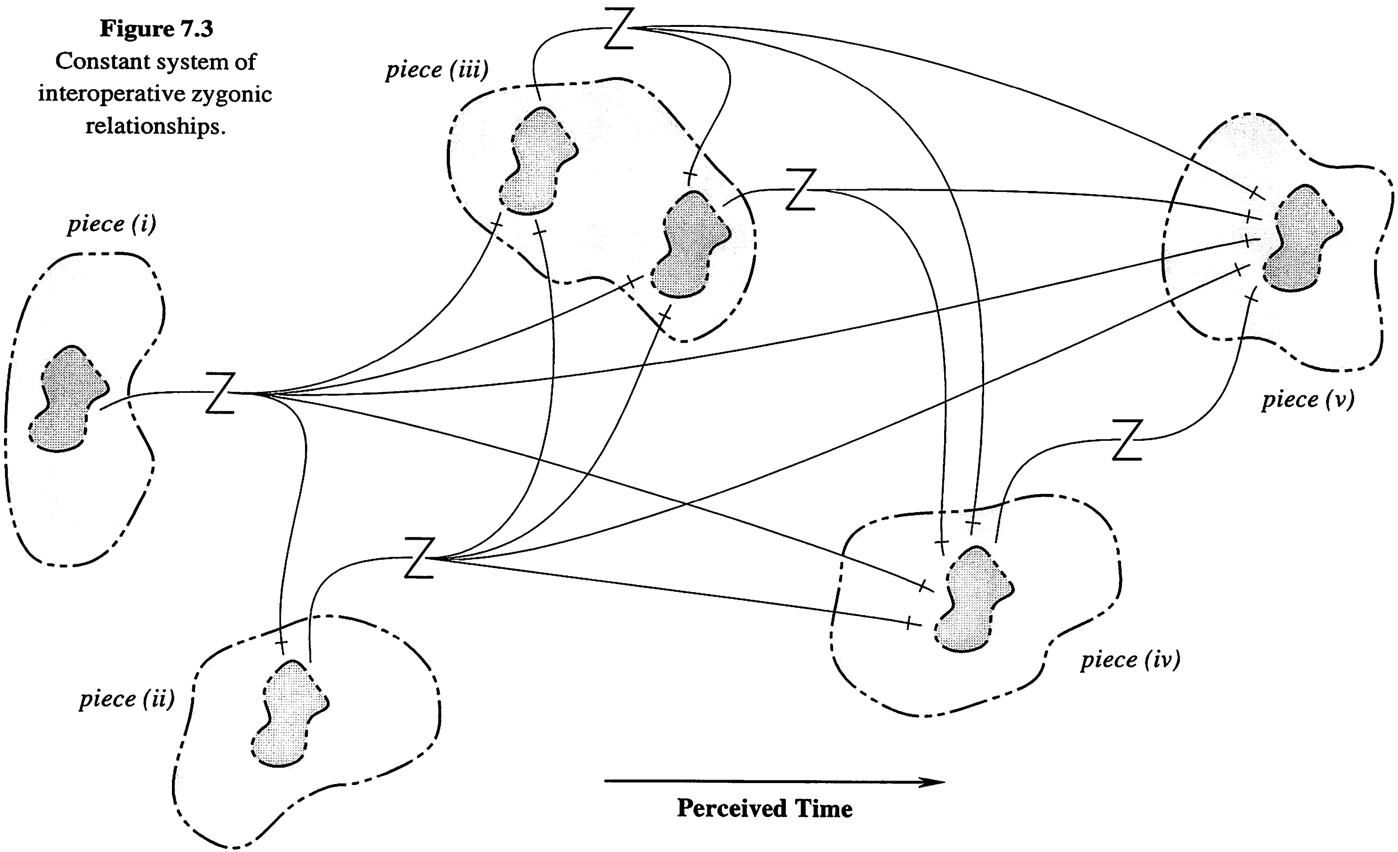
> modal and rhythmic features of the melody, its shape, and other features of mood and character that may be the sum of the above plus other, indefinable ingredients, such as extramusical associations. (Zonis, 1973, p. 46)

A composer may derive material like this through any of the numerous interoperative zygonic relationships potentially stemming from pieces in the appropriate style, or even hailing directly from an abstract model, such as the Iranian 'melody-type' described above (see Apel, 1969, p. 519)—a concept that was, after all, originally drawn from compositional convention. It follows that a constant system of proactive interoperative zygonic relationships may converge in the creation of a single musical component. This is shown in the following diagram, which traces the hypothetical transfer of a musical feature between five pieces. It is in the fifth of these that the chief convergence of zygonic relationships occurs (see figure 7.3).

By considering even smaller musical fragments, we move from complete stylistic archetypes (see, for example, Cumming, 1985, pp. 9 and 10) to single interperspective values (for instance, intervals of pitch) and even protractions. Here, attributes are encountered such as the perceived intraprotractive constancy or regularity of loudness, timbre and pitch (see, for example, pp. 281ff, 298ff and 451ff), whose utilisation is so pervasive that it transcends most cultural boundaries.

Organisation occurring within pieces may be termed **intraoperative**. The present theory suggests that composers structure material intraoperatively by deriving perspective or interperspective values through the imitation of a value or values previously selected. The number of possible orderly continuations grows rapidly with respect to the number of values taken as starting points. For example, starting from a single value, a perfect primary zygonic relationship provides one way forward, while imperfect primaries suggest many others, with varying degrees of control; see figure 7.4. (Here, values are limited to those outlined by the chromatic scale.)

Figure 7.3
Constant system of interoperative zygonic relationships.



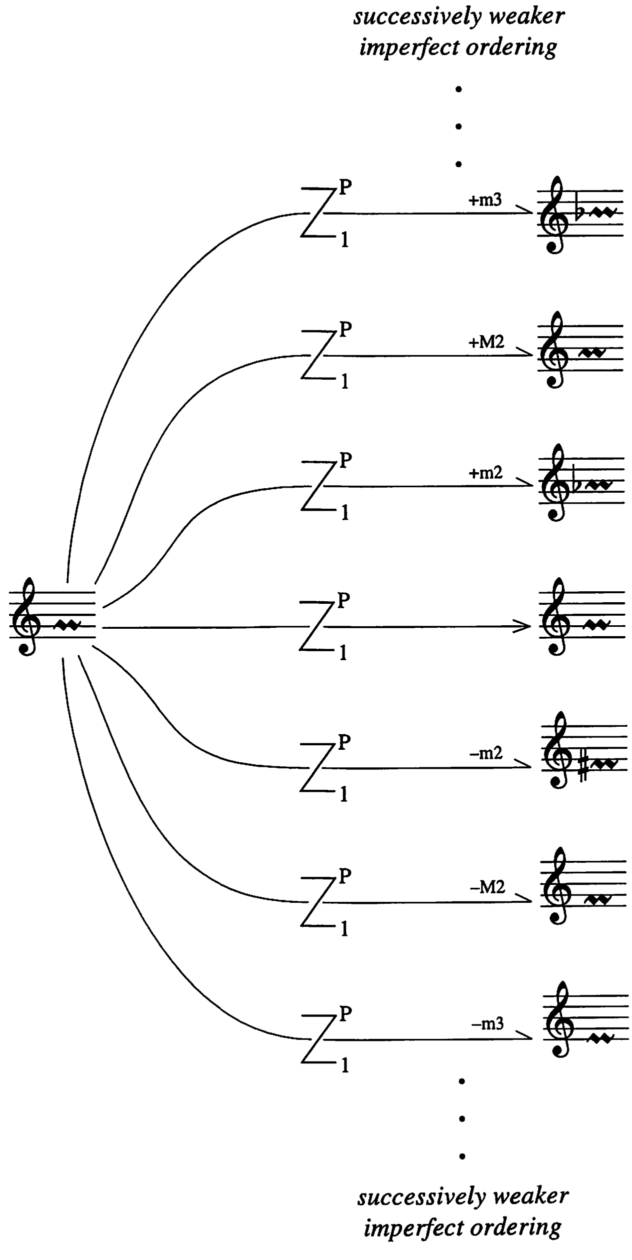


Figure 7.4 Zygonic projections from a single value of pitch.

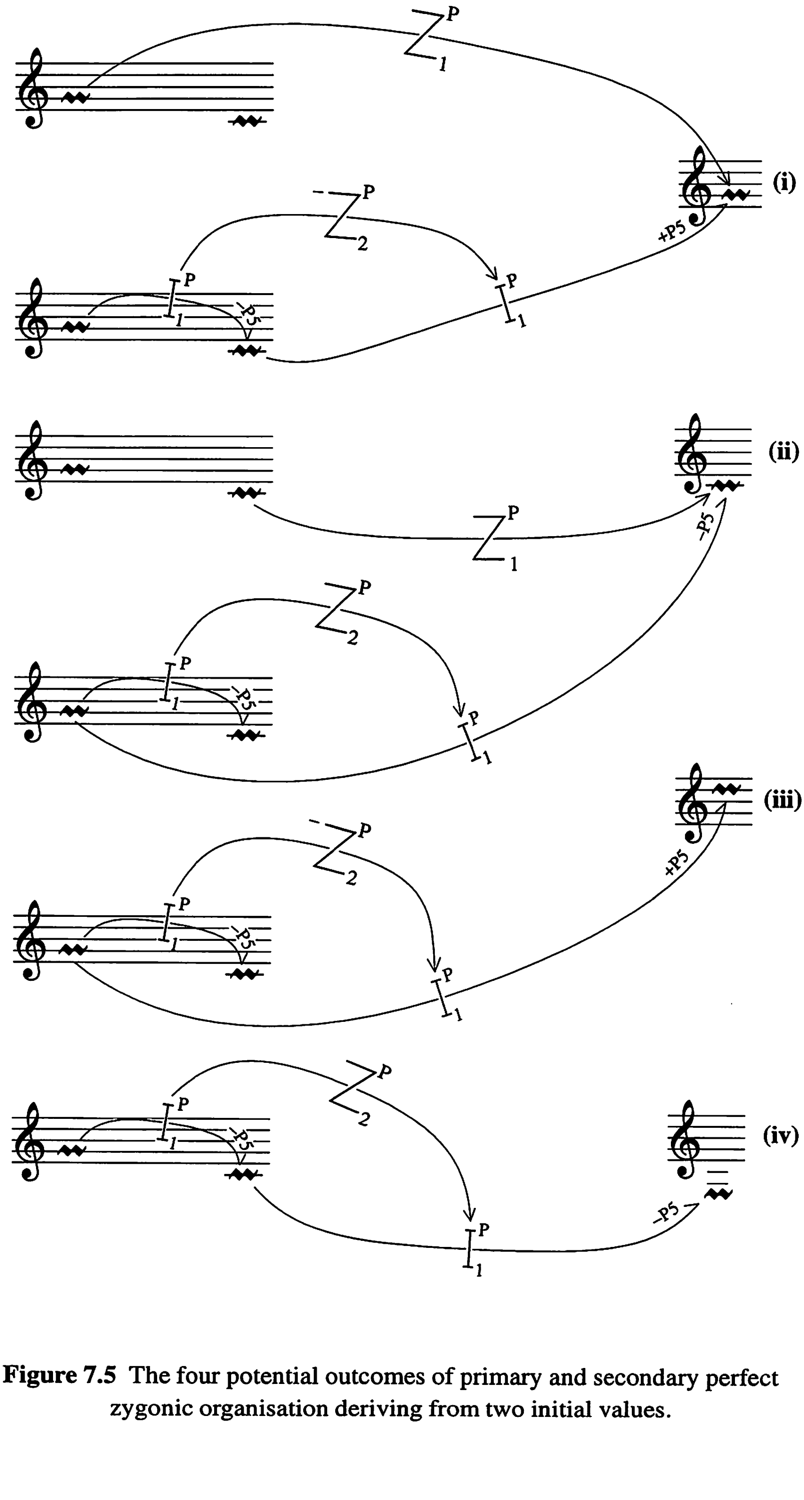


Figure 7.5 The four potential outcomes of primary and secondary perfect zygonic organisation deriving from two initial values.

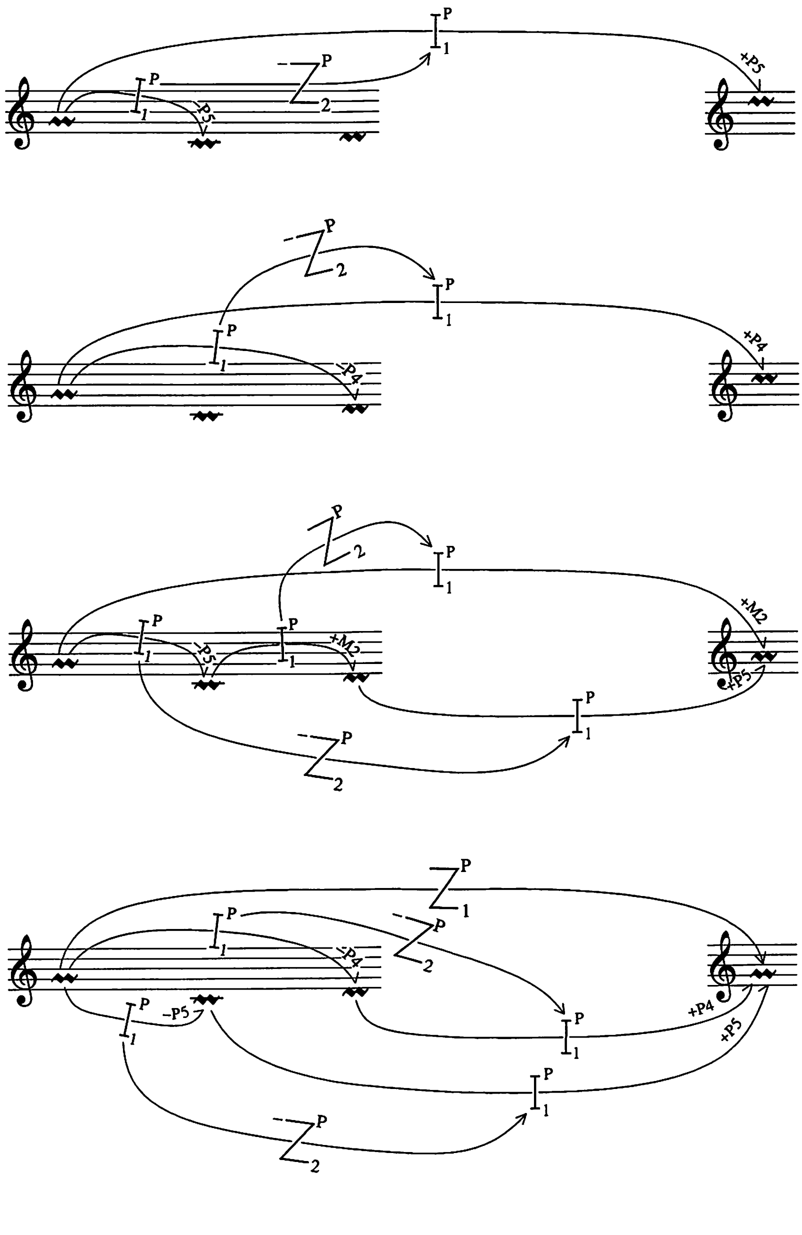


Figure 7.6 (part i) The thirteen orderly continuations from three starting values of pitch yielded by primary and secondary perfect zygonic relationships.

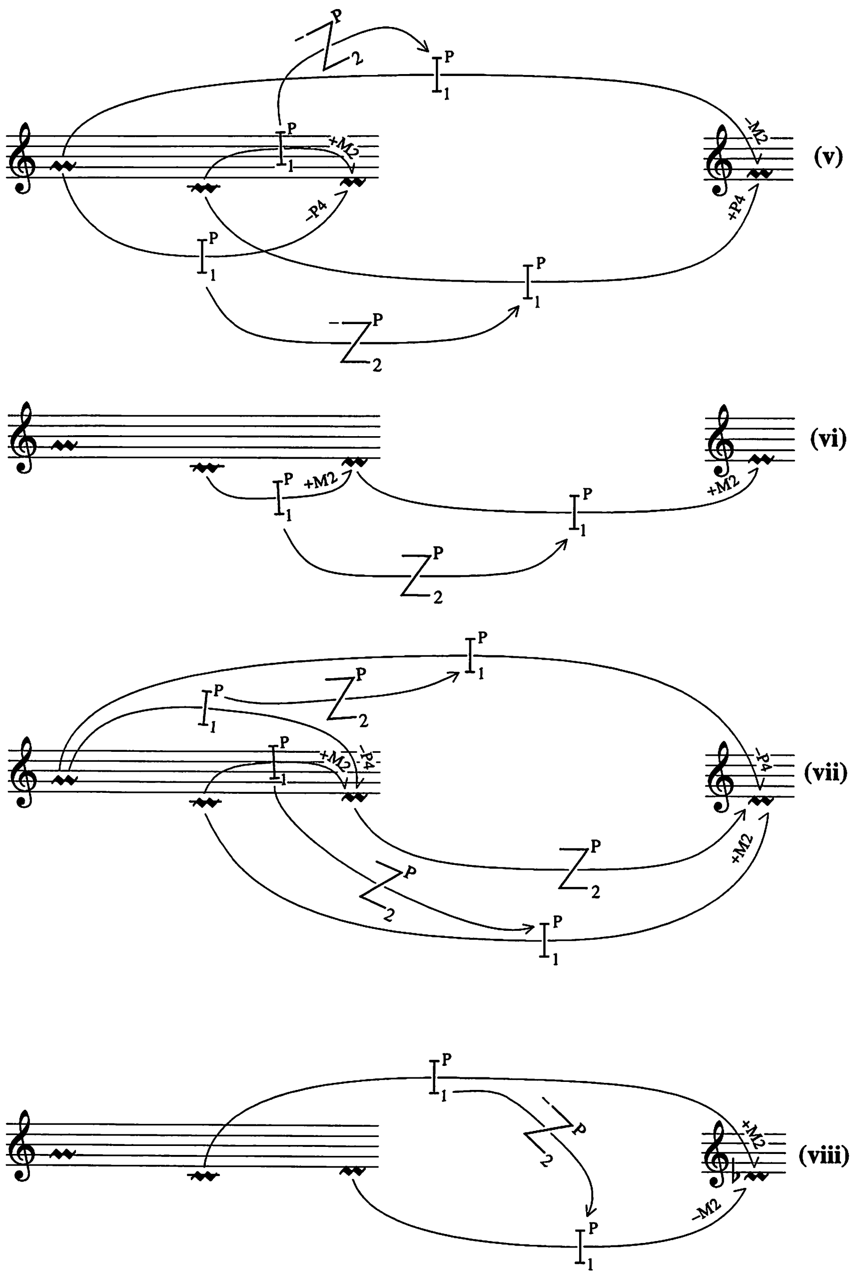


Figure 7.6 (part ii)

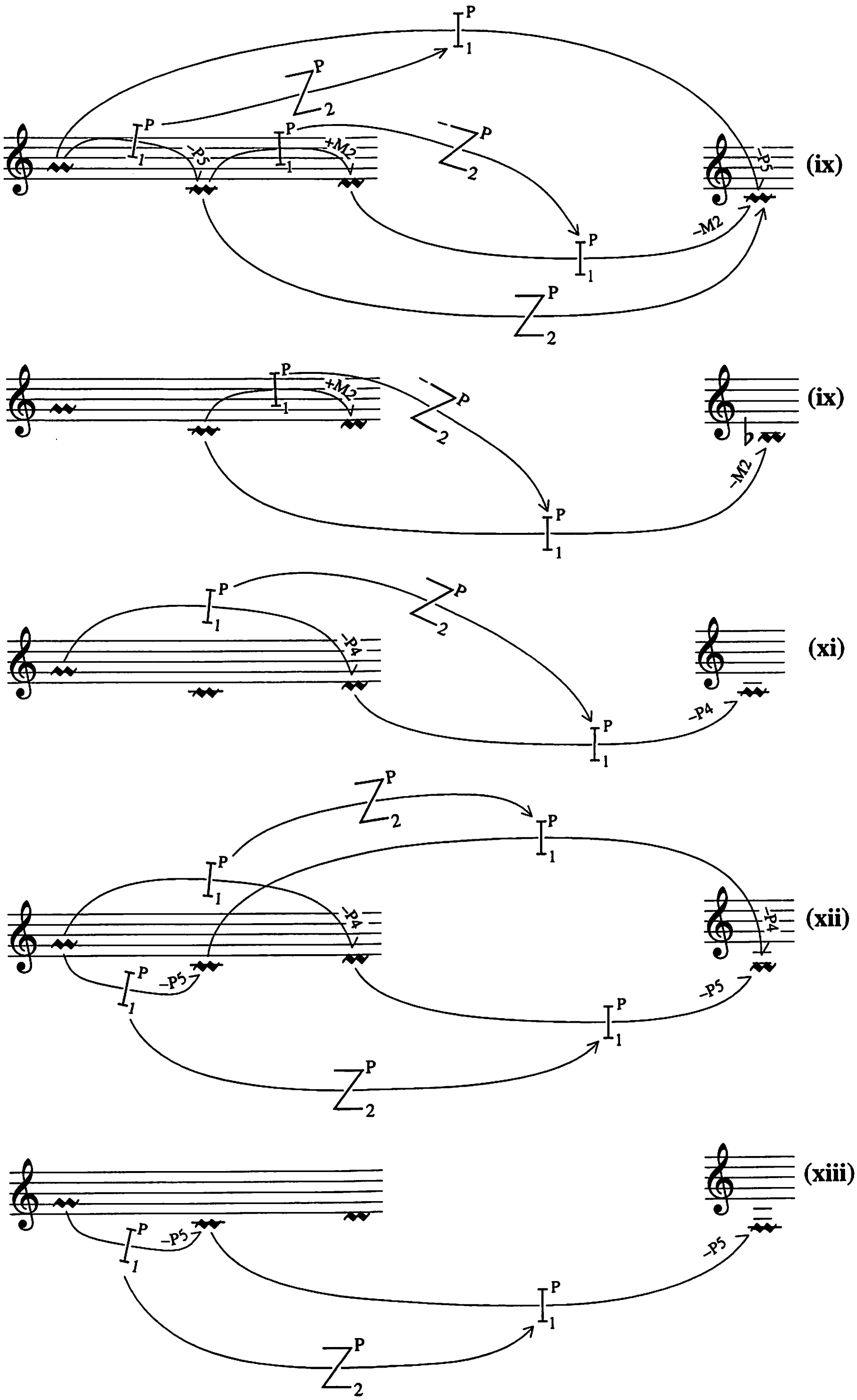


Figure 7.6 (part iii)

With two values, both primary and secondary zygonic relationships potentially offer routes to an organised future. Even if perfect relationships only are considered, and given the constraint that at least one of the original notes must be involved in the projection (rather than just the interval), four alternatives are still to be found; figure 7.5. (Observe that certain values may be derived in two different ways.) Three starting values have thirteen orderly continuations (cf. Ockelford, 1993, pp. 423 and 424); see figure 7.6.

Clearly, with the virtually limitless array of orderly options that just a few values offer, the use of zygonic relationships acting individually, even in substantial numbers, would in no way guarantee the production of a coherent musical structure. For this to be achieved, the relationships used must themselves be disposed in an orderly fashion. *Intra*holistically (that is to say, within a holon), such control may be gained by employing a series of similar relationships, implying the operation of constant or invariant systems. The other alternative, to place similar relationships in parallel, produces *inter*-holistic constants or invariants. These two effects may be equated with Meyer's notions of 'process' and 'form' (1973, pp. 97ff)—though see pp. 657ff. The ways in which intraholistic and interholistic groups of relationships have manifested themselves musically is examined, perspect by perspect, in the chapters that follow.

As composers' sketchbooks and revisions indicate, various potential solutions may be tried out before a final selection is made. Equally, different developments of the same material may result in separate works: consider, for example, compositions based on a cantus firmus such as the *In Nomine*, which was favoured by English instrumental composers of the sixteenth and seventeenth centuries. It is even possible for much of the intraoperative organisation to be determined by the performer, and therefore to vary from one occasion to another.

In one sense, the task of the composer can be regarded as having to balance the forces of interoperative and intraoperative organisation.[4] Clearly, for a piece to stand as an entity in its own right it must be unique, yet this does not preclude any of the ideas or techniques that it may contain being derived, perhaps several times over, from other works; it is the way they are assembled that accounts for the originality of the whole. The manner in which internal and external ordering are counterpoised differs in detail from

[4]These may be equated respectively with stylistic analysis and critical analysis (see Meyer, op. cit., pp. 6ff); cf. also Sharpe (1993).

one composition to another, and is also subject to general historical and cultural variation (see, for example, Sachs, 1956, p. 18, for a comparison of Eastern and Western approaches). A level of borrowing that may incur a charge of plagiarism in one stylistic milieu may be found quite acceptable, even the norm, in another. Contrast, for example, the appropriations of Handel (see Taylor, 1906) with the position of Busoni (1911/1962, p. 88):

> The function of the creative artist consists in making laws, not in following laws ready made. He who follows such laws, ceases to be a creator.

This view notwithstanding, the need for composers to express themselves within established patterns appears to be incontrovertible and universal. Ackerman, for instance, in his theory of style (1962), observes that

> the artist cannot invent without reproducing; in order to make a meaningful innovation he must be able to concentrate his forces upon the few aspects of his work where circumstances favor fresh departures; for the rest, he relies on the support of his tradition and of his environment. An artist cannot invent himself out of his time and, if he could, he would succeed only in making his work incomprehensible by abandoning the framework in which it might be understood. (p. 228)

In conclusion, we consider why composers choose the forms of order they do, given the vast number of organisational options open to them. Why is one zygonic relationship selected in preference to another? Indeed, why, ultimately, are zygonic relationships chosen at all?[5] The answer must surely lie in the fact that canonic structures not only enable intelligible perceived sonic messages to be conveyed, but that such ordering is itself a facet of musical communication. As Selincourt (1920/1958, p. 156) puts it:

> in pure music, the meaning and the beauty are indistinguishable, and its greater like its lesser repetitions have no other aim than the development and creation of that meaning and that beauty. Repeatability is thus in music an element of the beautiful.[6]

[5]Observe that the value of repetition is culturally determined (Meyer, 1967, p. 52).

[6]Moreover, in likening the growth of a musical composition to that of a flowering plant, of which he says (op. cit., p. 155) "its repetitions are not redundancies; they are the means by which the fullness and soaring intensity of its life are exhibited", Selincourt unwittingly warns against the incautious application of information theory to music (see Cohen, 1962; Moles, 1958/1966; Beardsley, 1968; Arnheim, 1971, pp. 17ff). See also Kivy, 1993, pp. 352 and 353.

The order pertaining to performance

All performance is ordered to a greater or lesser extent by the wishes of composers. Circumstances other than the improvisation of a new piece demand that the directions for performance be conveyed to the performer. This may be achieved aurally, if a composer's execution of his or her work is heard and remembered by a player or singer, who subsequently reproduces it. The perceived sounds that constitute the new rendition, therefore, are ordered through the imitation of those that make up the old, implying the existence of **interterpretive**[7] zygonic relationships between the two realisations of the piece. However, by using notation, composers can intimate their requirements to other people without a note having to be played.[8] This implies an extended zygonic equation, through which perceived sounds (which may be purely in the mind of the composer) are echoed by the performer through the intermedium of a mutually agreed symbolic language.

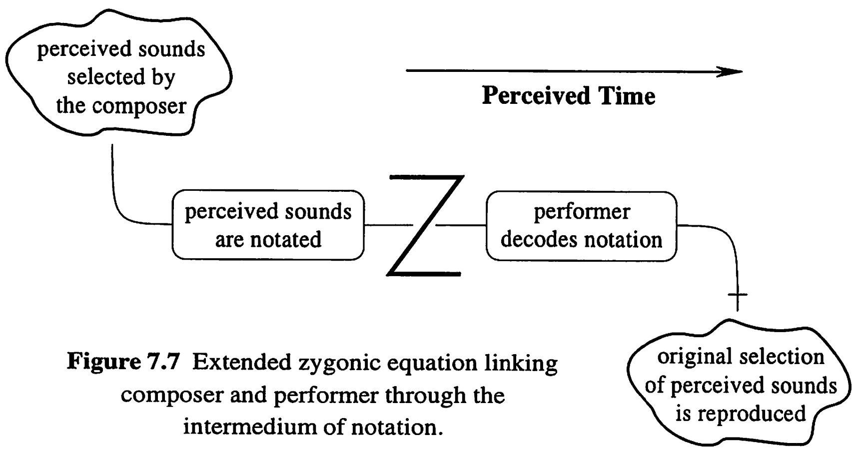


Figure 7.7 Extended zygonic equation linking composer and performer through the intermedium of notation.

[7]The word 'interterpretive' is derived from 'inter' + 'interpretive'; *i.e.*, 'between interpretations'. The family of relationships that pertain to performances as a whole may be termed 'interpretive' (cf. Meyer's use of the term, 1956, p. 173).

[8]The use, or non-use, of notation has various implications for musical order, since without it, performers must rely entirely on memory. It seems inevitable, therefore, that pieces intended to be learnt by ear should favour certain simpler types of perceived sonic organisation that lend themselves more readily to speedy learning and easy recall, while other more intricate structures are for the most part viable only with a system of symbols to assist in the process of memorisation (see Sloboda, 1985, pp. 242ff).

However a composer's wishes are communicated, performers' reception of them will inevitably be less than perfect. For example, orally transmitted pieces such as folksongs are subject to what Abrahams and Foss (1968, pp. 13ff) term 'degenerative' change, caused by mishearing and forgetting. Similarly, notation was originally conceived as nothing more than an *aide-mémoire* (Temperley, 1966, p. 323), and, despite efforts to make it more definitive, the blight of imprecision remains (see, for instance, Turner, 1938, p. 308; Moles, 1958/1966, p. 137; Martino, 1966): indeed, expressive deviations from a score are not only expected but required if the full communicative potential of the perceived sounds it prescribes is to be realised (Meyer, 1956, pp. 199ff). This means that renditions of a piece by a second party will have attributes that were not stipulated by the composer, but determined by the performer, who acts in part, therefore, as a composer too.

The balance between compositional control and the freedom enjoyed by performers varies from one style to another. In the Western classical tradition, for example, with occasional exceptions (such as the realisation of figured bass in some Baroque music), their liberty has been comparatively restricted: most executants of a Beethoven piano sonata, say, would take the underlying framework of pitch and rhythm to be a non-negotiable commodity, while treating tempo, rubato, phrasing, dynamic contrast and so on rather more flexibly.[9] The second half of the 20th century, however, saw radical developments in composition which is indeterminate in performance (see Cage, 1958/1961b, pp. 35ff), exemplified in works ranging from Boulez's third piano sonata (1957), through which the performer may select different 'routes', to Cage's *Renga* (1976) for orchestra, which uses graphic notation, and to Stockhausen's *Aus den Sieben Tagen* (1968), which consists merely of fifteen texts. Here, stipulations of a purely musical nature are minimal.[10] Consider, for example, *Goldstaub* ('Gold Dust'), in which a small ensemble of players is instructed to live completely alone for four days without food in complete silence, without much movement, sleeping as little as necessary and thinking as little as possible. Then, late at night, without conversation beforehand, they are enjoined to play single sounds. WITHOUT THINKING what they are playing they are told to close their eyes and just listen.

[9]Note, however, that in a coherent performance, expressive deviations of timing *etc.*, derive from the artist's understanding—whether intuitive or calculated—of the structure of the piece (see, for instance, Clarke, 1988, pp. 11ff). See also Repp (1996), who reveals pianists' (largely inconspicuous) divergencies from given scores.

[10]Though the extramusical demands may prove too exacting for many players!

Freedom on this scale shifts much of the creative burden onto the players, and in effect, the roles of composer and performer are merged. There is, of course, ample precedent for this dual function both in Western culture (such as jazz) and in others. The players and singers of Indian music, for instance, are not typically presented with a completed composition, but with a scheme to guide them in their individual creations. A performer is expected to

> reach the stage where he can play each *raga* in a new way every time without losing its characteristics, which are his guides. (Malm, 1977, p. 103)

Having examined how the single performance of a work relates to the composer's intentions, we now consider the bearing that different performances have upon one another. Just as composers do not work in a cultural vacuum, neither do performers. As Harwood (1976, p. 529) says:

> a musical performance relates to prior performances. That is, performers and listeners have expectations ... based on experience with other performances—other hearings in other contexts. New musical behavior always borrows from what has come before, since prior experience is a highly salient body of knowledge for environmental and social adaptation.

Certainly, an audience is likely to experience some distress if they find the execution of a familiar piece too revolutionary.[11] Consider, for example, Sams's (1981) criticism of Elly Ameling's rendition of Schumann's *Lieder-Album für die Jugend*, Op. 79 (on Philips 6769 037):

> Worst of all is the crass gimmickry of having the singer perform duets and trios with her own voice by some tiresome trick of superimposition. The resulting constraint and lack of contrast strike me as an imposition, and anything but super. Can Miss Ameling possibly believe that this three-Elly and two-Elly effect is really and truly what the composer intended?

The consistency that is expected to exist between interpretations of a piece means that performers must imitate the manner in which the free aspects of a composition have previously been realised, implying the operation of direct interterpretive zygonic relationships—see figure 7.8.[12]

[11]Cf. Repp (1997, p. 439) whose "findings lend support to the idea that an average music performance represents a prototype and an aesthetic ideal, at least in the sense that it is most similar, on average, to individual aesthetic ideals."

[12]Observe that such relationships may function through notation: consider, for instance, all except the *Urtext* editions of a piece.

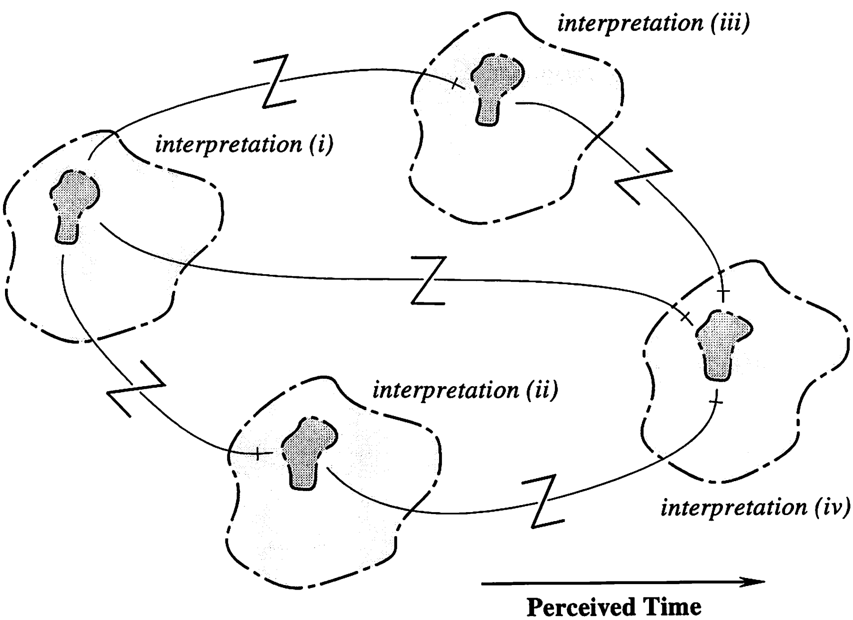


Figure 7.8 Interterpretive zygonic relationships between diffeent performances of a piece.

However, as well as the need for players and singers to render pieces in accordance with established practices, change is also a necessity:[13,14] too derivative a performance is likely to be censured just as much as one that exceeds the interpretive norms. Consider, for example, the following comments by Keyte (1986):

> A double album from the Hilliard Ensemble (Reflexe 27 0096 3) is devoted to the music of ... Byrd .... As an admirer of this group I must confess to a certain disappointment. The singing is polished and assured as ever, but all three Masses are given conventional interpretations .... .

Various reasons have been posited to explain this desire for innovation. For example, Meyer (1967, p. 51) notes that:

[13]Recording (as on tape or disc, for example) merely makes further hearings of the same interpretation possible. Physical ordering is involved here.

[14]Even the manner in which composers interpret their own works may well differ from one occasion to another (Busoni, 1911/1962, p. 85).

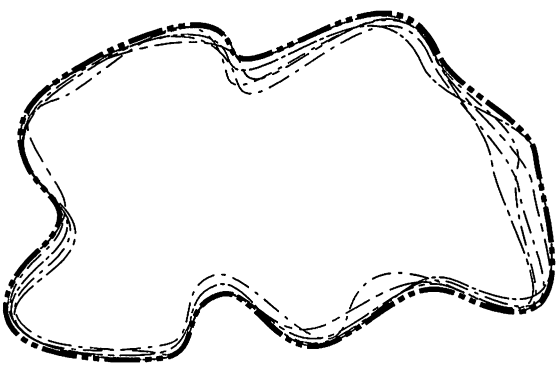
> the mature artist—perhaps even more than the less experienced one—tends to vary his performance of familiar works. He does so partly because he is seeking the "ideal" performance of his imagination, which can never be realized because as his experience grows and changes, so does his imagined ideal. Partly, however, interpretations are changed because the performer delights in the challenge of creating—of making something new and fresh, not alone for the sake of the audience, but for himself. He reinterprets a work not because he could not play it as before but because through his discovery of new possibilities and implications in it, the work becomes revitalized for him.

See also Serafine (1983, p. 24) and Clarke (1985, p. 210). Copland is of the opinion that the preponderance of old music on concert programmes

> overemphasizes the interpreter's role, for only through seeking out new "readings" is it possible to repeat the same works year after year. (1952, p. 17)

In summary: it is appropriate to think of a work not as a single immutable entity, but as a set of different performances—discrete reflections of the same essential image.

Figure 7.9
Representation of a piece as a set of possible interpretations.



It is fair to assume that the disparity between individual realisations will correspond to the degree of freedom at the performer's disposal: the more latitude granted by the composer, the wider the variation between renditions can be, and *vice versa*. It should be recognised that in certain freely structured pieces (such as Stockhausen's *Goldstaub* mentioned above), it is conceivable that the difference between separate performances may be greater than that between two nominally distinct pieces. And in *Plus-Minus,* of 1963,

> in which the essential processes are expressed symbolically, allowing an interpreter to decide, within limits, what musical form the piece may take (Maconie, 1976, p. 177),

Stockhausen himself resorts to labels such as the 'Cardew-Rzewski version', to make it clear which rendition he is referring to (see Maconie, op. cit., p. 181). In circumstances such as these, it is not easy to distinguish between interoperative and interterpretive relationships.

The presence of **intraterpretive** zygonic relationships should also be acknowledged. These are implicative connections *within* an interpretation which are determined by the performer. Take, for example, Gould's idiosyncratic execution (on CBS 77225) of the opening motive of Bach's prelude in *C* major from the first book of the *Well-Tempered Clavier* (1722), which is imitated in many of its subsequent appearances.

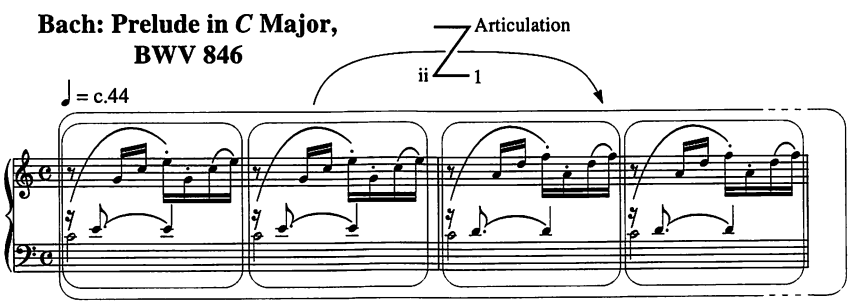


Figure 7.10 Intraterpretive zygonic constant system order ii of articulation.[15]

Finally, mention should be made of **interteroperative**[16] relationships, which exist between interpretations of different pieces. An example of an interteroperative zygonic relationship is found in Czerny's edition of the *Well-Tempered Clavier*, in which the bass line is sometimes reinforced at the lower octave in the culmination of fugues. See, for instance, figure 7.11.[17]

[15]See p. 380.

[16]That is, 'interterpretive' + 'interoperative'.

[17]Note the assumption underlying the direction of the interteroperative zygon that Czerny arranged the fugues following the order of their appearance in the '48'.

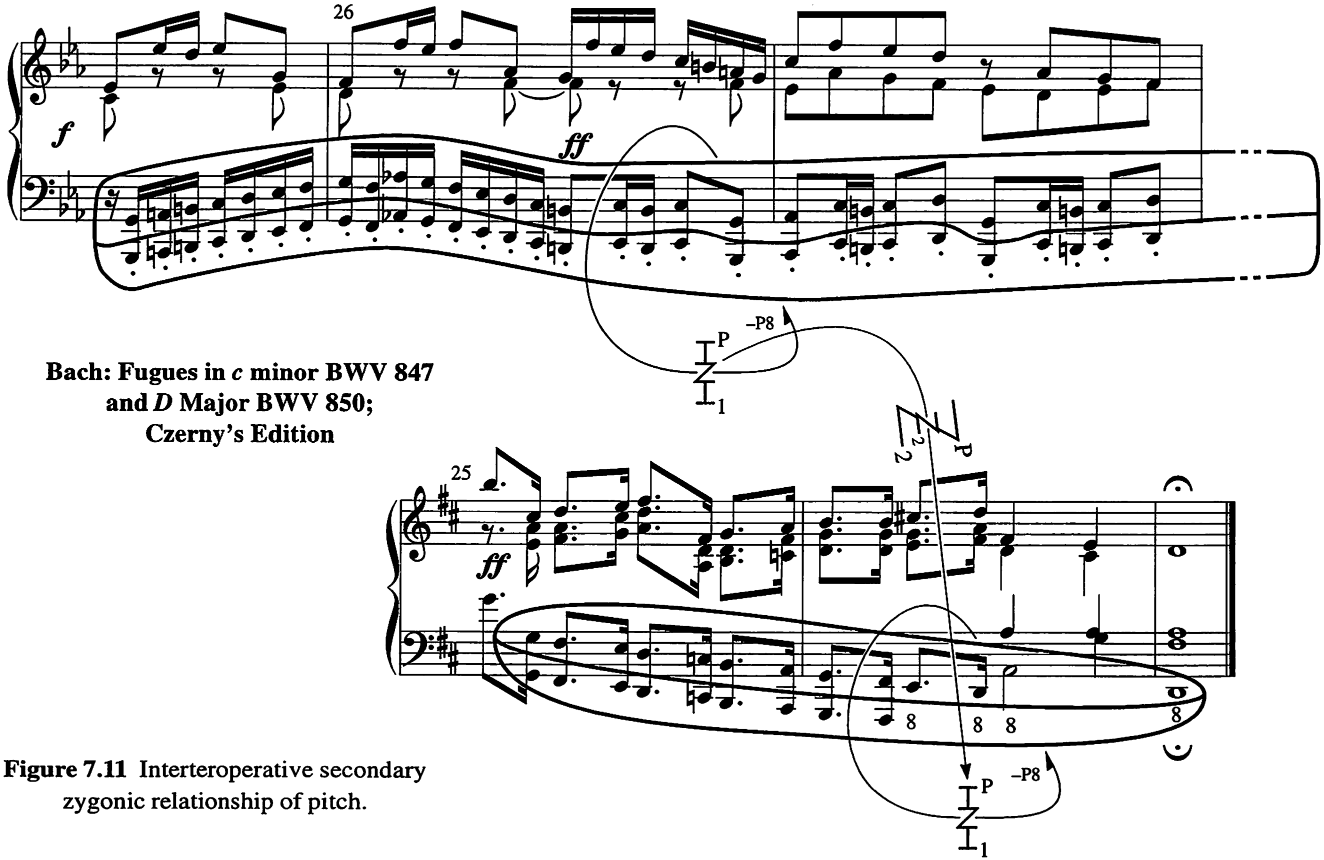



Figure 7.11 Interteroperative secondary zygonic relationship of pitch.

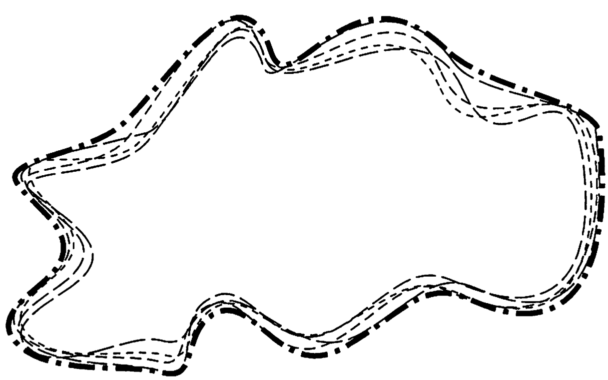
The order pertaining to listening

For a transfer of musical information to occur it follows that the perceived sonic organisation founded by the composer and realised by the performer must be apprehended (if only subconsciously) by the listener. In terms of the present theory, this means that whoever attends intelligently to music must be recreating, in his or her own mind, the zygonic relationships that were devised by another person. Yet is it reasonable to assume that the order conceived at the compositional stage will be the same as that which listeners eventually perceive?

Consider, for example, that the physical conditions for the reception of a performance will almost certainly be unique for every listener. The members of an audience, for instance, occupy different positions relative to the sound source, leading to a corresponding variation in the values of plot that are perceived. Loudness and timbre are also affected since the intensity and spectral composition of sound are dependent on the distance it has to travel (see, for example, Plomp and Steeneken, 1973).

Using this information, the model presented in figure 7.9 (which viewed a work not as a single, invariable entity, but as a set of possible interpretations), can be extended by considering each performance itself to constitute a set of different hearings.

Figure 7.12 Representation of a set of different hearings of a performance of a work.



The relationships that exist within one hearing of a work may be termed **intraauditive**, and those between the different hearings of a single interpretation, **interauditive** (figure 7.13).

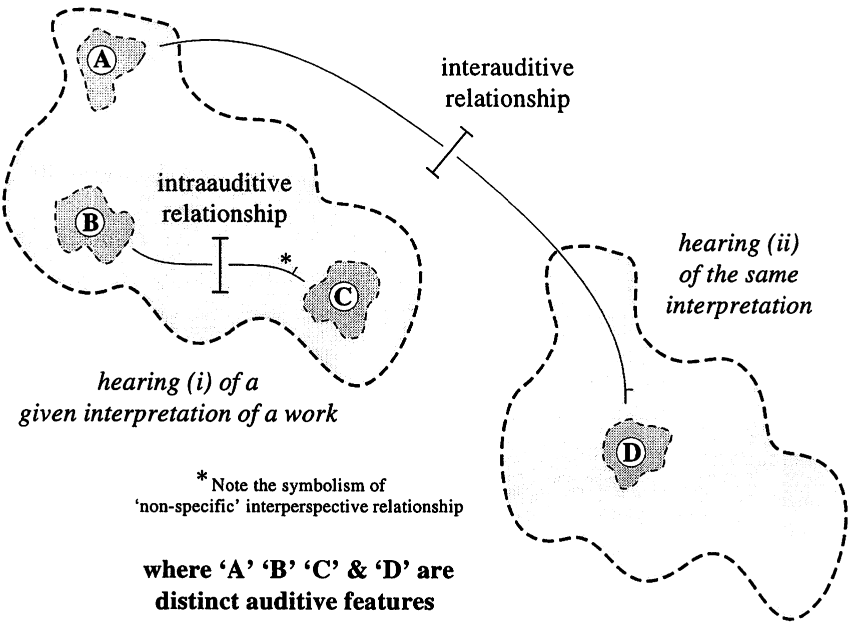


Figure 7.13 Intraauditive and interauditive relationships.

These are not the only possibilities: relationships can also be considered to exist between the hearings of different performances of the same work. These may be termed **interterauditive** (a portmanteau-word, into which 'interterpretive' and 'interauditive' are compressed). See figure 7.14. Further relationships link hearings of different pieces. These may be termed **interaudoperative** (formed by telescoping 'interauditive' and 'inter-operative')—figure 7.15.

Listeners have a certain control over the form in which a piece of music reaches them (effectively giving them a limited say in the processes of composition and performance). Traditionally, the degree of freedom granted to the members of an audience has been minimal, amounting to little more than the liberty to sit where they choose in a concert hall, for example, or to adjust the volume or tone controls on their radios, CD players *et cetera,* thereby allowing them a restricted influence on plot, loudness and timbre.[17]

[17]Though some composers have allowed their listeners a far greater say in what goes on. Consider, for example, Cage's *Les chants de Maldoror pulverisés par l'assistance même* (1971), for a French-speaking audience of not more than 200. (See also Cage, 1973, foreword; 1974/1980, p. 181).

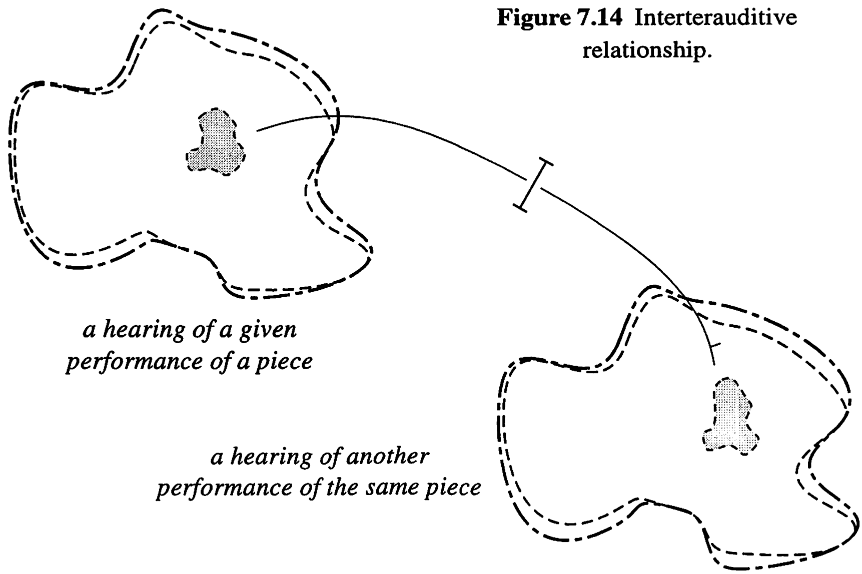


Figure 7.14 Interterauditive relationship.

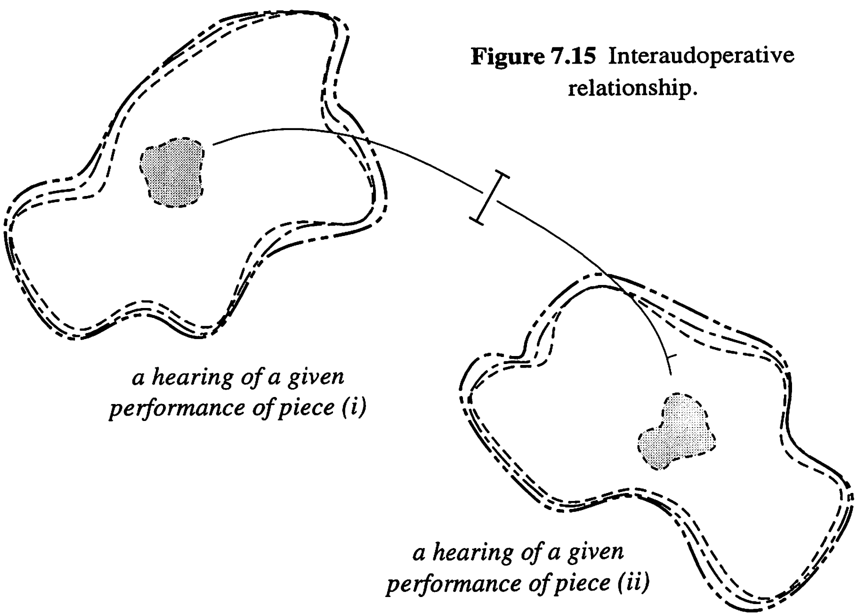


Figure 7.15 Interaudoperative relationship.

The fact that listeners can modify what they hear means that, potentially, they are able to order perspective values by causing them to imitate others. Take the concert-goer, for example, who consistently opts for a particular seat in the auditorium, or the 'hi-fi' buff whose equipment is habitually adjusted to produce a 'bright' sound (through the enhancement of higher frequencies). On such occasions it is possible to consider auditive relationships, within or between hearings, to function zygonically.

So much for the physical reasons why the order contrived by composers is likely to differ from that apprehended by listeners. There are other, cognitive, factors that need to be taken into account too. For instance, there is the fundamental issue of whether all the organisation laid down at the compositional stage is actually picked up by the majority of listeners: whereas composers may become deeply involved in the creation of a new work (possibly pondering its intricacies for substantial periods of time, and perhaps using notation to help them think their ideas through), the approach adopted by many members of an audience is likely to be a good deal less rigorous than this. They may attend only a few performances of a piece—even just one—thereby confronting it for a relatively brief period; they will probably not have the advantage of a score to follow, which would have enabled the eye to subsidise the income of the ear; and, above all, listeners may well lack the motivation to concern themselves with every twist and turn of a composition's perceived sonic organisation. How many people do we honestly imagine bring anything more than a small proportion of their full attention to bear on a long and complex piece of abstract music? Listeners may well pay scant attention to certain features, while focusing on others attentively; and, for sure, they forget a good deal of what is heard. Indeed, there may be periods when members of an audience are not concentrating on the music at all. Hence, it seems reasonable to assume that most listeners will have rather less knowledge of the structure of a piece than its composer has, or had. Finally, one could argue that some of the order employed in composition was never really intended to form an essential part of the musical message, but was used merely as an aid to the creative process: certainly, one wonders whether many serially constructed pieces should not be viewed in this light. Consider, for example, Boulez's *Le Marteau sans Maître* (1954), whose organisation, according to Lerdahl (1988), is quite impenetrable, even after many hearings by competent listeners. As he observes:

> There is a huge gap here between compositional system and cognized result. (p. 231)

In the light of these observations, it would seem advisable for music theorists and analysts to state at the outset whose point of view their work is intended to reflect. Are they, for example, seeking to identify the organisation they imagine to have been conceived by the composer in creating a piece? Or are they thinking in terms of the order that expert listeners may perceive after several hearings? It is regrettable that the position of those who are rather less musically proficient or experienced is hardly ever taken into consideration, despite the fact that the great majority of people fall into this category.[18] The analysis of serial music is particularly prone to bury its head in the sands of compositional and pre-compositional structures rather than worry about the organisation that most people actually hear. Not, however, that such tendencies are unique to workers in the field of serialism: as Cook (1987) has shown, while theorists as diverse as

> Schenker ([1935/]1979), Meyer (1973), and Lerdahl and Jackendoff (1983) all explain the aesthetic effect of music in terms of hierarchical relationships between ... large-scale tonal structure and the local events of a given composition (p. 198),

in fact, most listeners' sense of tonality does not extend over the necessary periods of time, and he argues that

> the theory of tonal music is more usefully regarded as a means of understanding ... [compositional] organization than as a means of making empirically verifiable predictions regarding the effects of music upon listeners (p. 197).[19]

Although music may be regarded as self-sufficient, since it does not need the assistance of other media to get its message across, a considerable contribution to the listening process is almost invariably made by 'extra-operative' information (that is, data not vested in the fabric of works themselves). At the most basic level, for example, the members of a

[18]On the whole, music psychologists seem to be rather more eclectic in their choice of subjects, and their research often distinguishes (somewhat arbitarily perhaps) between 'expert' and 'non-expert' listeners, or 'musicians' and 'non-musicians'; see, for example, Deliège, Mélen, Stammers and Cross (1996).

[19]See also Cook (1994, pp. 70–76).

prospective audience would normally arrive armed with at least some knowledge of what they were about to hear: people do not generally buy a blank ticket to a concert (programme undetermined), but to a performance of particular pieces, whose titles alone usually convey something of their musical substance. Moreover, in some cultures, elaborate programme notes form an accepted—even expected—part of the paraphernalia associated with the presentation of music (see Simonton, 1995). Failing any of this, even the simple act of sitting in a concert hall, seeing those who are about to play or sing while listening, perhaps, to the ambient chat, yields an abundance of clues as to what is to come.

Whilst extraoperative information is liable to affect listeners' perception of intraoperative organisation,[20] its presence is essential for those adopting an analytical approach to appreciate the zygonic status of interoperative relationships. In order to understand how the material of a work was derived, they must be conversant with the pieces—including the chronology of their composition—that at the time formed the composer's stylistic milieu. This may be informed by a knowledge of any self-confessed creative influences on the composer.[21] In the absence of such data, what is thought to be a unique feature of a composition may in reality have been derived from another.[22] Similarly, in hearing two comparable passages from different works, without the necessary extramusical information, how are listeners to know which exists in imitation of the other, whether they both share a common origin, or even if their resemblance is simply the result of chance? By the same token, those with only a limited knowledge of the stylistic environment in which a composer was working may attribute the genesis of a musical component to the imitation of one like it in a single other piece, when in fact it constituted nothing more than a stylistic archetype.

Moreover, just by listening, how is one to know where composition ceases and interpretation takes over? Observing the discrepancies between separate renditions would indicate which aspects were definitely performer-based, but this would not enable a distinction to be drawn between those

[20]See, for example, Francès (1958/1988, pp. 182–190), who found that people's ability to recognise themes and their variants differed according to the level of verbal information given prior to hearing a piece.

[21] Not, of course, that we should necessarily take composers at their word (see p. 272).

[22]Cf. Tovey (1936, p. 179) who, having noted how Mendelssohn's violin concerto, op. 64, was a source of inspiration for many later composers, observes: "Yet I rather envy the enjoyment of any one who should hear the Mendelssohn concerto for the first time and find that, like *Hamlet*, it was full of quotations."

interpretive characteristics that were common to all the performances. The zygonic status of interterpretive and interteroperative relationships themselves can also be determined only through extramusical information. Otherwise listeners may be unaware, for example, that two recordings were being replayed in the reverse order to that in which they were performed, effectively inverting the polarity of the interterpretive or interaudoperative connections that may be perceived between them. Similarly, just by listening, it would impossible to know whether zygonic relationships between different performances were direct or indirect. The latter may occur interterpretively if two realisations of a piece were each thought to derive qualities from a previous rendition.

Extramusical information is also necessary for the recognition of non-canonic ordering forces. For instance, a passage that may seem to have been shaped purely by intraoperative forces may in fact have been limited by aspects of instrumental technique. Consider, for example, the possible misapprehensions of someone hearing Ravel's piano concerto for left hand alone (1931) in ignorance of the particular circumstances of its composition.

As regards the discernment of extramusical canons, it goes without saying that intelligence beyond that immediately contained in the notes is required. For instance, unless he or she had heard a nightingale, a quail and a cuckoo, what would a listener make of the following passage?

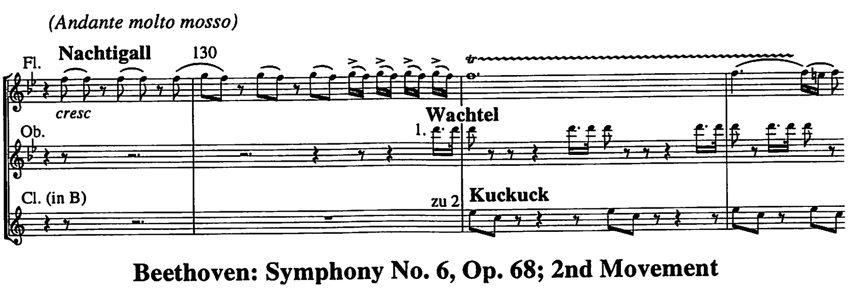


Figure 7.16 A passage whose appreciation requires extramusical knowledge.

Finally, although canonic ordering is to varying degrees self-evident, its cognition can greatly be affected by extraoperative knowledge. For example, Schoenberg's comments (1947/1975, pp. 405 and 406) concerning a thematic relationship between the first and the last movements of Brahms's 4th symphony (1885) have affected my understanding of the work.

We now consider the situation of someone hearing a work for the first time. Since listening to music demands the apprehension of relationships between perceived sonic items that are separated in time, it is essential that these are memorable (see Sloboda, 1985, pp. 174ff). Canonic organisation assists in the necessary learning process because the information contained by musical components evincing a regularity of design can be stored parsimoniously (cf. Simon and Sumner, 1968; Restle, 1970; Deutsch, 1980; Deutsch and Feroe, 1981), and since the repetition of such items further enhances their memorisation.[23]

As well as remembering what has gone before, listeners anticipate what is to come: at any point before the end of most pieces, the music suggests continuation of a more or less definite nature (see Meyer, for example, 1956, p. 35). This implies that future perceived sounds can be predicted on the basis of those past. Such prognostication occurs, albeit subconsciously, through the active projection of interperspective relationships into the future. Naturally, whatever listeners anticipate may, but need not, in fact occur, and reactive relationships can retrospectively equate what was forecast with what actually happened (cf. Meyer, 1973, p. 111). Prediction can be founded either on a knowledge of other pieces, and so function interoperatively, or derive intraoperatively, from the work in question. The former eventuality is considered first.

Upon hearing a piece, especially for the first time, comparisons with other music seem inevitable. These may but need not be guided through extraoperative information: for example, if a hitherto unkown work is labelled 'symphony', then similarly entitled compositions with which the listener is already familiar are sure to spring to mind, eliciting preconceptions as to the nature of the new piece. Irrespective of the existence of data of this type, all intramusical interoperative prediction occurs in essentially the same way. A value or values in the present work may trigger memories of a corresponding value or values previously heard in another piece or pieces, and through these the listener is led to expect the same sequel as occurred earlier. See, for example, figure 7.17. (Note that the relationships recorded here need not be the same as those used by Beethoven in *creating* the fragment shown—cf. figure 11.84.)

[23]The importance of repetition for the process of memorisation is widely recognised. See, for example, Rufer, 1952/1954, pp. 25 and 26; Schoenberg, (c.1930)/1975, p. 103; Dowling and Harwood, 1986, p. 164.

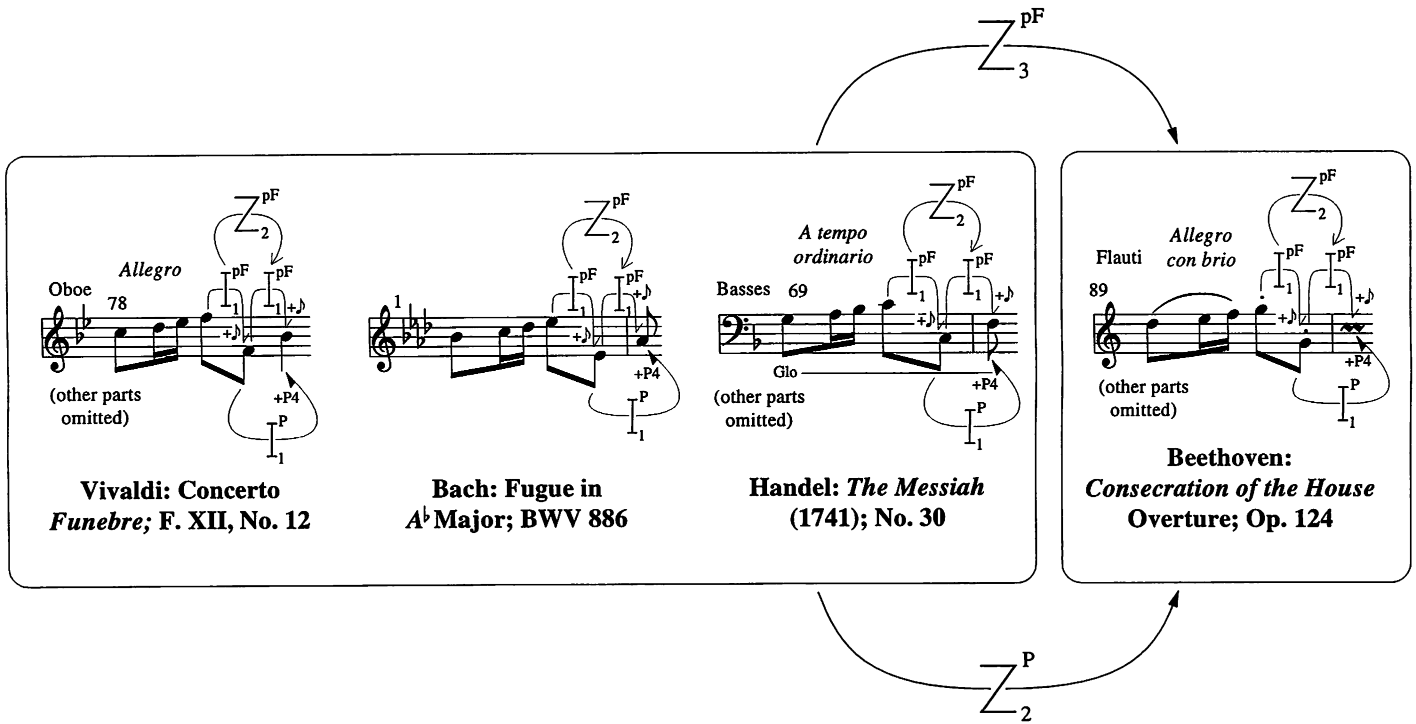


Figure 7.17 The interoperative prediction of pitch and prefix.

Previous appearances of a value or values may have had various sequels, any of which can be used by the listener as the basis for prediction. The likelihood with which it is felt that a given continuation will occur is partly determined by the number of previous occasions on which it has been heard. The higher this is, the greater a listener's habituation to that sucession of perceived sounds, and the more certain its future occurrence seems to be (see Meyer, 1956, pp. 54ff). Stylistically generated expectations of this sort are dependent not only upon which works a listener knows, but also on how often each is heard (cf. Moles, 1958/1966, pp. 27ff): clearly, the patterns of perspective and interperspective values that make up a relatively familiar piece must bear comparatively more weight than those in one with which the listener is scarcely acquainted. As LaRue (1970, p. 199) observes:

> The more popular works of any period ... tend to become the pillars of convention in their time.[24]

The process of predicting what will occur in a piece on the basis of what happens in others has much in common with that aspect of composing that uses interoperative relationships. Generally speaking, the more values in a given series that the listener has heard, the more definite its association with a smaller number of other groups, yielding fewer likely continuations, and ultimately a surer future.[25] Hence, with only one mid-range constant of pitch, for instance, to go on, there will be a great many potential interoperative connections.[26] Between them these will suggest so many possible outcomes that interoperative anticipation would be purposeful. However, with five successive constants, for example (as in figure 7.17), predicting the sixth is likely to be considerably easier.

We now consider how listeners can anticipate the future course of an unknown piece of music by using intraoperative relationships. Again, extraoperative information may be important in giving advance warning of

[24]See also Bukofzer (1947, p. 337), who notes that although the *Messiah* of 1741 "has become the archetype of the Handelian oratorio by virtue of its tremendous popularity, it is actually a highly individual work standing outside of the general trend of Handel's oratorio composition."

[25]This principle does not apply universally, since at certain points in a series of values more transitions may have been used than at others, irrespective of how far through the sequence one has moved.

[26]This is not the case with all perspects, however. With timbre, for instance, there is a fair chance that one constant will be followed by another the same, and with plot the odds of this occurring are even higher.

what interperspective connections listeners can look forward to. Consider, for example, the following excerpt from the programme notes that were written for a performance by Rachmaninov of Chopin's scherzo in *c#* minor, op. 39:[27]

> ... it consists of two strongly contrasted sections, the first, *presto con fuoco*, being impetuous and of extraordinary power, the second, *meno mosso*, in D flat, taking the form of a chorale whose phrases alternate with delicate, filigree-like arpeggio passages. After a return to the first section the chorale is resumed, and a modulation of great beauty ... leads to a brilliant coda.

There are two fundamentally different ways in which intraoperative prediction can take place. The first of these, occurring *inter*holistically, closely resembles the process of interoperative anticipation described above, through which listeners expect a sequence of values once initiated to continue in the same way as a similar series did previously (cf. Bharucha, 1987). Here, it is as though a group of values has an external tendency to emulate others. The second form of intraoperative prognostication is *intra*holistic, occurring within a formation of values. Here, it is as though a group has an internal tendency to propagate itself, a phenomenon which is now examined.

A listener can predict the continuation of a pattern by projecting a zygonic relationship or relationships from the material presented.[28] These may be primary or, with some perspects, of higher ranks too.[29] See, for example, figure 7.18. Here, the relationships through which projection occurs are shown with a dashed line. A single series of values may be indicative of a one outcome or more than one, any or none of which may subsequently be realised.

Intraholistic and interholistic prediction—whether intraoperative or interoperative—may operate in conjunction. Consider, for example, Meyer's general rule for proximate realisations (1973, p. 130):

[27](Evans, 1938) for a Nottingham Charity Subscription Concert, March 21st.

[28]Cf. the concept of 'implicative' relationships proposed by Meyer (1973) and further developed by Narmour (1977).

[29]The use of primary and secondary relationships in this way may be compared respectively with the two forms of anticipation identified by Cohen (1962, p. 158): "Predictions may be direct: e.g., if the past sequence is simply *A*, the only possible prediction for the next event on the basis of experience is *A*. Or predictions may be analogical: e.g., from the sequence of *ABCDEF* the most plausible prediction is *G*."

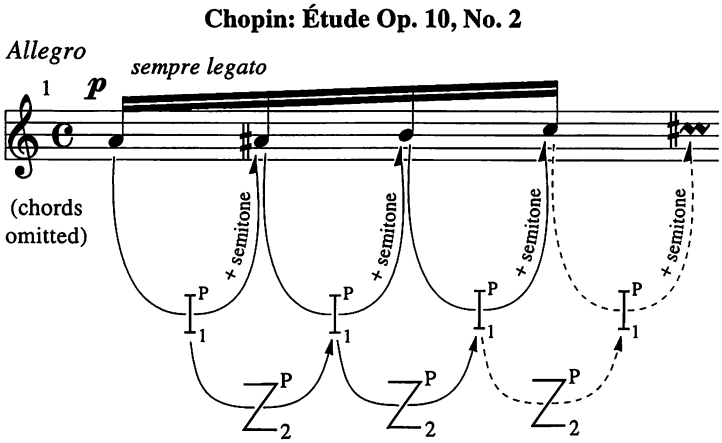


Figure 7.18 Intraholistic projection through secondary zygonic relationships.

Once established, a patterning tends to be continued until a point of relative tonal-rhythmic stability is reached.[30]

Here, intraholistic projection suggests the immediate course that a series of pitches will take, while their point of termination can be anticipated interholistically (for previous experience of comparable passages is needed to assess just what constitutes tonal-rhythmic repose).

We now consider some of the cognitive processes involved in listening to pieces for a second time. As previously observed, it seems entirely natural for listeners to relate their current aural input to previous musical experiences, the most potent of which may well be the first impression of the work in question—subject to the fidelity with which it can be recalled. Between this and the new hearing, a chain of interauditive or interterauditive relationships potentially exists (depending on whether the listener is faced with an exact repeat of the earlier performance, or a new rendition). Such relationships are capable of functioning reactively or proactively, thereby serving respectively either to reinforce memory or to fuel anticipation. Which of them are realised depends partly on the roving focus of the listener's concentration, although external factors are important too: unless, for

[30]Cf. Serafine (1983, p. 172): "patterns give rise to two forms of expectation: continuation (of the pattern or sequence at hand) and cessation (since ultimately all patterns cease)."

example, the title of the piece is known in advance, interauditive or interterauditive links can be instigated immediately only by chance, and various tentative interoperative connections may be fielded before the true identity of the work is finally established.

Whatever the initial circumstances, interaudoperative relationships may well continue to function side by side with interauditive or interterauditive connections throughout this second hearing: an awareness of the piece based on past experience does not prevent comparisons with others. Indeed, it may be surmised that it is the presence of these interoperative bonds that to an extent enables music, in any hearing after the first, to retain that part of its aesthetic appeal which relies on differing sequels to a given set of values each being felt to have a different probability of occurrence. An 'irregular' termination to an harmonic progression may engender a feeling of surprise for a second time (and on subsequent occasions), since listeners compare it not only with its parallel appearance in an earlier hearing of the work in question, but with the many comparable 'regular' resolutions from other pieces too.[31,32] Such issues are central to Meyer's theories of emotion and meaning in music (see, for example, Meyer, 1956; 1967, pp. 42ff).

Generally speaking, listening to further performances enables listeners to build up an ever more complete and accurate impression of the work, against which each new hearing is compared before its image gradually merges with that of the others, although distinctions may remain, perhaps between classic performances by famous artists. As Serafine (1983, p. 156) says:

> At best, the central artwork/object is an idealized, hypothetical piece—the area of overlap among all the individual performances and conceptions of

[31]Cf. Gerhard (1958, p. 51): "One is reminded of that personage in Peacock describing the surprise-effect of a certain perspective in landscape-gardening; what becomes of the surprise—he was asked—when you walk past the same place for the second time?" Surely, we still do feel amazement, because of our greater experience with more conventional layouts? See also Bharucha (1987, p. 4): "The possibility of conflict between schematic and veridical expectancies permits an enduring interest in a piece of music with which one is familiar." Schmuckler (1989, p. 144) writes: "One way of characterising this effect is that expectancies are formed along the basis of ingrained general stylistic regularities (such as tonal structure, melodic process and common harmonic progressions) which operate impervious to one's experience of a particular piece. Working atop this general frame is specific knowledge, which selectively affects some expectancies, particularly at highly unstable ponits, where unusual events occur." Cf. also Narmour (1990, p. 40).

[32]For a rather different view, see Zuckerlandl, 1956, pp. 232 and 233.

> the work. This artwork is not a fixed, eternal object, but an abstract and fluid one ...
> ... we all come to the artwork expecting that repeated hearings will be slightly different, believing that the performer's rendition always diverges from the composer's intention, and knowing that, as listeners, we vary enormously in what we hear.

Becoming more and more familiar with a piece is likely to affect the cognition of its intraoperative relationships, which in turn will alter listeners' understanding of its internal organisation. For example, being aware of a particular motivic development requires first that the original figure be recognised, isolated and committed to memory, and second that the similarities with its transformation be apprehended; complex intellectual operations that may take several hearings to accomplish. This assertion is borne out by the results of Pollard-Gott's (1983) experiment, in which

> Listeners' changing conceptions of a composition were investigated through repeated presentation and multidimensional scaling of short passages drawn from the composition. (p. 92)

Her results showed that the

> relationships that listeners perceived among passages corresponded with higher order thematic structure after repeated exposure, but not after a single exposure to the music. (ibid.)

Finally, we should note the effect of repetition on listeners' response to a piece. One theory (summarised in Hargreaves, 1986, pp. 110ff; Smith and Cuddy, 1986, pp. 17 and 18), states that people's enjoyment of music is linked to its subjective complexity. From this, the hypothesis is derived that favourability and familiarity are linked by an inverted U-shaped curve, which, roughly speaking, means that the pleasure that is experienced in listening to a work could be expected to grow as listeners became better acquainted with it, and then to fall back again as boredom figured more and more in the equation. As long ago as 1933, Verveer, Barry and Bousefield had reached just this conclusion, with the proviso that an

> intervening time interval ... tends to enhance the pleasantness of subsequent repetitions. (p. 134)

Conclusion

In this chapter a number of different classes of relationship have been identified. These are summarised below.

no.	class of relationship	description
(i)	**intraoperative**	*exists within a work of art*
(ii)	**interoperative**	*exists between works*
(iii)	**intraterpretive**	*exists within an interpretation of a work*
(iv)	**interterpretive**	*exists between different interpretations of the same work*
(v)	**interteroperative**	*exists between interpretations of different works*
(vi)	**intraauditive**	*exists within a hearing of a work*
(vii)	**interauditive**	*exists between different hearings of the same interpretation of a work*
(viii)	**interterauditive**	*exists between hearings of different interpretations of the same work*
(ix)	**interaudoperative**	*exists between hearings of different works*

Figure 7.19 The classes of relationship that potentially exist within and between works, performances and hearings.

8

Ordering perceived reverberation, plot, loudness, timbre and number

Introduction

In this chapter the organisation of perceived reverberation, plot, loudness, timbre and number are investigated, using the theoretical framework outlined in the preceding chapters.

Ordering perceived reverberation

Perceived sound has various qualities which stem from the environment in which it is propagated. Foremost among these is the compound perspect **perceived reverberation**, which qualifies the way music sounds without affecting its substance. The identity of Beethoven's *Appassionata* sonata, op. 57, for instance, is unchanged by the nature of the surroundings in which it is heard. This relates to the fact that, historically, composers have exerted virtually no control over perceived reverberation, although in producing compositions that were intended for performance in a particular type of building (music for the liturgy, for example), or even in creating pieces meant to be executed *al fresco* (such as Handel's *Music for the Royal Fireworks* of 1749, which was originally written to accompany a display in London's Green Park), they clearly had definite kinds of acoustical environment in mind. Certainly, differing musical genres have come to be associated with, and apparently to tolerate, only specific bandwidths of perceived reverberation (cf. Maconie, 1990, pp. 149ff). Hence, playing a composition for church organ (say, Franck's *Grande pièce symphonique*, op. 17) in a dry acoustic would strike the initiated ear as incongruous, no doubt; conversely, it seems reasonable to assume that the Tutsi of Ruanda, accustomed to hearing their songs for taking cattle home at the end of the day in the open air, would find a rendition of them in a resonant room strangely anomalous (see Merriam, 1964, p. 214). Here are Berlioz's views on the matter, expressed emphatically in his *Grand traité d'instrumentation et d'orchestration modernes*, op. 10:

> The place occupied by musicians, their disposal on a horizontal plane or an inclined plane, in an enclosed space with three sides, or in the very centre of a room, with reverberators formed by hard bodies fit for sending back the sound, or soft bodies which absorb and interrupt the vibrations, and more or less near to the performers, are all of great importance. *Reverberators* are indispensable; they are to be found variously situated in all enclosed spaces. The nearer they are to the point where the sounds proceed, the more potent is their influence.
>
> This is why there is *no such thing* as music in the open air. The most enormous orchestra placed in the middle of an extensive garden open on all sides—like that of the Tuileries—would produce no effect. (1855/1858, pp. 240 and 241)

Further evidence of how highly listeners value having just the right amount of perceived reverberation is provided by the enormous effort that is expended on the design of concert halls; consider too the trouble taken to enhance acoustically 'dry' studio-recorded sounds with what is held to be a lifelike, or at least an aesthetically pleasing, level of perceived reverberation.

Listeners would normally expect an acoustical environment, and therefore the degree of reverberation perceived, to remain constant during a performance, although the kaleidoscopic worlds of perceived sound inhabited by those musicians who perform on the move—the members of marching bands, for instance—should not be forgotten. Finally, consider Lucier's *Vespers* of 1968 (to which the matter of perceived reverberation is central). The work is

> performed in darkness and based on the principle of echolocation. Echolocation is a process for locating distant or invisible objects by means of sound waves reflected back to the emitter by the objects. Blindfolded performers armed with sondols wander about the performance area in an

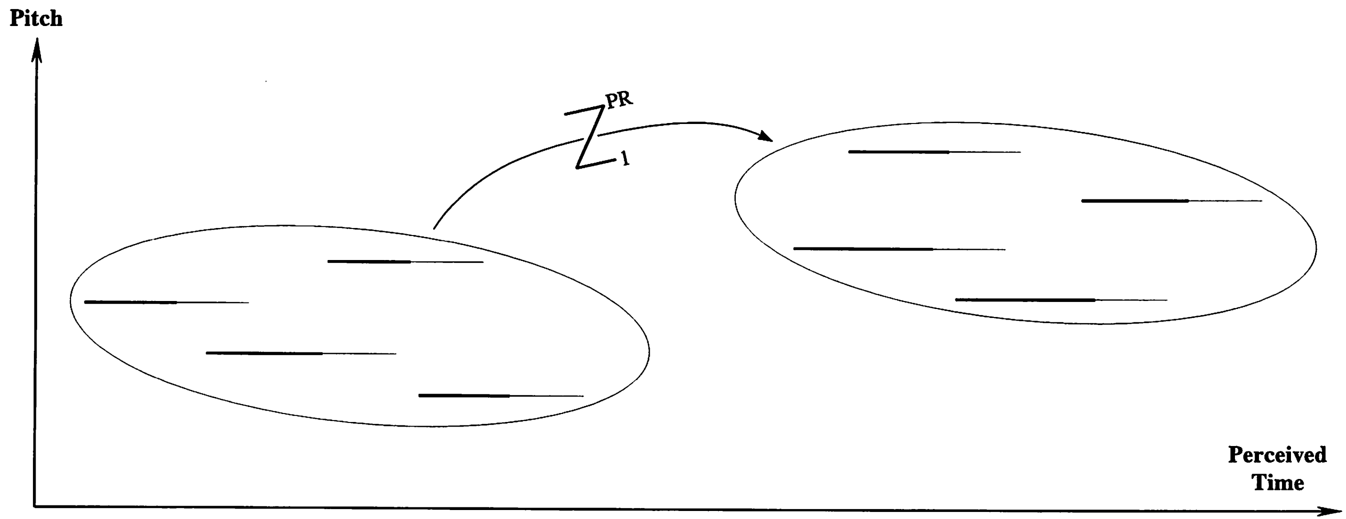


Figure 8.1 Primary zygonic constant system of perceived reverberation.

> attempt to avoid colliding with one another. This is facilitated by the sondols, electronic devices that emit clicks to survey the environment, like the sensory perception of dolphins and bats. (Ernst, 1977, p. 186)

Through electronic means, perceived reverberation can be controlled canonically. A group of notes, for instance, could be made to resound to an extent that was considered to duplicate the level of perceived reverberation

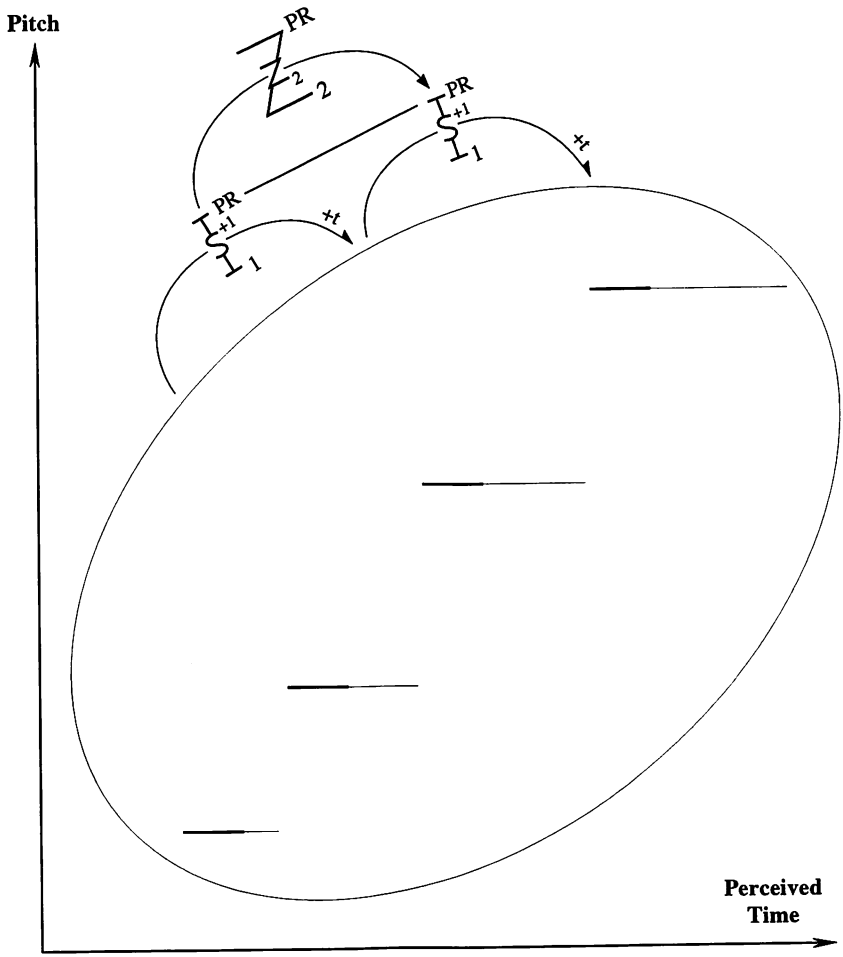


Figure 8.2 Secondary zygosequential zygonic constant system of perceived reverberation.

pertaining to one occurring previously—see figure 8.1. (Here, perceived reverberation is represented by the thinner line following each constant of pitch.) Equally, perceived reverberation may be made to vary regularly across a configuration through the effects of a secondary zygosequential zygonic constant system (cf. figure 6.40). See figure 8.2.

Ordering plot

To facilitate the investigation that follows, the concept of a **perspective set**[1,2] is introduced, a theoretical construct which itemises all the values occurring in a perspective domain over a given period of time. See figure 8.3. Sets function like atemporal associations. Hence all the relationships identified in chapter 6 are relevant to them.

Interauditive differences in plot inevitably exist between different members of an audience, and composers do not generally stipulate the location of listeners relative to the source of sound. The direction in which people suppose the music to be coming from, and the range, are not factors that usually figure in the equation linking performer and listener (see Brant, 1967, p. 223). Admittedly, the designs of concert halls, opera-houses, and other buildings constructed with public performance in mind, respect the convention that those listening should face the subjects of their attention (cf. Menuhin's comments in Daniels, 1979/1980, p. 71). Even this general principle fails to apply, however, if the music is relayed electronically. Loudspeakers in the home, for example, may well be located behind the sitting-room chairs.

Nevertheless, composers normally expect the members of orchestras, choirs and other groups of performing musicians to be positioned close to one another, effectively forming one compound source of perceived sound. (It seems more natural to refer to the 'perceived location' of a band, for example, rather than its 'perceived locations'.) Hence the set of values of plot pertaining to a given performance of a piece for three performers or more (which, in this and the following examples, are considered from the

[1]The term 'set' has been used before in the context of music theory, but in a slightly different sense from the one intended here: see, for example, Babbitt (1960, p. 247), who designates an ordered series of pitches in this way.

[2]Compare this with the term 'gamut' used by Cage (for example, (1958)/1961a, p. 23).

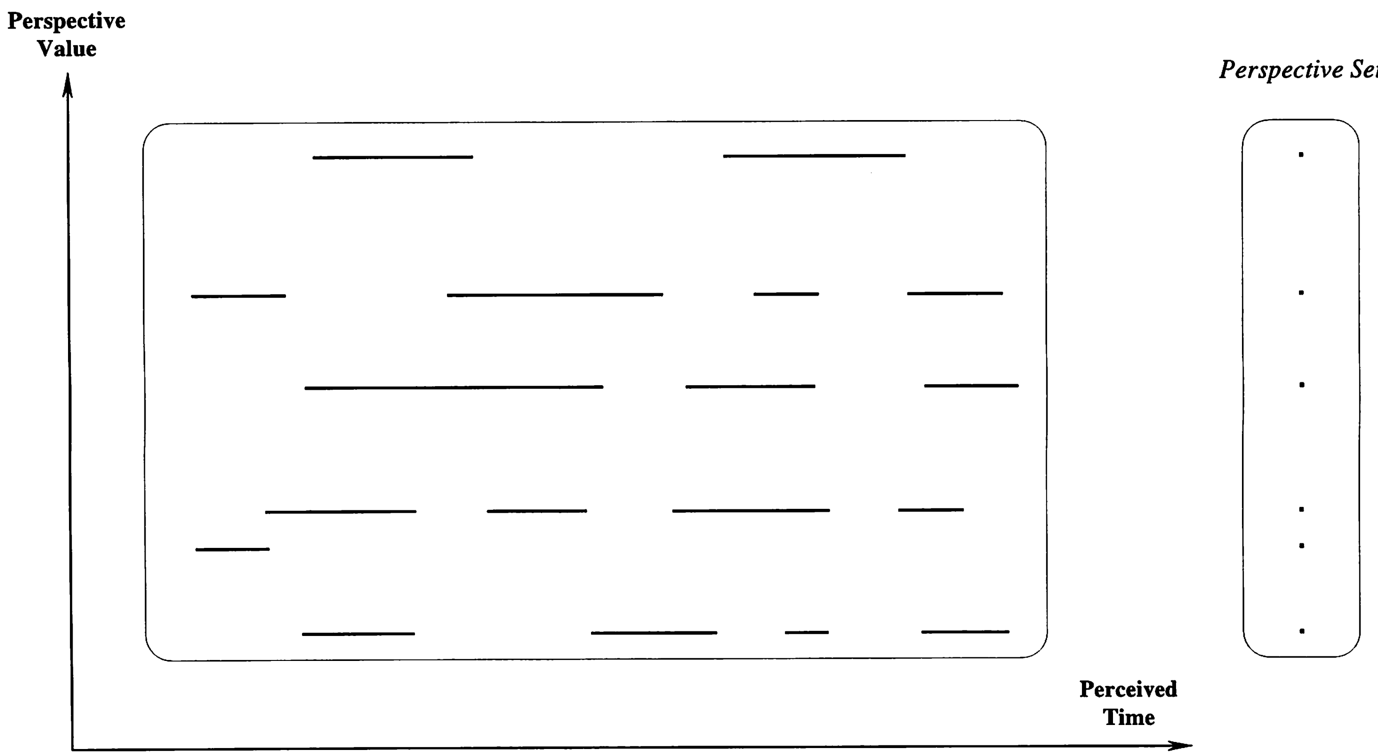


Figure 8.3 Perspective set, derived from the association shown.

standpoint of a single listener, whose position may be taken as typical) may be described in terms of a primary intraterpretive imperfect constant system. Without doubt, the proximity this describes is partly attributable to practicalities such as the fact that increasing the distance between performers makes ensemble playing more difficult. However, the same organisation can also be perceived in canonic terms, since the perceived location of each player in a group may be deemed to exist in imitation of another or others, implying a network of relationships in the form of a primary intraterpretive imperfect zygonic constant system of plot (cf. figure 6.24).[3] Moreover, if one such mode of performance is felt to exist in imitation of another, then interterpretive and interteroperative zygonic connections, in the form of secondary imperfect zygonic constants (cf. figure 6.33), are implicated too.

Some pieces depend for their full effect on having two perceived sources or more, whose separation is well defined. Music conceived in terms of two perceived locations ranges from the antiphonal singing characteristic of Negro cultures (Nettl, 1965/1973, p. 140) to the sixteenth and seventeenth century Venetian technique of *coro spezzato* or 'divided choir' (see, for example, Arnold, 1959), and from the *concerto grosso* of the Baroque era (Bukofzer, 1947, p. 223) to Brant's *American Debate* (1976), for wind and percussion in two groups. Composers sometimes demand three distinct groups of players, examples of which range from certain passages in Mozart's *Don Giovanni* (first performed in 1787), for example, to Stockhausen's *Gruppen* (1955–1957). Even more groups are specified on occasions: Berlioz's *Grande Messe des Morts* (1837) for instance, calls for an exceptionally large orchestra including four brass bands. Compositions employing the same number of distinct perceived locations may be supposed to be linked through interoperative zygons, if one is held to imitate the other. See, for instance, figure 8.4. The issue may not be clear-cut. Stockhausen, for example, while admitting a close acquaintance with a number of spatially conceived works from the last 450 years (1959/1961, pp. 67 and 68) is loathe to admit that his own compositions are indebted to them.

Frequently, music is written for set instrumental or vocal combinations, and the arrangement of players within groups like these is often standardised too, a state of affairs largely attributable to the practical demands of per-

[3]Just as a set is a theoretical construct, so are the relationships that pertain to it. Hence, the constant system referred to here can be considered to exist atemporally, as an abstraction from the fabric of the music itself.

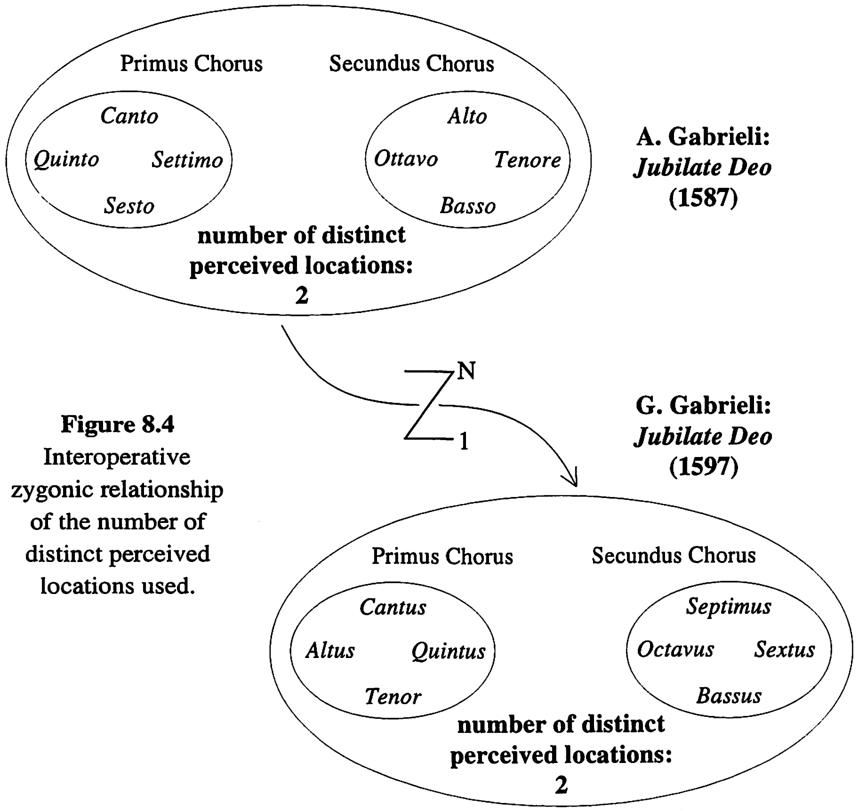


Figure 8.4 Interoperative zygonic relationship of the number of distinct perceived locations used.

formance. It makes sense, for example, for those doubling parts, such as the first violins in an orchestra, or the sopranos in a choir, to sit or stand together. Moreover, it is reasonable for performers who are intended to be particularly prominent—the soloists in concertos, for instance—to be placed at the front of groups. Finally, consistency reduces the risk of confusion: imagine the plight of a conductor, faced with the task of directing an orchestra that adopted different seating arrangements on different occasions (cf. p. 5).

In addition to these factors, it is conceivable that groups of instrumentalists and vocalists tend to be disposed in the ways to which musicians have grown accustomed, since performances of pieces imitate previous practice. This means that the manner in which the layout of performers is organised can be understood in canonic terms, through interterpretive and interteroperative secondary zygons of plot, running parallel with primaries of timbre.

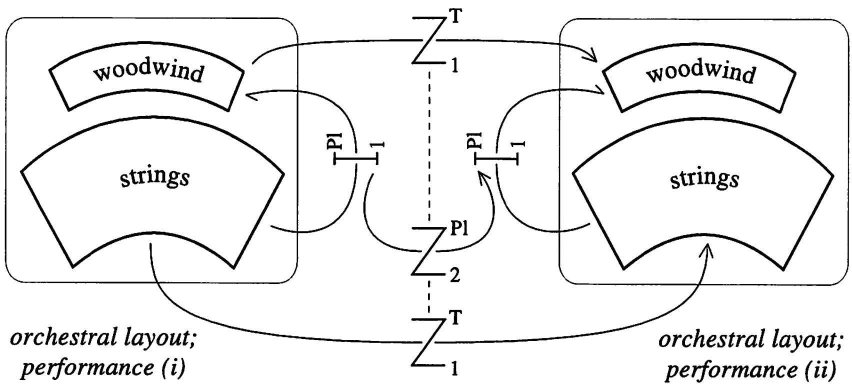


Figure 8.5 The layout of performers ordered at the secondary zygonic level.

Usually, plot remains constant during a performance, and, again, there are practical reasons why this should be so. However, these do not preclude a canonic interpretation of the typical uniformity of perceived location during the rendition of a piece, which would implicate both intraterpretive primary zygonic constant systems (reflecting the unchanging values of plot) and interterpretive or interteroperative secondary zygonic constants (relating to the fact that most performances evince this regularity). See, for instance, figure 8.6, in which, for graphical convenience, plot is shown on a single axis.

Indeed, the fact that constancy of plot is not a necessary condition of performance is demonstrated by the occasions when change is to be found. Consider, for instance, a processing church choir, a marching band, or an opera singer enacting a part that demands action. Occasionally, composers stipulate the movement required: in *Circles*, for instance, by Berio (1960), the path taken by a female singer with respect to two percussion players and a harpist is indicated with a fair degree of precision. In circumstances such as these, if the movement is consistent, either within or between performances of the same or different pieces, this too can be construed canonically, involving on the one hand intraoperative or intraterpretive primary invariant systems (cf. figure 5.32), and on the other interoperative, interteroperative or interterpretive secondary zygonic constants of plot (cf. figure 5.38). See figure 8.7.

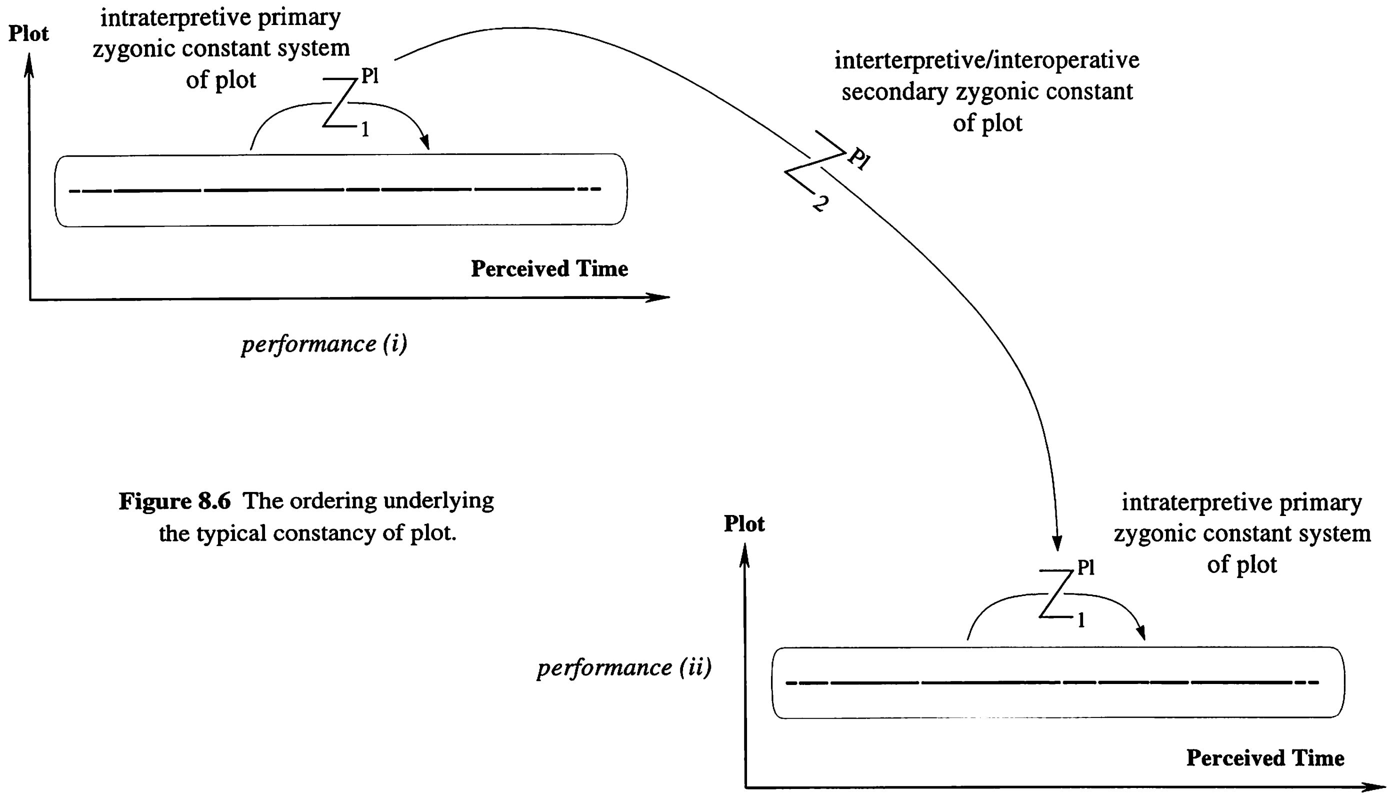
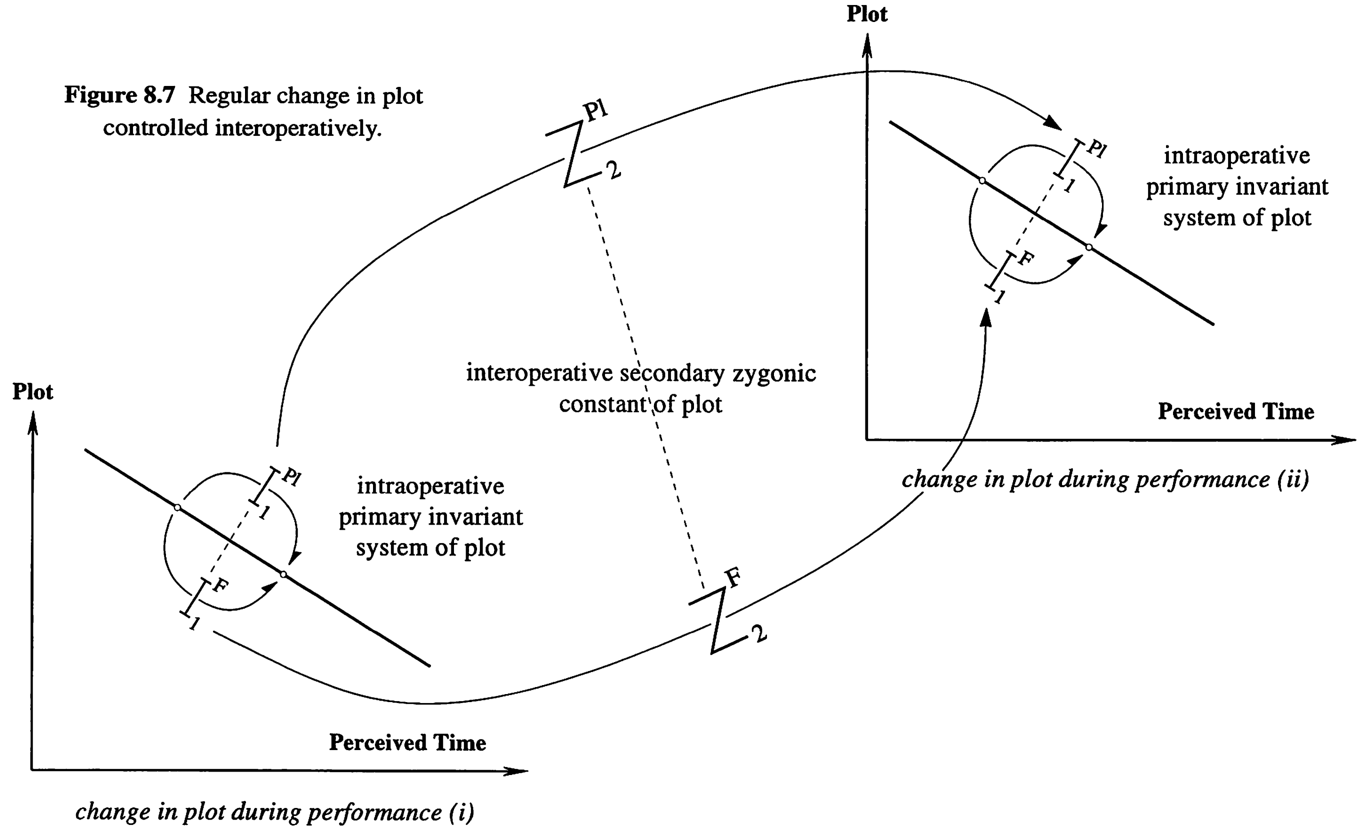


Figure 8.6 The ordering underlying the typical constancy of plot.

Figure 8.7 Regular change in plot controlled interoperatively.



However, it is the electronic manipulation of sound that offers the most promise for the control of varying values of perceived location during the performance of a piece (see, for example, Chowning, 1971). With a building such as that constructed for the *Expo 70* in Osaka, for instance, (see Mumma, 1975, pp. 334 and 335) the wide range of protractive, continuous and associative ordering explored in chapters 5 and 6 is generally applicable to plot. For example, a moving perceived sound may appear to describe an invariant system of ratio (see figure 5.34), or perceived sounds may be presented simultaneously in a controlled distribution around the members of an audience, through a secondary zygosequential intrasociative zygonic constant system (cf. figure 6.43), or a comparable secondary zygosequential tertiary system (cf. figure 6.45), in either case sequential with respect to plot (cf. Boulez, 1963/1971, p. 67).

Ordering loudness

Loudness is affected by the position of listeners relative to the sound source, a variability that has two components. The first pertains to the fact that intensity wanes over distance, leading to a corresponding decrease in loudness as one moves further from its source, and the second is related to the directional inconsistency of the sounds that emanate from instruments (see Olson, 1952/1967, pp. 231ff). Interperspective values appear to be rather less dependent on plot, though perhaps not entirely so.

The consequences of this perspective interdependence can be interpreted in terms of the model proposed in chapter 7. It means, for example, that dynamic levels can be expected to be coherent *intra*auditively; that is, if a performer realises separate markings of, say, *piano* in the same way during the course of a piece, then they should strike the listener as being the same too (even though in absolute terms there may well be a difference between what the two people are hearing). Exceptions to this principle occur when plot itself changes during a performance: as a band marches into the distance, a sustained *forte*, for instance, would have the effect of a *diminuendo* to the stationary observer. *Inter*auditively, only relative values of loudness will be maintained: what appears to be very loud to those in the front row of a large concert hall will seem less so to the members of the audience seated at the back (cf. pp. 54 and 55), although a change in level—a *crescendo* for instance—would be recognised anywhere in the auditorium.

The same principles apply to pieces that are electro-acoustically reproduced, although the interauditive discrepancies may be even greater. First, the environment in which the music is relayed will inevitably have unique acoustical properties, within which the intensities of the sounds that are propagated will be dissipated, or compounded through reverberation, in distinct ways (cf. Stockhausen, 1959/1961, p. 74). Second, the music may be heard at any level, from the barely audible whisper of a crystal set to the potentially damaging kilowatts of sonic power pushed out by a large amplification system.

As far as performers are concerned, perspective values are liable to be treated with a certain latitude (though nothing approaching that with which listeners subsequently have to contend), a tendency for which there are both perceptual and physical reasons. For example, people's inability to categorise securely any more than about five different values of loudness in the long term (see p. 53) clearly limits the fidelity that can be expected of interterpretive and interteroperative relationships. Then there is the fact that indications such as *forte*, for instance, rather than meaning "loud *per se*", denote "loud for the circumstances", which may be taken to include the type, and even the model, of instrument involved, as well as the dynamic levels realised by other players at the same time (cf. Schoenberg, 1929/1975, p. 341).[4] The same haziness inevitably characterises the interpretation of interperspective values since they are usually expressed as the transition between two perspective values (for example: "make a *crescendo* between *piano* and *forte*").

The scale of these auditive and, to a lesser extent, interpretive inconsistencies would make it seem quite futile for composers to stipulate perspective values of loudness; they would be better advised, it would appear, to confine themselves purely to relative indications. Such a conclusion does not accord, however, with the common practice of Western composers of the last two hundred and fifty years or so, who have often left detailed instructions as to the loudness levels required. The solution to this quandary lies in the fact that it is not just dynamics as they are perceived that are aesthetically important, but also levels of loudness as they are deduced to be. This information may be based partly on the awareness of how sounds seem to diminish with distance, partly on the fact that timbres are not entirely invariant under different dynamics (consider the characteristic *fortissimo*

[4]Carter, in a performance note to his *Brass Quintet* (1974), refers specifically to this issue: "The dynamic markings of this score are 'absolute'—that is, forte in the horn part should sound as loud as the forte of the other players, etc.".

of a trumpet, for instance; Clark and Milner, 1964), and partly through extramusical information, such as the observed vigour of players (cf. Nattiez, 1990, p. 40). Hence, being seated close to the performers and hearing them execute a phrase *pianissimo* does not offer the same musical experience as sitting at the back of the hall and listening to the same passage rendered *mezzo forte*, even though the actual values of loudness apprehended may in both cases have been the same.

In summary: pieces are recognisable, and even artistically satisfactory, irrespective of the general level of loudness at which they are heard, for listeners have a remarkable capacity for perceptual accommodation, whereby they can quickly attune to the set of values offered by a particular set of circumstances.

Composers' choice of dynamics are constrained in a number of ways. For instance, on some instruments there is no control of the loudness of notes following their initiation. The levels of perceived sounds produced by striking or plucking, for example, subside of their own accord, although whether this decrease is apprehended as such depends on the circumstances in which it is heard (cf. pp. 120 and 121). In contrast, notes played, for instance, on an organ, often maintain a constant loudness irrespective of their duration. Yet other perceived sounds, which result from bowing or blowing, can be subject to dynamic variation at any point. Composers must also bear in mind that only certain dynamic levels can be produced on a given instrument, and these differ from one type to another. For example, quieter perceived sounds are feasible on the acoustic guitar, generally speaking, than on the saxophone, whilst the trumpet can play louder than the flute (see Olson, 1952/1967, p. 231). Moreover, the range of loudnesses that can be produced is variable: notes on the harpsichord, for example, short of a change of stop or manual, can be played at only one dynamic level, whereas according to Patterson (1974, p. 87), even amateur players can make a contrast of over 40dB on the violin (corresponding to a considerable difference in values of loudness). The number of discrete levels that a player can execute, or, as Clark and Luce, 1965, p. 154) put it,

> the fineness with which it is practical to subdivide the intensity markings

is also limited, to a degree that varies from one instrument to another, and more generally between instrumental families. With the brass, for instance, the figure is around ten, whereas the woodwinds can manage between two and five such quanta (op. cit., p. 153). The orchestral average, according to Clark and Luce (ibid.), lies between five and six—much the same number, it is interesting to note, as the perceptual categories to which isolated loudnesses can be assigned. Composers have to contend too with the fact that the available levels of loudness vary between different models of the same instrument and between different performers (Patterson, op. cit., pp. 80ff). In contrast to these limitations, with modern electronically reproduced or synthesised sound, the composer has complete physical freedom, since levels of loudness beyond the thresholds of hearing and pain are possible: here, the restraining influences are, respectively, the values which can be perceived and those that can be tolerated.

We now examine the intraoperative and interoperative organisation of dynamics. As one might expect, this varies from style to style, though in virtually all music up to the mid-twentieth century, when multiple serialism and related techniques were devised, loudness was used merely to articulate events in other perspective realms, and was not treated as an independent structural factor.[5] Hence the control of dynamic levels can be understood fully only in relation to the ordering of other musical features.

The range of loudnesses that is employed in pieces varies from style to style. For example:

> Extremes of dynamic gradations from the Classic outer limits of *pp* and *ff* began with the French "rescue opera" composers of the 1790's and reached, with late Romantic composers, extremes from *ppppp* to *ffff*, or even greater. (Longyear, 1973, p. 27)

In contrast, the second of Webern's *Fünf Sätze für Streichquartett*, op. 5, confines itself solely to a range of dynamics extending from a little over *p* to rather less than *ppp*, a level additionally described by the composer as *kaum hörbar* ('scarcely audible'). If these values are felt to exist in approximate imitation of one another, then they may be regarded as being ordered through an imperfect zygonic constant system (see figure 8.8). Moreover, the fact that Webern utilised a similar narrow band of values in subsequent works can be understood in terms of interoperative zygonic relationships. See figure 8.9.

[5]Indeed, as far as I am aware, there is no work in which loudness is the chief expressive element. As a result, the dynamic levels of any piece could be randomly altered without destroying its identity (although such mutilation may well wreak aesthetic havoc).

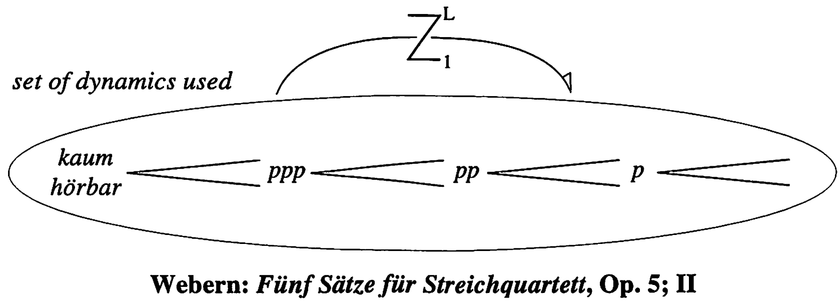


Figure 8.8 Imperfect constant system of loudness used by Webern, op. 5; II.

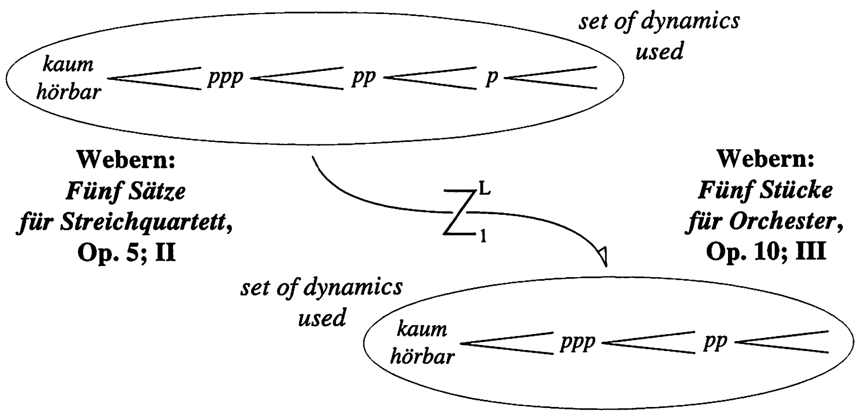


Figure 8.9 Imperfect primary zygon of loudness linking movements by Webern.

Similarly, the range of loudnesses deployed in a section of a composition may be subject to internal or external canonic control. Take, for instance, the trio from Haydn's symphony in *A*, no. 28, which is marked to be played '*p*' throughout, a practice typical of the composer.

We now examine the organisation of loudness in perceived time, beginning with values the same. Our enquiry starts at the level of protractions. It is conceivable that the dynamic uniformity of a note may be attributed to imitation through a primary zygonic constant system.

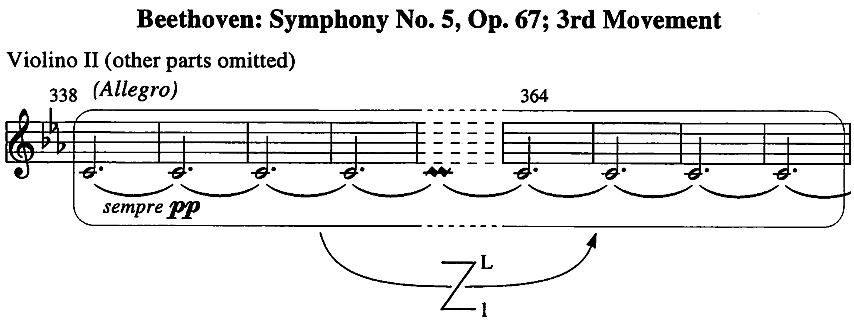


Figure 8.10 The dynamic uniformity of a note attributed to a primary zygonic system of loudness.

The value of a uniform protraction may itself be considered to imitate one heard previously. However, unless such a relationship connected elements in close perceived temporal juxtaposition, the limitations imposed by listeners' relatively weak long-term memory for loudness may make it difficult for the them to infer a sense of implication binding one protraction to the other. (See, for example, figure 8.11.) Moreover, the invariability of a note may be felt to exist in imitation of another or others similar, in which case the operation of a secondary zygonic constant, or a network of such relationships, is implied; again, see figure 8.11. (Observe that the crotchets illustrated are subject to similar—though less extended—dynamic ordering, and that the effect of the intraprotractive constancy shown is enhanced by the simultaneous changes in loudness that occur in other parts.)

We now consider associations of values the same, starting with chords. Here, notes are frequently allocated the loudness level, which may be deemed to be ordered through intrasociative primary constant systems. See, for example, figure 8.12. However, chords like these may well be perceived as having one chordal loudness rather than as an ordered association of protractive dynamics. However they are apprehended, the dynamics of chords may be considered to reproduce values or constants occurring earlier (see figure 8.13).

The vast majority of music makes use of other constant associations of loudness, whose typical duration varies from style to style. In considering the performance of music from the Baroque period, for instance, according to Rosen (1971/1976, p. 62), entire works

Mahler: Symphony No. 4 (1900); 1st Movement

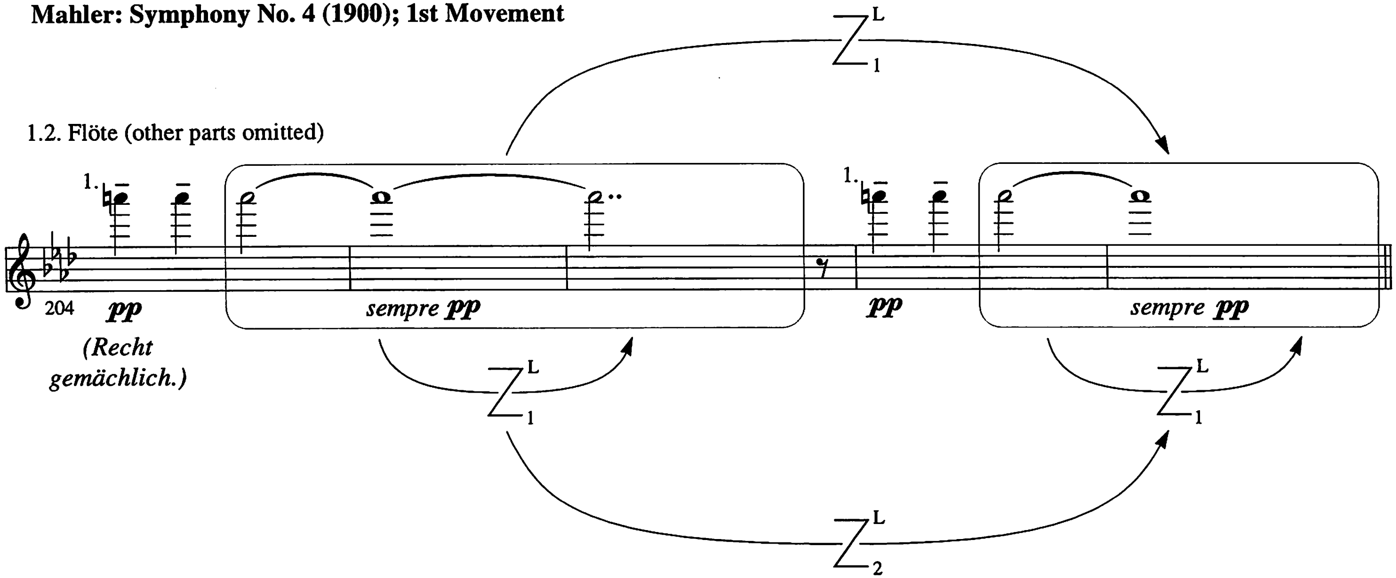


Figure 8.11 The dynamic uniformity of one note imitating that of another through a secondary zygonic constant of loudness.

Honegger: Symphony No. 2 (1941); 1st Movement

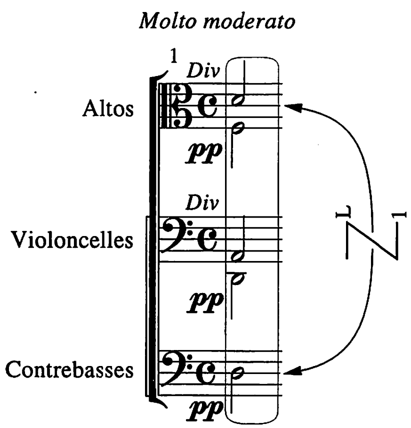


Figure 8.12 Intrasociative primary zygonic constant system controlling the loudness of a chord.

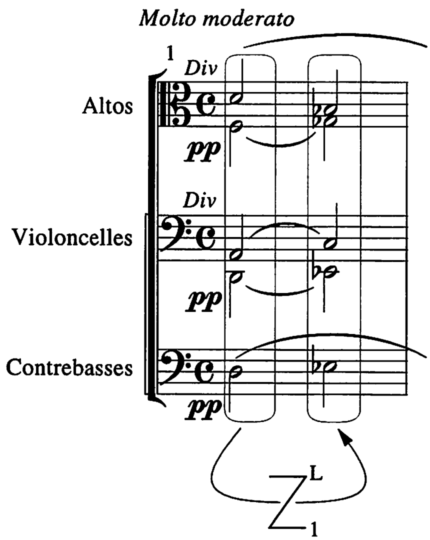


Figure 8.13 Intersociative primary zygonic constant of loudness relating two chords.

> may be played at a fairly constant level of sound, or two levels may be superimposed or juxtaposed without the use (at least structurally) of *crescendo* and *diminuendo*

(although, as Rosen concedes, these were important as ornamental and expressive nuances). By the time of the Romantics, Western classical music had for the most part lost this dynamic stability, and although constant associations of loudness were still much in evidence, they tended to be rather shorter than their seventeenth and early eighteenth century counterparts. It was not until the appearance of the pointillist style in the 1950s, though, that the ultimate degree of brevity was attained. Pieces appeared with constant associations of loudness comprising as few as two or three notes, and indeed, on occasions, the perceived sonic texture became so fragmented that groups even of this brevity disappeared altogether, and uniformity was limited to single protractions (see, for example, Stockhausen's *Klavierstücke I–IV* 1952/1953).

The organisation underlying constant perspective associations—whatever their duration—is similar to that pertaining to protractions. For example:

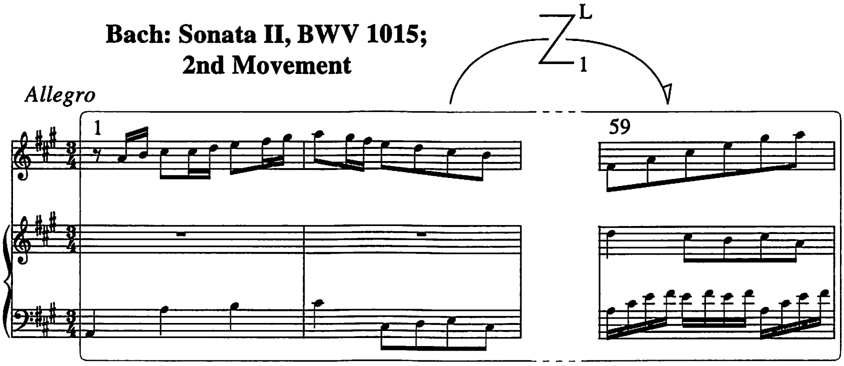


Figure 8.14 Extended primary intrasociative zygonic constant system of loudness in Bach's 2nd violin sonata.

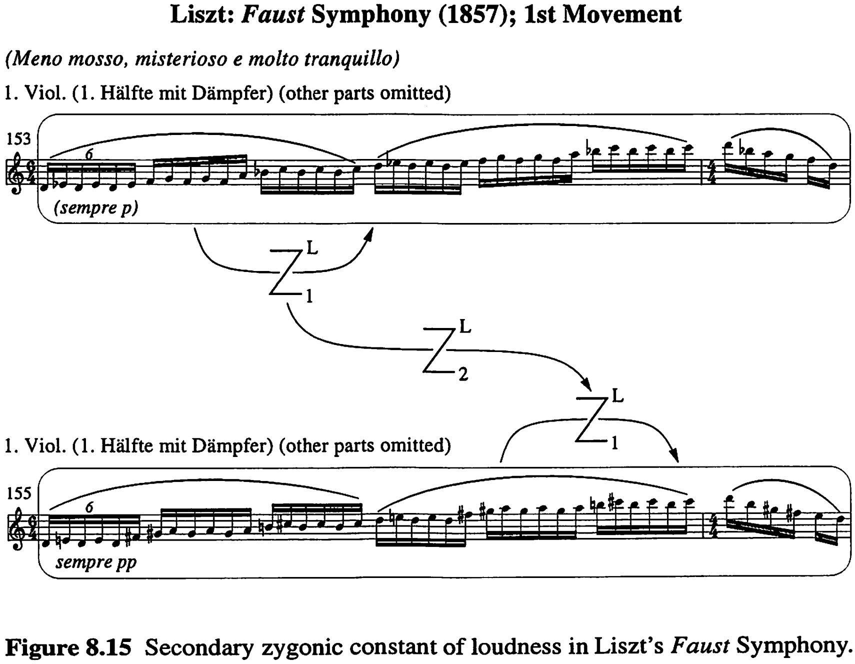


Figure 8.15 Secondary zygonic constant of loudness in Liszt's *Faust* Symphony.

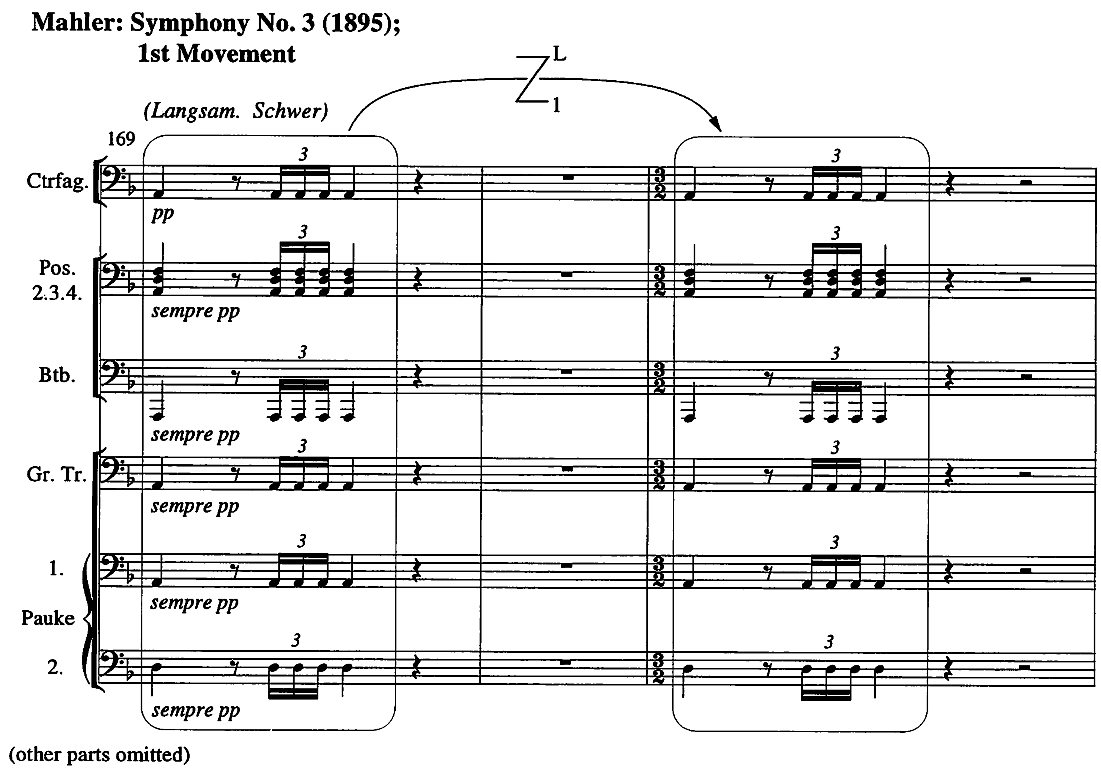
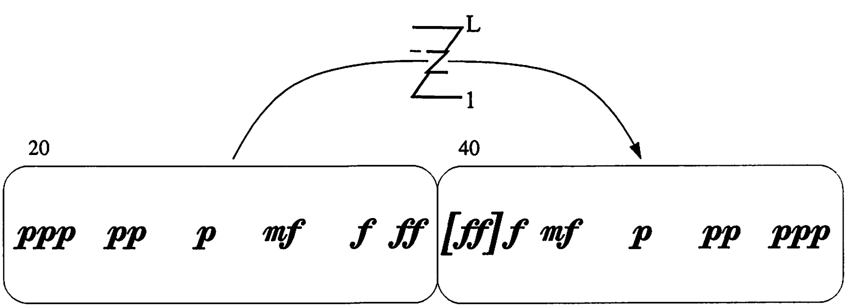


Figure 8.16 Primary intersociative zygonic constant of loudness in Mahler's 3rd symphony.

Where the uniformity of one association is felt to imitate that displayed by another, they may be considered to be related through a secondary zygonic constant. Associations of loudness so connected may exist in any perceived temporal relationship, from simultaneity to isolation. See, for instance, figure 8.15.

If the value of a constant association is felt to emulate that pertaining to another, then a primary intersociative zygonic constant is implicated, such as the one illustrated in figure 8.16.

So much for the organisation pertaining to values of loudness the same, or almost so. Next, we investigate the control of levels that differ. A series of different loudnesses may be related to another the same through a primary zygosequential zygonic invariant. Such ordering almost invariably operates in conjunction with configurative repetition of one form or another (cf. figure 8.20), although there are exceptions. For example, the middle section of MacDowell's 'Told at Sunset' (*Woodland Sketches*, no. 10, op. 51) has the following symmetrical pattern of dynamics:



MacDowell: *Woodland Sketches*, Op. 51; No. 10, 'Told at Sunset'

Figure 8.17 Retrograde primary invariant of loudness.

Secondary zygonic relationships of loudness, whether between protractions or associations, are cognitively feasible, but unless they operate in conjunction with primary zygonic links, it is difficult for listeners to ascertain whether the interperspective values involved were actually the same or not. As Rahn (1983, p. 53) puts it:

> the notion of identical intervals of loudness seems to be inapplicable. This is not to say that such a notion cannot be developed. It is only to observe that no

means for applying it, or pieces to which it might fruitfully be applied, have been found.

Despite observations such as this, passages are encountered in which secondary organisation does appear to be indicated. For example:

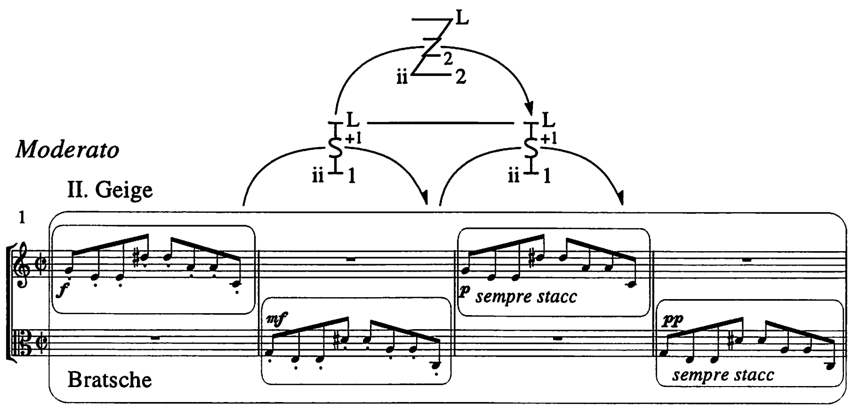


Figure 8.18 Secondary zygosequential zygonic constant system of loudness, order ii.

Here, the assumption is made that the differences between successive dynamic levels are perceived to be the same. If this were not the case, the secondary zygonic constant system would be imperfect.

Interperspective organisation in the realm of loudness manifests itself most frequently in the form of *crescendi* and *diminuendi*.[6] These may exist intraprotractively or intracontinuously, their duration ranging from the brevity of an *fp*, lasting, perhaps, less than a second, to an extended period of transformation such as that found in the first violin part of movement I of Sibelius's 3rd symphony, bars 156–168, which, at the suggested tempo of ♩=126, takes between 24 and 25 seconds. Whatever its extent, the precise nature of the variation involved is rarely, if ever, specified, and attentive listening suggests that change approximating to the uniform or the proportional may each be used on different occasions for the specific effects

[6]Boulez (1963/1971, p. 60) refers to these as *line-dynamics* (as opposed to the constant *point-dynamics*).

they evoke.[7] The primary invariant systems thereby implicated may be considered to be zygonically controlled, where order through imitation is felt to lie behind the consistency of their intraprotractive or intracontinuous variation. For instance:

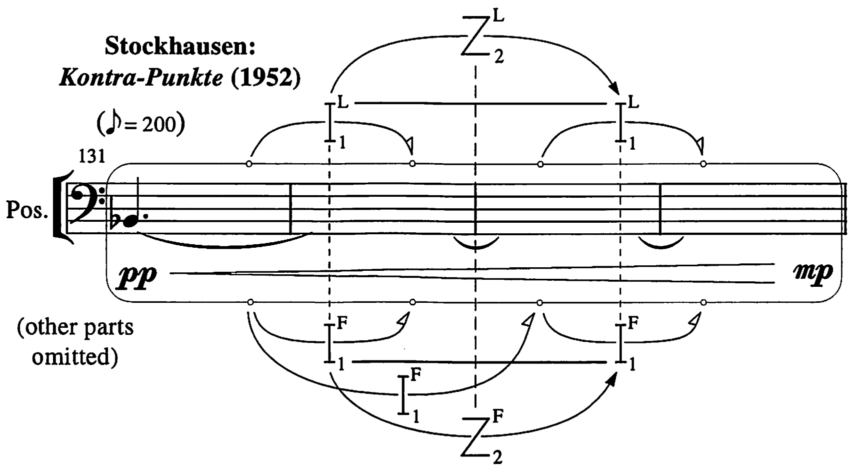
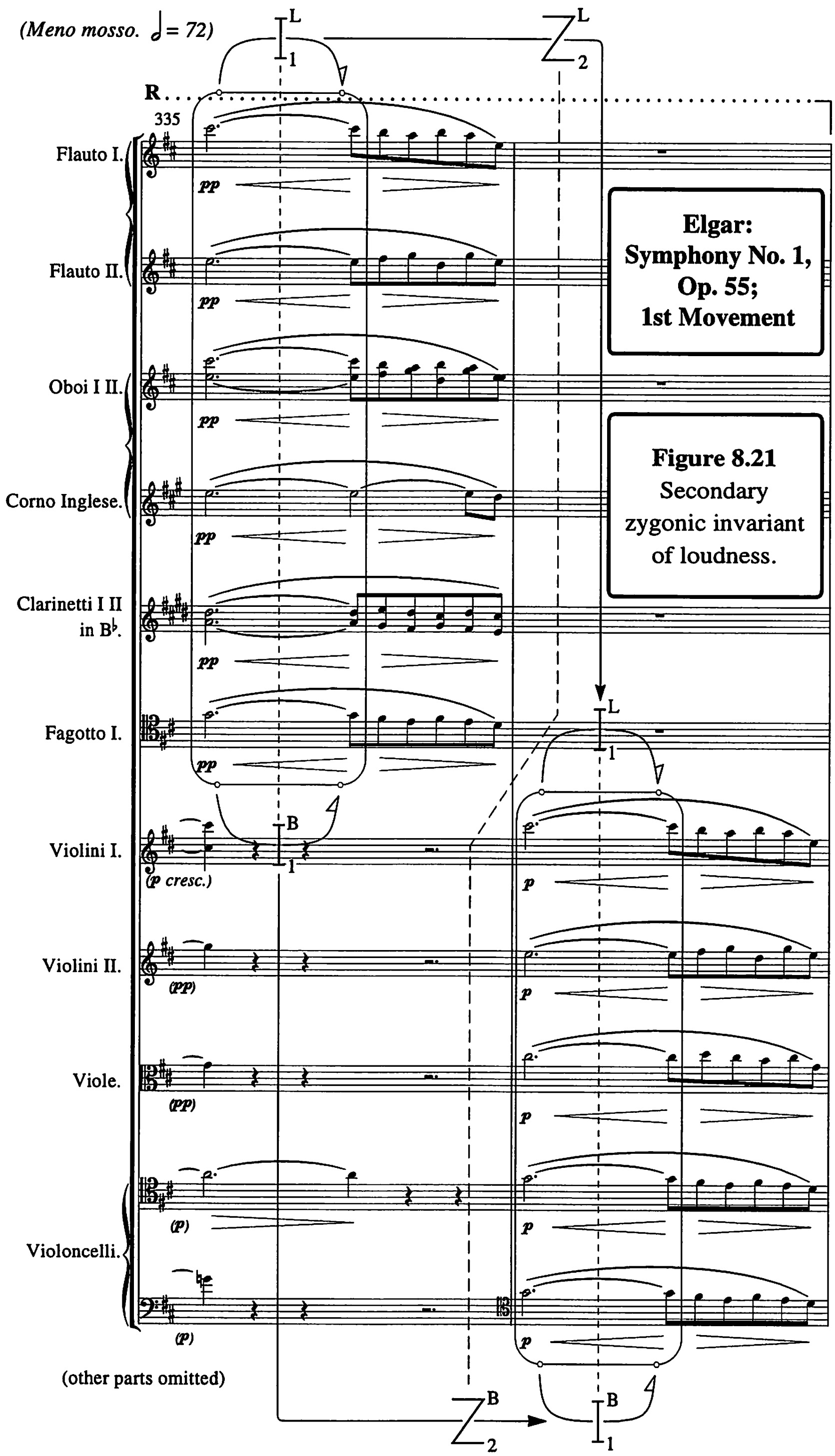


Figure 8.19 Uniform secondary zygonic constant systems of loudness.

If a *crescendo* or *diminuendo* is perceived to exist in imitation of another the same, then the presence of a uniform primary invariant is implied (cf. figure 5.37). See, for instance, figure 8.20. Similarly, a secondary zygonic invariant can be assumed to link *crescendi* or *diminuendi* that, through imitation, display the same rate of variation. In the example shown in figure 8.21 the changes in loudness are constant with respect to the beat, which is subject to a gradual *rallentando.* The assumption is made that the increase in level from *pp* in bar 335 is the same in degree as the rise from *p* in 336. A *crescendo* may be related to an equivalent *diminuendo*, moreover, through a retrograde secondary zygonic invariant. See figure 8.22.

Whatever form it takes, any impression of order through imitation in the domain of loudness will be enhanced through the co-existence of other zygonic relationships, although due acknowledgement should be made of Epstein's claim (1979, pp. 99 and 100) that the

[7]The visual appearance of the *crescendo* and *diminuendo* signs suggest, if anything, uniform change.



Elgar: Symphony No. 1, Op. 55; 1st Movement

Figure 8.21 Secondary zygonic invariant of loudness.

Liszt: *Faust* Symphony (1857); 3rd Movement

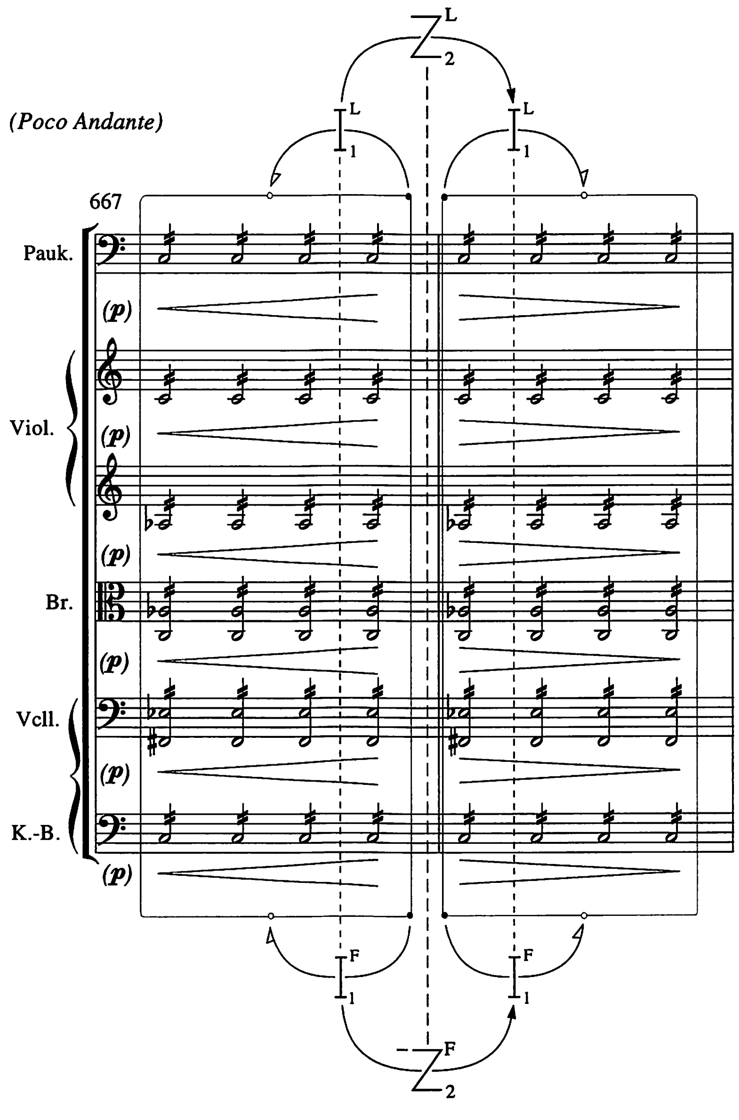


Figure 8.22 Retrograde secondary zygonic invariant of loudness.

Mendelssohn: 'Cello Sonata No. 1, Op. 45; 1st Movement

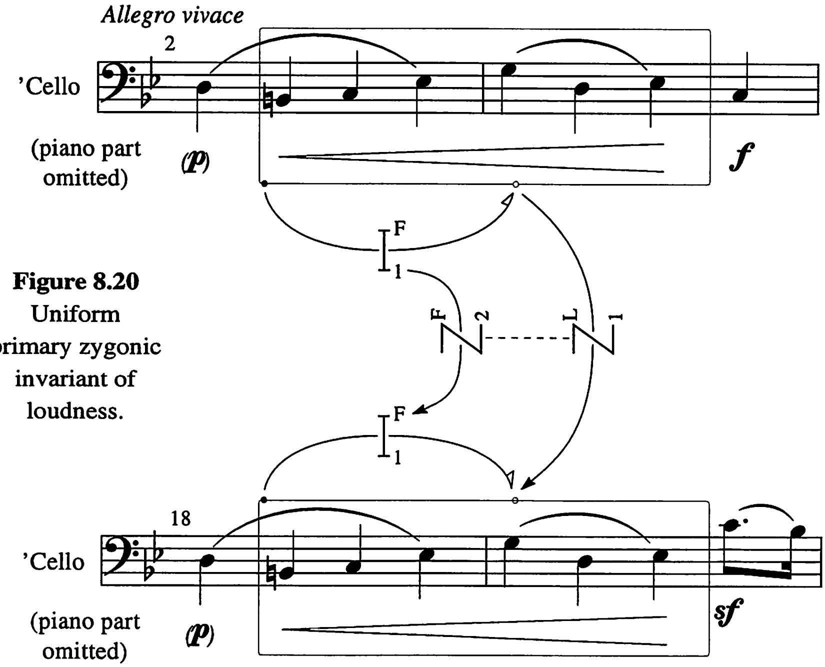


Figure 8.20
Uniform primary zygonic invariant of loudness.

> first movement of Schubert's *Unfinished* Symphony contains a nuance of unusual autonomy. This nuance ... consists of a loud and accented attack, variously indicated as *ff, fz, fp,* followed by a diminuendo extending from one to four measures.
>
> The nuance occurs throughout the movement ... to such an extent that in itself it assumes aspects of an integral motive. Its appearances are associated with a variety of different themes, allied with no particular one (save for similarities of exposition, recapitulation and coda) ... The nuance thus seems an independent idea, though a secondary one in the hierarchy of musical ideas.

In examining the organisation of loudness as a whole up to the middle of the twentieth century, two general points can be made. First, the majority of successive values are similar (despite the use of dynamic accents and contrasts), implying the existence of imperfect constant or invariant systems of zygonic relationships.[8] See, for instance, figure 8.24. (Here, for diagram-

[8]See Huron (1992), who describes the 'ramp' archetype in dynamics, whereby intensity increases tend to be small and incremental, whereas stimulus decreases are typically large and abrupt.

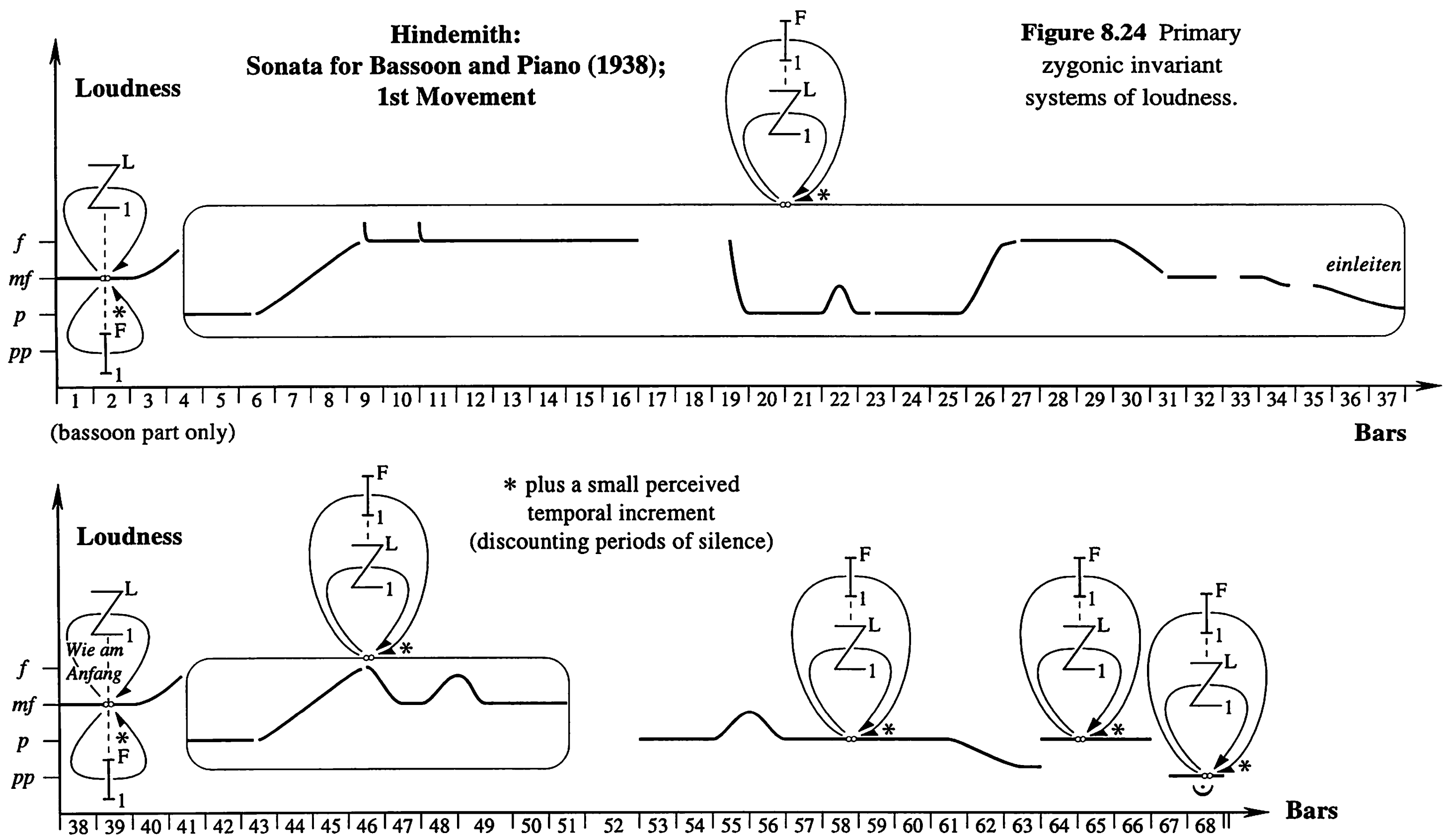


Figure 8.24 Primary zygonic invariant systems of loudness.

matic convenience, idealised values of loudness are extracted from the score. In performance, although the situation would be far more complex, the organisational principle illustrated would remain the same). Second, the control of loudness is almost entirely subservient to other perspective structures.

However, in the 1950s, in the West, new forms of organisation were tried that respected neither of these conventions. The use of pointillism in music, which reduced the continuity of loudness to the level of protractions, has already been mentioned above (see also Brindle, 1987, p. 40). This process of fragmentation was compounded by the advent of multiple serialism, which radically altered, moreover, the way values of loudness were ordered. Consider, for example, Boulez's *Structure Ia* (1951–1952), whose highly intricate dynamic organisation, involving twelve different levels (of which eleven actually appear in the piece), has been analysed by Ligeti (1958/1960, pp. 40 and 41). However, as Ligeti points out:

> it is problematic to differentiate dynamics so subtly as this; the regions of the individual intensity-values overlap, and one can certainly not be sure, for example, that a *p* at one point in the work will not be louder than a *quasi p* or even a *mp* at another point.

However, quasi-serial techniques could be used to order rather smaller sets of discrete loudness levels—say four or five—which would be distinguishable in isolation (though see Carterette, Kohl and Pitt, 1986). Moreover, through electronic means, the control of dynamics could be developed by any of the means introduced or implied in chapters 5 and 6.

Ordering timbre

A composer's choice of timbre is inevitably checked by the physical availability of instruments, players or vocalists, whose technical limitations impose further restrictions. Such conditions vary both from culture to culture (for example, in previous times the didgeridoo was no more accessible to Japanese musicians than the koto was to the Australian Aborigines), and historically as well. In the West, for instance, over the years, there has been a gradual expansion of timbral resources, which has come about through the adoption of instruments from other civilisations, such as the xylophone (see

Sachs, 1940, p. 439); through the invention of new ones, such as the saxophone (patented by Adolphe Sax in 1846); and through the temporary elevation of everyday objects to instrumental status, like the aeroplane propellers in Antheil's *Ballet mécanique* (1923–1925). Moreover, developments in technique have enabled a wider range of timbres to be produced on instruments whose use was already established (see Bartolozzi, 1967, for example). In the twentieth century, the advancement of timbre has received fresh impetus from the ever more sophisticated electronic creation and manipulation of sound; a dual revolution, which has yielded instruments like the synthesiser on the one hand, and on the other has permitted the production of pieces such as Stockhausen's *Mikrophonie I* (1964). In these respects, then, the timbral freedom of composers has been growing.

Other non-canonic forces may limit the choice of timbre too.[9] Among these are considerations of finance: the composer who writes for exotic instruments, unconventional combinations, or exceptionally large groups, runs the risk of having few, if any, performances, not because the necessary musicians do not physically exist, but since the money to pay them, or at least to cover the expenses that even most amateur concerts entail, may be forthcoming only rarely. These restraints apply in varying degrees to all composers—the great and the modest alike. It is clear that Stravinsky, for example, was keenly aware of operating within the confines of a tight budget when, as an impecunious Russian émigré living in Switzerland during the First World War, he scored *The Soldier's Tale* (first performed in 1918) for a 'miniature orchestra' of only seven players (Vlad, 1974/1978, pp. 62 and 63). Matters of finance and the control of timbre are also linked in other ways: composers working to a commission, for instance, may well have the timbral set determined for them. Consider, for example, Mozart's *Adagio and Allegro* in *f* minor for mechanical organ (K. 594) written (apparently rather grudgingly) at the behest of Count Josef Deym (see Einstein, 1946, p. 269).

We now consider how this complex network of practical restrictions ties in with canonic ordering, which may be supposed to prevail if the selection of timbres, or 'timbral set', of one piece or section is thought to exist in

[9]A fascinating example of extra-canonic timbral control is mentioned by Schneider (1957, p. 11), who, in speaking of 'primitive' music, discusses the widespread 'personal song', which may be sung exclusively by the person to whom it belongs; only after its owner's death may another venture a performance. According to Schneider, it is not (as one may have supposed) in the melody that the individuality of the music lies, but in the manner of performance, and especially the timbre of the voice.

imitation of that used in another. The issue is a complex one since so much music is written for the standard groups of performers that abound in cultures across the world, ranging from the classical symphony orchestra to the Javanese gamelan. Admittedly, such combinations often display a certain flexibility of design: in renditions of Haydn symphonies, for example, it is common for the typical orchestral complement to be reduced, or for it to be supplemented with extras like the E♭ clarinet in performing music such as Strauss's *Ein Heldenleben*, op. 40. Nevertheless, there is a core of players that remains intact. This makes it difficult for the music analyst to ascertain whether the timbral set of a piece—or at least the better part of it—arose on account of the practical advantages, alluded to above, of writing for a combination that already existed, or whether it came about in deference to the assortment of timbres found in another work or works, through zygonic relationships. Both factors, non-canonic and canonic, may operate side by side. In the absence of evidence to the contrary, the fact that a composition employs the same highly distinctive set of timbres as one that was written earlier strongly suggests the scenario of individual model and imitation. An example is provided by Rawsthorne's *Suite* (1968), which, scored for the unusual combination of flute, viola and harp must, it seems, have been based—at least in part—on the instrumentation used by Debussy in his *Sonata* of 1915, implying the operation of a primary zygonic invariant.

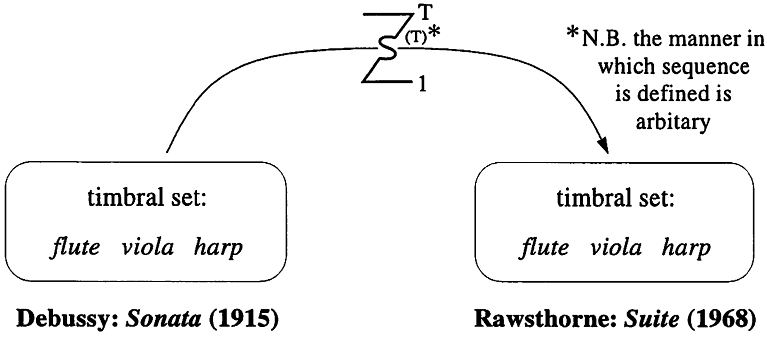


Figure 8.27 Interoperative primary zygosequential zygonic invariant of timbre.

Even a single value of timbre may display sufficient singularity to be attributed a specific zygonic *raison d'être*. Consider, for instance, Jolivet's use of the ondes martenot in his concerto of 1947, which was presumably influenced by pieces such as Varèse's *Ecuatorial* (1932–1934), which uses two of the instruments.

Finally, observe that the selection of timbres in works that aim to represent external objects or events may be influenced by zygonic relationships operating extra-musically, an effect found in pieces ranging from Tchaikovsky's *1812 Overture* (1882), with its cannon and bells, to Honegger's *Pacific 231* (1924), in which the orchestra imitates the noises of a train.

So much for the interoperative and extraoperative control of timbral sets. We now examine their intraoperative organisation. Despite the evident value of contrast (for pieces often incorporate timbres that are markedly dissimilar), a great deal of music makes use of timbral homogeneity. Many works, for example, are scored for vocal or instrumental families, such as the string quartet, the male voice choir and the brass band, implying the operation of impefect zygonic constant systems. It is even conceivable that timbral sets may be linked internally through 'antizygons'—a concept deriving from the fact that perspective values not only have the quality of being what they are, but also of *not* being what they are *not*, and that this negative aspect may be imitated. Take, for example, Strauss's *Concerto for Oboe and Small Orchestra* (1945), in which the oboe is consciously omitted from the orchestral parts. Hence these may be considered to be related through an antizygonic constant system as follows. (Note the symbolism of an antizygon using a mirror image of the letter 'z'.)

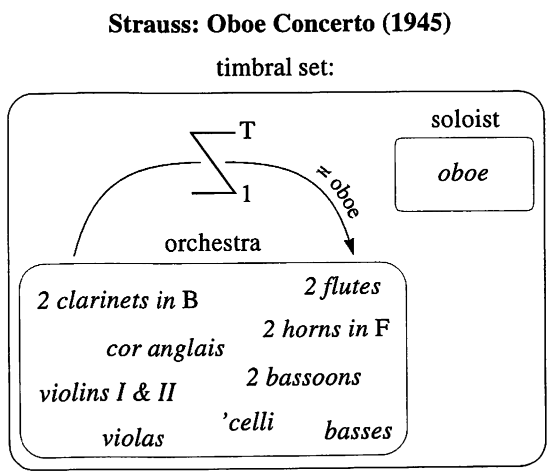


Figure 8.28
Antizygonic constant system of timbre.

We now examine the main ways in which timbre is ordered with respect to perceived time. We begin by considering various circumstances in which two or more perspective values are found to be the same. For example, in the Western instrumental tradition, timbre is usually held to be subjectively constant throughout the durations of notes; and this is true also of a good deal of vocal music, if the sub-elemental modulations in tone colour produced through the enunciation of words are ignored (since such variation is not intrinsically musical).[10] This implies the operation of primary intraprotractive zygonic constant systems. For example:

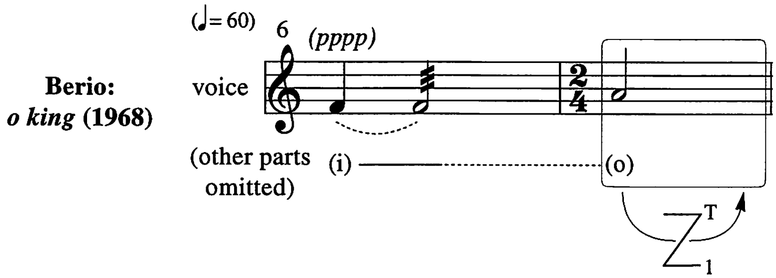


Figure 8.29 Primary intraprotractive zygonic constant system of timbre.

Moreover, if the timbral uniformity of one note is thought to echo that of another, then the presence of a secondary zygonic constant is implied, linking the two. See, for instance, figure 8.30. Observe that the effect of this particular link, out of many similar that could have been cited, is strengthened by parallel similarities in pitch and duration, which exist both between the notes illustrated and those preceding.

In many styles, the consistency of protractions continues up to the level of associations, for groups of notes that constitute entire motives, phrases, melodies or even longer passages frequently exhibit timbral constancy.[11] To use Erickson's term (1975, p. 12), timbre is treated as a 'carrier' for the

[10]Erickson's comments (op. cit.) on the Tibetan Lamaist chant are relevant here. The chants contain many interpolated syllables, whose purpose is to render the texts meaningless to non-initiates. "To the extent that the syllables are incomprehensible they are music, occasions for timbral nuance on a drone tone—timbre words—and the musical progression is ordered and regulated by their sequence. When semantic constraints are relaxed syllables and phonetic sequences may be composed entirely for their musical sound properties." (p. 97)

[11]Indeed, in discussing pieces as a whole, LaRue (1970, p. 205) observes how important the consistency of the medium is to perceived musical unity.

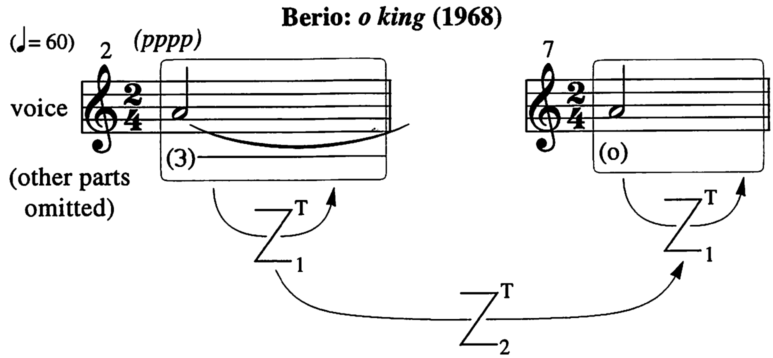


Figure 8.30 Secondary interintraprotractive zygonic constant of timbre.

burden of the musical message, which is conveyed by pitch and rhythm. This unequal division of perspective labour was established, no doubt, in the earliest stages of musical development, for while it seems entirely natural for a tune to be played or sung through by the same person, to divide the notes of a melody between different performers is an act of considerable artifice, demanding a level of coordination between performers that could be achieved only through careful planning and a great deal of practice (although the technique of hocketing appears to have been established in ancient times: see, for example, Reese, 1940, pp. 320ff; Schneider, 1957, pp. 38 and 81). The uniformity of an association may be interpreted through the operation of a primary intrasociative zygonic constant system. For example:

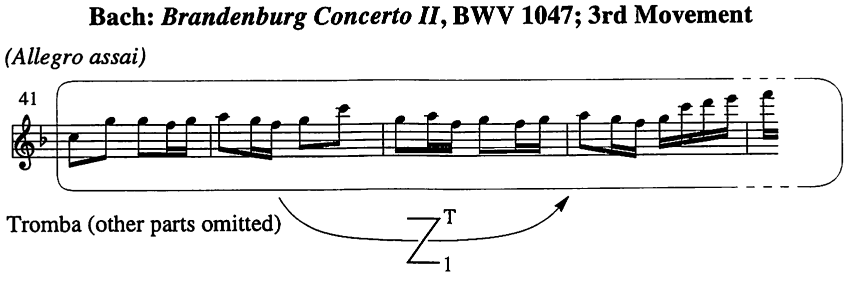


Figure 8.31 Primary intrasociative zygonic constant system of timbre.

(Observe that in this and similar pieces the timbral consistency of each contrapuntal line greatly assists the listener in perceiving the fugal texture.)

The fact that a phrase is timbrally invariable can further be attributed to the imitation of the consistency of other passages, that is, through the operation of secondary zygonic constants, which may function inter-operatively or intraoperatively. As so many interperspective connections of this kind are conceivable, though, for any one of them to achieve significance above the others, a concurrent motivic link may well be necessary:

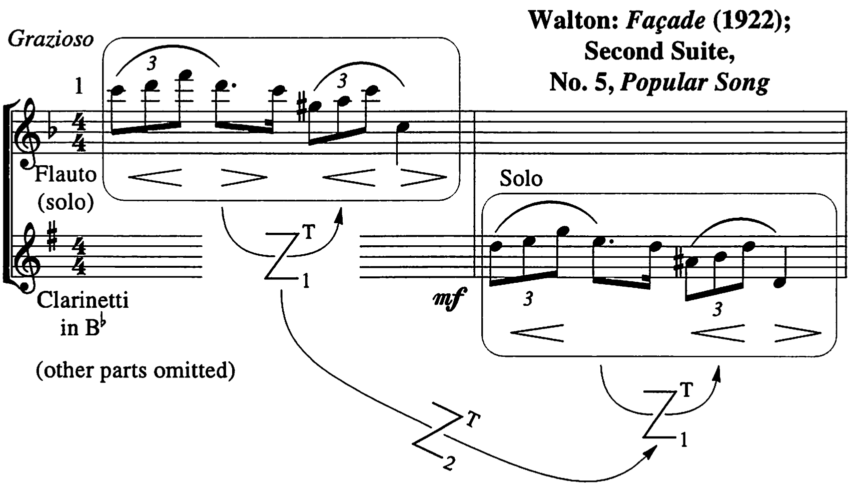


Figure 8.32 Secondary interintrasociative zygonic constant system of timbre.

Two groups of timbres that uniformly display the same value may be thought to be governed through a primary intersociative zygonic constant. This effect is commonly encountered when a melody retains its timbre on a second appearance, thereby enhancing the strength of the repetition. See, for example, figure 8.33. (Organisation of a similar nature is to be found in the excerpts from Dvorák's 5th symphony cited in figure 4.10.) Equally, timbral similarity may serve to link passages that differ configuratively (figure 8.34).

So much for the organisation of tone colours the same; we now investigate how differences in timbre may be structured. The differences between two pairs of values can be compared only if they are judged in the same timbral dimension (see pp. 55ff). However, since the instrumental and vocal tone colours that have traditionally been available are not distributed tidily along

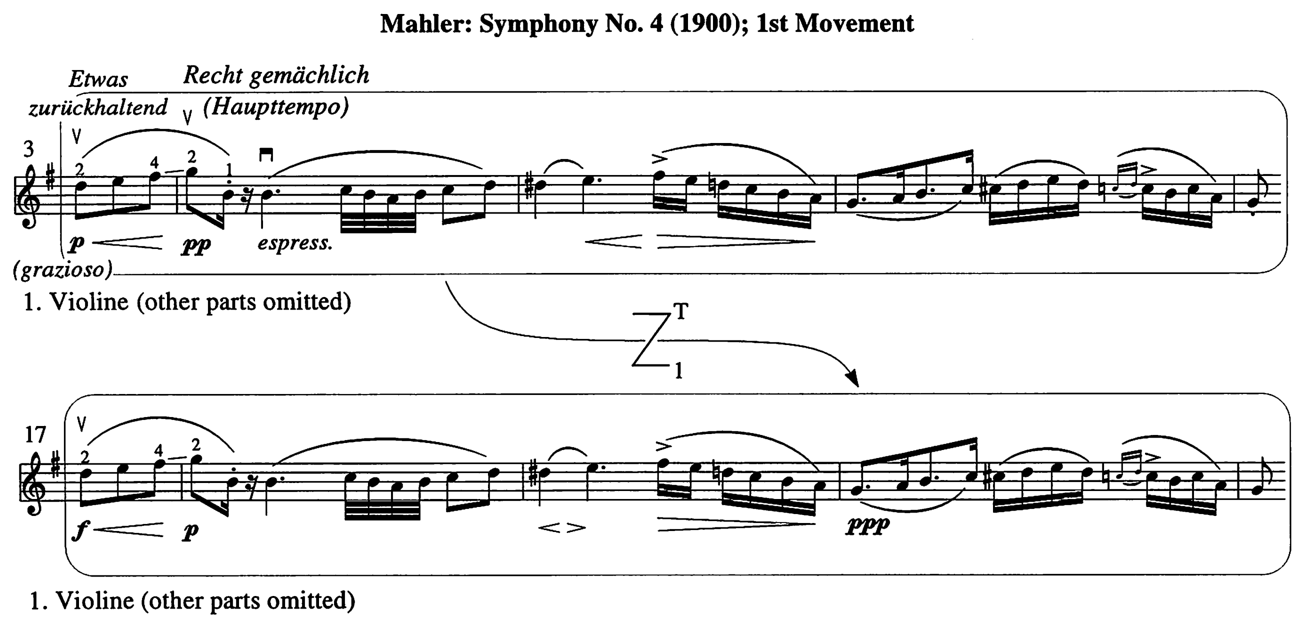


Figure 8.33 Primary intersociative zygonic constant of timbre linking a melody and its subsequent reappearnce.

Sibelius: *Karelia* Suite, Op. 11; II, *Ballade*

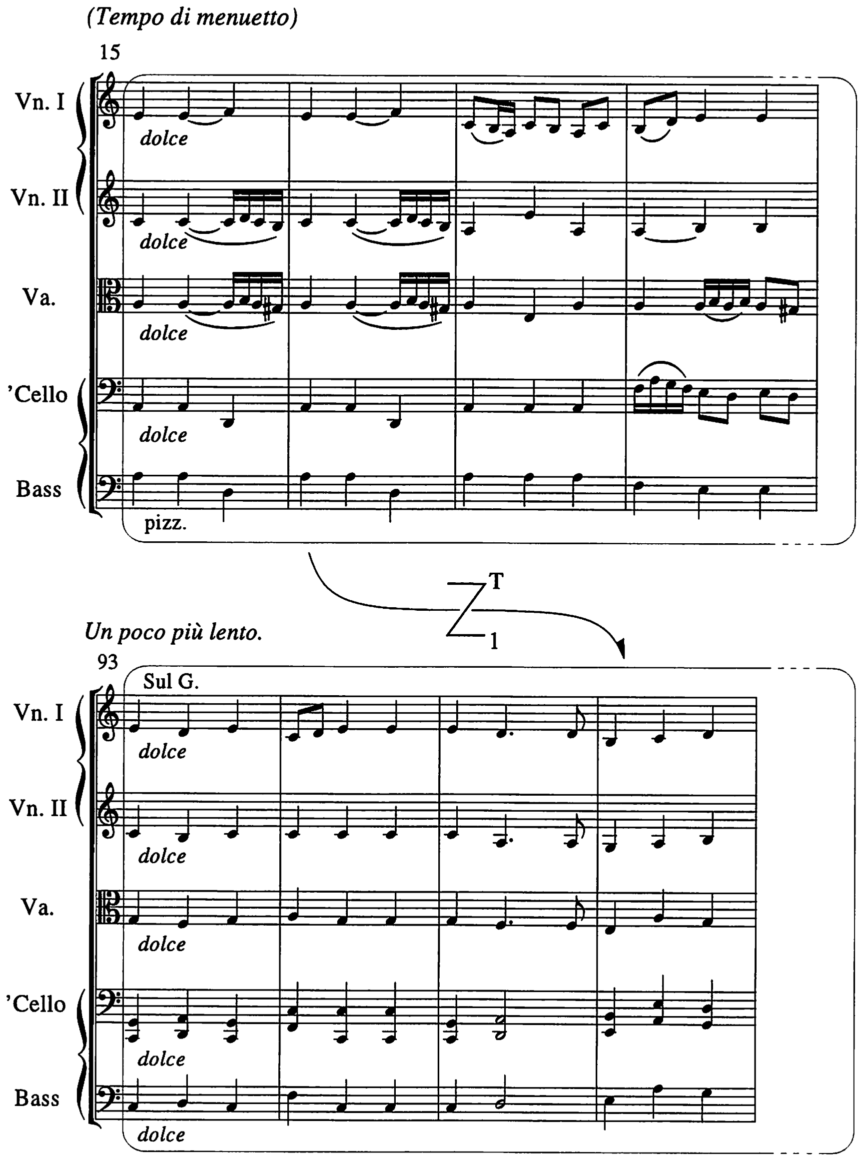



Figure 8.34 Primary intersociative imperfect zygonic constant system of timbre linking passages that differ melodically.

Bartók: *Music for Strings, Percussion and Celesta* (1936); 1st Movement

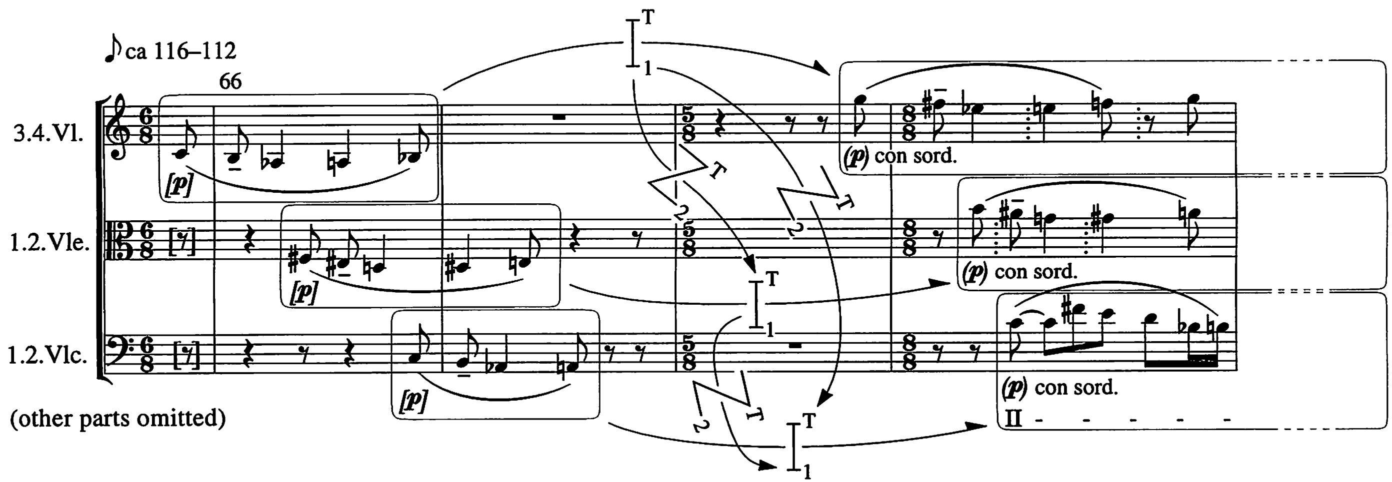


Figure 8.35 The ordering of timbre through secondary zygons.

one axis of timbral variability (rather they characteristically differ from each other in several respects, and to varying degrees) the use of secondary relationships of timbre as a self-sufficient ordering force has been very limited. Examples are to be found, though: consider, for instance, the following passage from Bartók's *Music for Strings, Percussion and Celesta* (1936), in which mutes are added first to violins, then the violas and then the cellos, implying the zygonic connections shown in figure 8.35.

Secondary zygonic relationships are also associated with timbral variables whose regularity is considered to result from internal imitation. However, before the advent of electronically synthesised sound, composers in the West seldom made use of continuous timbral change, and even when variables were used, only their initial and final values tended to be specified, and not the rate of change in between.[12] Take, for example, the string parts of Delius's *Appalachia* (1902), bars 196–201, to which the following instruction is applied:

Tutti gli archi poco a poco con sord.

It seems reasonable to assume, however, that in performance, the implied primary invariant system should lean towards uniformity, and so organisation is implied as follows (see figure 8.36).

What forces underlie composers' choice of timbral apposition? Clearly, the same constraints apply that initially limit the availability of perspective values of timbre. Beyond this, although certain vertical combinations of sonorities may well be more effective than others, as a glance at any textbook on orchestration will show (see, for example, Rimsky-Korsakov, 1922/1964), there is no limit as to which timbre may follow another: any contiguous or isolated transition is apparently acceptable. As Schoenberg says (1911/1978, p. 421):

> we go right on boldly connecting the sounds with one another, contrasting them with one another, simply by feeling ... .

As far as canonic organisation is concerned, timbral associations may well be repeated intraoperatively with reference to the pitch and rhythmic patterns that they colour—see, for example, figure 8.37—although some

[12]Though there are notable exceptions. See, for example, Berg's *Wozzeck* (1917–1922), Act III, bars 109–113.

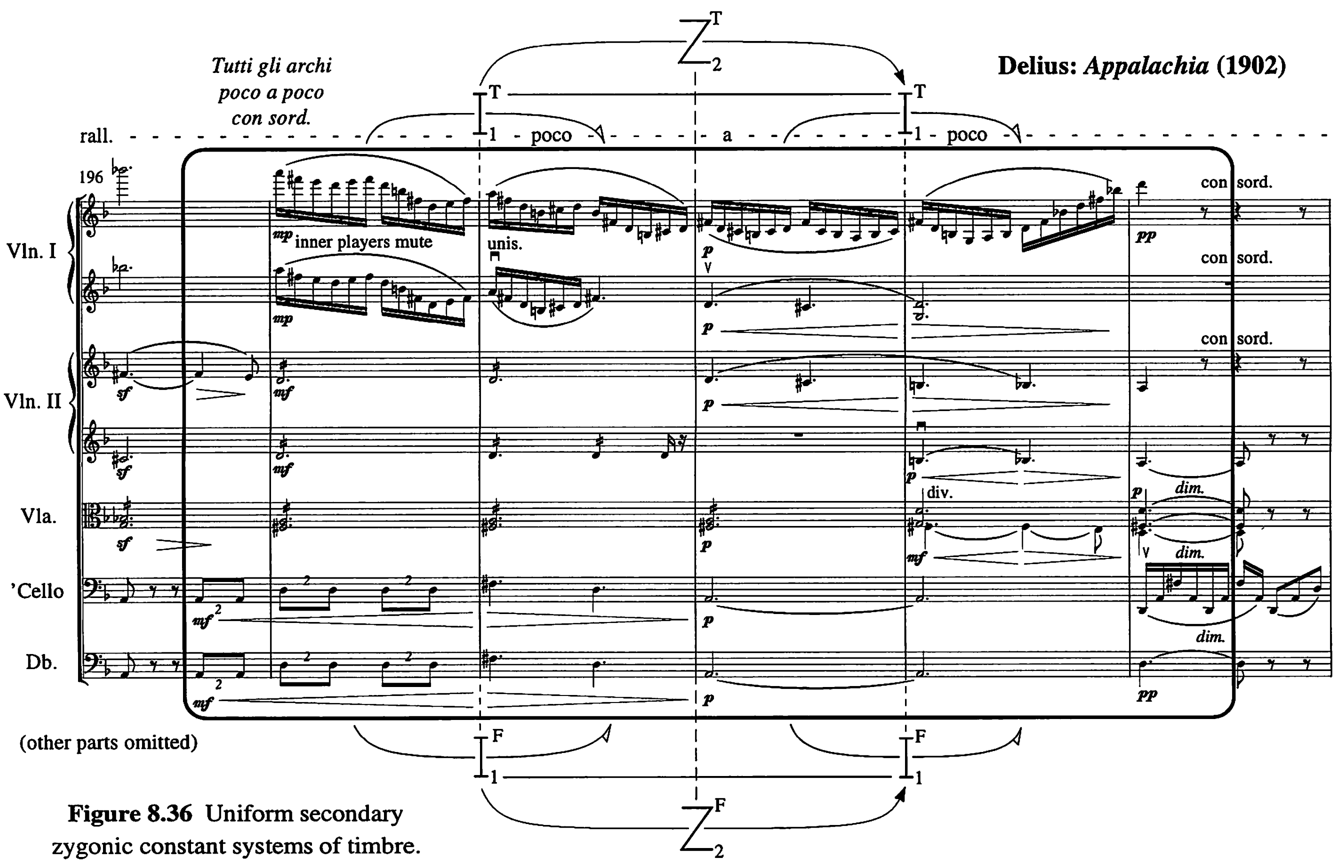


Figure 8.36 Uniform secondary zygonic constant systems of timbre.

Brahms:
Symphony No. 4, Op. 98;
1st Movement

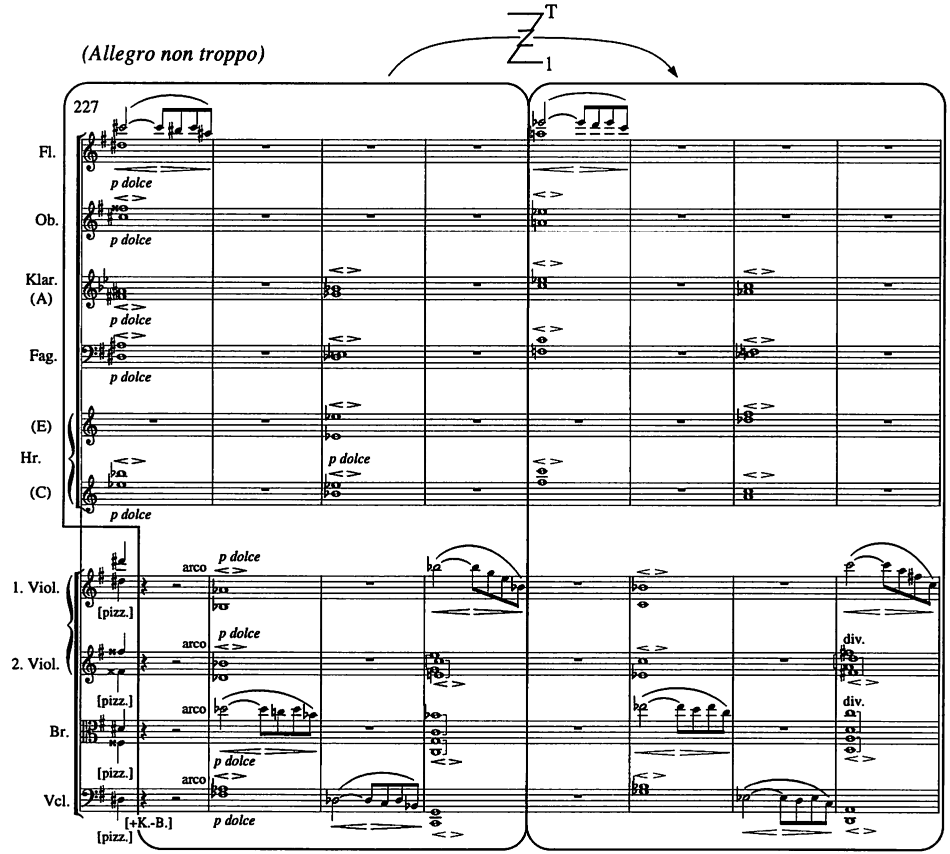



Figure 8.37
Primary zygosequential intersociative zygonic invariant of timbre.

composers, including Schoenberg (*Five Orchestral Pieces,* op. 16), Carter (*8 Etudes and a Fantasy for Woodwind Quartet,* 1950) and Babbitt (*Composition for 12 Instruments,* 1948; *Relata 1,* 1965) have treated timbre with a greater independence. However, it seems that groups of timbral values, divorced from the other perspects they qualify, have not been transferred interoperatively. Since series of timbres can quite easily be committed to memory, it seems reasonable to assume this merely represents a form of organisation that composers to date have chosen to neglect, and that the future may well hold a place for such ordering.

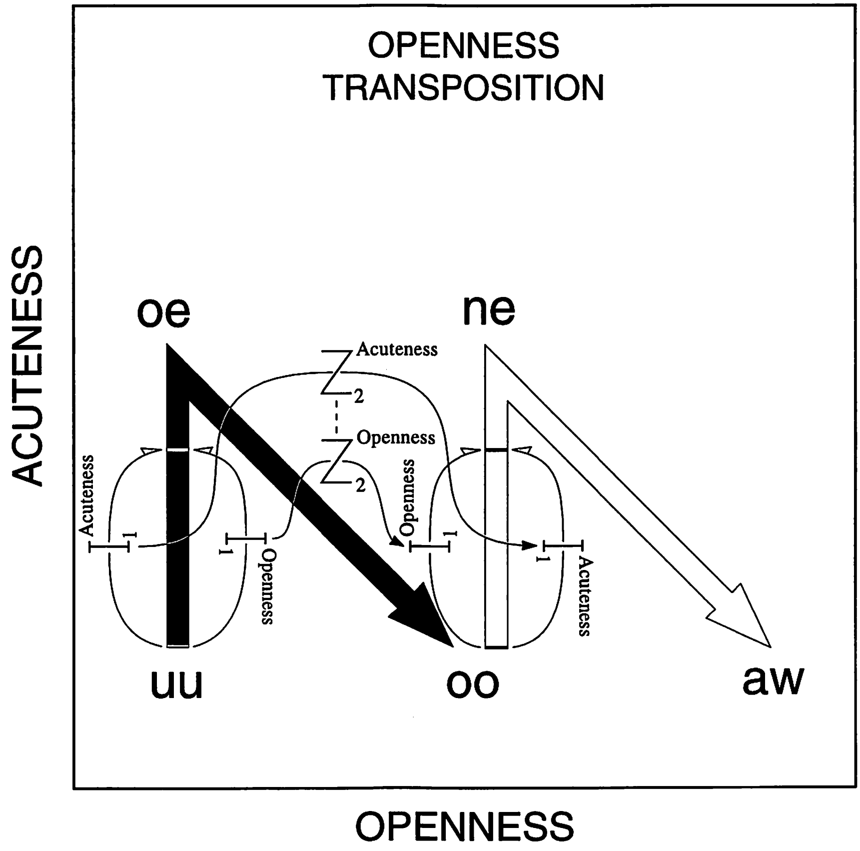


Figure 8.38 Secondary zygonic invariant of 'openness'/'acuteness' (cf. figures 5.37 and 5.38; after Slawson, 1985, p. 71).

Sounds that are controlled or produced electronically dramatically increase the range of obtainable tone colours. It is through such means that Schoenberg's vision of timbral progressions,

> whose relations with one another [would] work with a kind of logic entirely equivalent to that logic which satisfies us in the melody of pitches (1911/1978, p. 421)

becomes a reality. For example, as Slawson has shown (1985, pp. 68ff), the transposition and inversion of values can be undertaken in any of the four timbral dimensions he proposes: acuteness, openness, laxness and smallness. The organisation governing such transformations may be interpreted through the canonic model proposed in the present work. See, for instance, figure 8.38. These ideas may be further extended using the more complex forms of organisation outlined in chapters 5 and 6.

Ordering number

Finally, there follows an examination of the order pertaining to a perspect that has received only scant theoretical attention, but one that is frequently subject to a high degree of organisation—that is, the **number** of elements in complements and sets (cf. p. 155). Consider, for example, the amount of music written in four parts, ranging from the traditional arrangements of hymn tunes to string quartets. In the case of the former, number is often perfectly consistent from chord to chord, implying the operation of primary zygonic constant systems (see figure 8.39). With string quartets, a less regular texture is generally encountered: one or more of the instruments may temporarily be silent, for instance.[13] Conversely, sonorities may be enhanced with double or triple stops. Here, the number of notes in chords can be regarded as being ordered through primary imperfect zygonic constant systems. Consider, for example, the passage from Haydn shown in figure 8.40. Here, the organisation is expressed in terms of the perspect **chordal number**.

[13]Consider, however, that an instrument may still be present in the mind of the listener even when it is not playing, and that in this sense, the four parts of a quartet may be supposed to exist for the duration of a piece, despite periods of inactivity by one or more of the players.

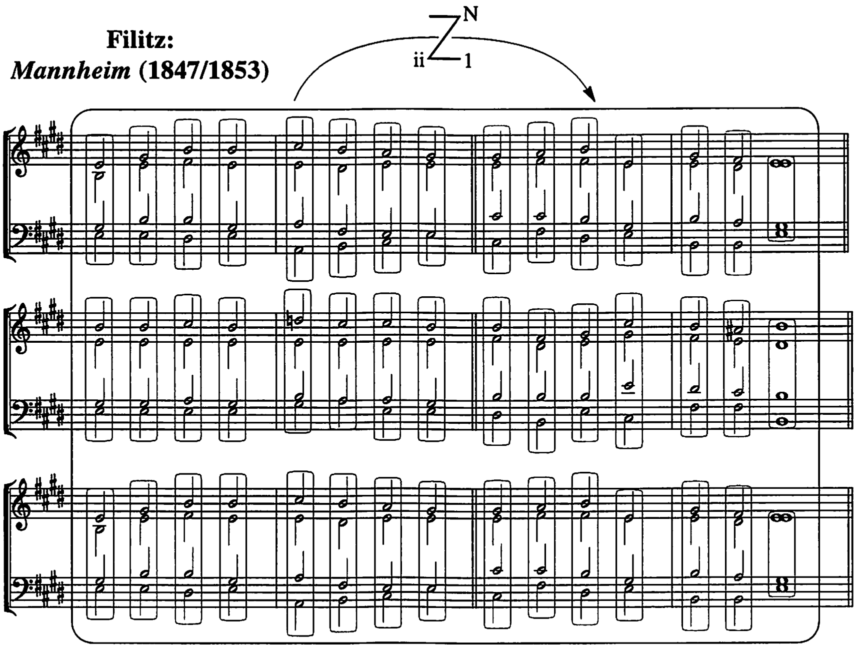


Figure 8.39 Primary zygonic constant system of number, order ii.

Aside from four-part music, there are other standard numbers too: consider, for example, the numerous duets, trios, quintets *et cetera* that have been written for various instrumental and vocal combinations over the years. Moreover, the majority of keyboard pieces contain passages, often substantial in length, in which the number of simultaneously sounding parts is entirely uniform. This may be attributed to intraoperative and interoperative imitation. See, for example, figure 8.41. Here, the number of simultaneous parts used by Domenico Scarlatti in a passage from his harpsichord sonata, K. 395, is judged to have a wide range of influences. Since their exact nature is indeterminable, the ordering present is shown in an abstract way. A ***general zygonic relationship*** is indicated, which may function directly or indrectly, and is undetermined as to temporal polarity.

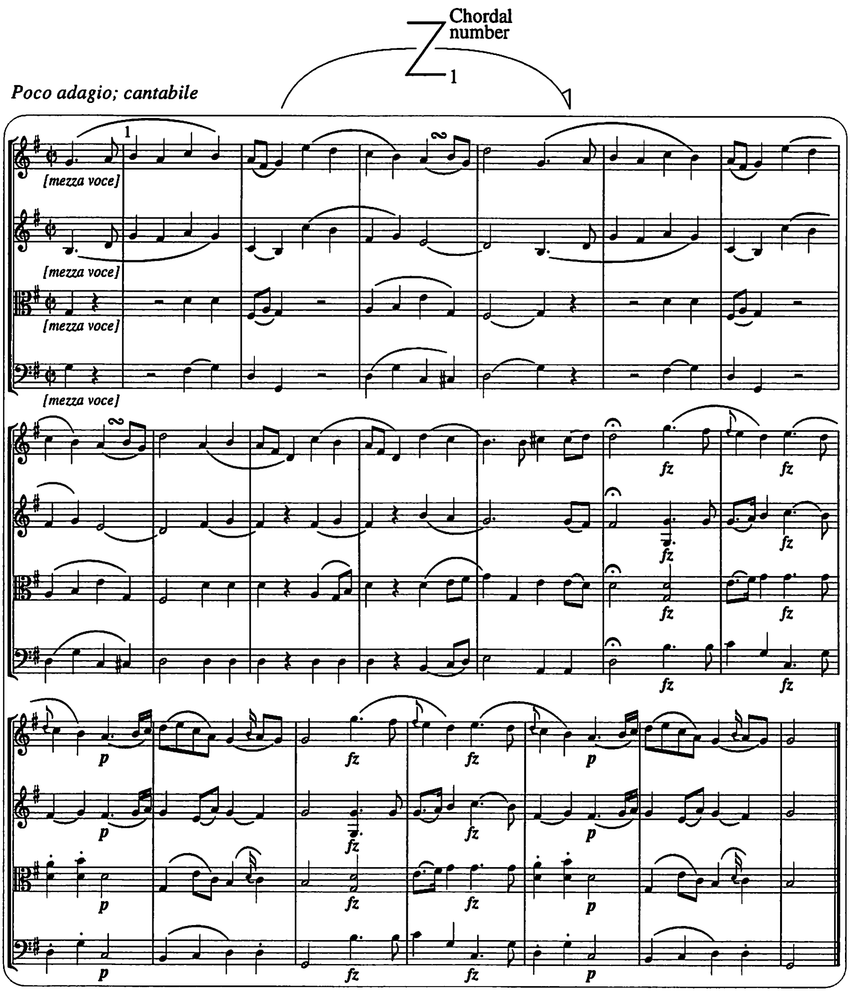
Chordal number may be subject to regular variation. Take the passage, shown in figure 8.42, for example, which may be thought to be controlled through a secondary zygosequential zygonic constant system.

Haydn: *Emperor* Quartet, Op. 76, No. 3; 2nd Movement

Figure 8.40 Primary imperfect zygonic constant system of chordal number.

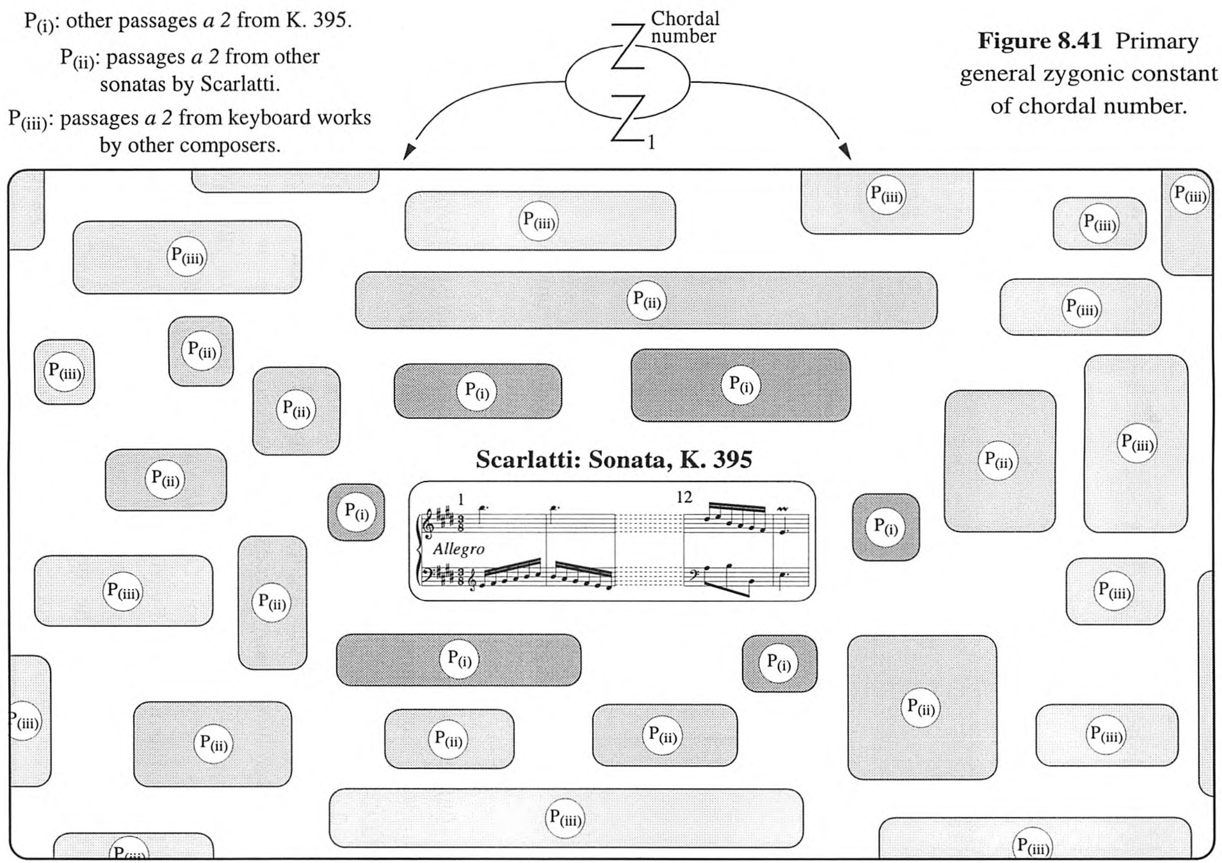


Figure 8.41 Primary general zygonic constant of chordal number.

Bartók: String Quartet No. 4 (1928); 3rd Movement

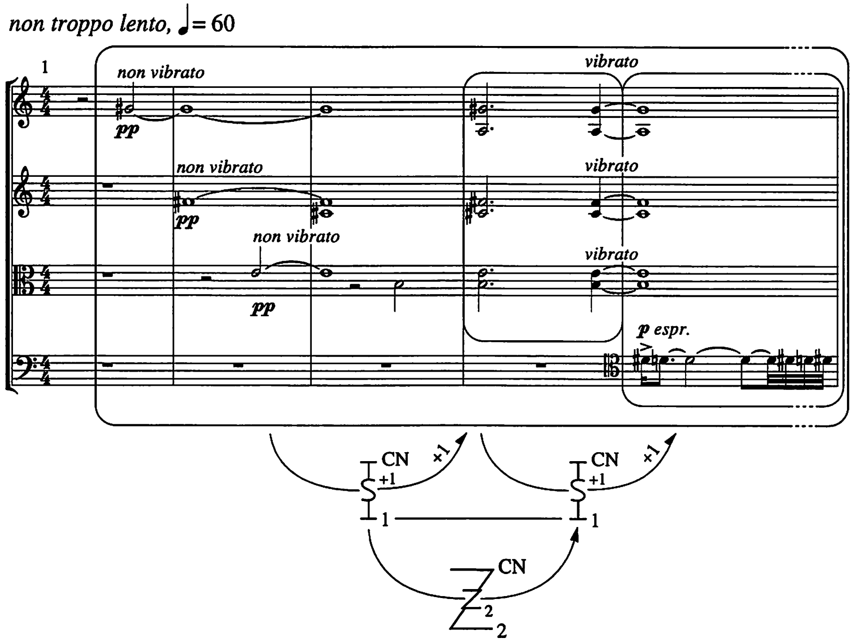


Figure 8.42 Secondary zygosequential zygonic constant system of chordal number.[14]

One such a process may be considered to exist in imitation of another through the operation of secondary zygosequential zygonic constant (cf. figure 6.40). See, for instance, figure 8.43.

The organisation of number commonly pertains to holons other than chords too. At the highest intraoperative structural level, for instance, consider how many pieces are arranged in three or four movements, a characteristic that can be attributed to the agency of interoperative primary zygons. In Beethoven's *Diabelli* variations, op. 120, according to Geiringer (1964), the number of variations conforms to the structure of the theme. The eight groups each of four variations can be understood to emulate the eight four-bar phrases of the theme, followed by variation 33 which serves as an epilogue. This interpretation of the work implies a zygon of number as shown in figure 8.44.

[14]Observe that in this figure and in figure 8.43, successive chords with the same number of elements are treated as one sequential unit.

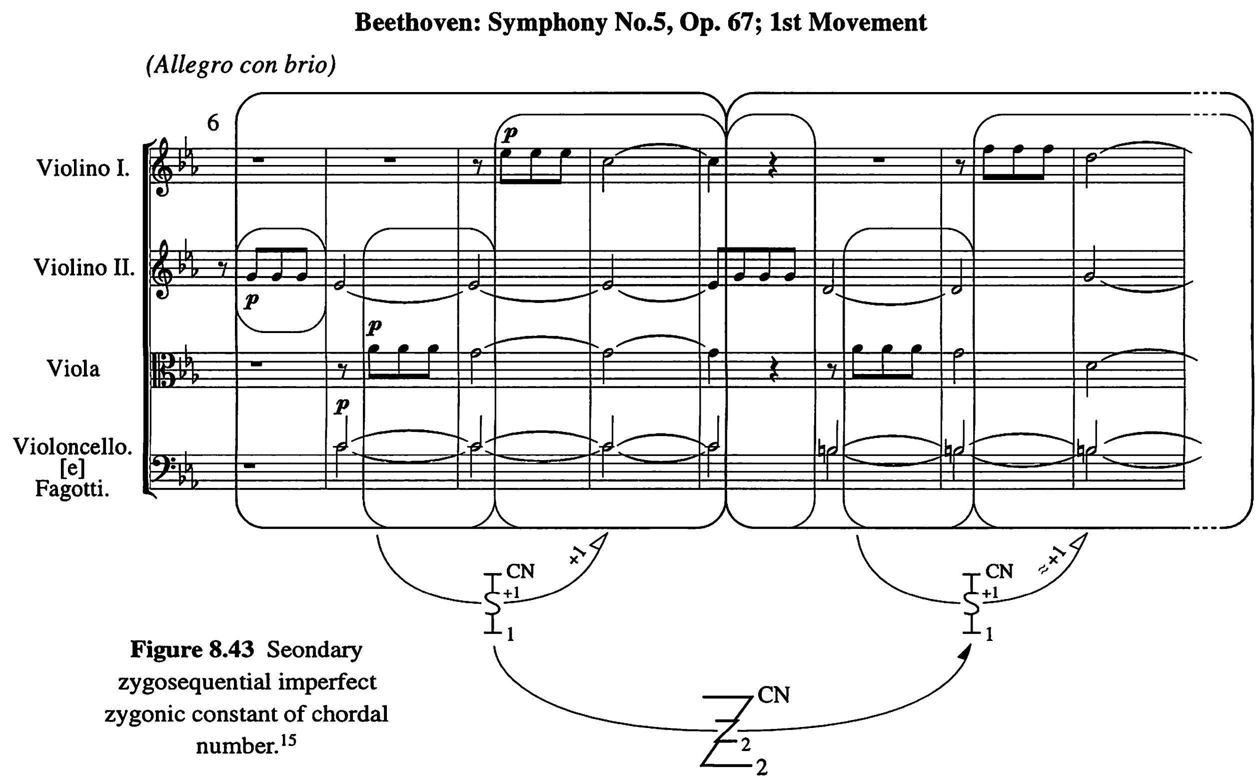


Figure 8.43 Seondary zygosequential imperfect zygonic constant of chordal number.[15]

[15]The imperfection here arises since the 2nd violin figure in bar 10 (unlike its model in bar 6) is accompanied.

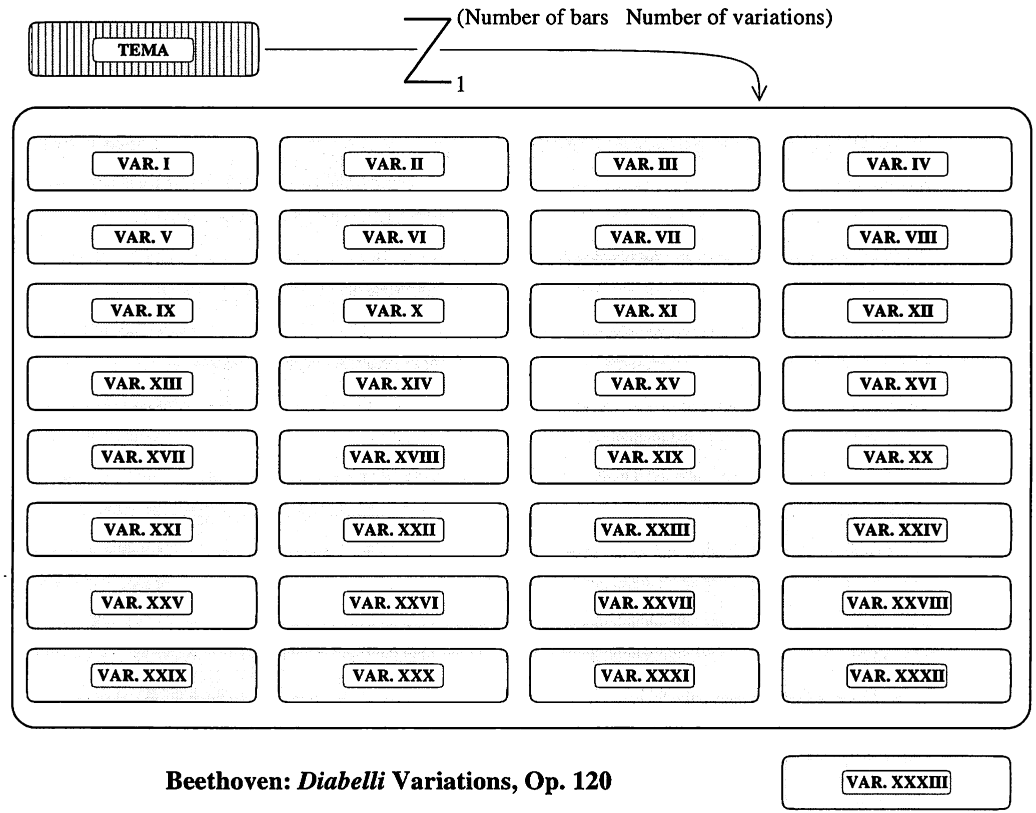


Figure 8.44 Primary zygon of number underpinning the formal structure of Beethoven's *Diabelli* variations (after Geiringer, 1964).

On a much smaller scale, series of complements exist, each with one more note in than the last, implying the following method of organisation:

Beethoven: Symphony No. 1, Op. 21; 4th Movement

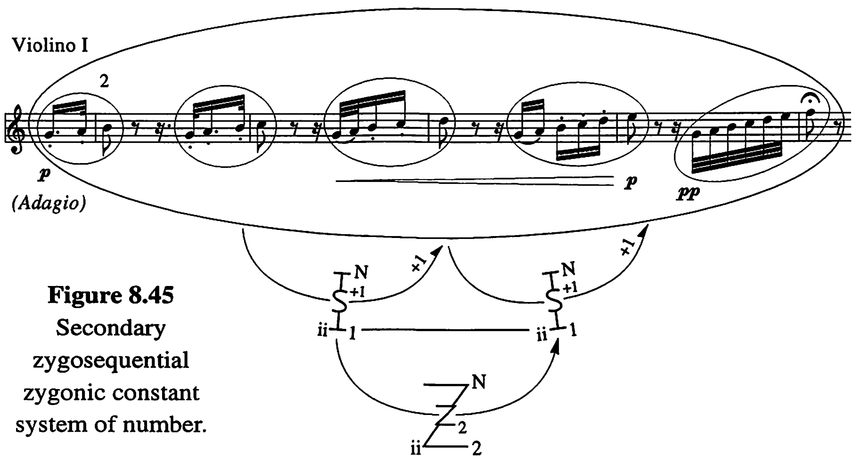


Figure 8.45
Secondary zygosequential zygonic constant system of number.

Extramusical canons of number are occasionally encountered too. For example, the 'clock' in Strauss's *Sinfonia Domestica*, op. 53, twice strikes seven, implicating intraoperative as well as extraoperative imitation.

Strauss: *Sinfonia Domestica*, Op. 53

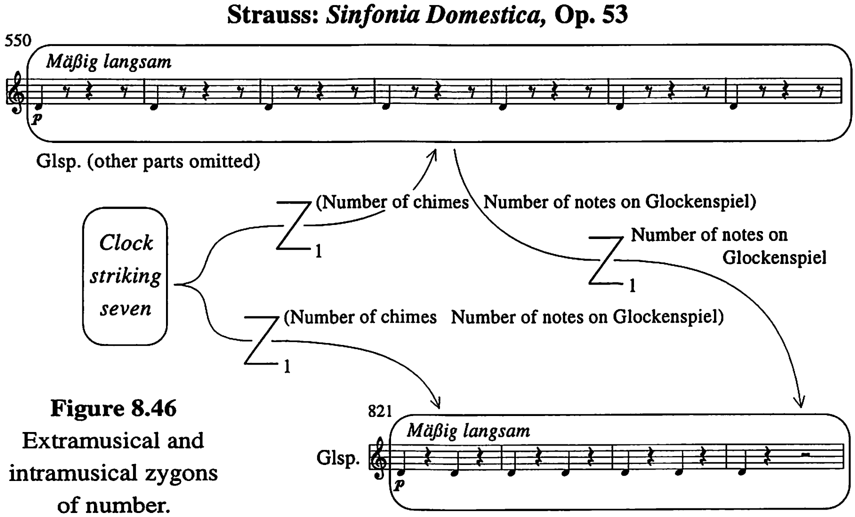


Figure 8.46
Extramusical and intramusical zygons of number.

Finally, consider that the number of notes played in a given period of time may be controlled too, as in Stockhausen's *Mixtur* (1964), for instance, which makes use of the *Fibonacci* series (see Brindle, 1987, p. 48), and Berio's *Sequenza II* for harp (1963).[16] Take bars 3–8, for example, whose organisation may be expressed in canonic terms as follows:

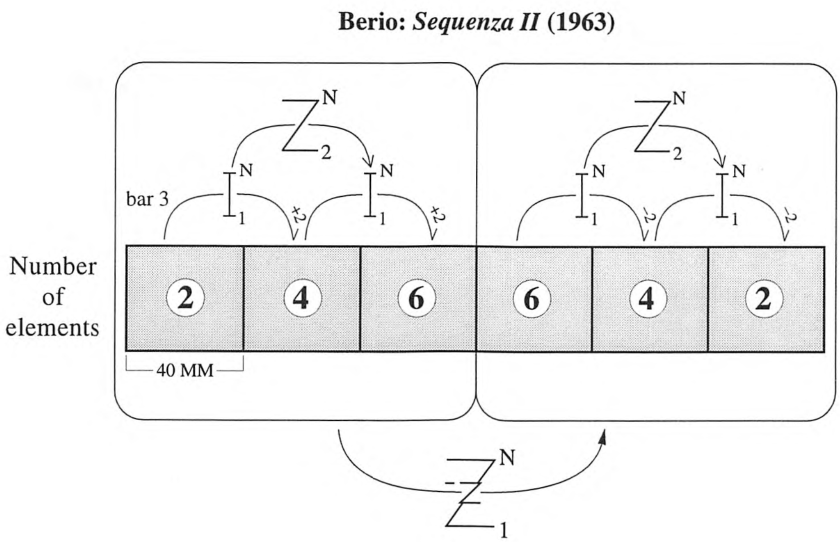


Figure 8.47 Organisation of number in bars 3–8 of Berio's *Sequenza II* (after Berry, 1976/1987, p. 310)

Conclusion

In viewing this chapter as a whole, it is striking just how much organisation typically pertains to perceived reverberation, plot, loudness, timbre and number, even though these normally function as secondary aspects of musical structure. The wide range of musical effects engendered by the one ordering principle—imitation—is worthy of comment too.

[16]See also Krenek (1960, p. 225) for remarks concerning the serialism of density.

9

Ordering the temporal perspects

Introduction

This chapter examines the organisation of the temporal perspects. We begin by discussing the order pertaining to fix, followed by a consideration of the control of metre, the organisation of duration and the coordinated order of prefixes and durations. However, the bulk of the chapter is devoted to the ordering of rhythm, both intrafiguratively and interfiguratively, as well as interoperatively and extramusically. Finally, mention is made of the organisation of the temporal perspects belonging to holistic complements.

The organisation of perspective values of fix

As a rule, composers do not specify when works should be performed, and values of fix tend to be reckoned purely intraterpretively, although some music may be written for, or may come to be associated with, a particular period of perceived time regarded cyclically.[1] For example, according to Daniélou (1949, pp. 131 and 132),

> Orthodox musicians in India never play a raga at any other than its proper time, for at the wrong hour it could never be developed so perfectly, nor could it so greatly move an audience.

[1]Consider Christmas carols, for instance, and pieces pertaining to other religious festivals such as Purcell's odes for St. Cecilia's Day, first performed on 22nd November 1683 and 1692. Clock chimes may be regarded in this way too.

If the time of a performance is considered to exist in imitation of a previous one, then the presence of interterpretive cyclic zygonic relationships of fix is implied. Of this group, the perfect zygons form a uniform primary zygonic invariant (cf. figure 5.37), which may exist between entire performances, or any portion of them.

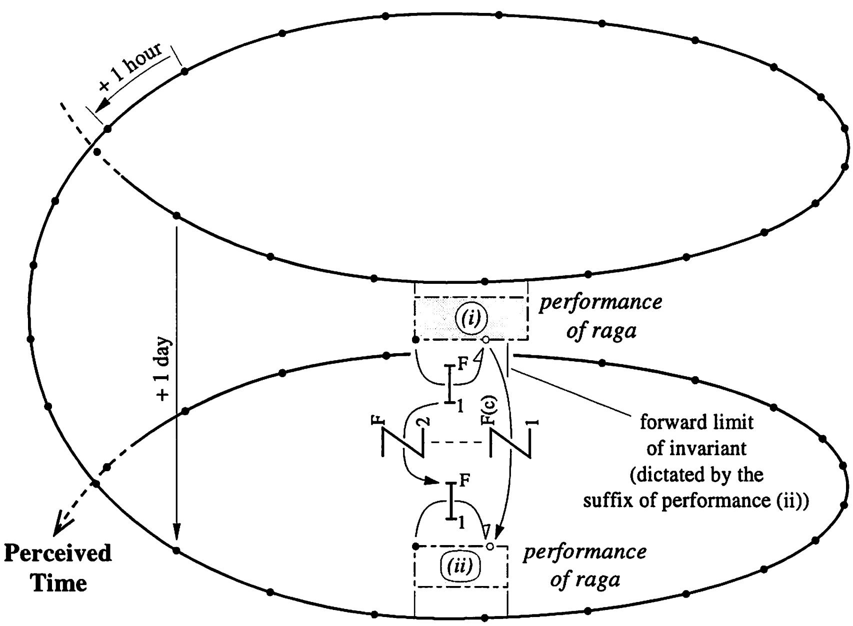


Figure 9.1 Uniform primary zygonic invariant of fix (cyclic) linking two performances of the same raga beginning at the same time on successive days.

A fuller, and perhaps more apt, description of the ordering involved can be obtained by including all relationships of fix, perfect and imperfect, that exists between the two performances. This yields a primary imperfect zygonic constant; see figure 9.2.

In Western cultures, concerts are frequently put on at the same time, or at least similar times, each day—frequently in the evening. Aside from convention, there are practical reasons why this should be so, including the fact that for most prospective listeners, music is a leisure activity that must be fitted in between such essentials as working and sleeping; clearly,

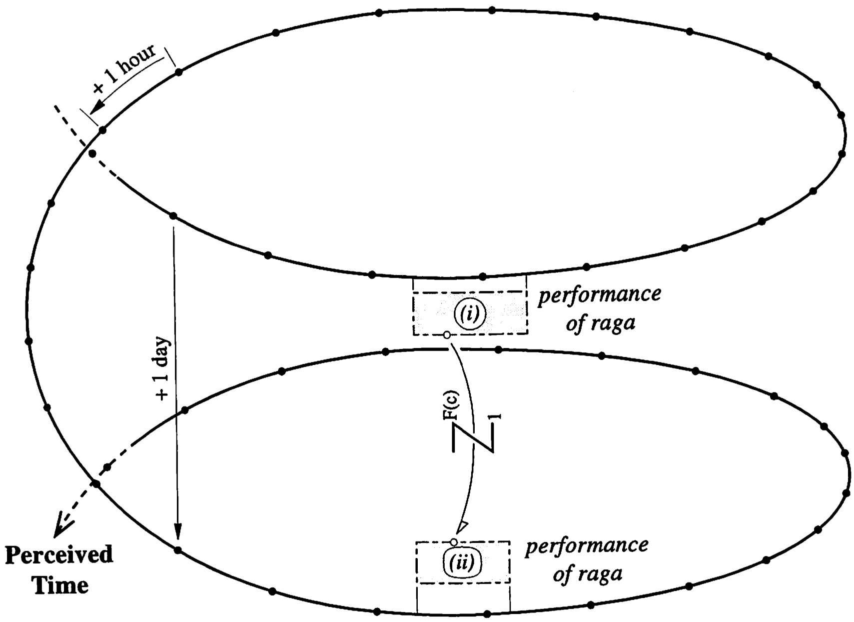


Figure 9.2 Primary imperfect zygonic constant of fix (cyclic) considered to exist between the same two performances.

potential members of an audience are likely to be thin on the ground, say, in the middle of the night. However, one has only to consider the number of radio stations that pump out music twenty four hours a day to realise that this is far from being an absolute rule, although even here, a series of programmes devoted to a particular genre may well be given a regular weekly slot. Still, the greatest freedom of all is enjoyed by those people with access to recorded music which can be replayed whenever they desire. To the extent that the timing of a listening session (whether in the form of a public concert or just the private playing of CDs at home) is considered to imitate that of one occurring earlier, so cyclic zygonic relationships of fix (interteroperative or interterpretive) can be assumed to operate.

The manner in which concerts are traditionally disposed implies various restrictions on values of fix. For example, most programmes involve the performance of several pieces, which all occur, therefore, around the same time. Here, however, it seems less appropriate to attribute the forces underlying this similarity to imperfect interteroperative zygonic relationships than to the practicalities of concert management: two works or more tend to be performed in close temporal proximity, not because the position in perceived time of one is held to imitate that of another, but because people would not normally deem fifteen minutes or so of music to be worth the trip.[2] Moreover, within a concert, members of the audience would not usually expect to be presented with the same work more than once (although immediate repeats are not unprecedented). Neither do listeners typically attend successive concerts comprising the same programme—though musicians on tour may not have the choice. However, favourite discs or tapes may be replayed any number of times with only the minimum of interruption.[3]

A great deal of music is associated with events in other media, which may impose varying degrees of perceived temporal constraint. For example, composers of film music may well be told, among other things, precisely when their contributions must start and stop (see figure 9.3).

It often happens that films, plays and so on themselves have predetermined times of occurrence, implying further perceived temporal control of any music that may be allied with them. For example, cinemas and theatres commonly have a schedule that does not change, at least during weekdays; and consider too the theme music for television series, whose episodes are shown at the same time each week. Finally, mention should made of music's most venerable partner, religious ceremonial: in the catholic church, for instance, services most frequently occur at an appointed hour on Sunday mornings.

Since a perfect canon of fix implies simultaneity and a value that has passed can never be repeated, it can be perfectly zygonically related only in the sense that time is considered to be cyclic. Because composers generally reckon on pieces being performed on more than one occasion, this means that values of fix cannot be specified; rather, the perceived temporal structures of compositions are laid out on primary interperspective levels and above. Bear in mind the comment made on p. 59, however, that primary values of fix judged from the beginning of a piece can in effect assume the role of perspective values.

[2]The interval left between the performance of successive pieces on a programme (or, indeed, between the movements of a single piece), aside from the dictates of convention, is determined largely by such practical matters as the re-positioning of performers and the need to re-tune instruments.

[3]Consider too the familiar (though questionable) method of practising which entails repeating a piece, to the best of one's performing ability, several times in succession.

"THE UNCANNY"

MUSIC MEASUREMENTS

SECTION 3 - (1M3)

FTG.		MINS/SECS
0'	Wilbur reacts with horror	00.00
½'	Cut to quick zoom in to white cat	00.00⅓
2'	End zoom Cut to Wilbur reacting	00.01⅓
7'	Cut to white cat jumping down	00.04⅔
8'	Cat stops and stares at Wilbur	00.05⅓
11'	Cut to close shot Wilbur and dialogue starts, "I didn't know you had a cat"	00.07⅓
14'	End of above dialogue and he stares at cat	00.09⅓
15'	Cut to white cat staring at him	00.10
16½'	Dialogue starts "Sit down..."	00.11
17'	Cut to Wilbur and Frank "It's perfectly alright..." and they move forward	00.11⅓
19½'	"He won't bite you"	00.13

END OF MUSIC SECTION

Figure 9.3 Shot-list for a scene from the film *The Uncanny* (the Rank Organisation), by courtesy of the composer of the score (Josephs, 1977).

In music that is intended other than for a single-line instrument or for solo voice, the use of simultaneities is almost inevitable; indeed, many pieces have more than one part playing for their entire duration. If this synchronicity is held to exist through imitation, the presence of numerous mutual primary zygons of fix is implied. Each is indicative merely of two events occurring at the same point in time, which is itself not specified (see figure 9.4).

A glance at almost any score shows that prefixes frequently occur together, ranging from two to the number it is feasible to control simultaneously. This may be considerable, as in a work such as Mahler's 8th symphony (1906–1907). Here, mutual primary constant systems of substantial propor-

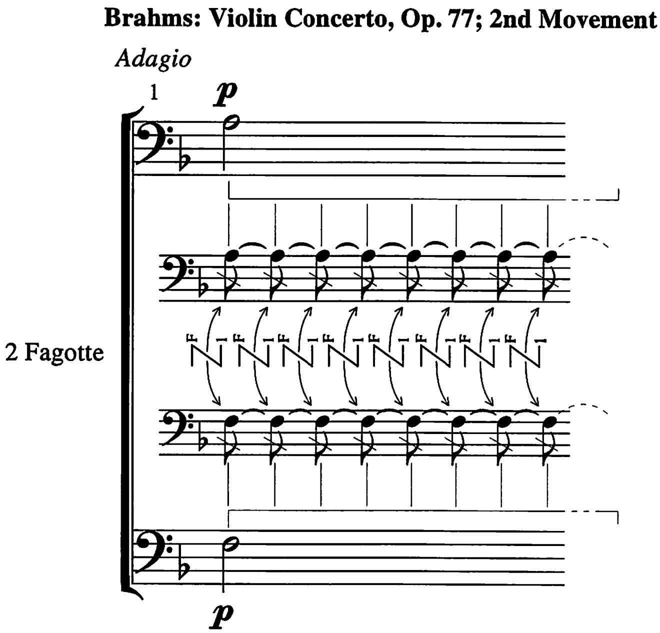


Figure 9.4 The first of numerous mutual primary zygons of fix in the 2nd movement of Brahms's violin concerto.

portions serve to control the coincident onset of the many-voiced chords.[4] See, for example, figure 9.5. Suffixes are often simultaneous too, and subject, therefore, to comparable forms of organisation.

The very presence of co-instantaneity can be thought to be derived through imitation. See, for instance, figure 9.6.

If a composer directs that two notes occur, if not simultaneously, then in perceived temporal apposition, we may suppose the fixes of one to be imperfectly ordered by those of the other. If this sounds implausible, consider the situation in which the perceived temporal locations were not so dictated: since the continuum of perceived time stretches infinitely into the past and the future, the probability of two notes, chosen at random, appearing even within an hour of one another would be utterly remote. That is to say, although a perceived temporal difference of this magnitude may be judged lengthy in musical terms, in comparison with the interperspective values of

[4]Moreover, any of the parts are performed by two players or more.

Mahler: Symphony No.8 (1906–1907); 2nd Movement (bar 1528)

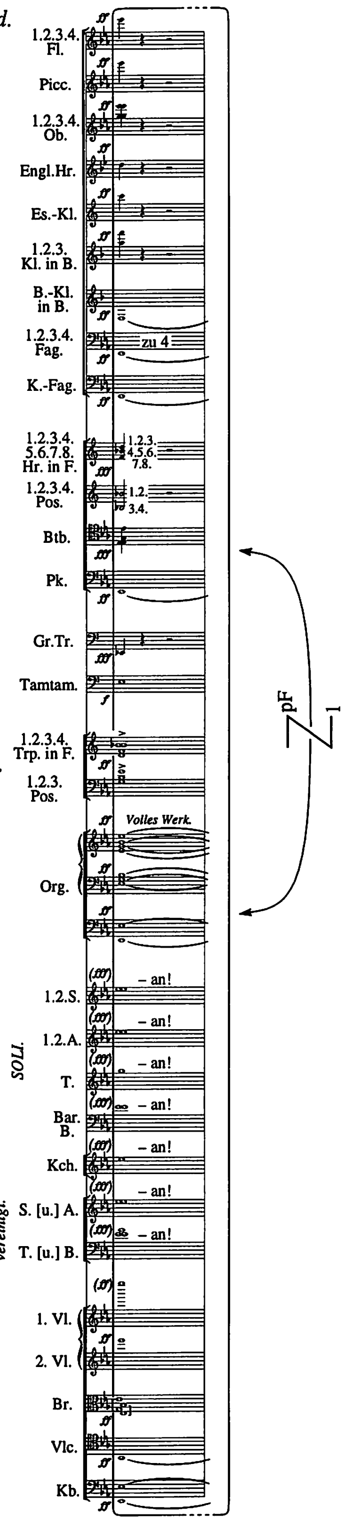
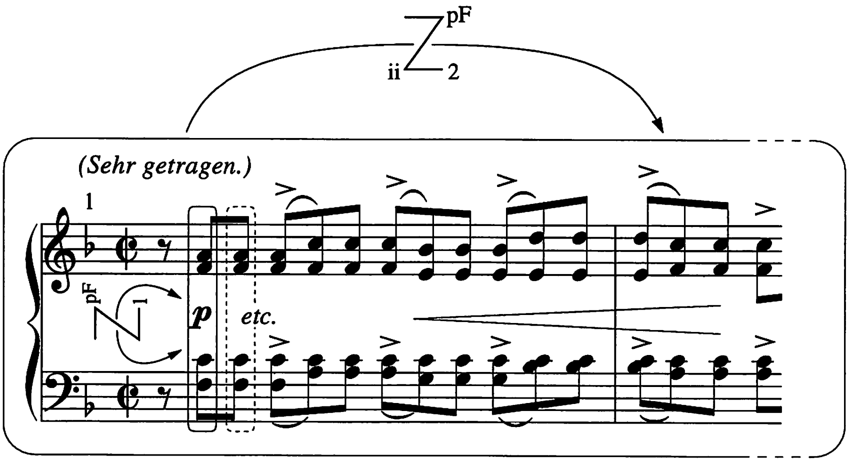


Figure 9.6 Mutual zygonic constant system of prefix.



Schumann: *Bunte Blätter,* Op. 99; *Marsch,* Trio

Figure 9.6 Secondary zygonic constant system of prefix, order ii.

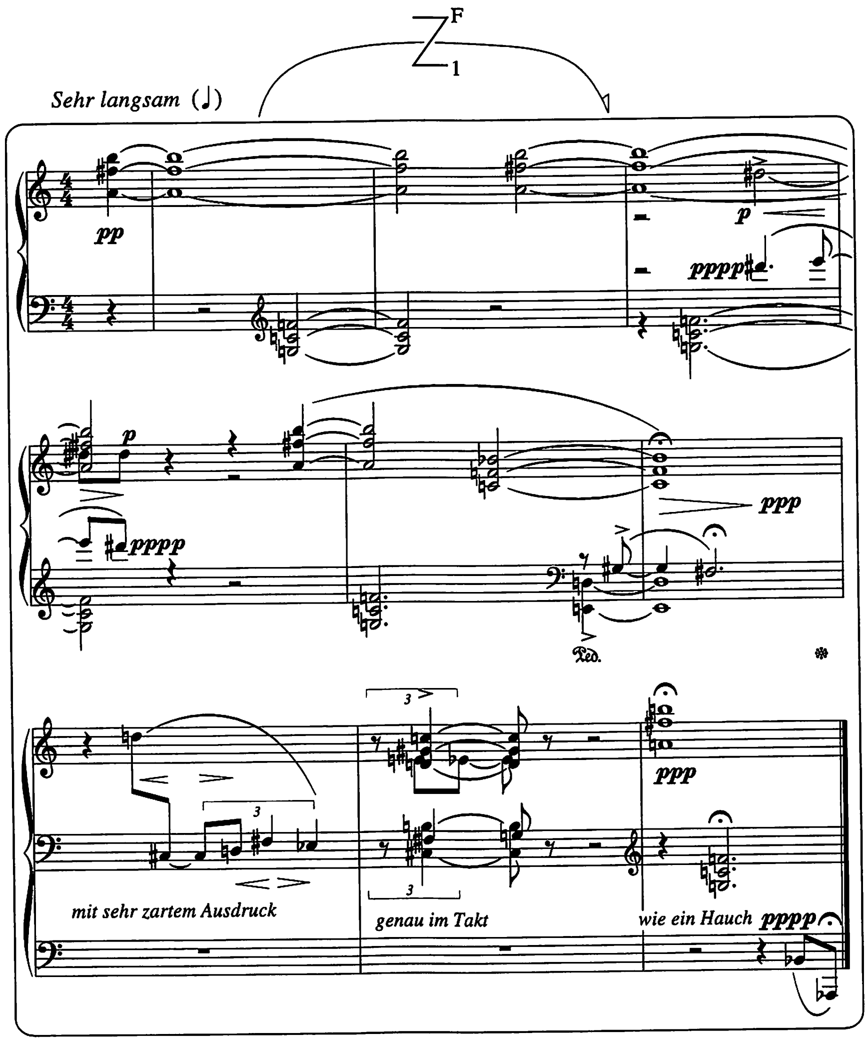
fix that are theoretically available, it is very short. Hence there should be no difficulty in considering an interperspective relationship of fix whose value is several minutes functioning as an imperfect zygon. Moreover, the perceived times of occurrence of all the notes of a piece following the first can be understood as being imperfectly ordered on the basis of the perceived temporal locations of those preceding. See figure 9.7.

The organisation of interperspective values of fix

The most important values of fix, from a musical point of view, are prefixes, while perceptually the most immediate interperspective relationships are often those between adjacent elements. Taking both these factors into account, this section will largely be devoted to a consideration of how the attack points of successive notes are related.[5]

Although the individual parts in a texture may be static, as in the case of pedal points, for example, in considering the fabric of a piece as a whole, it would be unusual for the inter-onset intervals to be longer than a few seconds. Hence the primary interperspective values between successive

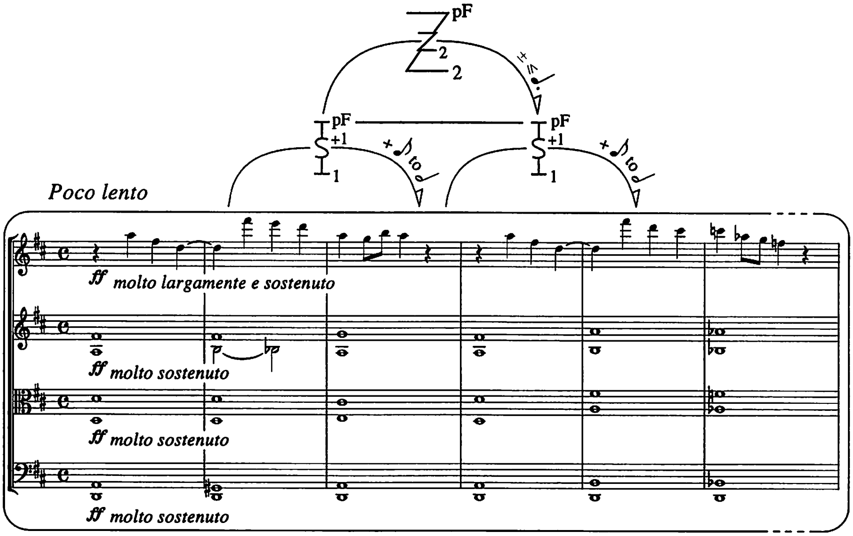
[5]For a consideration of the intraprotractive ordering of fix, see p. 187.



Schoenberg: *Sechs Kleine Klavierstücke,* Op. 19; No. 6

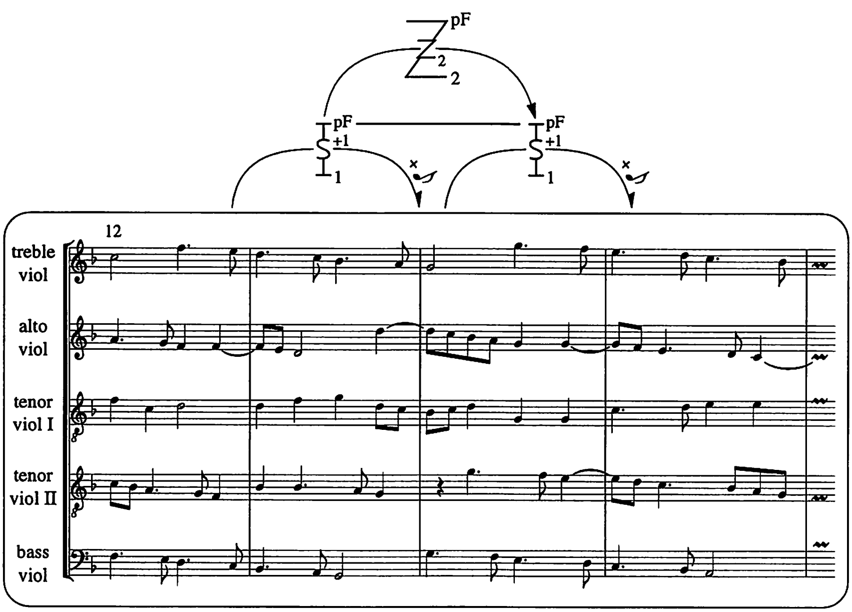
Figure 9.7 Imperfect zygonic constant system of fix.

prefixes are all similar, which in turn means that within pieces, secondary zygosequential imperfect zygonic constant systems of prefix can be thought to operate (cf. figure 6.44). See, for example, figure 9.8.



Franck: String Quartet in *D* Major (1889)

Figure 9.8 Secondary zygosequential imperfect zygonic constant system of prefix.



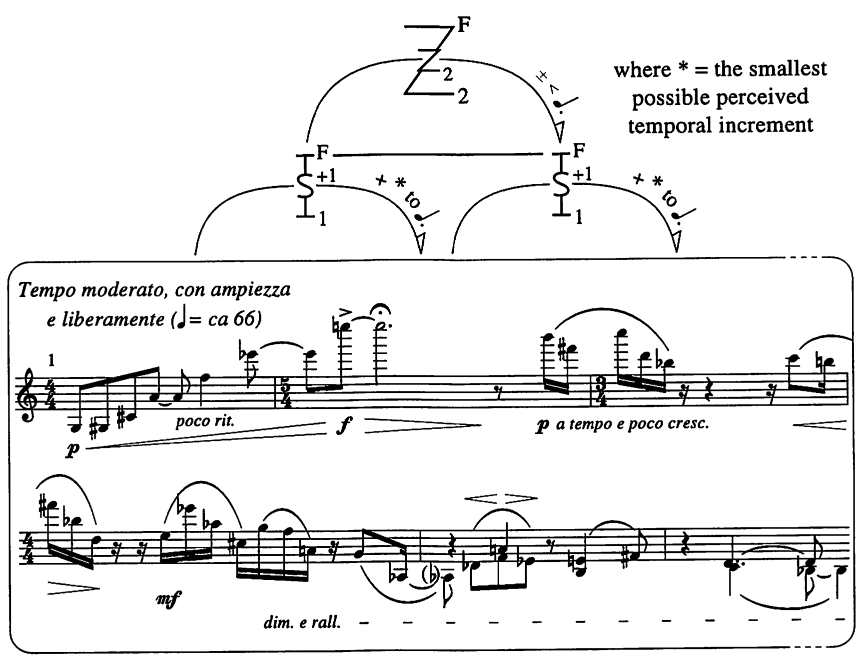
Tregian: *Balla d'Amore* (c.1600)

Figure 9.9 Secondary zygosequential perfect zygonic constant system of prefix.

Commonly, sections of works exist in which successive notes occur at identical perceived temporal intervals, implying the presence of perfect constant systems. See, for instance, figure 9.9.

Since the order exemplified by the passage in figure 9.8 is common to most works, interoperative forces of imitation can be assumed to operate too, through the medium of secondary zygosequential imperfect zygonic constants—see figure 9.10.

Elements tend to follow one another without a cessation in perceived sound, or with only short breaks. Indeed, a substantial period of silence is the surest indication that a movement or work has ended. Hence the distance between one particle and the next ranges from being as small as perception will allow to, at most, a matter of seconds. If this consistency is thought to occur through imitation, then intraoperatively a secondary zygosequential zygonic constant system is implicated, controlling a sequentially ordered primary invariant system of fix:



Sessions: Sonata for Violin (1953)

Figure 9.11 Secondary zygosequential imperfect zygonic constant system of fix.

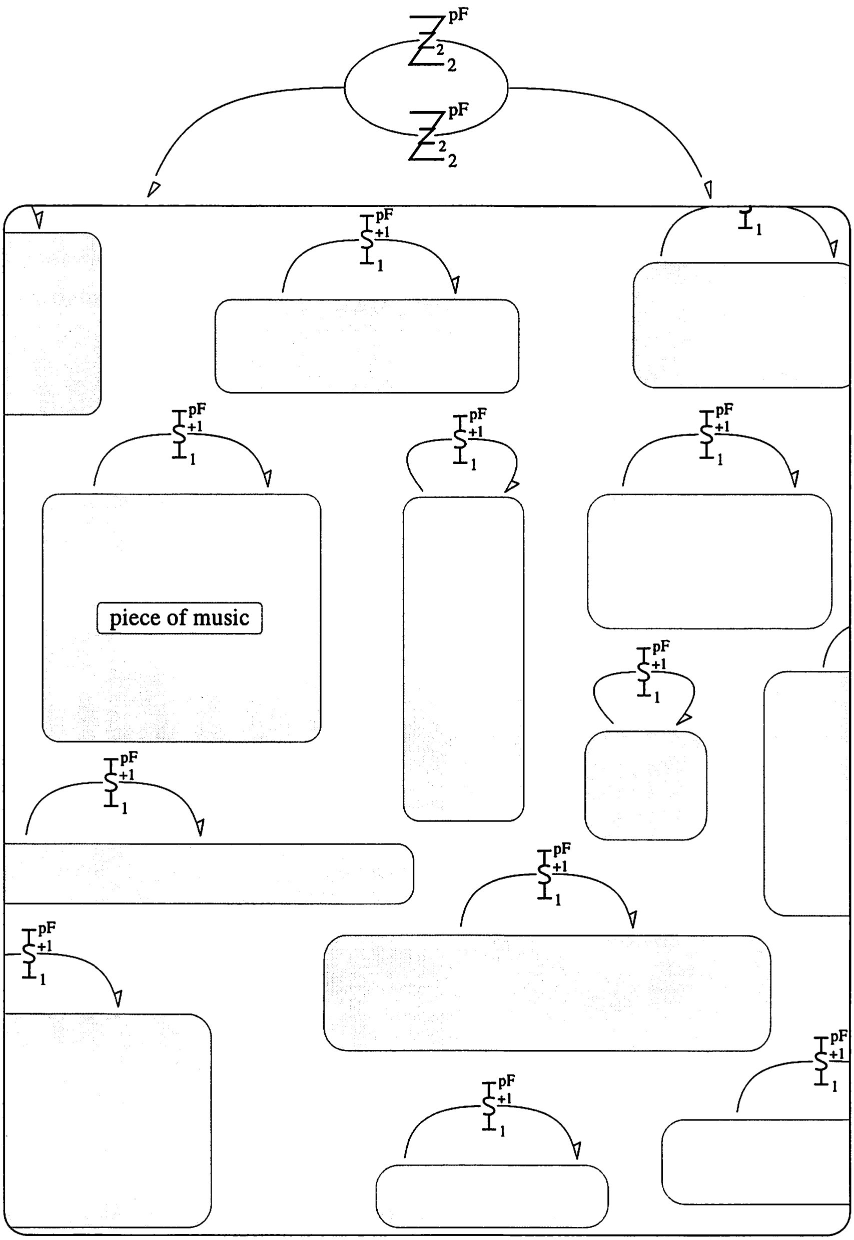


Figure 9.10 Interoperative secondary zygosequential imperfect general zygonic constant of prefix.

Interoperatively, the connecting medium is a secondary zygosequential zygonic constant, perfect or imperfect:

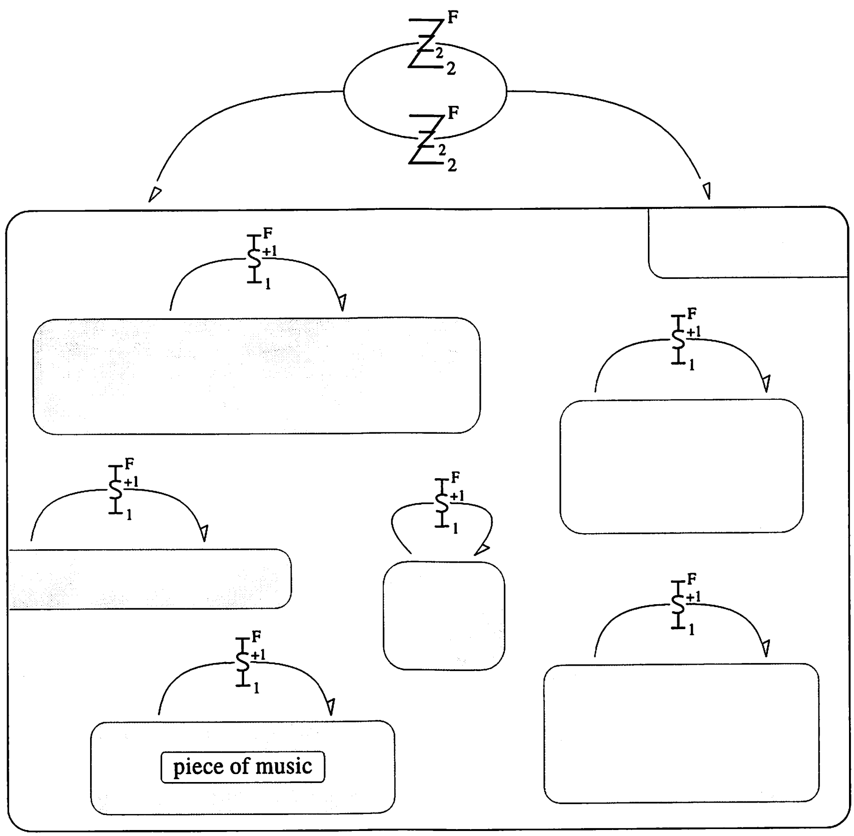


Figure 9.12 Interoperative secondary zygosequential imperfect general zygonic constant of fix (cf. figure 9.10).

Many pieces feature regular perspective change within the interval $^1/_4$ to $1^1/_2$ seconds, which is known as the 'beat' (cf. p. 59). Moreover, the beat is often fractionated into quicker **pulses**[6] and grouped into slower ones. Any beat or pulse may be considered perspectively in its own right (for which the abbreviations 'B' and 'Pu' will be used in diagrams). Neither need be regular. Where periodicity is present, however, the existence of a secondary zygosequential perfect zygonic constant system is implied—see figure 9.13).

[6]Examples of pulses faster than the beat that are not necessarily subdivisions of it are 'spread' or arpeggiated chords on the piano, harpsichord, guitar or harp, for instance.

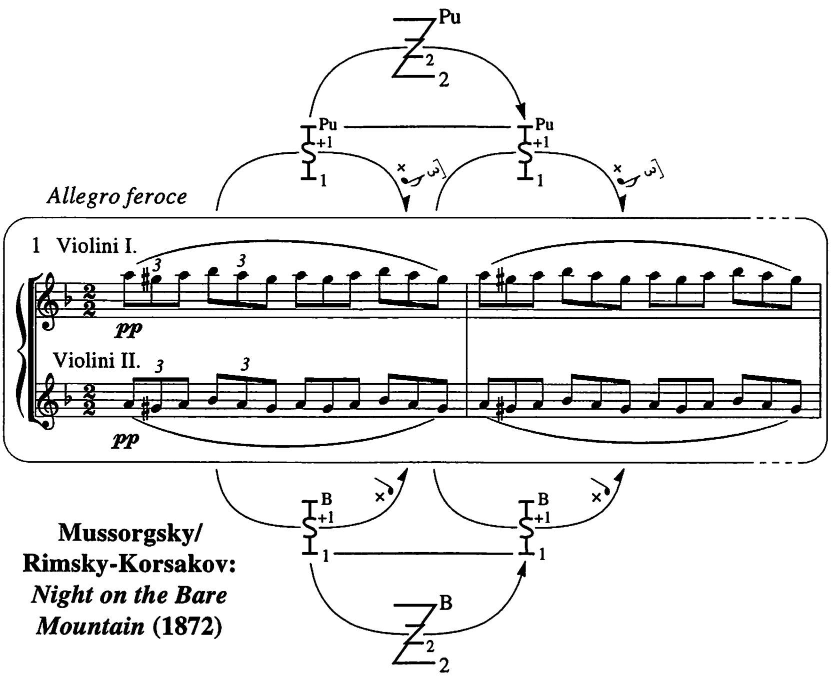


Figure 9.13 Secondary zygosequential zygonic constant systems of pulse and beat.

Such systems may be perceived reactively by listeners, but the fact that a

> sense of regular pulse, once established, tends to be continued in the mind and musculature of the listener (Cooper and Meyer, 1960, p. 3)

shows that the relationships can function proactively too. As Moles (1958/1966, p. 75) puts it:

> One of the most elementary temporal forms is *periodicity*. ... The perception of periodicity is the receiving organism's unconscious and immediate wager that he knows what will occur on the basis of what has happened in the past.

This means that the feeling of a pulse may continue even in the absence of a physical correlate. See, for example, figure 9.14.

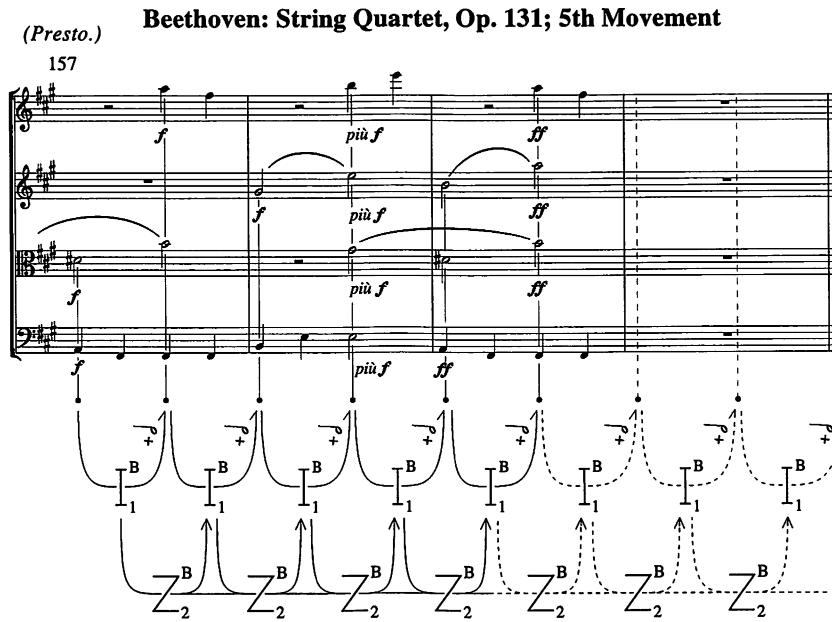


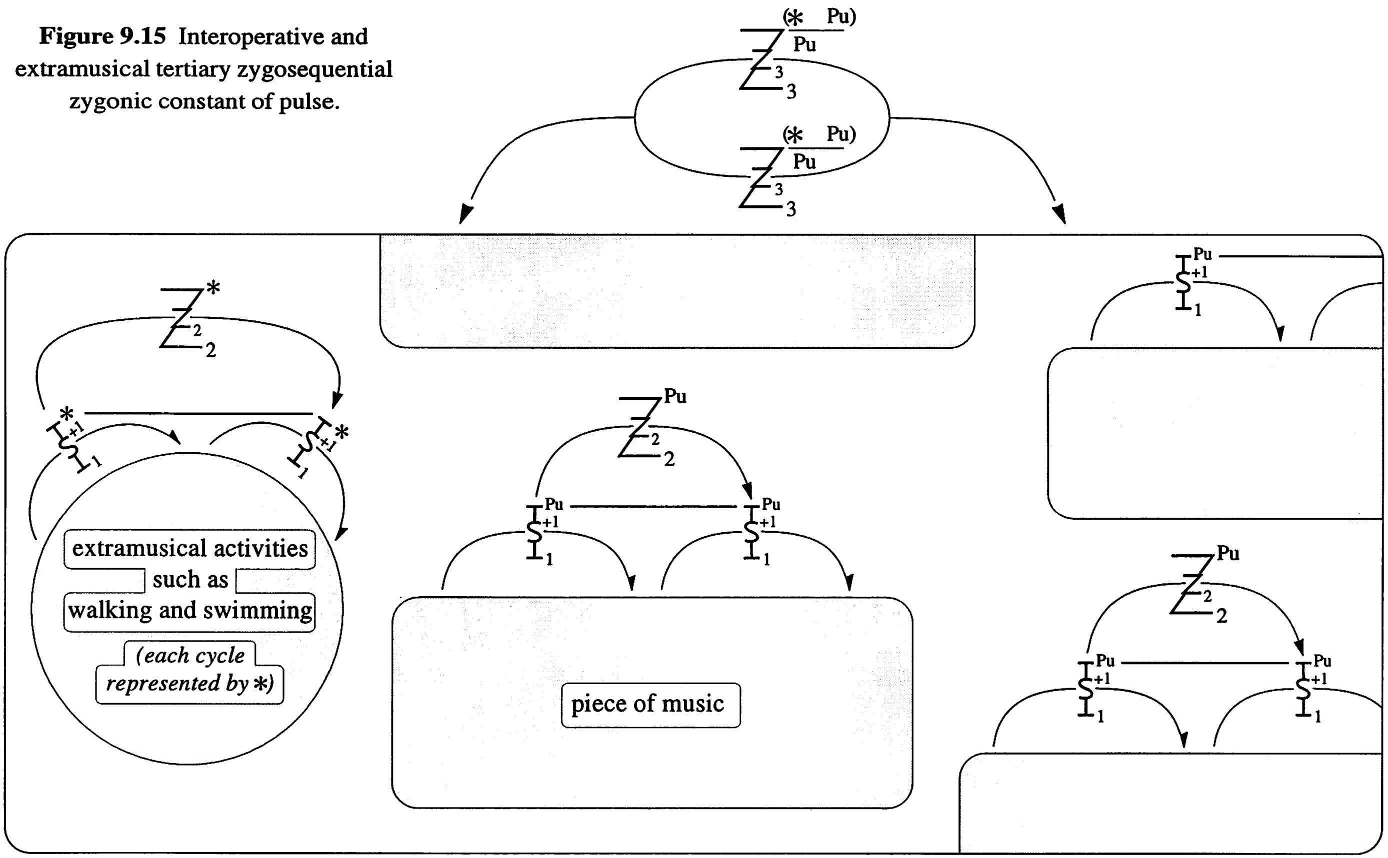
Figure 9.14 The feeling of a beat continuing in the absence of a physical correlate through the operation of proactive secondary zygons.

The sheer regularity of one pulse or beat may be thought to be imitated by another through the operation of a tertiary zygosequential zygonic constant (cf. figures 6.65 and 6.67). Potential models include such extramusical activities as walking and swimming (cf. Fraisse, 1982, p. 151), as well as the perceived temporal disposition of other pieces of music; see figure 9.15.

The period over which the same beat is maintained varies considerably. It may be as short as three separate values, with the implication of a single secondary zygonic relationship, or as long as an entire movement—a characteristic feature of much Baroque and Classical music—in which case a secondary zygonic constant system of considerable substance is implied. Indeed, according to Epstein (1979, pp. 77ff), entire multimovement works may be based on the same fundamental beat. Other pulses tend to be rather less enduring than the beat itself, although a notable exception is to be found in *perpetuum mobile* movements, such as that by Mendelssohn, op. 119, for example, whose construction is dominated by some 1,659 continuous semiquavers, which race by at the fastest speed the performer can manage.

The rate at which the beat occurs is known as the **tempo**, which exists, in

Figure 9.15 Interoperative and extramusical tertiary zygosequential zygonic constant of pulse.



round terms, over the range outlined on p. 329. There are several potential reasons why a given tempo should be selected. Brown (1979, pp. 25–30) lists some of them, including the fact, for example, that a lower tessitura,

> because of an associated greater resonance, often makes a rather slower tempo necessary (p. 29).

Apart from practical limitations such as these, composers are, of course, guided in their choice of speed by the effect they may wish to create. As Davies (1978) says;

> fast tunes usually have energetic connotations, and slow tunes more leisurely connotations. This seems perfectly reasonable, since a state in which events occur rapidly is usually more energy-consuming than one in which they take place slowly (p. 106).

These leaves the question of how 'fast' and 'slow' are gauged with respect to a musical beat. According to Brown (op. cit., pp. 23 and 24), who cites various studies that point to a fundamental physiological periodicity in the region of 750 milliseconds,

> the MM = 60–80 area could represent an ideal, average or neutral speed of movement with which all others are unconsciously compared.

Such considerations aside, the tempo of a beat itself, or the rate of any subsidiary pulse, may be derived in imitation of another (with a variable degree of perfection) through a secondary zygosequential zygonic constant. This may function extramusically. See, for example, figure 9.16. By treating 'tempo' ('Te') as an independent perspect, ordering of this type may be interpreted more simply in the manner shown in figure 9.17.

A good deal of music in which more than one part appears at the same time makes use of a single beat,[7] which coincides throughout the texture. Here, as well as the organisation of tempo through a mutual secondary zygosequential zygonic constant, the operations of a mutual primary zygosequential zygonic invariant is implied too, reflecting the fact that

[7]Exceptions include, for example, a fair portion of native African music (see, for instance, Sachs, 1953, pp. 40ff; Brandel, 1961), and pieces such as *Gruppen* by Stockhausen (1955–1957). Here, however, the sheer regularity of one beat may be taken to exist in imitation of the consistency exhibited by another.

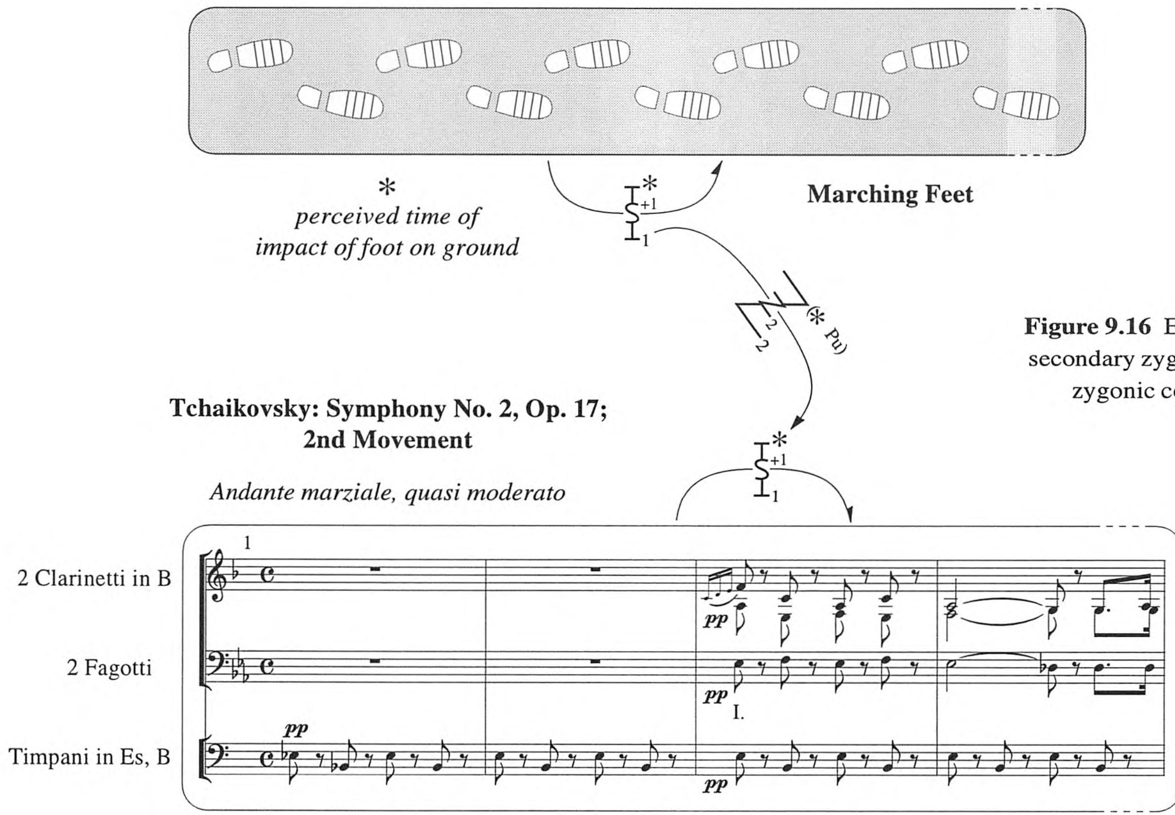


Figure 9.16 Extramusical secondary zygosequential zygonic constant.

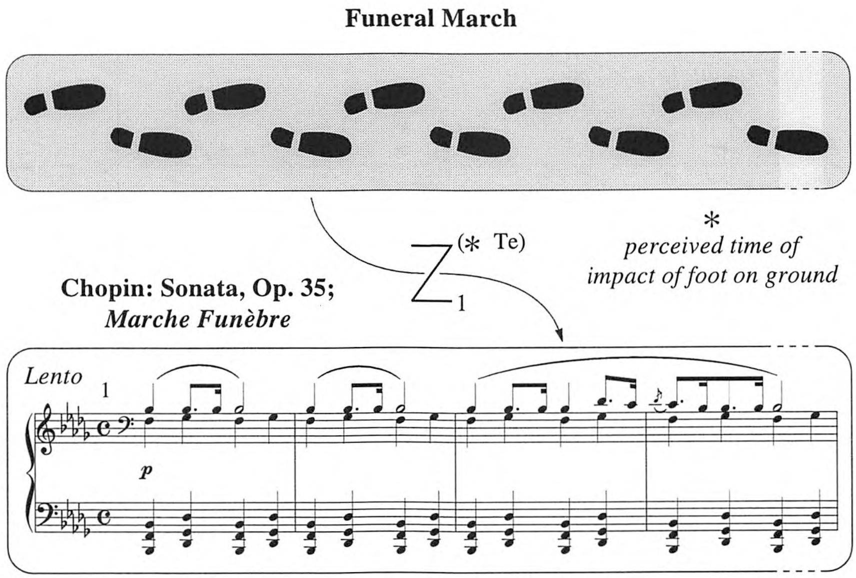


Figure 9.17 Extramusical zygonic relationship of tempo.

individual beats are synchronised. Both canonic links may be effective mutually, as the excerpt quoted in figure 9.18 shows. Similar ordering may pertain to pulses that are subservient to the main beat.

Composers may also opt to order the tempo of a piece interoperatively, by imitating one used in a previous composition. This procedure is apparent, for example, in Western music of the 15th and 16th centuries, in which the 'tactus' was fixed around MM = 60–70 (Apel, 1969, p. 832). This meant that throughout the period

> there was a uniform "normal" tempo from which only slight deviations were possible. (ibid.)

Although the range of permissible values subsequently increased, interoperative organisation continued to be an important force. This is particularly evident in works of more than one movement that make use of a distinct pattern of tempi—at least in approximate terms. Consider, for example, the Italian opera overture, which by definition consists of two fast movements separated by a slow middle part (see, for instance, Bukofzer, 1947, p. 243), or think of the Classical sonata: the very fact that musicians

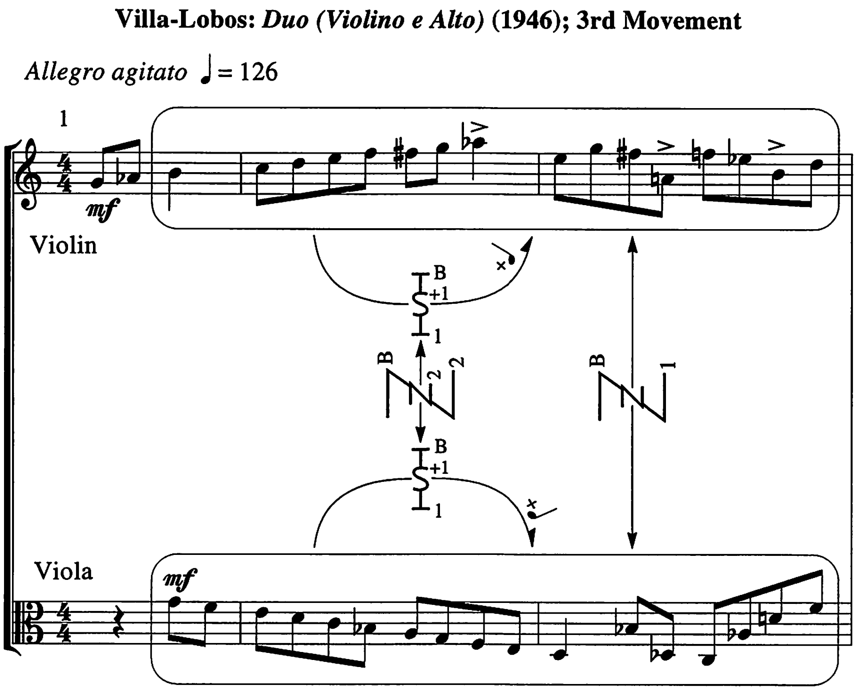


Figure 9.18 The synchronicity of a beat ordered through the operation of a mutual secondary zygosequential zygonic constant and a mutual primary zygosequential intersociative zygonic invariant.

can speak of a 'slow' movement (as does Berry, 1966/1986, p. 148, for example) shows the extent to which tempo was an indispensable stylistic feature. The ordering of series of tempi—such as that characteristic of the *Italian* overture—may be held to occur through the agency of a system of interoperative primary zygosequential imperfect zygonic invariants (cf. figures 6.51 and 6.53). Hence connections between pieces such as that shown in figure 9.19 may be identified.

Other means of organising tempo were tried in the second half of the twentieth century. Krenek's *Quaestio temporis* (1958–1959), for example, according to the composer's own account of the work (1960, pp. 230 and 231), comprises eleven sections of varying lengths, to which six different speeds are assigned:

MM ♩ = 20, 30, 50, 80, 130, 210.

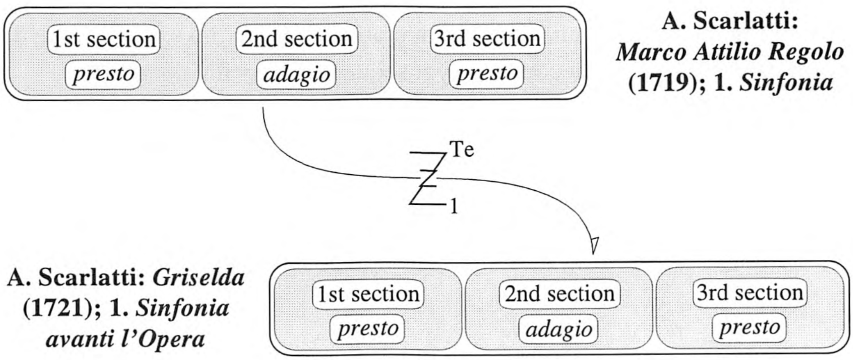


Figure 9.19 Primary zygosequential imperfect zygonic invariant of tempo.

This is a form of *Fibonacci* sequence, in which each term is the sum of the two preceding, a type of ordering that may be interpreted canonically as a secondary zygosequential zygonic constant system controlling a series of primary triadic relationships (cf. figure 4.29).

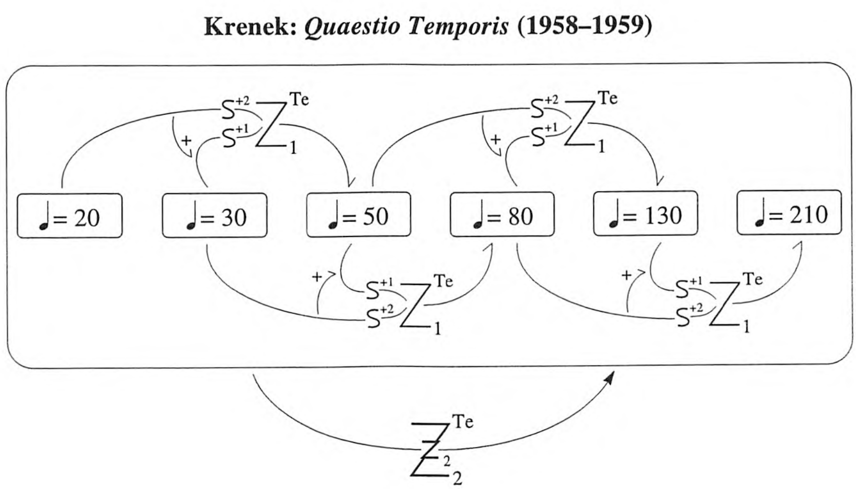
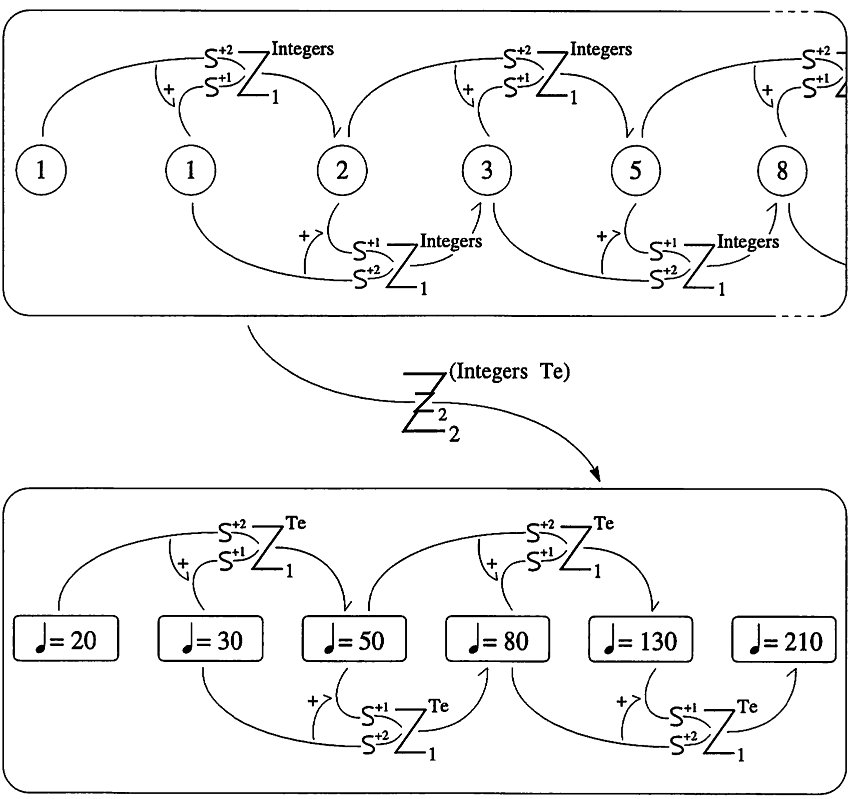


Figure 9.20 Secondary zygosequential zygonic constant system of primary triadic relationships of tempo.

The fact that the series Krenek uses is based on a familiar mathematical model implies the existence of extraoperative zygonic links, which take the form of a cross-modal secondary zygosequential zygonic constant.

***Fibonacci* Series**



Krenek: *Quaestio Temporis* (1958–1959)

Figure 9.21 The tempo of *Quaestio temporis* shown to exist in imitation of the *Fibonacci* series through the operation of a cross-modal secondary zygosequential zygonic constant.

Similarly, in pieces such as *Klavierstück V* (1954–1955), *Gruppen* (1955–1957) and the revised version of *Punkte* (1962), Stockhausen makes use of a series of tempi which emulates the frequencies necessary to produce an equally tempered chromatic scale. So, if for argument's sake we start with

MM 𝅝 = 60

(as does Stockhausen, 1957/1959, p. 21), then the next tempo will be

MM 𝅝 = 60 x $2^{1/12}$

→ MM 𝅝 = 63.6

(to one decimal place); the one following,

MM 𝅝 = 67.3;[8]

then

MM 𝅝 = 71.4, 75.6, 80.1, 84.9,

and so on, up to

MM 𝅝 = 120.

Although the derivation of the series from acoustical phenomena affords a wholly imperceptible means of control, its internal structure can be interpreted (at least theoretically) in terms of a sequentially ordered primary invariant system of ratio, governed by a secondary zygosequential zygonic constant system:

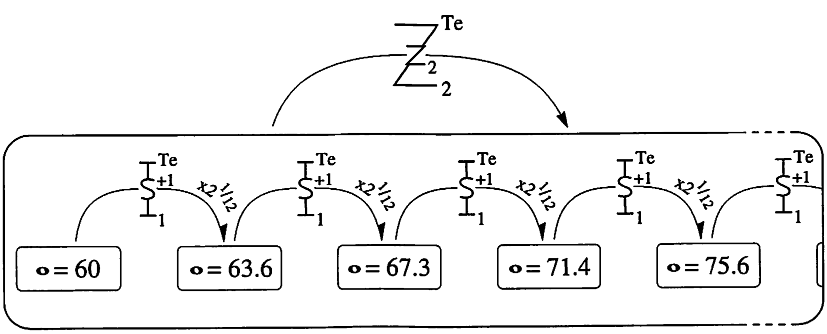


Figure 9.22 A series of tempi controlled through a sequentially ordered primary invariant system of ratio, governed by a secondary zygosequential zygonic constant system (after Stockhausen, op. cit).

[8] Incorrectly given as MM 𝅝 = 67.4 in the article mentioned.

It is doubtful, however, whether the progression would be perceived as anything more than an increase in tempo; certainly it would not typically be heard as isomorphic to the perceived arithmetic ascent of the chromatic scale.

Tempo is one aspect of music that is particularly susceptible to the whim of performers. Moles (1958/1966, p. 139), for instance, lists the playing times of Beethoven's 9th symphony, op. 125, as interpreted by eight well-known conductors, and reveals a variation of over 15% in comparison with the normalised value. In contrast, however, Clynes and Walker (1986) found that the performances of an acclaimed string quartet over a number of years of the same works have a remarkable temporal stability, which is greatest in moderate and fast compositions (of the order of 0.4%; see p. 116). Where the tempo or tempi of one rendition of a piece is or are considered to exist in imitation of another or others, an interterpretive zygonic connection or connections may be inferred. For example:

Beethoven: String Quartet No. 13, Op. 130;
3rd Movement *(Andante con moto ma non troppo)*
as performed by the Sydney String Quartet on 5.8.76, 6.8.76 & 13.8.76

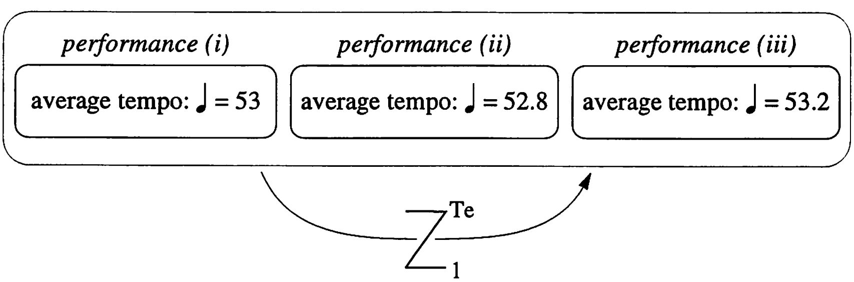


Figure 9.23 Interterpretive zygonic relationship of tempo.

(Observe that the relationship is shown as being perfect, since the differences in tempo between one performance and another are imperceptible.)

Likewise, a performer may realise one piece at the same tempo as another similar in style, potentially indicating the operation of a interteroperative primary zygon. See, for instance, figure 9.24.

So much, then, for the organisation that lies behind the unvarying marking of musical time, whether through the beat or through a secondary pulse. We now consider some of the circumstances in which deviations from this regularity occur, and the ways in which they are ordered. Even a beat or

Bach: ***Well-Tempered Clavier*****;**
Preludes BWV 846 & 848
as performed by Helmut Walcha, June, 1973 ***(Archiv 2723 054)***

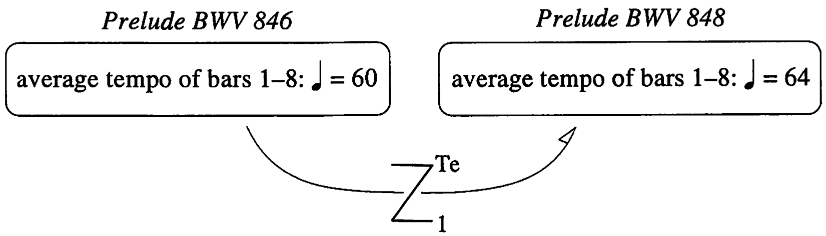


Figure 9.24 Interteroperative primary zygon of tempo.

other pulse that is essentially constant is in fact rarely rendered with metronomic accuracy. Rather, minute discrepancies in timing are continually pulling or pushing against the inertia of perceived temporal invariance. This form of *rubato* pertains to the expressive realisation of structure: Clarke (1988, pp. 17ff), for example, observes that graduated timing changes can be used to indicate group boundaries, and that the significance of a note may be highlighted either by delaying its onset or that of the note following. Hence the precise placement of beats and other pulses is dependent on considerations of pitch and rhythm, implying coordinated perspective ordering. This may be transferred interterpretively from one performance to another of the same work, or even interteroperatively, when different pieces share features in common, through the agency of secondary zygonic relationships. Since most listeners are unaware of the micro-temporal inflections discussed here, it must be assumed that a form of categorical perception normally operates (Gabrielsson, 1981, p. 30). However, such discrepancies may be acknowledged perceptually by players or singers who consciously seek to emulate the performing style of a fellow musician.

A second form of departure from a consistent pulse occurs when the underlying tempo itself is altered, as in *rallentandi* and *accelerandi.* Whereas the small-scale deviations from mechanical regularity described above, although presumably anticipated (if only sub-consciously) by composers are, within the Western tradition, not typically notated, it is accepted that rather more substantial temporal effects such as *ritardandi* may either be added to the perceived sonic mixture at the compositional stage—through overt indications in the score—or introduced subsequently, according to the stylistic tastes of the performer. Turner's (1938) paper on tempo variation in the works of Elgar demonstrates these two possibilities somewhat pointedly, since the composer himself conducted the performances that were studied. In a rendition of the first movement of the 1st symphony, op. 55, for example, of the 74 major changes in speed that occurred, it seems that over half were not notated (p. 316).

Irrespective of the stage at which they are introduced, such variations in tempo are essentially expressive in nature. Their source can be attributed partly to extramusical imitation: for example, just as one's heartbeat increases as the level of excitement or tension is raised, so accelerating the musical beat is likely to produce a comparable effect in perceived sound. On other occasions, the use of rubato may serve to point up structural features, or to highlight a particular note, chord or phrase (cf. Clarke, op. cit., p. 19). Moreover, *rallentandi, accelerandi* and so on may be held to exist in imitation of similar features found elsewhere, through interoperative, interterpretive or interteroperative zygonic links. The internal organisation of tempo changes is difficult to discern. However, primary invariant systems of difference and ratio are both possible, controlled by secondary zygonic constant systems. See, for instance, figure 9.26; also Ives, *Three Places in New England*, 1st movement, 1911–1912, bars 71–73.

Finally, consider relationships between associations of prefixes that lack internal consistency. These may be ordered through primary zygosequential secondary invariants. For example (cf. figure 6.60):

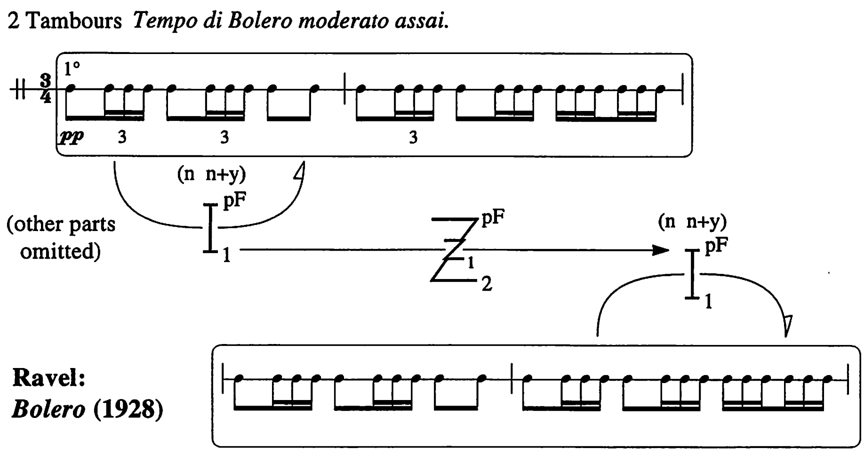


Figure 9.27 Primary zygosequential secondary invariant of prefix.

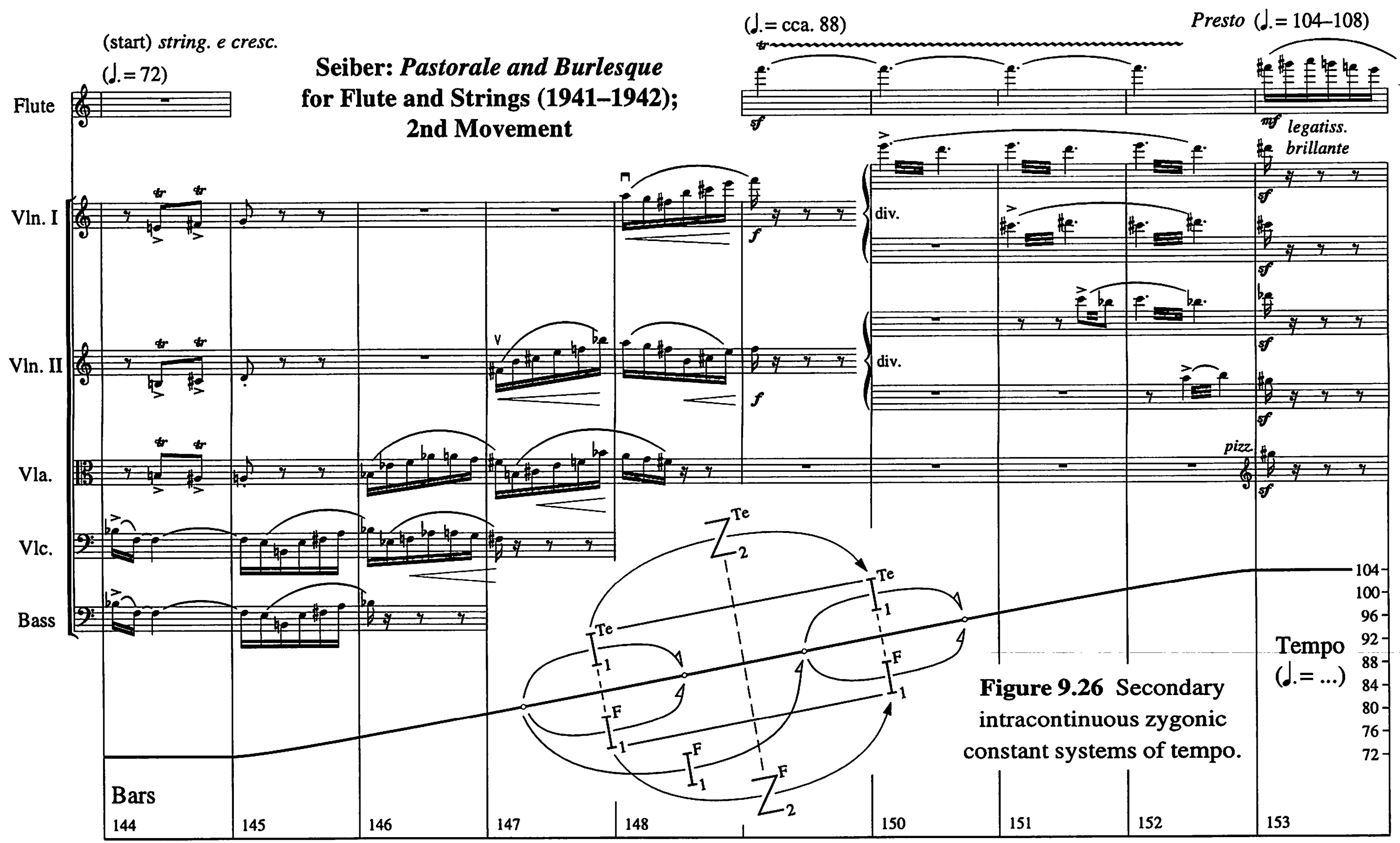


Figure 9.26 Secondary intracontinuous zygonic constant systems of tempo.

Ordering metre

The feeling of 'metre' derives from the cognitive interaction of pulses of different speeds that are presented at the same time. Perceptually, the quicker pulse is grouped by the slower (cf. Fraisse, 1978, pp. 235 and 236). See, for example, figure 9.28. Here, the two pulses necessary for the formation of metre derive from discrete melodic lines, but this need not be the case: a slower pulse may be drawn from a faster one if certain elements are accented relative to others by being, for example, louder, higher or longer than they are, although other forms of emphasis are possible too (see, for instance, Berry, 1976/1987, pp. 339ff; Lerdahl and Jackendoff, 1983, p. 17). Metrical grouping can also be instituted through *Gestalt* perception (cf. pp. 224–229). See, for example, figure 9.29.

These principles may be extended further, since a pulse formed by grouping a beat may itself be grouped, thereby engendering a still slower sense of periodicity; while, conversely, a regular subdivision of a beat may itself be subdivided. At their simplest, these ideas underly compound metres such as 6/8, which implies the presence of at least three separate pulses, making up two groups of three per bar:

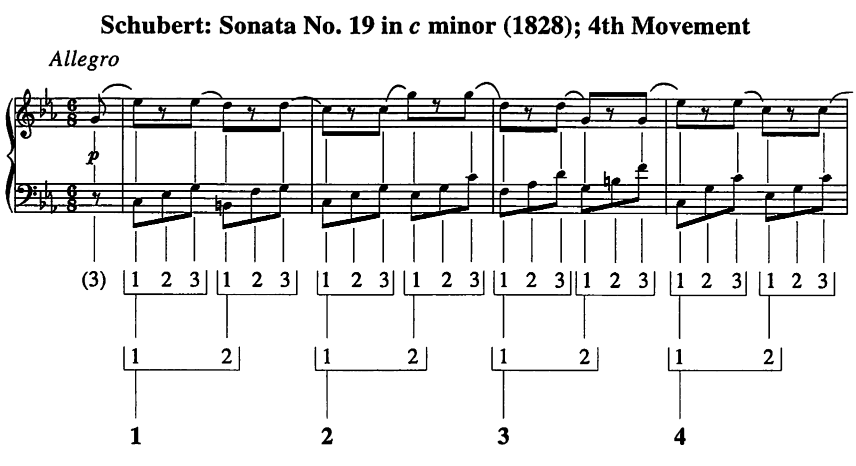


Figure 9.30 The three separate pulses underlying 6/8 metre.

(Adagio ♩=56) **Martin: *Petite Symphonie Concertante* (1944–1945)**

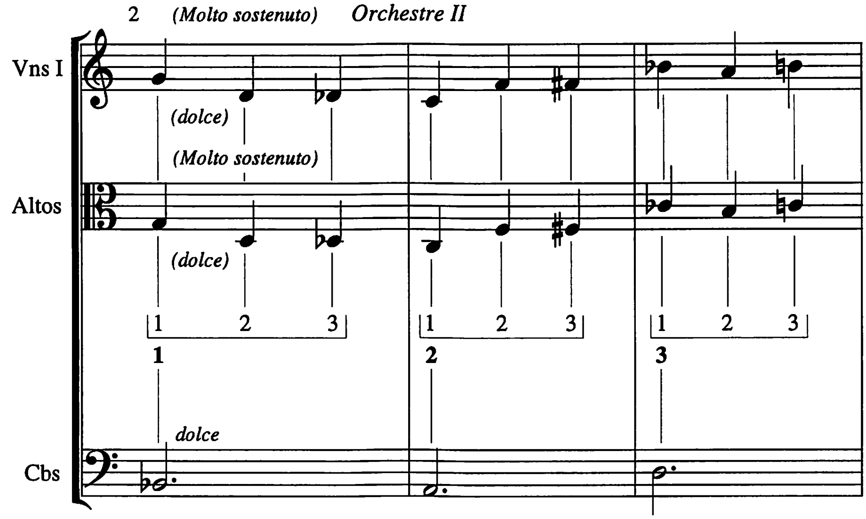


Figure 9.28 The feeling of metre formed by the cognitive interaction of two pulses.

Scarlatti: Sonata, K. 133

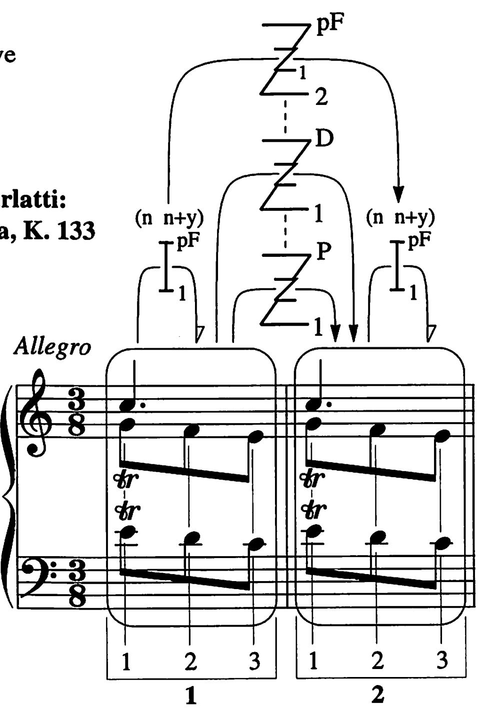


Figure 9.29 The formation of metre through the *Gestalt* principle of common fate, or, in canonic terms, parallel intersociative invariants of prefix, duration and pitch (cf. figure 6.86).[9]

[9]The feeling of metre is enhanced in this example too through the presence of a slower pulse (dotted crotchets) running simultaneously with a faster one (quavers).

Theorists such as Lerdahl and Jackendoff (1983), though, have shown that, in some styles, at least, metrical hierarchies exist well beyond the range of a single bar. Consider, for example, their analysis (p. 23) of the opening of Mozart's symphony no. 40 in *g* minor, K. 550, in which succeeding structural levels are ascribed successively lower lines of dots, each representative of a strong beat (see figure 9.31). However, Lerdahl and Jackendoff (op. cit., p. 21) warn against postulating the presence of metre much beyond this stage:

> At very large levels metrical structure is heard in the context of grouping structure, which is rarely regular at such levels; without regularity, the sense of metre is greatly weakened. Hence the listener's ability to hear global metrical distinctions tapers and finally dies out. ... Metrical structure is a relatively local phenomenon.[10]

Irrespective of its position in the hierarchy, each complete metrical unit, whether simple or compound, and regardless of the number of separate pulses involved, may be viewed as one perspective value, and may be zygonically related. For example:

Bartók: Sonata for Solo Violin (1944)

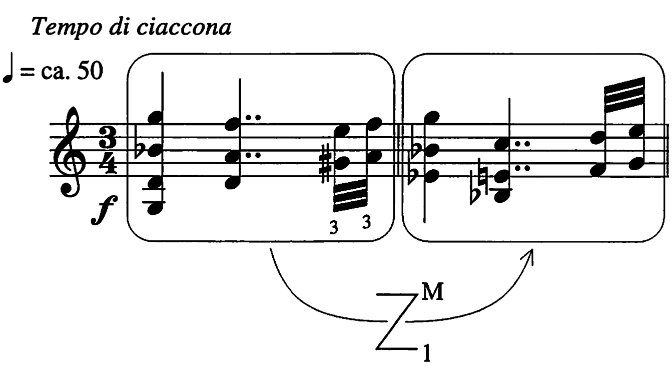


Figure 9.32 Primary zygonic relationship of metre.

(Here, the abbreviation 'M' is used to indicate 'metre'.)

[10]This view is clearly at odds with Cooper and Meyer's analysis of Beethoven's 8th Symphony, op. 93, (1960, see p. 203) in which the existence of groups (which admittedly are rhythmic rather than purely metrical) on the highest formal level is hypothesised.

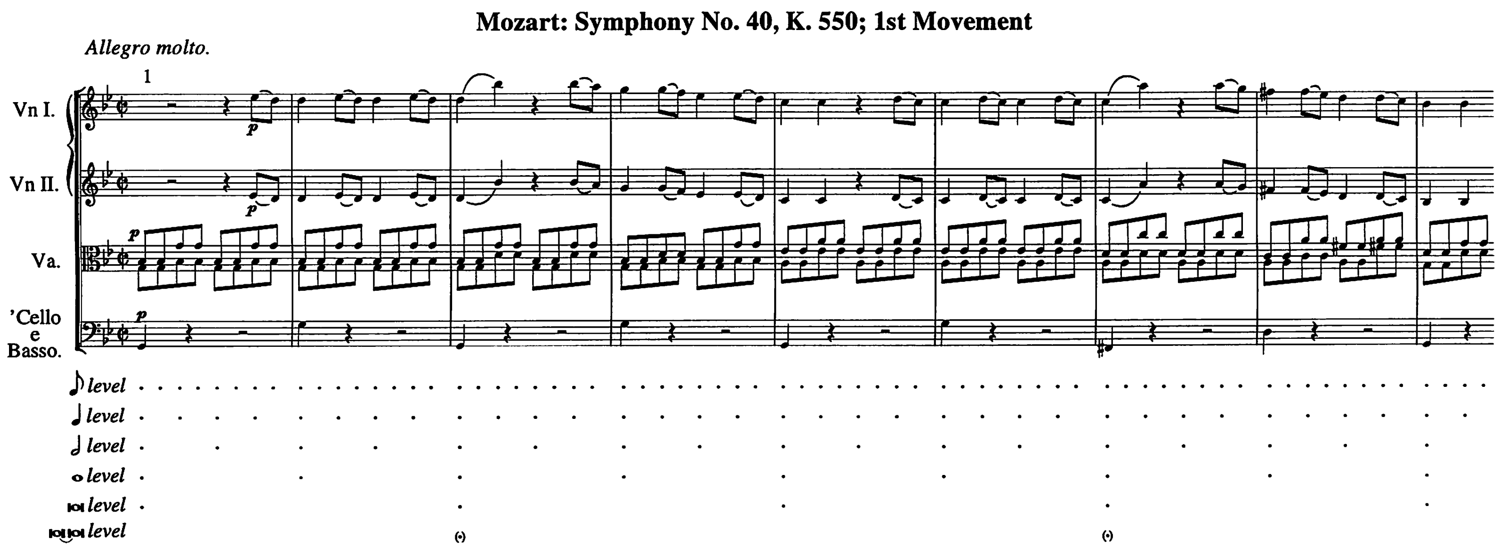


Figure 9.31 Representation of metrical hierarchy using a system of dots (after Lerdahl and Jackendoff, 1983, p. 23).

Which stratum in the hierarchy of different pulses predominates perceptually depends partly on where the listener's attention happens to be focused, although it seems that the metre most closely associated with the beat is likely to be most prominent (cf. Lerdahl and Jackendoff, ibid.), and it is with this structural level that we are largely concerned.

Many pieces display a high degree of metrical consistency. In the Western classical tradition, for example, one metre tends to be maintained throughout a movement. Consider, for example, the Beethoven piano sonatas. With the exception of the occasional slow introduction (which may recur, as in the first movement of the *Pathétique*, op. 13), or cadenza-like passage, in which metre is temporarily suspended (as in no. 16, 2nd movement, bar 26), the sonatas up to and including no. 27 (op. 90) very rarely depart from the isometric principle (to borrow Nettl's term, 1965/1973, p. 46).[11] If metric values are thought to exist in imitation of those preceding, then the presence of a primary zygonic constant system is implied.

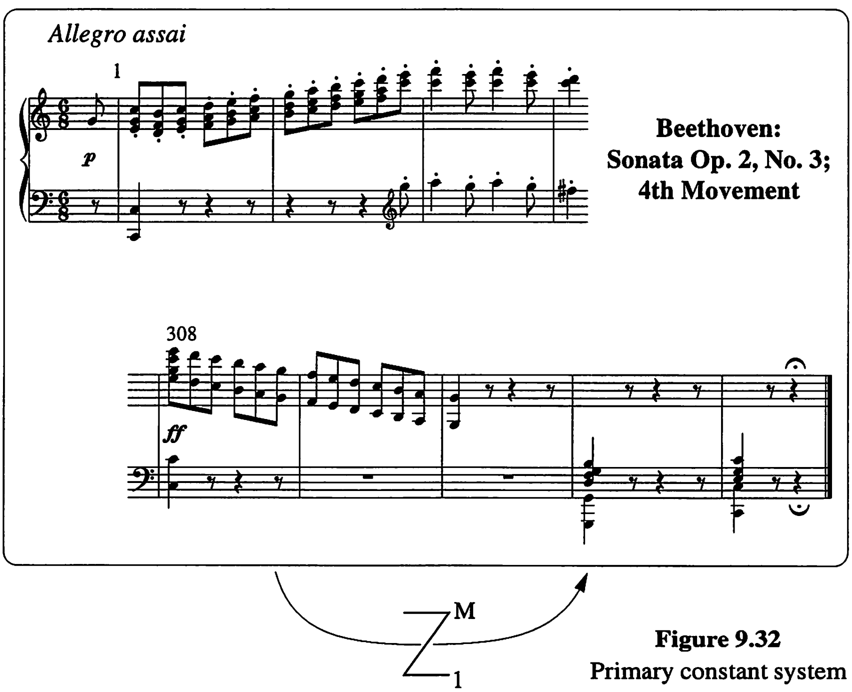


Figure 9.32
Primary constant system of metre.

[11]He finds the same feature in a good deal of European folk-music.

Since so many movements exhibit metric isometry, each new one that respects this convention may be deemed to be ordered through numerous intraoperative and interoperative secondary zygonic constants.

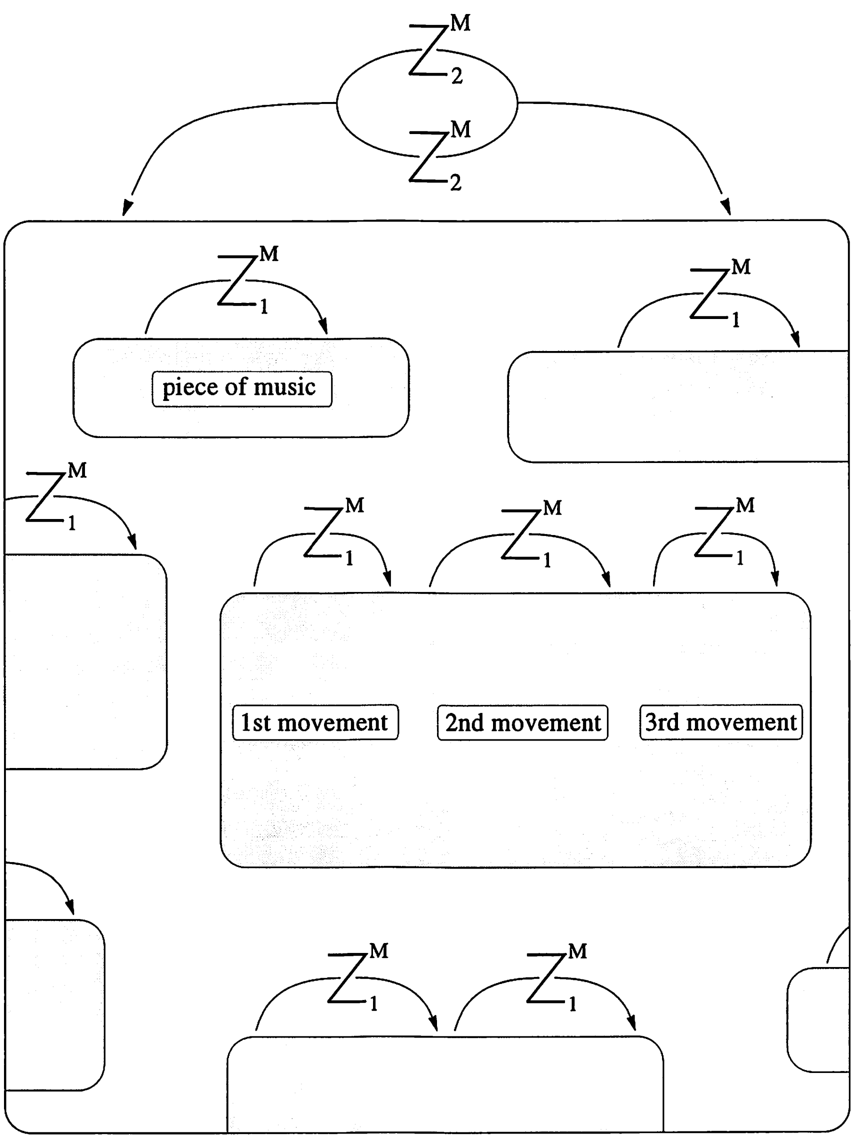


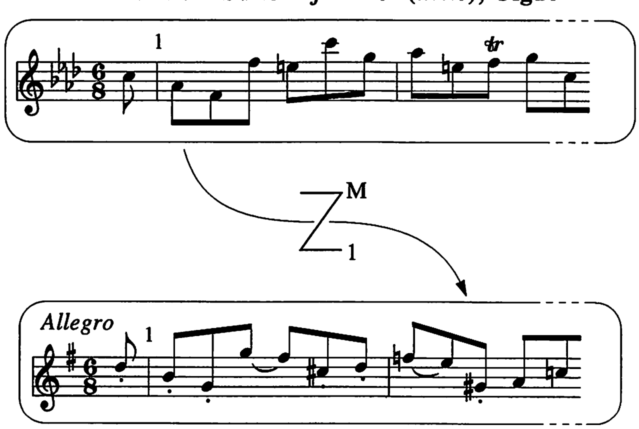
Figure 9.33 Secondary general zygonic constant of metre.

The degree of metric organisation typically present is compounded still further since very few different metres tend to be used. As Davies (1978, p. 178) says,

> Western music has confined itself largely to the use of metres involving units of two, three, or four beats. ... Even the distinction between two and four time is in a sense artificial, since what can be grouped in fours can also be grouped in twos.

This saturation with duple and triple grouping may be considered to occur through imitation, and the operation of numerous interoperative primary zygonic links is implied, whose strength resides largely in their combined effect. Occasionally, however, extramusical evidence may lend particular weight to one or more of these connections. Consider, for example, Mozart's gigue in *G*, 1789, which is known to be modelled on the gigue from Handel's 8th suite in *f* minor of 1720 (Gale, 1990).

Handel: 8th Suite in *f* Minor (1720); Gigue



Mozart: Gigue in *G* Major (1789)

Figure 9.34 Interoperative primary zygonic constant of metre.

Zygonic relationships may link different levels of the metrical hierarchy. This form of ordering may be particularly apparent in cases of rhythmic diminution. For instance:

Bach: *Well-Tempered Clavier,* Part 2; Fugue 9, BWV 878

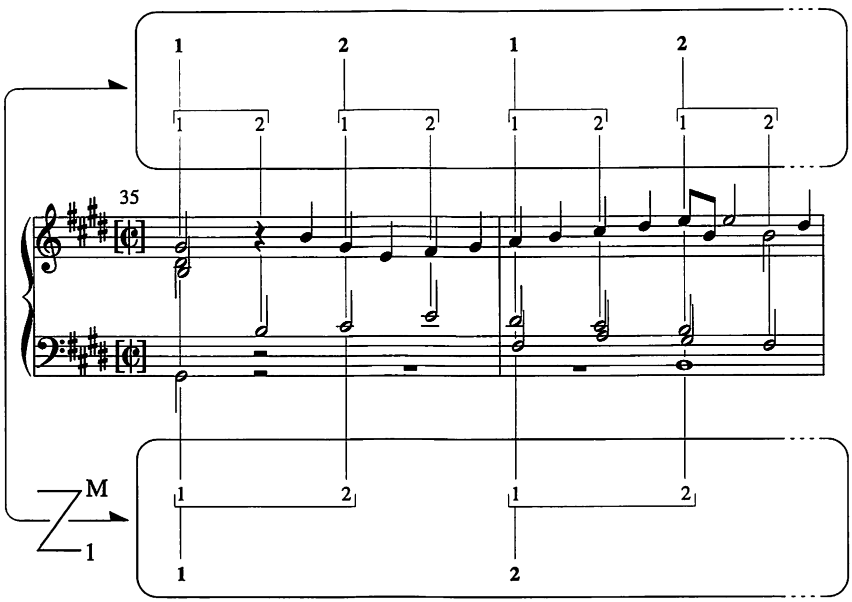


Figure 9.35 Primary zygon linking different strata in the metrical hierarchy.

When different metres are juxtaposed, whether simultaneously or consecutively, both intrasociative and intersociative organisation is possible. For example, the following sequence of 5/4, 4/4 and 3/4 may be regarded as ordered through a secondary zygon (figure 9.36).[12,13]

Blacher (1952/1954, p. 178) proposes various ways of organising metrical change, including summation series such as 2–3–5–8–13, with the idea that this be transferred to equal note-values such as quavers. This implies order through a secondary zygosequential zygonic constant system controlling a series of primary triadic relationships. See figure 9.37.

[12]Given the assumption that shortening a bar of 5/4 by one beat is in some sense metrically equivalent to removing one crotchet from a bar of 4/4.

[13]Note that more complex interconnections of metre—a compound perspect—may have to be indicated on relationships as such. See, for instance, figure 9.38 (cf. figure 3.12)

Jolivet: *Cinq Danses Rituelles pour Piano* (1939); 3. *Danse Nuptiale*

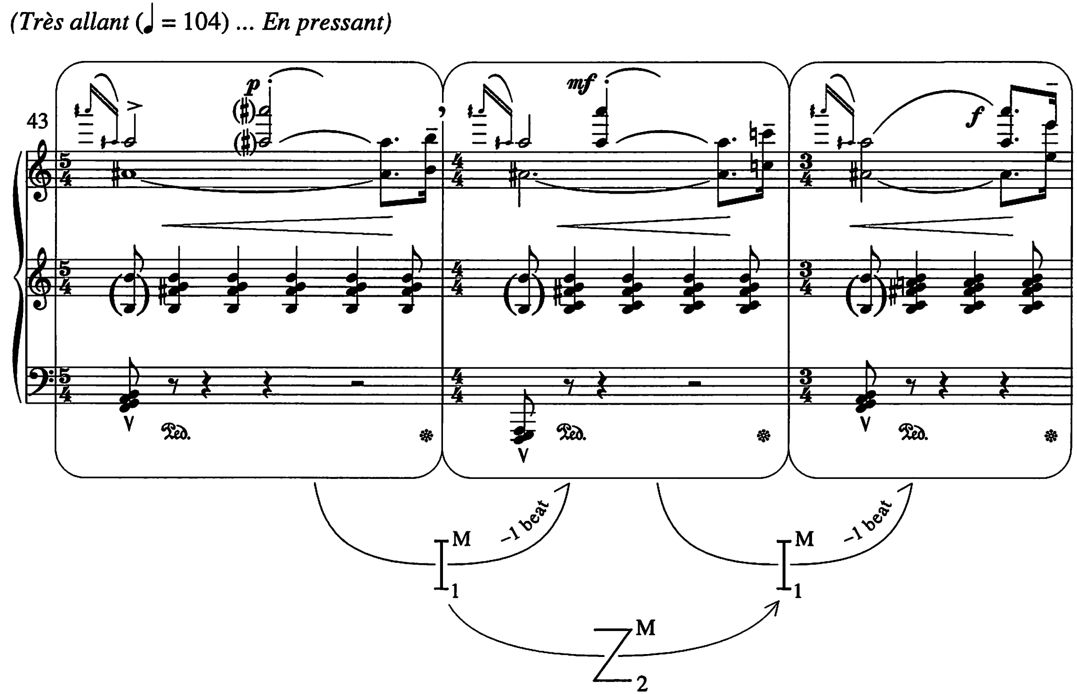


Figure 9.36 The ordering of metre through successive differences the same.

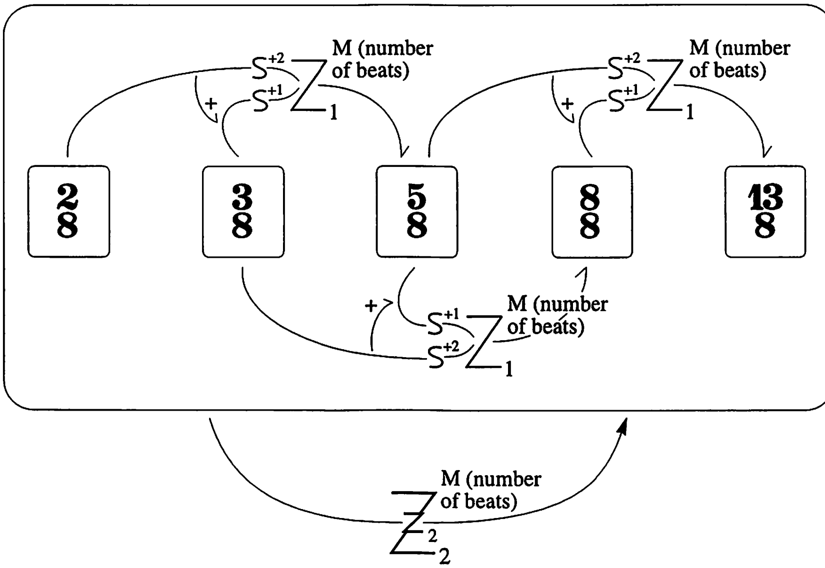


Figure 9.37 The organisation of metre through a form of the *Fibonacci* sequence, as proposed by Blacher (op. cit.). Cf. figure 9.20.

Bartók: ***Mikrokosmos*** **(1926–1939); Vol. V, No. 126,** ***Change of Time***

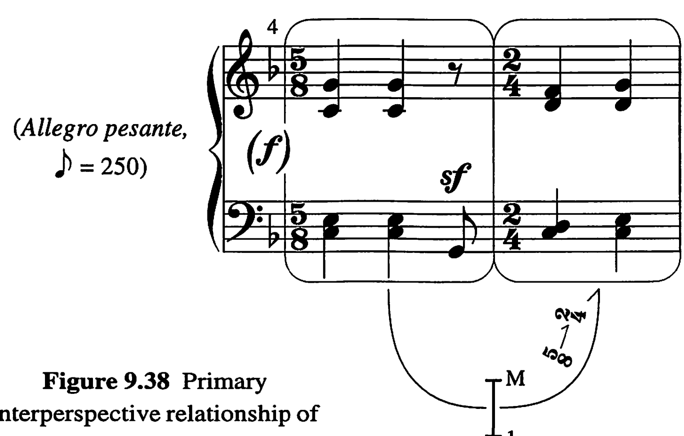


Figure 9.38 Primary interperspective relationship of metre, expressed as the transition between reference and comparison values.

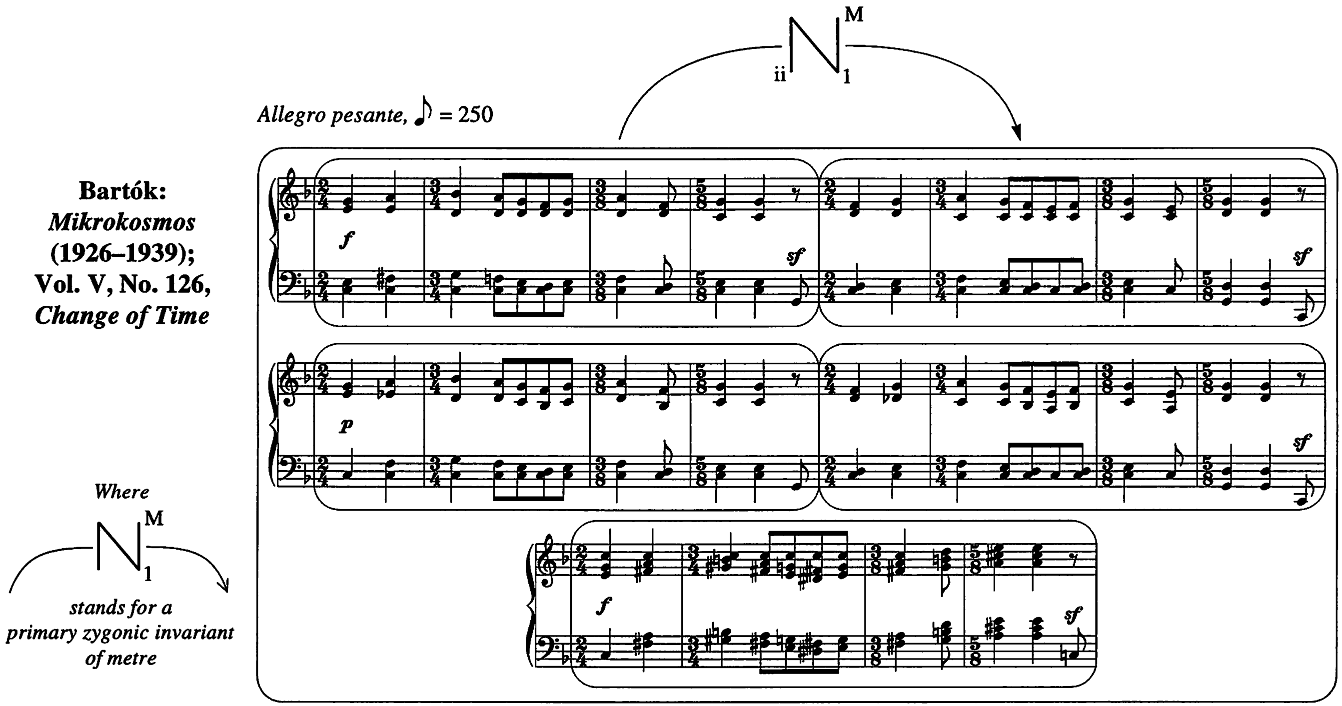



Figure 9.39 Constant system (order ii) of primary zygosequential zygonic invariants (order i) of metre.

Where similar successions of metres recur, these may supposed to be controlled through primary zygosequential zygonic invariants. See, for example, figure 9.39.

Finally, it is conceivable that metres may be derived extramusically, particularly from poetry, whose schemes—as one might expect, given the frequency with which words are set to music—it often resembles closely (see Apel, 1969, p. 682). As Nettl observes (1965/1973, p. 47):

> The metric character of European folk music is closely related to the metric organization of much of the poetry.

Other writers point out how metre corresponds to certain forms of human and natural activity. Idelsohn (1944, p. 113), for instance, notes that

> Arabic meter—so Arabic tradition claims—sprang from the rhythm of bodily motions, such as the pendular beating of the blacksmith and the trot of the horse and the camel.

The implication of zygonic relationships is clear.

Ordering duration

Non-canonic limitations on duration include the fact that the lengths of notes produced by striking, plucking, bowing and blowing are physically constrained. Perception sets further limits, since a certain length of sound is required to register fully with the mechanisms of aural processing (see Turnbull, 1944; Doughty and Garner, 1947). All durations are liable to be affected by the perceived resonance of the acoustical environment in which they are heard.

The organisation of durations almost invariably goes hand in hand with the ordering of prefix, a coordination of control that is considered in detail in the sections that follow. Despite this, a number of general observations concerning durational order can usefully be made at this stage.

Movements, or even entire works in one tempo, are inclined to use—on paper, at least—few discrete values of duration. Fraisse (1978, p. 243), for example, found that 80–90% of the notes in each of fourteen Classical pieces selected at random could always be accounted for by only two different durations (whose values varied from one composition to another).

This tendency is evident in the work which will be analysed here: Chopin's prelude no. 6 in *b* minor, op. 28. Although the piece is made up of 405 notes, a set of only nine distinct durations is used, which occur with the frequencies shown in figure 9.40. Observe that the crotchet and the quaver between them make up 79% of the total. If the semiquaver is included too (giving three distinct values), this figure rises to almost 95%.

duration	𝅘𝅥𝅰	𝅘𝅥𝅯	𝅘𝅥𝅮	𝅘𝅥𝅮.	𝅘𝅥	𝅘𝅥.	𝅗𝅥	𝅗𝅥.‿𝅘𝅥𝅯	𝅗𝅥.‿𝅘𝅥
number of appearances (total **405**)	2	63	197	4	123	10	4	1	1

Figure 9.40 Set of durations used in Chopin's prelude in *b* minor, op. 28.

In performance, however, each of these categories does not constitute a single duration but a group of values. This is dictated by intraterpretive variations in the realisation of perceived time of the types described on pp. 340ff (in relation to tempo), ranging from the highly localised forms of *rubato* illustrated in figure 3.19, to the more immediately apparent *accelerandi* and *ritardandi* that are characteristic of many performances. Indeed, it is not inconceivable that in certain performances two or more durational categories may overlap: at different points in the piece, a dotted quaver may be sustained for longer than a crotchet, for example. Interterpretively, the values of durations vary considerably too, because of differences in tempo and articulation. Hence in speaking of the durations of a piece, it is appropriate to regard each not as a single, immutable value, but as a set of possibilities, abstracted from the range of what are considered to be acceptable interpretations.

The repetition of durational values is partly be attributable to the fact that notes tend to fill up the gap between one regular pulse and the next. However, durations are perceived to be ordered through imitation in their own right too, through zygonic relationships grouped in primary constant systems. These may be regarded as imperfect or perfect (for the sake of analytical simplicity). See, for example, figure 9.41. (Where necessary, the mixed temporal polarity of the constants is shown using the 'dot' notation introduced in figure 6.47.)

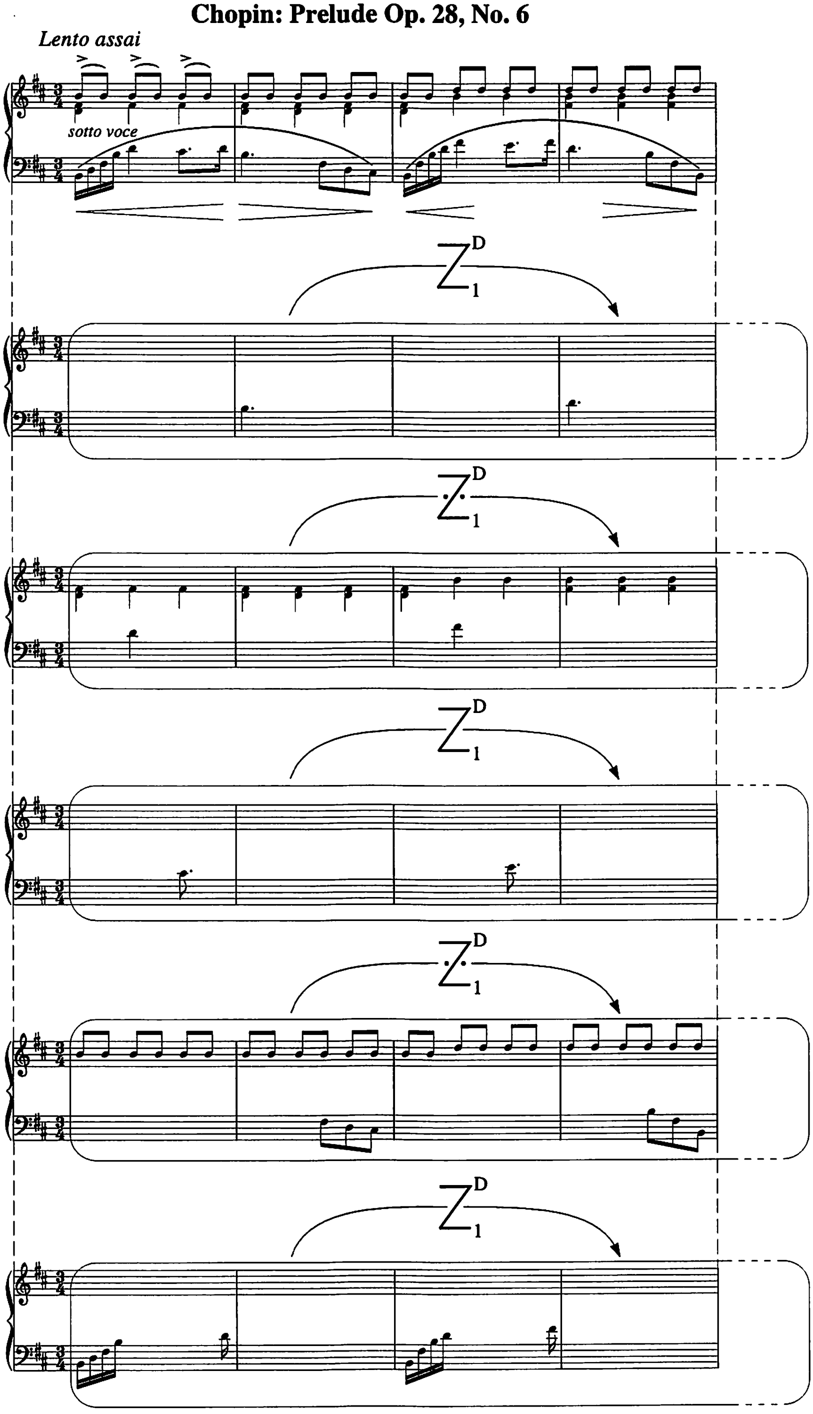
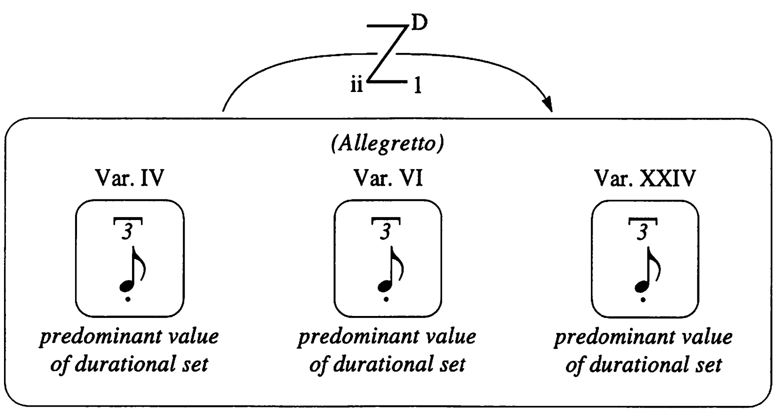


Figure 9.41 Primary zygonic constants of duration operating in Chopin, op. 28.

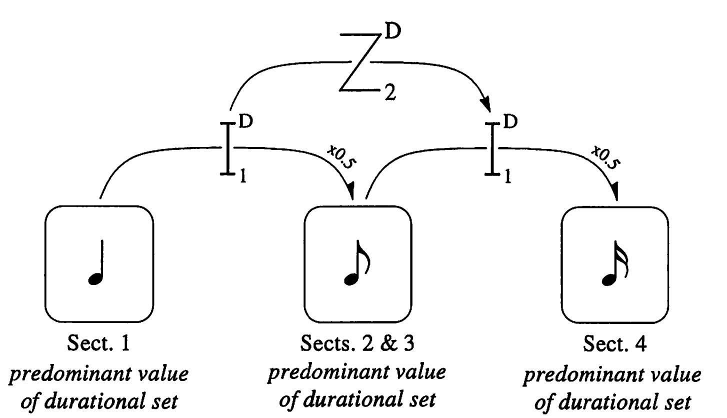
Although the different durations used here are distributed fairly evenly throughout the piece, this is by no means a feature of all compositions: a particular durational value or values may predominate in a given passage, in which case order through imitation is a possibility. For example:



Beethoven: 32 Variations in *c* minor, WoO 80

Figure 9.42 Primary zygonic constant system of duration, order ii.

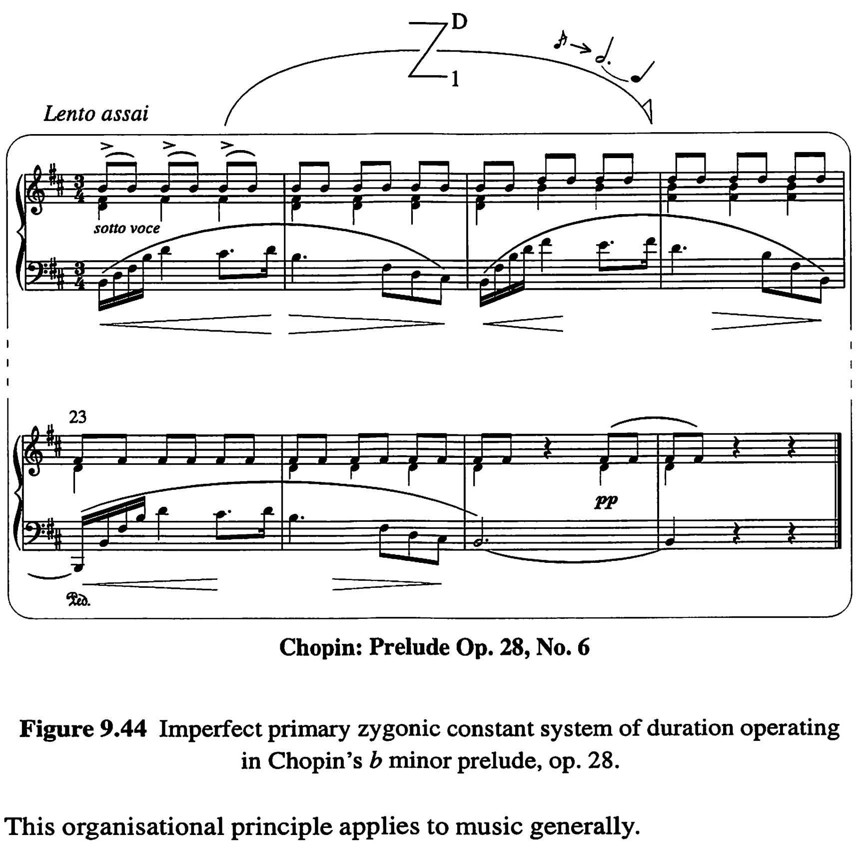
Secondary zygonic ordering may operate along the following lines:



Byrd: *Fortune* (1612)

Figure 9.43 Secondary zygonic constant of duration linking sections in Byrd's keyboard variations *Fortune*.

In Chopin's prelude, op. 28, the difference between the longest note used and the shortest is something less than a semibreve (which, at a tempo of say ♪ = 88 would last for about 5 ½ seconds). Hence it is possible to consider every duration in the piece (except the four that make up the initial chord) as existing in approximate imitation of those preceding.



Chopin: Prelude Op. 28, No. 6

Figure 9.44 Imperfect primary zygonic constant system of duration operating in Chopin's *b* minor prelude, op. 28.

This organisational principle applies to music generally.

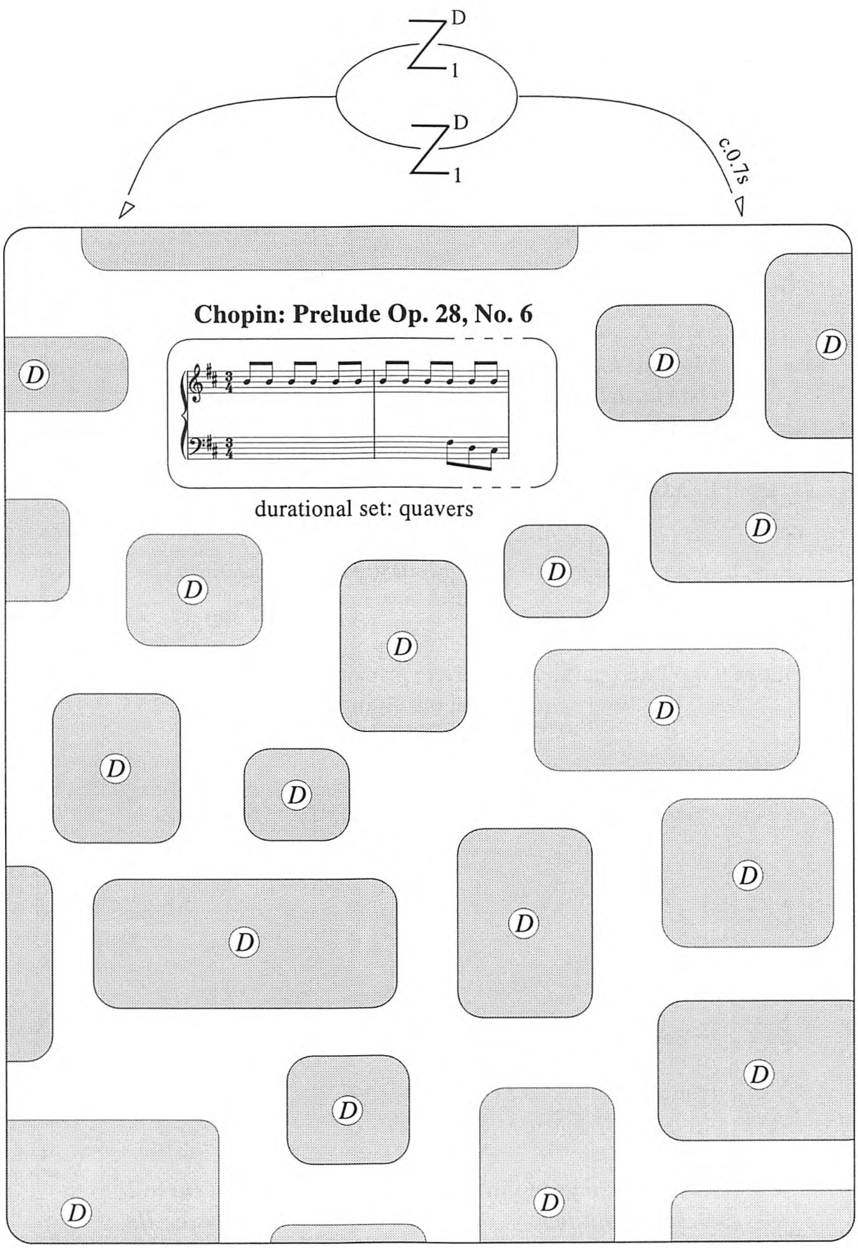
Just as most durations can be matched up with many others that are identical or very similar *within* the same work, so the same is true *between* pieces: composers have used durations that are equal, or virtually so, time and time again. This phenomenon may be attributed to the operation of interoperative primary zygons. However, since so many compositions share values of duration that closely resemble one another, unless parallel ordering is present in other perspective realms, or appropriate extramusical information is available, there will be no reason for listeners to ascribe particular significance to any one of these relationships. It is through their combined effect, as systems of primary zygonic constants, relating many different works, that they attain organisational significance. This ordering may be expressed in terms of a general zygonic constant of duration (see figure 9.45).

The link between pieces may also be strengthened if more than one different duration is common to both. Indeed, the entire durational set of a particular work or movement may be emulated by that of another through a primary interoperative zygonic invariant. In performance, one would expect differences to exist both between the sets as a whole and between the many realisations of durational values that are notated in the same way, implying the presence of two types of imperfection. See, for example, figure 9.46. Here, the interoperative durational link is strengthened by the fact that both movements are from concerti by the same composer, that are scored for the same distinct combination of instruments.

Then, just as all the durations that belong to a given work or movement can, for the most part, be considered to be imperfectly zygonically related, so the same is often true interoperatively. Hence imperfect primary zygonic constants may be supposed to function as follows (figure 9.47).

Canons involving interperspective values of duration are our next area of concern. The fact that durations typically have a close association with a regular beat has two consequences. First, since musical pulses tend to be related to one another proportionally rather than additively, ratios of duration, on a note-to-note basis, are normally of greater consequence than differences. Second, because division or grouping of the beat on all levels of the metrical hierarchy is characteristically achieved through low, whole-number ratios, comparatively few different classes of primary interperspective durational value are to be found. In performance, each of these categories actually covers a range of values, which is liable to differ from one interpretation to another, and is an inevitable consequence of the variability that typifies the production of durations themselves. Listeners may but need not be cognisant of these discrepancies. In any case, for convenience, in the discussion that follows, durational ratios will be referred to in the simplified form inferable from notation.

Consider, once more, Chopin's 6th prelude, op. 28. If inverse values are taken to be equivalent (so that no distinction is drawn between 2:1 and 1:2, for example), 23 distinct primary ratios of duration are used. Together these form a **primary interperspective set** (see figure 9.48). This represents a



(D) = *intraoperative set of durations whose members are each c.0.7s long*

Figure 9.45 Interoperative imperfect general zygonic constant of duration.

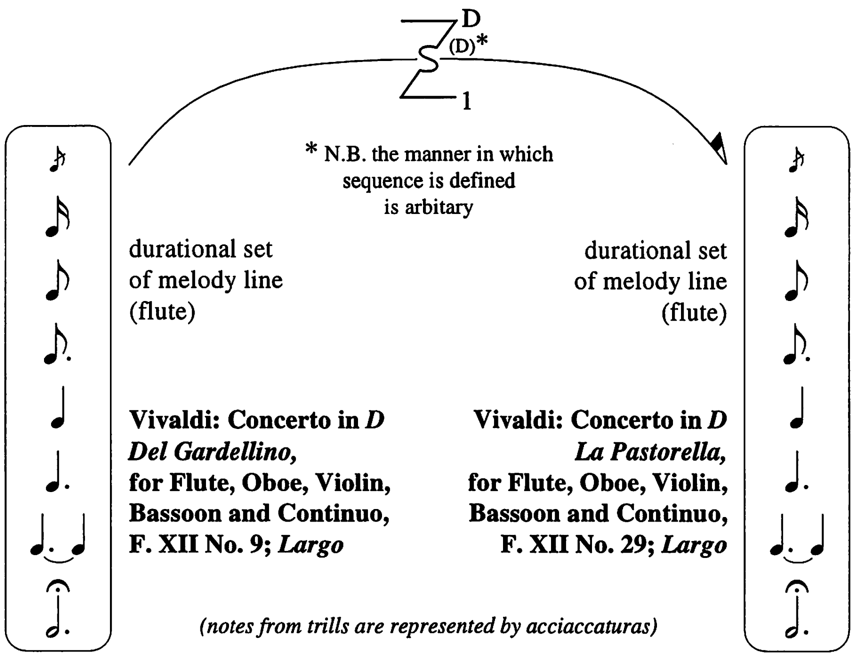


Figure 9.46 Interoperative imperfect primary imperfect zygonic invariant of duration (cf. figure 6.55).

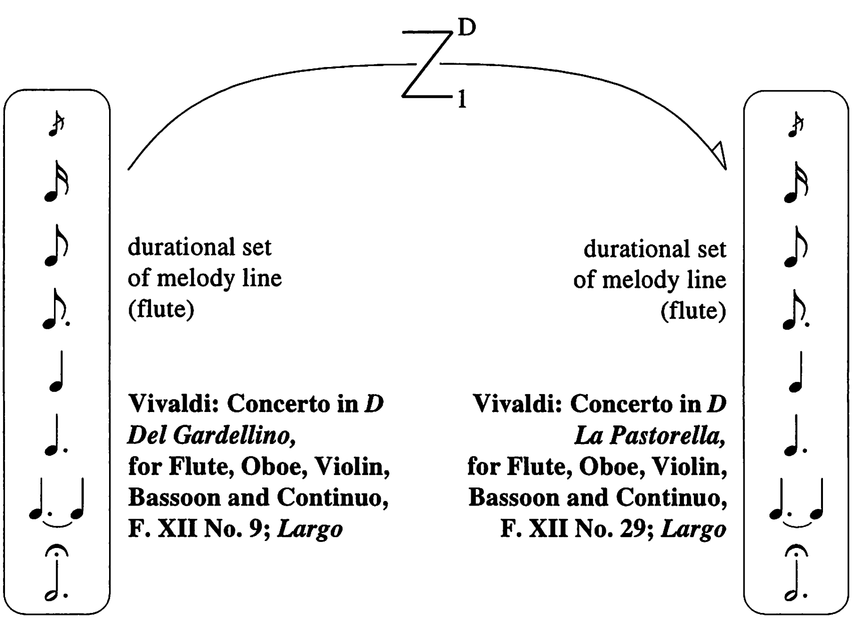


Figure 9.47 Interoperative imperfect primary zygonic constant of duration.

ratio	represented by the following durations						
1 : 1	𝅘𝅥𝅱 : 𝅘𝅥𝅱	𝅘𝅥𝅯 : 𝅘𝅥𝅯	𝅘𝅥𝅮 : 𝅘𝅥𝅮	𝅘𝅥𝅮. : 𝅘𝅥𝅮.	𝅘𝅥 : 𝅘𝅥	𝅘𝅥. : 𝅘𝅥.	𝅗𝅥 : 𝅗𝅥
4 : 3	𝅘𝅥 : 𝅘𝅥𝅮.	𝅗𝅥 : 𝅘𝅥.					
3 : 2	𝅘𝅥. : 𝅘𝅥	𝅘𝅥𝅮. : 𝅘𝅥𝅮					
2 : 1	𝅘𝅥𝅮 : 𝅘𝅥𝅯	𝅘𝅥 : 𝅘𝅥𝅮	𝅘𝅥. : 𝅘𝅥𝅮.	𝅗𝅥 : 𝅘𝅥	𝅗𝅥.‿𝅘𝅥 : 𝅗𝅥		
13 : 8	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅗𝅥						
13 : 6	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅘𝅥.						
16 : 13	𝅗𝅥.‿𝅘𝅥 : 𝅗𝅥.‿𝅘𝅥𝅯						
8 : 3	𝅗𝅥 : 𝅘𝅥𝅮.	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥.					
3 : 1	𝅘𝅥𝅮. : 𝅘𝅥𝅯	𝅘𝅥. : 𝅘𝅥𝅮					
13 : 4	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅘𝅥						
4 : 1	𝅘𝅥𝅯 : 𝅘𝅥𝅱	𝅘𝅥 : 𝅘𝅥𝅯	𝅗𝅥 : 𝅘𝅥𝅮	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥			
13 : 3	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅘𝅥𝅮.						
16 : 3	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥𝅮.						
6 : 1	𝅘𝅥. : 𝅘𝅥𝅯						
13 : 2	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅘𝅥𝅮						
8 : 1	𝅘𝅥𝅮 : 𝅘𝅥𝅱	𝅗𝅥 : 𝅘𝅥𝅯	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥𝅮				
12 : 1	𝅘𝅥𝅮. : 𝅘𝅥𝅱						
13 : 1	𝅗𝅥.‿𝅘𝅥𝅯 : 𝅘𝅥𝅯						
16 : 1	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥𝅯	𝅘𝅥 : 𝅘𝅥𝅱					
24 : 1	𝅘𝅥. : 𝅘𝅥𝅱						
32 : 1	𝅗𝅥 : 𝅘𝅥𝅱						
52 : 1	𝅗𝅥. : 𝅘𝅥𝅱						
64 : 1	𝅗𝅥.‿𝅘𝅥 : 𝅘𝅥𝅱						

Figure 9.48 Primary interperspective set of duration: Chopin, op. 28, no. 6.[14]

[14]The two grace notes used in bar 7 are taken to be semihemidemisemiquavers.

tiny fraction of the 80,000 or so relationships that potentially exist. Of these, approximately 35% express the proportion 1:1; about 45%, 2:1; and around 11%, 4:1—a total of 91%. These figures take no account of the cognitive significance of the interperspective connections they represent, and an even greater degree of organisation would be evident if only those relationships that are adjacent in perceived time were considered. Even as they stand, however, the figures are indicative of a remarkably high level of order. Where interperspective values of duration are considered to result from imitation, the operation of secondary zygons is implied. For example:

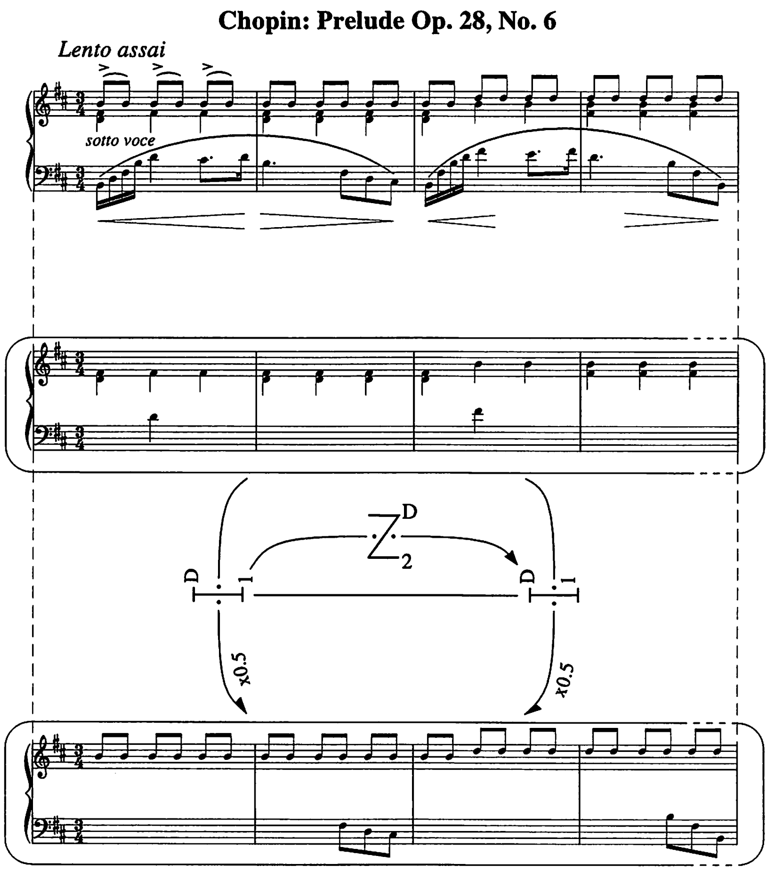
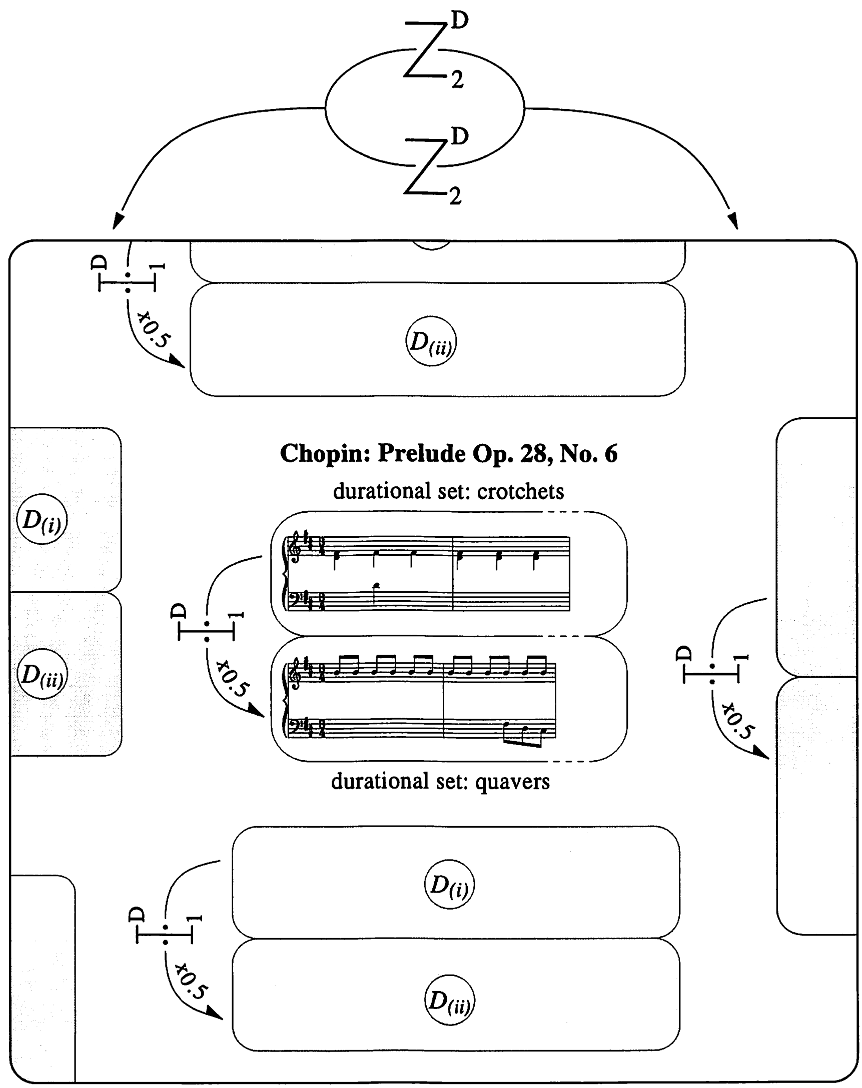


Figure 9.49 Secondary zygonic constant system of duration.

Interperspective durational control of this type dominates many musical textures (cf. Fraisse, 1982, p. 168), implying interoperative secondary zygonic activity along the following lines:



D(i) D(ii) = *intraoperative sets of durations whose members stand in the ratio 2:1*

Figure 9.50 Interoperative secondary general zygonic constant of duration.

In the prelude, the same low, whole-number ratios are used to relate durations at all levels of the metrical hierarchy. That is to say, not only is the beat divided into a pulse moving twice as fast, but this pulse is subject to a similar division itself, implying the operation of secondary ordering:

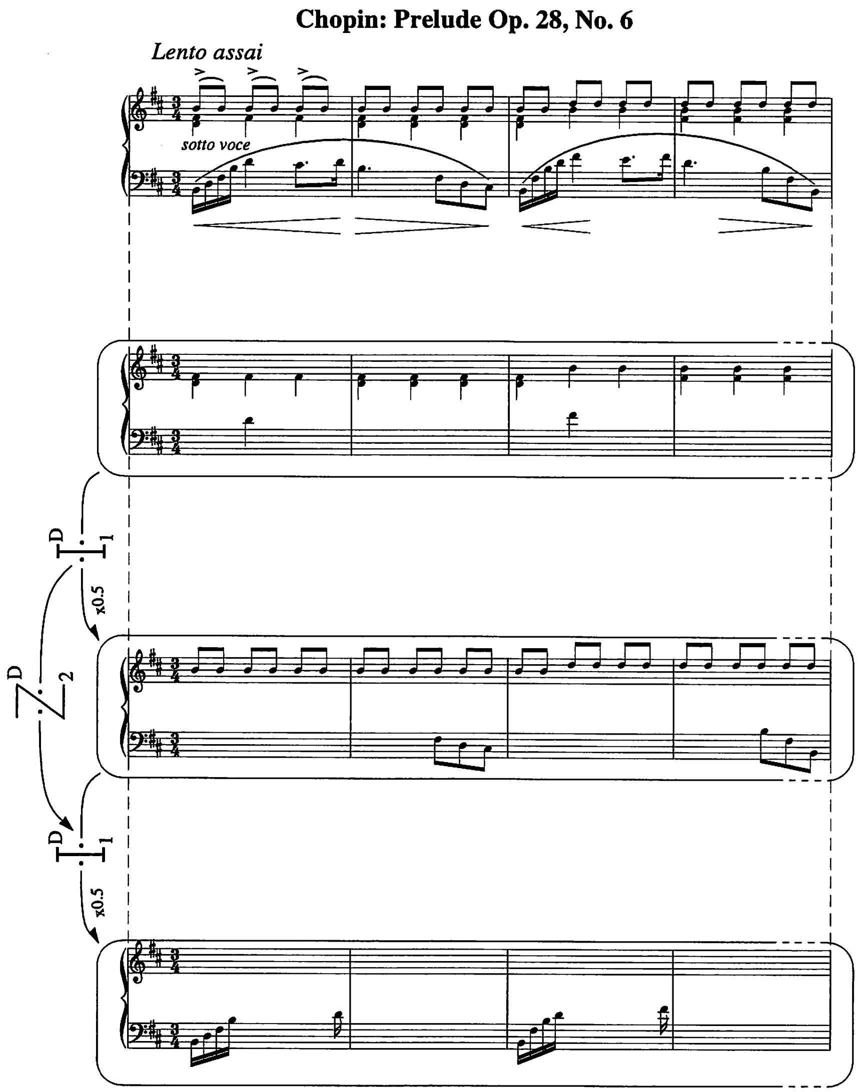


Figure 9.51 Secondary intersociative zygonic constant of duration.

Organisation of this type is characteristic of many styles of music, again implying interoperative imitation.

Another way of viewing interperspective durational order is in terms of the relationships between adjacent members of the perspective set (arranged in order of size). This approach seems particularly appropriate with pieces such as Messiaen's *Turangalîla-Symphonie* (1946–1948), Boulez's second piano sonata (1947–1948) and the *Composition for 12 Instruments* by Babbitt (1948), which employ sets of durations whose values are spaced equidistantly, or approximately so. Hence ordering is implied through the agency of a sequentially ordered primary invariant system, which may be perfect or imperfect. (See figure 9.52).

The fact that pieces are recognisable (if not aesthetically pleasing) at a broad range of tempi suggests that interperspective values of duration are of greater musical consequence than perspective values. So instead of regarding pieces in terms of series of durations, whose values are fixed, perception may be modelled more faithfully by thinking in terms of sequences of relationships *between* perspective values, which are specified only within certain limits. Hence the notion of **primary interperspective associations of duration**, in which only primary interperspective values are indicated, leaving the perspective values themselves undetermined.

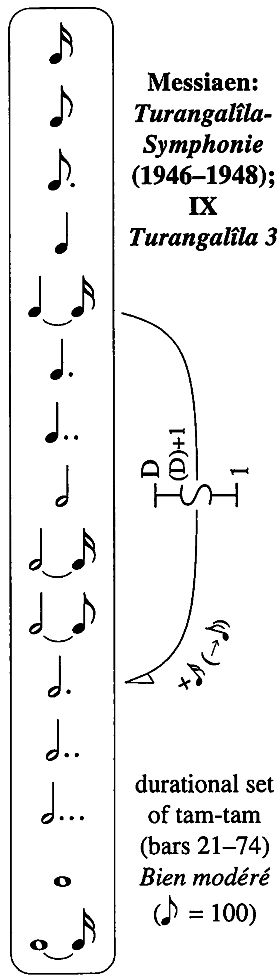


Figure 9.52
Sequentially ordered imperfect primary invariant system of duration in Messiaen's *Turangalîla-Symphonie.*

This concept is reflected in traditional Western notation, which offers an essentially comparative model of perceived sonic events. Consider the following transcription of the opening of 'Twinkle, twinkle, little star':

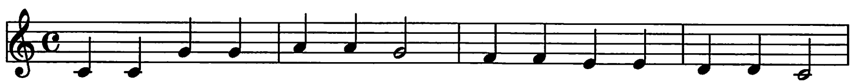



Figure 9.52 Transcription of the opening of 'Twinkle, twinkle, little star': perspective values of duration undetermined.

It is only through such additions as metronome marks (say, ♩ = 96) that schemes of this type can be made absolute.

Primary interperspective sets of duration summarise the primary interperspective values that occur in a given period. Take, for instance, the following set that pertains to the chorale *O Haupt voll Blut und Wunden*, which appears in Bach's *St. Matthew Passion* BWV 244.

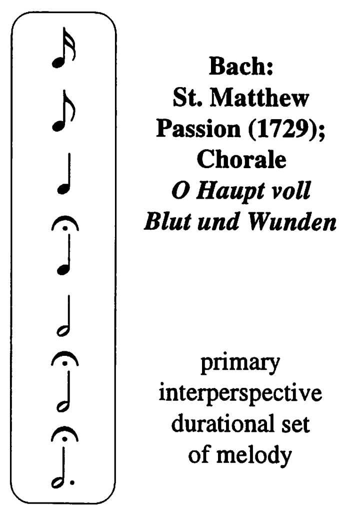


Figure 9.53 Primary interperspective durational set.

In my experience, these relative indications have been made absolute over a wide range of values, from Harnoncourt's ♩ = 60 (recorded in 1970 on Telefunken 6.35047-00-501) to the ♩ = c.43 realised by the Ebbw Vale Male Choir conducted by Savage (1971; on Decca DAF 220).

Primary interperspective sets may be related zygonically. For instance, see figure 9.54.

So much for the general organisation of duration pertaining to pieces, movements and sections taken as a whole. The next step is to examine how duration is ordered in rather more specific terms. Here, however, the almost

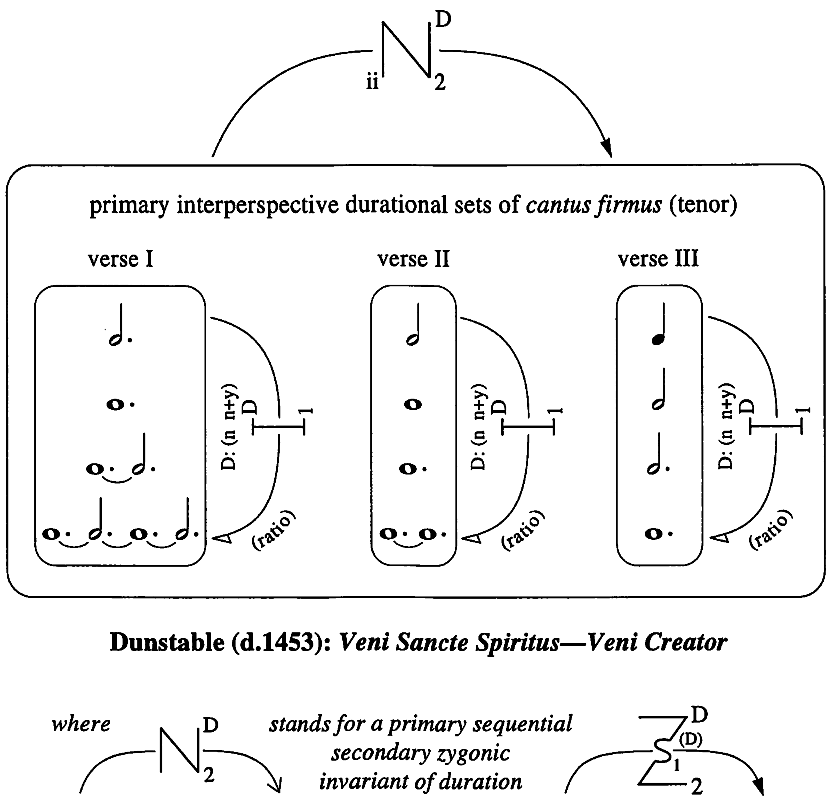
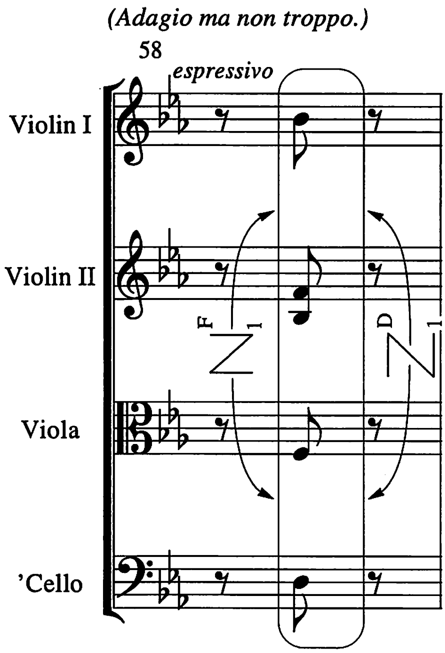


Figure 9.54 Constant system (order ii) of primary sequential secondary zygonic invariants of duration.

inevitable concomitant ordering of prefix is of such importance, that the investigation must be undertaken in terms of coordinated temporal perspective control. This is the subject of the sections that follow. At this stage, it is appropriate to make an observation concerning chords, whose constituent notes, often being initiated and terminated together, therefore share the same duration. Hence the mutual ordering of fix and duration coincide; see figure 9.55. Where this feature exists in imitation of previous practice, the combined operation of secondary zygonic constants of duration and secondary zygonic constants of uniform primary zygonic invariants of fix is implied. See, for instance, figure 9.56.

Beethoven:
String Quartet No. 10
(1809);
2nd Movement



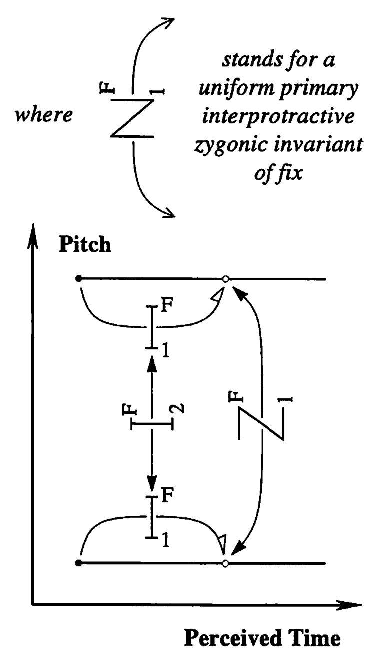


Figure 9.55
Synchronous operation of a mutual primary intrasociative zygonic constant system of duration and a constant system of uniform primary interprotractive zygonic invariants of fix.

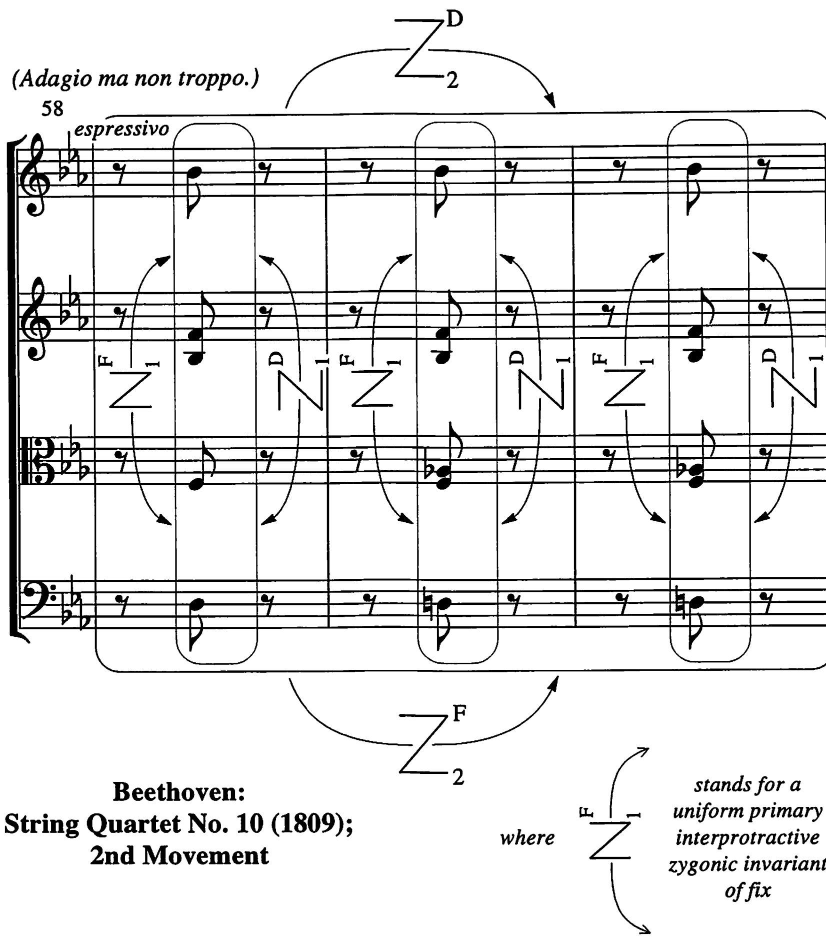


Figure 9.56 Constant systems of
(i) secondary zygonic constants of duration and
(ii) secondary zygonic constants of uniform primary zygonic invariants of fix.

The coordinated order of prefixes and durations

Durations frequently succeed one another contiguously. Hence the difference between the prefixes of two sequentially adjacent notes is equal to the duration of the first. This implies the existence of mutual mixed-rank (primary/secondary) zygonic relationships of duration/prefix. For instance:

Bizet: *L'Arlésienne* (1872); 1st Suite, No. 3, *Adagietto*

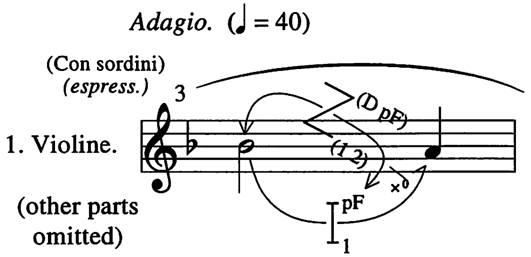


Figure 9.57 Contiguous durations, and the implied operation of a mutual primary/secondary relationship of duration/prefix.

This type of organisation may itself be ordered through imitation, both intraoperatively and interoperatively, through secondary-tertiary zygonic relationships of duration-prefix, commonly constituting constants or constant systems. For example:

Bizet: *L'Arlésienne* (1872); 1st Suite, No. 3, *Adagietto*

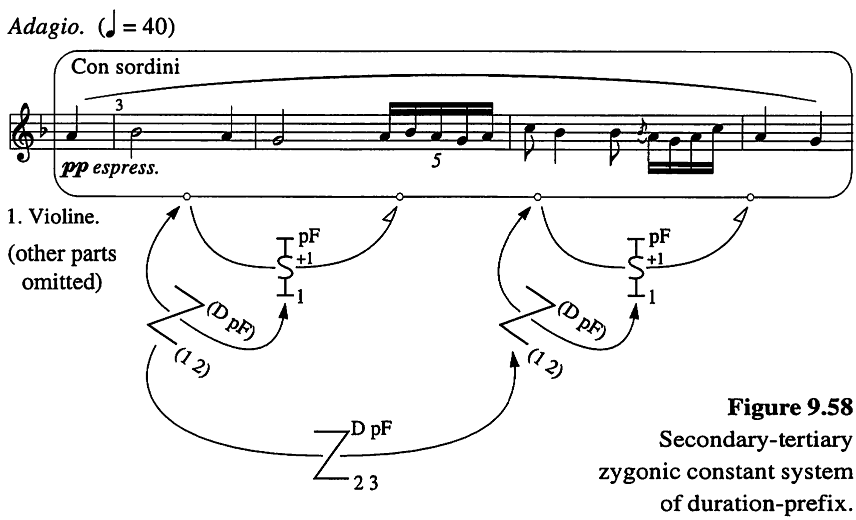


Figure 9.58 Secondary-tertiary zygonic constant system of duration-prefix.

The fact that prefix and duration are so often connected in this manner means that many of the comments concerning the organisation of adjacent interperspective values of prefix are applicable to durations too, and vice versa, although a change of rank is necessary to show the equivalence, since a primary interperspective value of fix corresponds to a perspective value of duration. For instance, the primary zygonic constant systems of duration pertaining to Chopin's prelude op. 28, no. 6 (see figure 9.41) are paralleled in secondary zygosequential zygonic constant systems of prefix.

Chopin: Prelude Op. 28, No. 6

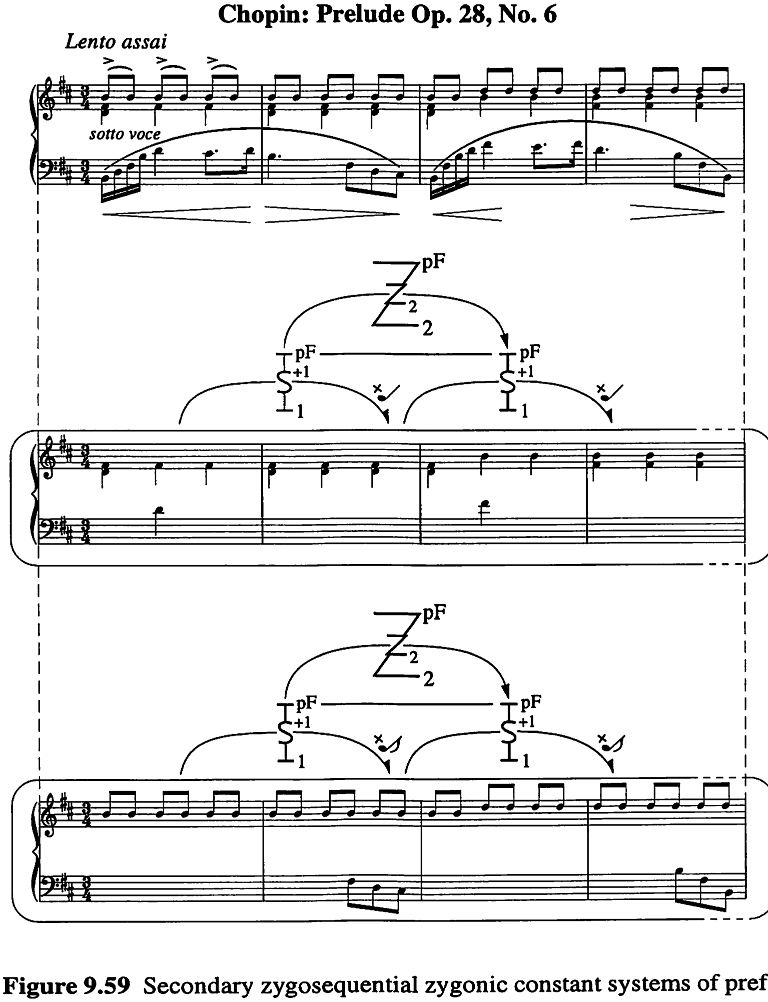


Figure 9.59 Secondary zygosequential zygonic constant systems of prefix.

Music which displays a regular beat is often characterised by series of contiguous equal durations. Two notes so disposed may be considered to be ordered through three zygonic relationships. For example:

Liszt: Piano Concerto No. 2 (1839); 1st Movement

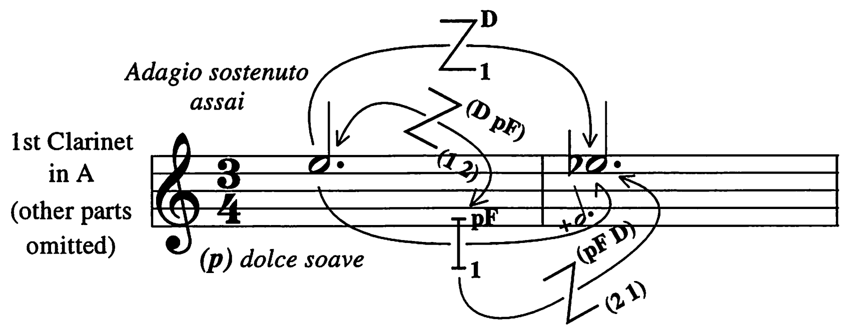


Figure 9.60 The three zygonic relationships ordering the perceived temporal disposition of two contiguous durations the same.

With three notes or more, the equality of successive interperspective values of prefix may be attributed to the agency of a secondary zygosequential zygonic constant system, controlling a sequentially ordered primary invariant system; durational uniformity may be ascribed to the operation of a primary zygonic constant system; and the link between durations and the interperspective values of consecutive prefixes may be heard in terms of mixed-rank zygonic constants. See figure 9.61.

Control of this type may be supposed to imitate comparable organisation involving different values through the operation of a tertiary zygosequential zygonic constant of prefix, a secondary zygonic constant of duration, and a secondary-tertiary zygonic constant of duration-prefix (figure 9.62).

Successive durations that display consistent change may be considered to be ordered along the lines shown in figure 9.63. Here, the connection between each duration and its corresponding interperspective value of prefix is reflected in the presence of a mutual primary/secondary zygonic constant of duration/prefix. The fact that the difference between successive interperspective values of prefix is the same as that between consecutive durations is attributed to the operation of a mutual secondary/tertiary zygonic constant of duration/prefix. A secondary zygosequential tertiary zygonic

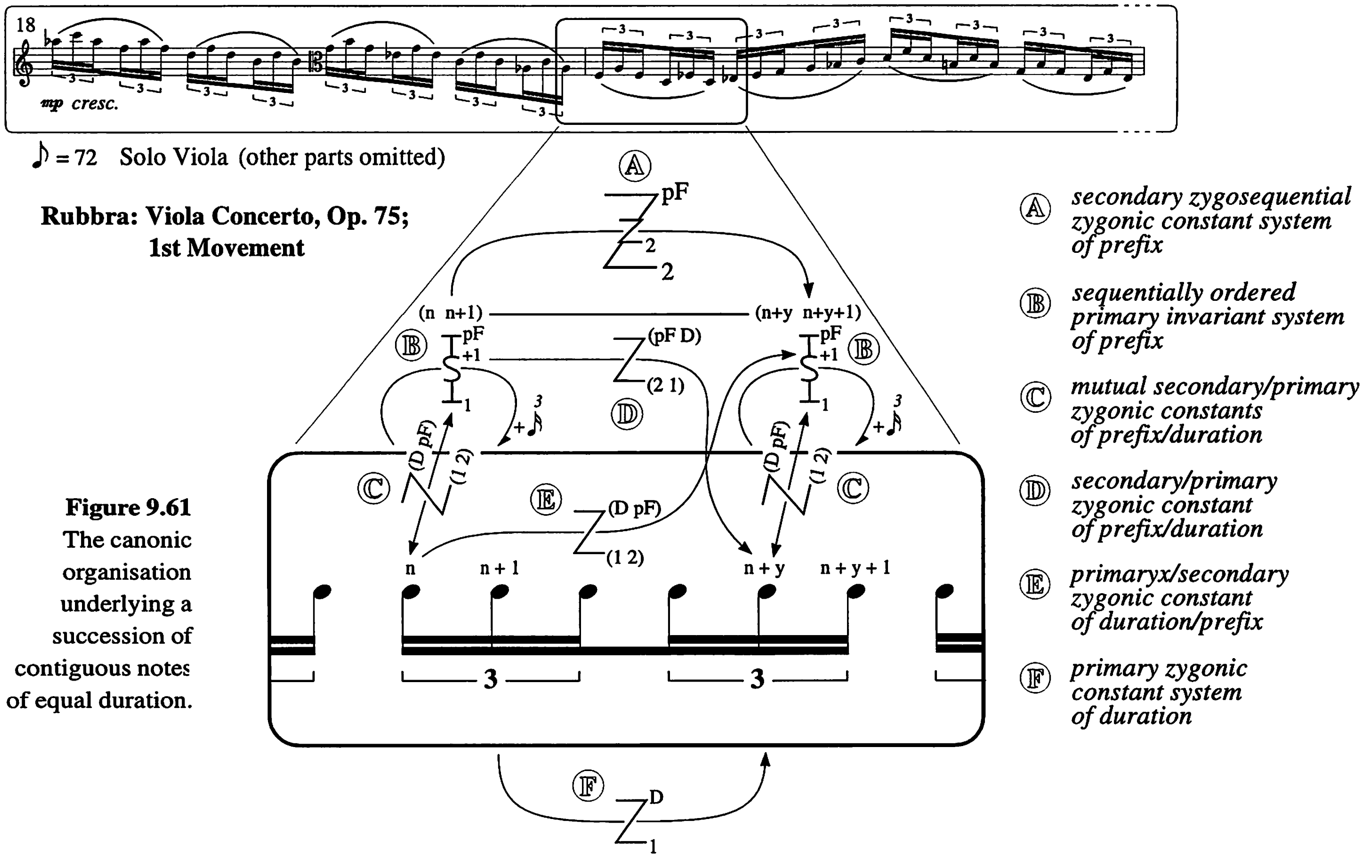
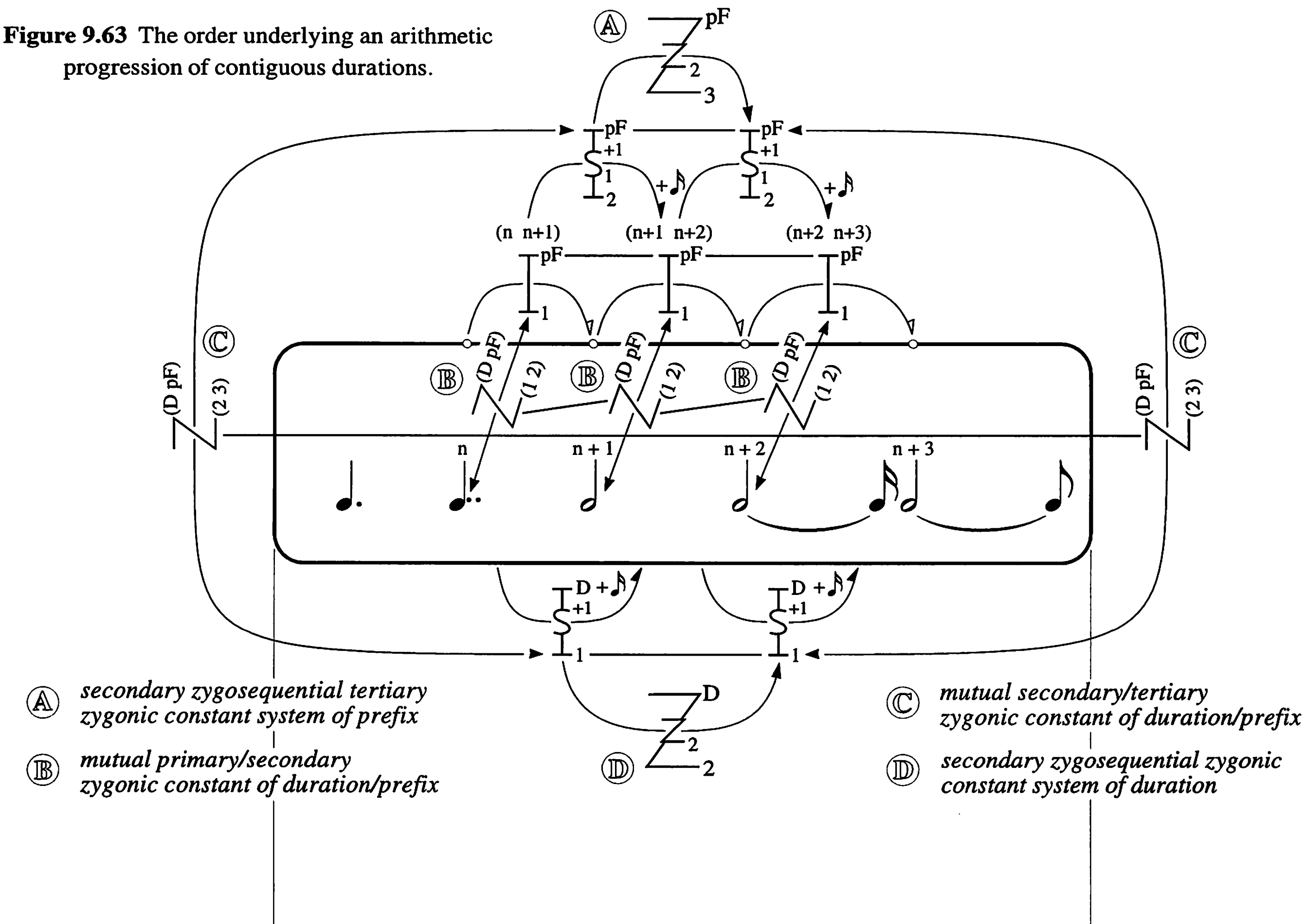


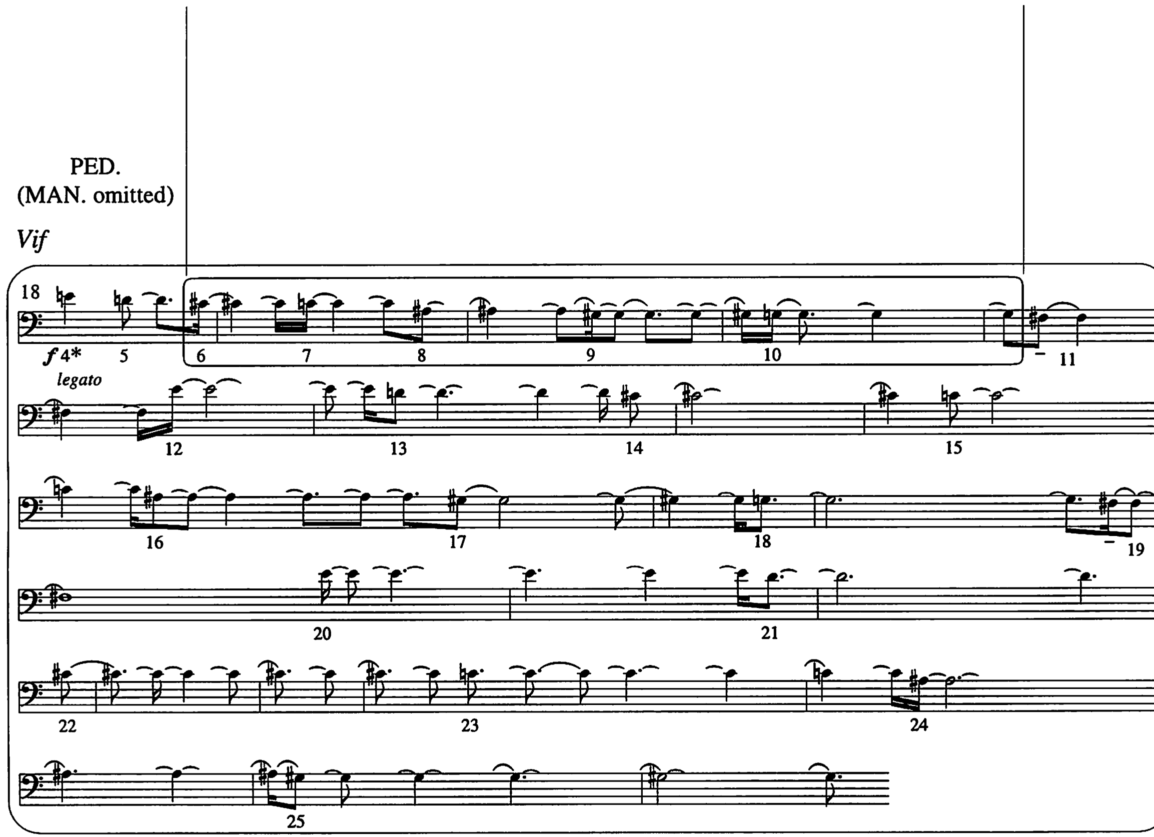
Figure 9.61 The canonic organisation underlying a succession of contiguous notes of equal duration.

Figure 9.63 The order underlying an arithmetic progression of contiguous durations.



PED.
(MAN. omitted)

Vif



* *Ces chiffres indiquent pour chaque durée sa valeur en doubles croches.*

Messiaen: *Messe de la Pentecôte (pour orgue)* (1949–1950); V—*Sortie (Le Vent de l'Esprit)*

Debussy:
Douze Etudes
(1915);
I—*pour les*
"cinq doigts"
(d'après
Monsieur Czerny)

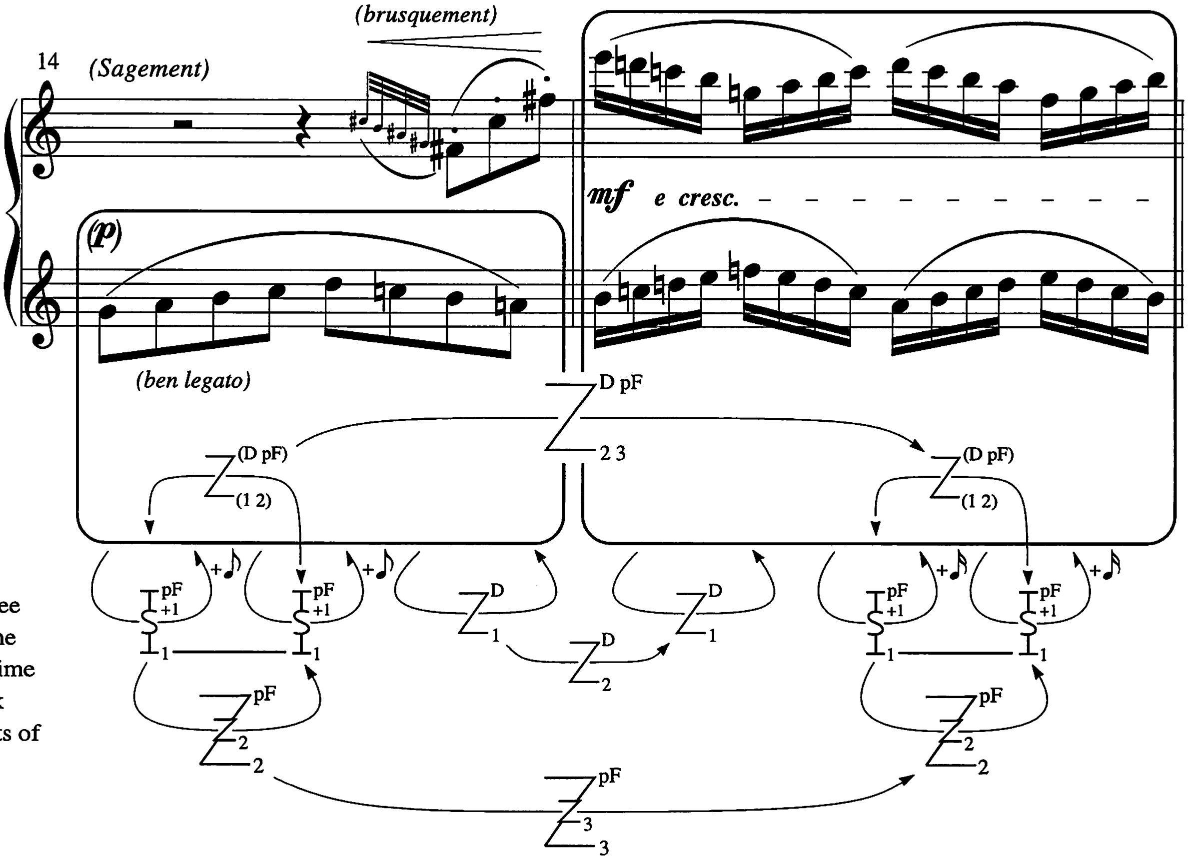


Figure 9.62 The three zygonic strands in the domain of perceived time that potentially link dissimilar complements of contiguous equal durations.

constant system of prefix and a secondary zygosequential zygonic constant system of duration are also present. Ordering of this type also underlies regular increases in tempo.

Virtually all music has passages of contiguous durations of two different values or more. The order implied is summarised in the following diagram, in which differing perspective values of duration and interperspective values of prefix are linked by a mutual primary/secondary zygonic constant of duration/prefix.

Rachmaninov: *The Isle of the Dead*, Op. 29

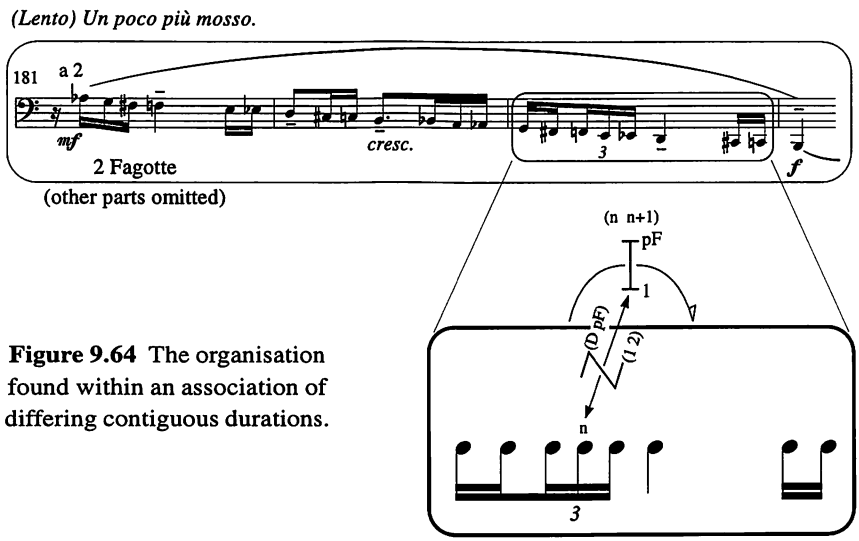
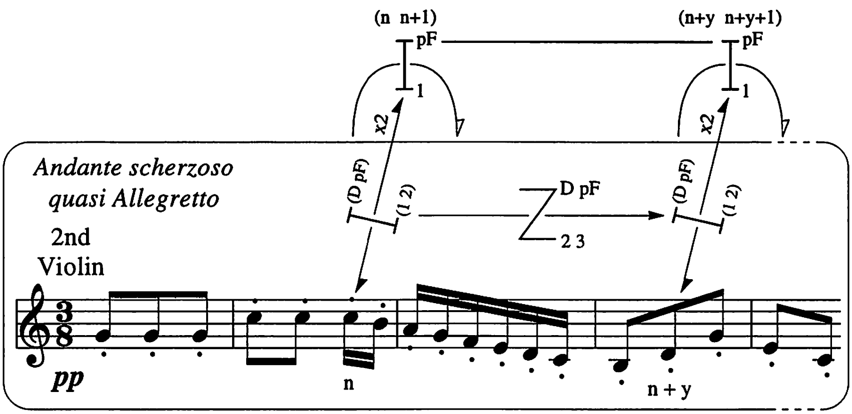


Figure 9.64 The organisation found within an association of differing contiguous durations.

In this example and those preceding, durations entirely fill up the gap between successive prefixes. However, this is only one form that coordinated ordering between the two perspects can take. For example, techniques such as *staccato* imply that perspective values of duration are consistently shorter than their parallel interperspective values of prefix. The order underlying this consistency may be attributed to the operation of a secondary-tertiary zygonic constant system of duration-prefix. Consider, for example, the following excerpt from the scherzo of Beethoven's string quartet, op. 18, no. 4, in which it is assumed that the durations are reduced in performance by precisely half their notated values (figure 9.65):



Beethoven: String Quartet, Op. 18, No. 4; 2nd Movement

Figure 9.65 Secondary-tertiary zygonic constant system of duration-prefix operating with respect to a series of contiguous *staccato* durations.

Imperfect relationships may model the nature of most performances more faithfully.

Devices such as *staccato* and *legato* contribute to **articulation** (abbreviated in diagrams to 'Ar'), which may either be composer-based or performer-based. A complement may display constancy of articulation, implying the operation of a primary zygonic constant system. For example:

Dvorák: 'Cello Concerto, Op. 104; 1st Movement

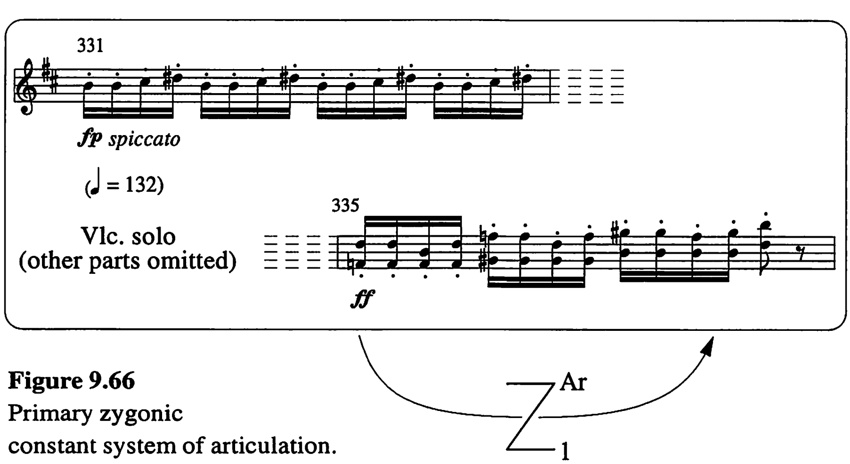


Figure 9.66
Primary zygonic
constant system of articulation.

The constant articulation of one passage may be held to emulate that of another through the agency of a primary zygonic constant of articulation. For example:

Berlioz: *Roméo et Juliette* (1838–1839);
3rd Movement, *La Reine Mab ou la Fée des Songes*

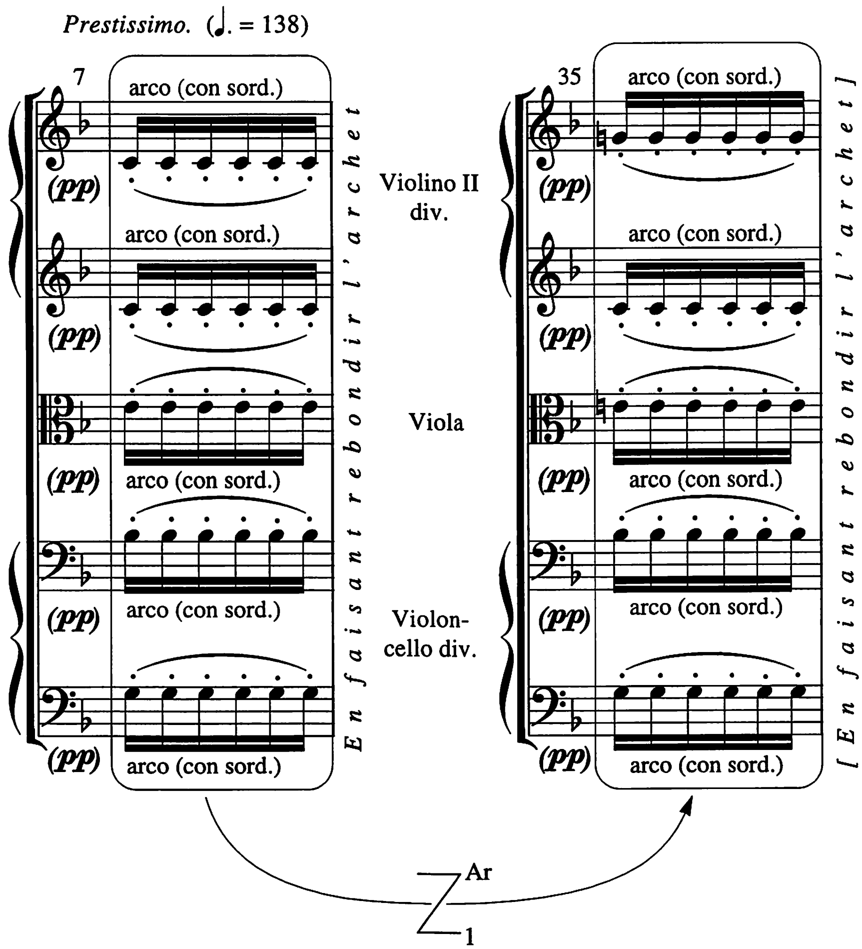
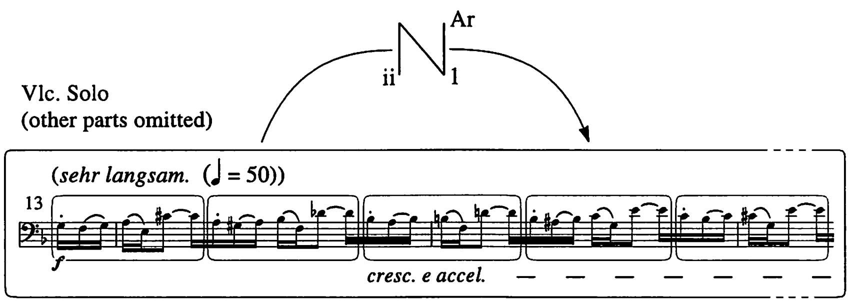


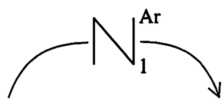
Figure 9.67 Primary zygonic constant of articulation.

Variable articulation may be transferred through primary zygosequential zygonic invariants. See, for example, figure 9.68.

Strauss: *Don Quixote,* Op. 35; Variation V



where



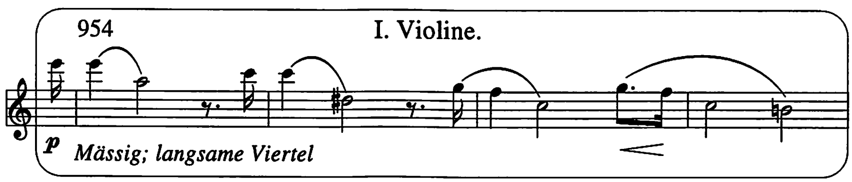
stands for a
primary zygonic invariant
of articulation

Figure 9.68 Constant system of primary zygosequential zygonic invariants of articulation.

Rhythm; intrarhythmic ordering

We now consider **rhythm**, a term which has been variously defined in the past (see Sachs, 1953, pp. 11ff). In the present context, it will be taken to mean a compound perspect pertaining to a complement of perceived sounds, which takes due account of interperspective values of prefix, durations and their relationship to metre, where this is present. This relationship has two components: the metre itself and the **relative metrical location** (or **RML**)—a measure of the position of the material relative to the metre concerned.

Exceptionally, a rhythm may involve just one note or chord, such as that found at the beginning of the overture to *The Magic Flute* (Mozart, 1791), for instance. Conversely, one rhythm may be compounded from smaller complementary fragments (whether simultaneously, successively, or a combination of both). For example:

Schoenberg: String Quartet, Op. 7

Chopin: Mazurka, Op. 7, No. 3

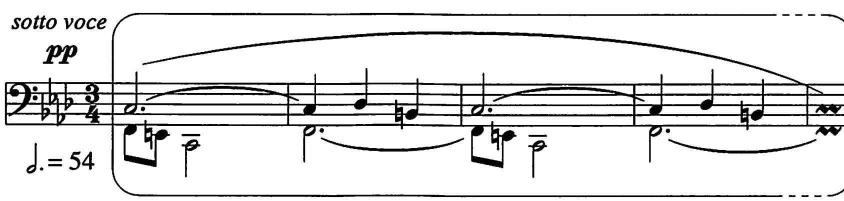


Figure 9.69 Rhythms compounded from successive and simultaneous complementary fragments.

The definition of rhythm given here disregards several perspects that are incorporated in other descriptions. Cooper and Meyer (1960, p. 6), for example, define rhythm as the manner in which one or more unaccented beats are grouped in relation to an accented one, and they take poetic feet (iambs, anapests and so on) as their basic terms of reference. However, I prefer to regard rhythm as one aspect of grouping[15] (rather than the other way round), particularly since it is influenced, among other things, by changes in

> pitch, duration, intensity, orchestration, and phrasing .... (op. cit., p. 12)

Similar comments apply to the idea that a feeling of progression is an aspect of rhythm—expressed by writers such as Apel (1969, p. 729), Gabrielsson (1973, p. 158) and Brown (1979, p. 19). However, since the impression of movement has as much to do with other perspective change

[15]There may seem to be a contradiction here, since metre, which is based on grouping, has been defined as one aspect of rhythm. Metrical grouping, however, is fundamentally different from the type mentioned by Cooper and Meyer which exists nearer the perceptual foreground: holistic complements can be overlaid on a metrical background. Hence it seems reasonable to assert that metrical grouping is potentially a component of rhythm, which in turn plays an important part in determining the boundaries of motives, phrases *etc.*

(in the domains of pitch and loudness, for instance) as it has to do with perceived temporal patterning, it would appear more reasonable to think of rhythm as one factor contributing to the illusion of musical motion. Consider, for example, how the dynamics imposed upon the rhythmic fragment cited below dictate its kinetic effect.

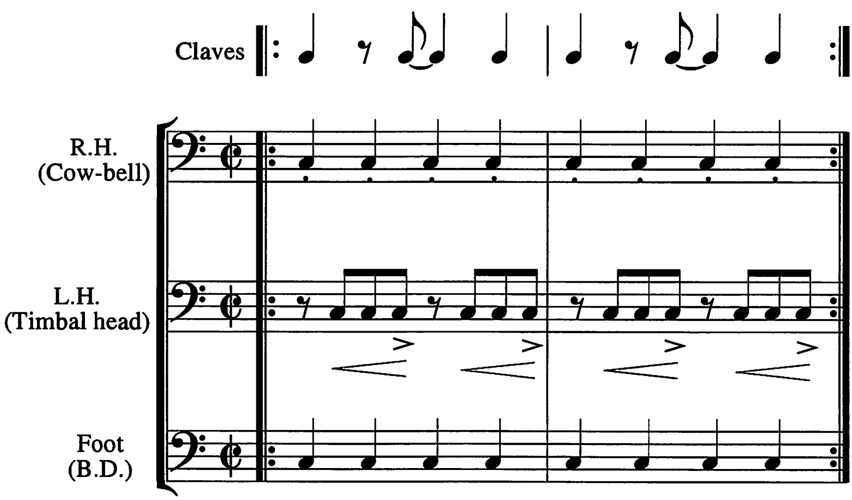


Figure 9.70 The kinetic effect of a rhythm dictated dynamically (after Morales and Adler, 1954/1958 (Belwin Inc.): *How to play Latin American rhythm instruments,* p. 121, Ex. 6).

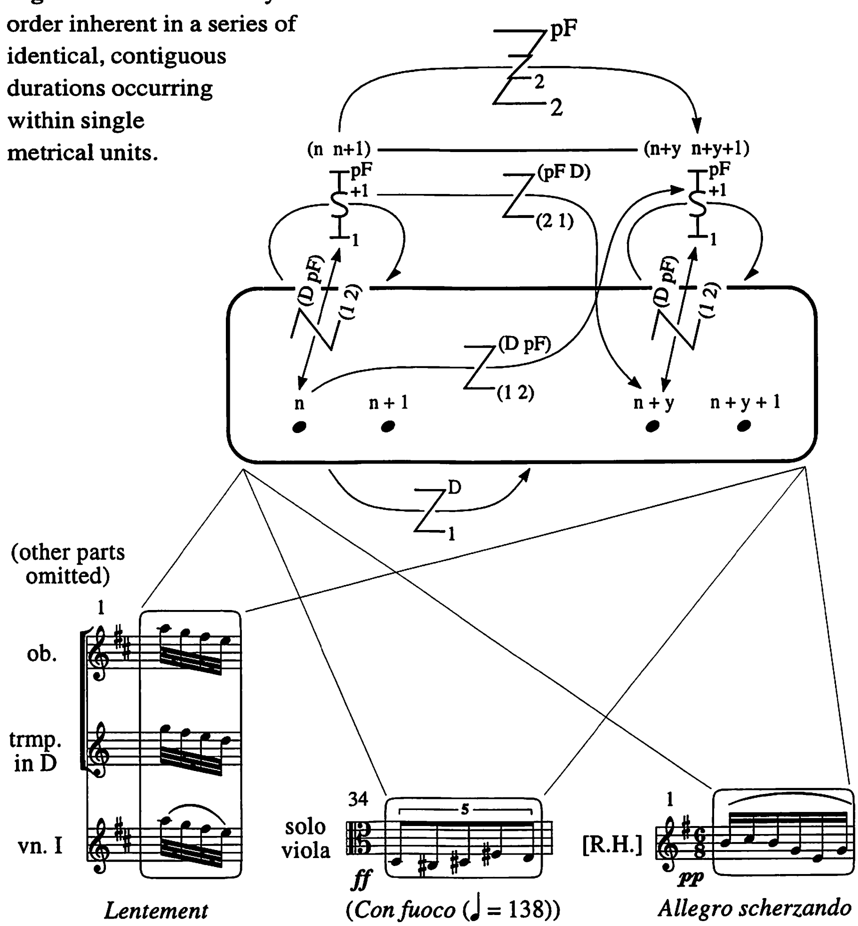
In the final analysis, semantic issues such as these do not affect the theory of musical order presented here; it is just that some definitions are better suited to certain contexts than others.

Rhythmic organisation most frequently occurs in combination with the ordering of pitch, such coordination being the subject of chapter 11. Still, there is much that can be discussed about the control of rhythm in isolation, and this is our present concern. We begin by investigating 'intrarhythmic' order, that is, how rhythms are structured internally.[16] Much of what needs to be said appears in the previous section (to which references are made where appropriate), although some further observations are pertinent here.

[16]Note that the intrarhythmic organisation of configurations order ii and above may well involve interrhythmic relationships (of lower orders), and these are examined in the sections that follow.

First, we consider rhythms whose durations and primary values of prefix are controlled by a common form of ordering throughout. The simplest of these is a series of identical, contiguous durations, which are potentially structured through the combined effect of a primary zygonic constant system of duration, a secondary zygosequential zygonic constant of prefix, and mutual zygonic constants of duration/prefix (cf. figure 9.61). Such a series may occur within any metrical framework. For example:

Figure 9.71 The intrarhythmic order inherent in a series of identical, contiguous durations occurring within single metrical units.



Telemann: ***Tafel-Musik*** **(1733); II. Teil, Ouverture**

Bennett: Viola Concerto (1973); 1st Movement

Grieg: ***Poetische Tonbilder,*** **Op. 3, No. 6**

Contiguous durations may successively increase or decrease by a given difference, potentially implying the dual operation of a secondary zygosequential zygon of duration and a secondary zygosequential tertiary zygon of prefix. For instance:

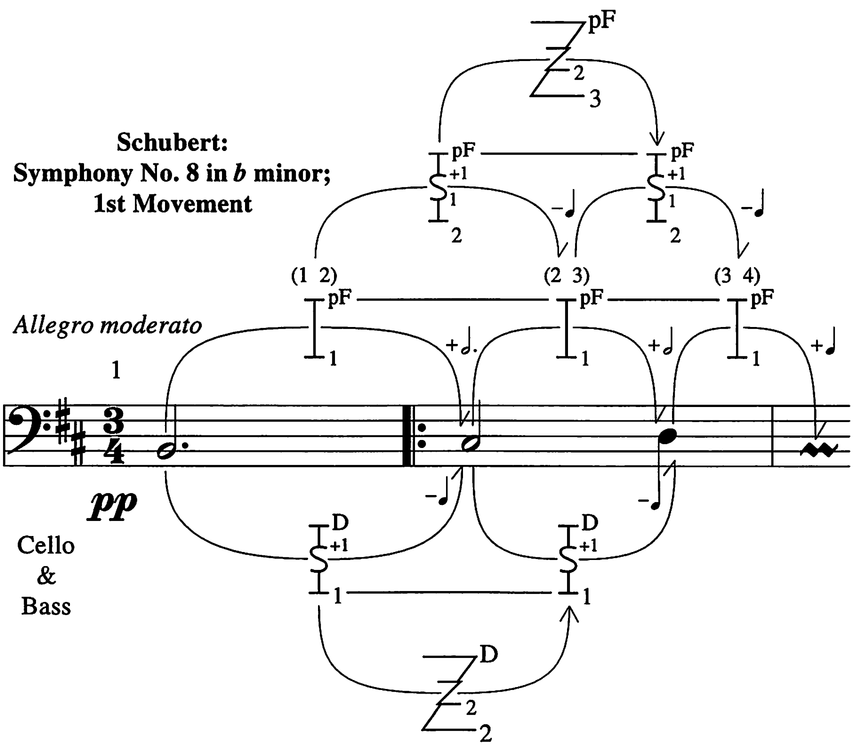


Figure 9.72 The order inherent in a series of three contiguous durations decreasing by a common difference (cf. figure 9.63).

In this regard it is interesting to observe, as do Hutchinson and Knopoff (1987, p. 284), that, in the vast majority of pieces,

> the number of events with many sequential diminishing or enlarging durations appears to be quite limited. It is rare to find more than three successive notes that have progressively shorter (or longer) durations ... .

In zygonic terms, this means that parallel secondary zygosequential zygonic constant systems of durational polarity and secondary zygosequential tertiary zygonic constant systems of prefix polarity (cf. figure 4.34) are uncommon. Still, occasionally they are to be found. For instance:

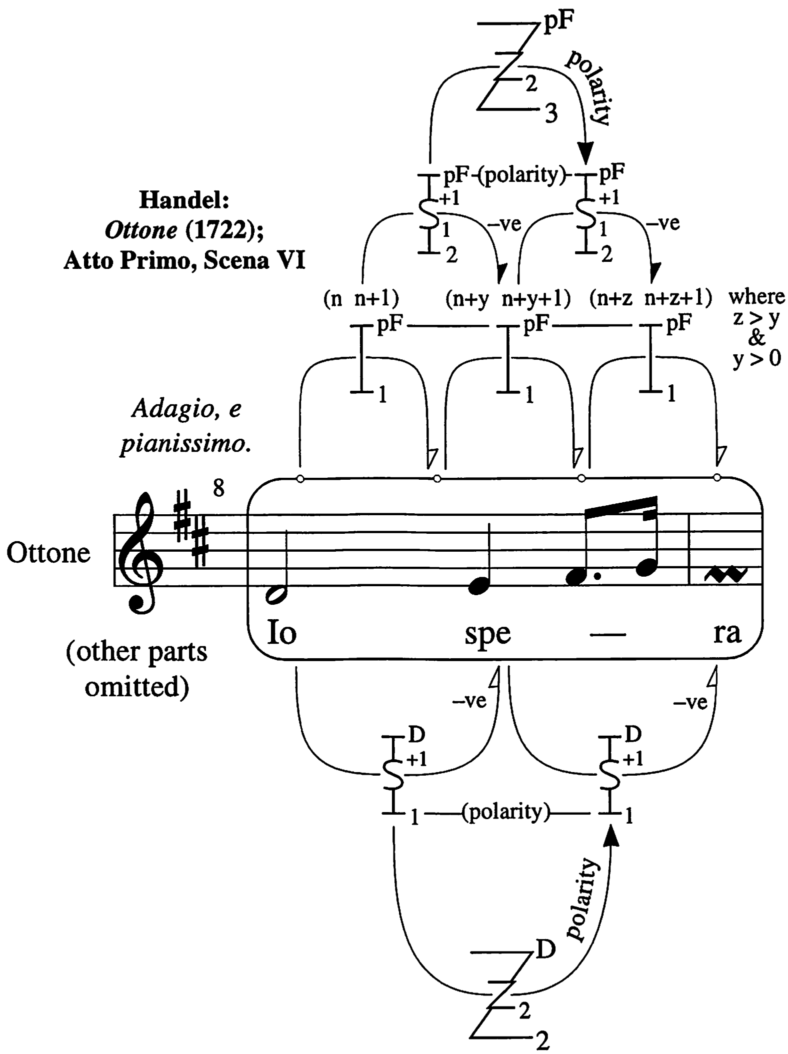
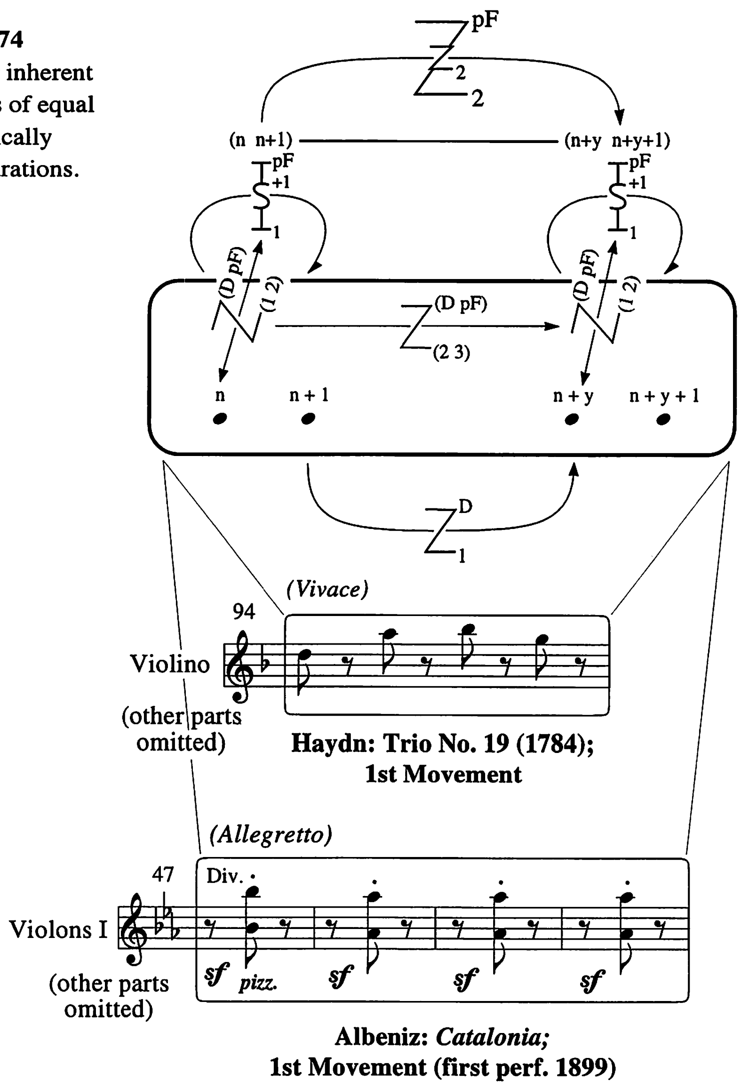


Figure 9.73 The order underlying a series of four contiguous durations, each (after the first) shorter than the one preceding.

Within a rhythm, both durations and primary values of prefix may exhibit constancy in differing measure, giving a series of identical and equally spaced durations (cf. figure 9.65). Canonically this type of passage, like those quoted in figure 9.71, implies the operation of a primary zygonic constant system of duration and a secondary zygosequential zygonic constant system of prefix, the distinction being that here each system controls a different value. A secondary-tertiary zygonic constant system of duration-prefix is also implied. For example:

Figure 9.74
The order inherent in a series of equal and identically spaced durations.



Constancy in one temporal perspect may be coordinated with regular variation in another.

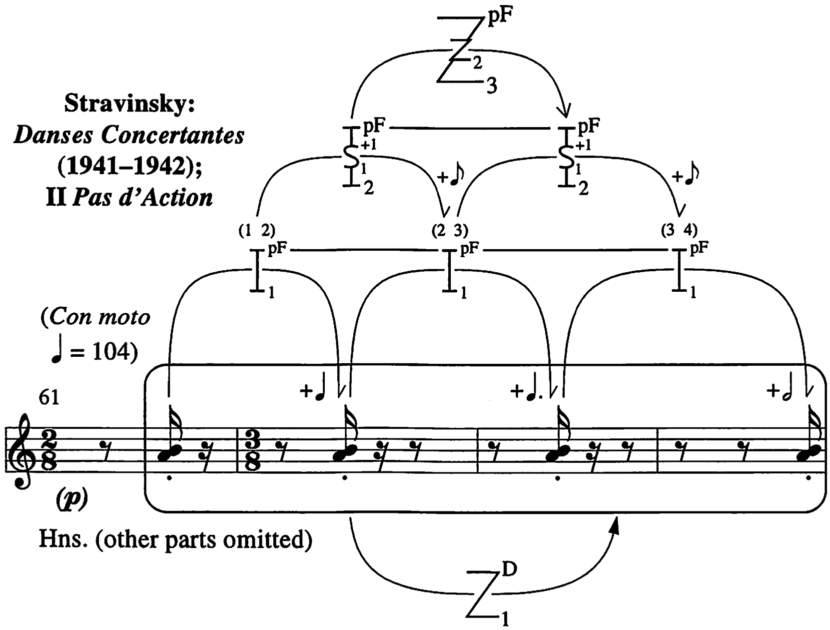


Figure 9.75 The order inherent in a series of notes displaying regular variation in primary interperspective values of prefix and constancy of duration.

The serialisation of perceived time in the manner proposed, for example, by Babbitt (1962, pp. 61ff), in which the twelve equal intervals of the chromatic scale are equated with a dozen identical primary interperspective values of prefix (and from this twelve contiguous durations) can be interpreted canonically in terms of a secondary asequential zygonic constant system of duration and a secondary asequential tertiary zygonic constant system of prefix, each of mixed polarity. See, for example, figure 9.76. Here, the asequentiality is indicated in each case by crossing the through the letter 'S'. Despite the high degree of order theoretically present in an excerpt such as this, the number of different values used poses seemingly insuperable perceptual difficulties (cf. Eschman, 1945/1968, pp. 187ff); the comparable organisation of shorter series may be easier to grasp.

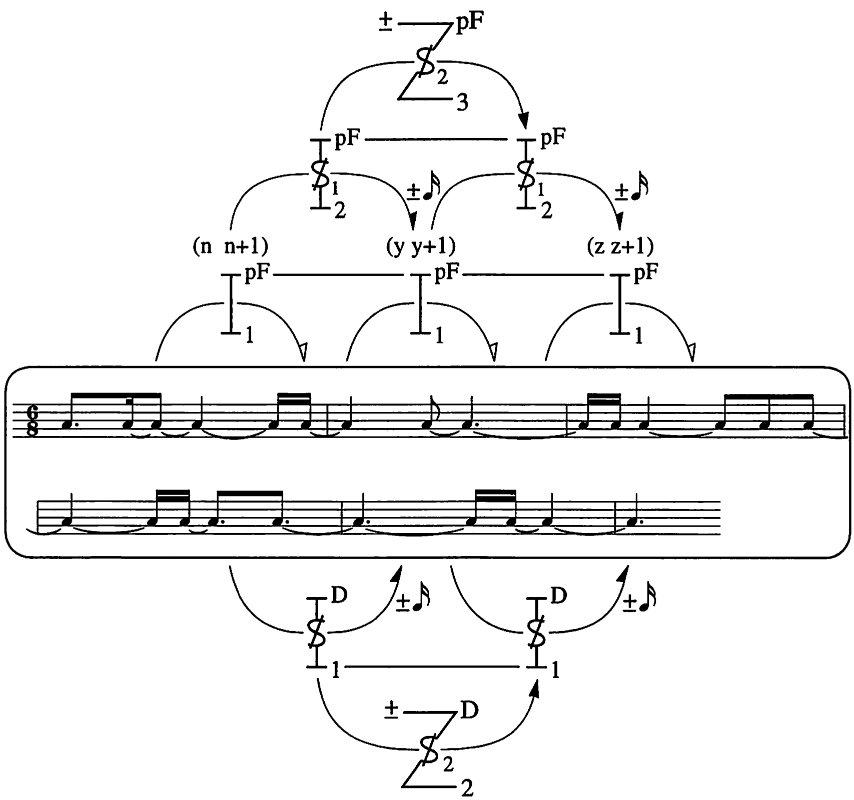


Figure 9.76 The order inherent in a series of contiguous 'chromatic' durations (after Babbitt, op. cit., p. 63).

Rhythms frequently juxtapose *different* forms of canonic control, which are generally reducible to primary zygonic relationships of duration and congruent secondary zygons of prefix. At its simplest, organisation of this type involves one series (or pair) of contiguous durations the same directly adjoining another or others; see figure 9.77.[17] In many rhythms, though, zygons or zygonic constants of duration overlap in one way or another—the possibilities are numerous. See, for example, figure 9.78.

[17]Each may be regarded as a discrete rhythmic fragment, between which a number of different zygonic relationships are conceivable. The constancy of one may be thought to emulate that of another, for example (see figure 9.62), or groups of contiguous durations may increase or decrease by a common difference or ratio, which listeners may consider to be imitatively derived. See, for instance, figure 9.79.

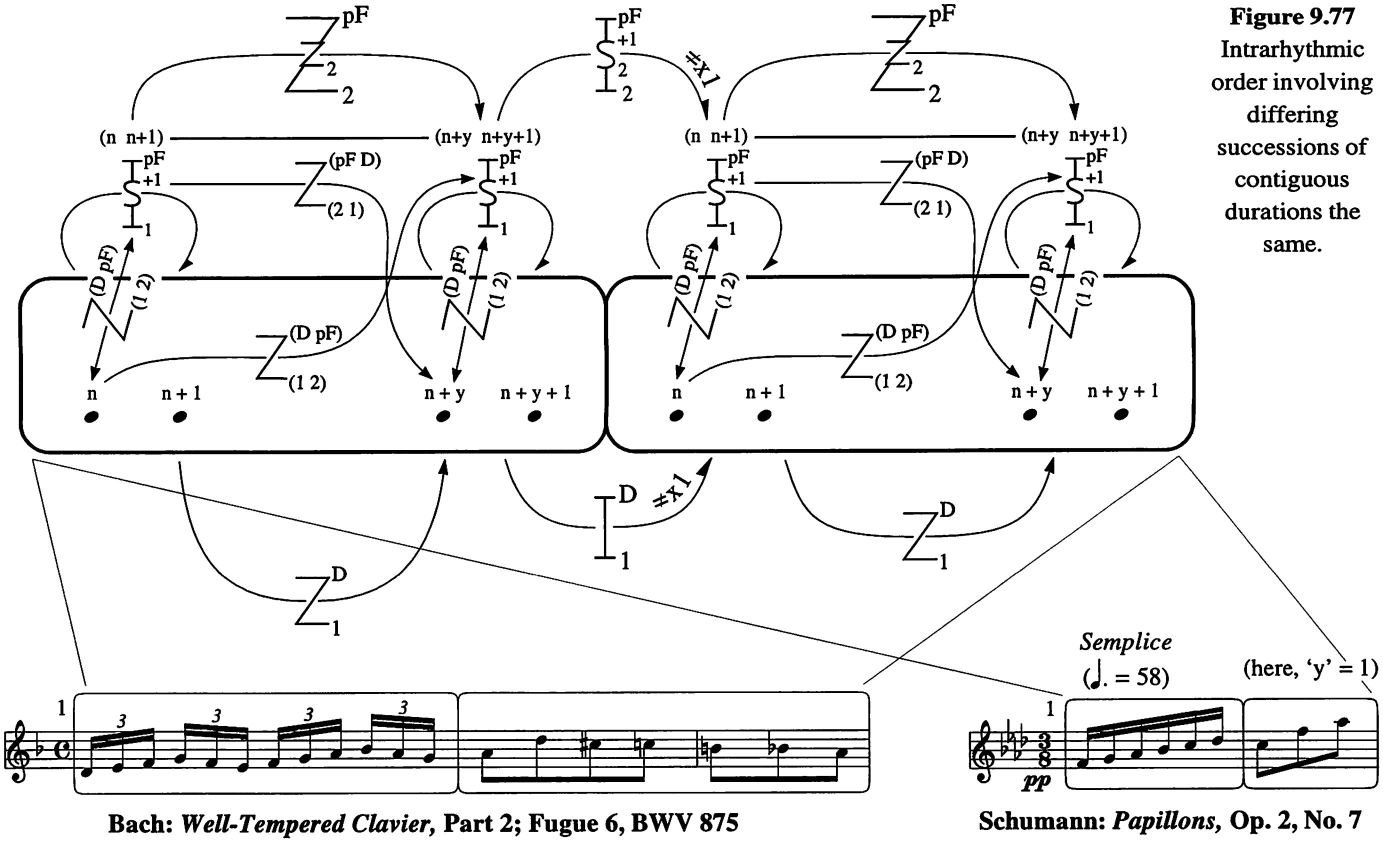


Figure 9.77 Intrarhythmic order involving differing successions of contiguous durations the same.

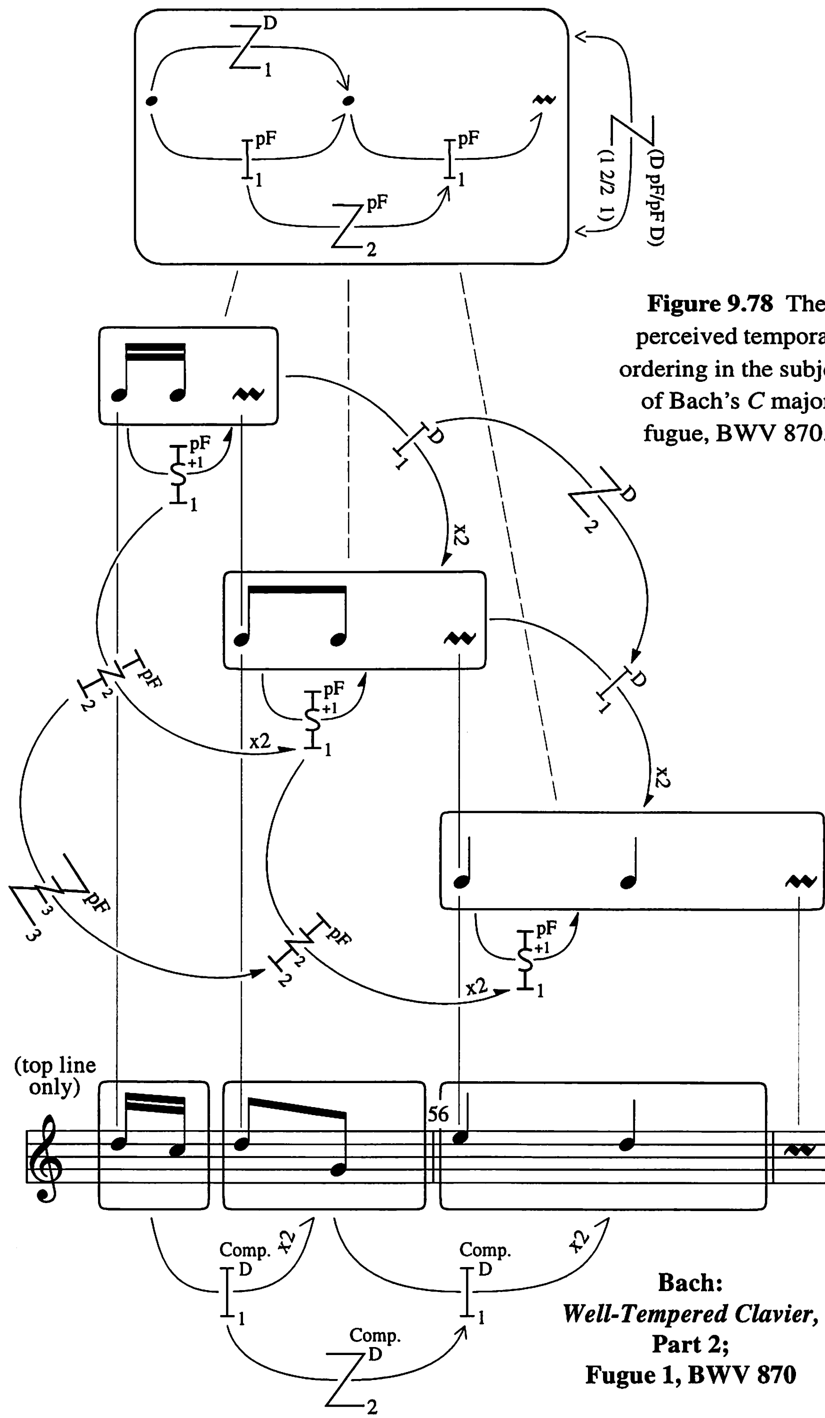


Figure 9.78 The perceived temporal ordering in the subject of Bach's *C* major fugue, BWV 870.

Bach:
Well-Tempered Clavier,
Part 2;
Fugue 1, BWV 870

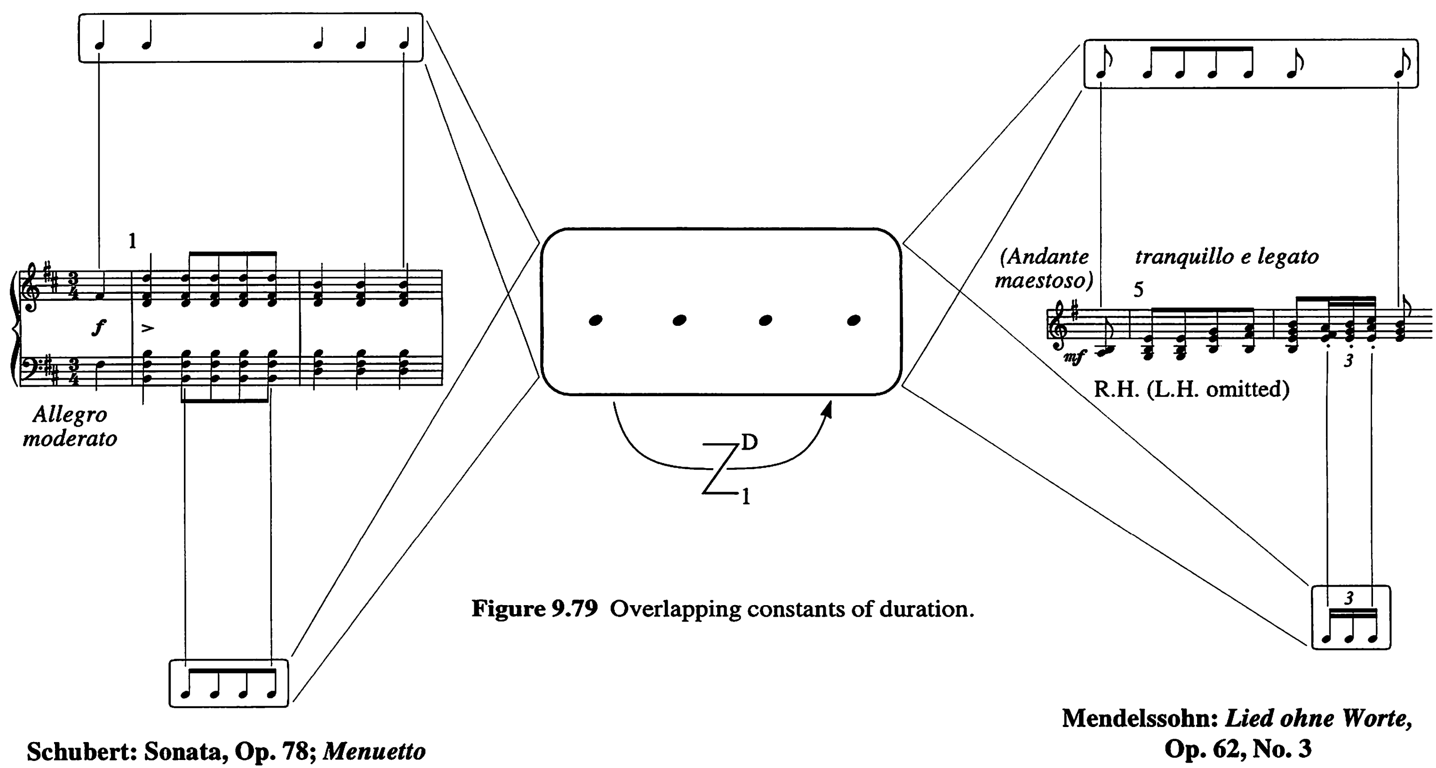


Figure 9.79 Overlapping constants of duration.

The intrarhythmic constancy of duration and primary values of prefix discussed above is a reflection (if not a cause) of the regular beat evinced by much music. The presence of other pulses arising from the subdivision or grouping of the beat is indicative of further control. In the following passage, for example, complements of equal duration follow each other contiguously. The order may be ascribed to primary zygonic constant systems of complementary duration, secondary zygosequential zygonic constants of complementary prefix, and mutual zygonic constants of complementary duration/prefix (cf. figure 9.71). For instance:

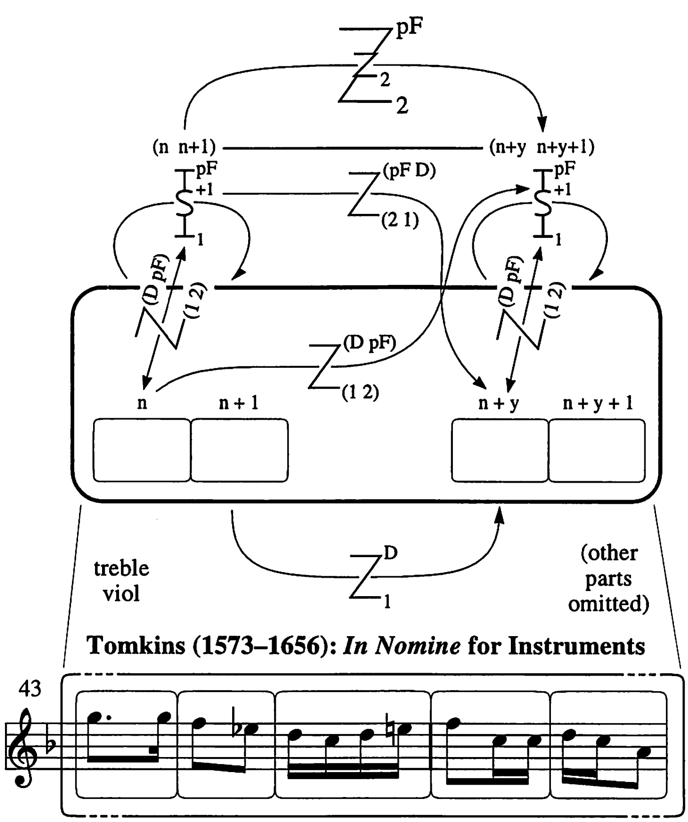


Figure 9.80 The order inherent in a series of contiguous complements of the same duration.

Similarly, the duration of one element or more is often found to match that of a subsequent group or groups, or *vice versa*:

Beethoven: Violin Sonata No. 5 in *F*, Op. 24; 1st Movement

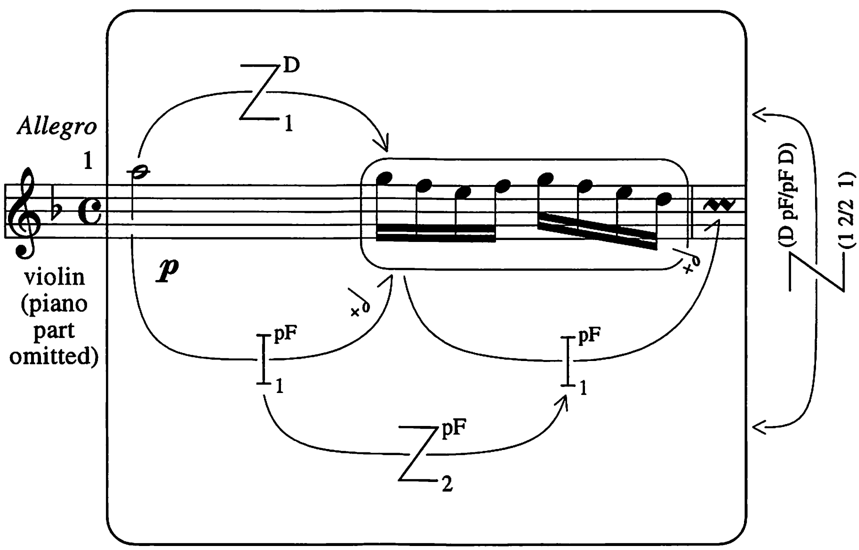


Figure 9.81 The order inherent in a complement directly following a single note of the same duration.

Multivariates afford an alternative mode of analysis, whereby the durational sum of two or more consecutive notes and the corresponding total of primary values of prefix are shown to equal those of another note or others—see figure 9.82.

Finally, even if no perceived temporal equality is immediately apparent, it may well be implied by the presence of a regular beat or pulse. See, for example, figure 9.83.[18]

[18]Observe the use of half arrowheads in depicting the multivariate relationships, despite their perfect status; imperfect multivariates of this type may be distinguished with the designation 'imp'.

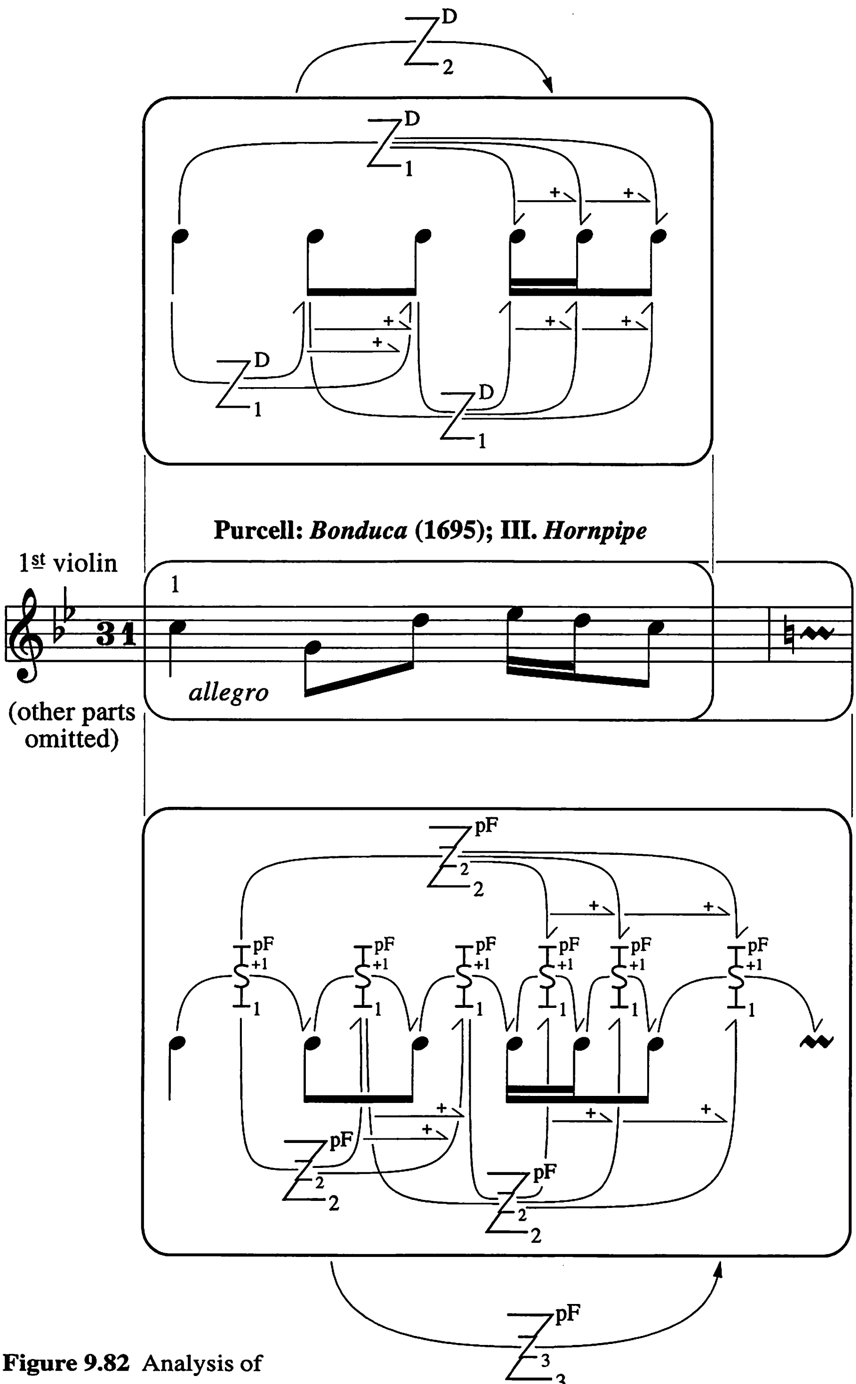
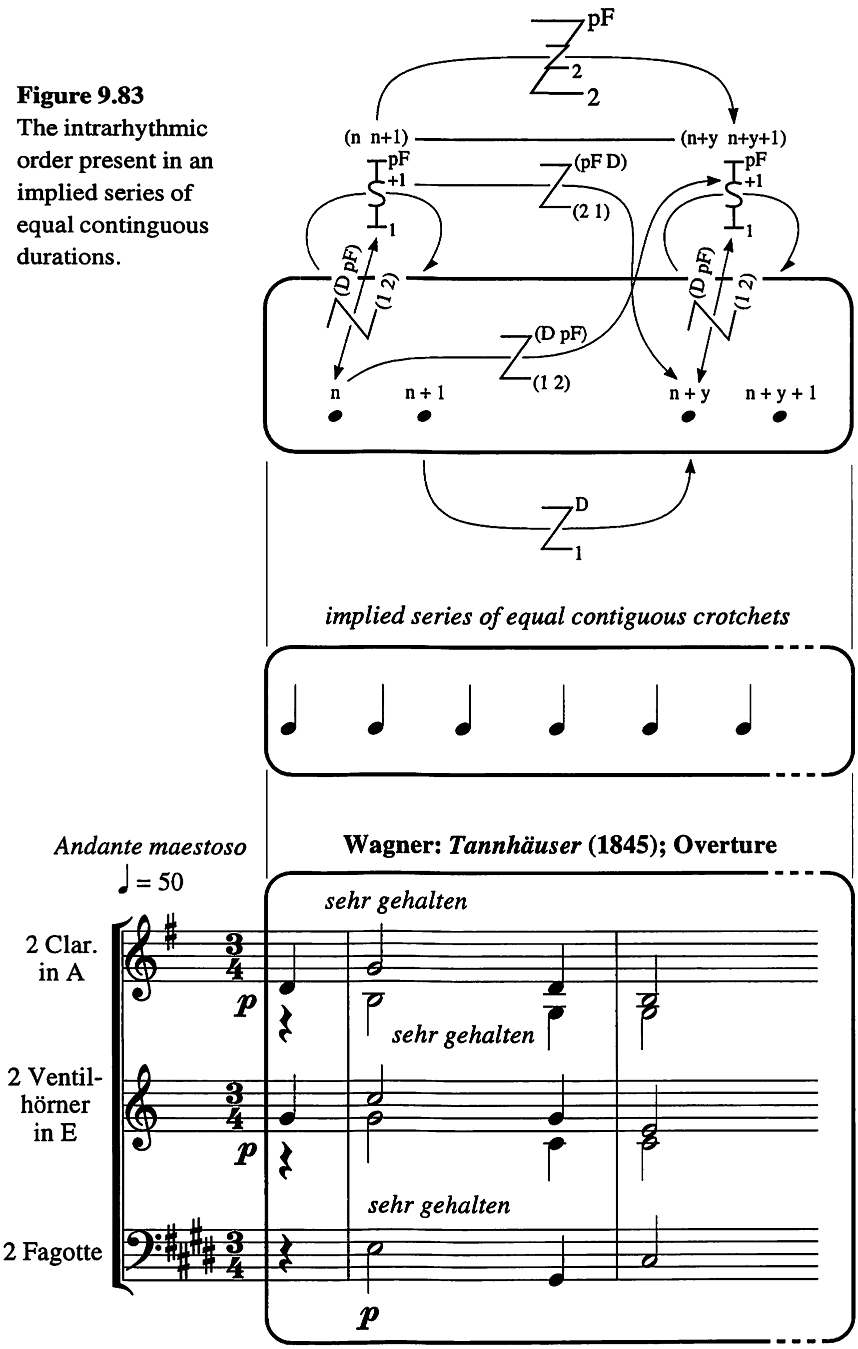


Figure 9.82 Analysis of contiguous equal durations (of a single note and two complements) using multivariate relationships.

Figure 9.83
The intrarhythmic order present in an implied series of equal continguous durations.



Interrhythmic ordering i: consistent transformations of duration and primary interperspective values of prefix; relative metrical location and metre maintained

In this section and those that follow, we consider the ways in which rhythms can be related to one another. Since rhythm has been defined as an individual perspect (albeit a complex of several perceived temporal qualities), two rhythms may be compared through a single compound relationship, substituting for the four separate strands that can be imagined to link prefix, duration, metre and relative metrical location. In diagrams, the letter 'R' supplies the necessary means of identification. For example:

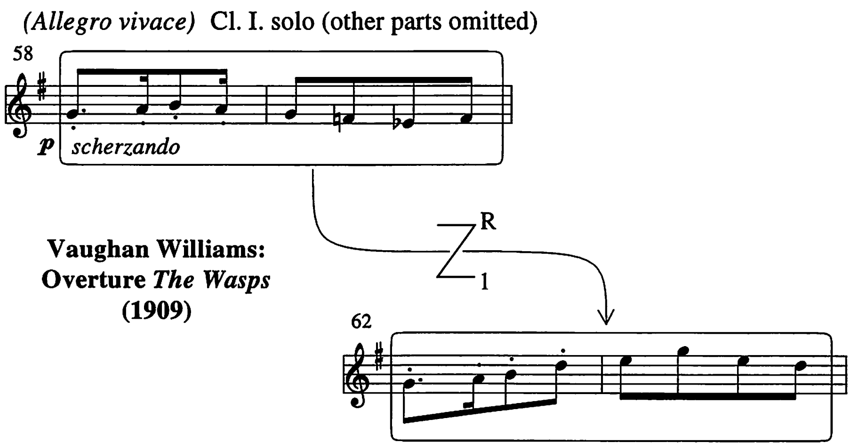


Figure 9.84 Primary zygonic relationship of rhythm.

Observe that in gauging the similarity of rhythms, metre can be defined between any levels in a hierarchy of pulses—commonly, the beat and the bar (as above). However, in terms of the present theory, the configurations illustrated in figure 9.85 may be considered to be rhythmically identical, even though they occur at different places in the same bar, since with regard to the beat and the pulses which subdivide it they are metrically equivalent.

Like all perspects, rhythm can be controlled perfectly or imperfectly. Perfect ordering implies that interperspective values of prefix and perspective values of duration, metre and relative metrical location are imitated exactly (see figures 9.84 and 9.85). In contrast, the notion of imperfect ordering is

Ibert: *Divertissement* (1930); VI–*Finale*

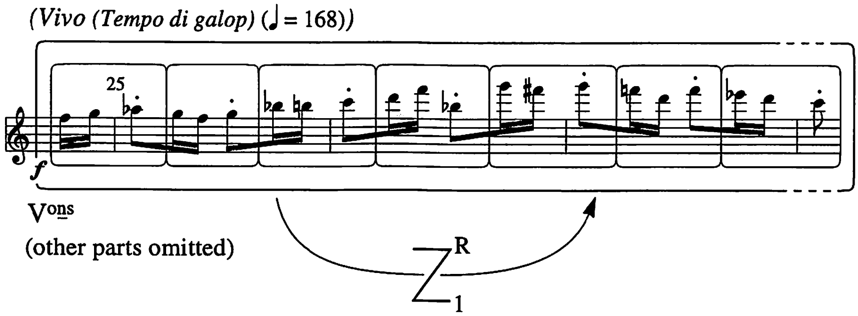


Figure 9.85 Primary zygonic constant of rhythm.

highly complex, embracing a wide range of possible transformations. These are explored systematically, beginning with **consistent** transformations, which affect each member of a group in the same way. In this section, possible alterations in duration or primary interperspective values of prefix or both are examined in the context of exact metrical repetition. This yields five options. Only those with known musical precedents are discussed below.

Number	Primary interperspective values of prefix	Durations
(i)	repeated	x ratio *(r)*
(ii)	repeated	+ difference *(d)*
(iii)	x ratio *(r)*	repeated
(iv)	x ratio *(r)*	+ difference *(d)*
(v)	x ratio *(r)*	x ratio *(R)*

Figure 9.86 Consistent transformations of rhythm involving changes in primary interperspective values of prefix or duration or both.

Scenario (i), the modification of durations by a common ratio, amounts to a change in articulation. This may be incurred, for example, through the use of *staccato* (see figure 9.65). The imperfect zygon of rhythm linking two such passages bears an indication of the transformation involved, here 'D.4' (that is, 'duration x 4').

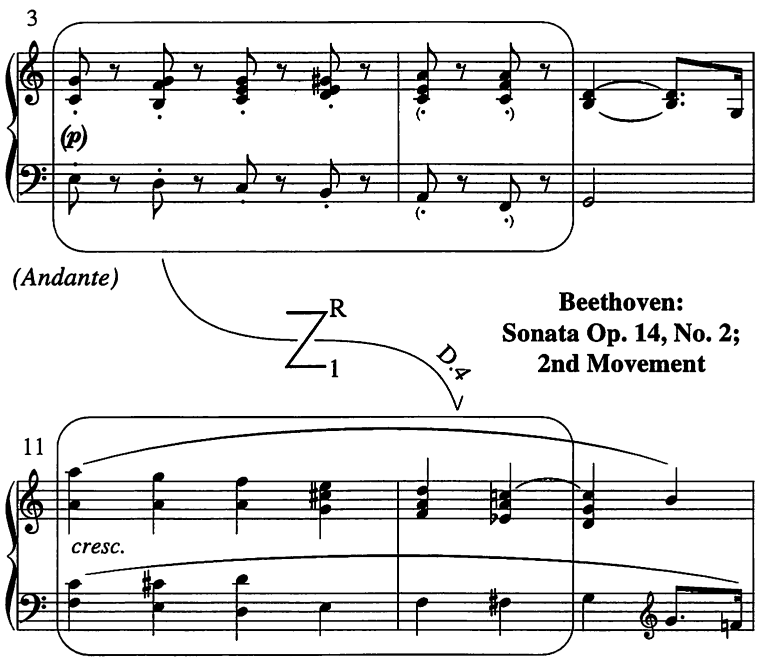


Figure 9.87 Imperfect interrhythmic ordering: the modification of durations by a common ratio.

This single relationship substitutes for a primary zygosequential secondary zygonic invariant of prefix (cf. figure 6.60), a secondary zygosequential zygonic constant system of duration (cf. figure 6.57), a primary zygonic constant of metre (cf. figure 6.31) and a primary zygosequential zygonic invariant of relative metrical location (cf. figure 6.51)—see figure 9.88.

Scenario (iii), in which durations are repeated in conjunction with primary interperspective values of prefix that are related by a common ratio, is very rare, although occasionally examples such as that shown in figure 9.89 are encountered, in which an instrument of fixed duration repeats a rhythm at a different tempo.

Given equal ratios, scenario (v) offers one of the most common types of interrhythmic transformation: a change of speed. Here, in *absolute* terms, rhythm is transformed. *Relatively,* though, it is not modified at all, and this seems the most natural way of making musical judgements in the perceived temporal domain. Playing a passage faster or slower leaves it perceptually intact—it is heard as 'the same thing' (but appearing at a different rate)—and the transformation is said to be **isomorphic**. Hence in the absence of any indication to the contrary, rhythms will be understood to be 'relative'. This means that complements such as those shown in figure 9.90 may be related rhythmically in perfect zygonic terms, where order through imitation is considered to be present.

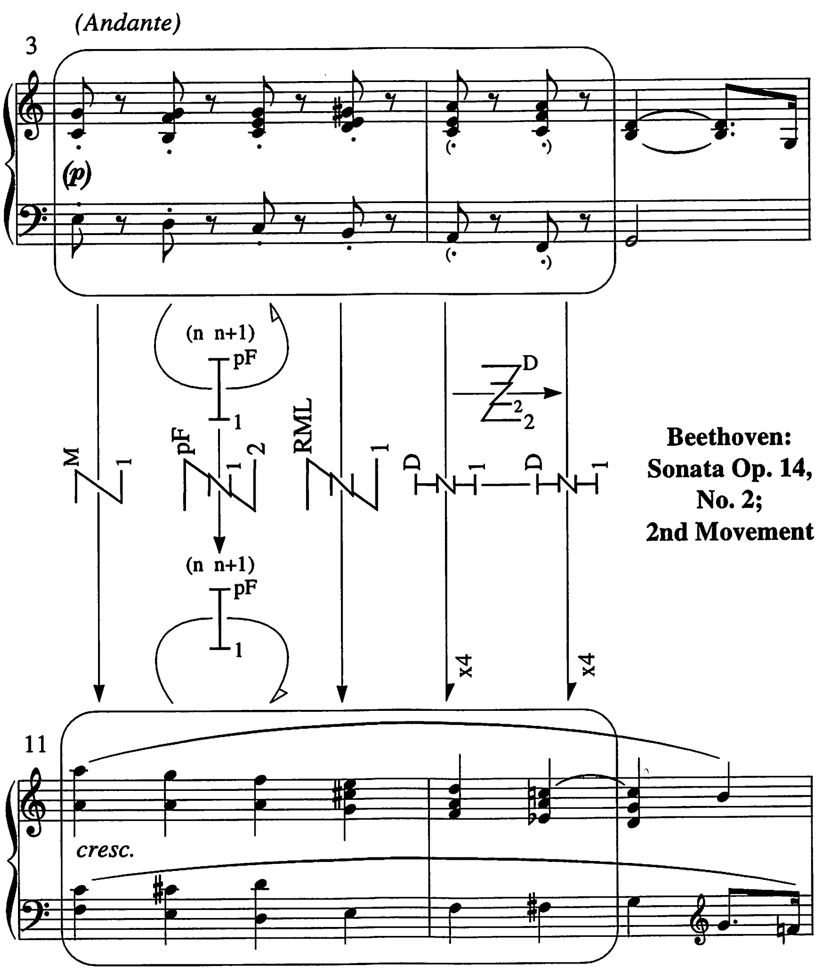


Figure 9.88 Imperfect interrhythmic ordering (through the modification of durations by a common ratio) illustrated as separate relationships of prefix, duration, metre and relative metrical location.

Bizet: ***Carmen*** **(first. perf. 1875); Act 11, No. 12,** ***Gypsy Song***

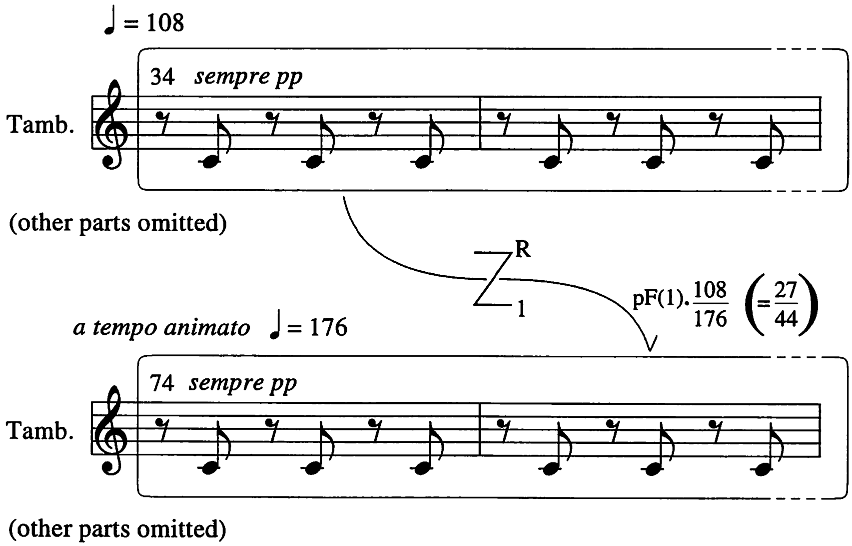


Figure 9.89 Imperfect interrhythmic ordering: the modification of primary interperspective values of prefix by a common ratio (durations maintained).[19]

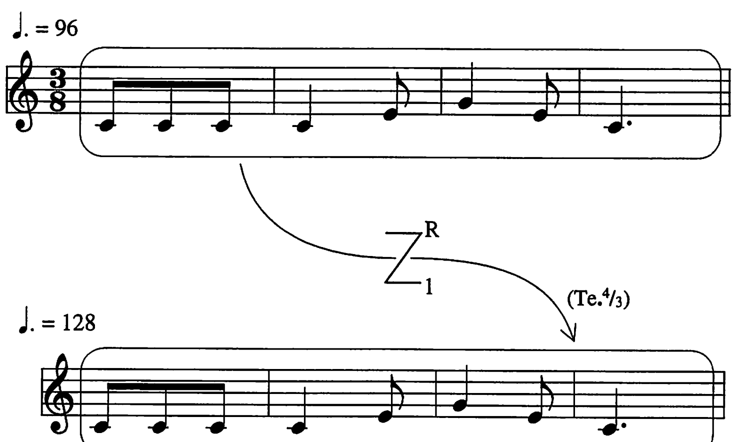


Figure 9.90 Perfect zygonic relationship of rhythm gauged in relative terms.

[19]Note the indication of primary interperspective values of prefix using a figure '1' in parantheses following the 'pF' sign.

(Observe the change of tempo is acknowledged in brackets.) Alternatively, judgements of 'absolute rhythm' can be made. Hence the fragments shown in figure 9.90 would be related as follows:

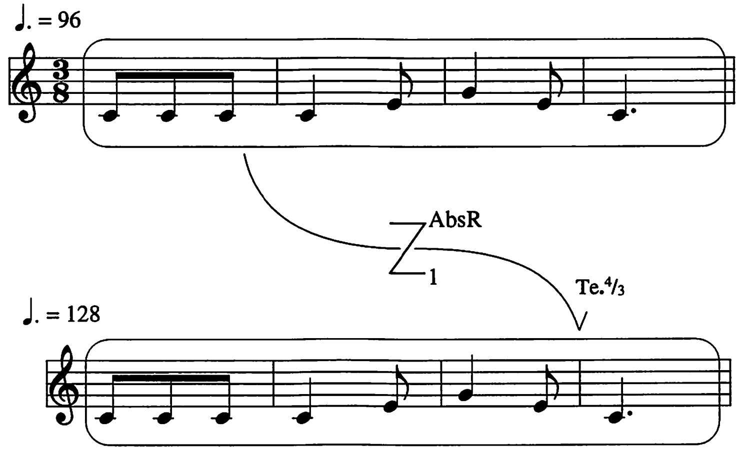


Figure 9.91 Imperfect zygonic relationship of 'absolute' rhythm.

In either case, the four underlying perceived temporal relationships are a secondary zygosequential tertiary zygonic constant system of prefix running parallel with a secondary zygosequential zygonic constant system of duration, a primary zygonic constant of metre and a primary zygosequential zygonic invariant of metrical location. See figure 9.92.

If substantial alterations in tempo are involved, it is possible that listeners' perception of metre may change—switching to a different stratum in the hierarchy of pulses. Consider, for example, the much speeded-up repeat of the second subject found in the coda of the last movement of Beethoven's 5th symphony, op. 67 (bars 362ff).

Modifications of speed occur in a number of musical contexts. For instance, a composer may require that a passage be played slower or faster on its second appearance in a piece. Then, changes of speed are often found when material is transferred from one work to another. Take chorale settings, for example, especially those with elaborate accompaniments (such as Bach's *Mit Fried und Freud ich fahr dahin,* BWV 616) where the tempo of the *cantus firmus* may well be slower than that of its source. Intra-terpretively, performers may slow down or speed up portions of music on

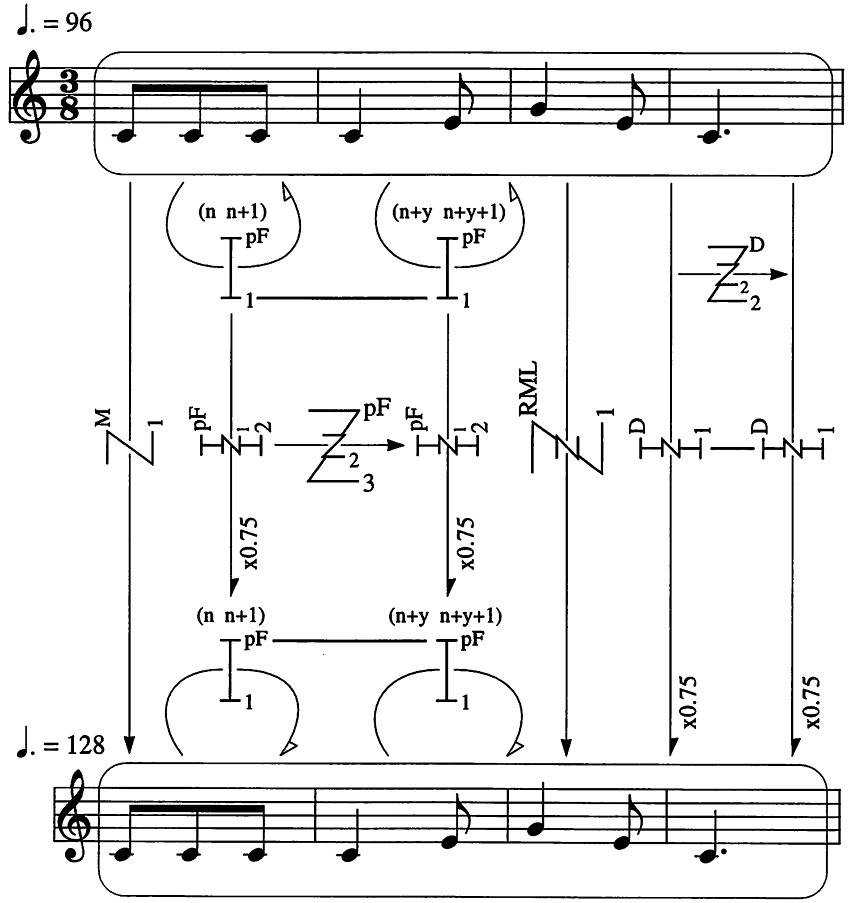


Figure 9.92 The separate zygonic strands underlying the maintenance of 'relative' rhythm.

their repeat to enhance the feeling of finality, perhaps, or to raise the level of excitement. Interterpretive differences in tempo are widespread (cf. p. 340). Principally, these occur for reasons of musical expression, although technical limitations may also figure in the equation: for example, a singer may risk running out of breath if a certain phrase is performed too slowly, while a given pianist may be unable to get his or her fingers round a particular passage beyond a certain speed.

Taking these points in conjunction with the interterpretive differences that are frequently characteristic of *rubato* and articulation, it is apparent that each 'rhythm' as specified by the composer in fact represents a field of aesthetically viable realisations, thanks to the idiosyncratic microtemporal inflections that characterise expressive individual performances. The term **protorhythm** may be used in referring to the general form of a rhythm dictated at the compositional stage.

Interrhythmic ordering ii: consistent transformations involving the non-maintenance of relative metrical location

In this section, our investigation of consistent rhythmic transformations continues with those that involve change in relative metrical location.[20] If metre and primary values of prefix are maintained, the following possibilities emerge (whose numbering follows on from figure 9.86).

Number	Relative metrical location	Primary interperspective values of prefix	Durations
(vi)	+ difference *(d)*	repeated	repeated
(vii)	+ difference *(d)*	repeated	x ratio *(r)*
(viii)	+ difference *(d)*	repeated	+ difference *(D)*

Figure 9.93 Consistent rhythmic transformations involving changes in relative metrical location.

Scenario (vi) merely entails a shift in relative metrical location (RML). This can have the effect of syncopating a melody, since its internal scheme of accentuation that originally coincided with the metrical layout is now displaced. The modification to RML may be indicated using an arrow to show the direction of change and a unit of duration to show the degree. See figure 9.94. Scenario (vii) adds a change in articulation. See figure 9.95.

Next, rhythmic modifications are examined that entail change in RML that is not intrinsically orderly, but occurs as a side effect of other alterations. The possibilities are shown in figure 9.96. Given that the two ratios involved are equal, scenario (ix) is encountered when, within the framework of the same basic tempo and metre, composers dictate that a portion of music be repeated at a speed differing from that of its first appearance, a device

[20]Cf. Temperley (1995), who hypothesises that relationships between segments that are parallel relative to the metrical structure are detected in 'modular' fashion (quickly and automatically) whereas others are recognised slowly and deliberately.

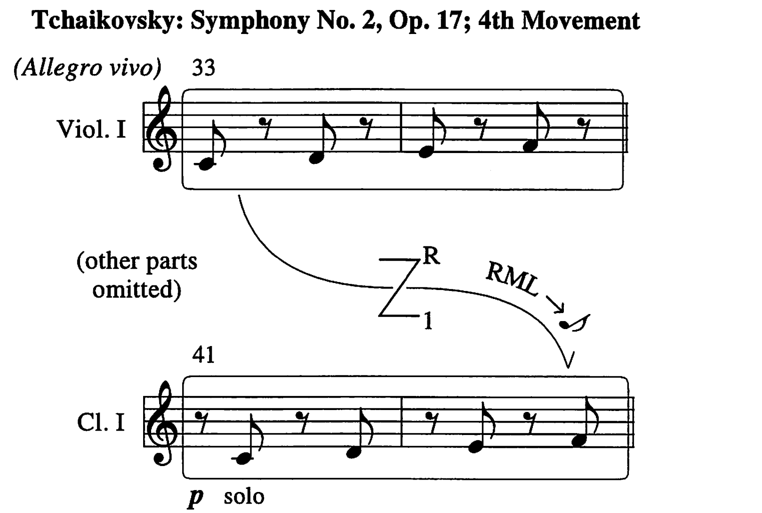


Figure 9.94 Imperfect interrhythmic ordering: the modification of RML by a common difference.

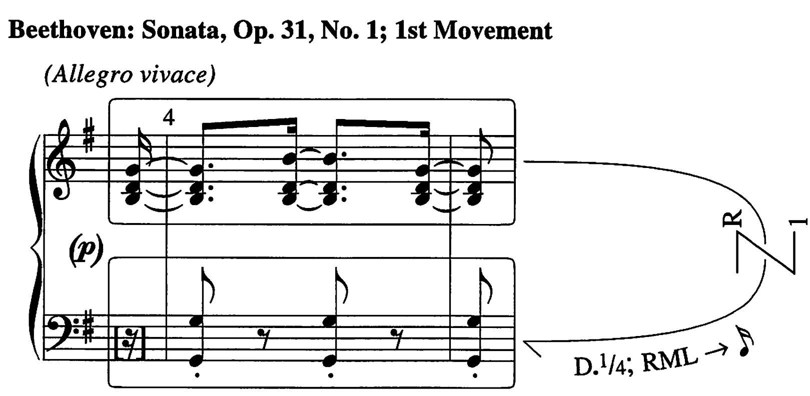


Figure 9.95 Imperfect interrhythmic ordering: the modification of RML by a common difference and durations by a common ratio.

Number	Relative metrical location	Primary interperspective values of prefix	Durations
(ix)	changed	x ratio *(r)*	x ratio *(R)*
(x)	changed	x ratio *(r)*	repeated
(xi)	changed	x ratio *(r)*	+ difference *(d)*
(xii)	changed	+ difference *(d)*	+ difference *(D)*
(xiii)	changed	+ difference *(d)*	x ratio *(r)*
(xiv)	changed	+ difference *(d)*	repeated

Figure 9.96 Rhythmic transformations incurring the non-maintenance of RML.

referred to as **augmentation** or **diminution**, (although these terms are also applied to changes of speed that take RML with them). Typically, the ratios involved are x2 or x$^1/_2$, although rather more exotic proportions are conceivable too (see, for instance, Messiaen, 1944/1957, pp. 18 and 19; Boulez, 1963/1971, pp. 54ff). Augmentation and diminution may be symbolised in the manner shown in figure 9.97; observe the cancelling of 'RML' to indicate its non-maintenance.

Scenario (x) can be described as augmentation or diminution with the preservation of durational values. See figure 9.98. (Note the use of '(imp)' to show that the transformation of primary interperspective values of prefix is itself imperfect.)

Scenario (xii) involves a uniform increase or decrease in primary interperspective values of prefix and durations. If these values are equal, additive change results. See, for example, figure 9.99, which shows the first pieces in Messiaen's *Livre d'Orgue: Reprises par Interversion* (1951). Here, the interrhythmic organisation takes the form of two sequentially ordered primary invariant systems, which may each be deemed to be ordered internally through a secondary zygosequential zygonic constant system, and linked through an inverse zygonic constant. (In fact, a slight degree of imperfection, which is not shown in the diagram, pervades these relationships due to changes in articulation.)

Bach: *Well-Tempered Clavier*, Part 2; Fugue 2, BWV 871

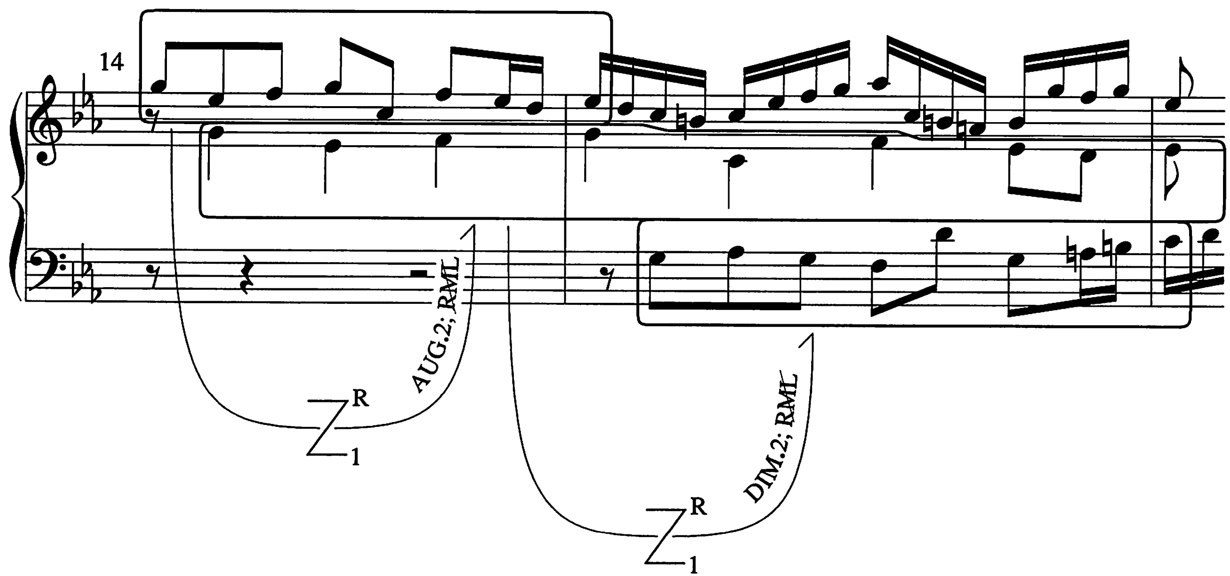
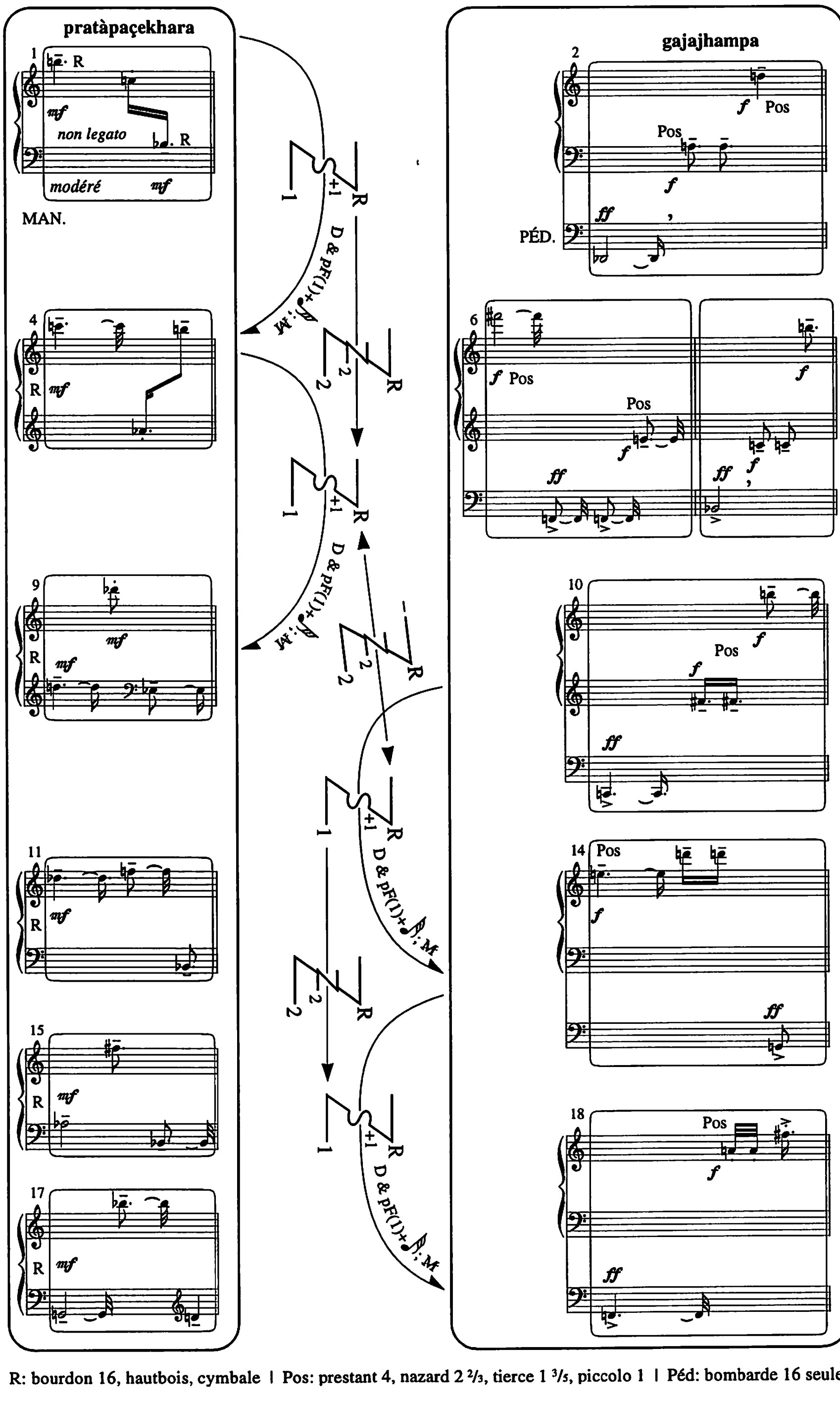


Figure 9.97 Imperfect interrhythmic ordering: augmentation and diminution.

Messiaen: Livre d'Orgue (1951); 1–*Reprises par Interversion*



R: bourdon 16, hautbois, cymbale | Pos: prestant 4, nazard 2 $^{2}/_{3}$, tierce 1 $^{3}/_{5}$, piccolo 1 | Péd: bombarde 16 seule

Figure 9.99 Imperfect interrhythmic ordering: the modification of durations and primary interperspective values of prefix by common differences the same and the non-maintenance of metre (and by implication RML).

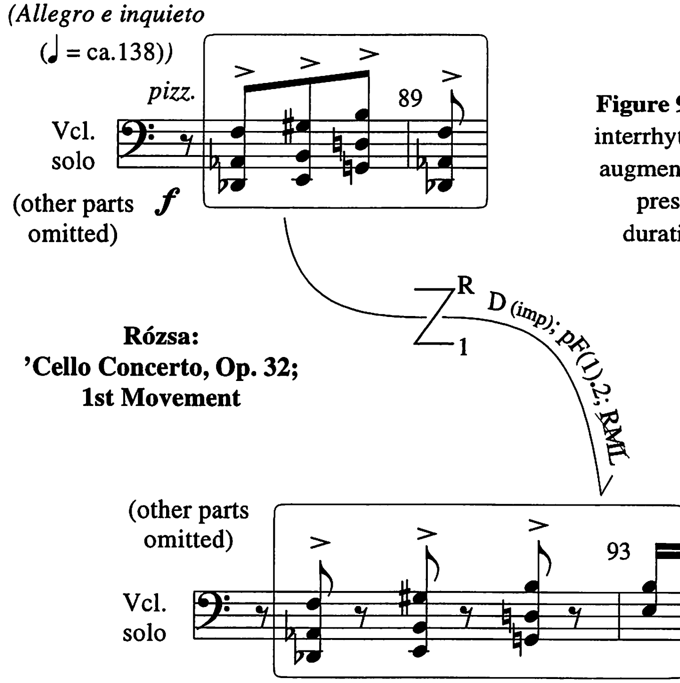


Figure 9.98 Imperfect interrhythmic ordering: augmentation with the preservation of durational values.

Interrhythmic ordering iii: further consistent transformations involving the non-maintenance of relative metrical location; sequential change

Although we have considered only those rhythmic transformations utilising differences or ratios, other functions are possible too. This is the case, for example, with the system of rhythmic 'inversion' proposed by Babbitt (1962, pp. 65ff), which is achieved through the mathematical process of 'complementation', whereby each duration and interperspective value of prefix is deducted from a predetermined span of perceived time (such as the length of a bar). See figure 9.100. As Babbitt says (op. cit., p. 64):

> Since duration is simply the directed distance between time points, the notated durations are not obligatorily the "actual" durations of the event ... the notated duration, under this interpretation, may represent an actual duration followed by a rest to complete the duration between time points.

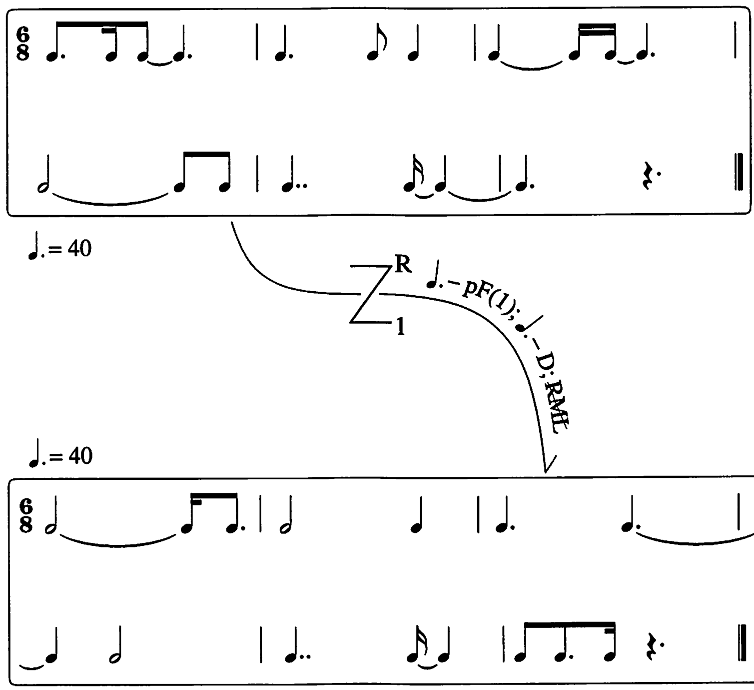


Figure 9.100 Rhythmic inversion (after Babbitt, 1962).

Durations may be subject to irregular change while primary values of prefix are maintained or transformed in an orderly way. For example, a new durational pattern may be adopted that has its own internal order. See, for example, figure 9.101.

A further area of potential transformation is sequence. Changes may be orderly, and occur alone or in combination with modifications to primary interperspective values of prefix or durations or both. Hence the number of possibilities is immense. However, since sequential alterations of any substance pose such grave problems of recognition, they have seldom found favour with composers. Retrogression is encountered most frequently, though even this is perceptually problematic (see, for instance, White, 1960, p. 105; Cone, 1961, p. 451; Meyer, 1967, pp. 251 and 252).

Rhythmic retrogression can be understood as the combined operation of a primary retrograde secondary zygonic invariant of prefix (cf. figure 6.62) and a retrograde primary zygonic invariant of duration (cf. figure 6.52). RML will inevitably be changed. See figure 9.102.

Webern, *Variations*, Op. 30

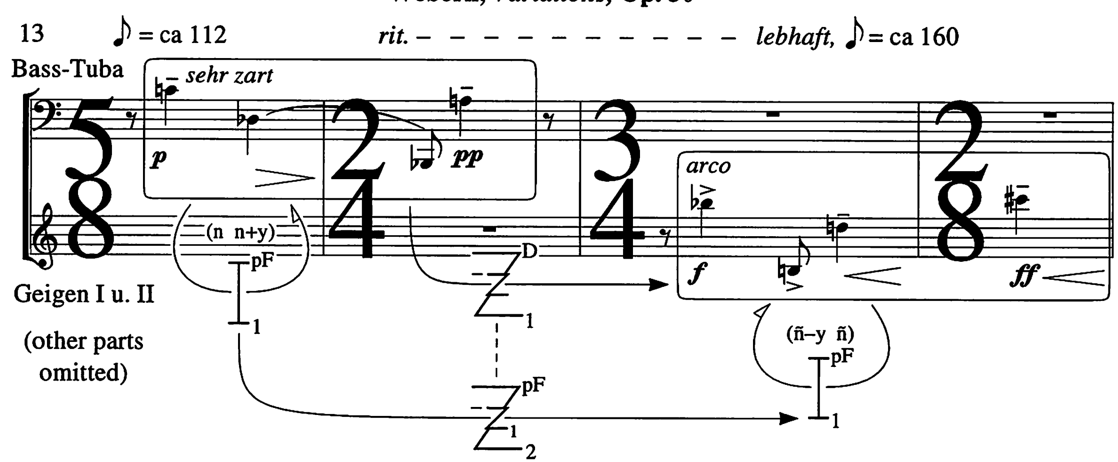


Figure 9.102 Rhythmic retrogression illustrated in terms of a primary retrograde secondary zygonic invariant of prefix and a retrograde primary zygonic invariant of duration.

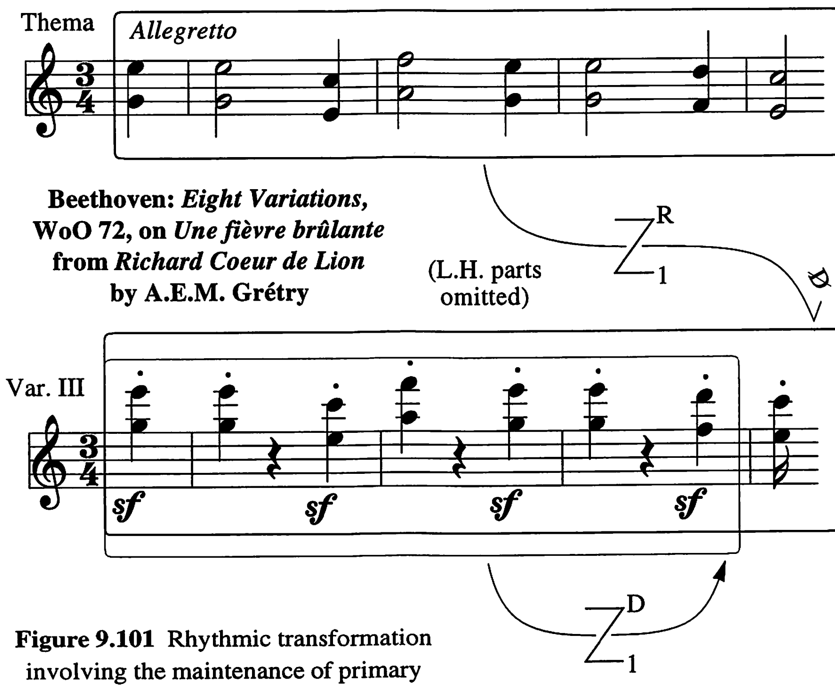


Figure 9.101 Rhythmic transformation involving the maintenance of primary interperspective values of prefix and the imposition of a primary zygonic constant system of duration.

Parallel sets of relationships such as these may be symbolised in the manner shown in figure 9.103.

Certain rhythms, that are symmetrical in perceived time, are what Messiaen describes as 'nonretrogradable' (1944/1957, pp. 20 and 21), since they sound the same played backwards or forwards.[21] See, for example, his *Neumes Rythmiques* for piano (1949), bar 12. This is one example of a link between intracomplementary and intercomplementary organisation, where the internal disposition of a complement affects the external order that can or tends to be imposed.

Occasionally, retrogression is allied with augmentation, diminution or change of speed. See, for example, figure 9.104. (This technique is used extensively by Webern in his *Variations,* op. 30; cf. figure 9.102.)

[21]Although, of course, it would be possible to analyse such rhythms in terms of two contiguous units, one the reverse of the other.

Bach: *A Musical Offering* (1747); No. 3 *Canones diversi super thema regium*, No. 1

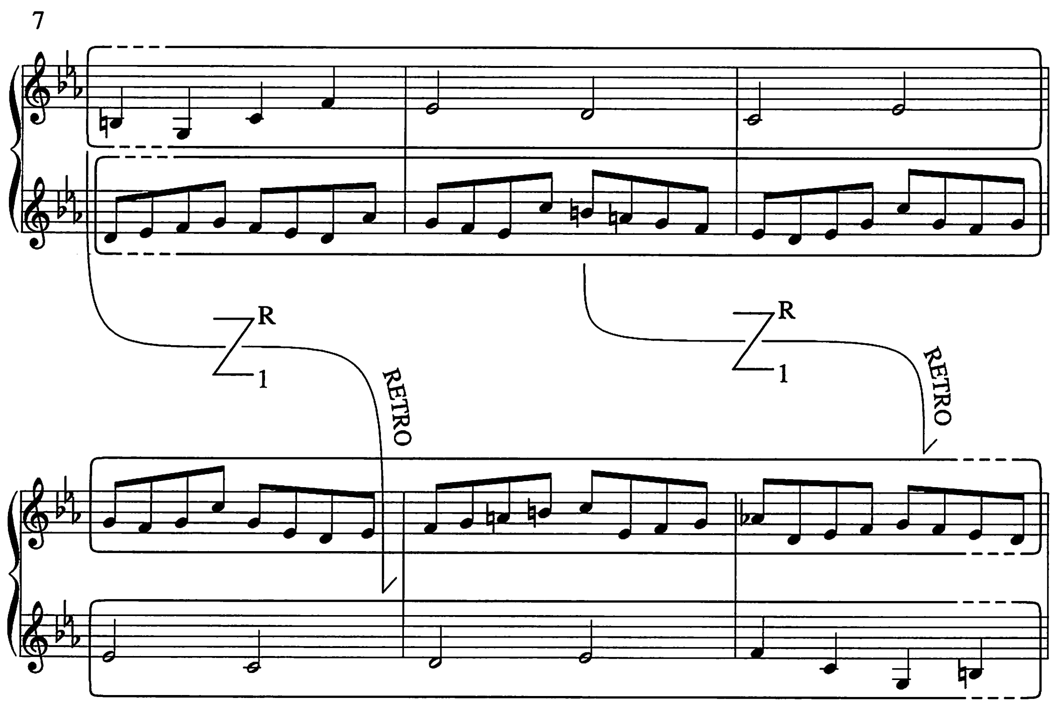


Figure 9.103 Symbolism of rhythmic retrogression.

Dufay: *Missa L'Homme Armé* (c.1450); V. *Agnus Dei*

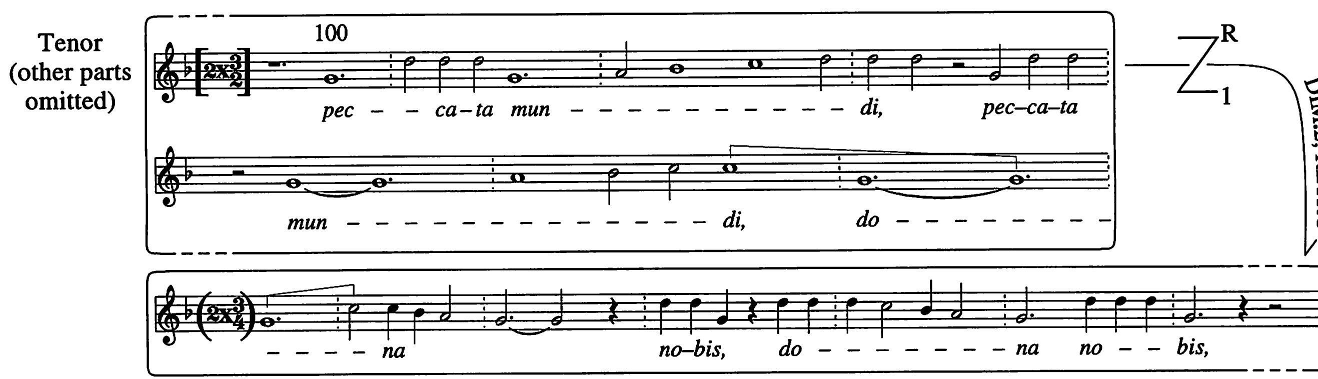


Figure 9.104 Rhythmic retrogression and diminution operating in tandem.

Other kinds of sequential modification (apart from retrogression) are also encountered occasionally. For example:

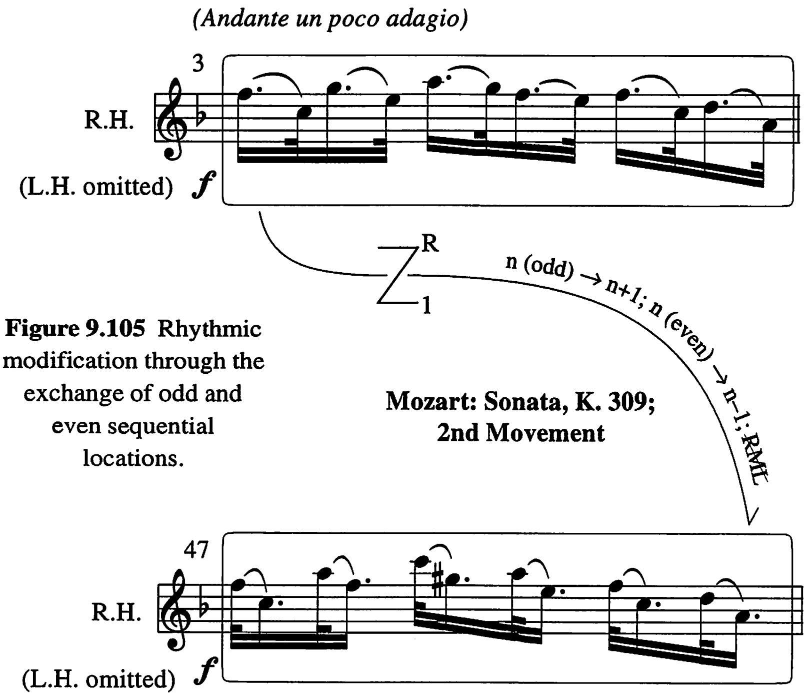


Figure 9.105 Rhythmic modification through the exchange of odd and even sequential locations.

Messiaen's *Chronochromie* (1960) makes extensive use of the principle of 'interversion'. A good deal of material is derived from a series of 32 contiguous durations, ranging in equal steps from a demisemiquaver to a semibreve, which are repeatedly subject to this predetermined sequential transformation:

1→10; 2→8; 3→1; 4→22; 5→3; 6→24; 7→5; 8→11; 9→13;
10→26; 11→28; 12→31; 13→32; 14→30; 15→29; 16→15; 17→16;
18→17; 19→20; 20→21; 21→19; 22→18; 23→14; 24→12; 25→9;
26→7; 27→27; 28→2; 29→25; 30→4; 31→23; 32→6.

In *Strophe I* this organisational system underpins the rhythmic construction of the string parts as follows:

Messiaen: *Chronochromie* (1960); *Strophe I*

Bien modéré (♪ = 92)

Violins I: ***Interversion 1***

3 28 5 30 7 32 26 2 25 1 8 24 9 23 16 17 18 22 21 19 20 4 31 6 29 10 27 11 15 14 12 13

Violins II: ***Interversion 2***

5 11 7 14 26 13 10 28 29 3 2 6 25 31 17 18 22 4 20 21 19 30 12 32 15 1 27 8 16 23 24 9

Violas & 'Cellos: ***Interversion 3***

7 8 26 23 10 9 1 11 15 5 28 32 29 12 18 22 4 30 19 20 21 14 24 13 16 3 27 2 17 31 6 25

Representation of series of contiguous durations where 1 = 𝅘𝅥𝅯

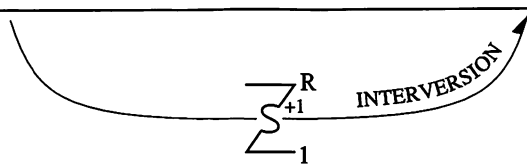


Figure 9.106 A sequentially ordered primary zygonic constant of rhythmic interversion in Messiaen's *Chronochromie.*

Interrhythmic ordering iv: non-consistent transformations

Non-consistent rhythmic transformations (that don't apply equally to all durations or primary values of prefix) can take many forms, reflecting the diversity of rhythm itself, and there is no easy way of classifying them all. Here, some of the possibilities are described.

Often, it will be appropriate to consider a non-consistent rhythmic transformation as an imperfect realisation of one of the consistent modes of development. As noted above (p. 407), such cases may be symbolised using an imperfect rhythmic zygon with the designation '(imp)' (to show a type of imperfection different from that implicated by consistent change) in conjunction with an interperspective relationship or relationships indicative of the departure from repetition or consistent transformation that exists. This may entail the alteration of a primary value of prefix (figure 9.107), change to a duration (figure 9.108), or both (figure 9.109)

Figure 9.107 Imperfect rhythmic repetition through the alteration of a primary interperspective value of prefix.

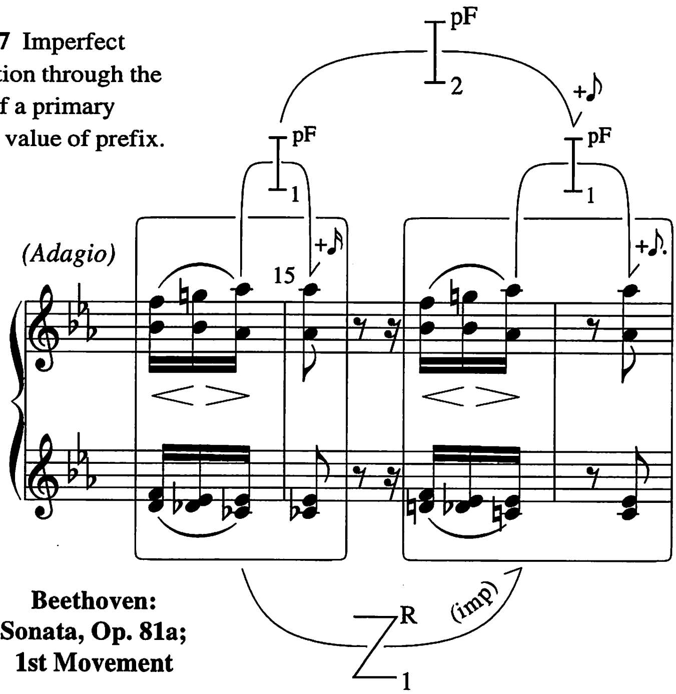
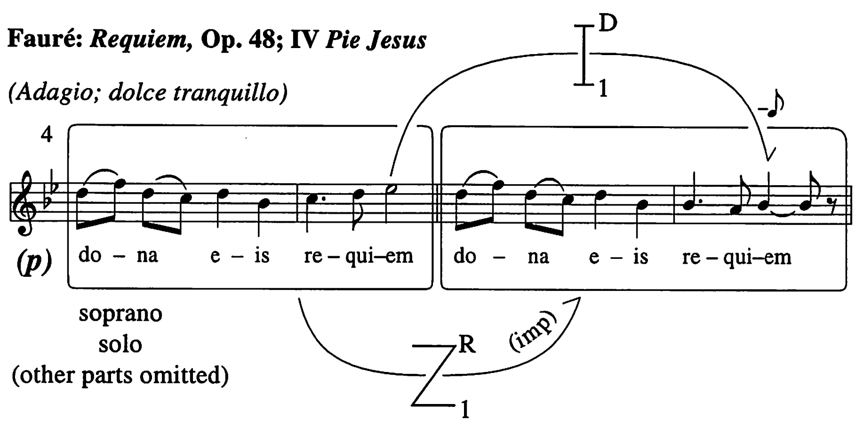


Figure 9.108 The imperfect repetition of rhythm through the alteration of a single duration.



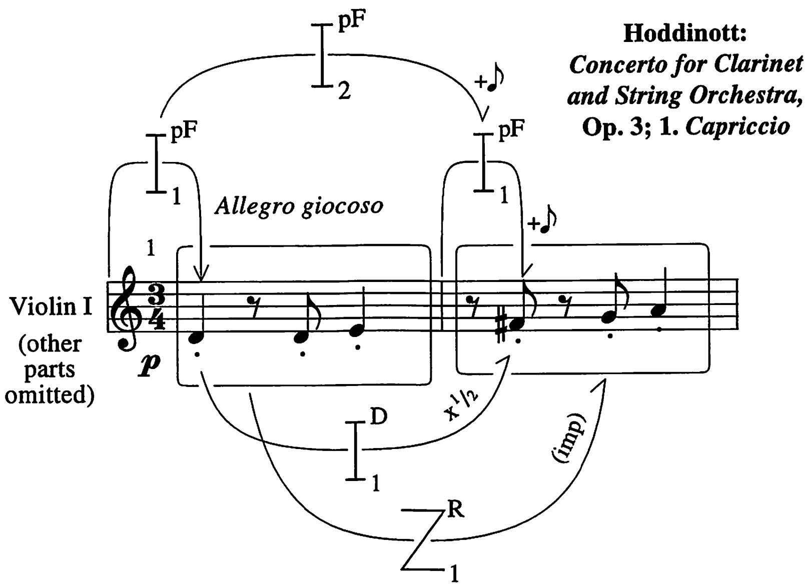
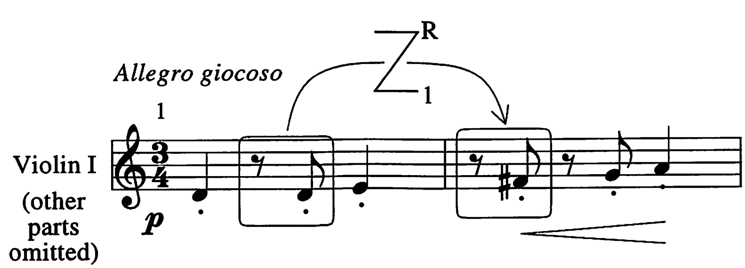


Figure 9.109 The imperfect repetition of rhythm involving the alteration of both a duration and the parallel primary interperspective value of prefix.

Any changes that are made may be considered to exist in imitation of previous material. For instance, in the excerpt by Hoddinott cited above, the first off-beat staccato quaver in bar 2 (a transformation of the opening crotchet of bar 1) emulates the quaver heard two beats earlier:



Hoddinott: ***Concerto for Clarinet and String Orchestra,*** **Op. 3; 1.** ***Capriccio***

Figure 9.110 The imitation of previous material in rhythmic transformation.

They may involve a plurality of values, in which case internal ordering is a possibility too.

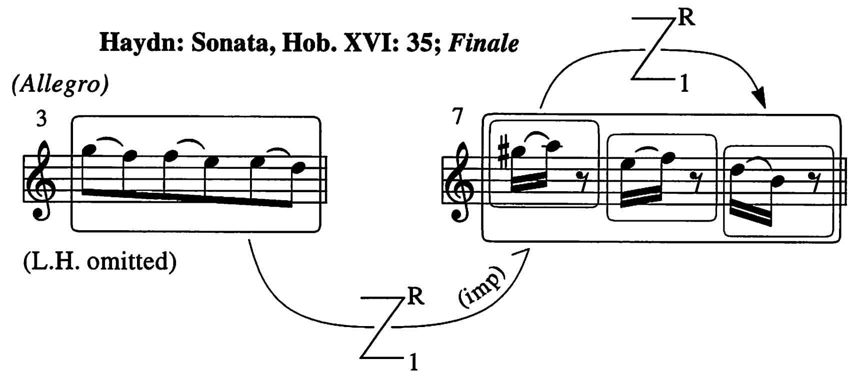


Figure 9.111 Imperfect rhythmic repetition incorporating intrafigurative ordering.

Where more than one value is involved, it may be appropriate to view a non-consistent transformation as the joint operation of two or more that are consistent. Their interaction may be orderly with regard to sequence. See, for example, figure 9.112. Equally, changes may be made only to each appearance of a certain value or values. See, for instance, figure 9.113. Observe that in this example, the changes are also orderly with respect to sequence.

Coordinated ordering may involve the first of two contiguous durations being lengthened by the same amount as the second is shortened (or being reduced by the same factor as the second is increased); the same change normally affecting the primary value of prefix linking these durations and the one following. In effect, therefore, within a similar continuum of perceived sound, the suffix and prefix of successive notes are moved together. See figure 9.114. This principle may well be employed more than once in a rhythmic fragment, and in an orderly way—see, for example, figure 9.115. The resultant change may borrow from pre-existing material, or, as in this case, serve as a model upon which subsequent passages are based.

Chabrier: *Joyeuse Marche* (1888)

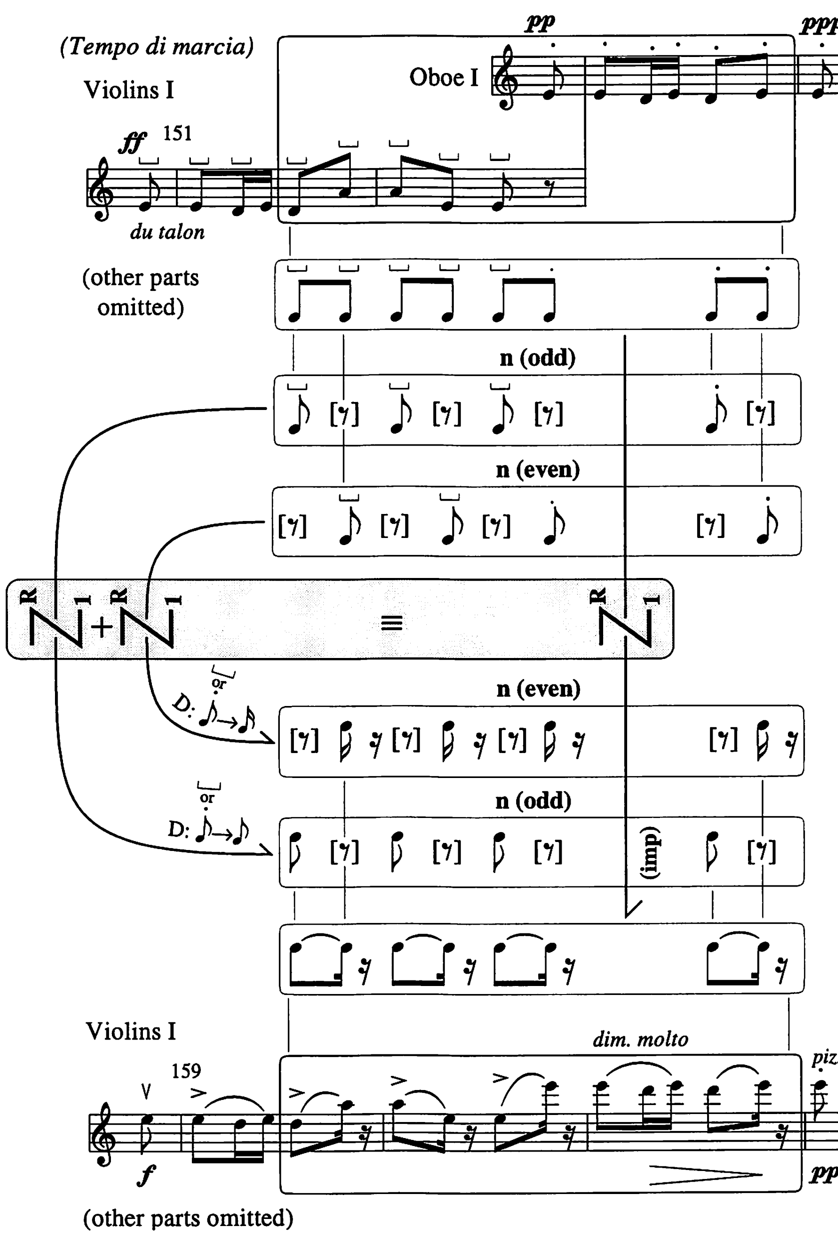


Figure 9.112 Non-consistent transformation of rhythm regarded as two consistent transformations, orderly with regard to sequence.

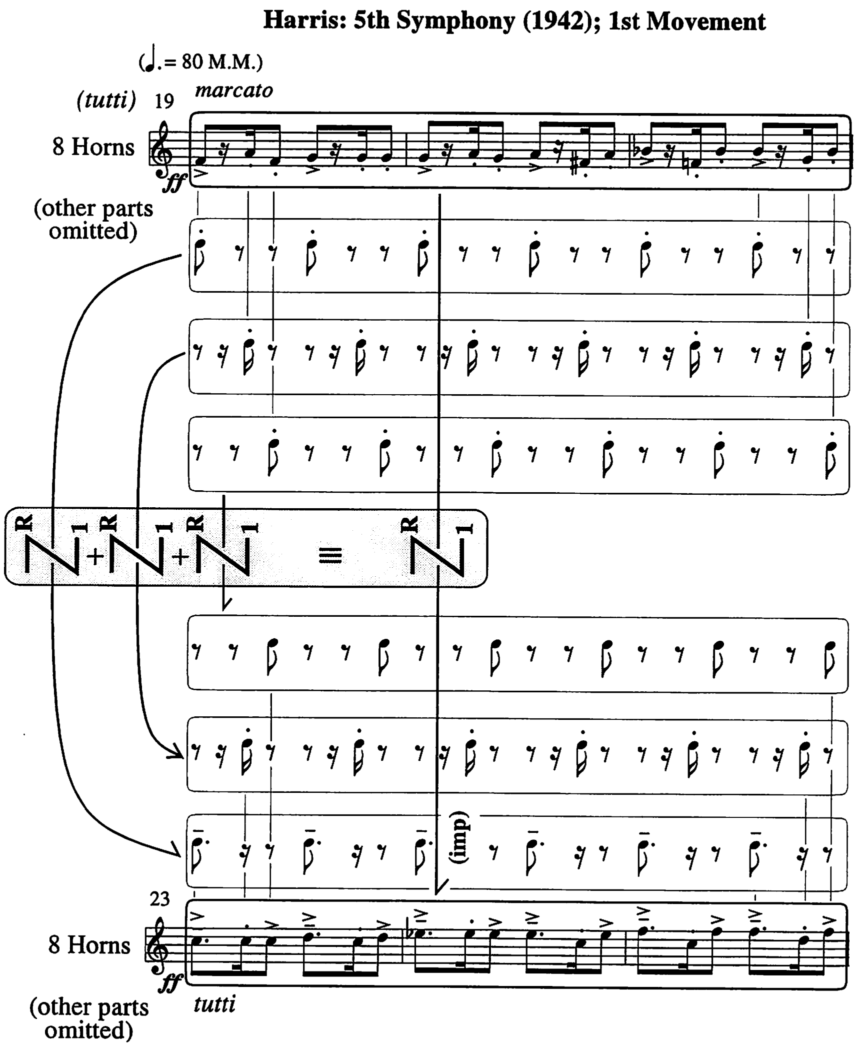


Figure 9.113 Imperfect rhythmic repetition consisting of three orderly transformations, each applying to a given duration.

Martinů: Concerto for Flute and Violin (1936); 2nd Movement

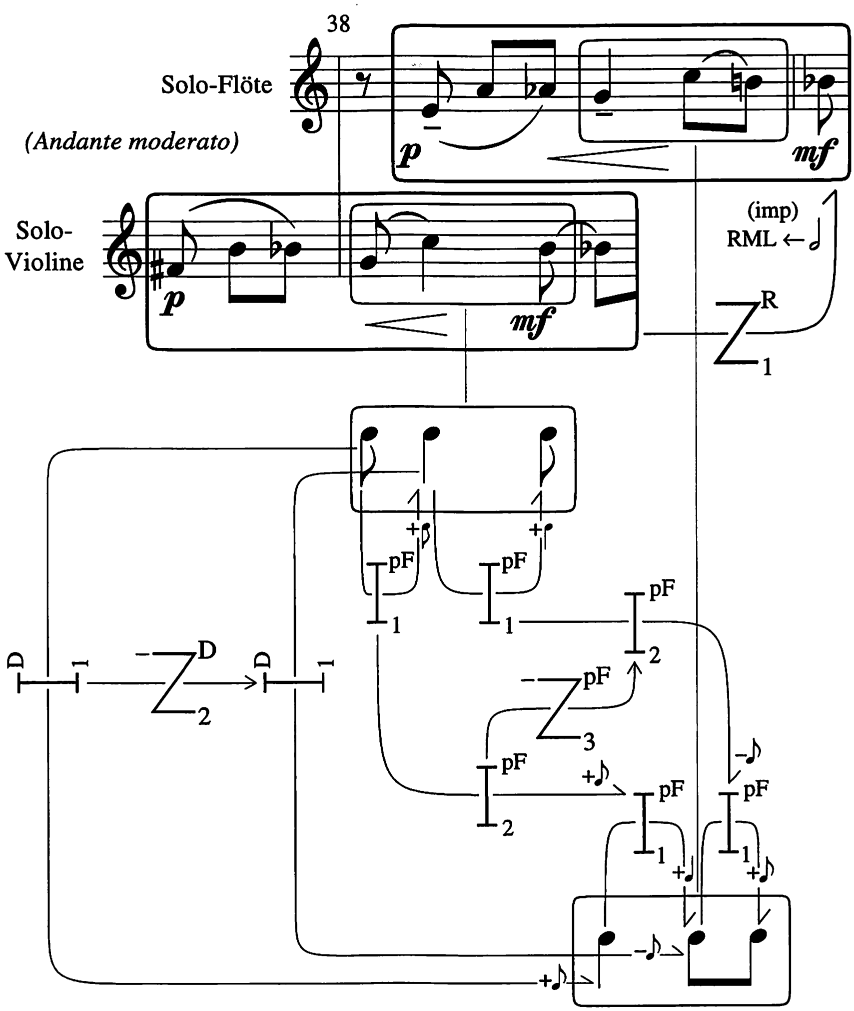


Figure 9.114 Imperfect rhythmic repetition involving the lengthening of one duration at the expense of the one following.

Bach: *The Art of Fugue* (1748–1750)

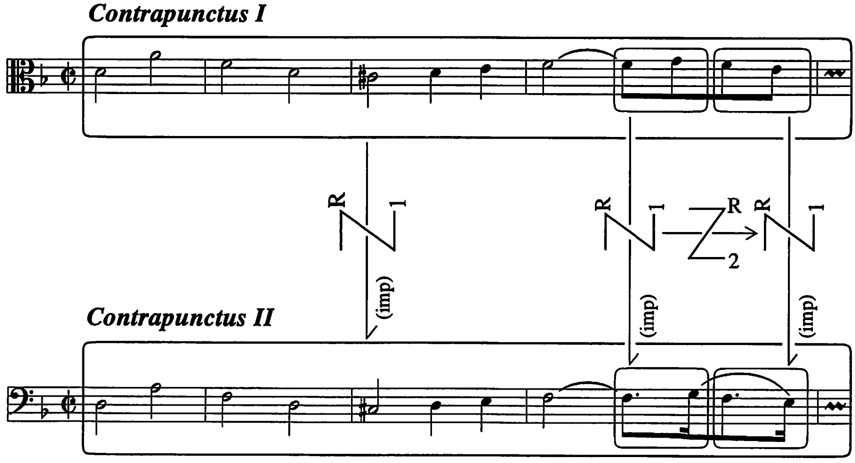
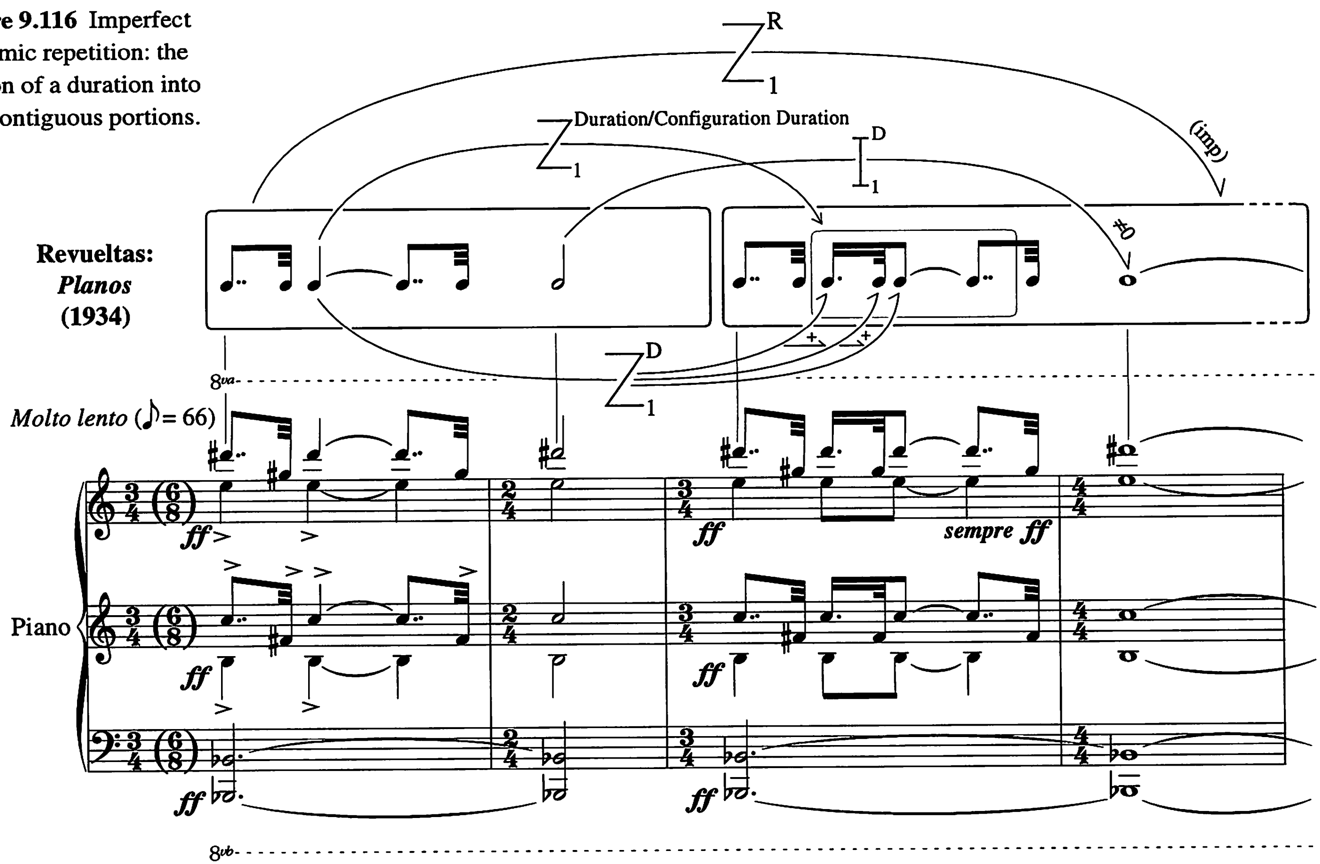


Figure 9.115 Imperfect rhythmic repetition incorporating imitation of the type illustrated in figure 9.114.

Other techniques of non-consistent rhythmic transformation should be mentioned too. For example, a duration may be divided into a number of shorter contiguous notes, implying the creation of new prefixes and suffixes from a given continuum of values of fix. Through such a procedure, the duration of an element is transferred to a configuration. Alternatively, the transformation may be considered in terms of a multivariate link. Either way, the connection between the rhythms concerned may be shown using an imperfect zygon alongside another relationship or other relationships detailing the change or changes that exist. See figure 9.116. The division of a duration may be equal, with the possibility of an intrarhythmic zygonic constant system such as the following (figure 9.117), or orderly in a more complex way. Moreover, the form of division, whatever its degree of internal order, may be common to more than one duration or may exist in imitation of pre-existing material, implying further zygonic connections. See figure 9.118. Conversely, rhythmic ordering may involve the merger of two or more durations. That is to say, the duration of a configuration is imitated by that of a single note—see figure 9.119. Again, note that the modification chosen utilises extant material, here a *tenuto* crotchet. Analysis in terms of a multivariate relationship is conceivable (figure 9.120).

Figure 9.116 Imperfect rhythmic repetition: the division of a duration into three contiguous portions.



Glazunov: Symphony No. 4, Op. 48; 1st Movement

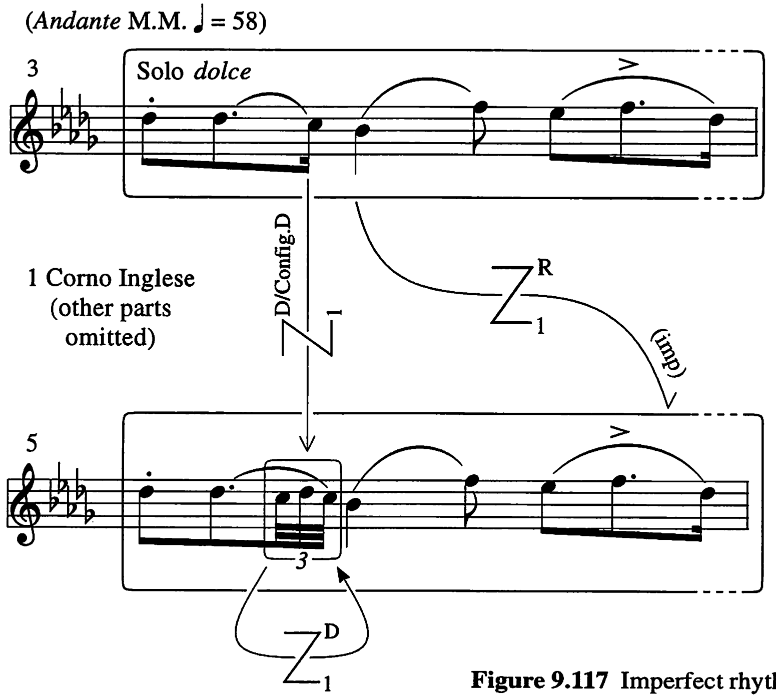


Figure 9.117 Imperfect rhythmic repetition involving the division of a duration into equal contiguous portions.

Kodály: *Háry János* Suite (1926); VI *Entrance of the Emperor and his Court*

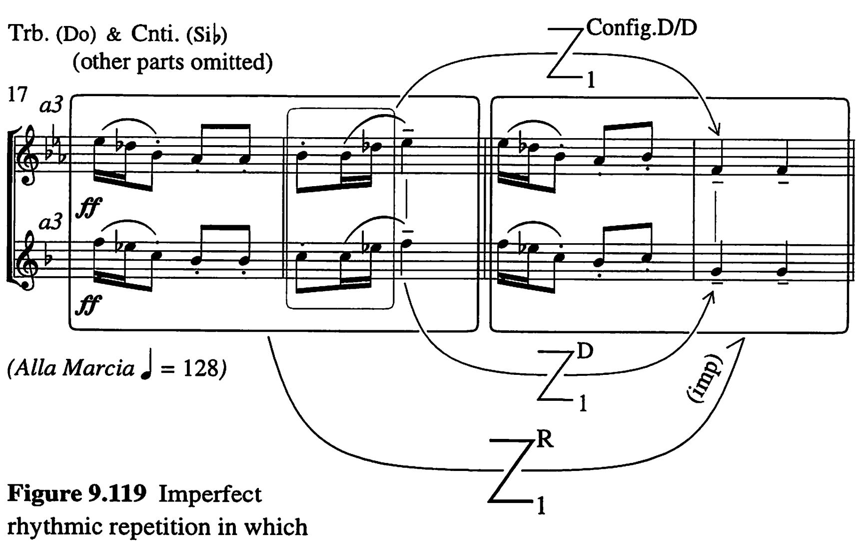


Figure 9.119 Imperfect rhythmic repetition in which three contiguous durations are merged into one.

Schumann: ***Dritte grosse Sonate (Concert ohne Orchester für das Pianoforte),*** **Op. 14;** ***Quasi Variazioni***

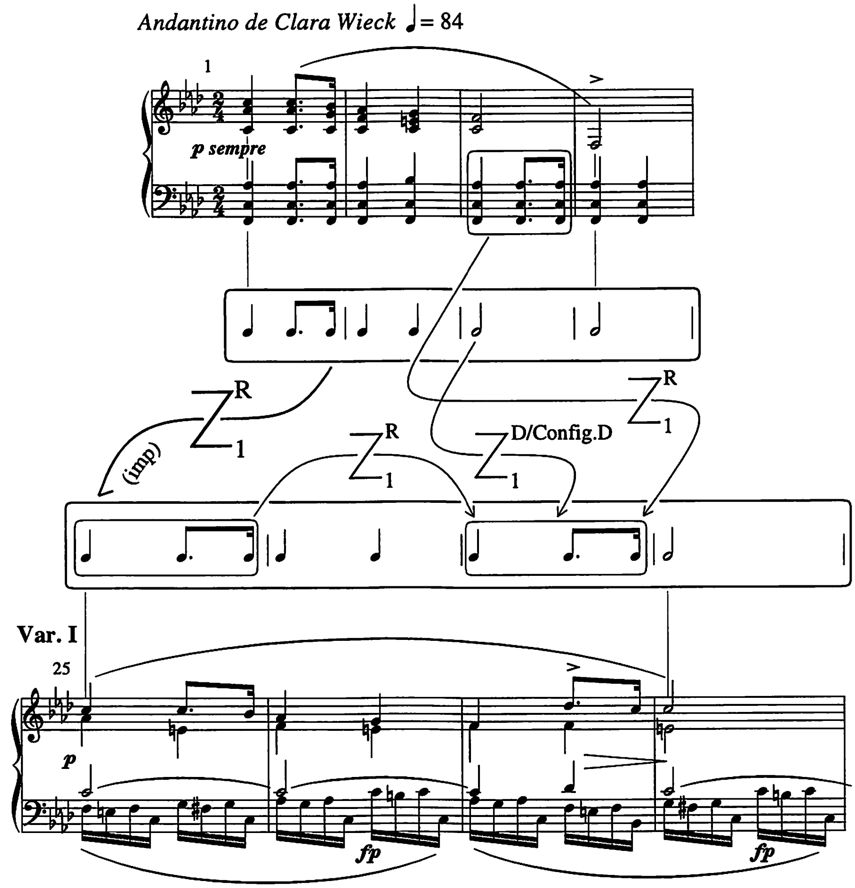


Figure 9.118 Imperfect rhythmic repetition incorporating the division of a duration into contiguous portions in imitation of existing rhythmic fragments.

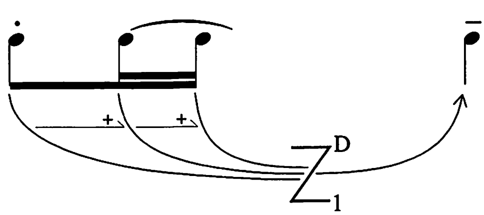
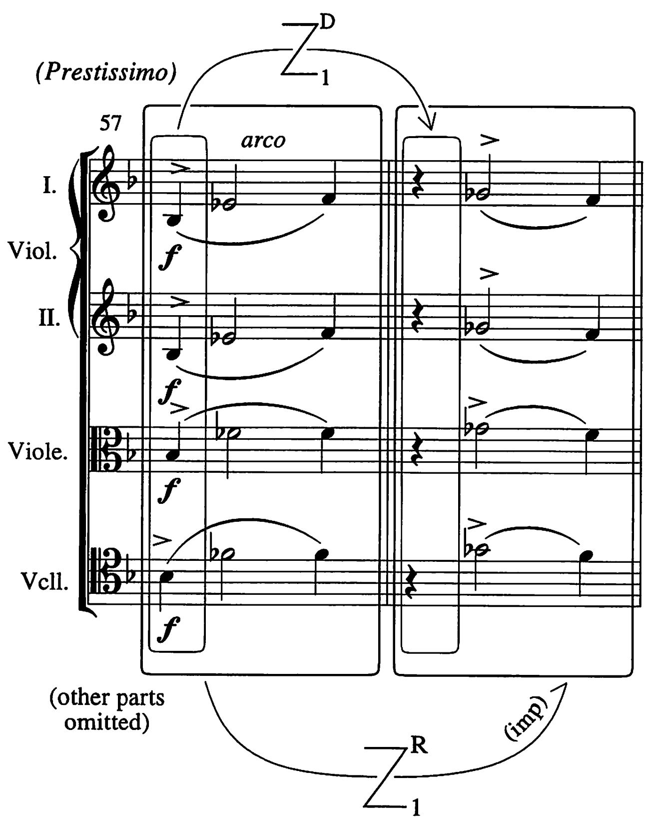


Figure 9.120 The analysis of the durational merger illustrated in figure 9.119 in terms of a multivariate relationship.

A further possibility is for two or more elements in one configuration to be substituted by a different succession in another. Once more, the new arrangement of notes may be orderly internally, externally or both. See, for instance, figure 9.121.

Material from a rhythm may be omitted on its reprise. The place of the missing duration or durations (whether complete or in part) may be taken with an equivalent rest or rests, thereby keeping the overall duration of the rhythm intact. For example:



Borodin: Symphony No. 2 (1869–1876); 2nd Movement, *Scherzo*

Figure 9.122 Imperfect rhythmic repetition in which notes are omitted and their places taken with rests of the same duration.

Kabalevsky: Violin Concerto, Op. 48; 2nd Movement

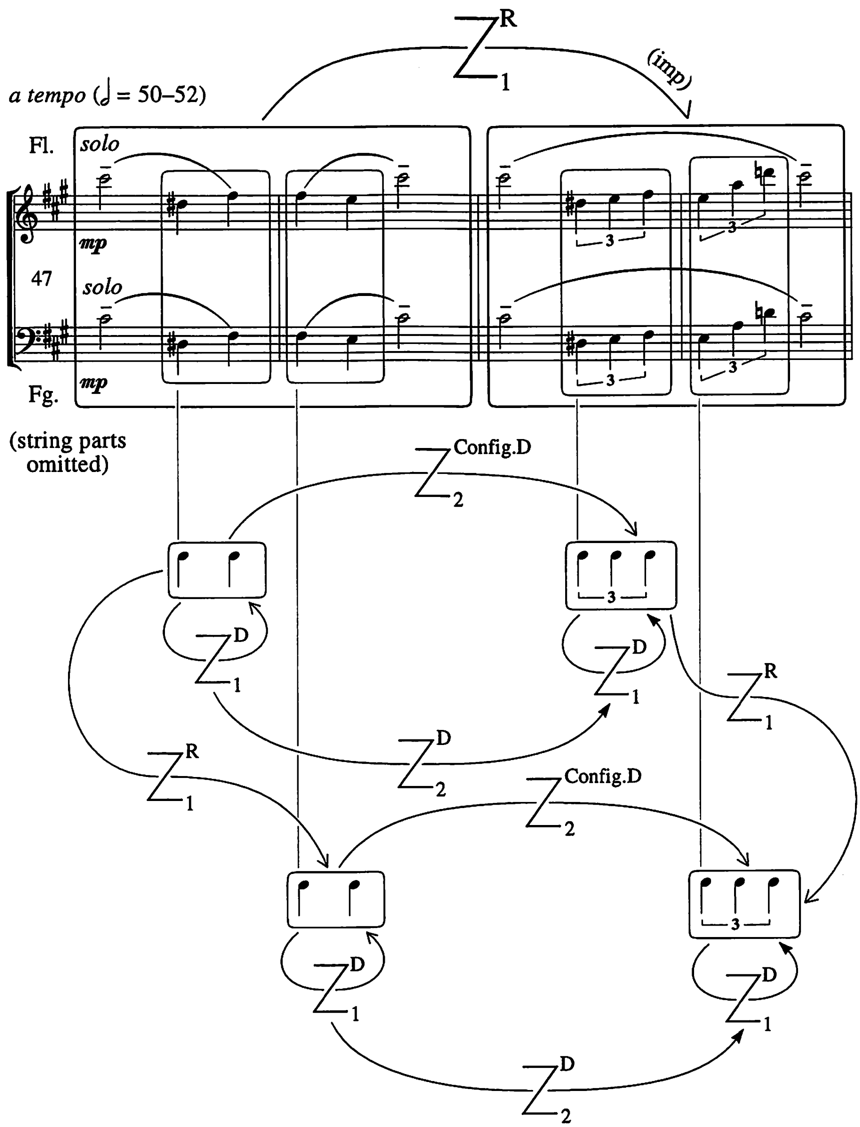


Figure 9.121 Imperfect rhythmic repetition involving the substitution of rhythmic sub-units, each subject to intrafigurative and interfigurative ordering.

although this need not be so, in which case primary values of prefix will be affected, and possibly the relative metrical locations of notes following the omission or omissions too (see figure 9.123). Where a number of notes are left out, the scheme of exclusion may be orderly with regard to sequence or even note lengths. See, for instance, figure 9.124.

Conversely, material may be added to a rhythm. This may well be ordered in its own right, or exist in imitation of a previous passage, or both. Through such means, a period of silence may subsequently be filled with perceived sound. For example:

Fricker: Symphony No. 1, Op. 9; 3rd Movement, *Tableau and Danse*

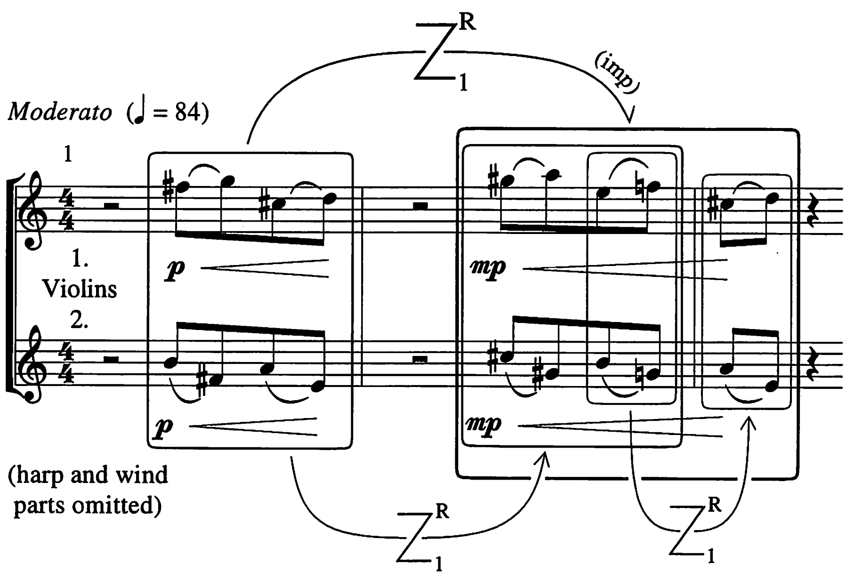
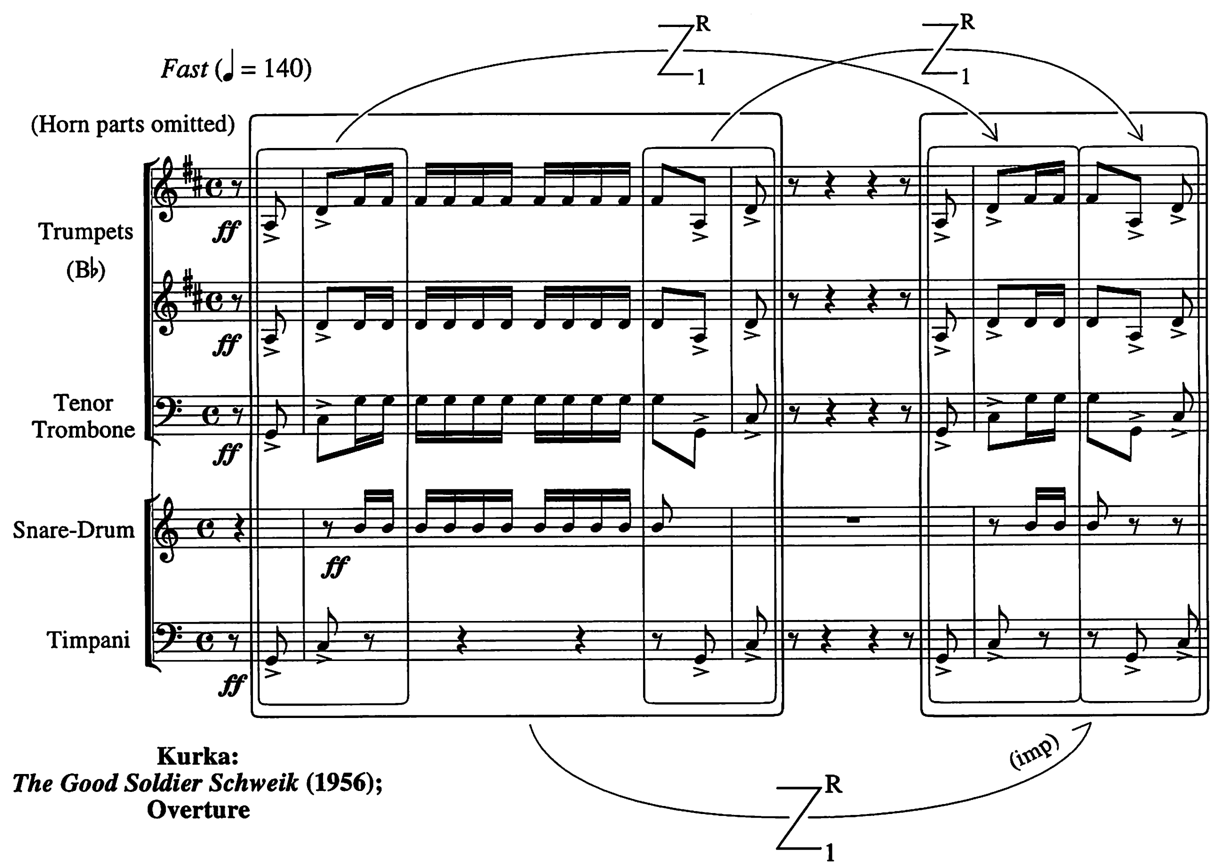


Figure 9.125 Imperfect rhythmic repetition in which material is added.

Alternatively, the new element or elements may have the effect of displacing the others in perceived time, a process which inevitably alters certain primary values of prefix. See, for example, figure 9.126.

This section concludes by considering just where the boundaries of imperfect ordering lie: that is, when is it appropriate to regard one complement as a rhythmic derivative of another, and when is it not. No hard and fast rules can be made, since the question of derivation cannot be reduced to a bimodal state of 'is' or 'is not', but is better imagined as existing on a



Kurka:
***The Good Soldier Schweik* (1956);**
Overture

Figure 9.123 Imperfect rhythmic repetition through the omission of material.

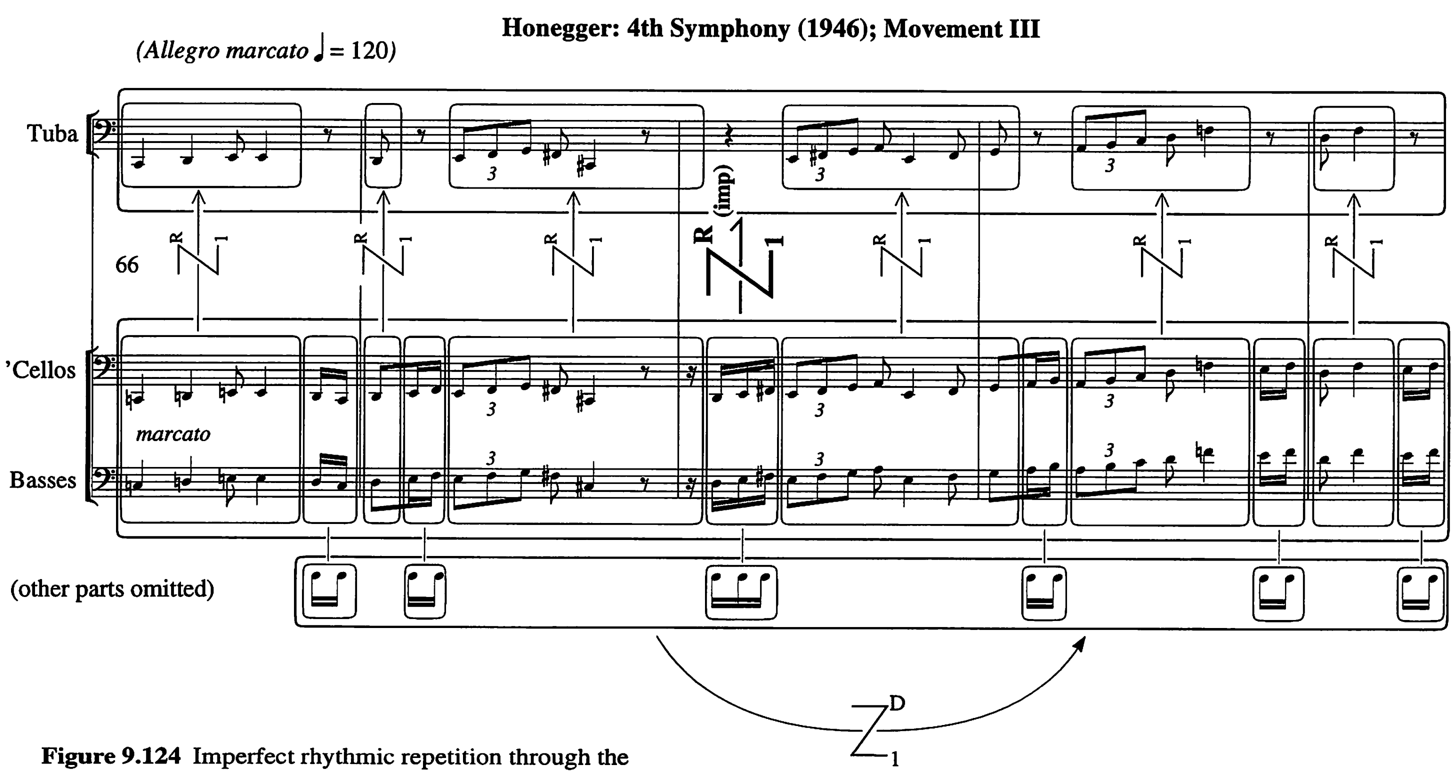
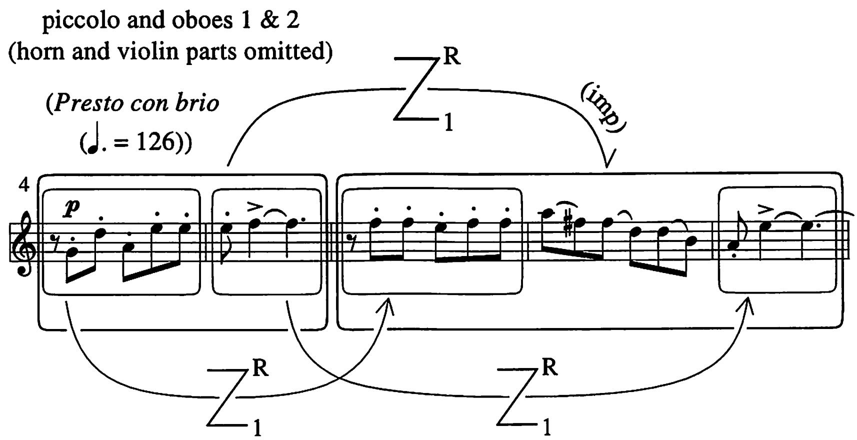


Figure 9.124 Imperfect rhythmic repetition through the omission of material, orderly with regard to duration.



Hamilton: Symphony No. 2, Op. 10; 2nd Movement

Figure 9.126 Imperfect rhythmic repetition in which the addition of material displaces some of that already present.

continuum of probability, ranging from near certainty to extreme doubt. It is not possible to say where on this scale the bottom line for zygonic existence is. All music analysts can do is to express an opinion as to the likelihood of one complement having been constructed in imitation of a second, or the chance of such ordering being perceived by listeners (albeit subconsciously). Various factors will play a part in the formation of such an opinion. One is the number of features that are maintained as opposed to those that are altered. The longer the excerpts involved, the more information is available upon which a judgement can be based, and the lower the probability of coincidental similarity. This is an important consideration in much music, which is saturated with a few basic perceived temporal proportions. Where modifications occur, the degree to which each departs from its model should also be borne in mind. Finally, parallel ordering in other perspective realms may strengthen the feeling of perceived temporal organisation.

Extramusical influences on rhythm

We now examine the extramusical derivation and control of rhythmic material. Rhythms may be intended by composers or thought by listeners to imitate, more or less exactly, perceived temporal patterns taken from outside music. Examples include pieces designed to accompany dancing (although here the transfer of order may also occur in the opposite direction—from music to movement) and songs to work to, whose rhythms ape bodily movements. Consider, for instance, sea shanties, such as "Paddy Doyle's Boots", which, as Smith (1927) says:

> was consecrated to one occasion, and one alone—namely, getting the bunt—or middle-part—of a large sail, generally a course, but sometimes a topsail, on to the yard. ... The big effort came at the word "Boots", which was shouted rather than sung.

Another example occurs in the rather more formal context of Beethoven's 8th symphony, op. 93, where the evenly ticking semiquavers of the second movement are traditionally thought to emulate Maelzel's Metronome (see figure 9.127).

In the numerous pieces that are conceived as settings for words, it may reasonably be expected the rhythm of the speech should have a considerable effect on the perceived temporal structure of the music (cf. LaRue, 1970, pp. 150ff).[22] As Nettl writes with regard to Western folk song (1965/1973, p. 87):

> the rhythmic ... quality of a musical repertory may be substantially influenced by the stress, length, and patterns of the words to which it is sung.

He illustrates this point by comparing the typical rhythmic structure of Czech and German folk songs, and finds the latter frequently use anacruses, which correspond to the unaccented articles that precede nouns in the German language. Czech songs, on the other hand, tend to begin with an accented beat, in the same way that the Czech language (which does not have articles) stresses the first syllable of each word. Comparable cross-media liaisons are to be found in other cultures too. Strangways (1914,

[22]Although, of course, there are many occasions when a musical setting exerts a profound influence on the rhythm of a text; consider, for example, the effect of devices such as *coloratura*.

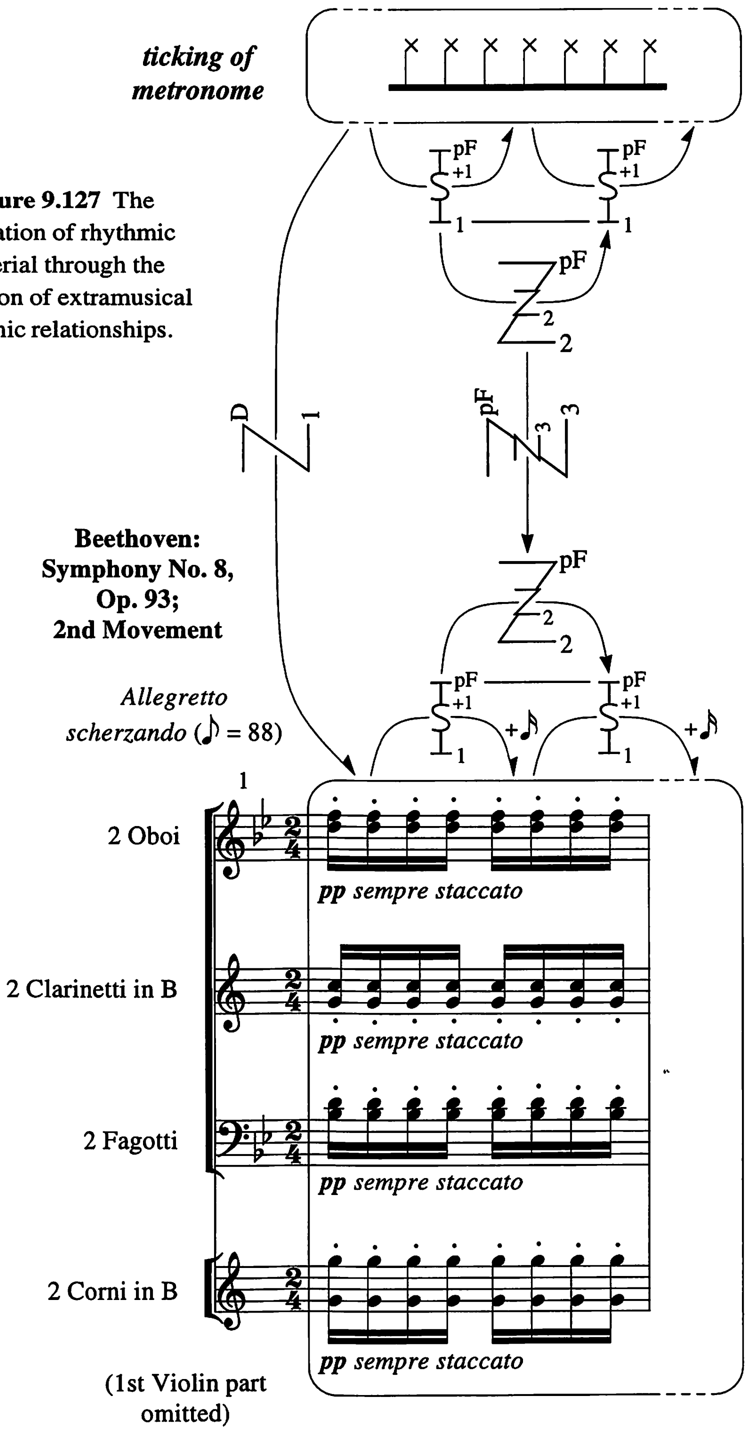


Figure 9.127 The derivation of rhythmic material through the operation of extramusical zygonic relationships.

Le Jeune: *Pseaumes en Vers Mezurez* (publ. 1606); 1. *Combien a d'heur l'homme dont le cœur*

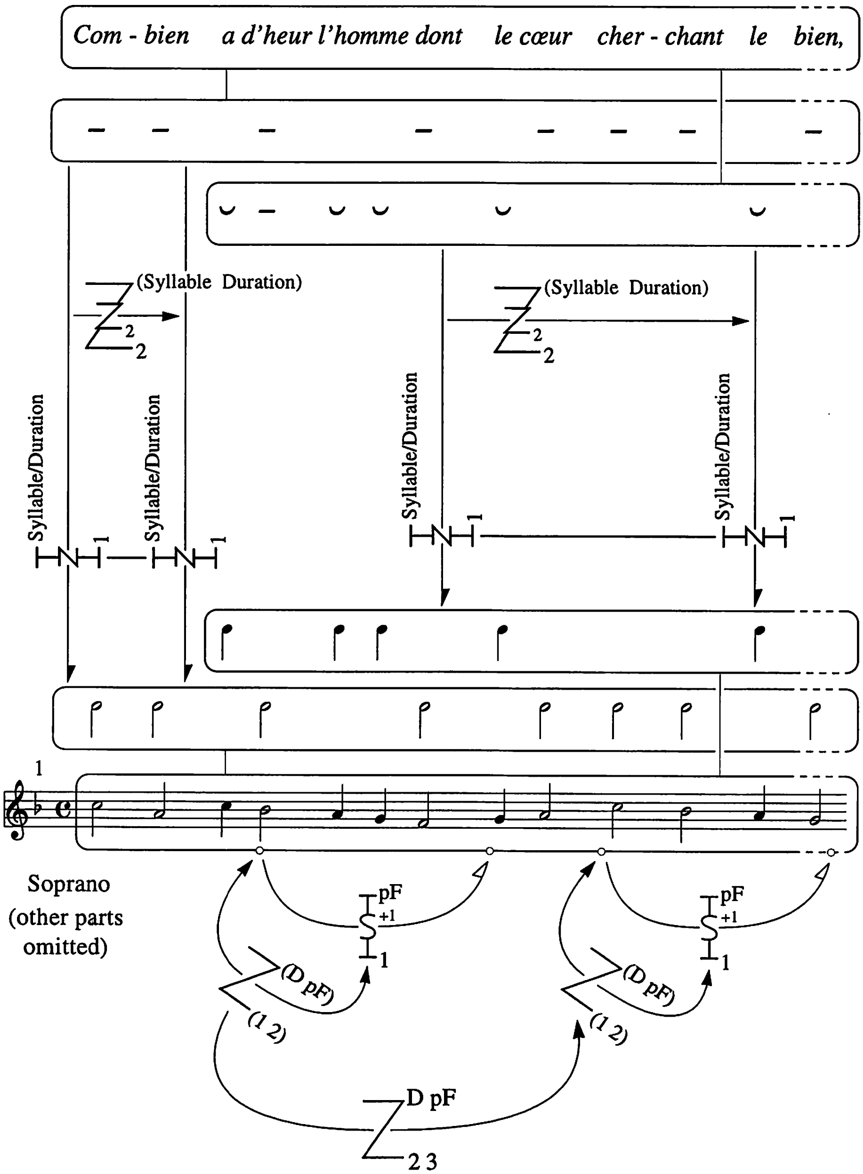
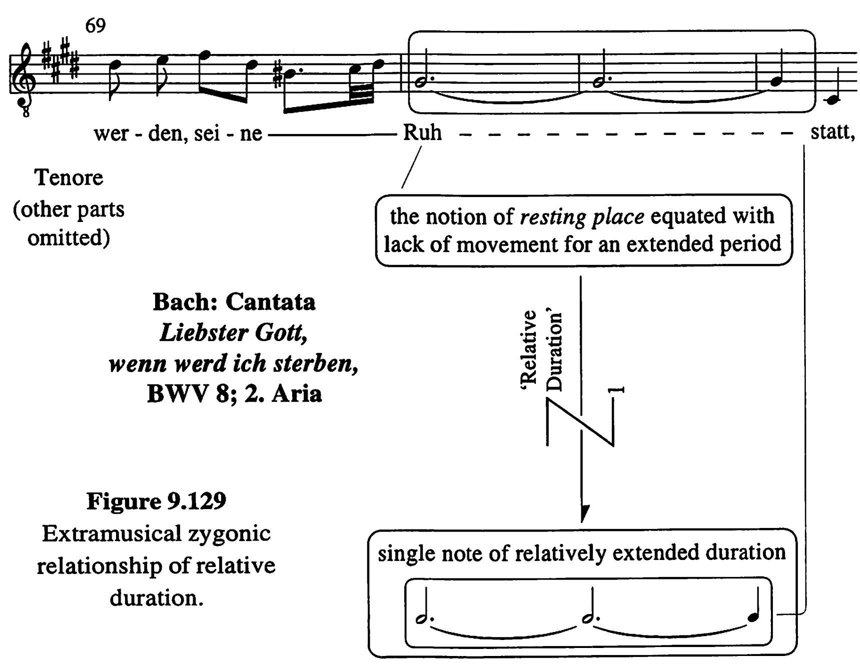


Figure 9.128 Extramusical rhythmic ordering through the imitation of the long and short syllables of a text.

pp. 191ff), for example, reveals just how closely the time-relations of Hindustani music are affected by the structure of the language.

In the early 16th century, the process of word-setting was codified in strict theoretical procedures, and composers such as Tritonius, Hofhaimer and Senfl set Latin poems to music whose rhythmic designs faithfully reflected the long and short syllables of the text metres (Sachs, 1956, pp. 126 and 127). Hence they anticipated by about seventy-five years the French settings of *vers mesurés*, which followed the same principle (Reese, 1954, p. 383). See, for example, figure 9.128. (Observe here the concomitant ordering of prefix—cf. figure 9.58).

The meaning of a word or phrase may influence the rhythm of the music to which it is set. This may occur through imitation, whereby some action or thing from outside music is either echoed (in the case of perceived sound) or translated isomorphically into the fabric of a piece (cf. pp. 111ff). This implies the operation of extramusical zygonic relationships. For instance, in the cantata "Liebster Gott, wenn werd ich sterben" by Bach, BWV 8, 2nd movement, bars 70–72, the notion of 'resting place' (*Ruh'statt*) is conveyed through the use of single note sustained for seven beats, indicative of stillness as opposed to movement.



Bach: Cantata
Liebster Gott,
wenn werd ich sterben,
BWV 8; 2. Aria

Figure 9.129
Extramusical zygonic relationship of relative duration.

Another, highly specialised, way in which a text has affected rhythm is through 'eye music', a technique found in certain 15th and 16th century compositions

> in which the affective meaning of the text of the music is made visible ... by ... special methods of notation. By far the most common device is the use of blackened notes for texts expressing grief or lament as well as for individual words such as 'night', 'dark', 'shade', etc. ... Since the notational significance of blackened notes is a change from duple to triple rhythm ..., the 'dark' passages appear in modern transcription as triplet formations. (Apel, 1969, p. 304).[23]

Numbers have constituted a further form of extramusical rhythmic influence. The temporal patterns of Nono's *Il Canto Sospeso* (1955–1956), for instance, are derived, with varying degrees of complexity, from the sequence 2, 3, 5, 8, 12, 17 (see Brindle, 1987, pp. 38ff). While it seems improbable that ordering of this type could ever be perceived directly by listeners, its potential value as a source of stimulation for composers cannot be discounted.

The organisation of the temporal perspects pertaining to complements that form holons

It frequently happens that the prefixes of holons occur simultaneously, implying the agency of zygonic ordering. See, for example, figure 9.130. When this takes place in conjunction with a canon of suffix, durational control is implied as well. See, for instance, figure 9.131.

Where holons are initiated successively, strict perceived temporal control is often in evidence too. Examples involving complementary imbrication are to be found in fugal expositions, in which pairs of subjects and answers are separated by the same perceived temporal interval (which is customarily measured in numbers of beats and bars). A secondary zygon may be considered to link each combined entry of *dux* and *comes* (see figure 9.132).[24]

[23]For further disucssion of the aesthetic implications of 'eye-music', see, for example, Chater, 1981, pp. 62ff (here in relation to the madrigals of Marenzio).

[24]It is also possible to consider all the entries in an exposition to be imperfectly related as to prefix.

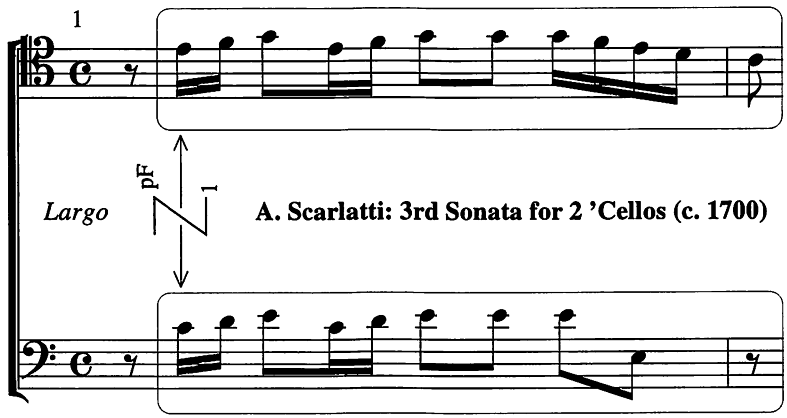


Figure 9.130 Canon of complement prefix (cf. figure 6.12)

G. Gabrieli: *Canzoni e Sonate* (publ. 1615); Sonata XVIII

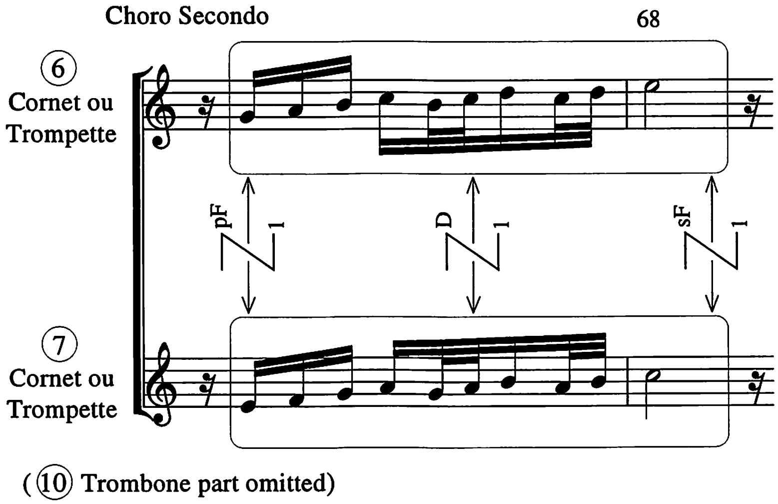
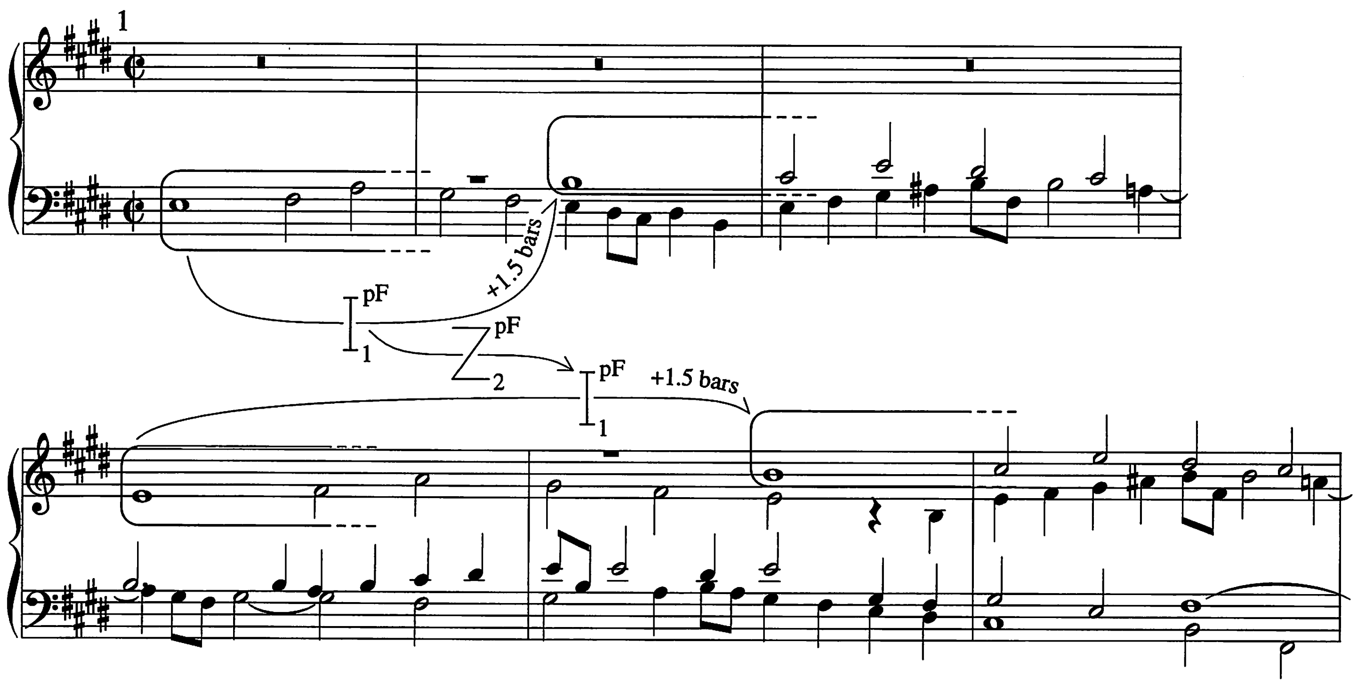


Figure 9.131 Canons of intercomplementary prefix, suffix and duration.



Bach: *Well-Tempered Clavier*, Part 2, Fugue 9, BWV 878

Figure 9.132 Secondary zygon of complementary prefix.

Monteverdi:
Laudate Dominum
(1640)

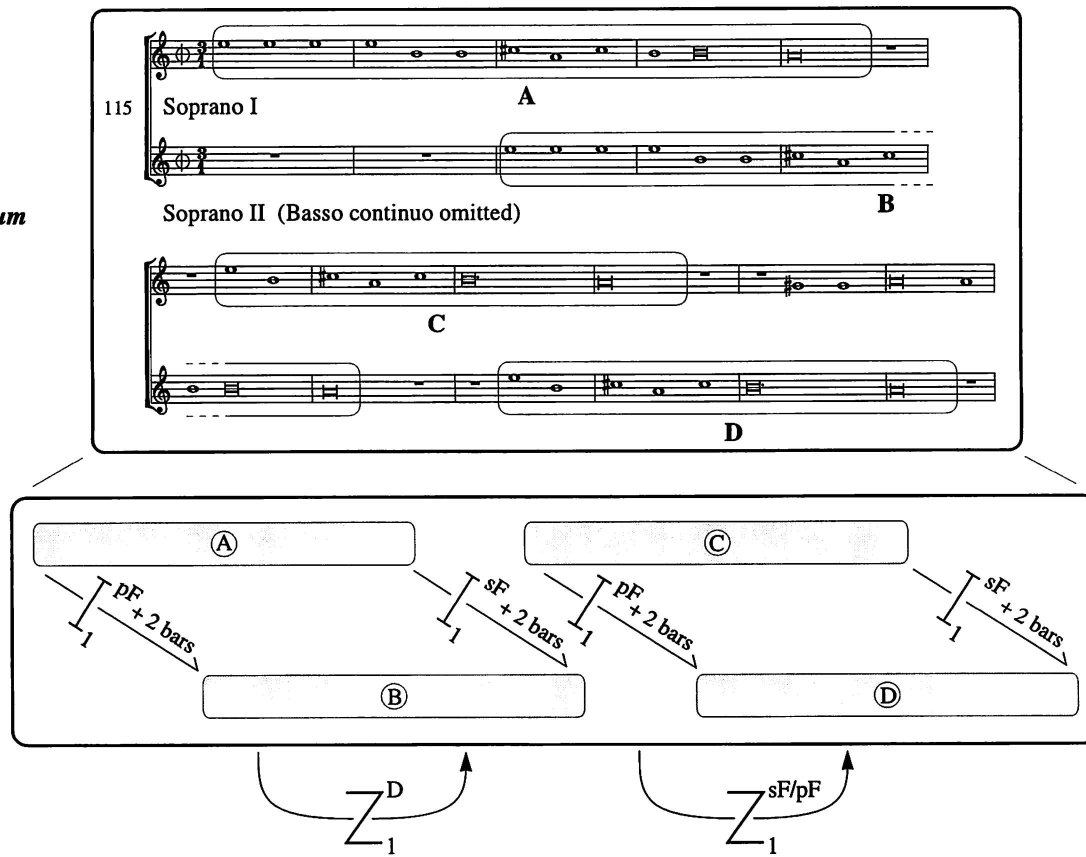


Figure 9.133
Secondary zygonic constant system of complementary prefix/suffix operating in tandem with a primary zygonic constant system of complementary duration.

Since such a procedure is common to many pieces, tertiary zygons can be assumed to function interoperatively.

Rather less frequently,[25] the suffixes of complementary holons are staggered in an orderly way. Consider, for example, the passage shown in figure 9.133, in which identical phrases overlap at a distance of two bars.

Within a series of holistic complements, the perceived time between successive prefixes is often equivalent to the duration pertaining to the first:

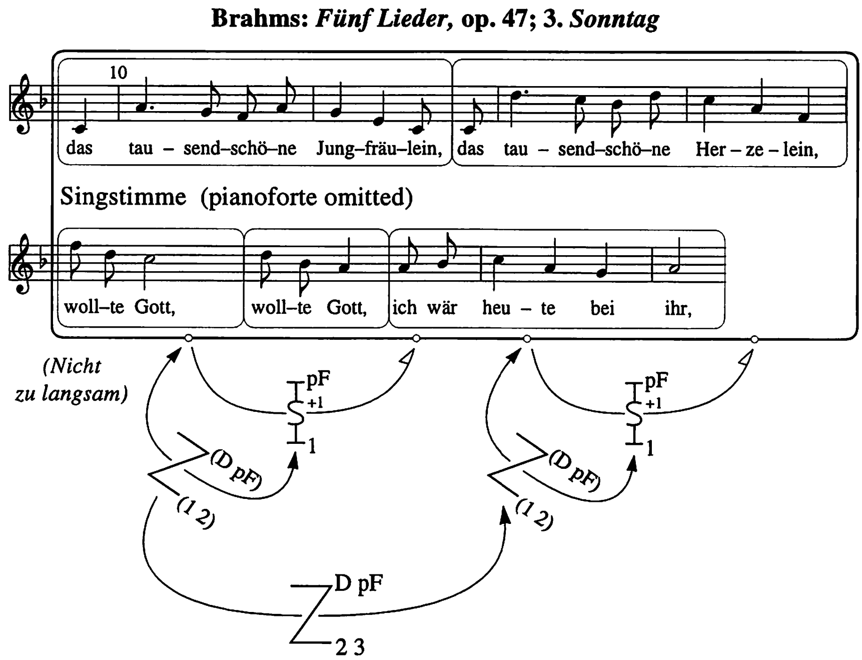


Figure 9.134 Secondary/tertiary zygonic constant system of duration/prefix.

Since rests can be integral to groups of notes, a period of silence need not impair the sense of contiguity.

Although the perceived temporal dimensions of complementary holons need not accord with those pertaining to metrical groups, there is frequently a close correspondence between the two; and since metres are so often regular in disposition, it is inevitable that complements that comprise holons

[25]Cf. Huron, 1990, pp. 385ff.

Anon: *Come all you Worthy Christians,* as sung by John Dingle (1904)

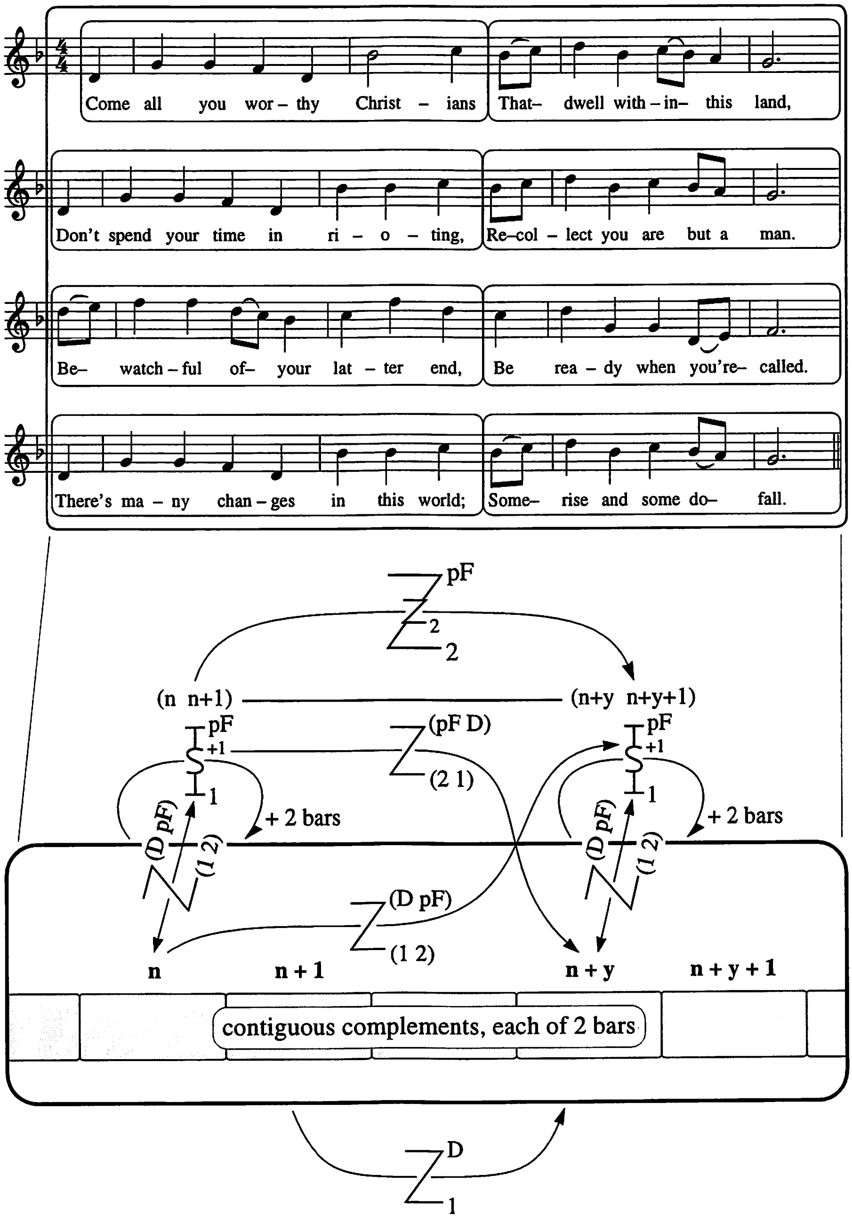


Figure 9.135 The order underlying complementary duration and prefix in a melody comprising equal contiguous holons.

should display a similar tendency (cf. Lerdahl and Jackendoff, 1983, pp. 12ff). Hence, many simple melodies comprise holons of equal extent, which occur at the same equally-spaced intervals, implying the presence of primary zygons of duration and secondary zygons of prefix.[26] The degree of perceived temporal ordering of the complements cited in figure 9.135 is particularly marked, although, of course, numerous tunes exist that are not as symmetrical as this (see, for example, figure 9.134). Such organisation, which is common to a large number melodies, may be considered to exist through imitation, implying systems of secondary zygonic constants of duration, tertiary zygonic constants of prefix, and secondary/tertiary zygonic constants of duration/prefix (cf. figure 9.61).

Control of this type also pervades higher levels of musical construction. Consider, for example, pieces in what Apel (1969, p. 95) terms 'symmetrical binary form', whose two sections are of equal length; see, for instance, figure 9.136. (Observe that this symmetry extends to the variations that follow the theme through ordering comparable to that illustrated in figure 9.135.) Many other pieces have two or more sections of approximately equal duration, implying imperfect zygonic control.

Some pieces are structured through high-level durational schemes of considerable complexity. For example, a number have been shown to use the ancient principle of the 'golden section', whereby a line is divided into two parts, such that the smaller is to the larger as the larger is to the whole, implying a ratio between the two of approximately 1 : 1.618. This proportion is approached ever more nearly by successively higher adjacent terms in the *Fibonacci* series: 1, 1, 2, 3, 5, 8, 13, 21, ... (see p. 337). It is this fact that composers such as Debussy and Bartók have apparently exploited in the large-scale planning of certain pieces (see, for example, Howat, 1983; Bent and Drabkin, 1987, pp. 67 and 68). Such organisation implies the use of imperfect secondary and tertiary zygonic relationships of duration. Take, for instance, the passage quoted from Bartók's *Sonata for Two Pianos and Percussion* (1937), where the proportions of sections, sub-sections and smaller units of these all correspond to the golden section (figure 9.137).

[26]Extra-musical influences should should also be taken into account. Consider, for example, the limitations imposed by word-setting—as Nettl (1965/1973, p. 42) says, in his examination of folk and traditional music of the Western continents: "The lines of music and text usually coincide, and the points at which the music comes to a temporary rest are also those at which a sentence, phrase, or thought in the words is completed".

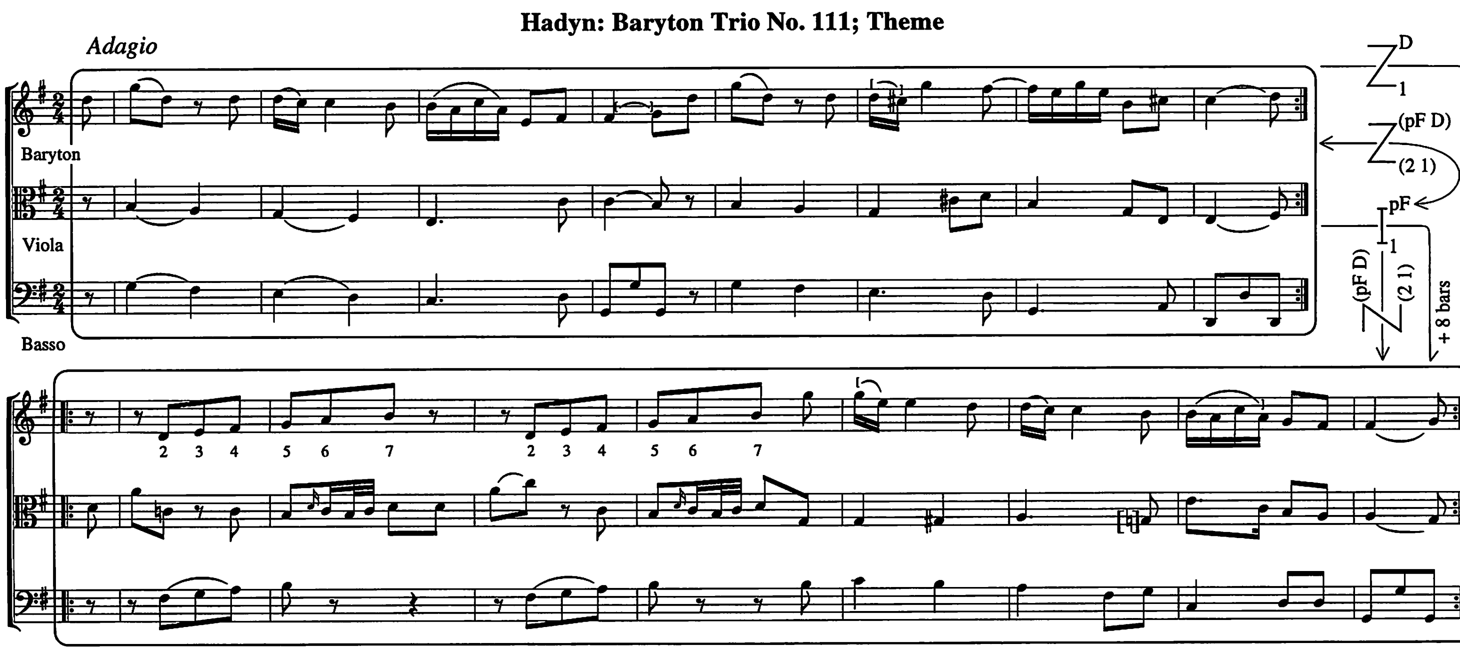
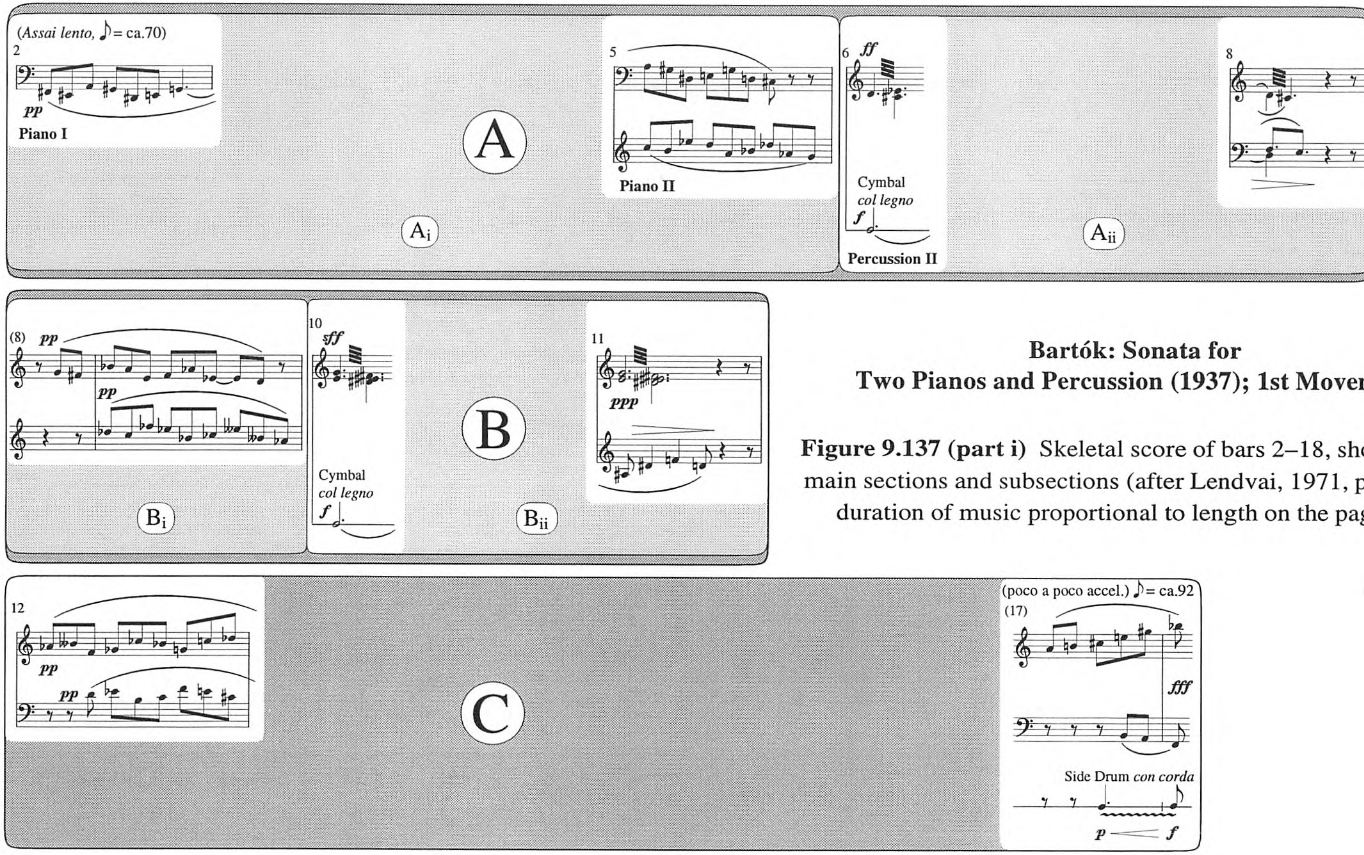



Figure 9.136 The perceived temporal order underlying symmetrical binary form.



Bartók: Sonata for Two Pianos and Percussion (1937); 1st Movement

Figure 9.137 (part i) Skeletal score of bars 2–18, showing main sections and subsections (after Lendvai, 1971, p. 18); duration of music proportional to length on the page.

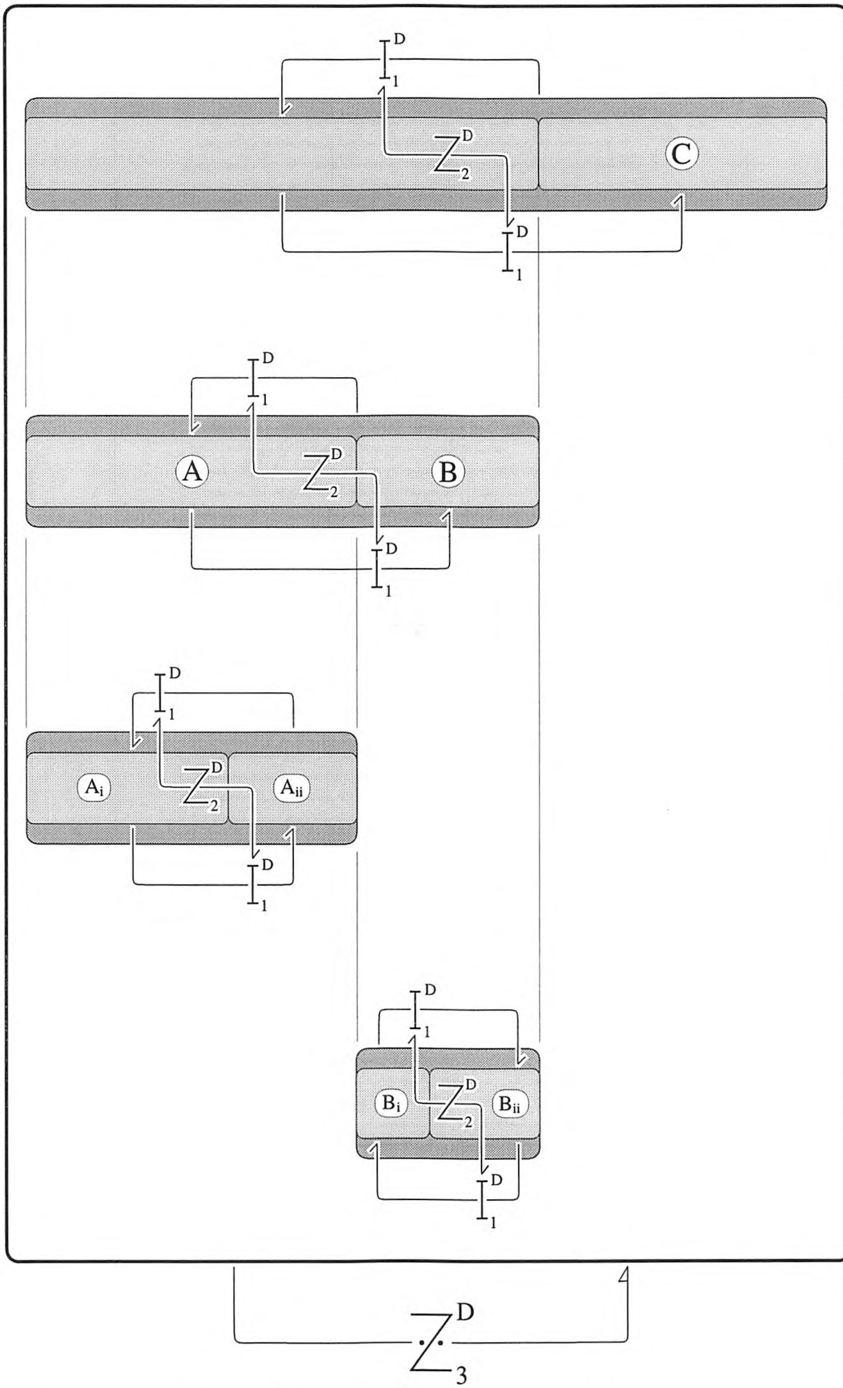
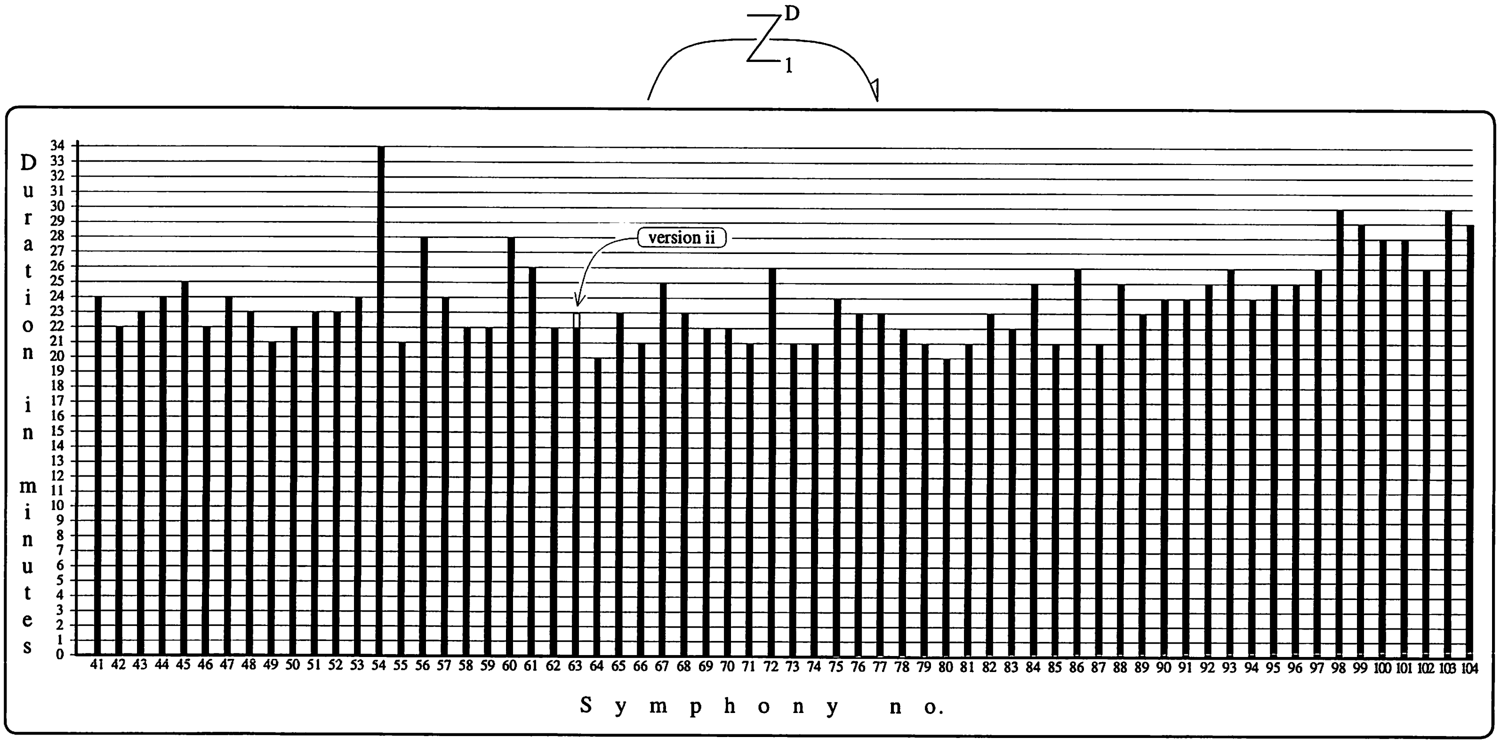


Figure 9.137 (part ii) Zygonic interpretation of the durational ordering of complements in bars 2–18 of Bartók's *Sonata for Two Pianos and Percussion.*



Haydn: Symphonies 41–104

Figure 9.138 Interterpretive constant zygonic system of duration linking Haydn's symphonies 41–104.

Observe that the imperfection of the durational organisation is made more pronounced by the *accelerando* of bars 13–17. The analysis is based on that by Lendvai (1971, pp. 18ff), who traces similar durational control even further than this, to divisions of the shortest units shown here.

Interoperative zygonic links can be considered to control the durations of complete pieces. Consider, for example, Haydn's symphonies. In particular, the durations of numbers 41–104, as observed by Landon in his complete critical edition (1963–1968), are remarkably similar, and may be deemed to be ordered through a substantial interoperative zygonic constant system (figure 9.138). (Observe that the symphonies are not shown here in their chronological order of composition—see Landon, 1955.)

Even the lengths of concerts, which normally involve the performance of several works, tend to be similar (cf. p. 320; Moles, 1958/1966, p. 27). Imitatively based order, operating through interterpretive zygons, plays a part here too.

Conclusion

This chapter has identified the principal ways in which the temporal perspects are ordered in music. This invariably involves the coordinated organisation of perspective and interperspective values of fix or duration or both, and involves perspects such as pulse, beat, metre, tempo, articulation and rhythm. It is evident from the foregoing sections just how comprehensively perceived time is typically structured in music, even disregarding the influence of other perceived aspects of sound. Further organisation will become apparent in chapter 11, when rhythm is considered in relation to pitch.

10

Ordering pitch

Introduction

After a brief consideration of the non-canonic organisation of pitch, the order pertaining to individual protractions and the intervals between them is examined. This is followed by an investigation into the control of perspective and primary interperspective sets of pitches and pitch-classes. The ordering of pitch in melody is a major area of concern (pp. 513–566), as too is the organisation of pitch in chords (pp. 567–595). The interaction of the two is discussed on pp. 598ff. The chapter concludes by addressing the issue of tonality.

The non-canonic ordering of pitch

Perception limits composers' choice of perspective and interperspective values of pitch, both in range and resolution: clearly, it would be futile to select pitches that were either too high or too low to be heard, or to stipulate the performance of different values that were in fact indistinguishable. Moreover, most music falls within the pitch domain to which listeners are most sensitive (corresponding approximately to the frequencies lying between 100Hz and 1000Hz; see Harwood, 1976, p. 525).

Various physical restrictions constrain composers in their choice of pitch too. The availability of voices and instruments, whose compasses are limited (see, for example, Seashore, 1938, p. 73; Olson, 1952/1967, p. 203), must be taken into account. The range of the voice and of some instruments depends on the capabilities of the performer: virtuosi, for example, may be expected to attain pitches beyond the reach of most musicians (see figure 6.10). Composers must contend with other limitations too: many instruments, for instance, are tuned to a series of discrete, immutable pitches. These may even be dictated by extra-musical principles, as when the breadth of thumb is used to determine the distance between flute holes (see Schneider, 1957, p. 15). Furthermore, combinations of pitches may be conditioned by factors such as the feasibility of playing a particular double or triple stop on the violin, or the manageability of a certain chord on the piano. In the West, there has been a gradual increase in the pitches that can be obtained, both through mechnical alterations such as the extension of the piano keyboard in the nineteenth century, and, more recently, on account of the newly-developed techniques of woodwind players, for example (cf. p. 295). Finally, with the electronic production of sound, pitch has found its complete emancipation.

In investigating the motives underlying a composer's choice of pitch, music analysts need to consider whether differing values elicit unique subjective responses. Certainly, the opinion has been expressed that, other things being equal, high notes may bring about a feeling of tension, whereas low notes seem to foster a sense of repose (Davies, 1978, p. 106). It is possible that such reactions are related to the degree of physical effort needed to produce the pitch in question. For example, it has been suggested that Stravinsky counted on the difficulty bassoonists would find in playing the fifth octave *c* that opens *The Rite of Spring* (1913; see figure 1.1) to imbue performances with a sense of heightened excitement. Whatever the verity of assertions like this, the ability of individual values to evoke distinct emotional responses in the listener would appear to exert only a miminal influence on pitch organisation as a whole.

Pitch constants i: intraprotractive and interprotractive primary zygonic organisation

A great deal of music comprises notes—that is, elements that are perceived to be constant in pitch (cf. p. 115)—whose organisation is now examined. The order pertaining to variables of pitch is considered on pp. 466ff below.

Following the reasoning presented on pp. 121ff, it may be inferred that the existence of a note implies the presence of a primary intraprotractive zygonic constant system of pitch. The order inherent in constants of pitch is particularly apparent in the case of drones and pedal points, simply by virtue of their length. These fundamental forms of pitch control feature cross-culturally in many vintages of music, from the most ancient (see Schneider, 1957, p. 23) to the most modern (consider, for example, Young's *Composition 1960 No. 7*, which consists simply of the *b* below middle *c* and the *f*♯ next above it, with the instruction "to be held for a long time"). They are an inbuilt characteristic of a number of instruments, from the hurdy-gurdy to the bagpipes; and from the double flutes and clarinets of the Balkans, such as the *dvojnice* (see Nettl, 1965/1973, pp. 100 and 113) to the celebrated Australian *didjeridu* (see Erickson, 1975, pp. 100–103). Aside from these, pedal points have a long association with a number of other instruments such as the organ. For example:

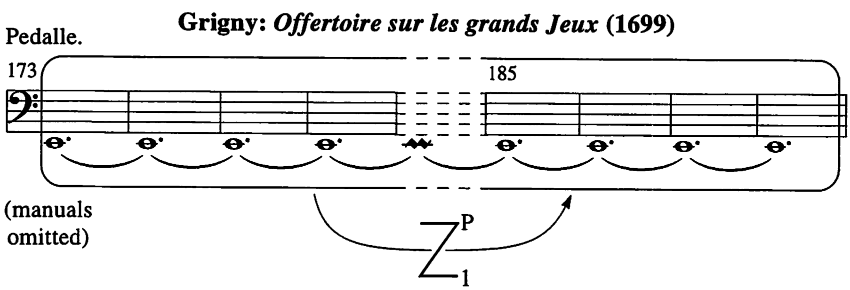


Figure 10.1 Primary intraprotractive zygonic constant system of pitch.

The very uniformity of a note may be supposed to exist in imitation of that displayed by others, implying the operation of secondary zygonic constants linking primary intraprotractive constant systems. Since the use of notes in music is so widespread, such constants form vast intraoperative and interoperative systems comprising many thousands of individual relationships. Consider, for example, the excerpt from Taverner's Mass *Small Devotion* cited in figure 10.2 (part i). Part ii shows the secondary zygonic constant system of pitch associated with this passage. It is the overall effect of this system that is important, rather than the limited force of any of its component relationships.

Taverner (c.1495–1545): Mass *Small Devotion; Agnus Dei*

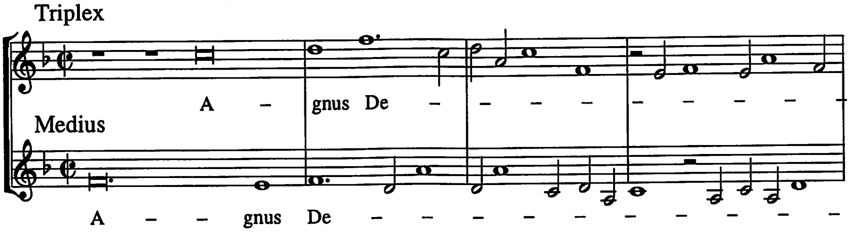



Figure 10.2 (part i) The opening bars of the *Agnus Dei* of the Mass *Small Devotion* by Taverner.

However, within a general context of variability, in which immediate models for pitch uniformity are few and far between, the influence of individual secondary zygonic constants may be far more apparent. See, for instance, figure 10.3.

A glance through a wide range of scores reveals the wholesale repetition of just a few different pitches, both within and between pieces. The values that are used, and the ways in which they are disposed, is the subject of detailed discussion later in this chapter; here, a few preliminary comments are made regarding their underlying organisation.

A primary zygonic interprotractive constant may be deemed to link two notes that share the same pitch, where one is thought to exist in imitation of the other. For example:

Ockelford: *All join in!* (1996); No. 14, *Listen!*

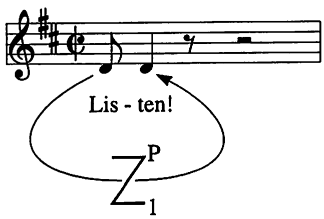


Figure 10.4 Primary zygonic interprotractive constant of pitch.

The notion of 'octave equivalence' (see p. 47) means that 'cyclical' interperspective connections of pitch are conceivable. Hence a zygonic constant may be considered to exist between two notes one octave or more apart. For instance (see figure 10.5).

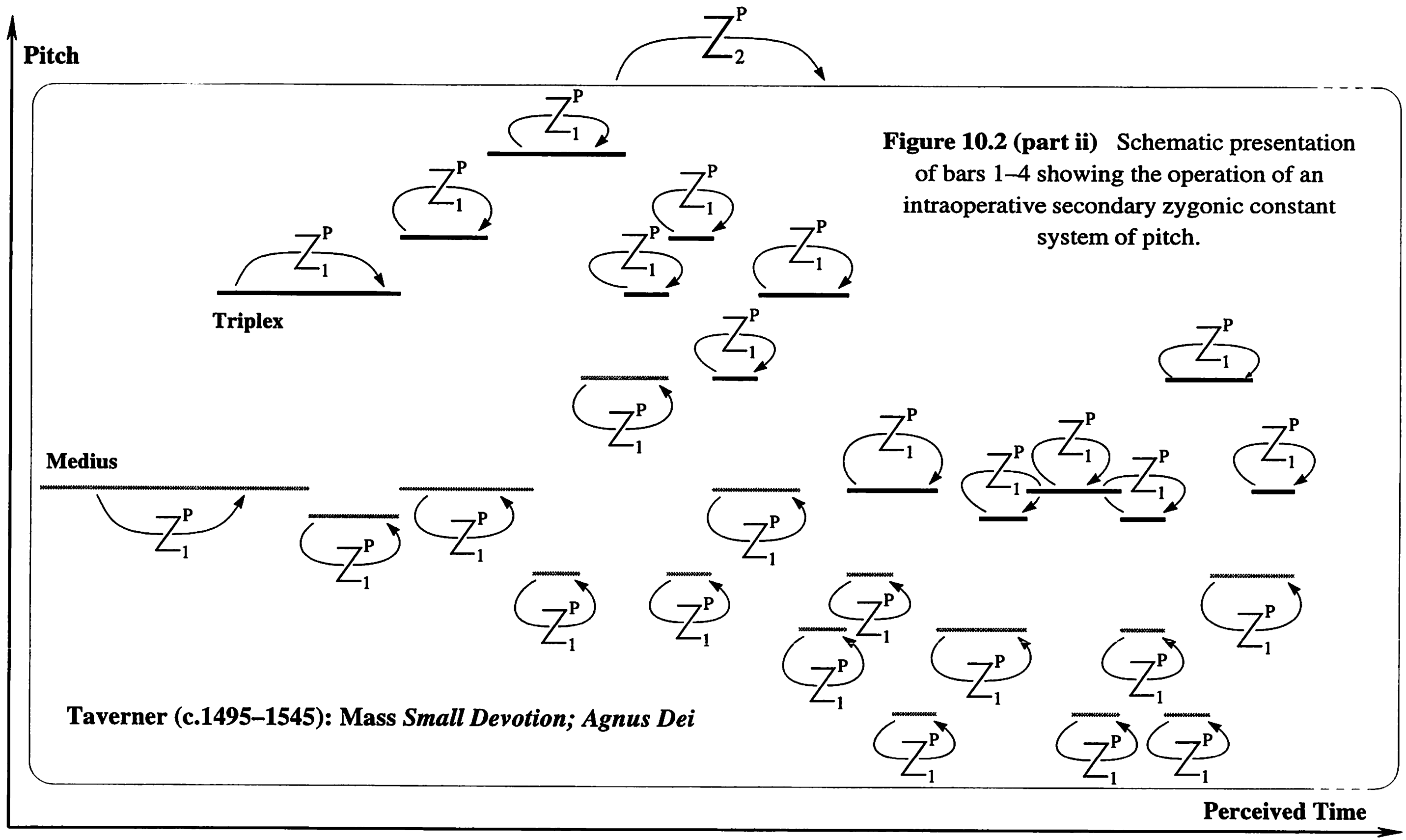


Figure 10.2 (part ii) Schematic presentation of bars 1–4 showing the operation of an intraoperative secondary zygonic constant system of pitch.

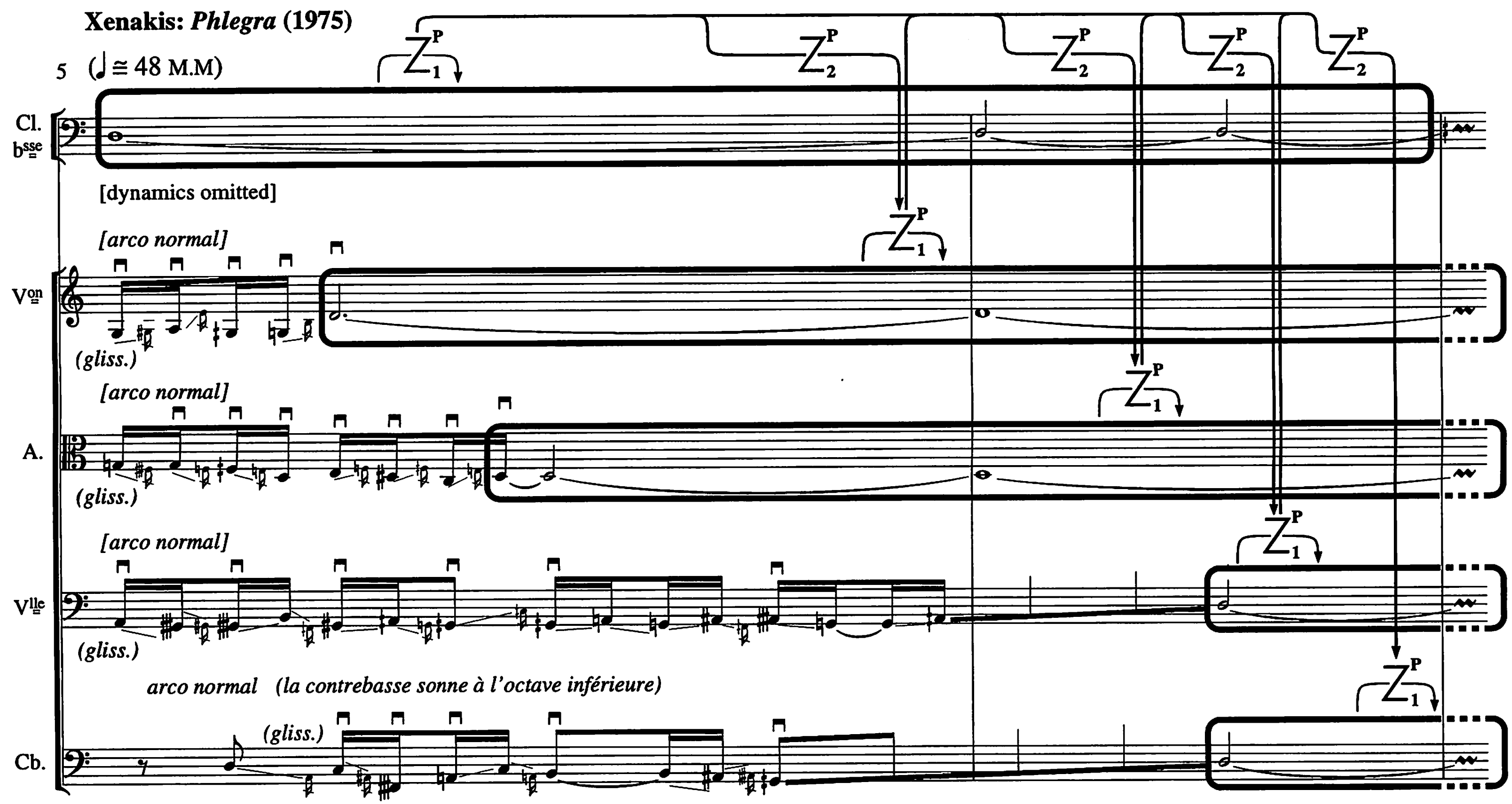



Figure 10.3 The imitation of the constancy of pitch occurring through secondary zygonic constants.

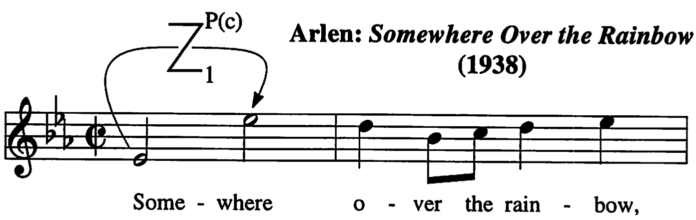


Figure 10.5 Cyclic canon of pitch.

Observe the use of 'P(c)' to show 'pitch (cyclic)'.

Perceiving or realising primary zygonic relationships between pitches that are separated in time depends on people's limited capacity for remembering values (cf. pp. 41 and 42). Hence, performers may unwittingly allow the general intraterpretive pitch level to rise (as in the case of a wind instrument warming up unchecked and going sharp) or fall (for example, when a choir goes flat); in such circumstances, zygonic relationships may be realised imperfectly. This is of no consequence if neither performers nor members of the audience are aware of the discrepancy. However, difficulties may arise if a listener's capacity for long-term pitch judgements is more highly developed than the performer's, for although long-term variations in pitch do not affect the recognition of a piece, they may be aesthetically disturbing. The surprising thing is that, despite few people ever being likely to discern them, composers have used extended zygonic relationships so widely; suffice to say that connections of this nature lie at the heart of the long-range tonal structures that are typical of much of the Western classical tradition. This points up the distinction between what Lerdahl terms 'compositional grammars' and 'listening grammars' (1988, pp. 233ff): it does not necessarily follow that the organisation conceived by composers will accord with the structure heard by listeners (cf. pp. 254 and 255).

Similar observations apply interterpretively: without being conscious of it, people sing, play and listen to different performances of a piece at differing levels of pitch, according to the fidelity of their long-term pitch memory. If interterpretive differences are detected then, again, these will not affect listeners' ability to recognise a piece, but may be considered less than pleasing in aesthetic terms. For example, if a work is realised a semitone lower than is customary, a keen-eared listener may find this disturbing. Indeed, there are some who claim that keys each have a unique expressive value, qualitatively distinguishing them from one another (see Révész, 1953, pp. 112ff). Hence playing a piece in $D^\flat$ major that was originally written in *D* will substantially alter its character. Against this, consider the position of a composer of such as Bach, who, apparently without complaint, had to contend with at least three different basic pitches: the *Kammerton*, for domestic instrumental use; the *Chorton*, which was used for church organs and, as a result, for sacred choral music (although apparently even this was variable from one church to another); and the *Cornett-ton*, which was characteristic of the brass instruments used by the town musicians (Apel, 1969, p. 678). Consider also the age-old practice of transposition, a particular feature of vocal performances, where a suitable shift in pitch is generally held to be perfectly acceptable in order to accommodate the particular range of a singer.

The influence of instruments that are tuned to fixed values is twofold. First, they ensure that pitches are realised with a consistency better than performers could manage unaided. Consider Bake's comments concerning Indian music, in which everything points to the fact that

> pitch was strictly relative and had no connexion with the names of the notes separately. The tendency to identify *sa* with *c*, very general in our days, cannot be much more than fifty years old and dates especially from the introduction and virulent spread of the portable harmonium through towns and villages (1957, p. 211).

Second, in ensembles, fixed-pitch instruments demand a higher degree of fidelity than players and singers can achieve unassisted, both between different renditions of the same piece and between those of separate works. Hence if the voice enters before a fixed-pitch instrument, a discrete pre-performance hint may well be needed to make sure the singer is on precisely the right track.

Then, consider the following account by Schneider (1957, p. 3):

> In the Solomon Islands, when an invitation is sent out to a neighbouring tribe it is customary to send the measurements of the tribal panpipes so that the guests can tune theirs beforehand, thus ensuring the greatest agreement in the mutual musical greeting.

In the West, as music using similar groups of instruments became more cosmopolitan, so did the need for a wider 'standard' pitch, although it was not until 1939 that the level of $a' = 440$Hz was universally adopted by the International Standards Association.

Very occasionally, composers exploit extramusical canonic ordering of individual pitches. An example occurs in the last movement of Smetana's string quartet in *e* minor, *From my Life*, of 1876, where a sustained seventh octave *e*, we are told, derives from the tinnitus that afflicted the composer at the onset of his deafness (Large, 1970, p. 318), although it is not clear just how faithful the imitation is.

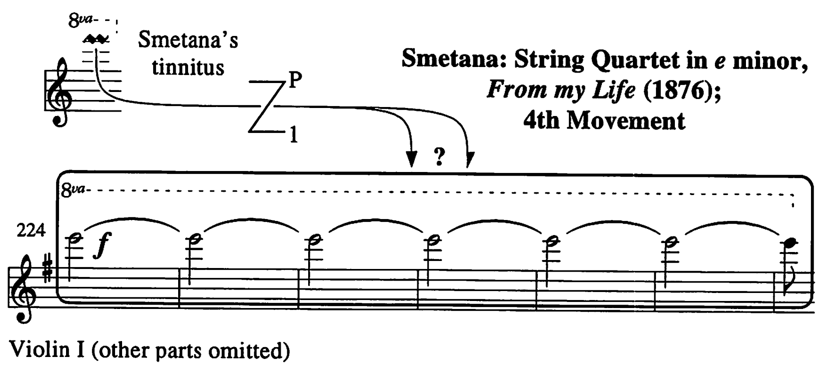


Figure 10.6 The extramusical imitation of a single perspective value of pitch.

In any event, the general musical importance of such procedures would appear to be negligible.

Pitch constants ii: interprotractive secondary zygonic organisation and that of higher ranks—some preliminary comments

Even a relatively short piece, such as Chopin's prelude no. 6 in *b* minor, op. 28 (analysed in perceived temporal terms in chapter 9), comprising only a few hundred notes, potentially harbours many thousands of interperspective relationships of pitch. These may be itemised in the form of a **primary interperspective pitch set**. See figure 10.7 (cf. figure 9.48). Not all these intervals need concern us here, however, and we will focus on those that are perceptually prominent, a quality achieved largely through the perceived

Chopin: Prelude Op. 28, No. 6

perfect unison	perfect octave	augmented 15th
augmented unison	augmented octave	minor 16th
doubly augmented unison	diminished 9th	major 16th
diminished 2nd	minor 9th	augmented 16th
minor 2nd	major 9th	minor 17th
major 2nd	augmented 9th	major 17th
augmented 2nd	diminished 10th	augmented 17th
diminished 3rd	minor 10th	perfect 18th
minor 3rd	major 10th	augmented 18th
major 3rd	augmented 10th	doubly augmented 18th
augmented 3rd	diminished 11th	diminished 19th
diminished 4th	perfect 11th	perfect 19th
perfect 4th	augmented 11th	augmented 19th
augmented 4th	doubly augmented 11th	minor 20th
doubly augmented 4th	diminished 12th	major 20th
diminished 5th	perfect 12th	augmented 20th
perfect 5th	augmented 12th	minor 21st
augmented 5th	diminished 13th	major 21st
diminished 6th	minor 13th	perfect 22nd
minor 6th	major 13th	augmented 22nd
major 6th	augmented 13th	minor 23rd
augmented 6th	diminished 14th	major 23rd
diminished 7th	minor 14th	minor 24th
minor 7th	major 14th	major 24th
major 7th	augmented 14th	perfect 25th
augmented 7th	diminished 15th	augmented 25th
diminished octave	perfect 15th	perfect 26th

Figure 10.7 Primary interperspective set of pitch.

temporal adjacency of the values that are linked. Typically, such proximity may take the form of simultaneity, as in a chord, or successivity, as in a tune, forming respectively 'harmonic' and 'melodic' intervals.

It is widely recognised that in many cultures the octave, the perfect fifth and the perfect fourth, or at least intervals that closely approximate to them, are accorded a privileged harmonic status (see, for example, Sloboda, 1985, p. 254). The fact that these differences in pitch correspond to those found at the lower end of the harmonic series is broadly accepted too, although there is no consensus as to the significance of this correlation. In terms of the present theory, since the similarity between nature and art is not only indisputable, but beyond the bounds of coincidence, then the intervals in question must ultimately be ordered through extramusical zygons.

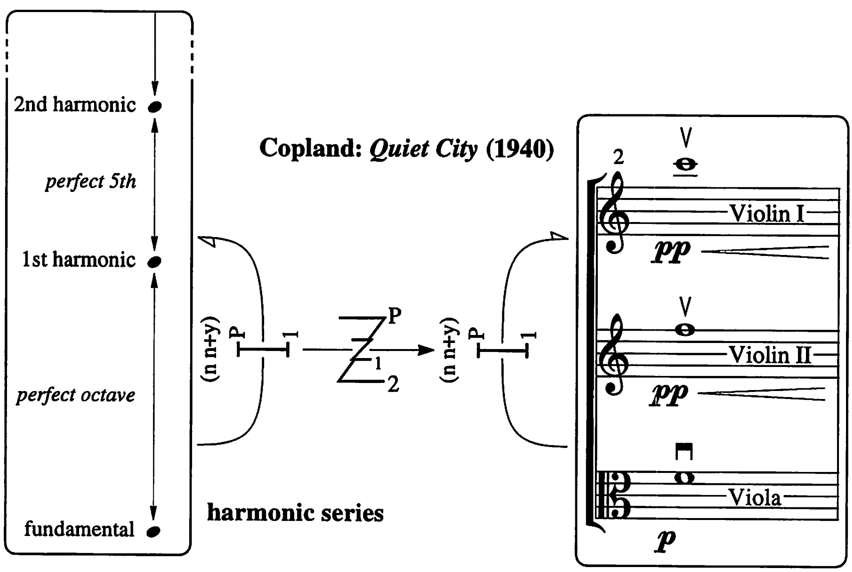


Figure 10.8 Derivation of harmonic intervals from the harmonic series through a primary zygosequential secondary zygonic invariant of pitch.

Since these intervals are used time and again by composers, this external ordering is subject to continual intramusical reinforcement.

Melodically, small intervals occur much more frequently than large ones. This tendency is confirmed by many studies, particularly of various Western *genres*, ranging from folksongs (see Nettl, 1965/1973, p. 42; Dowling, 1978, pp. 351 and 352), to many styles of classical music (Ortmann, 1926, pp. 27ff; Fucks, 1962) and to popular music of the twentieth century (Jeffries, 1974, p. 904). According to Shepard (1982, p. 376),

> The reason for the preponderance of small melodic intervals seems to be that the perceptual integration of successive tones into a coherent unit depends especially strongly on proximity in pitch height,

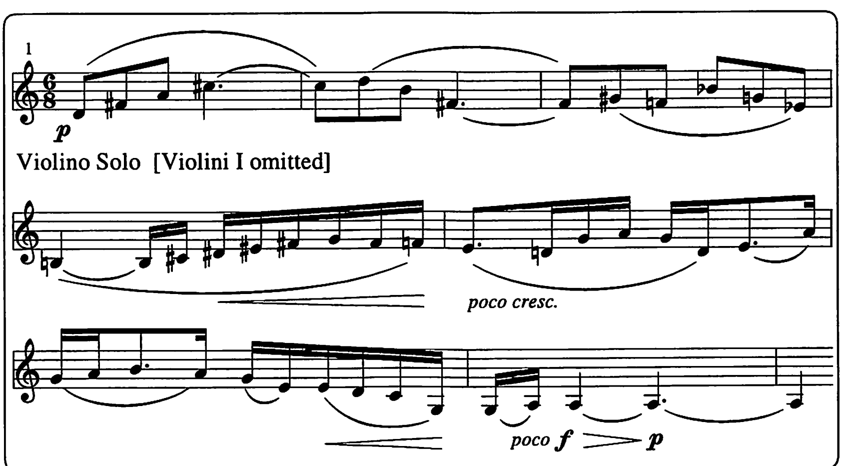
a view strongly supported by research such as that by Miller and Heise (1950), Bregman and Campbell (1971) and Deutsch (1978). That this principle is not inviolable, though, is recognised by Spender (1983, p. 280), who observes that

> However strong the psychoacoustic influences on melodic tracking may be, they can at times be overcome by musical grammar.

The fact that composers tend to choose small intervals between sequentially adjacent notes can be interpreted canonically, whereby each interperspective value of pitch may be thought to be zygonically related to the one preceding.[1] For example:

Bartók: Violin Concerto No. 1

Andante sostenuto (♪ = 72–76)



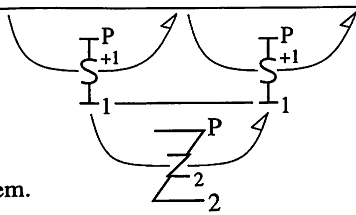


Figure 10.9 Series of intervals ordered through a secondary zygosequential imperfect zygonic constant system.

[1]Vos and Troost's (1989, pp. 383ff) finding that smaller intervals tend to occur in descending form while larger ones are inclined to be ascenders, means that the degree of imperfection of zygonic connections is in general terms tied in with their polarity.

An alternative, primary zygonic, interpretation exists as follows:

Bartók: Violin Concerto No. 1

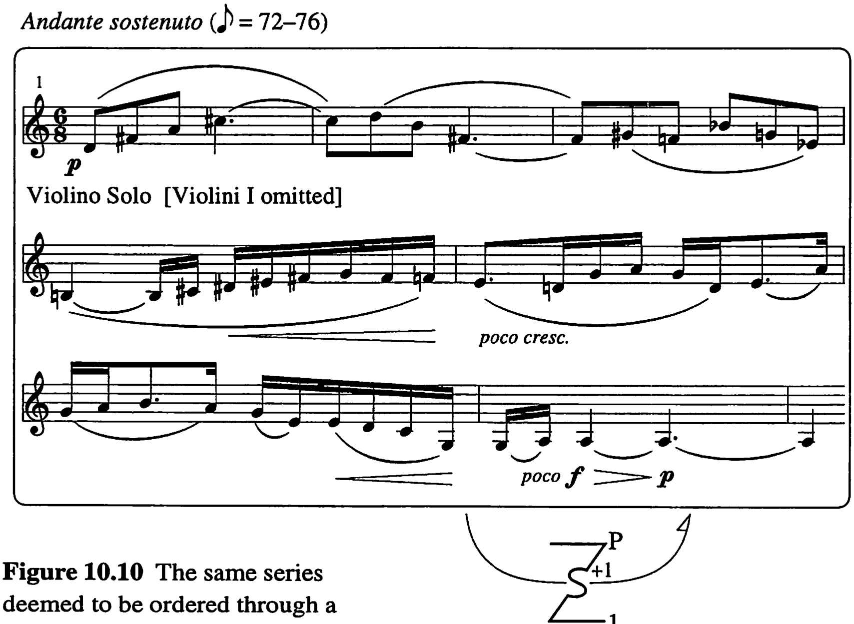


Figure 10.10 The same series deemed to be ordered through a primary zygonic imperfect invariant system.

(The fact that many of the relationships between non-consecutive notes can also be heard in this way is considered below—see p. 514.)

These analyses, however, leave unanswered the question of why specific intervals occur—the studies cited on p. 460, for example, point to a preponderance of unisons, major seconds and minor thirds. Theorists from Schenker (1906/1954, pp. 21–44) and Schoenberg (1911/1978, pp. 23–25) to Hindemith (1937/1945, pp. 14ff) and Bernstein (1976, pp. 16ff) attribute scalic intervals such as these to the overtone system. Such hypotheses have been criticised for two main reasons, however: first, since each requires manipulation of the harmonic series; and second, because they lack universal applicability (see, for example, Lerdahl and Jackendoff, 1983, pp. 290–293). Still, it is undeniable that a resemblance exists, and extramusical zygonic relationships may reasonably account for the order that is implied.

The fact that music tends to be saturated with only a few different intervals between consecutive notes indicates, according to the present theory, the agency of secondary zygonic constant systems of pitch, both

H. Lawes: *Wert thou yet fairer than thou art* (1659)

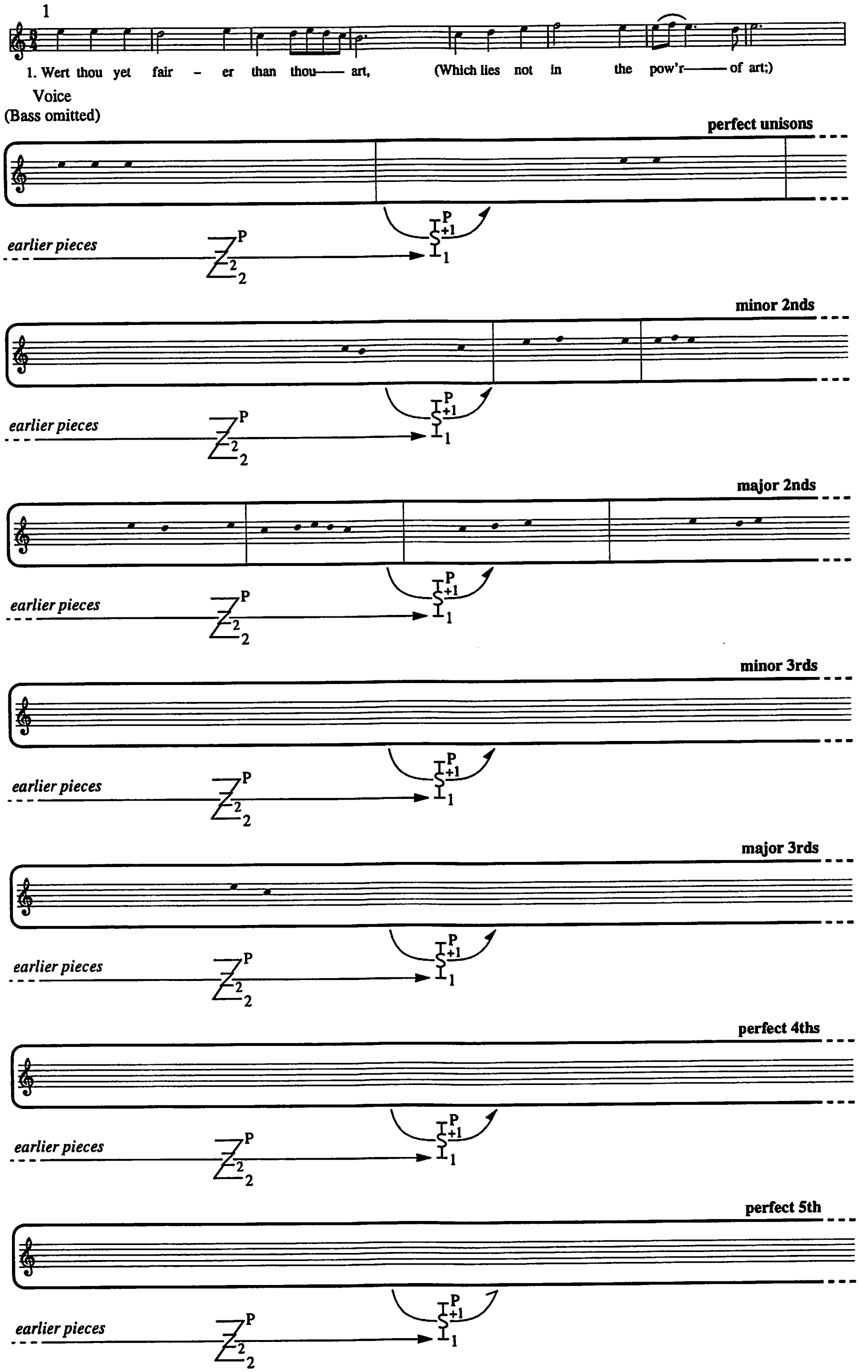


Figure 10.11 (part i) The ordering of successive pitches in a melody through perfect secondary zygons of interval magnitude.

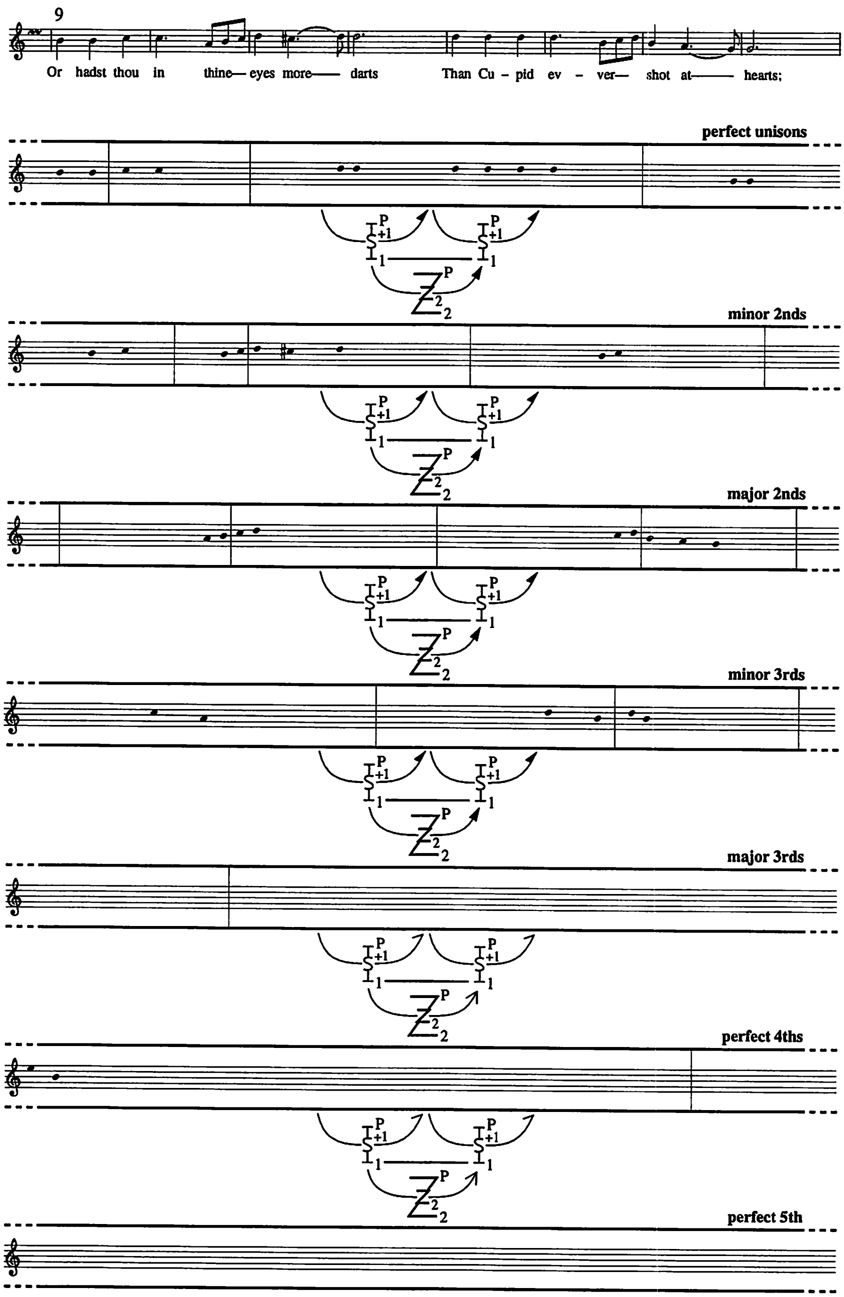


Figure 10.11 (part ii)

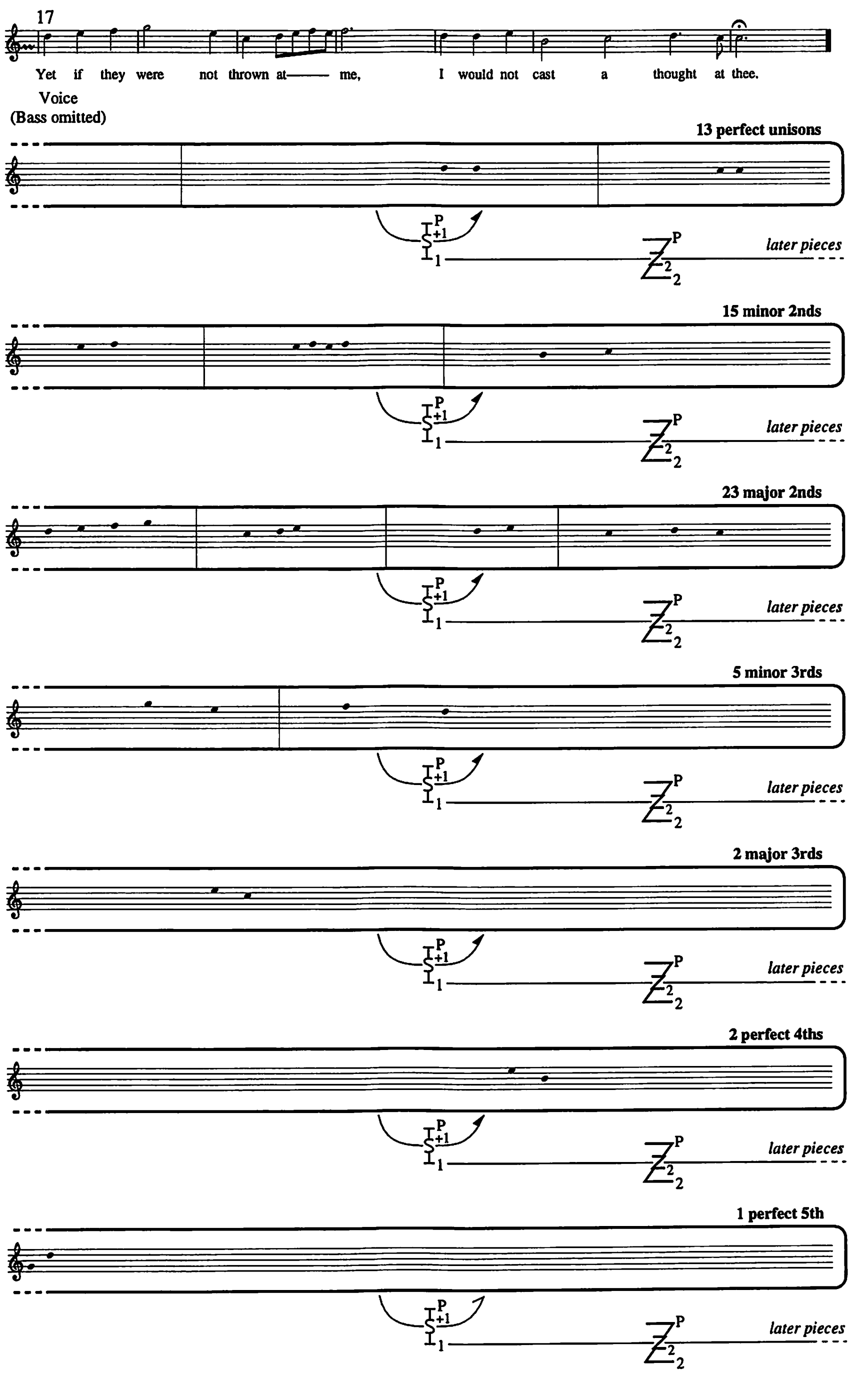


Figure 10.11 (part iii)

intraoperative and interoperative. Consider, for example, the melody by H. Lawes cited in figure 10.11, which, comprising 62 notes, nevertheless uses only seven different intervals between successive pitches, approximately 84% of which are perfect unisons, minor 2nds, major 2nds or minor 3rds.

Variables of pitch and their organisation

Constant change in pitch implies the existence of a uniform secondary intraprotractive (or intracontinuous) zygonic constant system. For example:

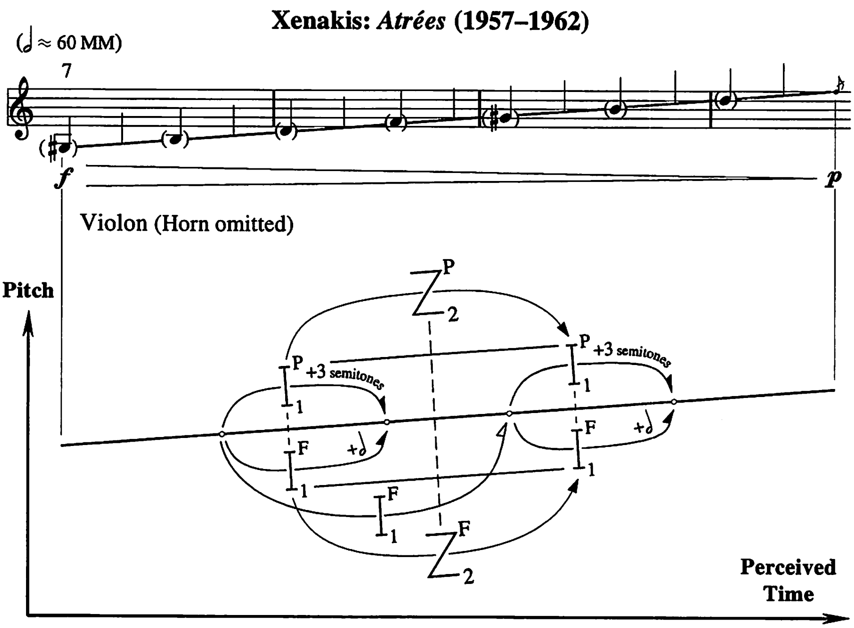


Figure 10.12 Uniform secondary zygonic constant system of pitch.

Where one constant variable of pitch is deemed to exist in imitation of another, the operation of a uniform primary zygonic invariant is indicated. The rate of constant change alone may be imitated through the agency of a uniform secondary zygonic constant. Both types of organisation occur in the opening bar of *Shaar* by Xenakis (1982); see figure 10.13.

The differences between two constant rates of change may be the same, and considered to be so as a result of zygonic ordering (figure 10.14). An alternative interpretation exists in terms of a uniform tertiary zygonic constant (figure 10.15). Either interpretation reflects organisation conceived during the process of composition rather than that which may typically be perceived by listeners.

Transformations such as inversion and retrogression are occasionally encountered too. See, for instance, figures 10.16 and 10.17.

Xenakis: *Dikhthas* (1979)

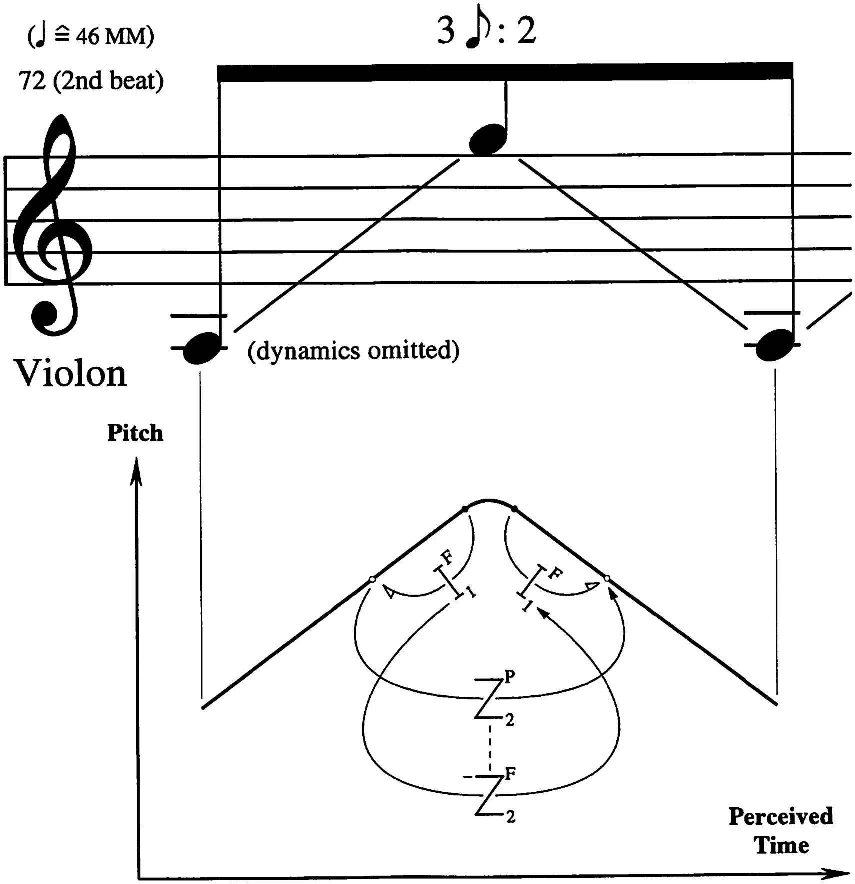


Figure 10.17 Retrograde primary zygonic invariant of pitch.

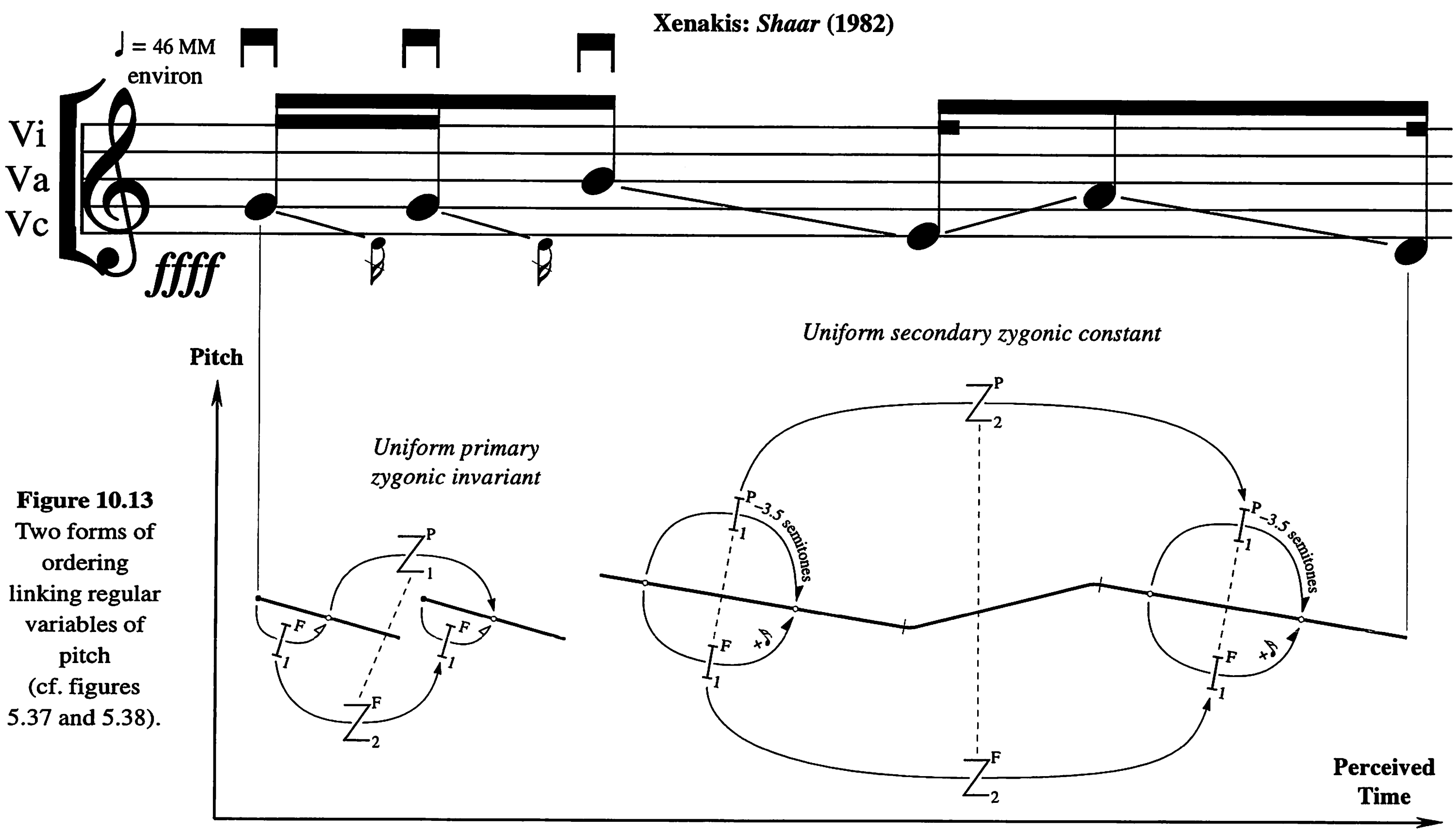
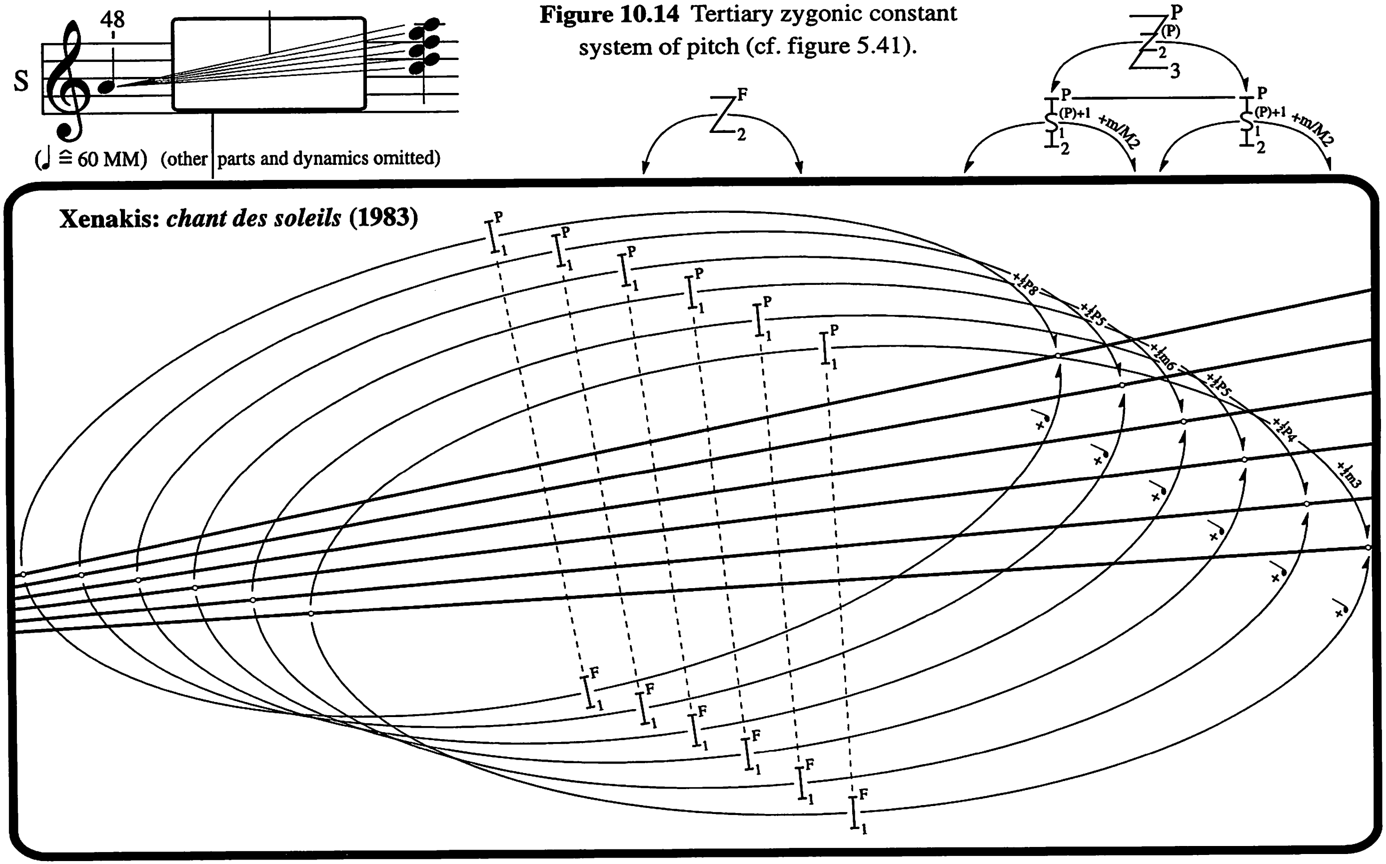


Figure 10.13
Two forms of ordering linking regular variables of pitch (cf. figures 5.37 and 5.38).

Figure 10.14 Tertiary zygonic constant system of pitch (cf. figure 5.41).



Xenakis: *chant des soleils* (1983)

(♩ ≘ 60 MM)

(other parts and dynamics omitted)

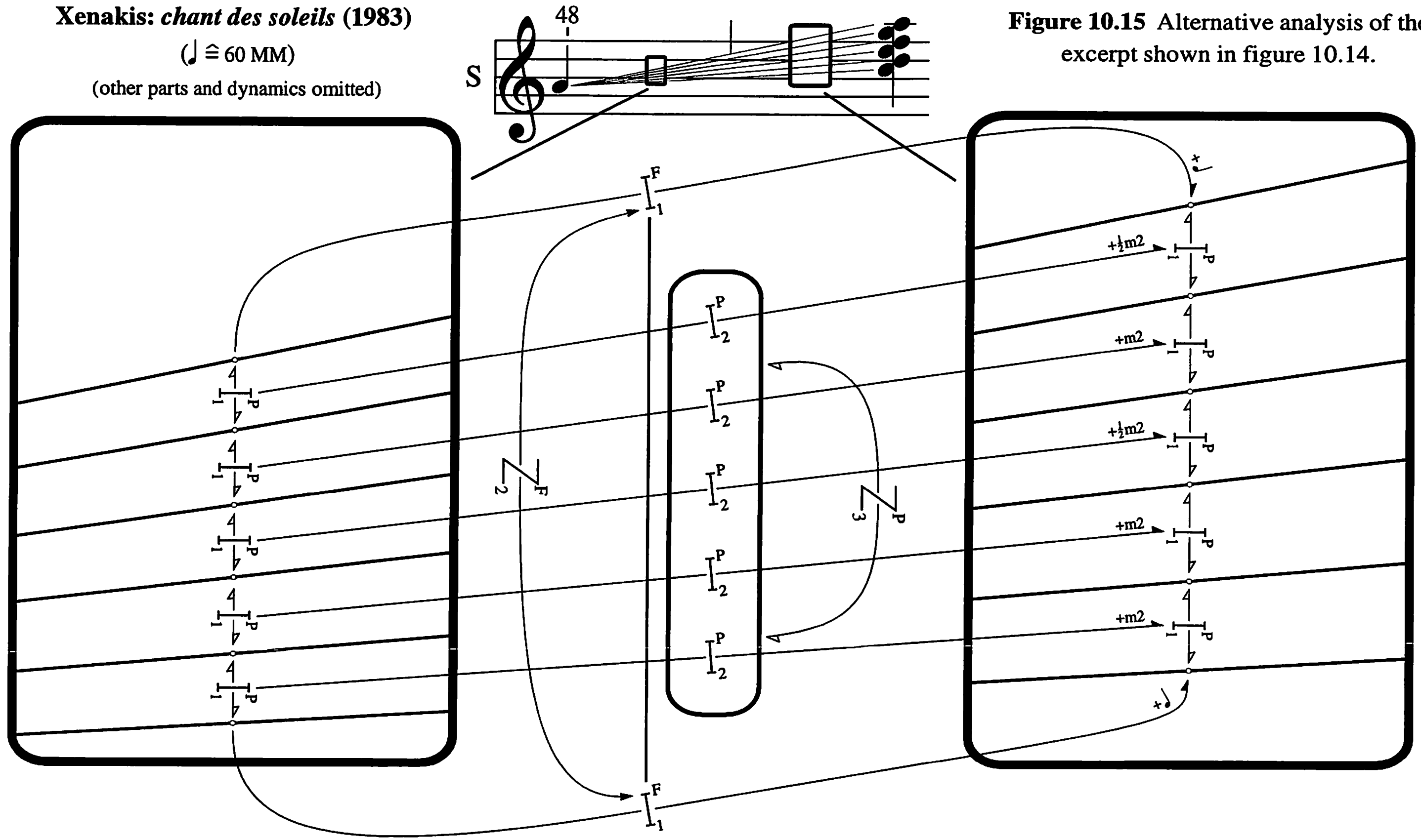


Figure 10.15 Alternative analysis of the excerpt shown in figure 10.14.

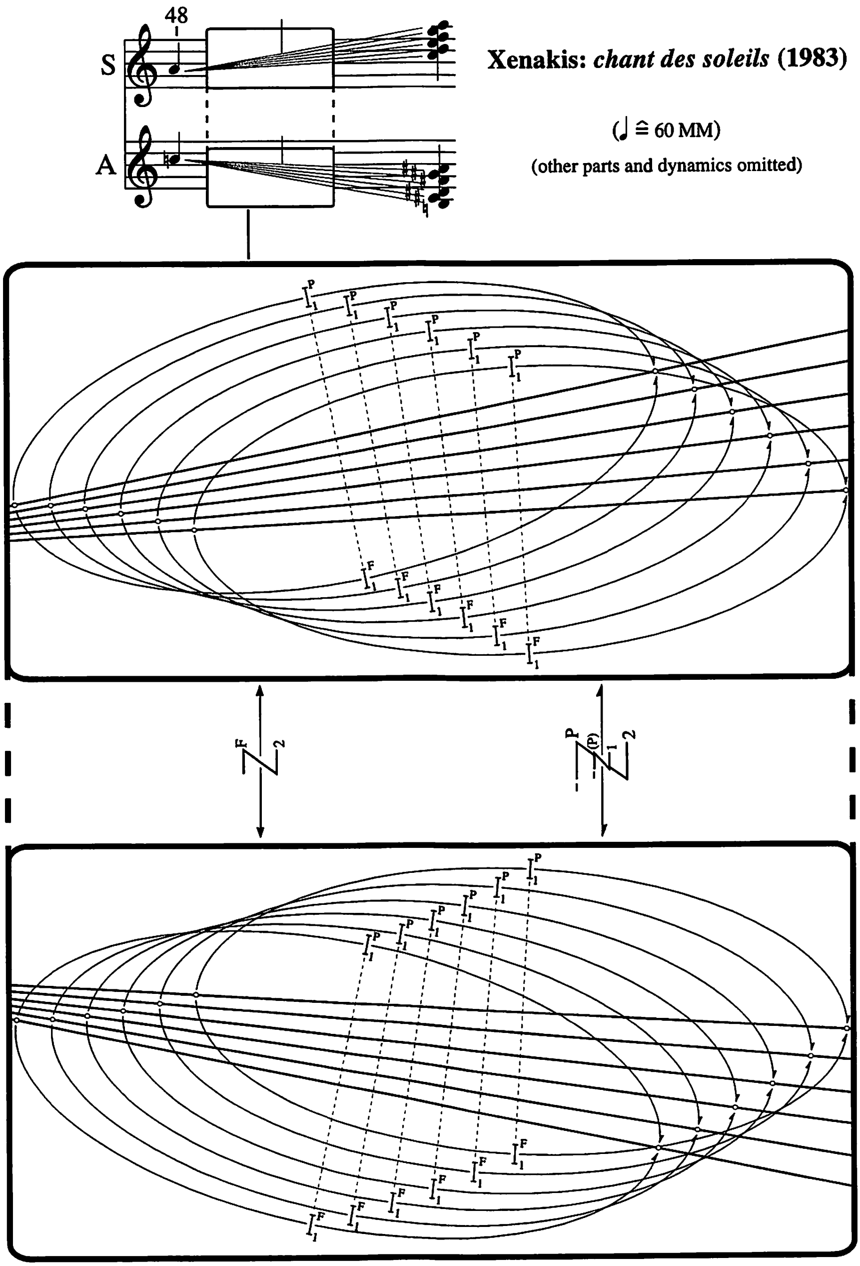


Figure 10.16 Inverse secondary zygonic invariant system of pitch.

Primary interperspective pitch and pitch-class sets: introduction

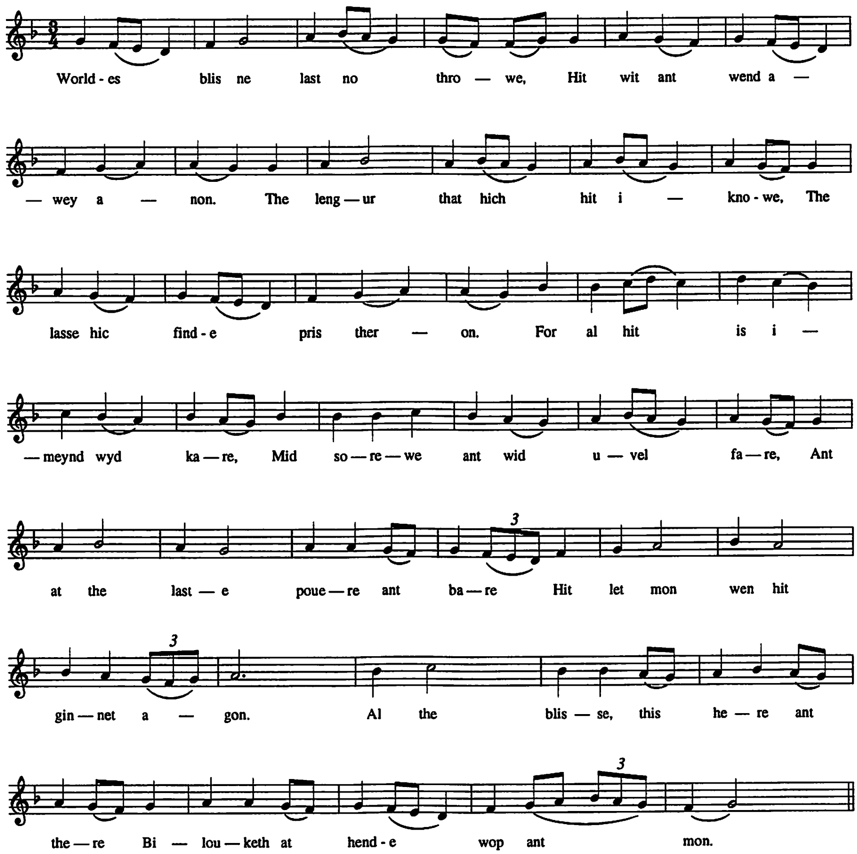
We begin by investigating the organisation pertaining to the sets of pitches used in whole pieces or sections. It seems likely that, from the earliest times, the creation of new works entailed utilising melodic fragments taken from other pieces (see pp. 233ff). Since people's long-term memory for perspective values of pitch tends to be comparatively poor (pp. 41 and 42), this translocation of material would normally have occurred on an intervallic level, through primary zygosequential secondary zygonic invariants (cf. figure 6.60). Had interoperative links of this nature not been forged, then the pitch structure of each composition would necessarily have been unique, an inconceivable state of affairs. It is reasonable to assume that some snatches of melody found wider service than others, while a few became well-established members of a general fund of ideas to which musicians were inclined to turn time and again. Today, theorists refer to the members of such a stylistic repertory as 'melodic formulae' (see, for example, Apel, 1969, p. 519).

In some cultures, it appears that melodic formulae were not just transferred from piece to piece individually, but in groups; evidently certain combinations were judged to be more fitting than others. Aggregations of this sort are known as 'melody types' (Apel, ibid.). One of the reasons for the alliance of a particular body of melodic formulae seems to have been that they shared the same primary interperspective pitch set (that is, the values of pitch employed in a piece or section assessed in relation to one another, rather than in absolute terms—see p. 458). See, for example, figure 10.18.

A number of different cultures have used, and some continue to use, melody types as the basis for the creation of new pieces. Examples range from the eight 'echoi' of ancient Byzantine chant (Wellesz, 1949/1961, p. 44), a classification that continues to apply in the Armenian, Russian and Serbian churches (Apel, op. cit., p. 251), to the ragas of Indian music, each of which may be defined as

> a fusion of scalar and melodic elements (Jairazbhoy, 1971, p. 28).

According to Becker (1969), much the same principle underlies the pitch structure of Burmese classical music. Iranian melody types are known as

Anon: *Worldes blis ne last no throwe* (13th century)

has the following primary interperspective pitch set:

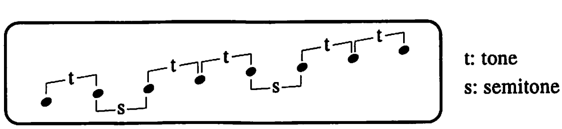


Figure 10.18 Example of primary interperspective pitch set.

'dastgah-ha' (see Zonis, 1973, pp. 44ff), while the term 'maqamat' is used in other Islamic countries (Malm, 1977, p. 72). In some cultures, however, while melodic formulae are still much in evidence in many musical genres, their influence is now less all-pervasive. As Reese (1940, p. 164) puts it:

> musicians find it possible to preserve modal character without adhering slavishly to formulas only.

Hence, within the constraints imposed by a given primary interperspective pitch set, original tunes have been composed and new melodic formulae have arisen. In the words of Balzano (1982):

> Just as the desired movement of a melody over time shaped the character of these pitch set materials, so it was found that the character of the pitch set in turn shaped the perceptible quality of its melodies (p. 348).

The primary interperspective pitch sets that are generally used by analysts, such as the one illustrated in figure 10.18, often represent an idealised version of the values that actually occur in performance. Certain discrepancies may be incurred, for instance, through the use of different tuning systems: in the West, for example, various forms of temperament have seen service over the years (cf. p. 47; Barbour, 1951). However, it seems that microtonal divergencies of this type often go unrecognised (cf. Ward and Martin, 1961). As Sloboda (1985, p. 85) says:

> Under 'ideal' conditions a listener may, indeed, be able to detect certain small differences in ... tuning, but in the welter of a complex musical event discrimination may be much poorer.

This perceptual indifference is compounded, no doubt, by listener's tendency to 'categorise' familiar intervals. Hence, the fact that certain of the primary interperspective pitch sets quoted in the present work only approximate to performance values is immaterial insofar as these are a fair reflection of what is modelled cognitively. However, there are some listeners for whom such constructs are inadequate: consider, for example, the position of the harpsichord tuner, who may be required to produce particular temperaments according to the stylistic milieu of the pieces to be played. Here, intonational differences assume an overriding importance.

Primary interperspective pitch sets can reflect other forms of cognitive processing too. For instance, only those pitches functioning at or above a particular structural level need be itemised. Consider, for example, the variations in value that are characteristic of all vocal performances and those using instruments of variable pitch (see, for instance, Seashore, 1938, pp. 254ff), and which, indeed, form an intrinsic feature of certain styles. In contexts such as these, although sub-semitonal data are a prerequisite of primary interperspective pitch sets that purport to be comprehensive, microtonal inflections may be ignored, and only the 'focal' values included.

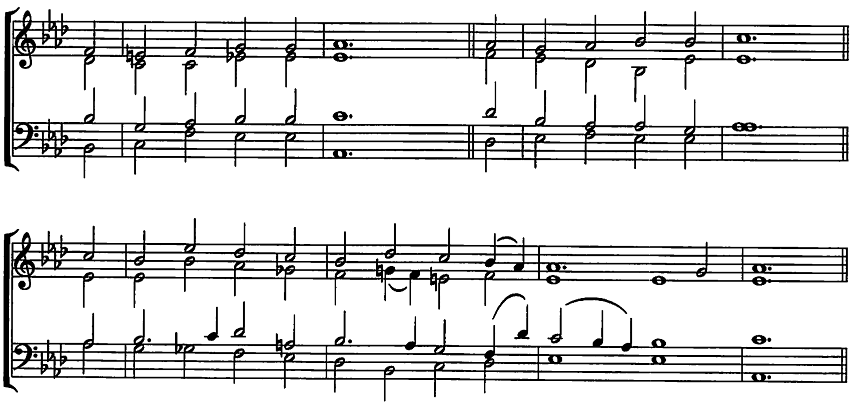
Similar principles apply to the many pieces in which listeners' hierarchical conception of pitch extends to higher strata, and analysts may choose to indicate the comparative structural weight of the relative pitches that are shown. For example, an inventory may be made of the values used 'at the level of diatonic consonance'. In addition, chromatic ornamentations may be detailed if required. See, for instance, figure 10.19. Although a bimodal distinction is drawn here, several differing structural weights can be shown by using a series of durations.[2]

While there are exceptions (such as the choral songs of Central Australia, described by Ellis, 1965), it is a feature of many primary interperspective pitch sets that their values repeat at the octave. This is reflected in the fact that pitches displaying octave equivalence are given the same letter name or number, a cross-cultural characteristic of music theory. Similarly, in considering the pitches used within a piece or section, it is customary to adopt a conceptual abbreviation whereby values are relocated, if necessary, so as to fall within the range of a single octave. These values may be referred to as a **primary interperspective pitch-class set** (cf. Forte, 1973, p. 1). See, for example, figure 10.20. Inevitably, the economy of expression gained through this procedure has a cost—the loss of information concerning range and register.

In the literature on tonal music, primary interperspective pitch-class sets are frequently arranged in ascending order with the tonic lowermost (cf. pp. 494 and 495), thereby forming 'scales' or 'modes'. Such arrangements are equivalent to 'end-on' views of the helical model of pitch perception shown in figure 3.9, eliminating the element of 'height' and leaving only 'chroma'. This correspondence implies that primary interperspective pitch-class sets (at any event, those in scalar form) have an inherent perceptual validity[3]—an important consideration in the section that follows.

[2]Cf. the notion of 'weighted scales'—see p. 156.

[3]Cf. the procedures for deriving and manipulating primary interperspective pitch-class sets such as those described by Forte (1973, pp. 3 and 4); after Babbit, 1961, and Teitelbaum, 1965, whose perceptual relevance for most listeners is highly questionable. (In order to facilitate comparison, sets are reduced to 'normal order', 'prime form', a procedure that maximally compresses sets—so that the interval between top and bottom notes is the least possible—and then assigns '0' to the lowest value, using the system of numerical notation associated with serial analysis, whereby the twelve notes of the ascending chromatic scale are each given a number from 0 to 11.)

Luard-Selby (1853–1918): *Eccles*

has the following primary interperspective pitch set:

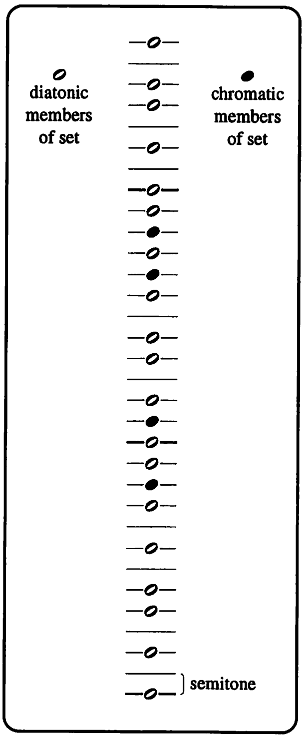
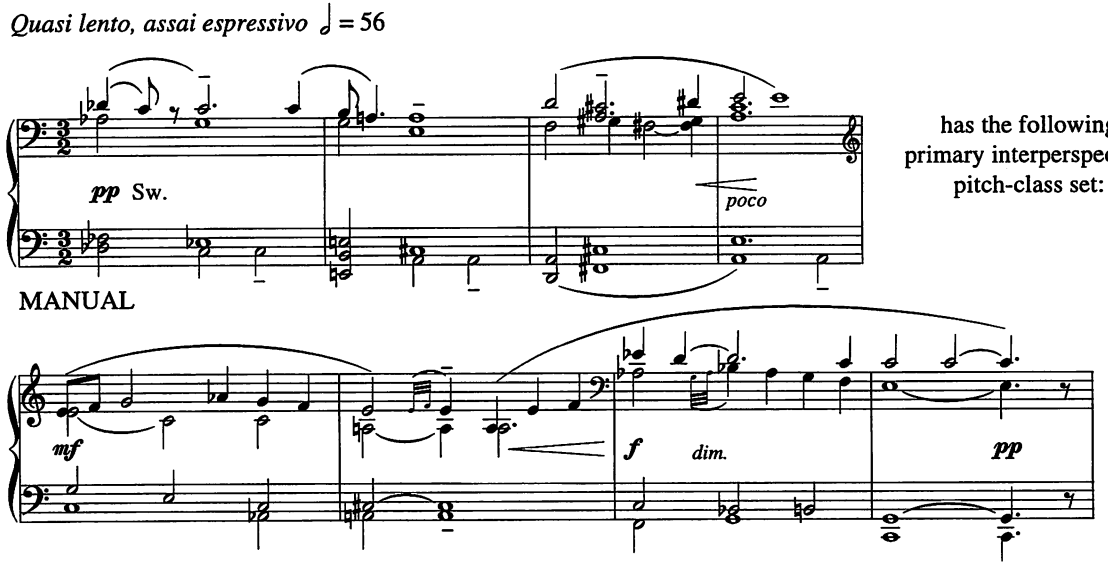


Figure 10.19 Interperspective pitch set which distinguishes between diatonic and chromatic members.

Howells: *Six Pieces for Organ* (1953); No. 5, *Saraband*

has the following primary interperspective pitch-class set:

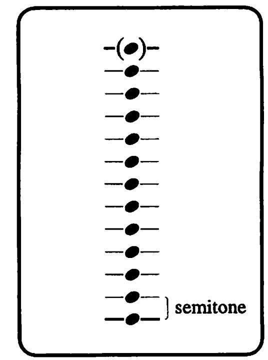


Figure 10.20 Primary interperspective pitch-class set.

Primary interperspective pitch and pitch-class sets: principles of organisation

A basic quality of primary interperspective pitch and pitch-class sets is their number of members. Although it is conceivable, in liturgical chants, for example, that one pitch alone may be used, it seems that even the simplest melodies, such as those found among the Botocudos in East Brazil, employ at least two distinct values (see Sachs, 1943, pp. 31 and 32). Songs with three different notes figure in many repertories. Indeed, according to Nettl (1965/1973, pp. 44 and 45), the music of certain tribal cultures, as performed in previous times by the Vedda of Ceylon, for instance, and the last member of the Yahi Indians, Ishi, hardly extends beyond these tight confines, although an additional fourth or fifth note does occasionally appear. Moreover, it seems that tritonic songs are produced by children in many cultures (see Hargreaves, 1986, p. 68). Primary interperspective pitch sets and (where melodies extend beyond the confines of a single octave) pitch-class sets of five notes are characteristic of folk music across the world: for example, Chinese, Japanese, Polynesian, African, European and American Indian (see Apel, 1969, pp. 652 and 653). Pieces constructed heptatonically are widely distributed as well: from Java and Bali (see Picken, 1957b, p. 166; McPhee, 1966, pp. 36–55), for instance, to India (Daniélou, 1943, pp. 108ff); from Iran (Zonis, 1973, p. 53) to Israel (Idelsohn, 1944, p. 50); and from Africa to Europe and America (Nettl, op. cit., p. 143). Finally, consider how rarely even contemporary Western music uses primary interperspective pitch-class sets with more than twelve notes (although a number of composers such as Ives, Hába, Carrillo and Boulez have contributed pieces to the microtonal repertoire).

Why are such stringent restrictions should be adhered to so widely? One theory is that

> The use of a relatively small number of discrete pitch relationships in music is probably dictated by inherent limitations on the processing of high information-load stimuli by human sensory systems. (Burns and Ward, 1982, p. 264)

Dowling (1978, p. 343) links the frequent use of five or seven distinct scale steps per octave to Miller's (1956) observations regarding people's limited ability to make categorical judgements, although this connection is roundly criticised by Serafine (1988, pp. 57 and 58) for the oversimplicity of its underlying assumptions. Aside from these hypotheses (whatever their merits), the present theory suggests that so many primary interperspective pitch-class sets are similar in size because of extensive interoperative imitation, operating through perfect and imperfect zygons of number (see figure 10.21). (Observe that this proposition neither supports nor counters the theory that larger pitch-class sets evolved from smaller ones, whereby the heptatonic scale, for example, is seen as a later development of the pentatonic, and so on—for contrasting opinions, see Daniélou, op. cit., pp. 62 and 63, and Meyer, 1956, pp. 132ff.) The range of one primary interperspective pitch set may be considered to exist in imitation of another too. See, for instance, figure 10.22.

We now examine the order pertaining to the intervallic structure of primary interperspective pitch-class sets. It should be appreciated that while the intervals that make up a pitch-class set are the same as those found in the music from which it is derived, there is no guarantee that their relative perceptual priority will be maintained. The most prominent intervals within a primary interperspective pitch-class set are those between sequentially adjacent values.[4] This is borne out by musicians' typical descriptions of scales. For instance, the major mode is customarily defined as eight ascending notes outlined by the intervallic pattern: tone, tone, semitone, tone, tone, tone, semitone. However, in listening to music, it is those intervals that are *temporally* adjacent that are perceptually the most immediate. Although the prominent intervals in a piece and its pitch-class set may well be the same, this need not be the case. Consider, for example, the passage cited in figure 10.23, and its primary interperspective pitch-class set. Upon hearing the melody, it is thirds and fourths that predominate, whereas contemplating the pitch structure as a whole, a major scale is traced out, in which seconds are the main objects of intervallic attention.

As a general rule, primary interperspective pitch-class sets may be related internally through secondary zygosequential imperfect constant systems. These will be zygonic if order through imitation is perceived to operate (figure 10.24). In many cases, though, stricter control than this is present: most sets possess at least two intervals the same between adjacent members. Take, for instance, the anhemitonic pentatonic scale, comprising three major seconds and two minor thirds, and the major scale, made up of five major and two minor seconds. In both cases, a secondary zygonic relationship and a secondary perfect constant system is implied (figure 10.25).

[4]Sequentially adjacent, that is, with regard to pitch.

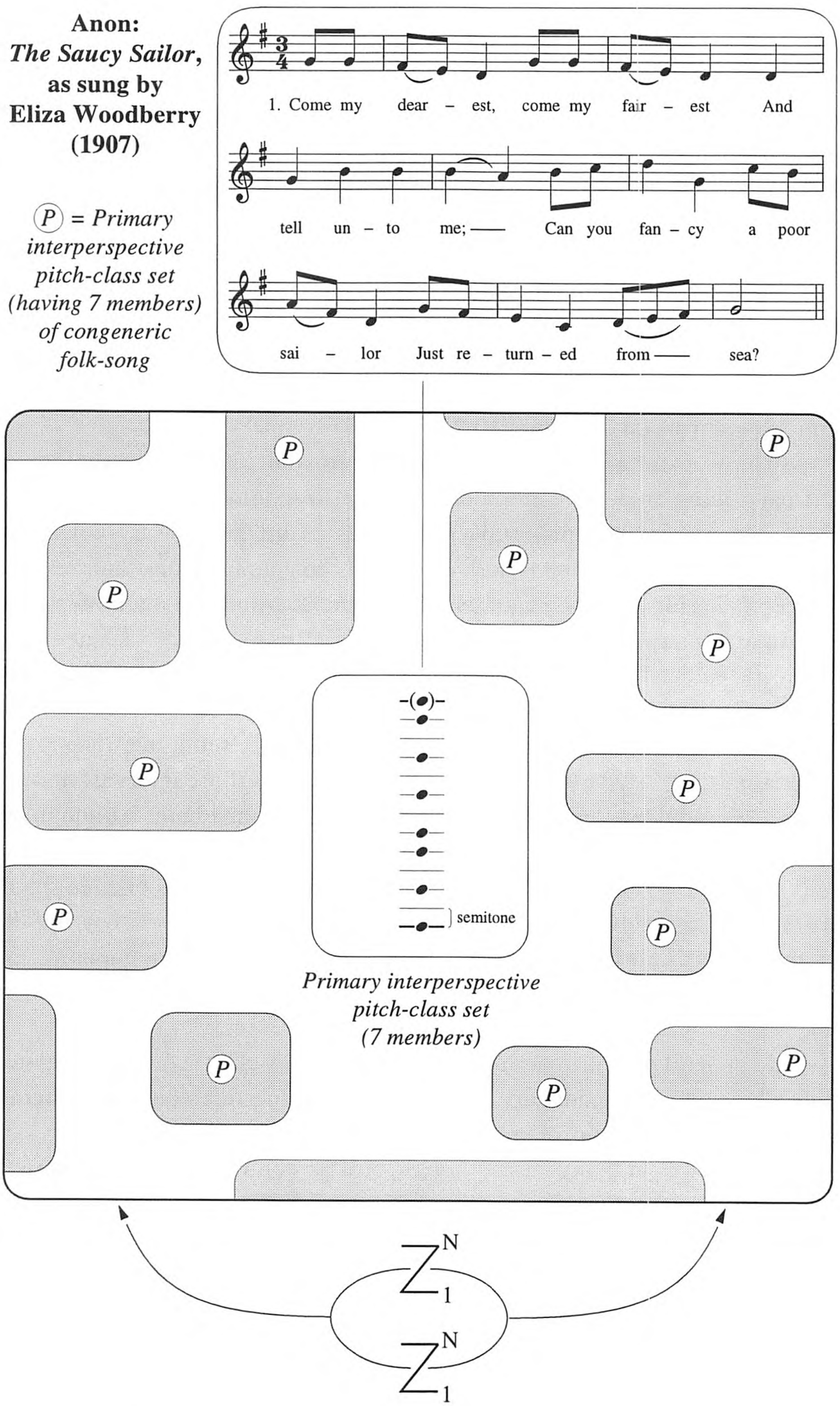


Figure 10.21 Interoperative general zygonic constant of number (pertaining to the primary interperspective pitch-class sets of congeneric folksongs).

Anon: *Veni Creator Spiritus* (8th Century)

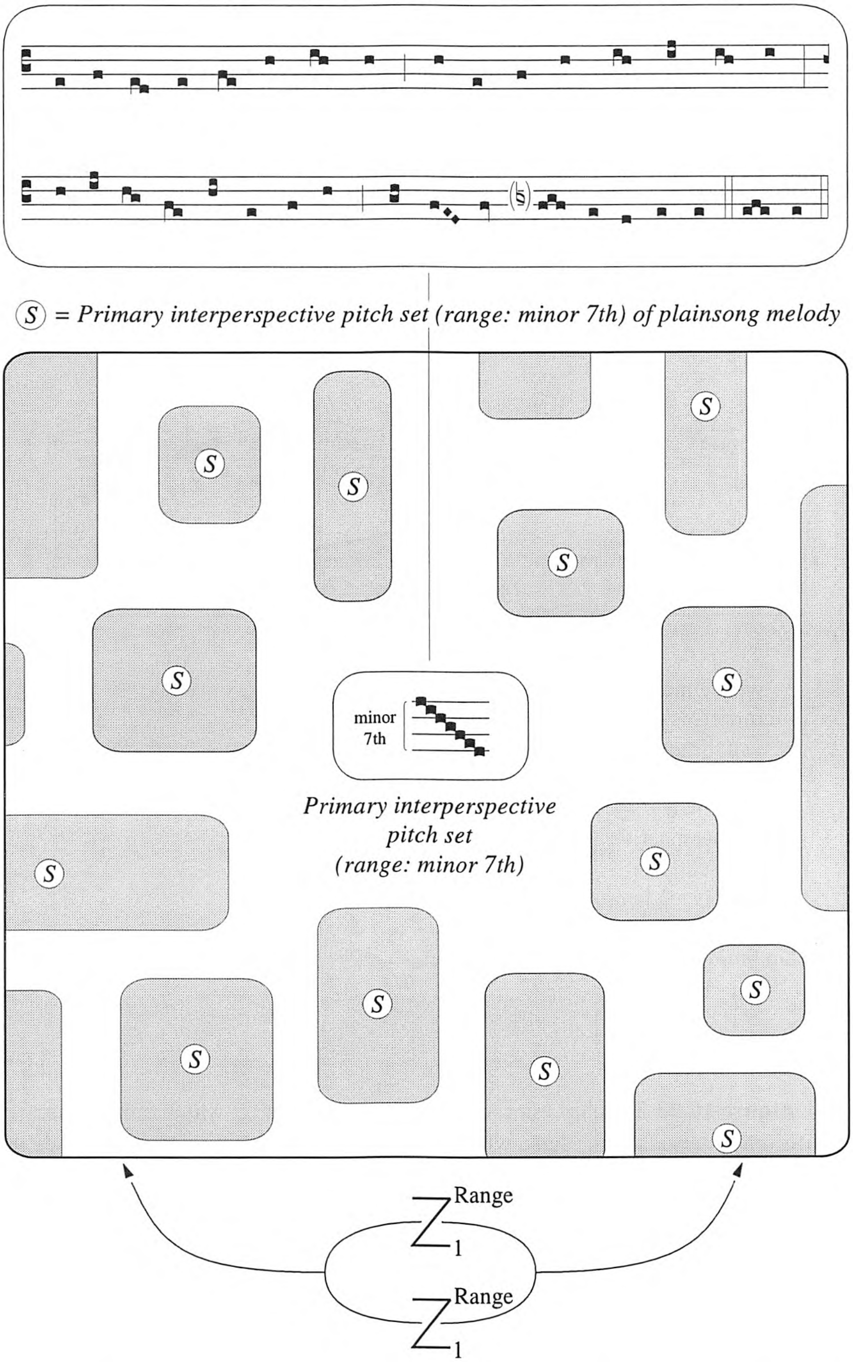
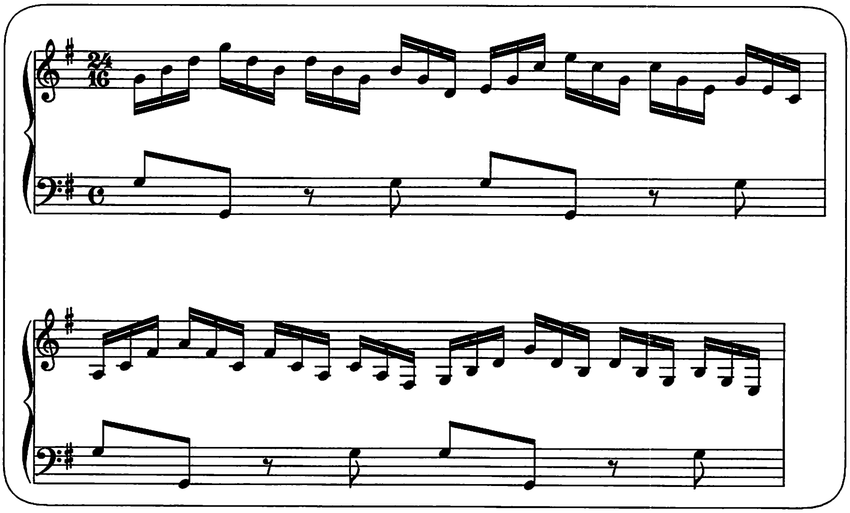


Figure 10.22 Interoperative general zygonic constant of range (pertaining to the primary interperspective pitch sets of different plainsong melodies).

Bach: Prelude and Fugue in *G* major, BWV 860



whose melody comprises thirds and fourths, has the following primary interperspective pitch-class set, which is made up of major and minor seconds:

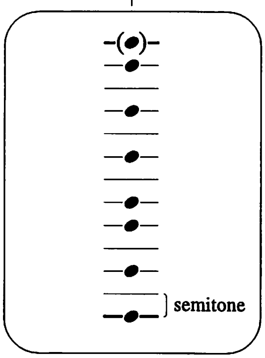


Figure 10.23 Primary interperspective pitch-class set which emphasises different intervals from those which have immediate perceptual prominence in the melody from which it is derived.

Anon: *Frunză verd'i* (Rumanian folksong; in Bartók, 1967)

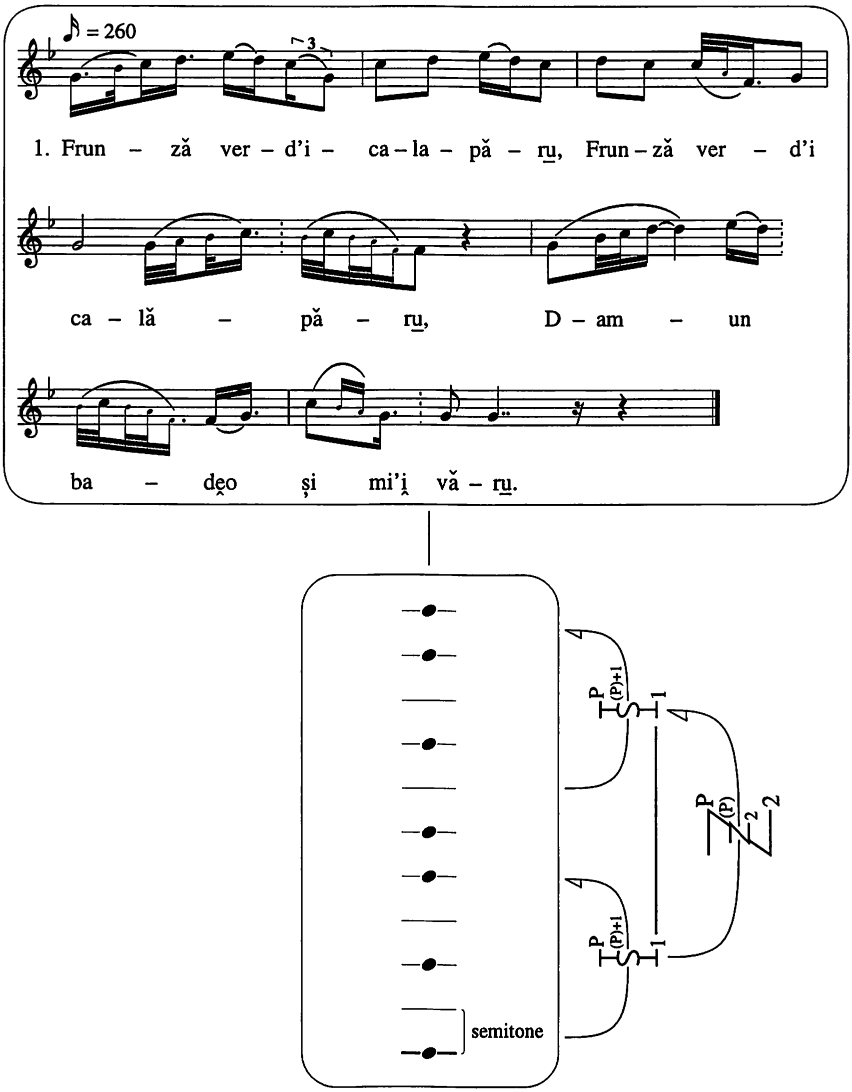


Figure 10.24 Primary interperspective pitch-class set deemed to be internally ordered through a secondary imperfect constant system.

Purcell: Suite I (1696); Prelude

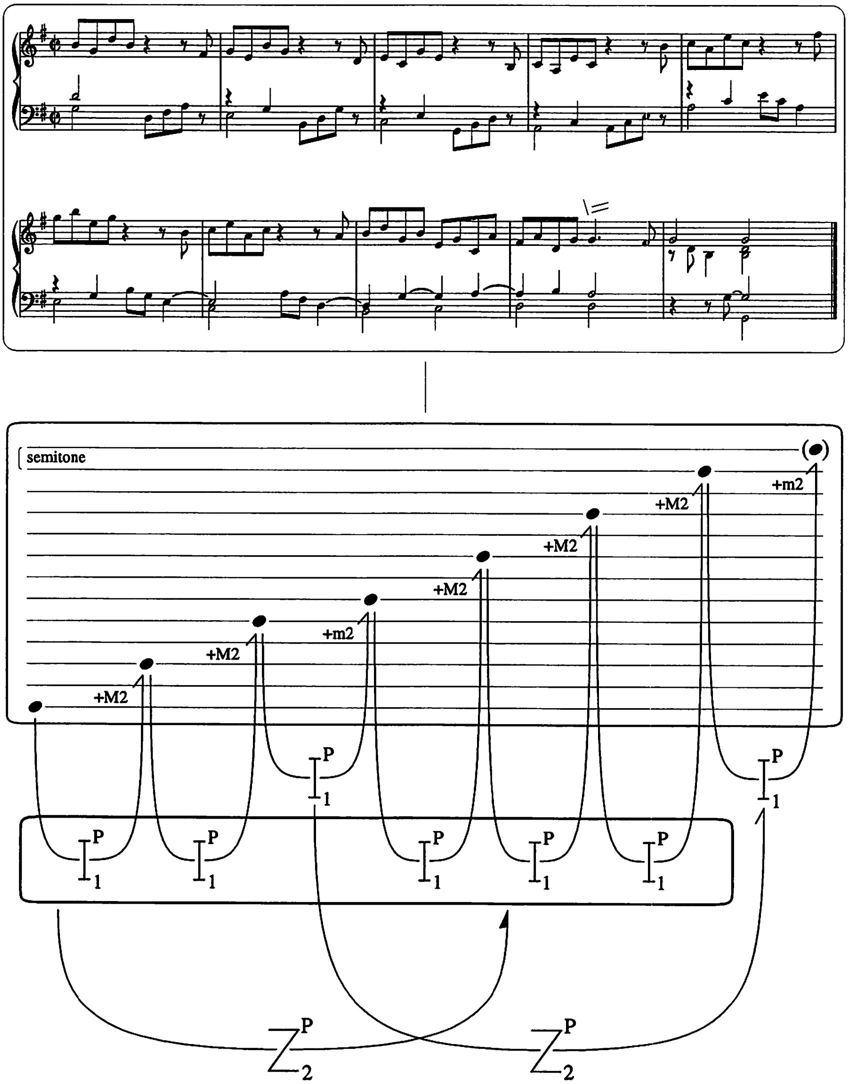


Figure 10.25 The secondary zygonic ordering pertaining to a major scale.

A secondary zygosequential perfect zygonic constant system may apply across an entire primary interperspective pitch-class set. Take, for example, a piece such as the *Klavierstück*, op. 33a, by Schoenberg, whose values of pitch define the equally tempered chromatic scale; see figure 10.26.

It is possible that a primary interperspective pitch-class set may display orderly internal variation, a characteristic of Messiaen's 'modes of limited transpositions' (1944/1957, ch. XVI). Consider, for instance, the second mode—effectively an alternating succession of tones and semitones (op. cit., p. 59), which may be considered to be ordered through a primary zygosequential secondary zygonic constant system:

'Mode 2' (Messiaen)

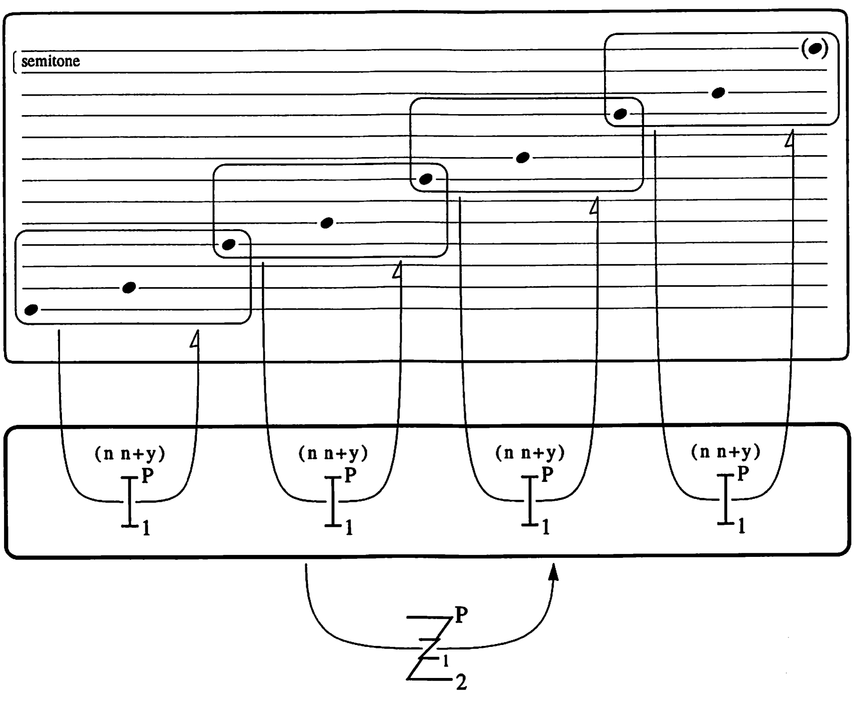


Figure 10.27 The order inherent in Messiaen's 2nd mode of limited transposition.

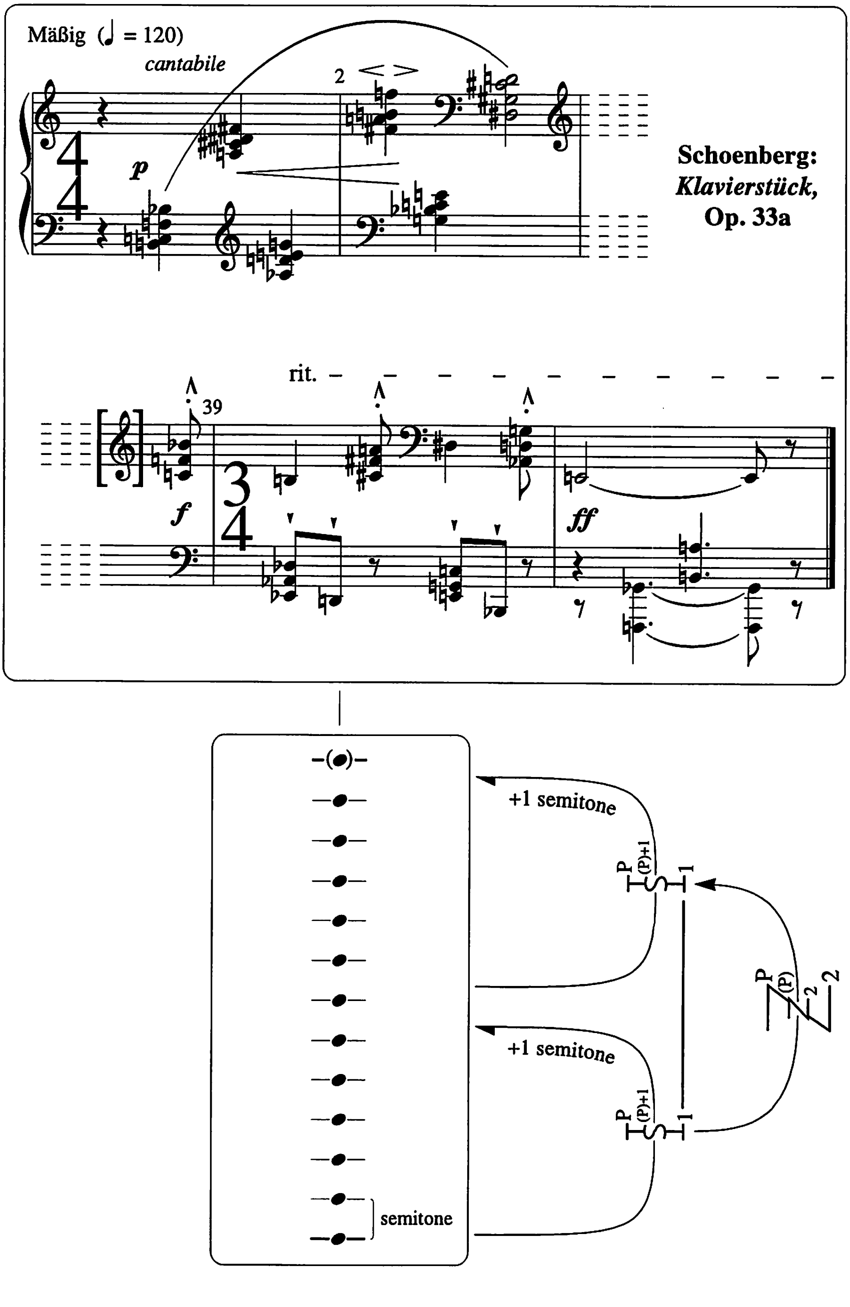


Figure 10.26 Primary interperspective pitch-class set ordered through a secondary perfect zygonic constant system.

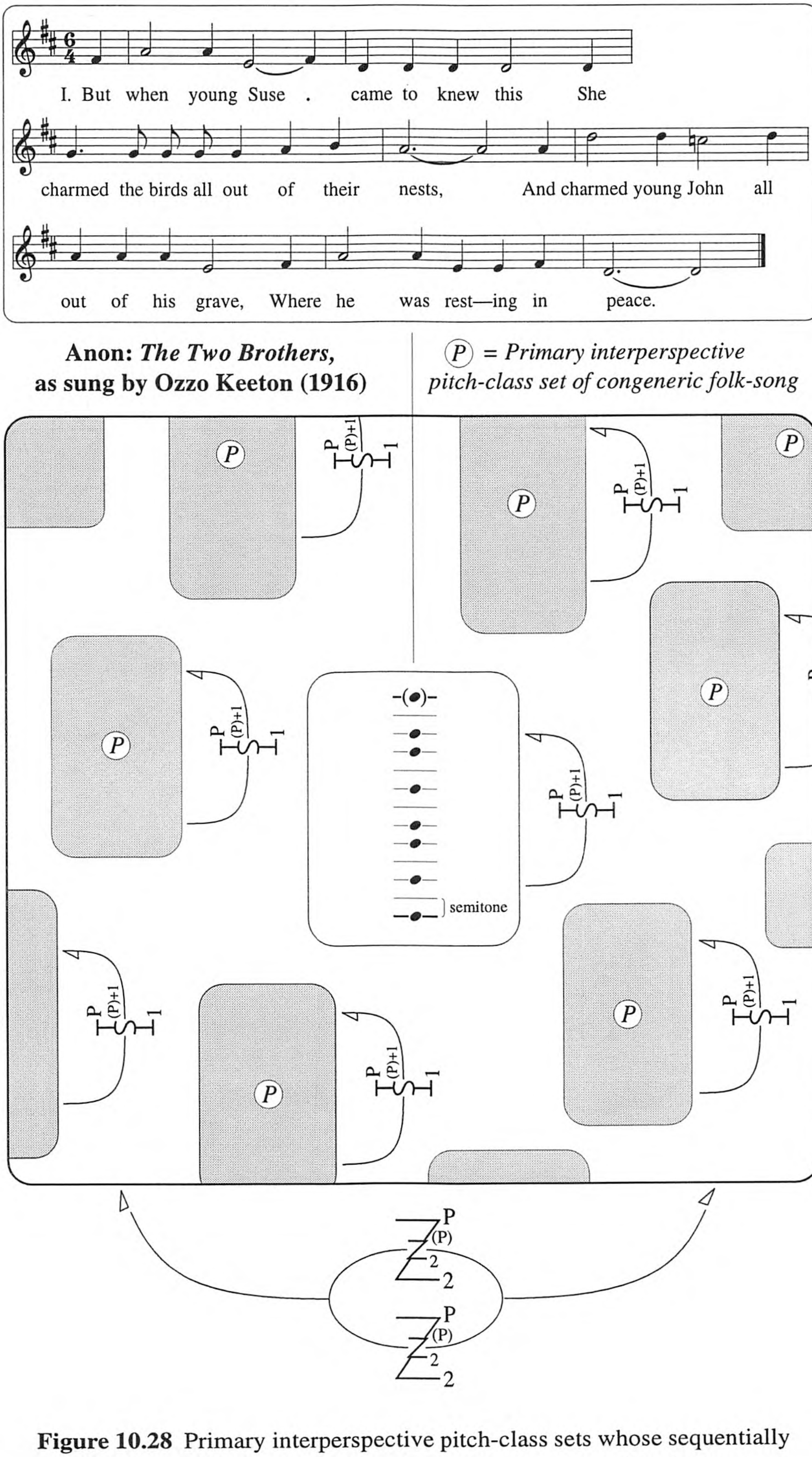


Figure 10.28 Primary interperspective pitch-class sets whose sequentially adjacent members are approximately the same through imitation.

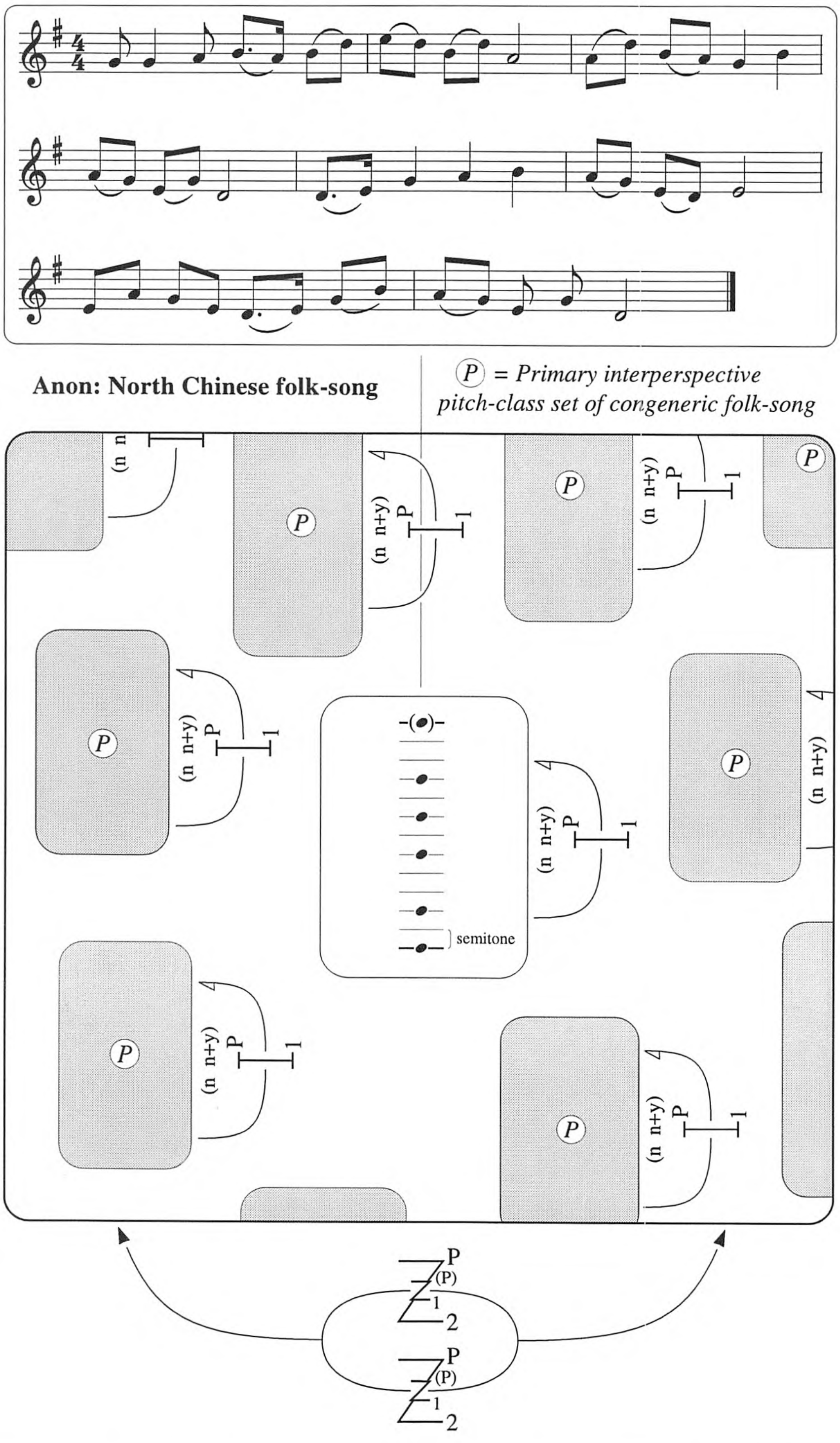


Figure 10.29 Primary zygosequential secondary zygonic invariants linking the primary interperspective pitch-class sets of Chinese pentatonic folksongs.

Relationships between primary interperspective pitch-class sets exist in a number of forms. For instance, the fact that the interval between sequentially adjacent members of one primary interperspective pitch-class set is approximately the same as any other of equivalent sequential disposition in a second set may imply the operation of a secondary zygosequential imperfect zygonic constant. See, for example, figure 10.28.

Primary interperspective pitch-class sets may be identical, and this perfect similarity attributed to imitation. Hence primary zygosequential secondary zygonic invariants may function as shown in figure 10.29. Equally, the intervals linking adjacent members of one pitch-class set may be the same as those of another, but occur in a different order. Consider, for example, two of the mediaeval modes: the 'Dorian' and the 'Phrygian'. It is possible to consider these to be related through a primary sequentially ordered secondary zygonic invariant, to the extent that imitation is reckoned to link one with the other.

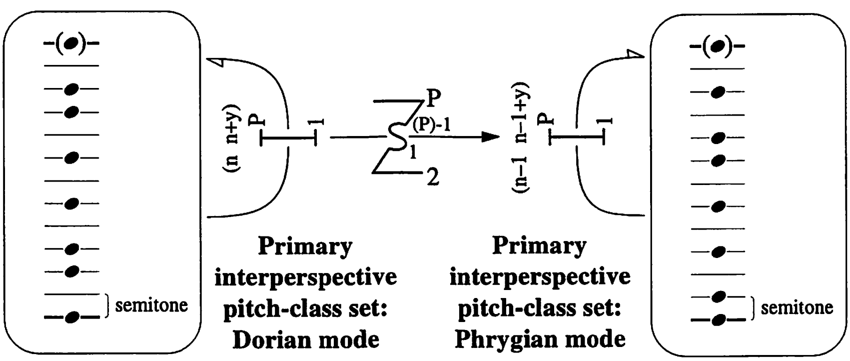


Figure 10.30 Primary interperspective pitch-class sets whose intervallic content is identical and ordered sequentially.

Theoretically, one primary interperspective pitch-class set may be derived from another through a regular transformation such as inversion. In this way, according to Ziehn (1912/1976, p. 25), the 'Phrygian' mode may be obtained from the 'Ionian', for example, implying a zygonic link as follows—see figure 10.31 (and cf. figure 6.61). It is not clear to what extent this implicative connection is a fair reflection of typical musical experience, however.

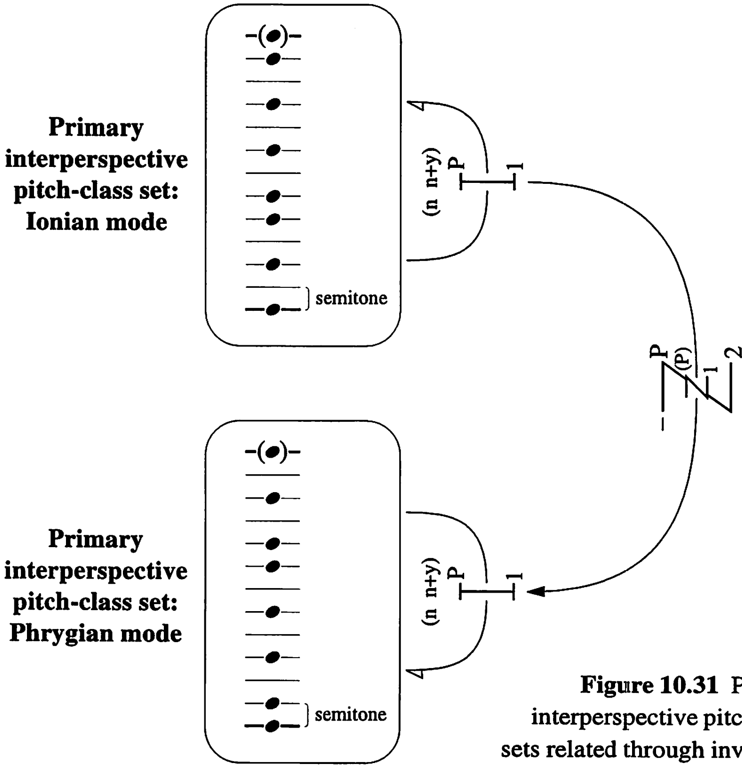


Figure 10.31 Primary interperspective pitch-class sets related through inversion.

It is possible that one primary interperspective pitch-class set may be a subset of another. Indeed, most of the sets used in Western societies, and many of those found in other cultures too, constitute portions of the chromatic scale. Their derivation may be orderly as to sequence. Consider, for example, the extraction of the whole-tone scale, whose values are derived alternately from a semitonal framework (figure 10.32).

This section concludes by examining the organisation pertaining to primary interperspective pitch sets (cf. Morris, 1995). Extra-canonic ordering is to be found, for example, in music written for natural horns or trumpets, whose available values, following the harmonic series, differ from one octave to another. A comparable effect brought about zygonically is to be found in bars 1–26 of the first movement of Webern's *Symphony*, Op. 21, in which each pitch-name appears in a predetermined register (or registers) according to a symmetrical arrangement centred on the a below middle *c*. The primary

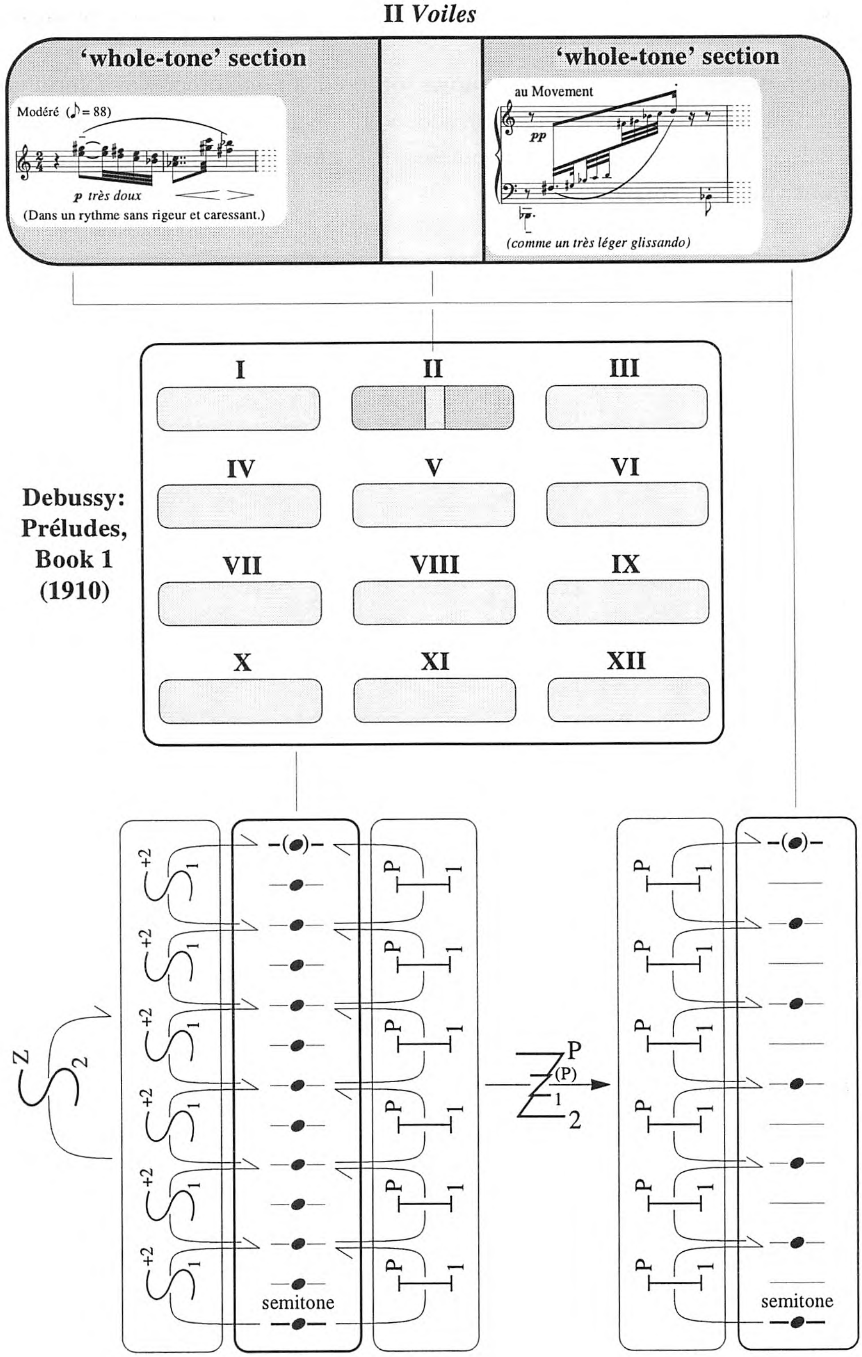


Figure 10.32 One primary interperspective pitch-class set a subset of another.

interperspective pitch set is as follows, ordered, among other ways, through a primary zygosequential inverse secondary zygonic invariant (see figure 10.33). Such a systematic arrangement is, of course, very much the exception rather than the rule.

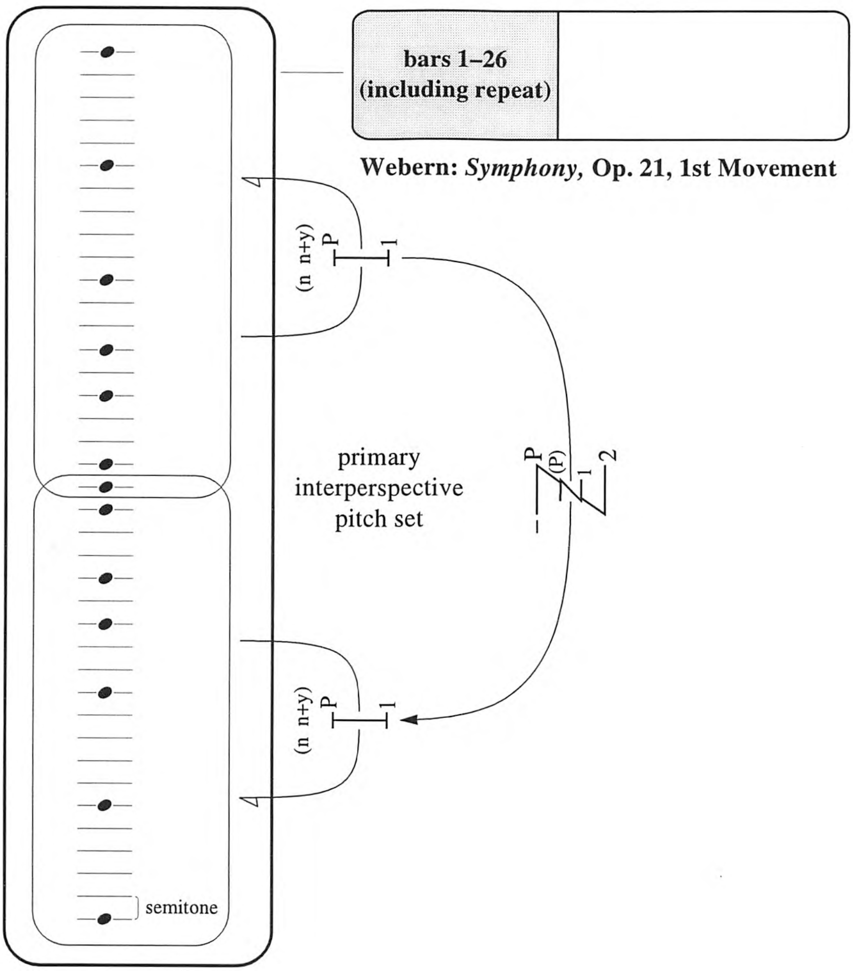
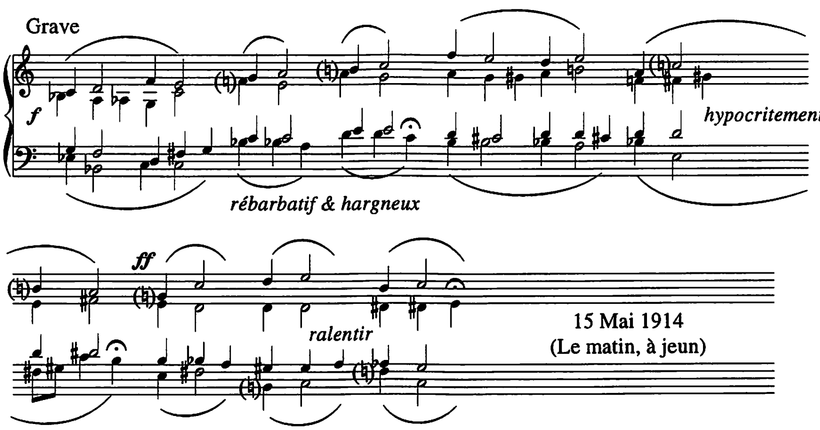


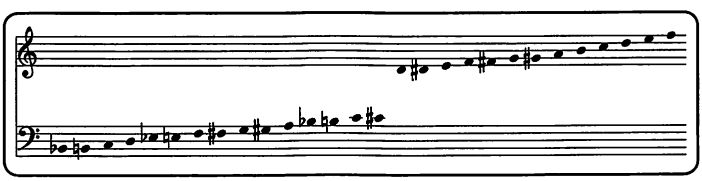
Figure 10.33 Primary interperspective pitch sets related through inversion.

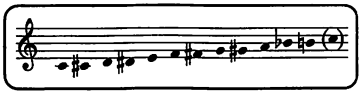
Pitch sets and pitch-class sets: principles of organisation

Cataloguing the pitches used in a piece or section produces a **pitch set**. This may be condensed into the span of a single octave, yielding a **pitch-class set**. For example:

Satie: ***Choral inappetissant*** **(1914)**



has the following pitch set:

and the following pitch-class set:



(enharmonic equivalence assumed)

Figure 10.34 Pitch set and pitch-class set.

(The term 'perspective' may be prefixed in either case to make clear the distinction between these and interperspective sets.)

Pitch sets and pitch-class sets may reflect the structural importance of the pitches they itemise at any desired hierarchical level. Hence microtonal or chromatic embellishments, for example, may but need not be included.

Pitch-class sets that use the internal patterns of intervals

tone, tone, semitone, tone, tone, tone, (semitone)

and

tone, semitone, tone, tone, semitone, 3 semitones, (semitone)[5]

come close to Western musicians' concept of 'key', although this term implies various conventions as to usage. Works that use these sets of pitch-classes without regard for the syntactical structures that grew up with them are sometimes referred as 'pandiatonic' after Slonimsky (1937/1994, pp. 1156 and 1157). Here, we will refer to the group of notes

a, b, c♯, d, e, f♯, g♯

for instance, as the 'pitch-class set of *A* major'; while

c, d, e♭, f, g, a♭, b

for example, will be termed the 'pitch-class set of *c* minor'.[6]

We now examine the order pertaining to pitch-class sets. Details of their internal organisation are covered by the observations made about primary interperspective sets, and no further discussion is necessary here. Relationships *between* sets are a different matter, however. Their sequentiality can effecively be described using the notion of 'scale-steps' or **degrees**. In the present work, these are shown using Arabic numerals:[7]

1, 2, 3, 4, 5, ...

[5]Slight modifications to this pattern are to be found: the sixth degree is often raised a semitone when it occurs within an ascending passage, for example, and the seventh lowered in descent. This polarity-sensitive inflection of values could be acknowledged in pitch-class sets if required.

[6]Assuming the harmonic version of the minor mode.

[7]This may be equated with the Chinese system of notation, whereby the notes of the diatonic scale are represented by the numerals 1–7 (see Picken, 1957a, p. 101).

'Degree' is an implied perspect—deriving from the apprehension of a number of perspective quantities, but applying only to one (cf. p. 158). Affirmation of its perceptual salience is to be found, for example, in Balzano (1982). In diagrams, the abbreviation 'P(d)', which stands for 'Pitch (degree)' may be used.

First, we will consider sets of pitch-classes that form major scales. Like degrees may be compared through primary zygosequential invariants, zygonic if the sets are the same, and order through imitation is considered to prevail:

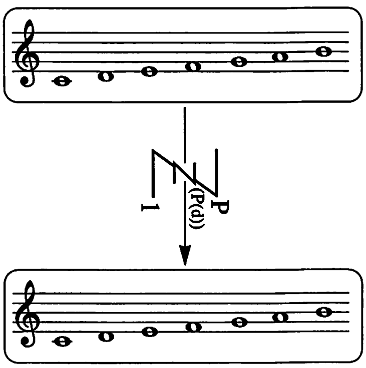


Figure 10.35 Pitch-class sets the same linked through a primary zygosequential zygonic invariant.

Primary invariants linking pitch-class sets may well express intervals other than a unison. Here, the similarity between pitch-class sets is a reflection of the interval separating them. The adjacency of differing pitch-class sets can also be measured through the number of members they have in common (cf. Balzano, op. cit., p. 347). By this reckoning, different major scales are maximally similar when they are a perfect 4th or 5th apart, either ascending or descending; for in these circumstances, only one value is different. With each successive 4th or 5th that is added, this difference is increased one stage further (cf. Cross, 1985, p. 14). Those pitch-classes that are found in both sets may be related through a primary invariant, zygonic if ordering through imitation is reckoned to be present. Both types of relationship—primary zygosequential zygonic invariant and sequentially ordered primary zygonic invariant—are shown in figure 10.36. The pitch-class sets of other modes may be connected through similar means.

Finally, we examine the relationships that potentially exist between pitch-class sets differing internally from one another. The field of possibilities

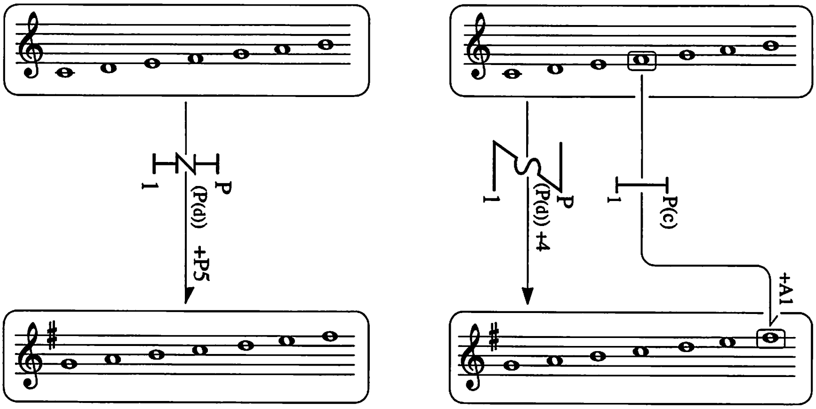


Figure 10.36 Pitch-class sets a perfect 5th apart linked through a primary zygosequential invariant and a sequentially ordered primary zygonic invariant.

is vast, and here we will concentrate on the link between the pitch-class sets of major and minor modes. Again, like degrees may be compared. Since the sets describe different intervallic patterns, however, the relationships so produced do not form an invariant (at least, not a perfect one). For example:

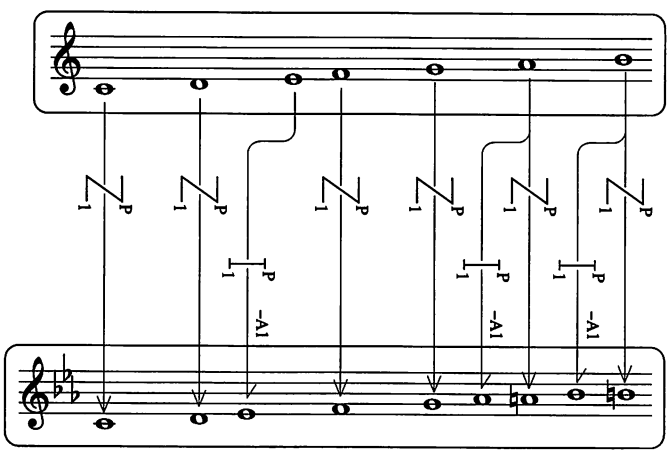


Figure 10.37 Pitch-class sets based on the major and minor modes (harmonic and melodic forms) linked through a series of primary zygonic and non-zygonic relationships.

The perceptual adjacency of pitch-class sets based on the major and minor modes again appears to be related to the number of pitch-classes they have in common. By this reckoning, the closest pair are a minor and its relative major (or *vice versa*), where at most only two differences are to be found (cf. Schoenberg, 1954/1969, p. 20; Krumhansl and Kessler, 1982).

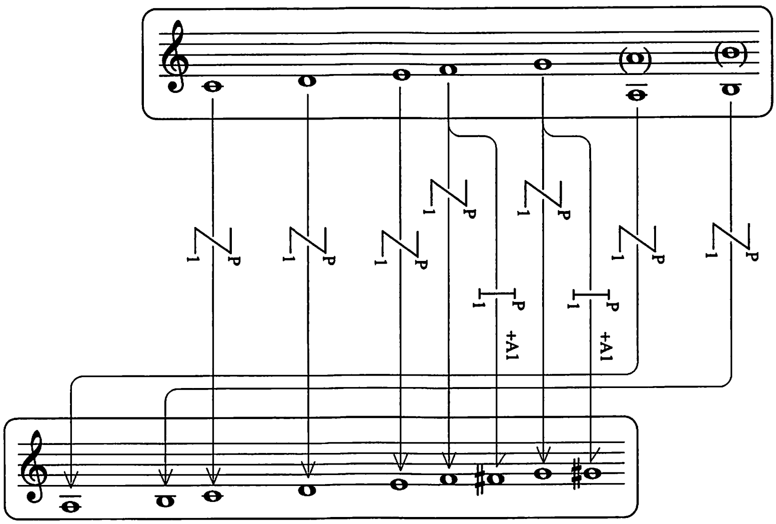


Figure 10.38 The zygonic connections between pitch-class sets based on a major mode and its relative minor.

The intraoperative and interoperative ordering of perspective and primary interperspective pitch sets and pitch-class sets

We now investigate how perspective and interperspective pitch sets and pitch-class sets they have been used intraoperatively. As the preceding examples show, it is possible to regard all the pitch-classes of a given work or movement as forming a single set. This approach may model perception rather poorly, however, and have only limited analytical value, since different sets of pitch-classes may be used (or at least dominate proceedings) at different points during the course of a piece, and the sense of these divisions is lost if all the values are lumped together indiscriminately. Hence it may sometimes be beneficial to record sets separately as they occur in perceived time. There are a number of forms such perceived temporal relationships can take (cf. pp. 159–160).

Simultaneity, in whole or in part (that is, prefixture, suffixal or enclosure), is associated with the effect of bitonality where two different pitch-class sets are involved, and polytonality in the case of three or more. Ordering through imitation is possible, as the following excerpt shows. The disposition

Milhaud: 4e Symphonie, *Dixtuor à cordes* (1921); 3rd Movement, *Etude*

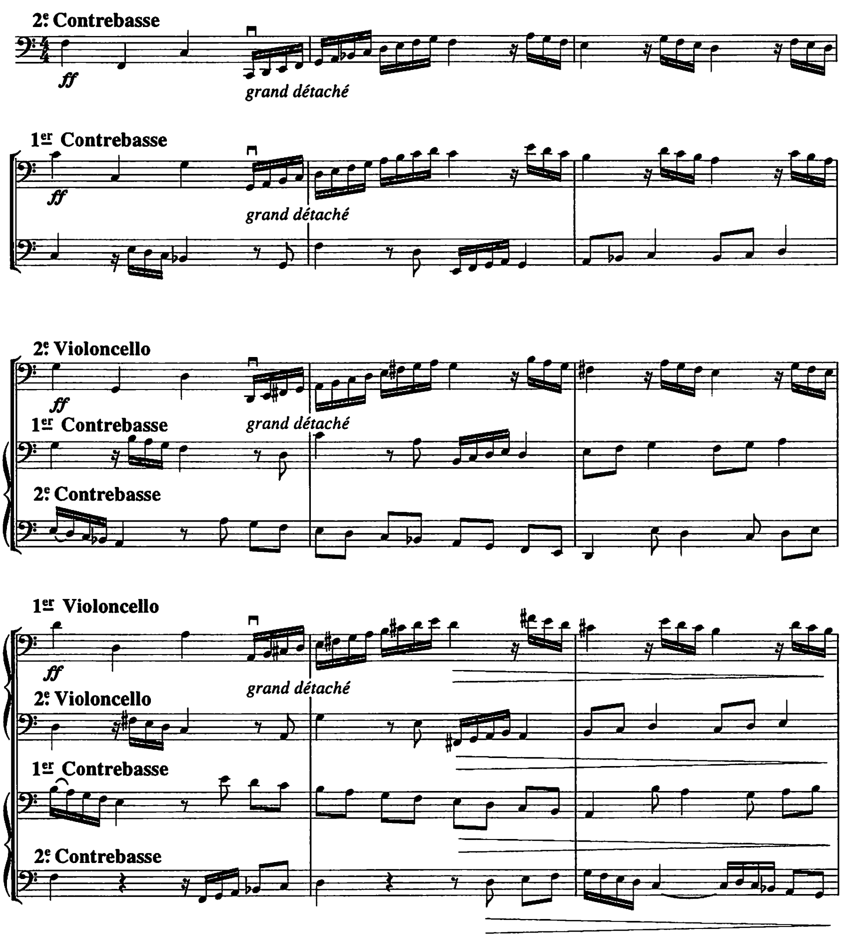



Figure 10.39 (part i)

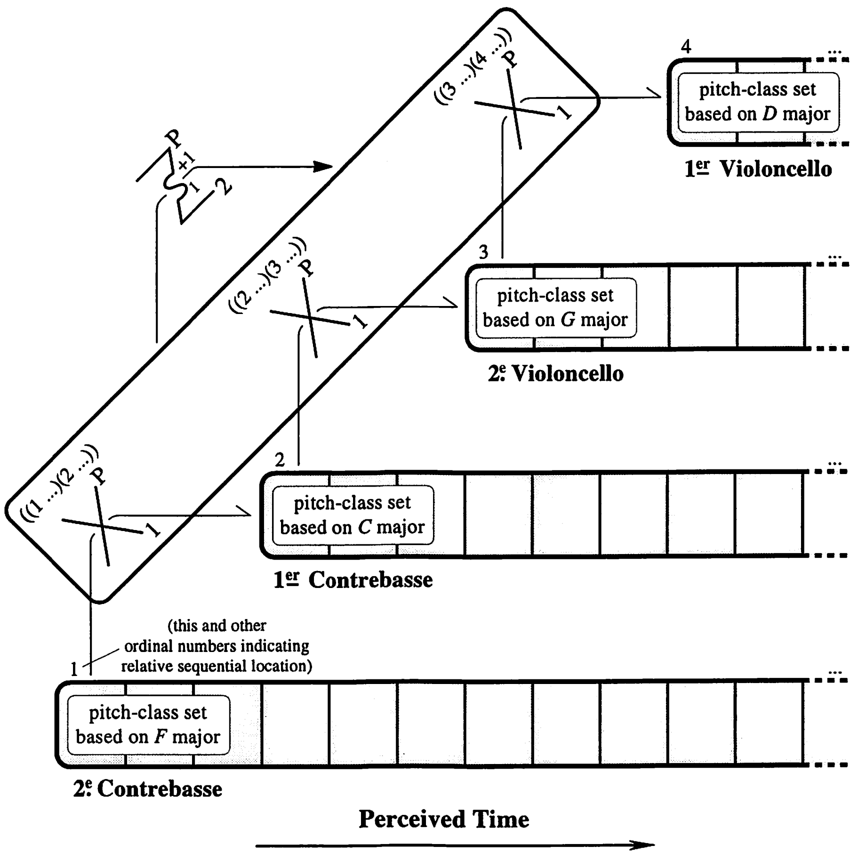
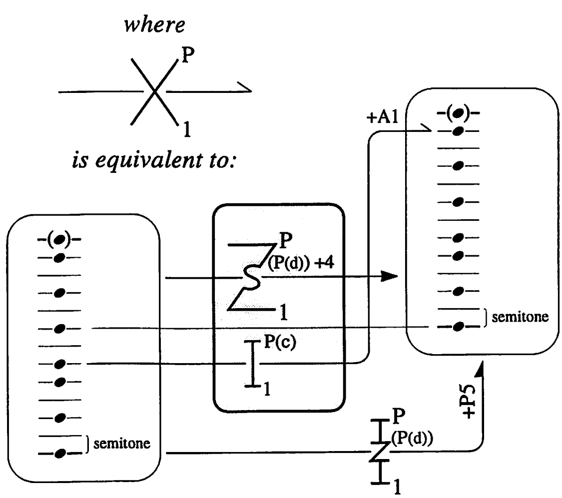
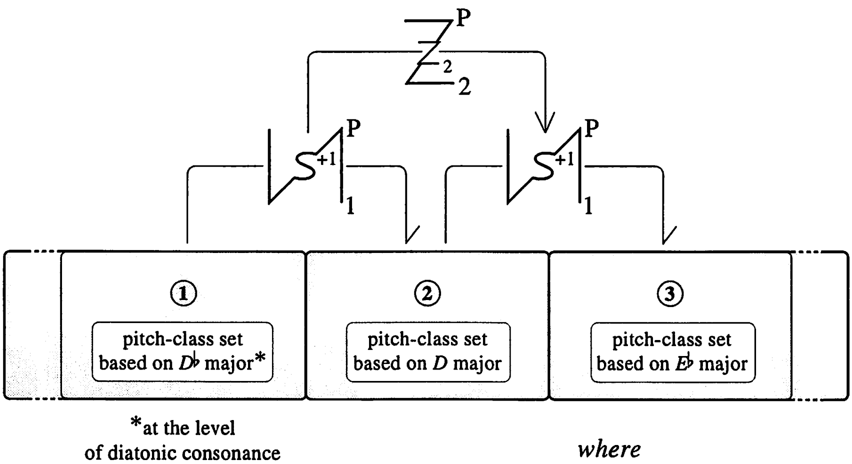


Figure 10.39 (part ii) Polytonal texture derived from the canonic organisation of pitch-class sets.



of the pitch-class sets in these opening bars foreshadows the complex polytonal symmetry which characterises the movement as a whole.

Isolation, with or without the interposition of other material, and contiguity, where the termination of one set of pitch-classes is followed directly by the initiation of another, are further possibilities which, again, may be subject to ordering through imitation. See, for example, figure 10.40 (parts i and ii).



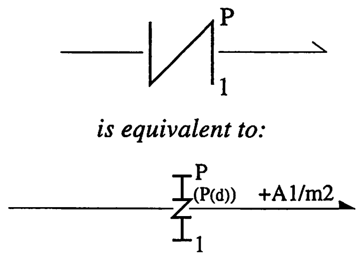


Figure 10.40 (part ii)
Pitch-class sets separated by a common difference occurring contiguously and deemed to be ordered through imitation.

In Western tonal music, pitch-class relationships of this perceived temporal disposition are rare compared with those that are imbricated, and in which pitch-classes are made to serve in two or more sets at the same time, operating as different degrees in each. See, for example, figure 10.41 (parts i and ii), which cites passages from the theme and first variation of the 3rd movement of Mozart's piano sonata, K. 284. The pitch-class sets pertaining to these excerpts reflect a transition from tonic to dominant. This transformation is a feature of subsequent variations too, indicative of ordering through imitation; see figure 10.42 (parts i and ii). (Observe the use of matrices to indicate the imbrication of pitch-class sets.) The fact that this

Wonder: *I just called to say I love you* (1984)

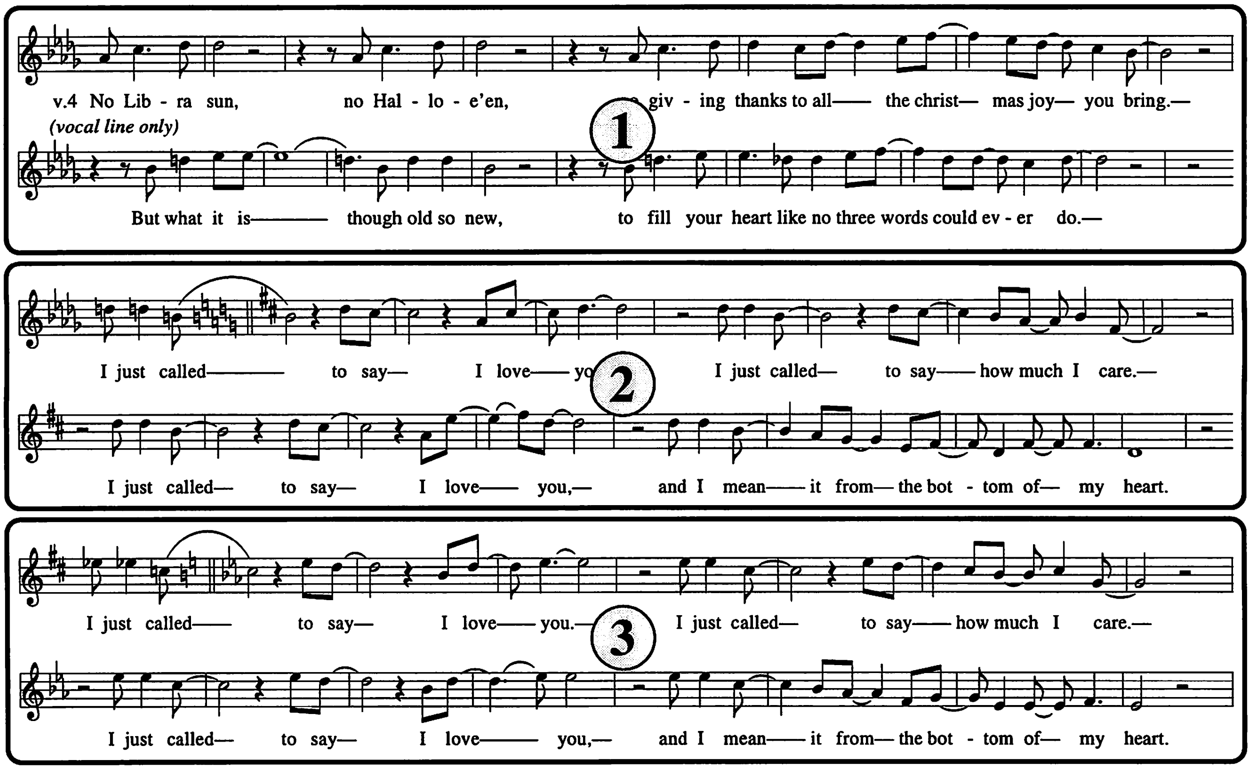


Figure 10.40 (part i)

Mozart: Sonata, K. 284; 3rd Movement

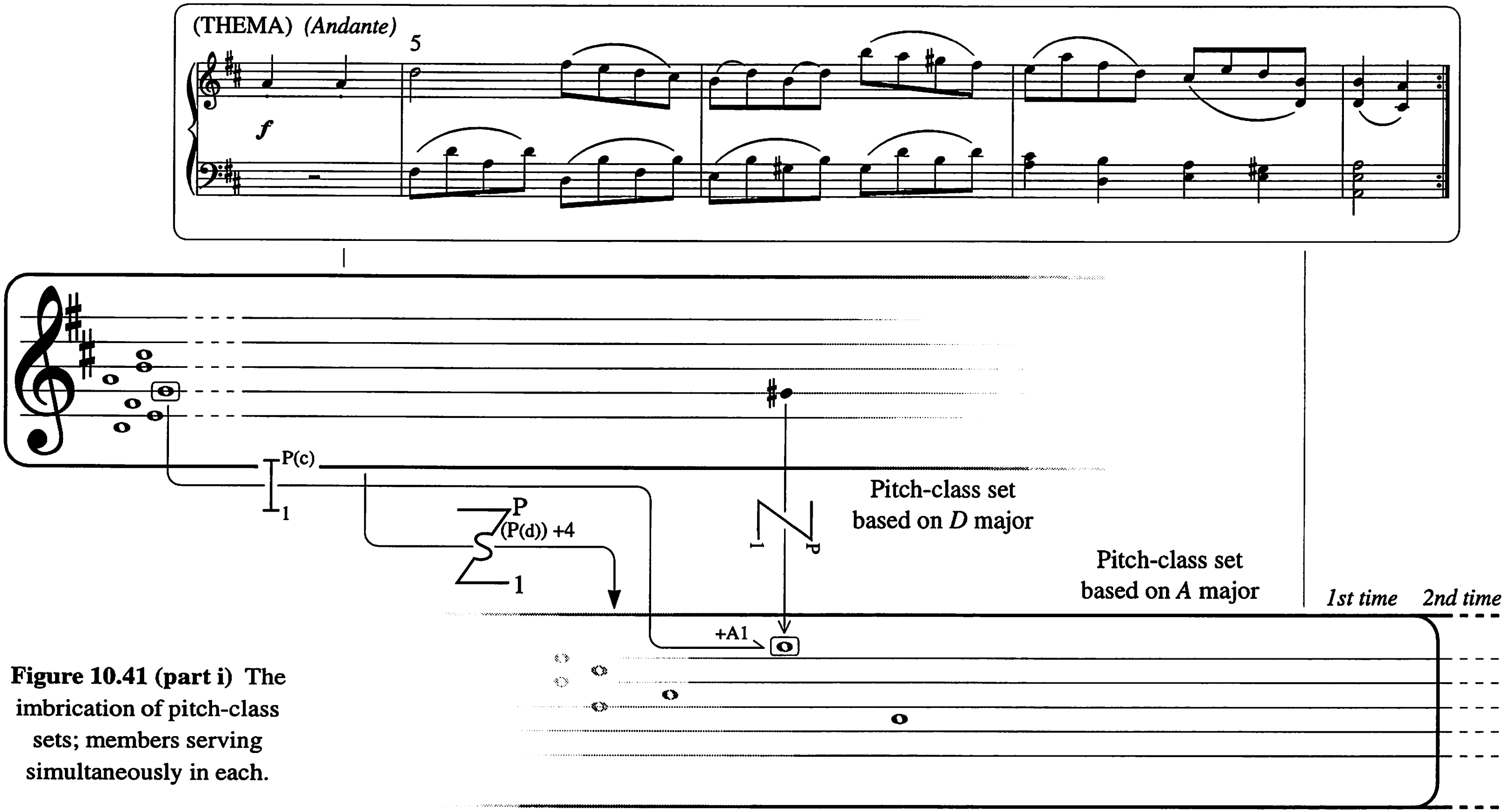


Figure 10.41 (part i) The imbrication of pitch-class sets; members serving simultaneously in each.

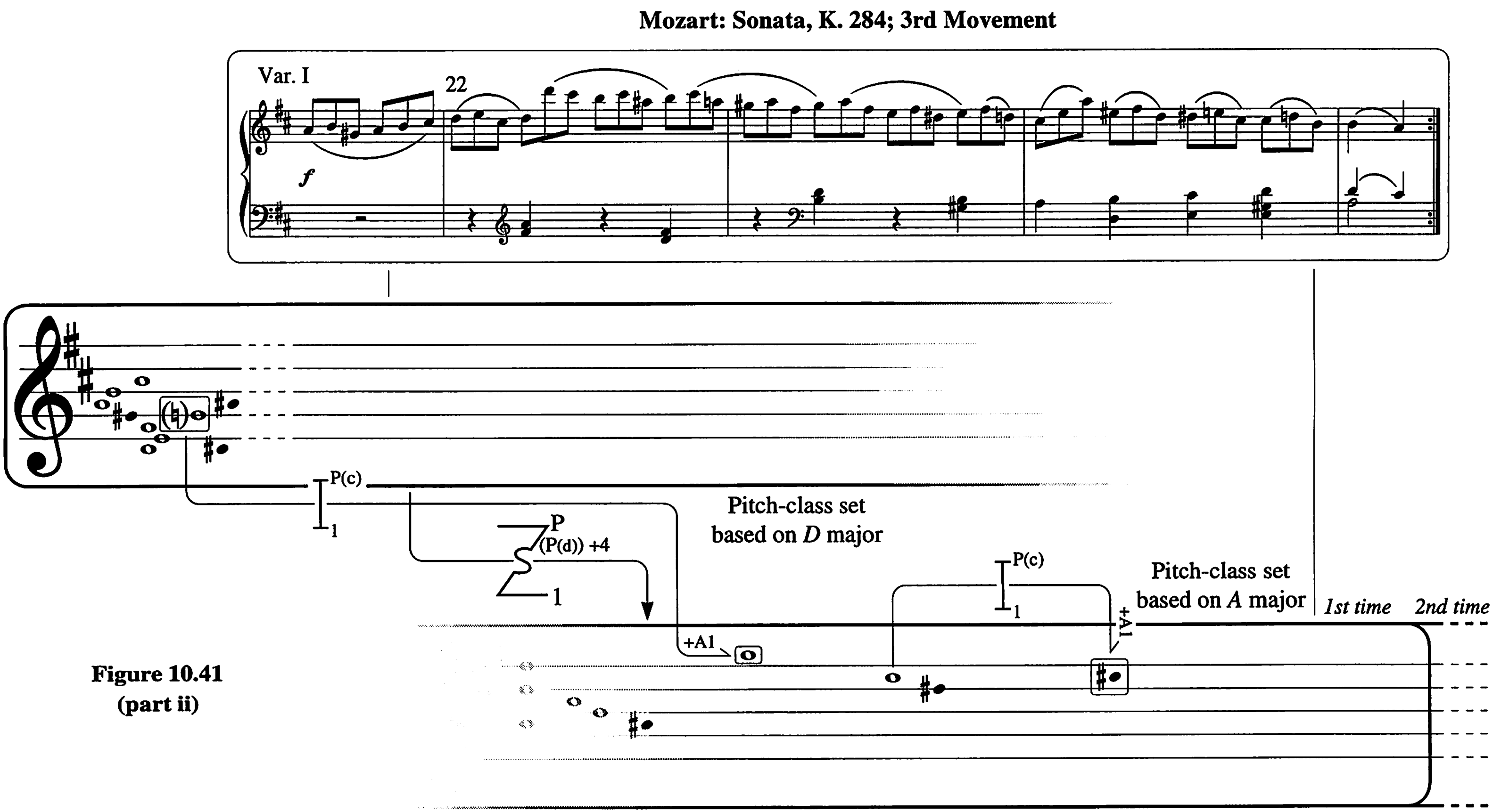
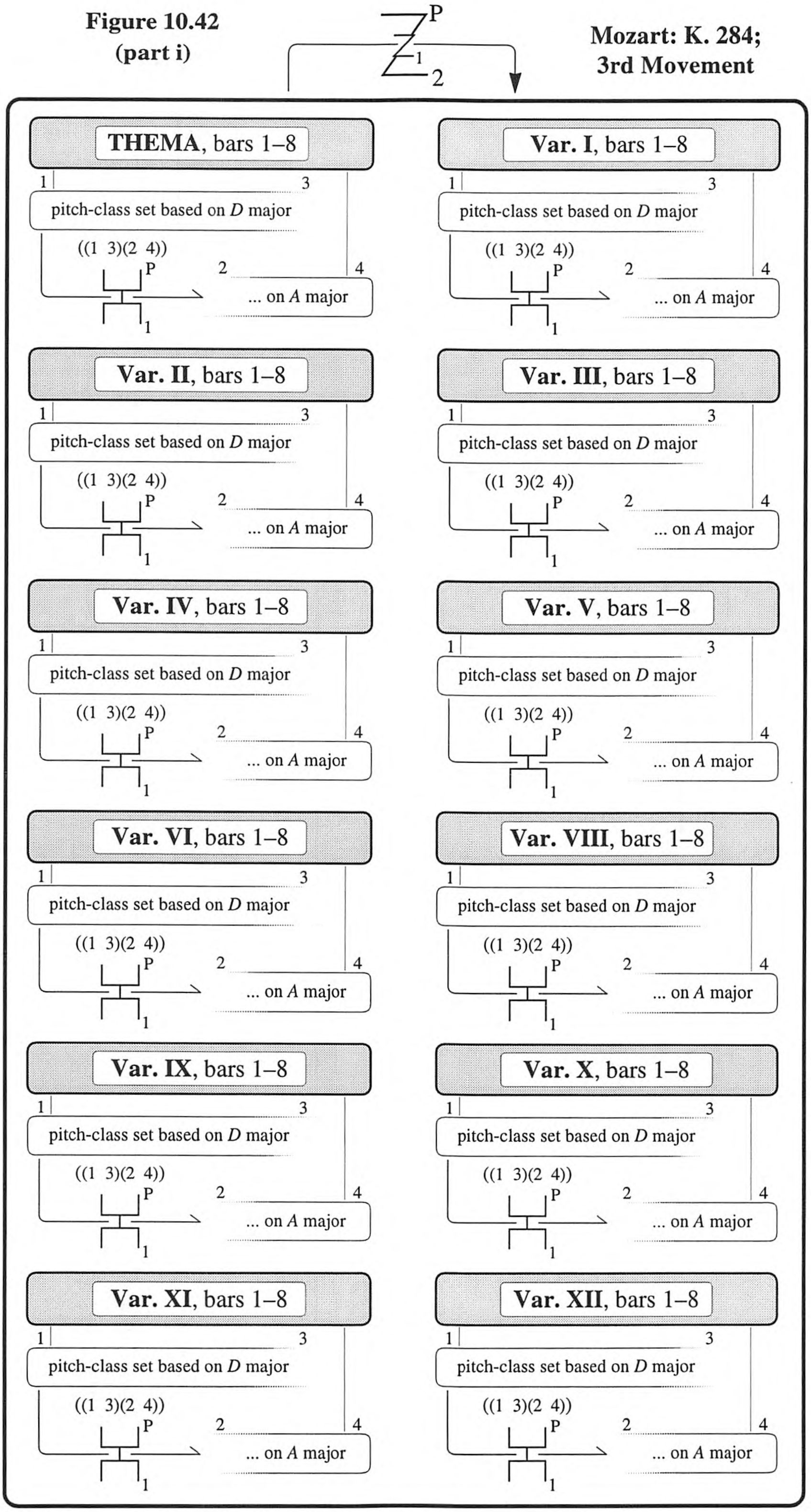


Figure 10.41
(part ii)

Figure 10.42 (part i)

Mozart: K. 284; 3rd Movement



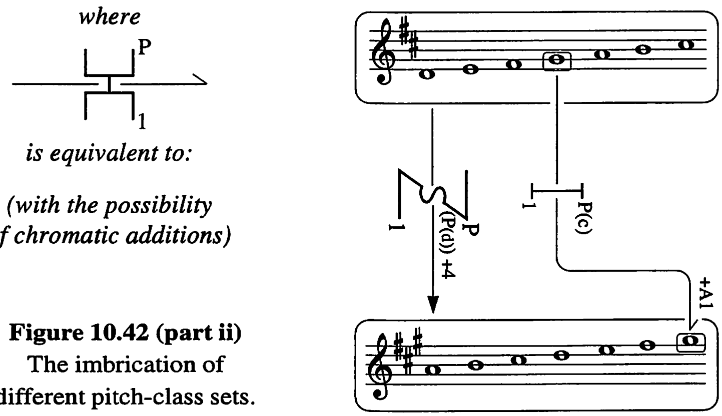


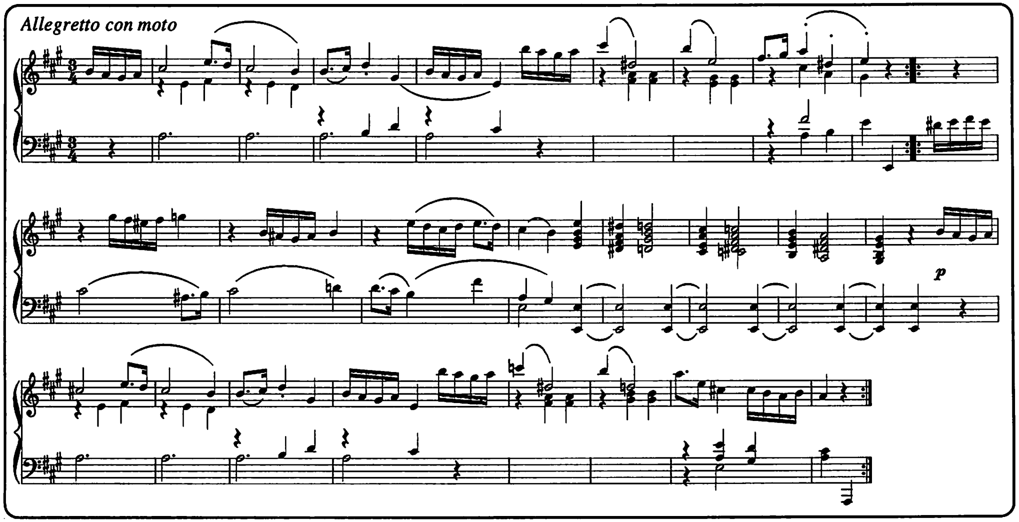
Figure 10.42 (part ii)
The imbrication of
different pitch-class sets.

form of transposition is a stylistic characteristic implies the operation of interoperative zygonic forces as well.

In these transitions, and in many others like them, it is not possible to pinpoint precisely when the authority of one pitch-class set yields to that of another. Indeed, the precise nature of the imbrication may differ according to the listener and the occasion. Hence, from an analytical point of view, it is often sufficient to consider just the sequential order in which successive pitch-class sets occur. This may be ordered through imitation. For example, the pattern which begins with the pitch-classes of a major mode, moves to an equivalent set a fifth higher and then returns to the original group, is particularly prevalent in Western music of the last four hundred years or so, forming the background of countless thousands of pieces. Hence both intraoperative organisation and interoperative, usually at the primary interperspective level, are implied. See figure 10.43 (parts i, ii, iii and iv).

Since it is often the case, in considering a work or movement as a whole, that one pitch-class set is felt to predominate over others subordinate to it (cf. Schenker, 1935/1979; Schoenberg, 1954/1969, p. 19),[8] one way of

[8]Consider also that, in referring to a complete piece, musicians usually speak of it as being in one particular key (rather than a number of keys) even if modulations occur. Observations such as this highlight the point that the reasoning followed in this section may appear to be somewhat artificial, avoiding as it does any reference to concepts such as 'tonality', 'key' and 'modulation', which may seem to be central issues in the line of thinking adopted. In part, it is for theoretical convenience that these matters are considered separately below, though in any case the approach taken is justifiable, since the ordering of pitch and pitch-class sets, perspective and primary interperspective, can exist in isolation from tonal forces (as the notion of pandiatonicism shows).

Menuetto

Clementi: 3 Sonatas, Op. 10, No. 1; 2nd Movement

Trio

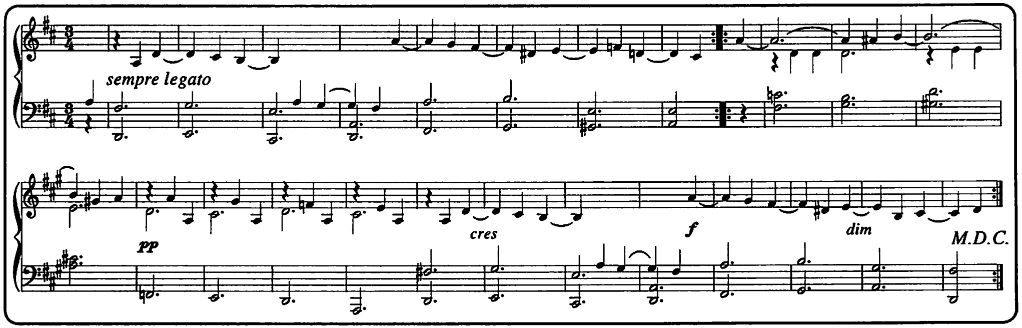


Figure 10.43 (part i)

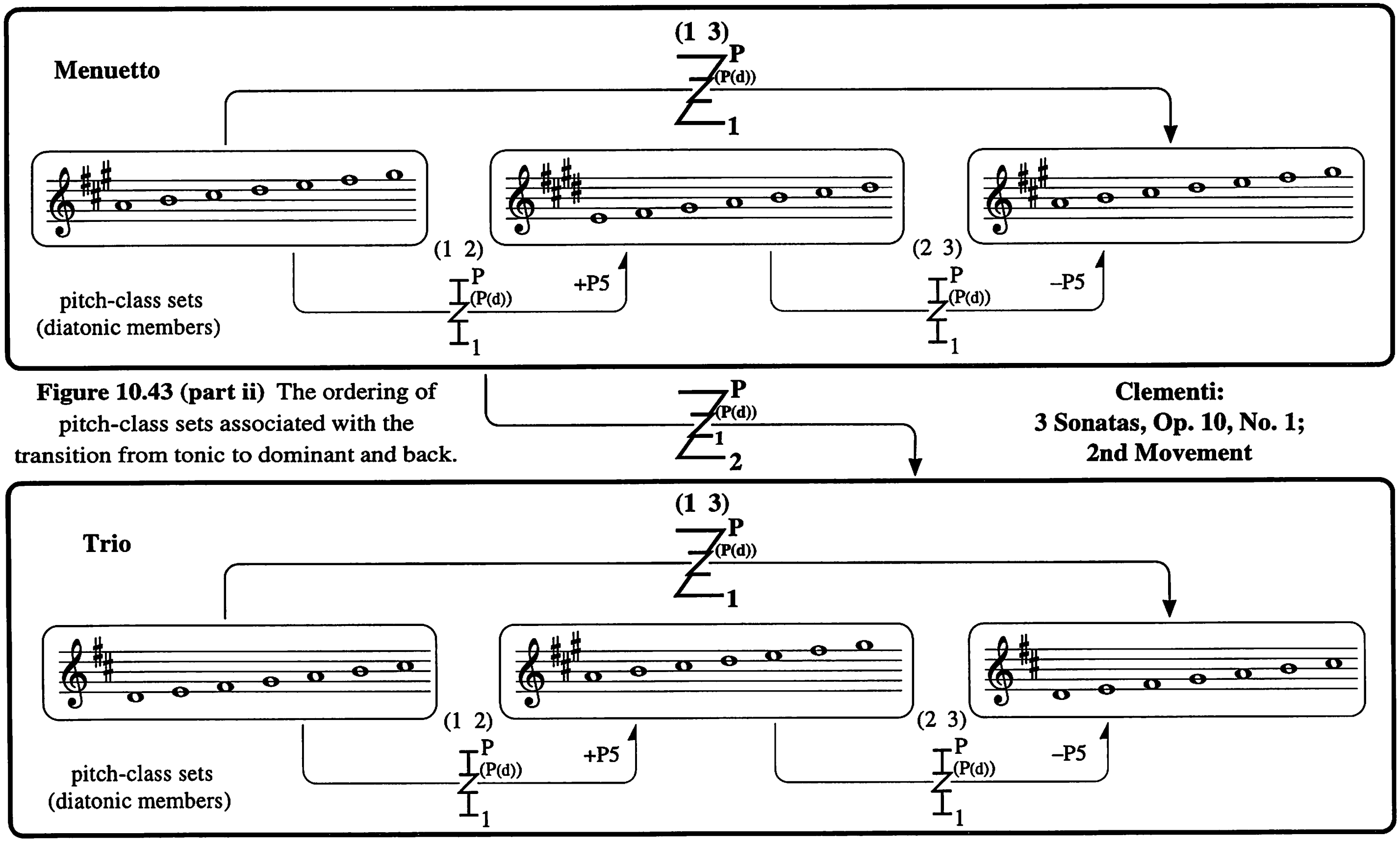


Figure 10.43 (part ii) The ordering of pitch-class sets associated with the transition from tonic to dominant and back.

Clementi:
3 Sonatas, Op. 10, No. 1;
2nd Movement

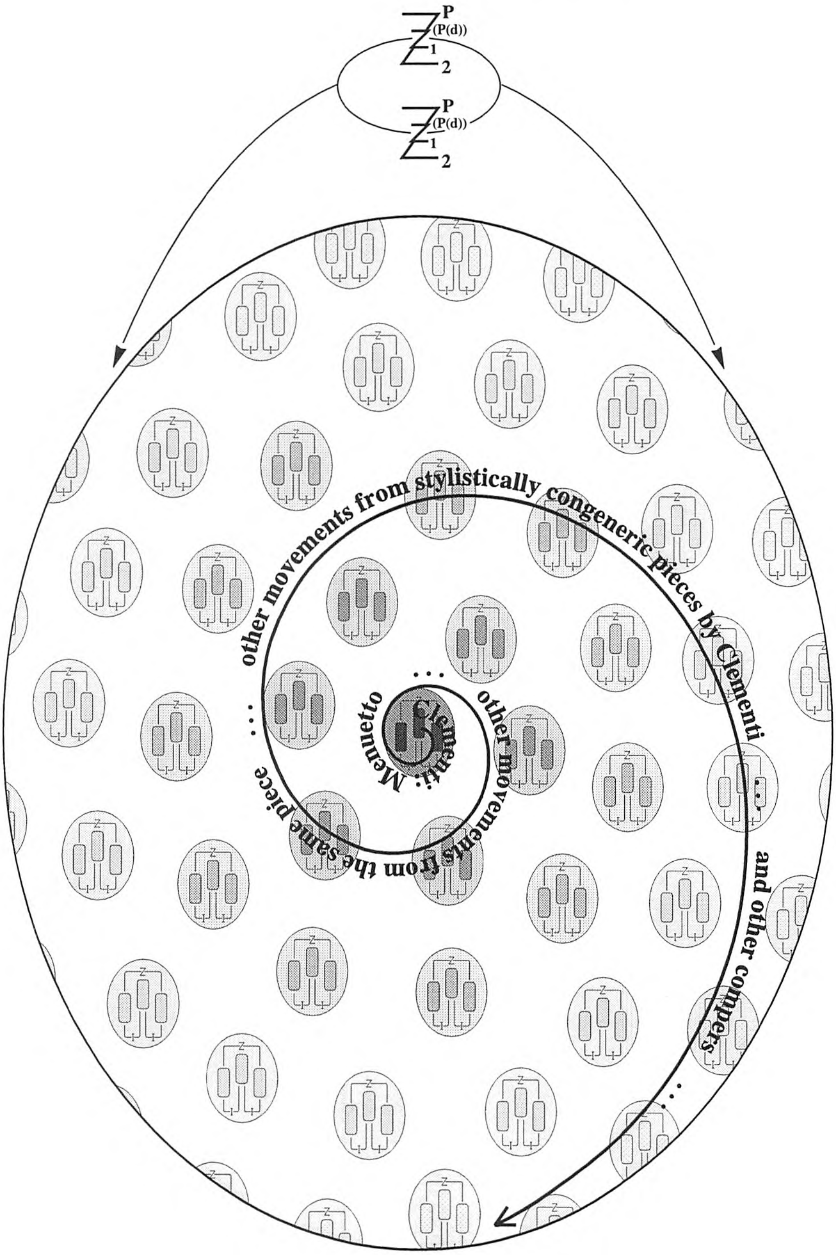
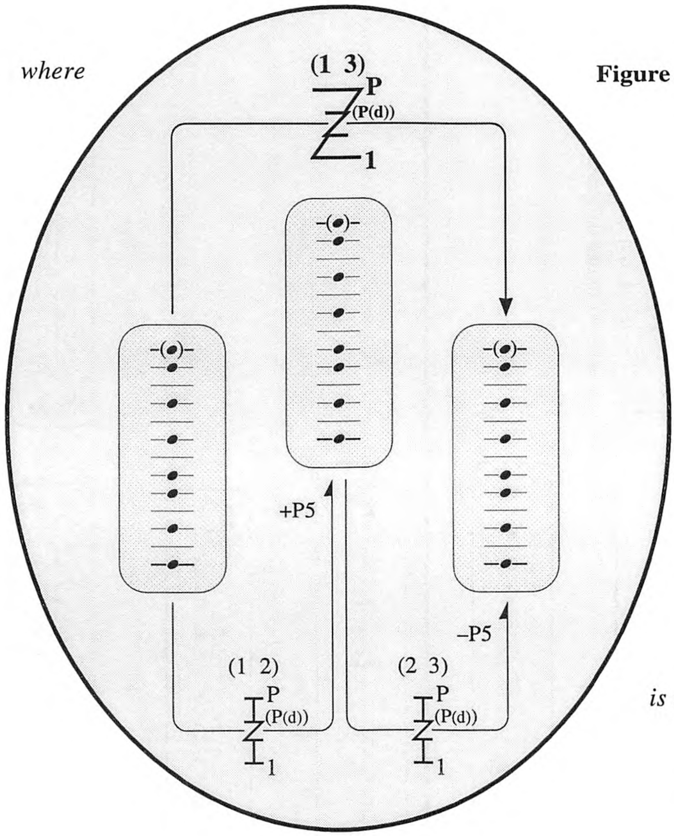


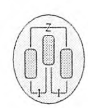
Figure 10.43 (part iii) Interoperative ordering at the primary interperspective level of pitch-class sets associated with the transition from tonic to dominant and back.

where

Figure 10.43 (part iv)



is represented by



simplifying the sequential model of events shown in figure 10.43 is to expunge the perceived temporal aspect completely by using the technique set out on pp. 475 and 476, in which a distinction is drawn between the functional and the ornamental at the level of diatonic consonance. The criteria by which the functional and the ornamental are distinguished include such qualities as the possible perceived temporal precedence of one pitch-class set over another and the relative durations of different sets. It is proposed that the members of the main pitch-class set of a piece appear as open noteheads, whilst those belonging to subsidiary sets are filled. By using notes of different lengths to represent the relative structural weights of the sets involved, this method can be widened to form a hierarchical inventory of the pitch-class sets that appear in a work. See, for example, figure 10.44.

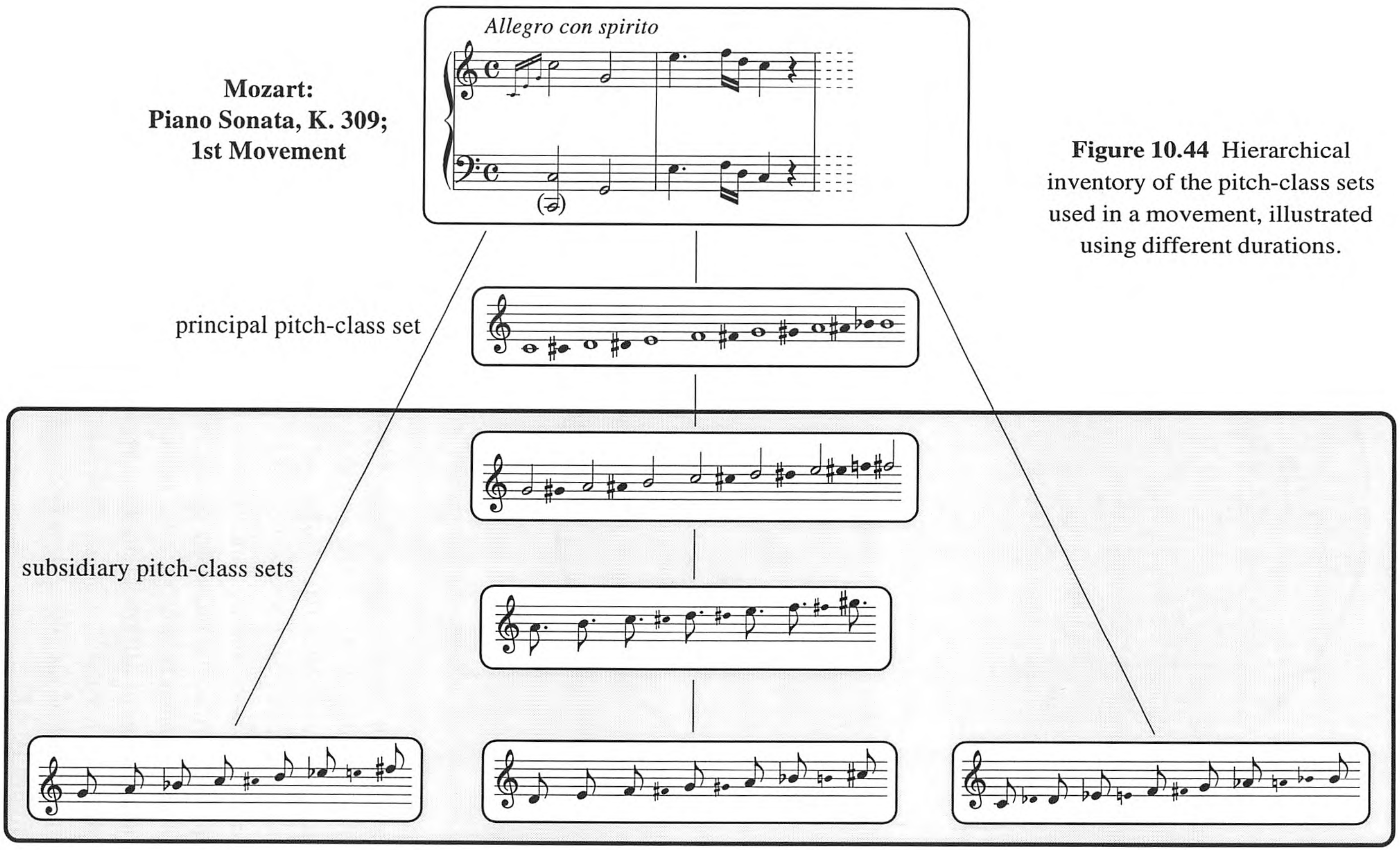
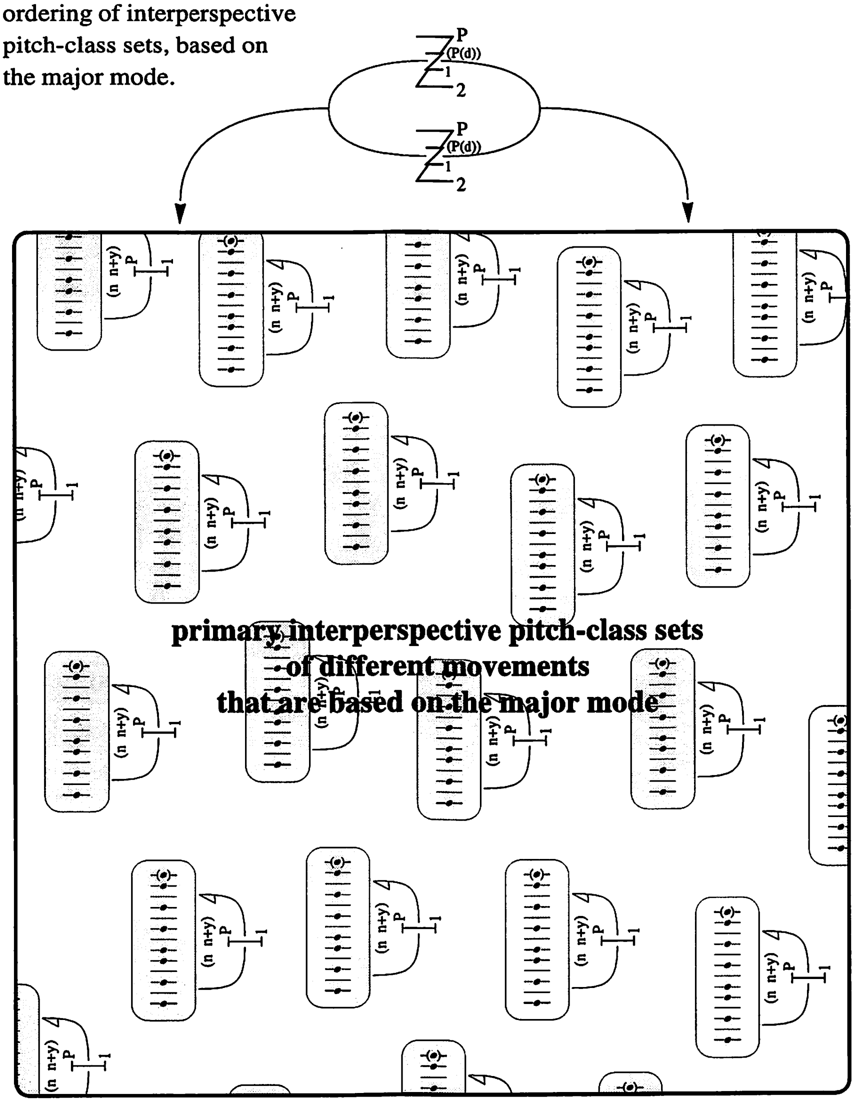


Figure 10.44 Hierarchical inventory of the pitch-class sets used in a movement, illustrated using different durations.

The majority of movements use a principal primary interperspective pitch-class set that is drawn from a small selection of culturally specific possibilities. In the West, for example, the sets of the great majority of pieces written in the last four hundred years or so form major scales. The interoperative ordering this implies can be shown thus:

Figure 10.45 The interoperative ordering of interperspective pitch-class sets, based on the major mode.



The pattern of primary interperspective pitch-class sets that exists between the movements of many multimovement works is commonly subject to interoperative ordering too. For example, the inter-movement framework used in Mozart's sonata K. 309 (cf. figure 10.44) which consists of pitch-class sets based on major keys with the roots I–IV–I, is employed in 10 of his 14 piano sonatas in the major mode. The remaining 4 sonatas adopt pitch-class sets associated with the inverse of this pattern: I–V–I.

Some of the pitch-class sets based on the major mode occur more frequently than others, a bias that is liable to differ from one composer to another. Take Mozart, for example. Révész (1953, p. 116), in examining 183 of his compositions, finds the great majority to be in *C*, *B♭* and or *D* major; next come *E♭*, *F* and *G*, and then *A*. These keys account for virtually all the works listed. Of the minors, which make up around $7\frac{1}{2}\%$ of the total, *c*, *g* and *d* are the most frequent. Révész accounts for Mozart's preferences partly through technical considerations, such as the manageability of wind instruments that are pitched in particular keys, and partly through habit and tradition—influences that can be interpreted canonically.

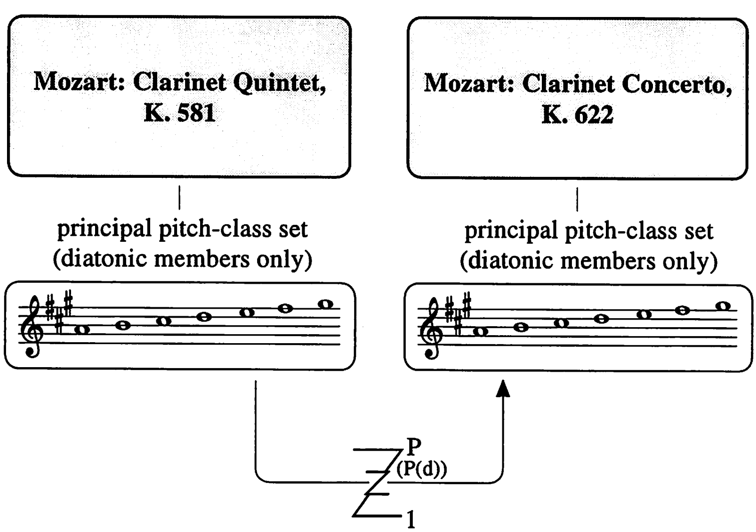


Figure 10.46 The interoperative ordering of pitch-class sets that are based on the major mode.

The principles of pitch ordering, discussed in this section with reference to music of certain 'mainstream' Western musical styles, are applicable to to a wide range of other works too. In India, for example, performers can

> link up râgas by a process comparable to modulation, starting in one râga and skilfully introducing—after a suitable lapse of time—characteristics of another, thus weaving what is called a râgamâla (garland of râgas). (Bake, 1957, p. 213)

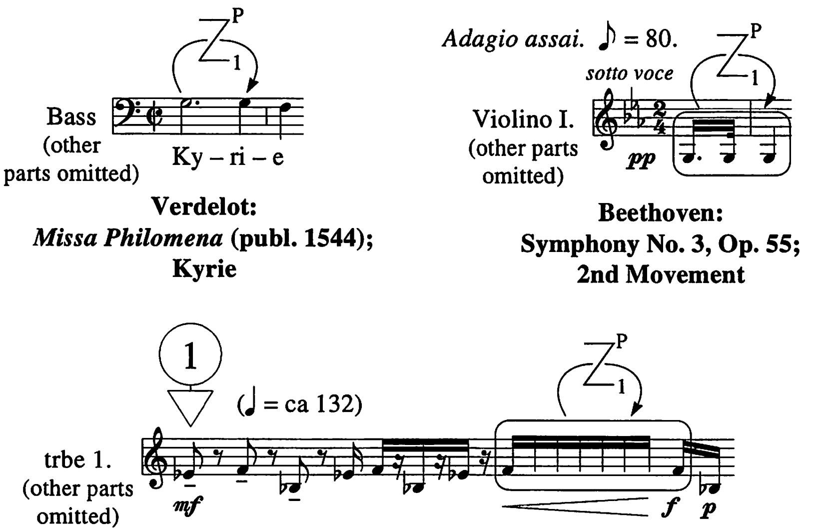
Principles underlying the ordering of pitch in melody i: intrasociative organisation

This section and the eight that follow are concerned with the organisation pertaining to 'horizontal' associations of pitch—that is, with the non-rhythmic aspects of melody. *Intra*sociative ordering is investigated first, followed by an examination of *inter*sociative connections. Inevitably, associative organisation is intimately connected with the control of pitch and pitch-class sets described in the preceding sections. Pitch holons (groups forming distinct units) are important within pieces using sets, since with comparatively few different perspective and interperspective values available, the basic requirements of musical material to be original, recognisable and memorable cannot otherwise be met. As Toynbee (1968, p. 47) says:

> If A recurs a number of times, this may be just accidental. If the cluster ABC occurs and there is another cluster ABC—well, the more elements there are in the cluster which all recur on some occasion or other occasions, the less likely this is to be due to chance, and the more likely there is to be some reason for it.

(See also Browne, 1974, p. 397; Benjamin, 1974, p. 185.)

Constant associations of pitch, perfect or imperfect, may be related internally through primary intrasociative zygonic constant systems, or, if two protractions only are involved, a single primary interprotractive zygonic constant. See, for example, figure 10.47.



Verdelot:
***Missa Philomena* (publ. 1544);**
Kyrie

Beethoven:
Symphony No. 3, Op. 55;
2nd Movement

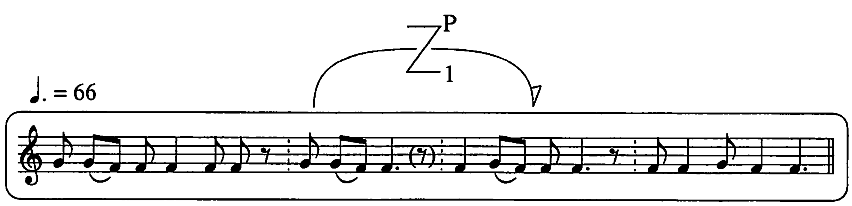
Lutoslawski: Symphony No. 2 (1967); 1st Movement, *Hésitant*

Figure 10.47 Constant associations of pitch zygonically ordered.

Many melodies use a restricted range of values. In so-called 'primitive' melodies, for example,

> many ... remain persistently within the tonal ambit given by the motive in the first place (Schneider, 1957, p. 18),

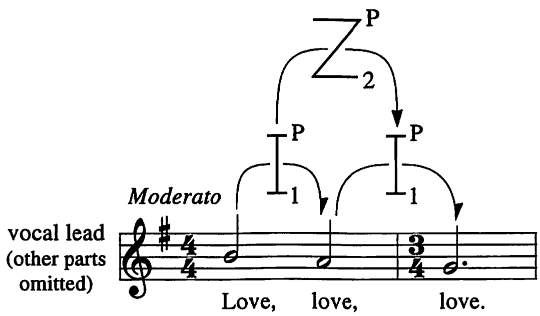
which may amount to an interval as small as a major second. Here, the operation of an imperfect primary zygonic constant system is particularly strongly in evidence.



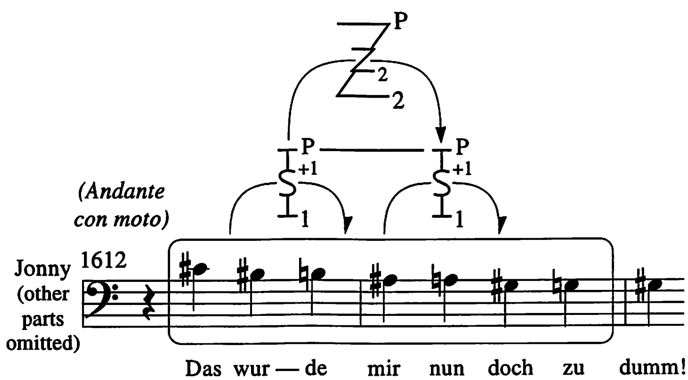
Anon: *Small black Albatross*
(folksong from Tierra del Fuego (Hornbostel); in Wellesz (ed.), 1957)

Figure 10.48 Melody ordered through imperfect zygonic constant system.

Regular variable associations of pitch may take a number of forms. The simplest involves a series of successive constants related through a common difference. Imitative order may be thought to operate through a secondary zygosequential intrasociative zygonic constant system, or, in the case of three notes, a secondary interprotractive zygonic constant. These may be perfect. For example:



Lennon & McCartney: *All you need is love* (1967)

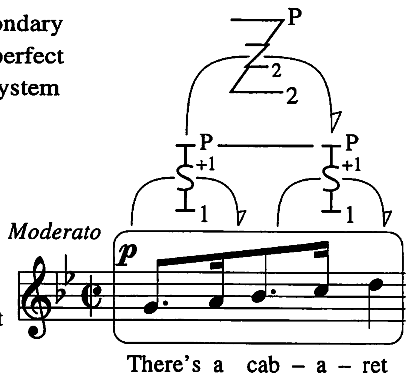


Krenek: *Jonny Spielt Auf* (1925/1926); 2nd Act, Scene 8

Figure 10.49 Successive pitches related through a common difference.

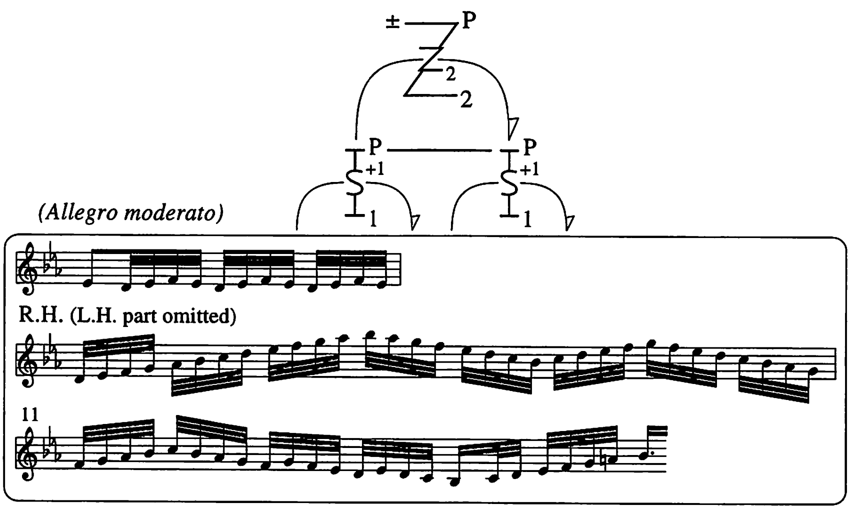
Imperfection is encountered more frequently, however, as a consequence of the inequality typical of successive intervals in primary interperspective pitch sets (see figure 10.50). Associations of this type may feature relationships of differing polarities (figure 10.51).

Figure 10.50 Secondary zygosequential imperfect zygonic constant system of pitch.



voice (piano part omitted)

Gerschwin: *Sweet and Low-Down* (1925)

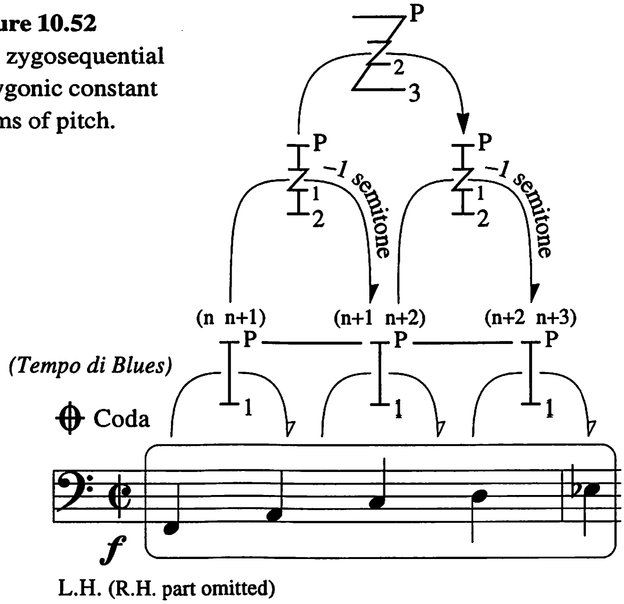


Haydn: Sonata in *E*♭, Hob. XVI : 38; 1st Movement

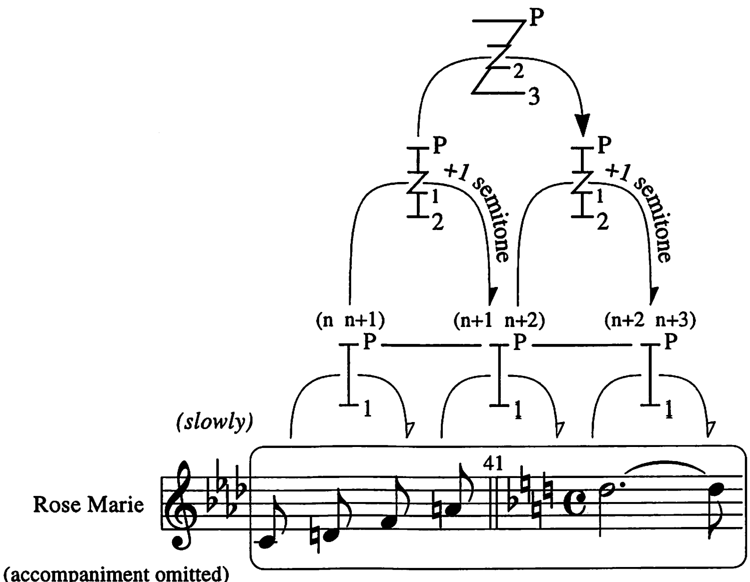
Figure 10.51 Secondary intrasociative imperfect zygonic constant system of pitch; mixed polarity.

A secondary zygosequential tertiary zygonic constant system or tertiary interprotractive zygonic constant, perfect ot imperfect, are possible too. See, for example, figure 10.52.

Figure 10.52
Secondary zygosequential tertiary zygonic constant systems of pitch.



Davenport: ***Cow-Cow Blues*** **(1928)**



Friml: ***Indian Love Call*** **from** ***Rose Marie*** **(1924)**

(Observe that this analysis does not imply that tertiary zygonic organisation is the principal force underlying the construction or perception of these passages, but that the incremental enlargement or reduction of intervals highlighted may have an auxiliary ordering effect.)

Higher-order intrasociative zygonic relationships are theoretically available to composers too.

The present theory predicts that *all* intrasociative ordering of pitch must ultimately occur through one or more of the forms of control described in the preceding paragraphs.

Pitch organisation in melody ii: intersociative ordering (isomorphic transformations—repetition and transposition)

For theoretical simplicity, we begin by examining associations that exist in mutual isolation. Just as the notion of 'rhythm' is essential in considering the organisation of the temporal perspects, so a comparable concept is needed in the realm of pitch, through which each association is regarded as a single entity. This perspect may be termed **profile.**[9] Like rhythm, profile may be reckoned in absolute terms (as a series of perspective values), or relative (as a succession of primary interperspective values). In the absence of an indication to the contrary, profile may be assumed to function at the primary interperspective level.[10] Similarly, an association of pitch-classes may be regarded as a ***pitch-class*** **profile** (perspective or primary interperspective).

In the same way that two rhythms may be connected through a single relationship, substituting for several underlying perceived temporal links, so can two profiles. Such relationships may but need not be zygonic (see figure 10.53). They may be imperfect in a number of ways, including the addition, omission or alteration of material—possibilities that are examined on pp. 537ff.

[9]Like 'rhythm', the term 'profile' can also be used in a general sense, permitting expressions such as "profile is a perspect of pitch", for example.

[10]The concept of 'protoprofile' is also available (cf. 'protorhythm', p. 405) to describe a profile prior to any interpretive subchromatic inflection.

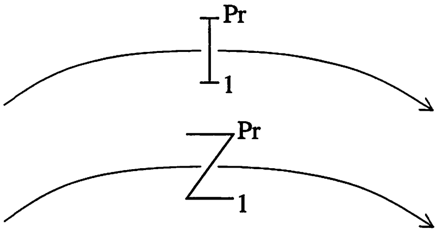
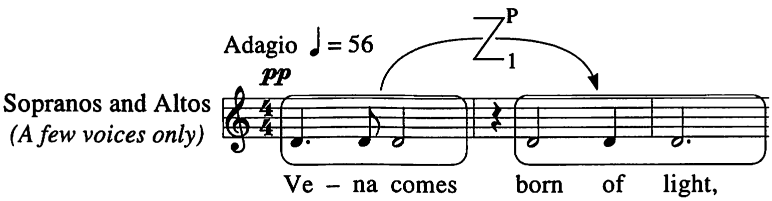


Figure 10.53
Relationships of profile.

If a constant association is repeated, the presence of a primary intersociative zygonic constant is implied. For example:



Holst: *Choral Hymns from the Rig Veda* (Third Group) Op. 26; No. 3, *Hymn to Vena*

Figure 10.54 Primary intersociative zygonic constant of pitch.

The repetition of a variable association, irrespective of its degree of internal regularity, can be understood in terms of a primary zygosequential intersociative zygonic invariant. For instance:

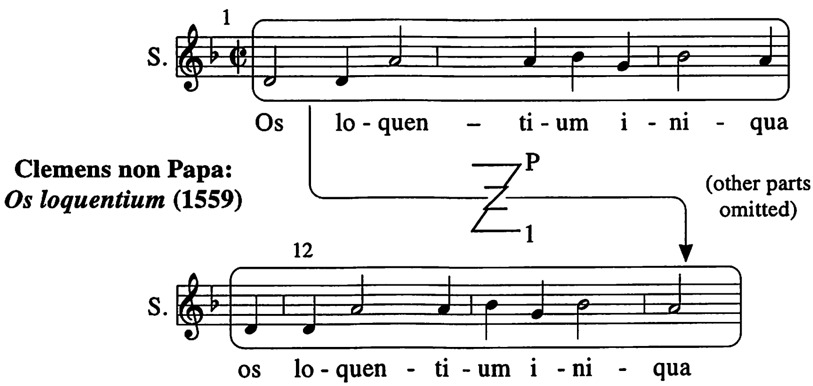


Figure 10.55 Primary zygosequential intersociative zygonic invariant of pitch.

Both the intersociative constant illustrated in figure 10.54 and the invariant shown in 10.55 may be replaced with a single relationship of profile.

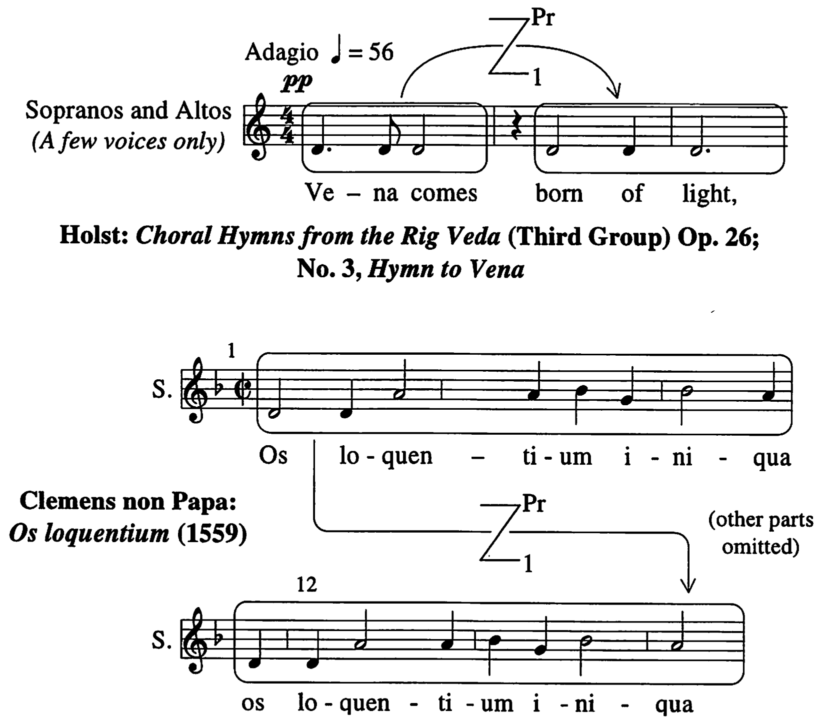


Figure 10.56 Relationships of profile.

Integral to the imperfect repetition of an association may be a change of mode—for example, major to minor, or *vice versa*. This type of ordering occurs with sufficient frequency in certain styles of music to warrant being specified on a relationship of profile. See, for example, figure 10.57.

Here, and in many other similar cases, despite the non-uniformity of the differences between the first association and the second, the standing of each pitch relative to those that immediately precede and follow it (where such protractions exist) is nevertheless unaffected. That is to say, from a music-theoretical and music-psychological point of view, the **contour** of the melody is unchanged (see, respectively, Adams, 1976; and Dowling and

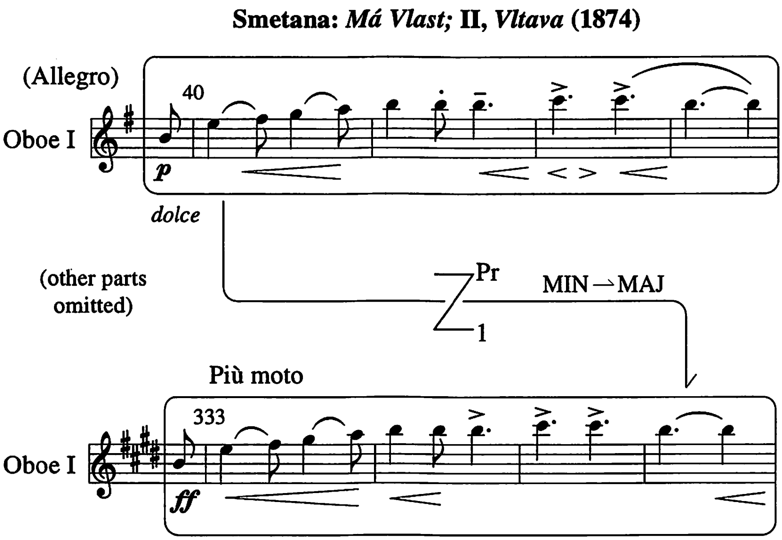


Figure 10.57 Relationship of profile; switch from minor to major.

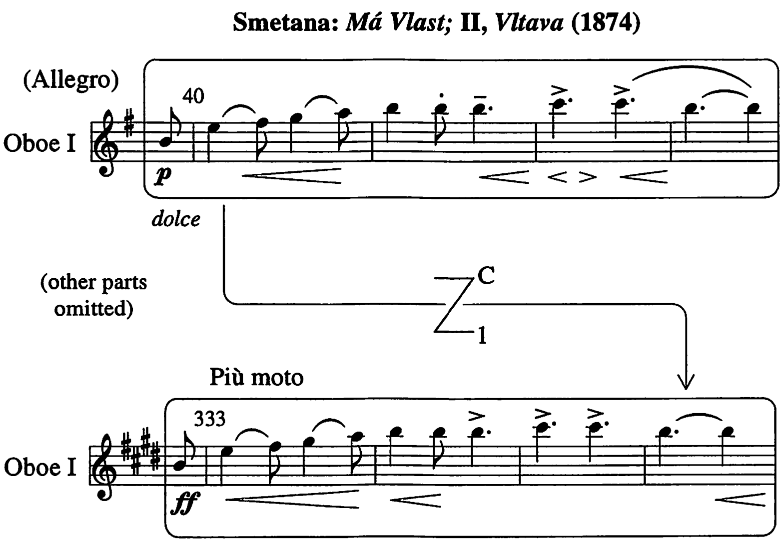


Figure 10.58 Primary zygonic relationship of contour.

Fujitani, 1971; Idson and Massaro, 1978, for example).[11] Contour may be regarded as a melodic perspect in its own right (and symbolised as 'C'). See figure 10.58. Alternatively, contour can be used as a measure of the imperfection of a relationship of profile.

Associations may be reiterated at a higher or lower level, or subject to **transposition**. The relationship between an association and its transposition may take the form a primary constant (see figure 6.28) or a secondary zygonic constant (figure 6.36), if the associations are themselves uniform. Two variable associations may be related through a primary zygosequential invariant (which takes into account the identical interval between sequentially equivalent notes—cf. figure 6.50) or a primary zygosequential secondary zygonic invariant (indicative of the fact that sequentially equivalent intervals are the same—see figure 6.60). If the association transposed consists only of two protractions, the link between model and imitation may be comprise a secondary interprotractive zygonic constant (cf. figure 5.15). The transposition of a regular variable association may be interpreted in terms of a secondary zygosequential zygonic constant (figure 6.63).

Any of these relationships or compounds may be substituted with a single relationship of profile, the interval of transposition indicated, if required, in parentheses.[12] Where the transformation is imperfect, this can be shown too, and imperfection that leaves contour unaffected can also be acknowledged. Transformations such as this, that are considered in terms of contour, will be linked through *perfect* relationships, and the fact that transposition is involved can again be indicated in brackets; figure 10.59.

Transposition occurs in a number of different musical contexts. Interterpretively, it may result from a singer's limited long-term memory for perspective values of pitch (see pp. 41 and 42). It may also occur in a calculated way, to suit a given vocal or instrumental range, for example, or to accommodate the key in which a given instrument is pitched. Even if listeners realise that a transposition has been made, this will not affect their ability to recognise a tune, although its aesthetic qualities may be impaired. What is generally thought of as a single melody actually exists (in terms of

[11]In fact, the contour of a passage may be reproduced with varying degrees of fidelity. For example, the relative sizes of all intervals may be maintained (rather than only those that are successive; cf. White, 1960, p. 103; Friedmann, 1985; Marvin and Laprade, 1987). The maintenance of contour at the level of pitch degrees is of such importance in certain styles that it may specifically be notated as such on relationships: C(d).

[12]Or without brackets in the case of absolute profile.

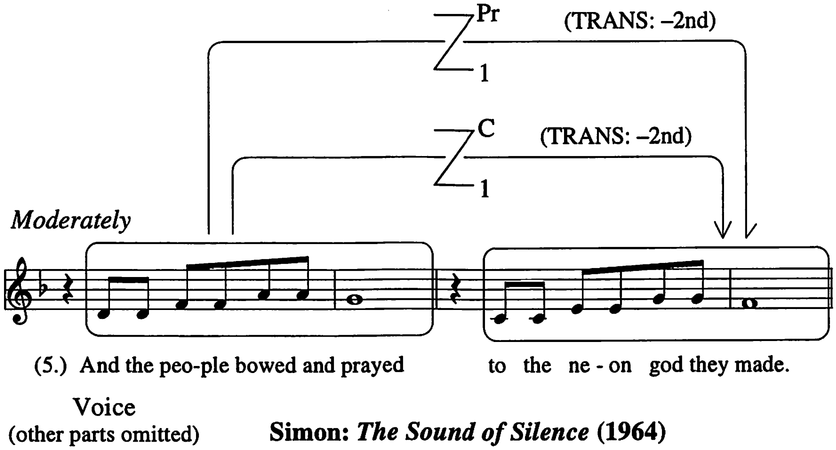


Figure 10.59 Imperfect transposition, considered in terms of profile and contour.

pitch) as a set of imperfectly related members—a spread of musically acceptable realisations (cf. pp. 404 and 405).

Comparable comments are applicable interoperatively: when transferring melodies from one work to another, composers may well change perspective values of pitch. See, for instance, figure 10.60. Intraoperatively, transposition is a feature that transcends stylistic boundaries. However, the typically asymmetrical disposition of primary interperspective pitch sets means that, at most intervals of transposition, either a melody must be modified to accommodate the pitch set, or the pitch set must expand to be able to assimilate the melody. Although both solutions are feasible musically, the power of the primary interperspective pitch set has tended to dominate.

With the first possibility—intervallic deformation—contour is maintained, often at the level of pitch degrees (see figure 10.59). This type of imperfect transposition has been examined by researchers such as Dowling (1978), who observes that the recognition of themes so transformed is not appreciably impaired. However, in the course of many pieces, different pitch sets are introduced, enabling perfect transpositions to occur. See, for example, figure 10.61. In pieces whose pitch sets are uniform, no compromise is necessary. Take the following example from the serial repertoire, built on the framework of the chromatic scale (figure 10.62).

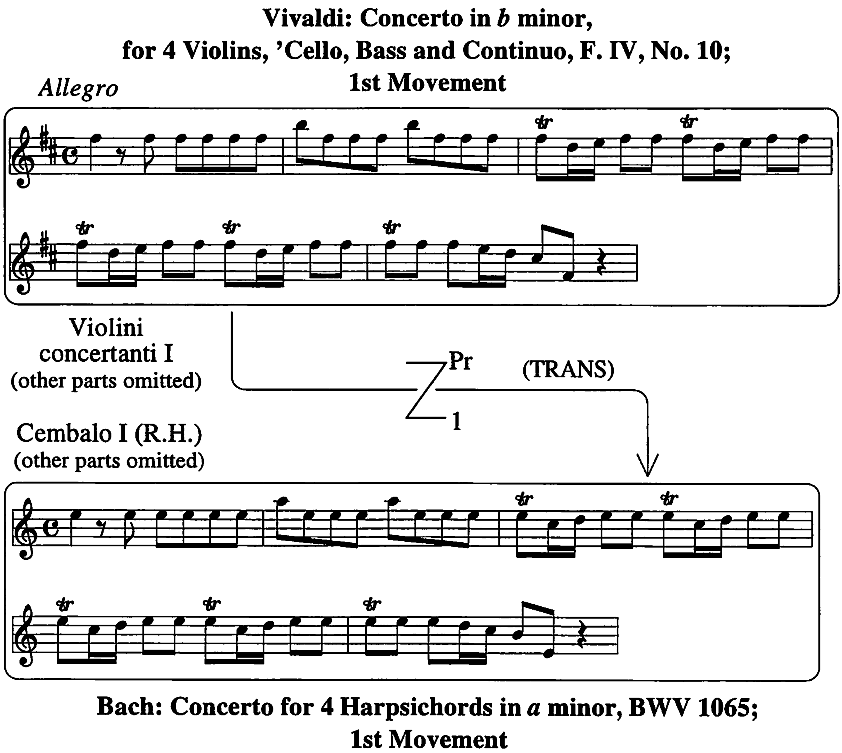


Figure 10.60 Transposition occuring between a work and its adaptation.

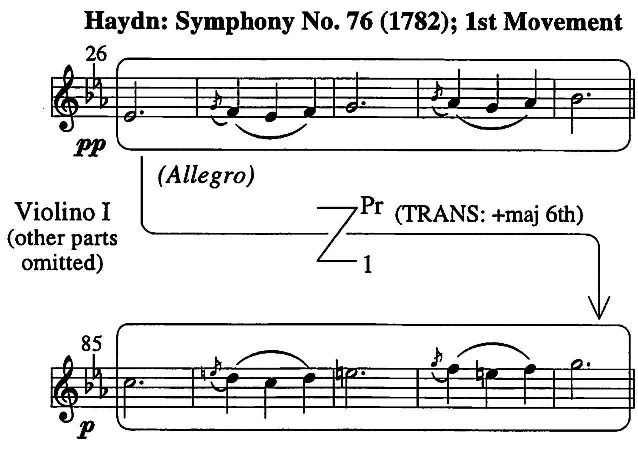


Figure 10.61 Perfect transposition occurring in combination with a change of pitch set during the course of a movement.

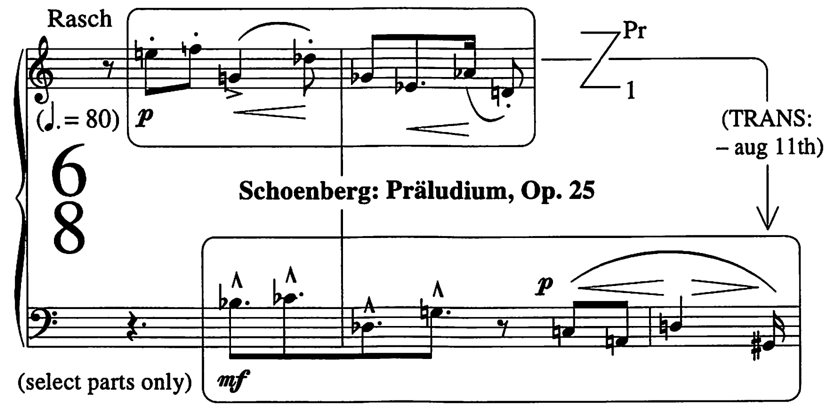


Figure 10.62 Perfect transposition occurring in a serial context.

Tchaikovsky: *Sleeping Beauty,* Op. 66; No. 22, *Polacca*

Violini I (other parts omitted) *(Allegro moderato e brillante)*

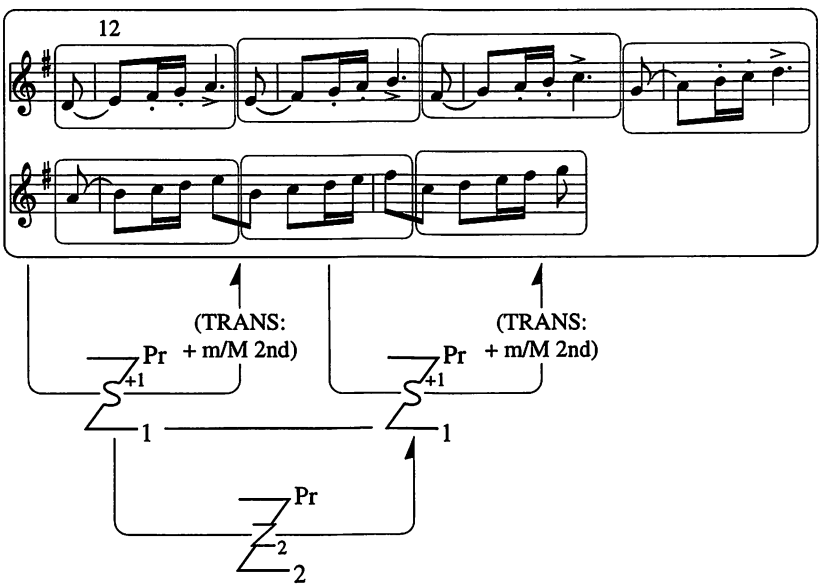


Figure 10.63 Secondary zygosequential zygonic constant system of profile.

In pieces like this, the forces of perfect associative transformation reign supreme.

Finally, we should acknowledge the possibility of unintentional intraterpretive transposition which may occur if a melody is repeated after the general pitch level of a performance has risen or fallen. Transposition may also occur interauditively if a tape is replayed at a speed different from that of its recording.

If a transposition involves moving pitches only a small interval, then it may be viewed as an imperfect form of repetition. The perceptual adjacency of two associations is also related to the number of values they have in common, however (cf. pp. 495 and 496), and transposition at the octave can be re-interpreted in cyclic zygonic terms.

In conclusion, observe that one frequently encounters an orderly pattern of transposition embracing three or more associations. In the excerpt shown in figure 10.63, for example, the organisation may be understood in terms of a secondary zygosequential zygonic constant system of profile.

Pitch organisation in melody iii: intersociative ordering (other isomorphic transformations)

Reversing the polarity of intervals causes **inversion**. If only a single interval is involved, inversion may be thought to result from an inverse secondary interprotractive zygonic constant. Inversion involving two intervals or more can be considered to occur through the agency of a primary inverse secondary zygonic invariant (cf. figure 6.61). The abbreviation 'INV' may be used to indicate inversion on relationships of profile. See, for example, figure 10.64.

Inversion which has to conform to the typically non-uniform pitch sets used in music is likely to be approximate, reducing the relationship or relationships between the associations involved to imperfect rank. See, for example, figure 10.65. Since some sets have inversional symmetry, however (see Ziehn, 1912/1976, pp. 25ff), provided that the inversion occurs at the appropriate transposition, no compromise will be necessary (as in figure 10.64).

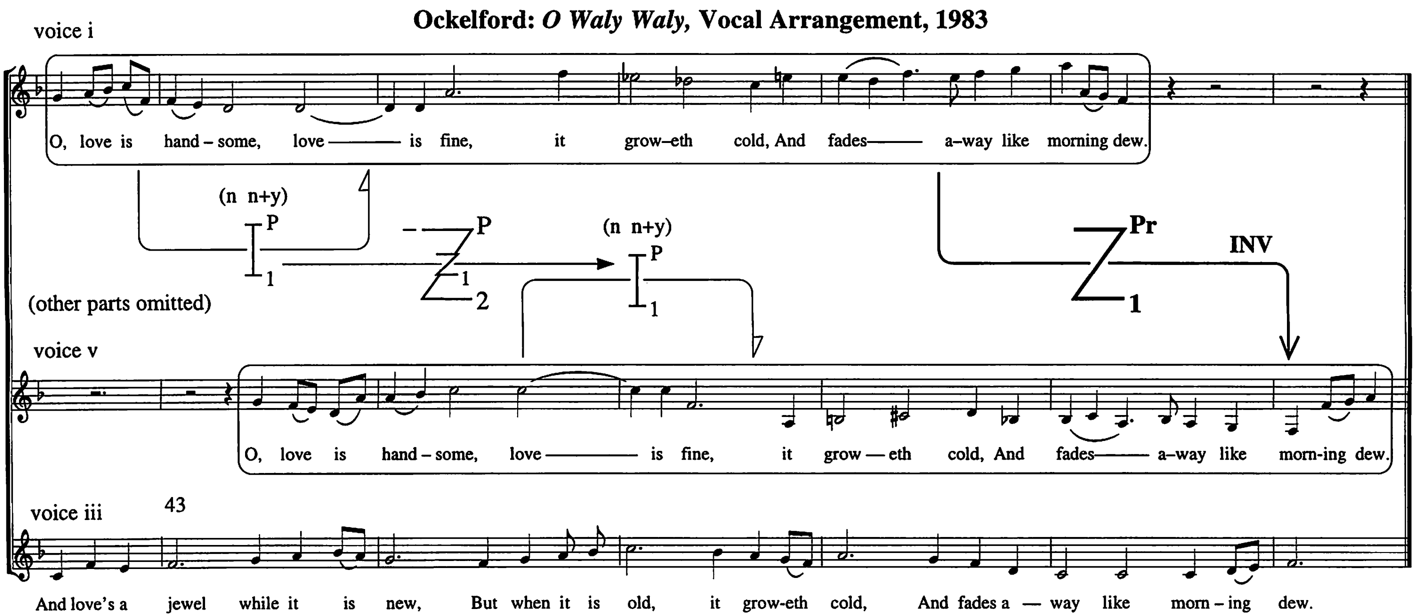


Figure 10.64 Inversion of profile.

Brahms: Symphony No. 4, Op. 98; 2nd Movement

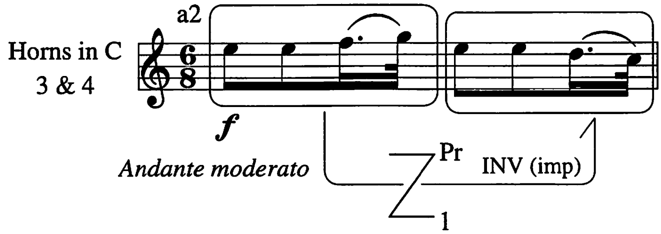


Figure 10.65 Imperfect inversion of profile.

According to Dowling (1971, p. 349), the ability to recognise inversions is the same, irrespective of whether exact interval sizes are maintained or not, provided the contour is left intact. In either case, inversion is harder to identify than straight repetition.

Associations that are subject to inversion, like the ones illustrated, tend to be comparatively short, a limitation that does not typically apply to those that are repeated or transposed.

A further isomorphic transformation of profile is retrogression, in which the order of appearance of a series of protractions is reversed. Here the relationship concerned is a retrograde primary intersociative zygonic invariant (cf. figure 6.52), which may be perfect or imperfect. Again, this may be expressed as a single relationship of profile. For example:

Gershwin: *I Got Rhythm* (1930)

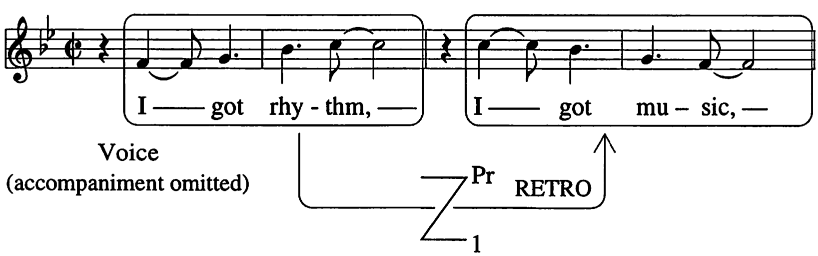


Figure 10.66 Retrogression of profile.

Beyond short motives such as this, retrogression is encountered comparatively rarely, doubtless on account of the perceptual challenges it incurs (see, for example, Piston, 1949, p. 104; Rubbra, 1960, p. 36; Apel, 1969, p. 728), although contrary views are expressed, for instance, by Walker (1962, pp. 58ff), and Dowling (1972) finds that the transformation is distinguishable from others with better than chance accuracy, at least in the conditions of his experiment. The fact that composers of the eminence of Machaut, Dunstable, Byrd, Bach, Haydn, Beethoven, Brahms and Hindemith, among others (quite apart from those of the serialist school), have seen fit use the technique is, of course, no argument as to its audibility; it merely provides another example of a marked difference existing between compositional order and the organisation detected by listeners (cf. p. 255).

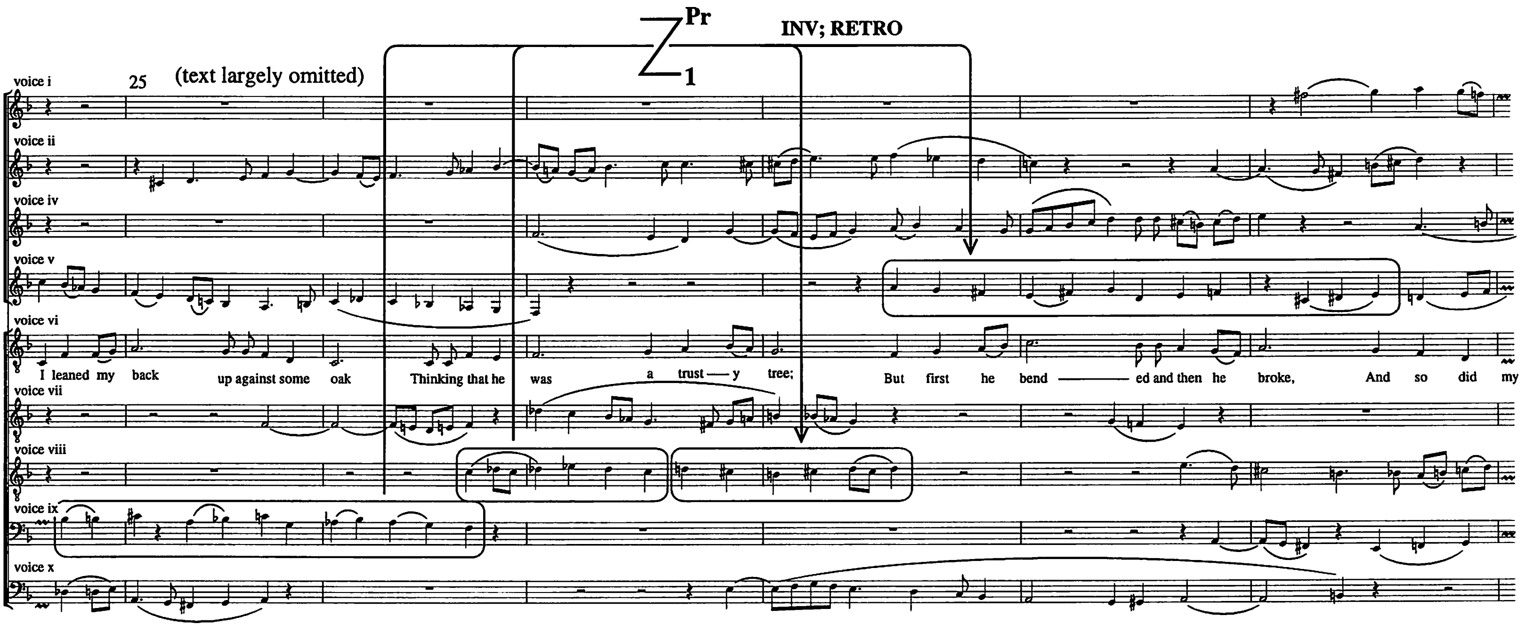
Retrogression and inversion are equivalent in that they both switch the polarity of relationships while leaving magnitude unaffected (cf. Babbitt, 1962, p. 57). Contextual evidence may suggest the operation of one or other: for example, if the opening members of the associations concerened are the same then inversion is the more likely alternative (see figure 10.65). Conversely, if the protractions of each association are equal to their sequential opposites, then retrogression is the likelier interpretation (figure 10.66). Naturally, the ear will light on the more straightforward route between the two associations (cf. Walker, op. cit., pp. 52 and 53).

A further consequence of the equivalence of retrogression and inversion is to be found in the transformation of certain associations that possess 'twofold rotational symmetry' (cf. Senechal and Fleck, 1977, pp. 7ff), whereby the first interval is equal and opposite to the last, the second is related in the same way to that occurring penultimately, and so on. Here, given the appropriate point of transposition, either reversing or inverting the association has the same effect. The series of Webern's *Variations for Orchestra,* op. 30, forms one such example (see figure 10.67).

The isomorphic transformations described may be combined in various ways.[12] For example, retrogression and transposition may occur together, and inversion and retrogression may operate concurrently. See, for instance, figure 10.68. Here, problems of perceptibility discussed above in respect of retrogression are exacerbated with the addition of a further transformation (see Dowling, op. cit., p. 420).

A further type of isomorphic transformation is intervallic augmentation or diminution. It is probable that most listeners would not consider the shape of a melody to be retained through this kind of variation, however,

[12]Some are inevitable, since inversion necessarily involves transposition.



Ockelford: *O Waly Waly,* Vocal Arrangement, 1983

Figure 10.68 Retrograde inversion of profile.

Webern: ***Variations for Orchestra,*** **Op. 30**

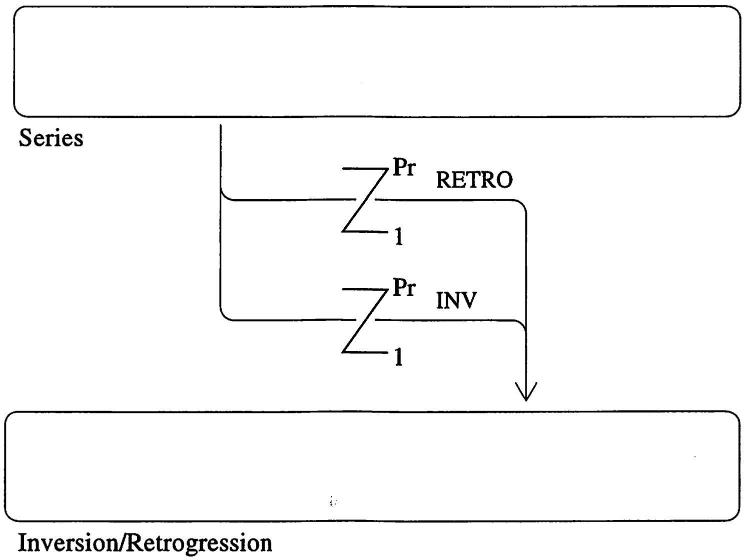


Figure 10.67 Inversion and retrogression producing the same result.

something that may be due to inexperience,[13] since its occurrences are so infrequent. The augmentation and diminution of intervals may be thought to occur through primary zygosequential secondary invariants (cf. figure 6.60). Where associations feature regular change, the operation of a secondary zygosequential constant or a secondary zygosequential tertiary zygonic constant are further possibilities (see figures 6.64 and 6.66). Each of these transformations may be expressed more simply as a single relationship of profile. See, for example, figure 10.69. Augmentation and diminution may be combined with any of the transformations (inversion, retrogression *et cetera*) outlined above.

[13]See White (1960, p. 100), who cites Werner's (1926) study, "in which the log frequencies of familiar melodies were so divided by a constant that a semitone was only one-sixth its normal size in the conventional musical scale. Such melodies were initially difficult to recognise, but with repeated exposure, were correctly identified and took on a more differentiated character".

Glinka: *Russlan and Ludmilla* (1837–1842), Overture

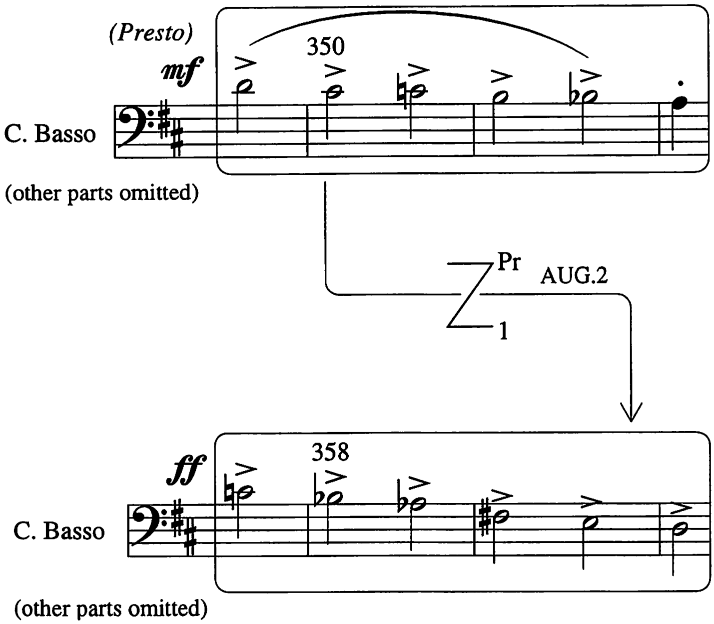


Figure 10.69 Augmentation of profile.

Pitch organisation in melody iv: intersociative ordering (consistent transformations)

A consistent transformation (see p. 399) applies across a variable association, modifying individual members in ways that are not mutually proportional. Hence profile is distorted. An example of such mutation is provided by 'additive' (or 'subtractive') intervallic change, whereby each interval is increased or decreased by the same margin.

A common manifestation of this type of ordering is found in chains of first-order associations, each comprising two protractions (and therefore a single interval) which is separated from the one preceding by an increment common to all. See, for instance, figure 10.70.

Bach: ***Toccata and Fugue in* d *minor*, BWV 565**

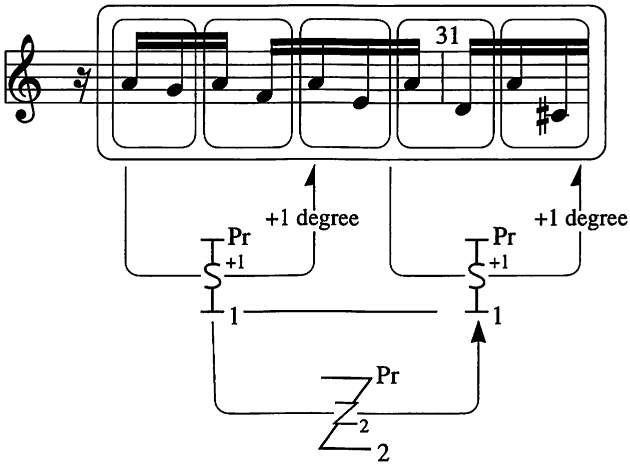


Figure 10.70 Uniform increase in profile.

(An alternative explanation of the order underlying patterns like these, taking into account the two melodic lines that are implied, is to be found on pp. 550 and 551.)

Consistent transformation may theoretically be combined with any of the isomorphic types described in the previous section.

Pitch organisation in melody v: the sequential ordering of intersociative transformations

The intersociative transformations described feature either the maintenance of sequence or its reversal. This need not, however, be the case: relationships between associations may utilise more advanced forms of sequential control. However, despite the enormous potential of sequential change beyond straightforward repetition or retrogression, its possibilities have only rarely been exploited by composers or explored by theorists.[14] Exceptions are to

[14]Perhaps on account of the perceptual problems posed: see White (1960, p. 106), in whose experiments it was found that those transformations are least disruptive that leave sequence intact.

be found, however: writers such as Reti (1951, pp. 72 and 73), Keller (1958, p. 19) and Walker (1962, pp. 73–75), working in the context of the Western Classical tradition, regard permutation as a distinct transformation, which they refer to as **interversion** (cf. p. 416). For example:

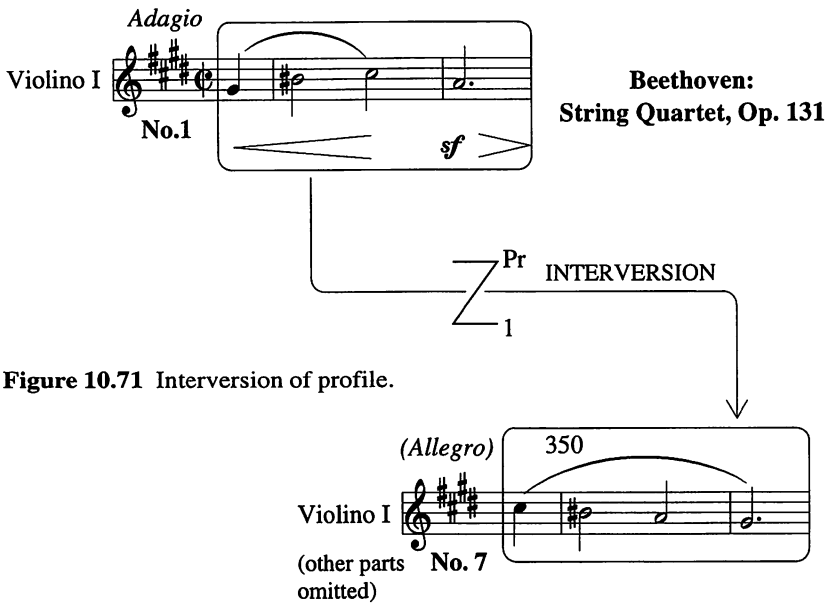


Figure 10.71 Interversion of profile.

Moreover, the idea of associations being ordered freely with regard to sequence is central to the kind of atonal analysis first propounded by Teitelbaum (1965), Chrisman (1971) and Forte (1973) among others, in which the piece or passage in question is segmented into sets of pitch-classes and the relationships between them examined.[15]

In both cases, the mere existence of sequential transformation is taken to be the important thing, and not the nature of the change. However, using the models of sequence and its organisation proposed in chapter 4, rather more telling analysis is possible. For instance, one of the examples of interversion cited by Walker (op. cit.) can be defined as transposition combined with sequential transformation: s $\rightarrow$ s+1.

[15]For criticism on both theoretical and perceptual grounds see, for example, Benjamin (1974) and Browne (1974).

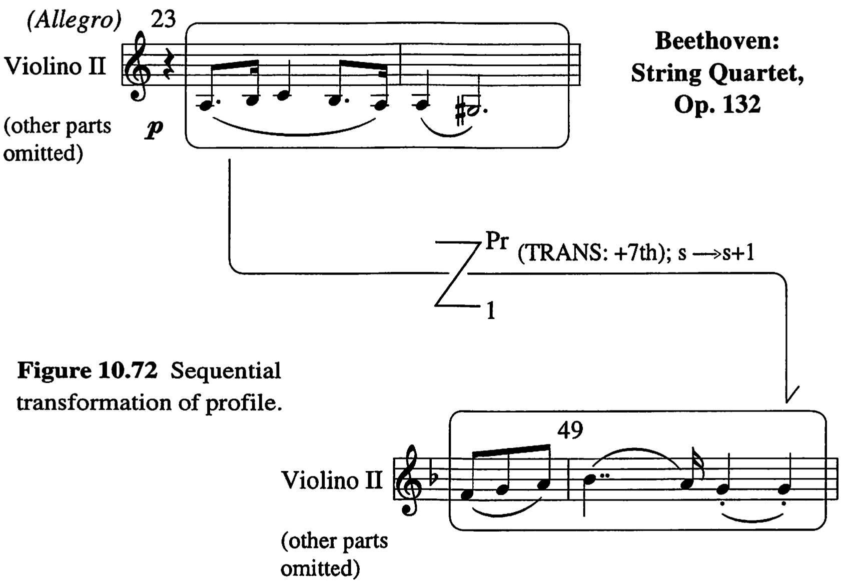


Figure 10.72 Sequential transformation of profile.

Whichever way it is described, this relationship seems unconvincing musically, however. Comparable connections that are less questionable are to be found, though, such as Davies's *Ave Maris Stella* (1975) which also employs transposition with sequential transformation (see Griffiths, 1982, pp. 73 and 74).

These examples notwithstanding, it is in that highly specialised branch of music-making, change-ringing, whose essence lies in the permuting of pitch, that the practice of sequential transformation is most systematically pursued, and advanced forms of intersociative sequential control are commonplace (see, for instance, Wilson, 1965).

Pitch organisation melody vi: intersociative transformations involving pitch-class equivalence

Any of the transformations outlined in the previous four sections may incorporate the notion of pitch-class equivalence. This principle was exploited by Schoenberg with respect to repetition, transposition, inversion, retrogression and their possible combinations in his method of composing with twelve tones (1941/1975, pp. 214–244; see also Rufer, 1952/1954, pp. 84ff). For example (observe that 'P-cPr' stands for 'pitch-class profile'):

Schoenberg: *Variations for Orchestra*, Op. 31

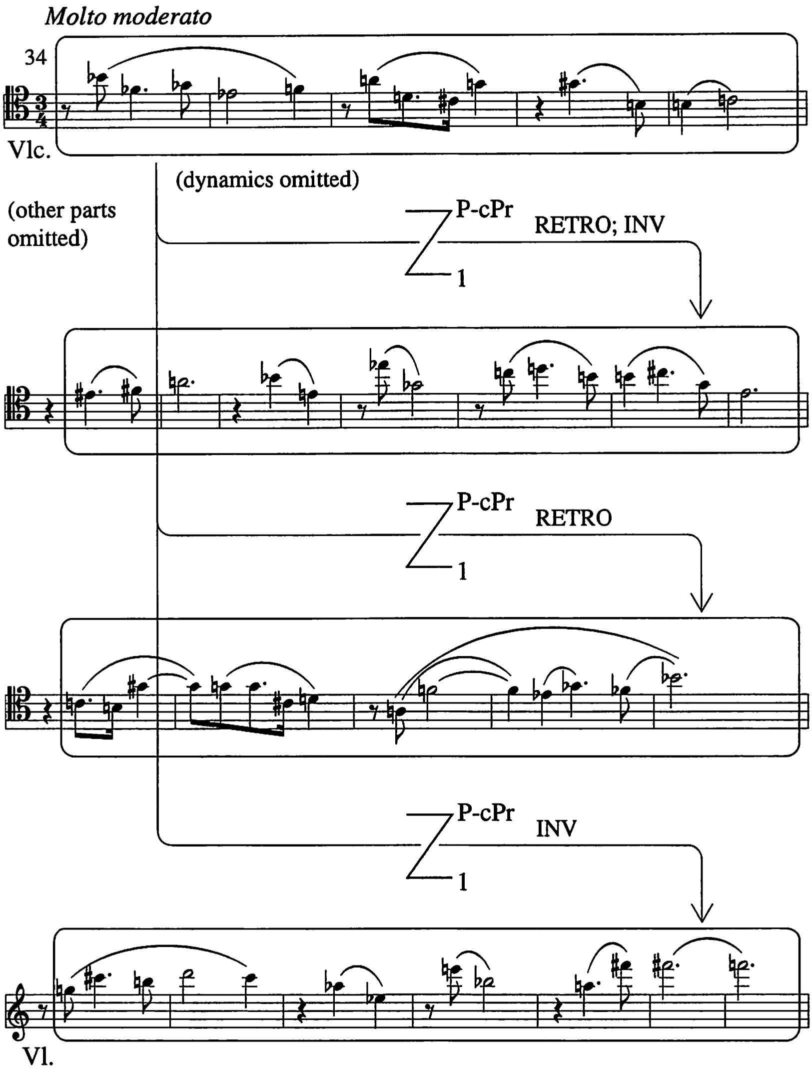


Figure 10.73 Transformations of profile: retrogression, inversion and retrograde inversion incorporating pitch-class equivalence.

As Babbit points out (1960, pp. 248 and 253), an important difference between serial techniques such as these and their counterparts in traditional practice is that the latter (unlike the former) necessarily imply the preservation of contour, albeit in an inverted or reverted form. The problem is that destroying the basic shape of a theme in this way can seriously impair its recognisability (see, for example, Pederson, 1975; Dowling and Hollombe, 1977). Hence there is likely to be a serious dichotemy between the structure as planned by the composer and that perceived by the listener.

Schoenberg's ideas were subsequently developed by other composers. Orderly sequential transformation was overlaid on serial practices by Berg, for example, in his opera *Lulu*, 1929–1935 (see Perle, 1962/1981, p. 145); while Krenek combined what he termed 'modal' concepts with those of twelve-tone music in his choral work *Lamentatio Jeremiae Prophetae* (1940–1941)—see Krenek, 1960, pp. 211–213.

A comparable scheme, employing complete freedom of sequence, had earlier been proposed by Hauer (1923)—described by Eschman, 1945/1968, pp. 83–104; see also Fortner, 1952, pp. 181–183. This involved composing with 'tropes', six-note cells with no predetermined order of appearance. Again, the pitches so specified could be placed in any octave.

Pitch organisation in melody vii: intersociative ordering involving the alteration, addition and omission of material; compound intersociative organisation

The transformations described above form the basis of all orderly intersociative change in the realm of pitch. The range of variation these processes offer is expanded considerably by their imperfect application, whose simpler expressions have already been discussed. Now we widen the scope of our invesigation to cover some of the more elaborate forms of imperfect transformation, including the alteration, addition and omission of material, compound intersociative relationships (comprising two or more different transformations), and combinations of these. We begin by considering the addition of material, which is commonly used as a means of intersociative variation. It is an inescapable requirement of musical coherence that whatever is added must be related in an orderly fashion to the given material, as the following examples show.

An intercalated protraction may be derived through a perfect primary zygonic constant stemming from a member of the existing association. Since the values of the original association are repeated in its developed form, an alternative intrasociative zygonic interpretation is available too, whereby the link with the first association is made only indirectly. See figure 10.74. The relative significance of these relationships will in part be determined by the period of time separating the two groups of notes.

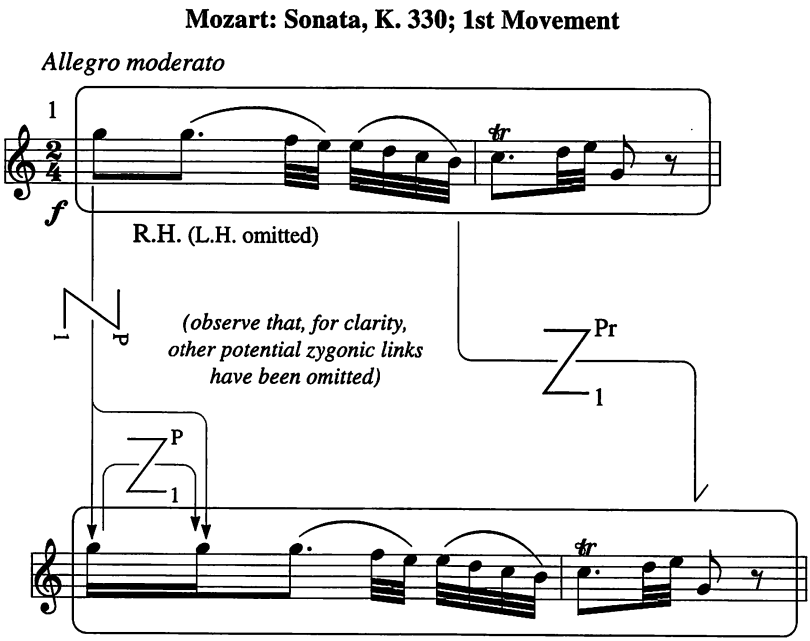


Figure 10.74 The addition of a single pitch to an association, generated through primary zygonic relationships.

Where more than one additional pitch is generated through a primary zygonic relationship, the manner of derivation may itself be viewed canonically, at the secondary zygonic level (figure 10.75).

Frequently, material is added upon the restatement of an association that bears only an approximate resemblance to pre-existing values, implying the operation of an imperfect zygonic relationship or relationships. Such ordering may result in embellishments such as auxiliary notes or appog-

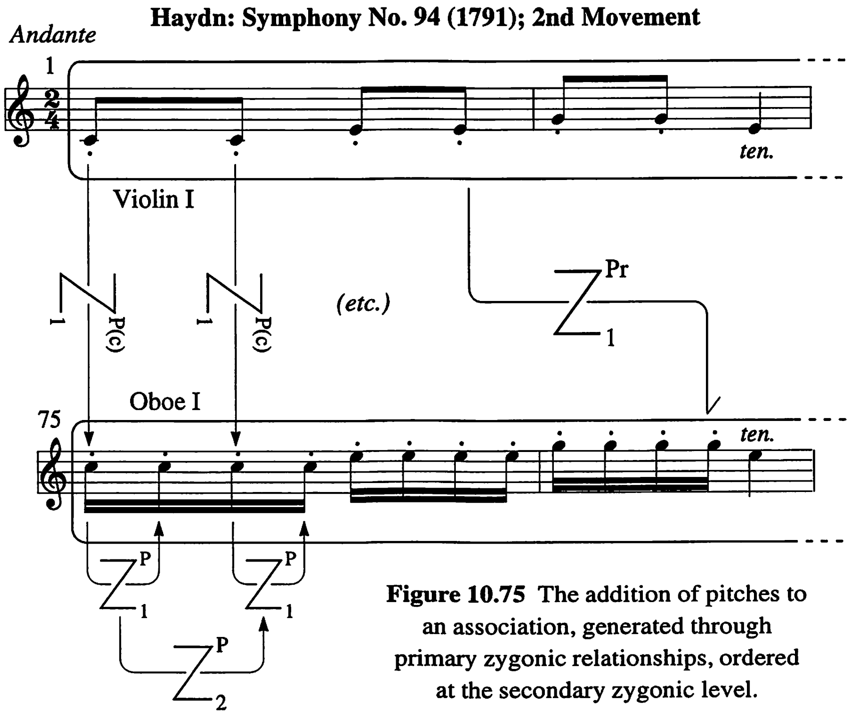


Figure 10.75 The addition of pitches to an association, generated through primary zygonic relationships, ordered at the secondary zygonic level.

giaturas. See, for instance, figure 10.76. Here the primary intrasociative zygonic constants linking the new material with the old act counter-chronologically, reflecting the fact that the structural pitches follow those that ornament them. Since the form of melodic enhancement used is the same on subsequent occasions, ordering at the secondary zygonic level is again indicated.

An additional pitch (or more than one) is commonly used to bridge the gap separating two values, both of which, therefore, play a part in the generation of the newly intervening material. This is derived in the following way. In perceiving tunes, listeners tend to hear not a series of pitches—each a discrete entity in its own right—but a single value that, with the passing of time, apparently occupies different positions in the perspective domain. With this model of perception, it is less appropriate to think of an interval between adjacent protractions as the difference between two separate notes than as a silent expression of the imagined movement of a pitch from one location to another. This implies that, in their apprehension of intervals,

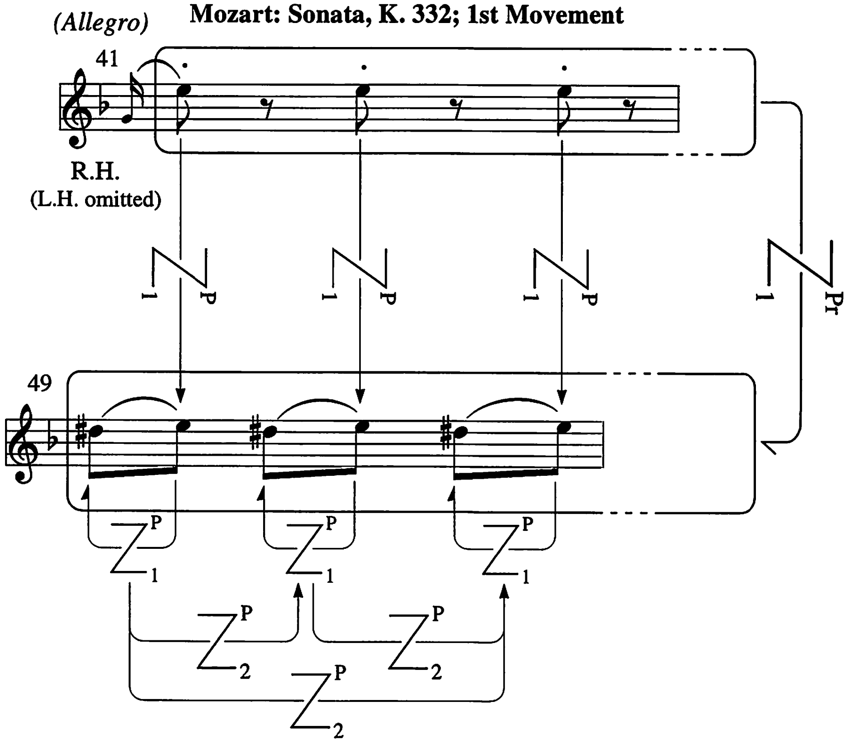


Figure 10.76 Material added to an association of pitch, generated through imperfect primary zygonic relationships.

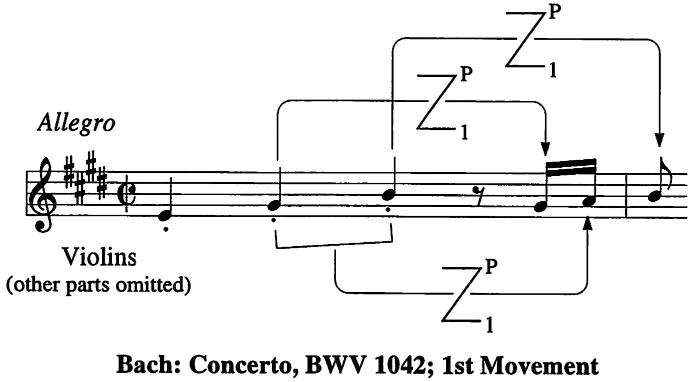
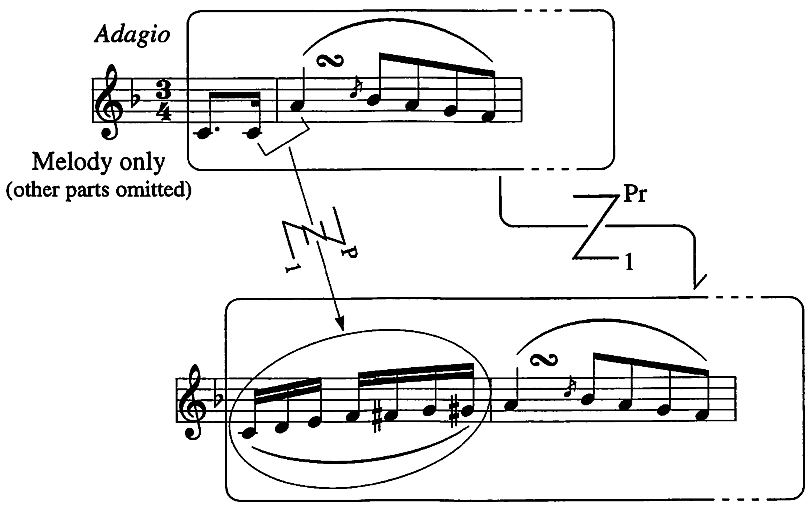


Figure 10.77 The zygonic ordering underlying the addition of a passing note.

listeners must mentally sweep over the range of perspective values outlined by successive pitches. Any of the values thus imagined can subsequently be realised in sound through the operation of zygonic relationships.[16,17] This can be shown diagrammatically with a square bracket linking the protractions whose vacant connecting interval is filled on a subsequent occasion. A primary zygonic constant leads from this to the newly created pitch. See, for example, figure 10.77. Two pitches or more may be derived by the same method.[18] For instance:



Beethoven: Sonata Op. 2, No. 1; 2nd Movement

Figure 10.78 Zygonic interpretation of a series of passing notes added to an association.

[16]Cf. Meyer (1973, p. 144): "A disjunct interval may be understood as a kind of incompleteness—a gap—that implies that the note or notes skipped over will be presented in what follows." This principle underlies his theory of 'gap-fill' melodies.

[17]It is possible to order other perspects in a similar way. Consider, for example, the following comments made by Rosen in relation to *The Classical Style* (1971/1976, p. 82): "The need to reconcile dynamic contrast is as important and as typical as the contrast itself. This reconciliation, or mediation, takes many forms. One of the simpler ways to resolve a contrast of loud and soft is to follow it with a phrase that goes gradually from one to the other." The opening of the minuet from Mozart's sonata K. 331 is quoted as an example, whose ordering in zygonic terms is equivalent to that pertaining to a *portamento*.

[18]A *portamento* represents the natural limit of this technique.

An interval may be transposed at the same time as being elaborated with intervening pitches. For example:

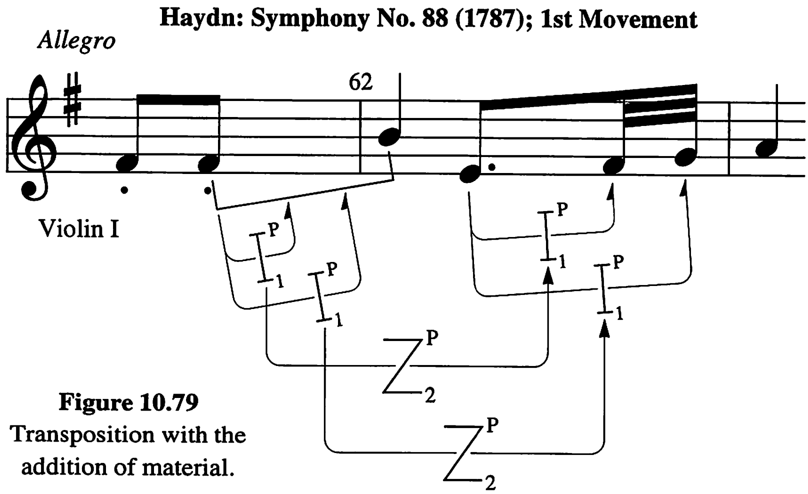


Figure 10.79
Transposition with the addition of material.

Associative transformation may occur through the elimination of material. For instance:

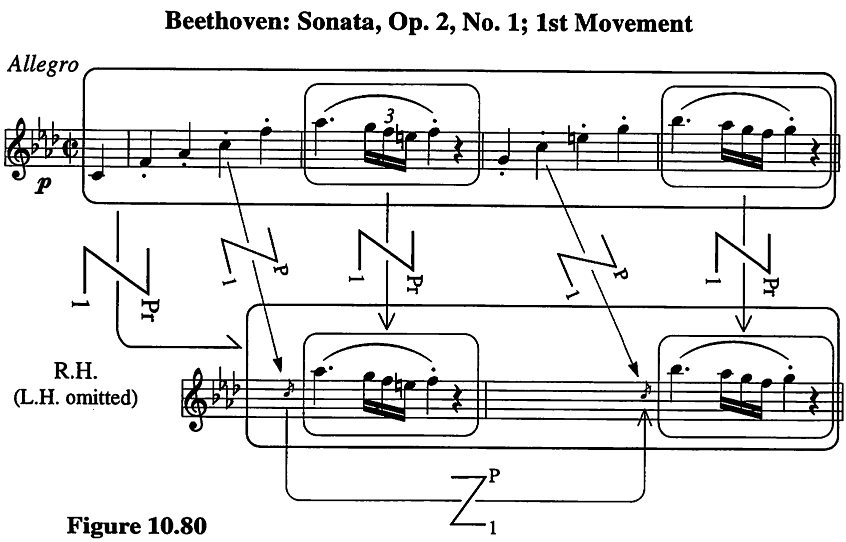
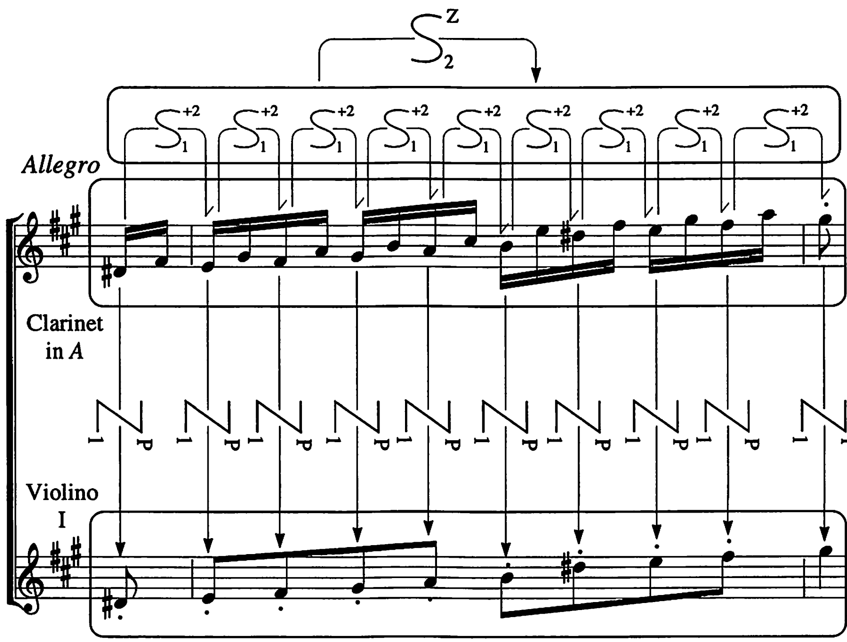


Figure 10.80
The omission of material.

The eliminated material need not be orderly with respect to sequence, although it may be—for example:



Mozart: Clarinet Concerto in *A* Major, K. 622; 1st Movement

Figure 10.81 The omisson of material, orderly with regard to sequence.

Some of the protractions in one pitch association may be deemed to be ordered, perfectly or imperfectly, in imitation of those in another, while the remaining protractions are not. See, for example, figure 10.82. Altered material may be derived intrasociatively (see figure 10.83) or intersociatively. Hence certain members of one association may be related to those of a second through one transformation, while the remainder are related through another or others. The overall effect is of one ***compound* transformation**. See, for example, figure 10.84.

Inversion and retrogression may operate together with the addition, subtraction or alteration of material. The developmental potential is vast. See, for example, figures 10.85 and 10.86.

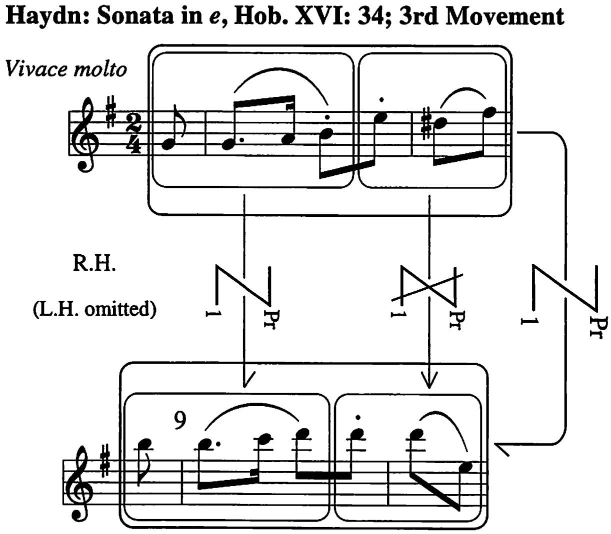


Figure 10.82
The alteration of material within an imperfect relationship of profile.

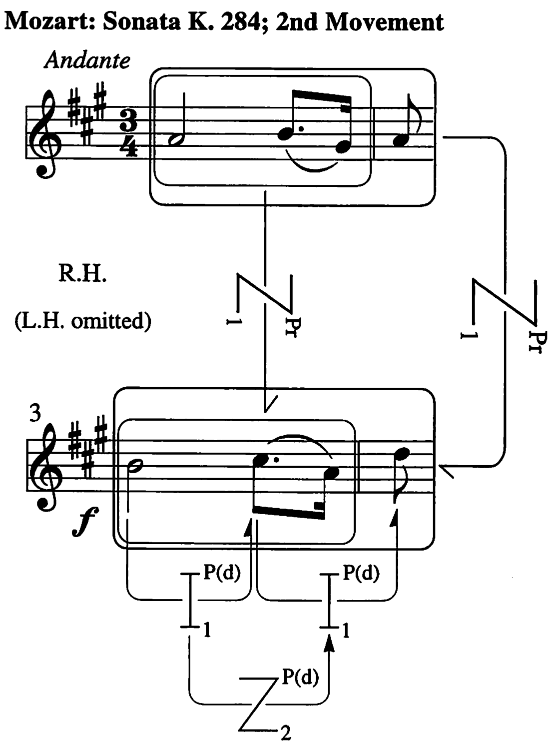
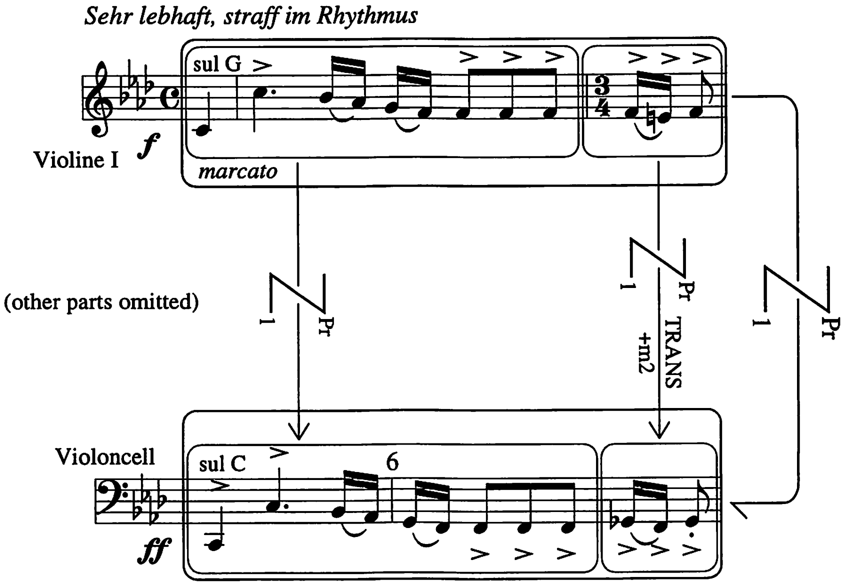


Figure 10.83
Altered material derived intrasociatively.

Hindemith: String Quartet, Op. 10; 1st Movement



Bartók: *Improvisations on Hungarian Peasant Songs;* No. 1

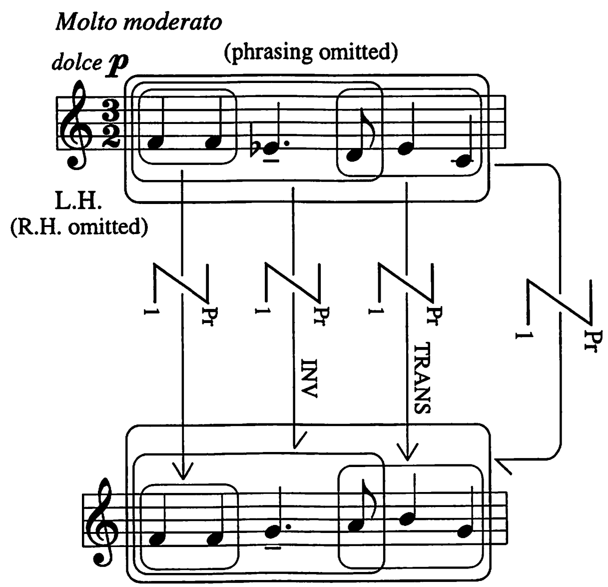


Figure 10.84 Compound transformations of profile.

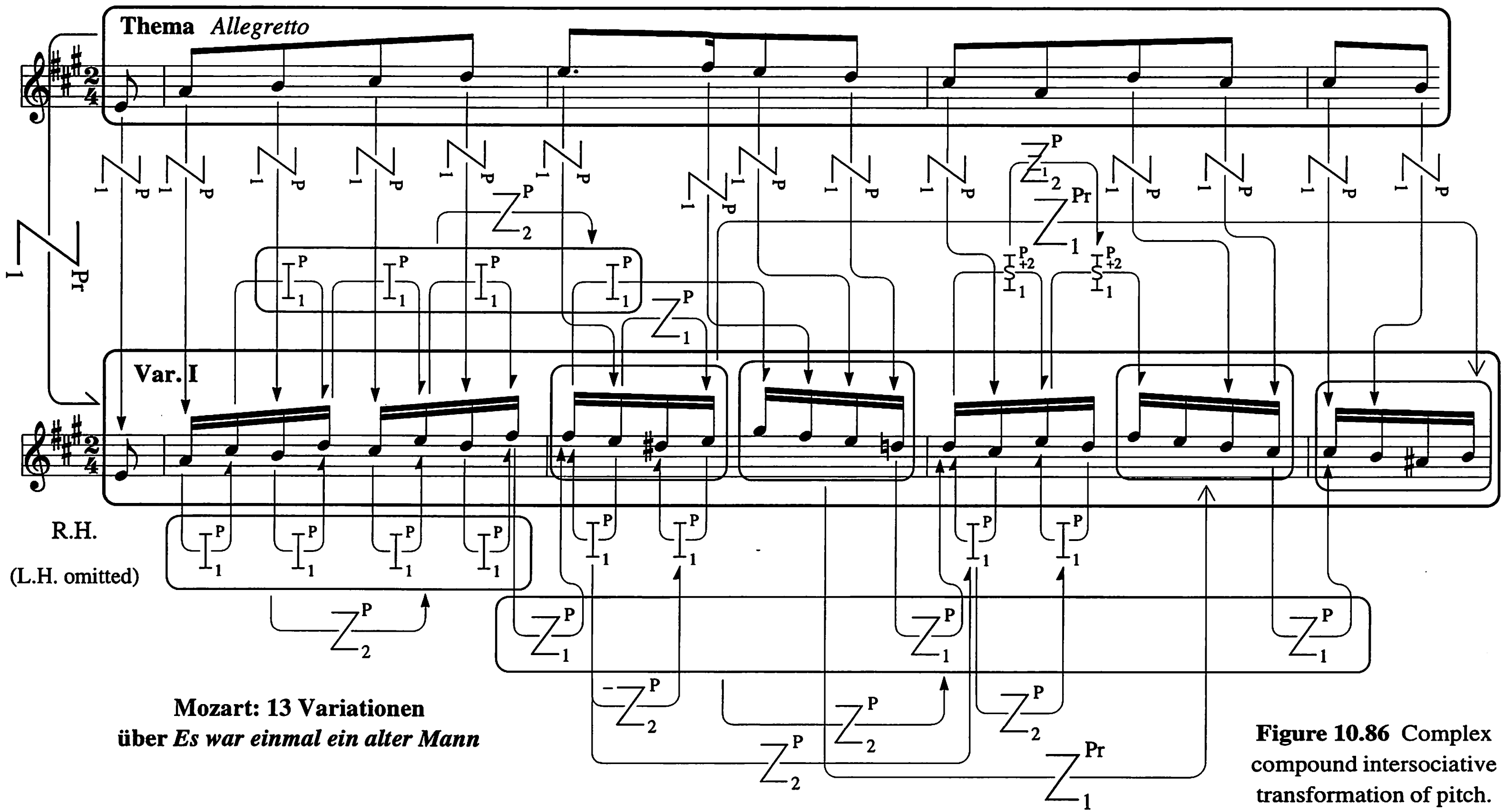


Figure 10.86 Complex compound intersociative transformation of pitch.

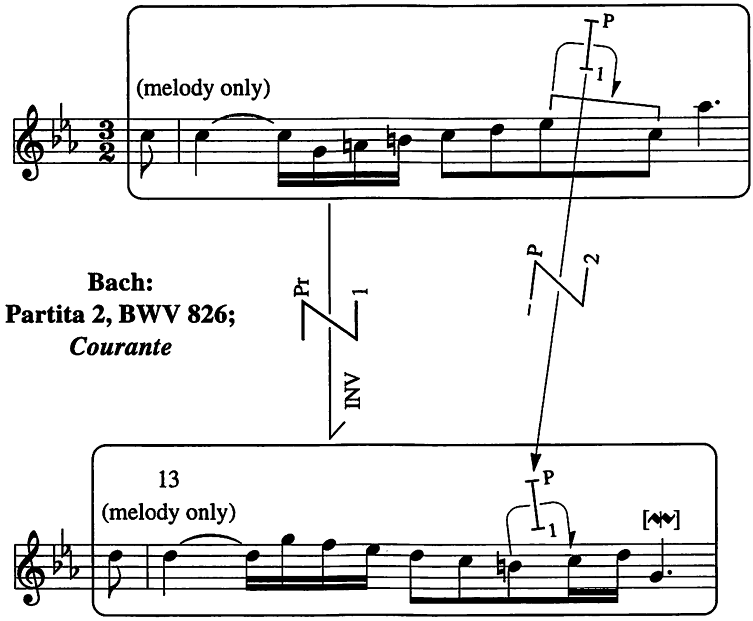


Figure 10.85 Inversion of profile with the addition of material.

In conclusion, it is appropriate to consider just how much an association can be modified before a relationship of derivation is no longer felt to apply. That is, where does the boundary between variation and non-variation lie? There is no simple answer to this question (cf. pp. 430 and 433), since the perception of similarity and dissimilarity varies according to the musical context in which passages are heard (including the existence or non-existence of parallel ordering in other perspective realms; LaRue, 1970, pp. 73–75), and the disposition of listeners: individual attitudes may even differ from one occasion to another. Although such ambiguity may represent something of an analytical inconvenience, it should not be a matter of regret: to doubt is such an essential human quality that its part in the musical experience must be acknowledged.

Pitch organisation in melody viii: compound intrasociative organisation; hierarchies

In the previous section on melodic intrasociative organisation (pp. 513ff), groups of pitches were examined whose internal disposition could in each case be attributed to the operation of a single ordering force. However, such simplicity does not accord with typical practice, in which the disposition of melodies may ascribed to the agency of two or more different types of zygonic ordering. Compound structures of this type may be analysed through a process of reduction, whereby the individual threads and patches of canonic control pertaining to a series of protractions are isolated. This in turn demands an appreciation of how associations may be juxtaposed in an orderly manner.

There are two main possibilities. First, one may exist in imitation of the other through any of the means of intersociative transformation mentioned in the preceding sections. The link between two associations need not be as comprehensive as this to achieve melodic coherence, however; even a single point of orderly contact may be sufficient, involving just one protraction from each of the pitch groups concerned, which may be perfectly or imperfectly related. See, for example, figure 10.87.

Mozart: Oboe Concerto, K. 314; 1st Movement

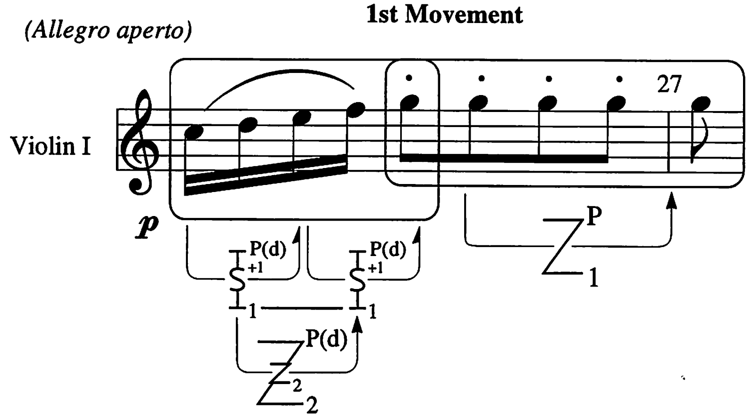
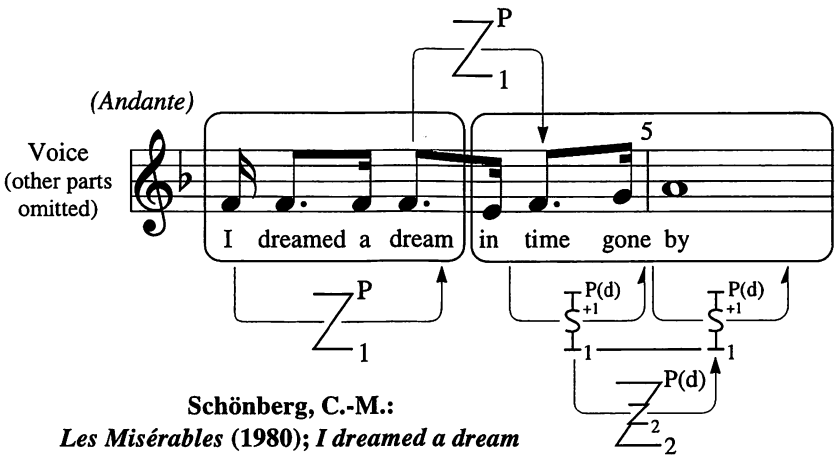


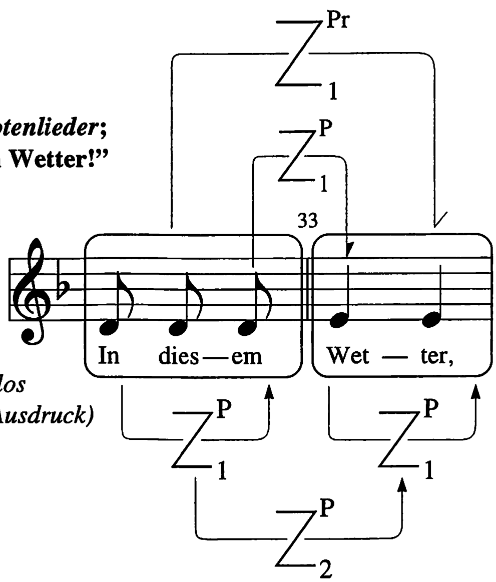
Figure 10.87 (part i) Single points of orderly contact linking adjacent associations of pitch.



Schönberg, C.-M.:
Les Misérables* (1980); *I dreamed a dream

Figure 10.87 (part ii)

The two forms of connection may operate side by side. For example:



Mahler: *Kindertotenlieder*;
No. 5, "In diesem Wetter!"

Figure 10.88 (part i) Contiguous associations of pitch linked through similarity of values and orderly relationships of profile.

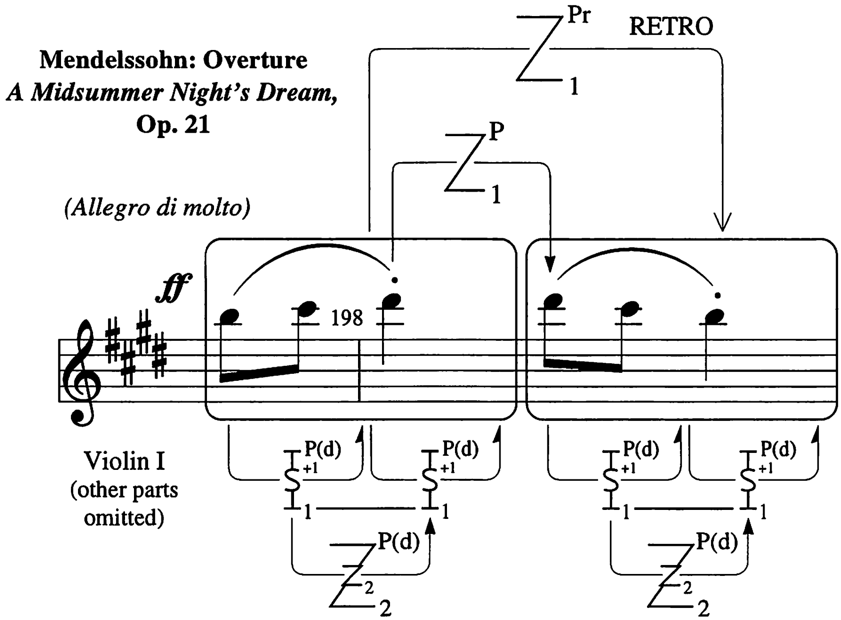
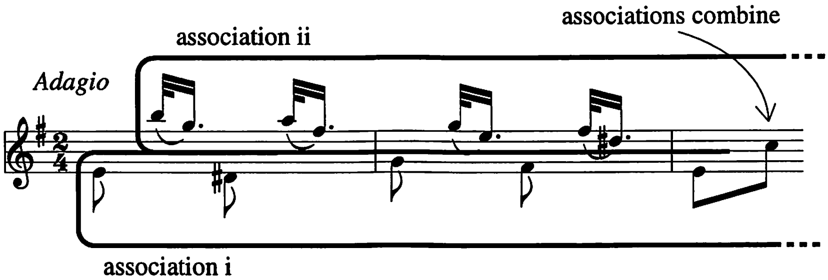


Figure 10.88 (part ii)

These examples of associative combination feature contiguity or a limited degree of imbrication. However, other perceived temporal relationships are often employed that add considerable depth and interest to melodies, whereby, in the same line, associations overlap substantially or are nested one within another. This has both practical and cognitive implications. Since the pitches in melodies occur successively, for their constituent associations to occur at the same time means that protractions from each must alternate. Hence listeners must remember the course of an association through the interruption of another or others. Structuring of this type yields a wide range of musical results, from strains that comprise two (or even more) distinct lines running concurrently to those in which discrete forces of associative order are integrated in a common thematic cause. In the former category come melodies such as the following (see figure 10.89).

The integration of separate incidences of associative control in the realm of pitch is a virtually universal characteristic of melody. This is because even a few pitches offer so many orderly options (cf. pp. 235ff). Consider,



Telemann: Six Canonic Sonatas for Two Violins (1738); Sonata I, 2nd Movement

Bach: ***Toccata and Fugue in*** **d** ***minor,*** **BWV 565**

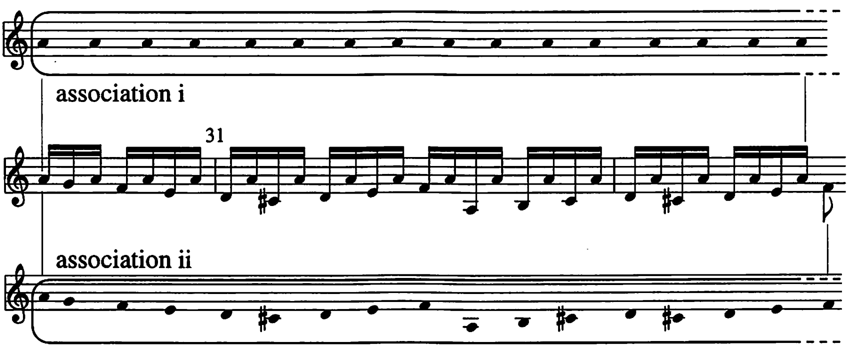
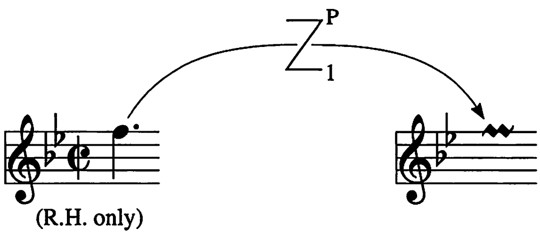



Figure 10.89 Associations of pitch running concurrently within the framework of a single melodic line.

for example, the last movement of Mozart's sonata K.333 in $B\flat$.[19] Taking into account only perfect zygonic relationships, the first note implies just one orderly continuation, a further *f*. See figure 10.90.

This potential is not realised at once, however, and the second note is the *d* a third below. This increases the number of perfect zygonic options dramatically. At the primary level, for instance, there is the possibility of

[19]For theoretical convenience, the analysis that follows concerns itself only with the intraoperative control of pitch in melody, and makes no mention of the associative organisation that arises interoperatively or the influences of harmony and rhythm (see pp. 598ff and chapter 11), which are highly significant. An awareness of these factors is implicit in the conclusions that are drawn, however.



Mozart: Sonata in $B\flat$ K. 333; 3rd Movement

Figure 10.90 Orderly projection of pitch from the first note of the melody of the 3rd movement of Mozart's piano sonata, K. 333.

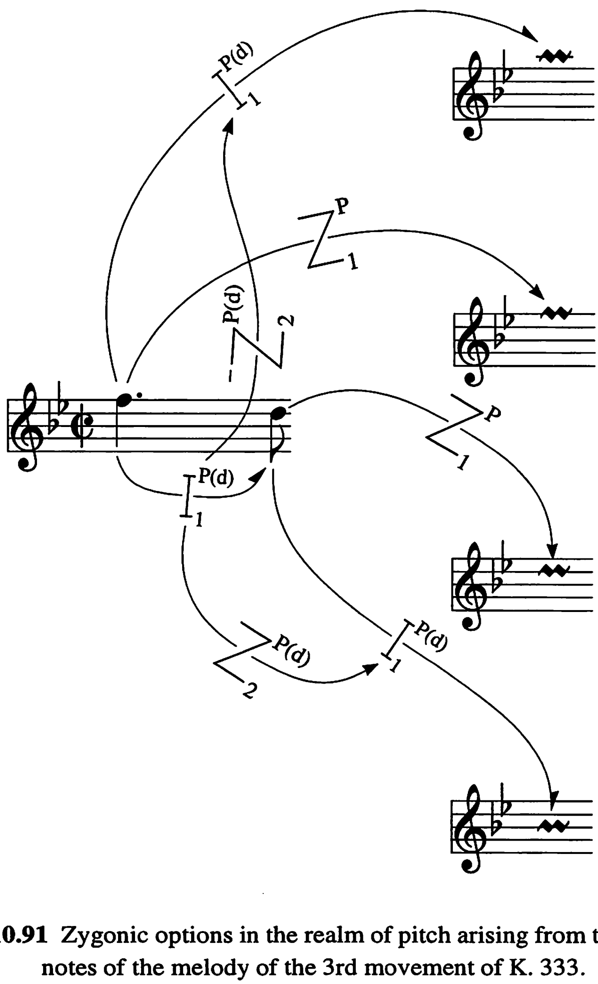


Figure 10.91 Zygonic options in the realm of pitch arising from the first two notes of the melody of the 3rd movement of K. 333.

repeating either of the opening notes. Secondary imitation rooted on either of these values leads additionally to $b^\flat$ in the fourth octave or *a* in the fifth. See figure 10.91. Freed of any primary zygonic constraint, the initial interval alone—a leap of a third—may be echoed anywhere on the keyboard. In fact, Mozart's preference at this stage is for the $b^\flat$, which is repeated straight away.

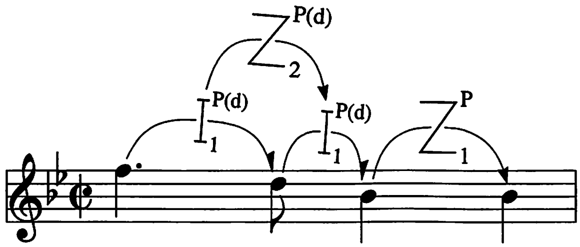
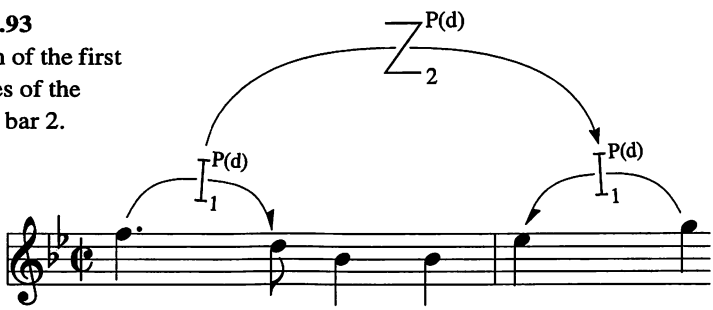


Figure 10.92 The organisation of pitch in the first bar of the melody of the 3rd movement of K. 333.

Up to this point, all ordering is derived immediately from the note or notes preceding, with no overlapping of relationships or associations. Moreover, each of the first three values is used only once as a reference from which another is derived. This situation changes in the second bar, however, whose first two notes can be interpreted as a transposed retrogression of the opening *f* and *d*.

Figure 10.93 Derivation of the first two pitches of the melody in bar 2.



Of the many orderly continuations available at this stage, Mozart opts for fourth octave *a*, for which there are two sources: descending a 5th from the preceding $e^\flat$ (in imitation of the transition from *f* to $b^\flat$ in the first bar) and dropping a 2nd from the $b^\flat$s in bar 1 (an inversion of the ascent from *f* to *g* at the top of the melody).

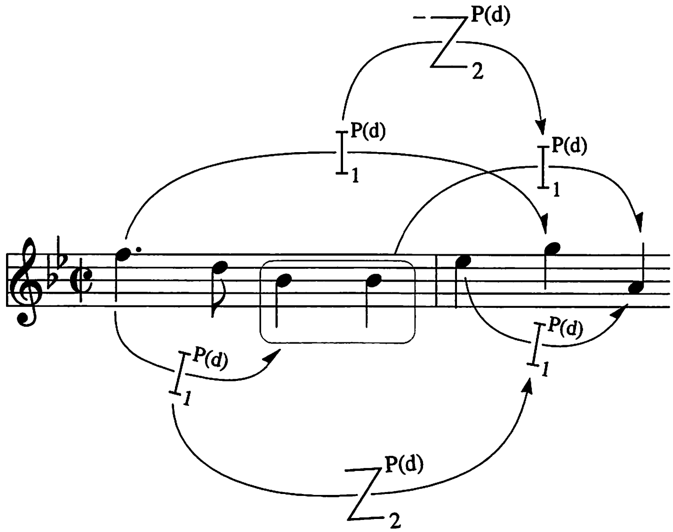


Figure 10.94 Derivation of the pitch of the seventh note of the melody.

Not only is the tune of the first two bars tightly controlled with regard to pitch, but the seven notes that appear imply a range of further structural possibilities, as yet unrealised. For example, will any of the six different pitches be imitated through primary zygonic relationships? Will the rise from *f* to *g* be extended to *a*, *b♭* and further? Will the fall from *f* to *e♭* be continued to *d, c, b♭* and even beyond? Similarly, take the descent from *b♭* to *a*: is this another line that will be pursued in due course?

These are some of the many options for orderly continuation. Clearly, not all of them can be realised within a relatively short, musically coherent movement. In one sense, Mozart's task can be seen as having had to choose between the numerous possibilities that were available to him. In the event, some were chosen consciously, no doubt, while others resulted from intuition, or even by chance in the course of composition. Mozart may or may not subsequently have become aware of some or all of these patterns (cf. p. 74).

In certain respects, the role of music analysts complements that of composers, as they identify the orderly connections present in music that are deemed to be of particular interest or significance. Inevitably, since composers order music so extensively, analysts only draw listeners' attention to a small proportion of the organisation that exists.

Figure 10.95 models some of the ways of hearing how the first 4 bars of the melody of the last movement of K. 333 are structured through zygonic relationships. The result is a complex network of possibilities, whose aural significance may vary from one occasion to another.

Some of the implications of the first two bars are realised, while others are not. A more general overview of the pitch patterning in bars 1–16 (figure 10.96) shows how initial trends find expression in the medium term.

It is evident from figures 10.95 and 10.96 that the pitch content of the melody is organised in a **hierarchy**. That is to say, one group of pitches is elaborated by another or others as it unfolds.[20] For example, in bar 3, the first of each of the pairs of quavers can be interpreted as ornamenting the second. At a deeper level, the opening four bars of the melody can be heard as embellishing the descending pattern *f, e♭, d, c* (though cf. Forte and Gilbert, 1982, pp. 41ff).

Both these patterns serve to delineate hierarchical strata. Members of a zygonically ordered association need not bear the same structural weight as each other, however, and therefore may operate at different levels in a hierarchy. Consider, for instance, the four note descent *b♭, a, g, f* that is initiated in bar 5 (figure 10.96).

Hierarchies function through a fusion of ordering in which foreground associations are keyed into the background they serve to enhance. This link is invariably made zygonically, although the orderly connection need only be implied when, as often occurs, certain values serve in a dual capacity, acting in effect as pivots, on which the two levels of associative organisation involved turn simultaneously. See, for example, figure 10.97.

The disposition of the zygonic strands of ordering operating within hierarchical levels and between them is immensely variable. Indeed, associations from different levels may exhibit a degree of controlled interrelationship beyond that necessary for basic melodic coherence. Schenker (1935/1979, p. 100), for example, cites an instance of repetition from Haydn's string quartet, op. 76, no. 4, 4th movement, bars 20ff[21]—see figure 10.98.

Where distinct hierarchical **levels** are deemed to be present (with due regard to the way a melody is thought to have been constructed or is likely to

[20]Cf. pp. 537ff—the addition of material to associations.

[21]In some ways this pattern and others like it can be considered the aural equivalent of fractals (see, for example, Mandelbrot, 1982), although for the parallel to be complete, the intervals of the more quickly moving stratum would have to be fractions of those that move more slowly.

Mozart: Sonata in $B\flat$ K. 333; 3rd Movement

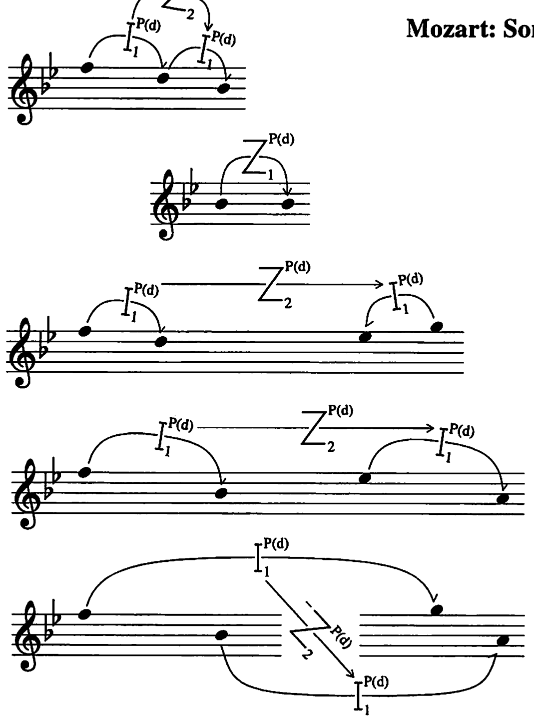
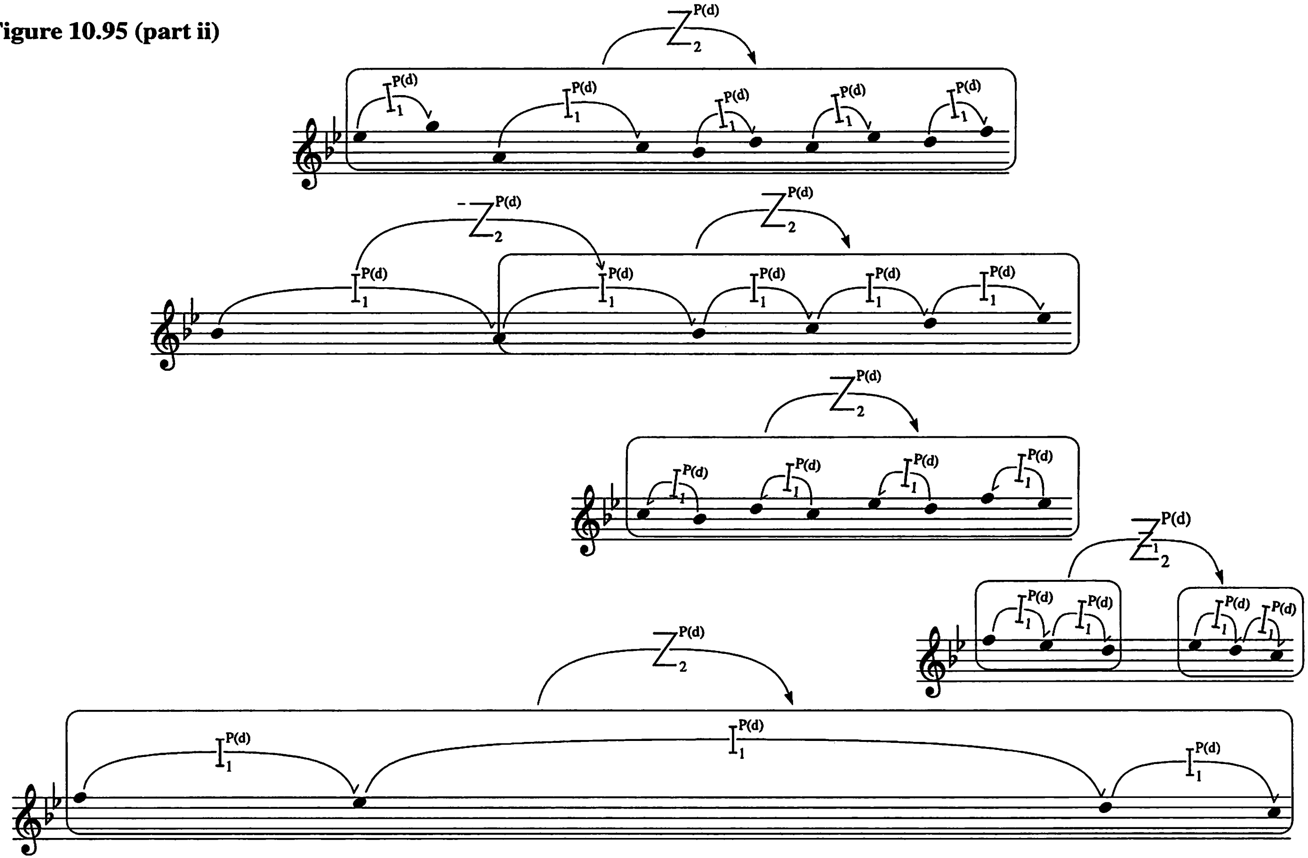
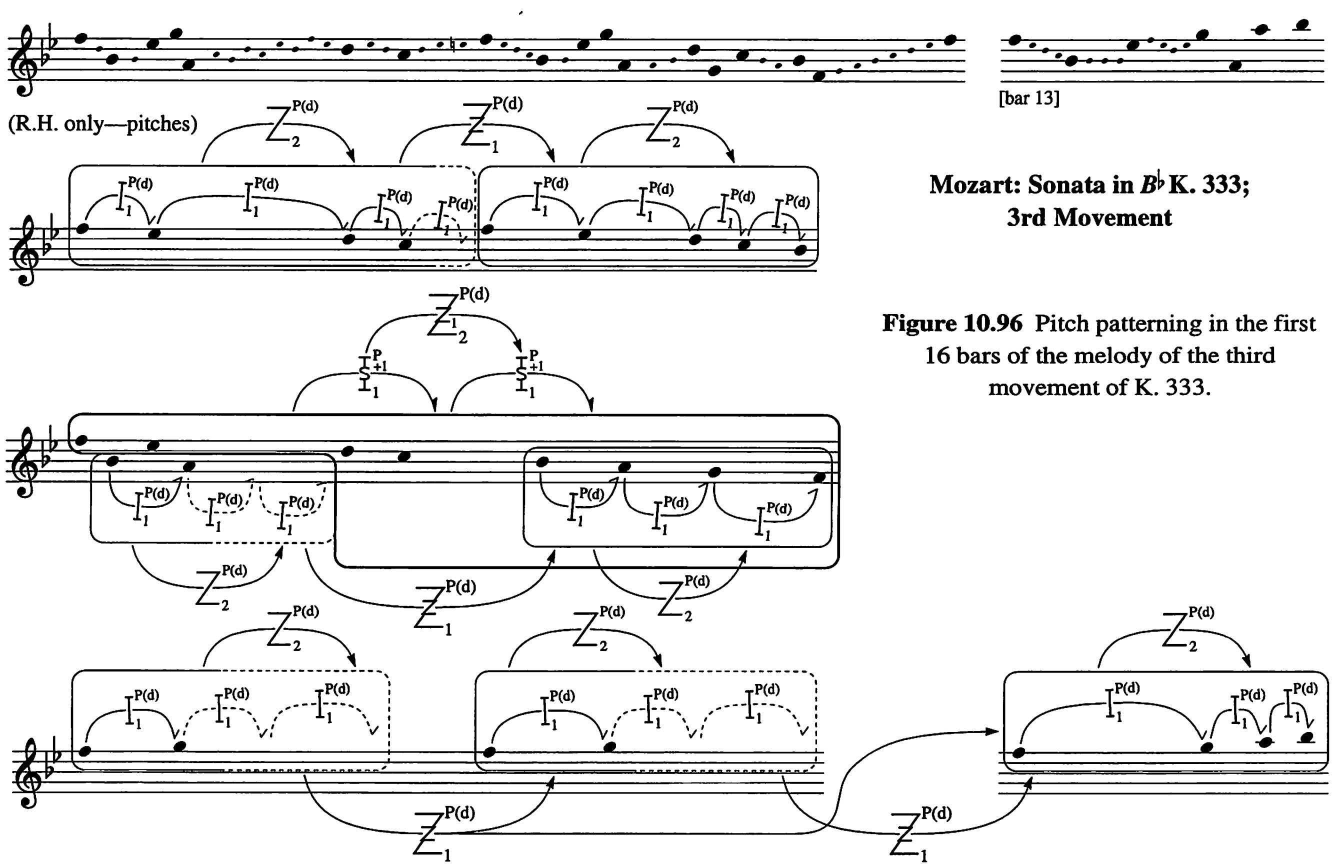


Figure 10.95 (part i) Some of the zygonic ordering that potentially underlies the structure of the first four bars of the melody of the third movement of K. 333.

Figure 10.95 (part ii)





Mozart: Sonata in $B^\flat$ K. 333; 3rd Movement

Figure 10.96 Pitch patterning in the first 16 bars of the melody of the third movement of K. 333.

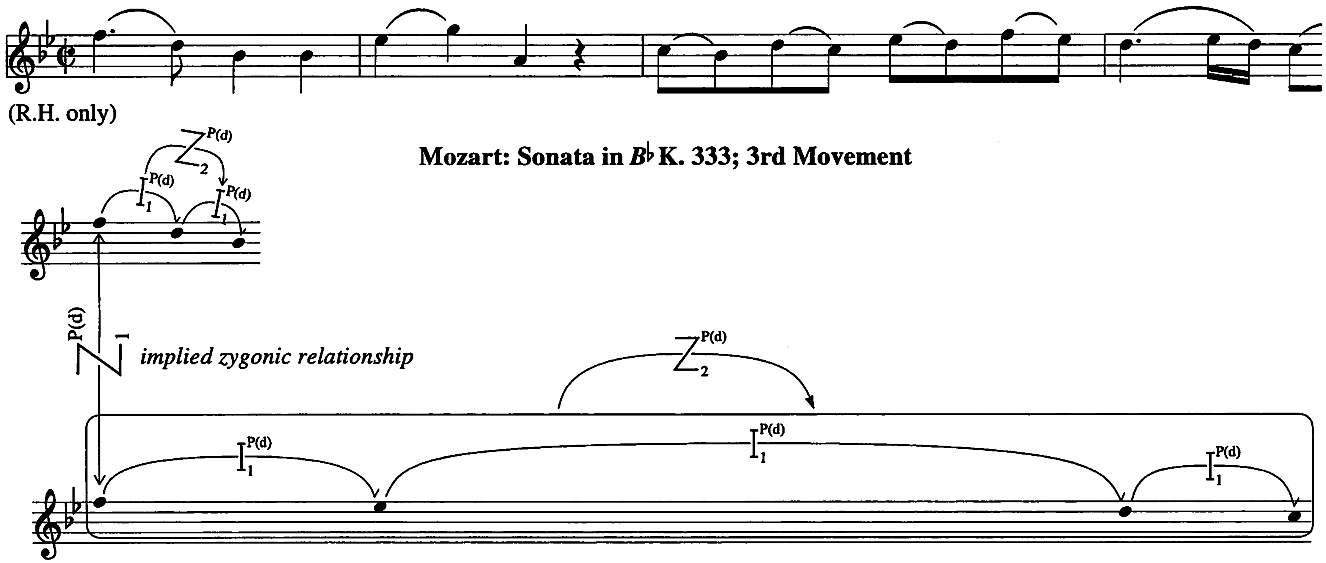


Figure 10.97 Implied primary zygonic relationship linking different strata in the pitch hierarchy.

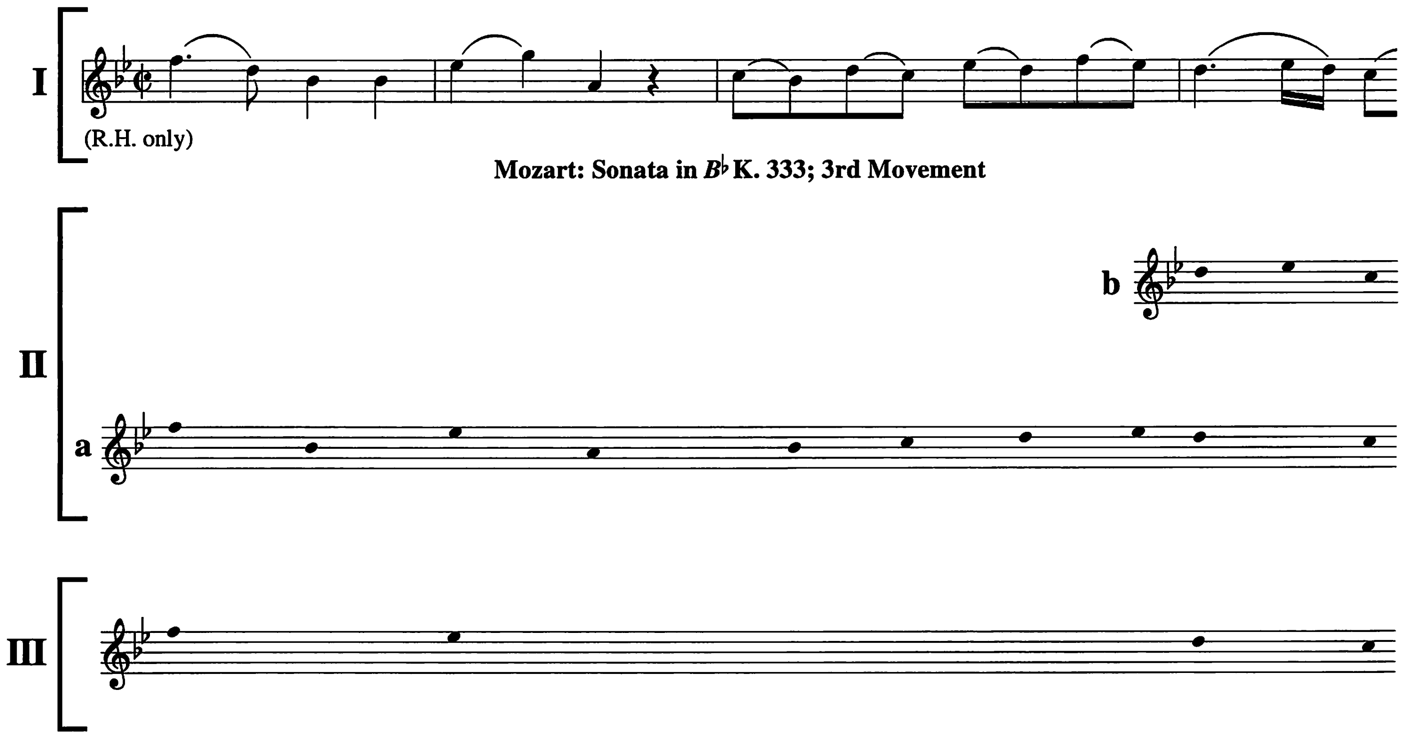


Figure 10.99 Proposed designation of hierarchical levels of pitch.

Haydn: String Quartet, Op. 76, No. 4; 4th Movement (after Schenker 1935/1979; Fig. 119)

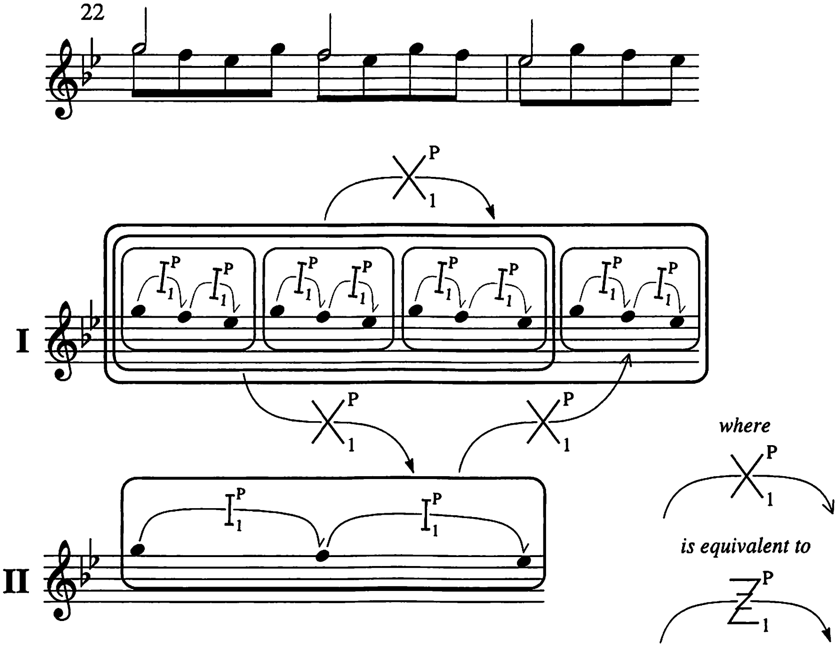


Figure 10.98 Primary zygonic relationships operating within and between hierarchical levels of pitch.

be perceived), these, and the relationships that pertain to them, may be labelled using upper-case Roman numerals as in figure 10.99 (cf. pp. 210ff).

Even within this short example, observe that there is subdivision within one level of the hierarchy, and that not all strata thread continuously through the melody from beginning to end. This illustrates the point that the structures of hierarchies are liable to vary during the course of melodies, just as their surface organisation waxes and wanes in complexity. Moreover, the deepest level illustrated is not far below the surface and, it seems reasonable to suppose, may well feature in the cognitive processing of most listeners.

Some analysts, however, consider abstract hierarchies to exist that are both structurally consistent throughout the course of a piece and have a depth which requires only a few values of pitch to span many minutes of music (typically, Schenker, 1933/1969). Not only does it appear unlikely that such levels form part of the perceptual reality of the vast majority of listeners—there is no compelling evidence of them playing a part in the process of composition either (cf. p. 255). Such reservations have not prevented elaborate theoretical edifices being constructed at these hierarchical depths, however, starting with those of Schenker, who sought to show that one basic design of association, which admittedly was open to slight variation, lay in the background of all masterpieces (which he considered to be composed in the era bounded, roughly speaking, by the works of J.S. Bach at one extreme and at the other by those of Brahms). This he termed the *Ursatz,* whose melodic component was the *Urlinie* or 'fundamental line' (1935/1979, p. 4).

Urlinie
(after Schenker 1935/1979; Fig. 1)

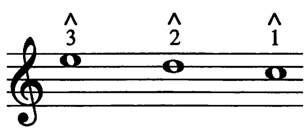


Figure 10.100 Schenker's *Urlinie.*

(Alternative versions of the *Urlinie* descend a fifth or an octave.)

Leaving aside the further questions of analytical propriety that are raised by this 'universal' pattern (albeit a universe shrunken by stylistic prejudice—cf. Narmour, 1990, p. 223), it is interesting to observe the canonic implications of its derivation, formation and use. Schenker contends that the *Urlinie* derives ultimately through imitation of the harmonic series (op. cit., p. 10; see also 1906/1954, pp. 25ff), implying the operation of extramusical zygonic relationships (cf. p. 462). Then, we may consider the internal order of the *Urlinie* to occur through the agency of a secondary zygon (see figure 10.101). Finally, one appearance of the *Urlinie* may be thought to emulate another through an interoperative secondary zygosequential zygonic constant of pitch (cf. figure 6.63).

The work of post-Schenkerists has on the whole been characterised by a rather more flexible approach. Meyer (1973, pp. 131–241), for example,

Urlinie
(after Schenker 1935/1979; Fig. 1)

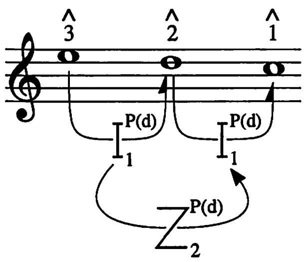


Figure 10.101 Zygonic ordering implicit in Schenker's *Urlinie.*

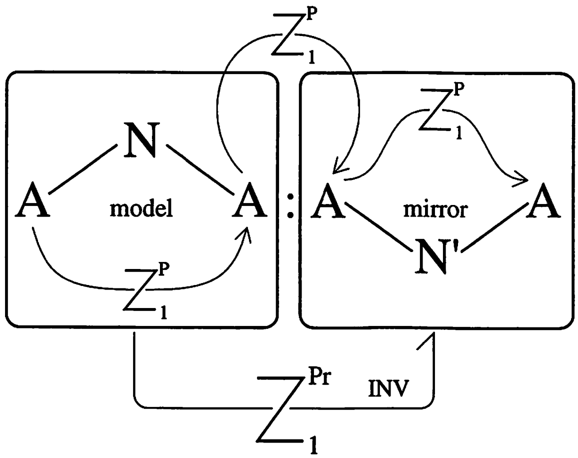


Figure 10.102 The order underlying axial melodic structure (after Meyer, 1973, p. 183).

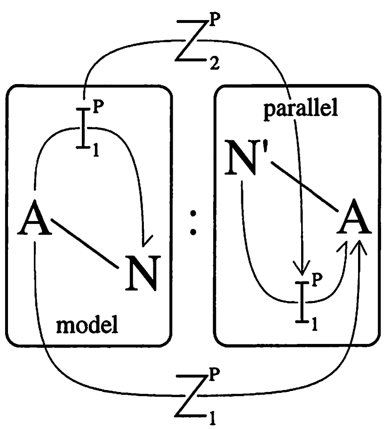


Figure 10.103 The order underlying the structure of changing-note melodies (adapted from Meyer, 1973, p. 191).

identifies a number of different basic melodic structures at a lower hierarchical level than the *Urlinie*, including conjunct patterns, which are based on scales; disjunct patterns, such as those deriving from arpeggios; and symmetrical patterns, which may largely be categorised as complementary, axial or changing note. All these display internal orderliness of one type or another, that may in each case be attributed to imitation, and therefore to zygonic control. See, for example, figures 10.102 and 10.103. Again, intersociative zygonic relationships may be deemed to connect different manifestations of the same background pattern.

Pitch organisation in melody ix: extramusical influences

One type of extra-musical ordering is possible since the domain of pitch bears the notion of 'height', which corresponds to the equivalent concept associated with physical position (see Kivy, 1984, p. 57). Hence a cross-modal transfer of interperspective values is feasible. In melodic terms, this amounts to the representation of motion, a process that has been widely exploited in word setting. Consider, for example, the following depiction of descent (see figure 10.104), whose order may be attributed to the activity of a cross-modal secondary zygonic constant of polarity (cf. figure 4.27).

The matter of certain interperspective values of pitch being selected on account of their supposed ability to summon up particular emotions is far less clear-cut than this, however, since feelings are abstract in nature and cannot claim an isomorphic relationship with pitch. Hence a theory such as that put forward by Cooke (1959), which states that the interval, or series of intervals, between prescribed scale degrees can evoke a distinct response has won far from universal acceptance (see, for example, Gabriel, 1978). However, more general principles, such as the association of chromaticism with poignant emotion, seem to be well-established in Western culture, as Meyer (1956, pp. 219 and 220) observes. This implies that one such representation can be considered to exist in imitation of another, through the operation of interoperative zygonic control.

A highly specialised kind of extra-musical ordering, unique to pitch, can be traced back to Guido d'Arezzo's treatise *Micrologus* of the early 11th century (see Kirchmeyer, 1962/1968, pp. 11–24). In chapter xvii, entitled 'Quod ad cantum redigitur omne quod dicitur' ('everything that is spoken can be turned into music'), Guido shows how the vowels (a, e, i, o, u) may

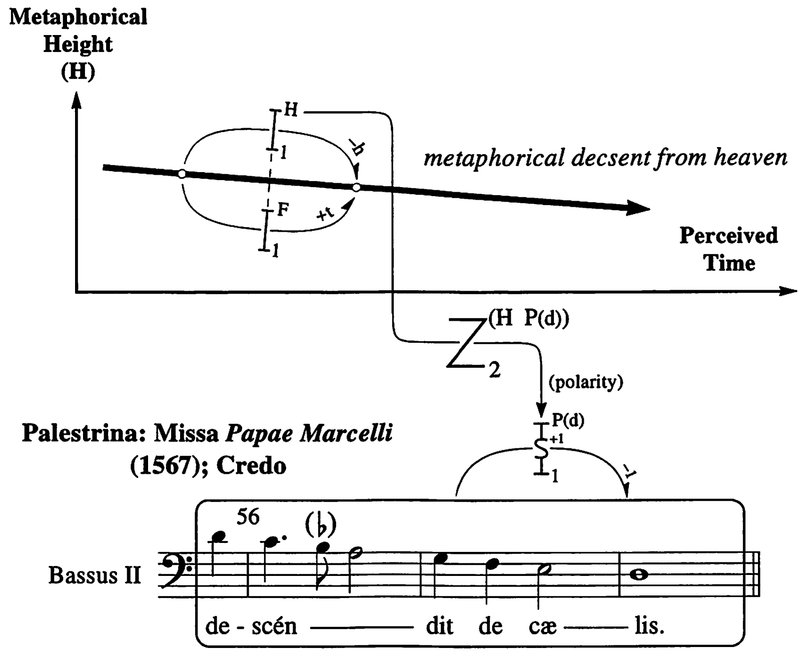


Figure 10.104 Metaphorical descent depitcted as a descending series of pitches through the operation of a cross-modal zygon of polarity.

be assigned to the first five scale steps (equivalent to the modern *c, d, e, f, g*). Through this system, the text 'Sancte Johannes meritorum tuorum' produces the pitch series *c d f c d d e f g g f g*. A canonic interpretation of this ordering, involving cross-modal zygons of vowel (V) and pitch degree, is shown in figure 10.105. The principle of *soggetto cavato* as it was later known (see Apel, 1969, p. 785) was subsequently adopted by other composers, among them Josquin des Prés, for example, in his *Missa Hercules dux Ferrariae* (for a description see Sachs, 1956, p. 123). In the *Art of Fugue*, Bach even wove his own name into the texture (just at the point of the work's untimely conclusion), an idea that was re-visited by Liszt, Reger, Schoenberg and Webern, among others. From an early stage, Schumann took great delight in the technique: the first five notes of the theme of the *Abegg Variations*, op. 1, for instance, are directly derived from a friend's surname. Finally, in the twentieth century, composers ranging from Shostakovich to Berg, and from Debussy and Ravel to Messiaen and Boulez have all employed ciphers at one time or another (see Griffiths, 1986, p. 50).

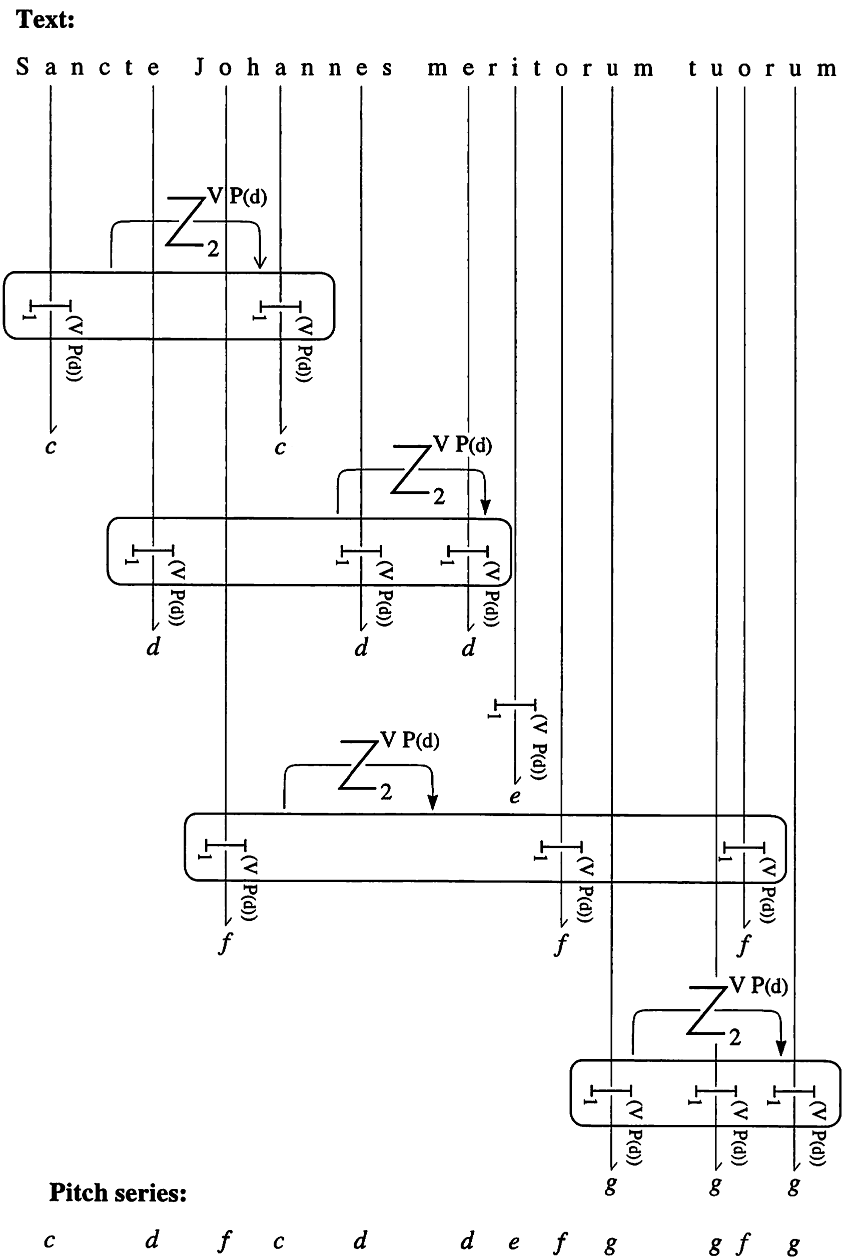


Figure 10.105 The organisation of pitch based on a series of vowels.

Pitch organisation in chords i: principles of intrasociative canonic ordering

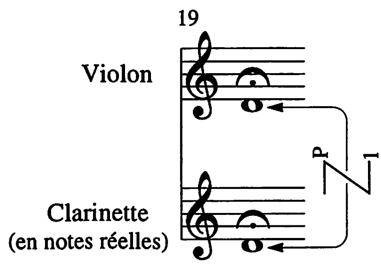
A great deal of music makes use of chords, and it is to the vertical pitch associations implicit in these that we now turn our attention. Very often each is perceived, not as a group of individual values, but as the single perspect 'harmony' (p. 163). This mode of perception is by no means inevitable, however, and in this section and the one following we examine briefly the principles of canonic ordering as they apply to simultaneous associations. How these forms of control relate to listeners' apprehension of harmony is an important issue which is considered as the investigation proceeds.

We begin by examining intrasociative organisation (each manifestation of which is potentially responsible for a distinct value of harmony). The possibilities are comparable to those available melodically (cf. pp. 513ff). Since chords normally have a palpable duration, a network of internal relationships potentially links each of their constituent notes to the others (cf. pp. 125ff). However, for theoretical simplicity, in this section and those that follow, each network will be regarded as a single constant relationship.

Primary zygonic constants (perfect or imperfect) are conceivable, when two or more instruments or voices produce the same value at once:

Milhaud: Suite for Violin, Clarinet and Piano (1936); IV. ***Introduction et Final***

Figure 10.106
Chord ordered through a perfect zygonic constant of pitch.



(piano part omitted)

The intervals between adjacent notes in a chord may be equal or approximately so, producing a pattern of pitches that may be deemed to be ordered through a secondary zygosequential intrasociative zygonic constant system (cf. figure 6.43), or, in the case of two notes, a secondary interprotractive zygonic constant, in either case perfect or imperfect. Examples are shown in figure 10.107.

Regular variation is feasible whose orderliness may be attributed to tertiary relationships; when the intervals between successive notes increase or decrease by a common difference, for example. In many instances, however, including the excerpt shown, the influence of the harmonic series is of greater musical significance (cf. pp. 580ff).

Chopin: Préludes, Op. 28; No. 17

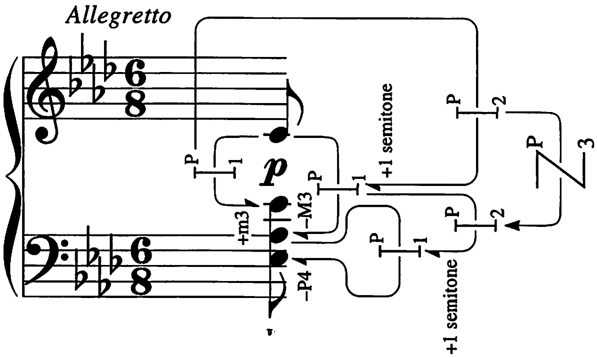


Figure 10.108
Chord in which intervals vary by a regular difference.

Compound intrasociative ordering of chords is also conceivable (see figure 10.109). Once more, it seems unlikely that the organisation illustrated would normally be discerned by listeners—although here it was clearly in the composer's mind.

Overton: ***Polarities No. I*** **(1958)**

Piano

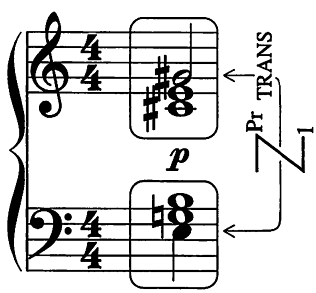


Figure 10.109
Chord constructed through compound ordering.

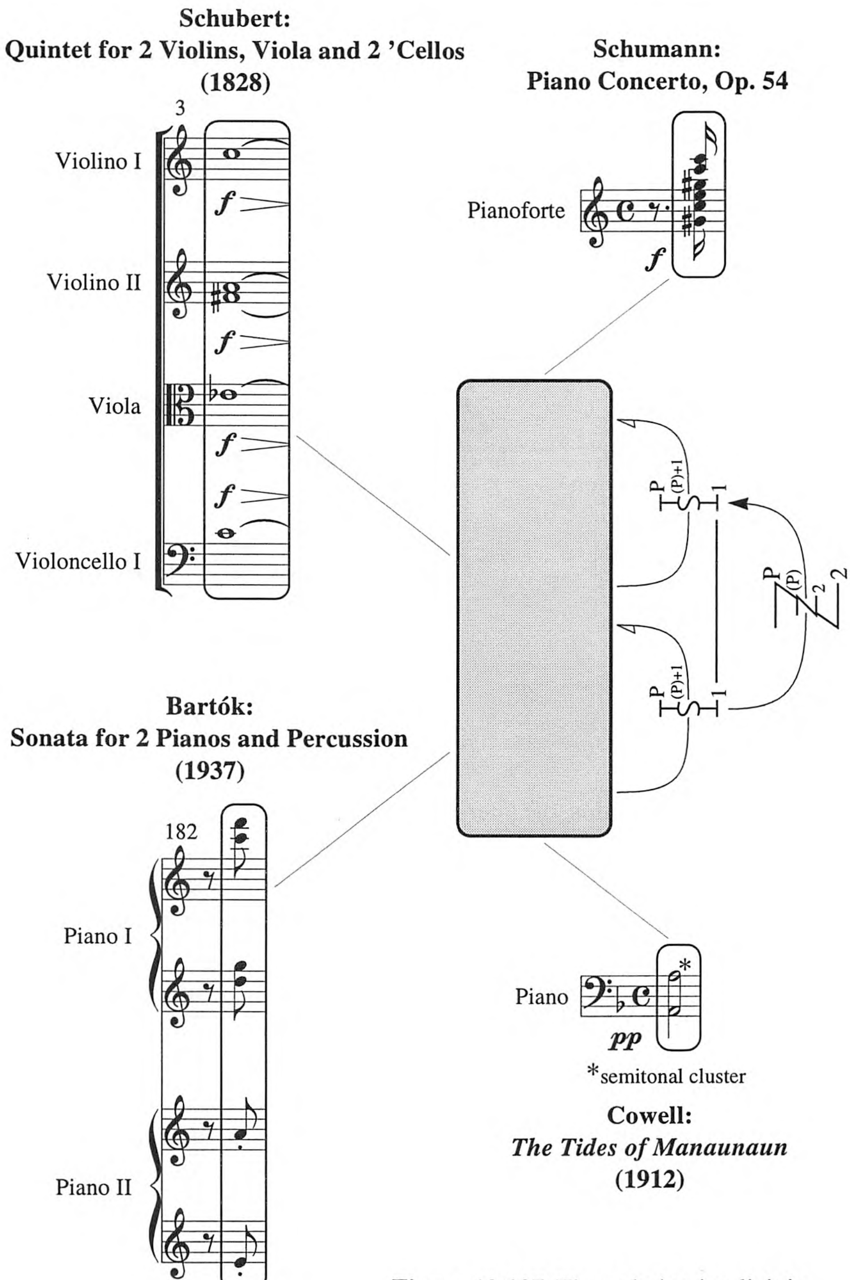
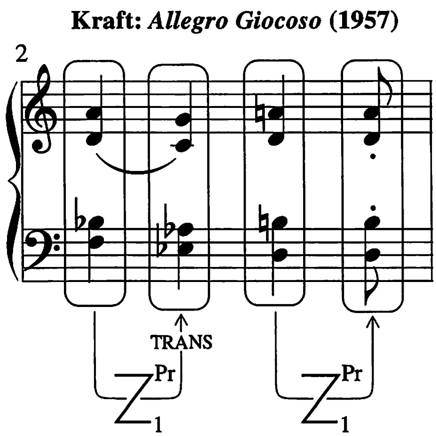


Figure 10.107 The ordering implicit in chords whose notes are spaced equidistantly.

Pitch organisation in chords ii: principles of intersociative canonic ordering

Intersociatively, many of the relationships identified in relation to the pitch content of melodies also find service in the context of chords, as the following brief survey shows. Both repetition and transposition, perfect and imperfect, are encountered frequently. For example:

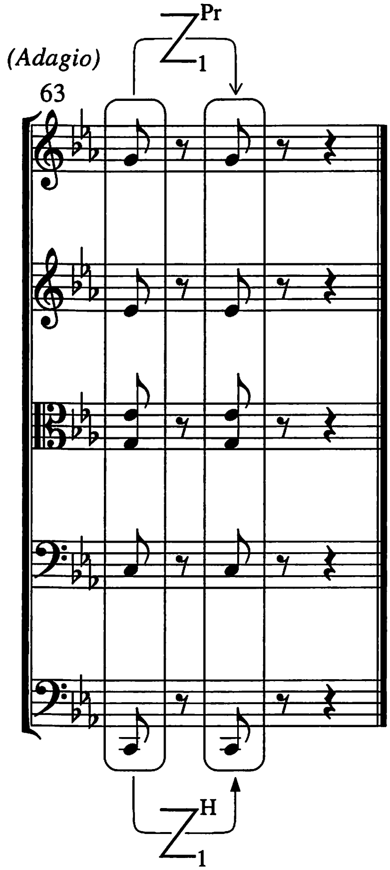
Figure 10.110
Perfect transposition and repetition of chordal profile.



Perfect relationships of intersociative repetition produce comparable interharmonic connections (see figure 10.111). The harmonic effect of associative transposition can be understood either as the transposition of absolute harmony or as the repetition of harmony in relative terms (cf. p. 163); see figure 10.112.

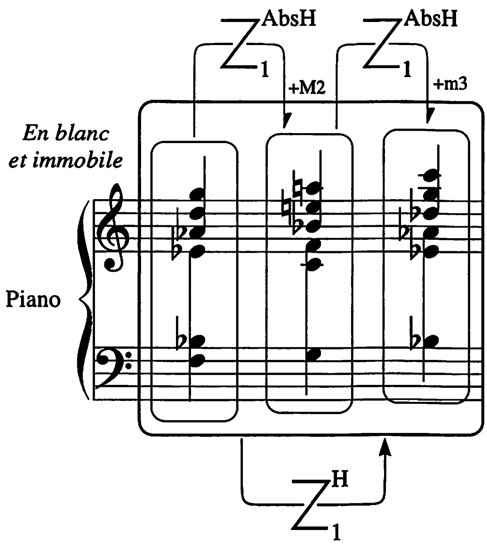
However, there are other transformations which, while modifying the intervallic structure of vertical pitch associations in an organised fashion, nevertheless generate changes in harmonic value that are neither intrinsically orderly nor even necessarily consistent. That is, while altering one association in a particular way may produce a certain mutation in harmonic value, performing the same operation on a different association need not produce a parallel harmonic shift. Hence, aside from perfect transposition, for harmonic change to be ordered through imitation further requires that such links exist between similar pairs of harmonies.

Intersociative inversion, for example, produces a range of harmonic effects. See, for instance, figure 10.113.



Boccherini:
Quintet Op. 10, No. 4;
2nd Movement

Figure 10.111
Repetition of chordal profile and harmony.



Satie:
Le Fils des Étoiles
(1891); *Prélude du*
1er Acte–La Vocation

Figure 10.112
The harmonic effects of the transposition of chordal profile.

Bach:
The Art of Fugue, BWV 1080;
Contrapunctus XVI

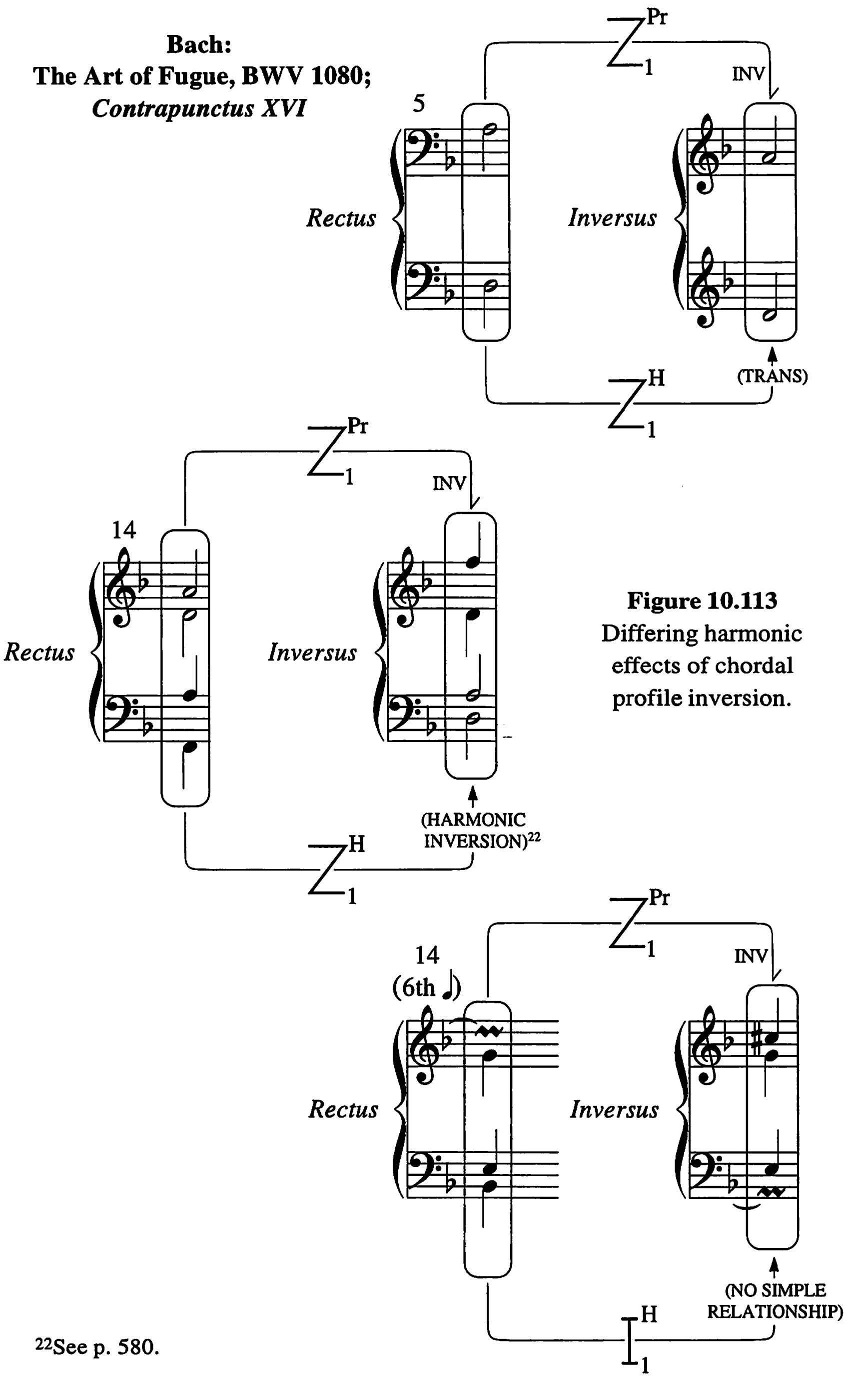


Figure 10.113
Differing harmonic effects of chordal profile inversion.

[22]See p. 580.

The intervals between adjacent pitches may be modified by a common difference, or all may be stretched or compressed by a common ratio. Again, the effects on the perspect harmony are very variable. For example:

Bartók: String Quartet No. 4; 1st Movement

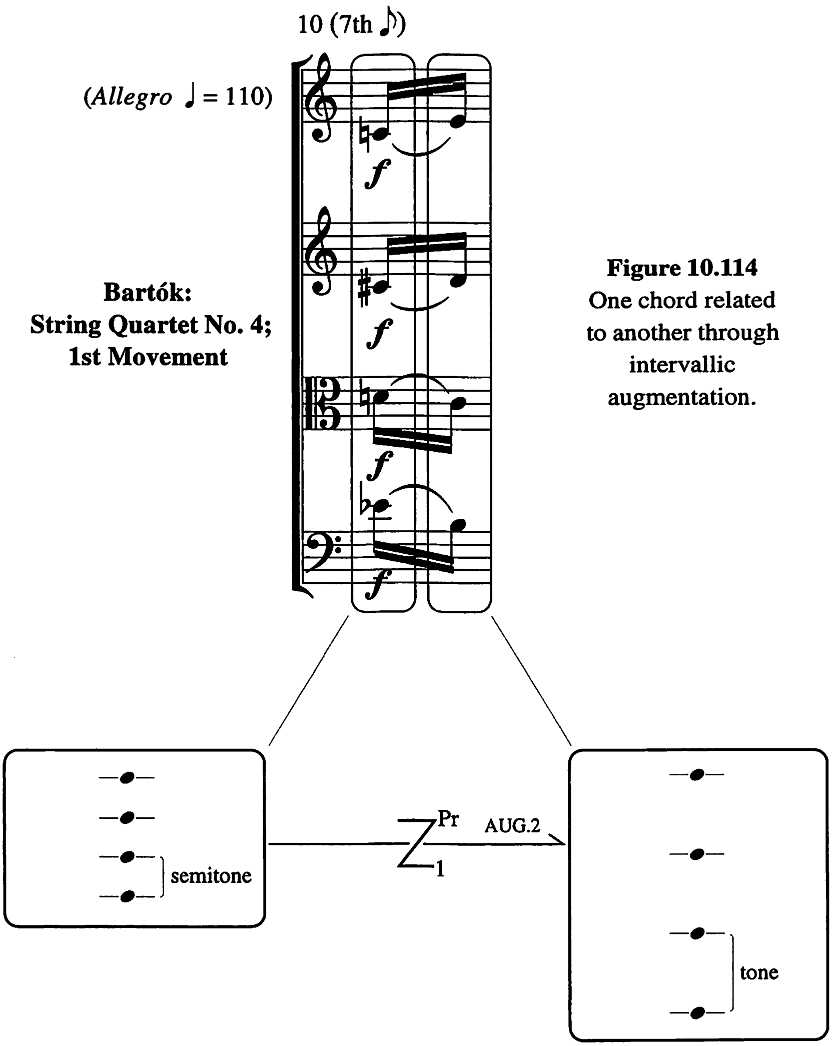


Figure 10.114
One chord related to another through intervallic augmentation.

Material may be added to the pitch association of a chord, or omitted from it. These processes may be orderly in a number of ways (cf. p. 224). See, for example, figure 10.115.

Bach:
Toccata and Fugue in* d *minor,
BWV 565

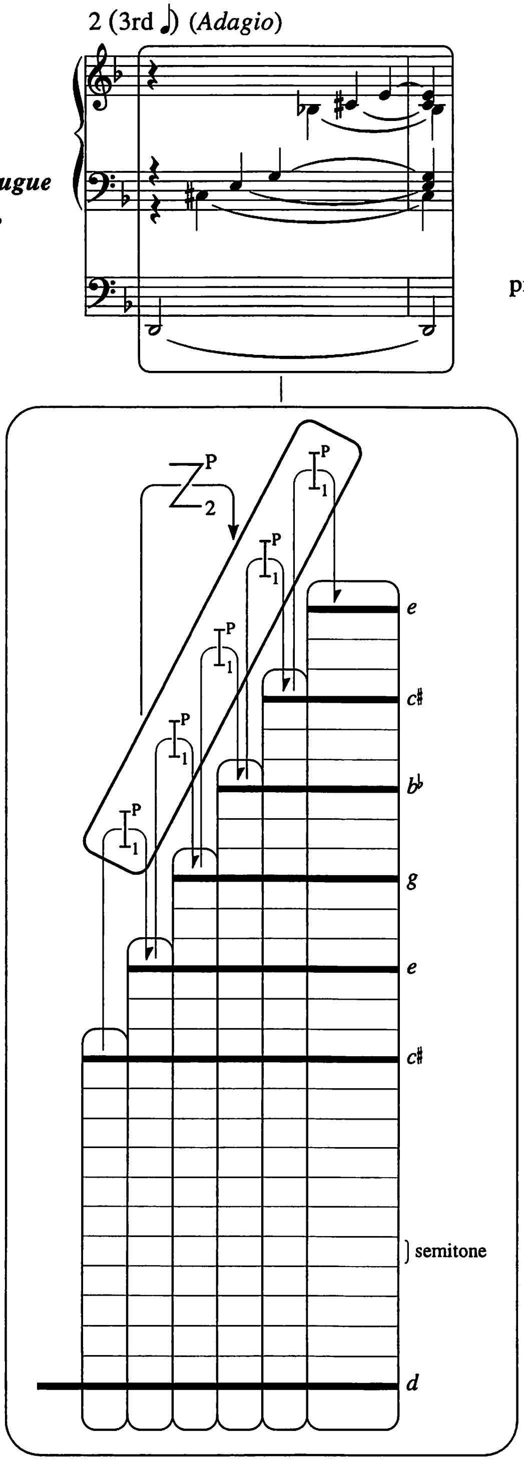


Figure 10.115 (part i)
The orderly addition of material to the pitch associations of chords.

Beethoven:
Piano Sonata, Op. 14, No. 1;
2nd Movement

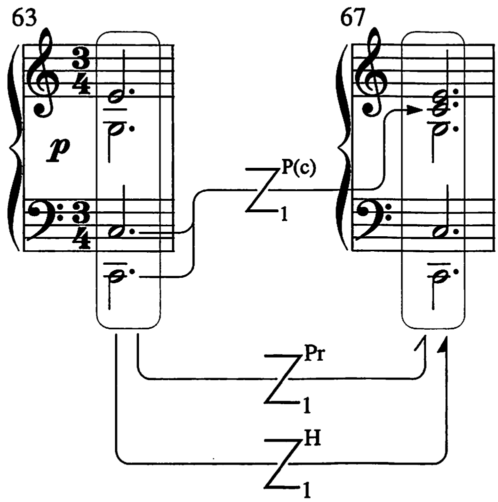


Figure 10.115
(part ii)

Ammons and Johnson:
***Boogie Woogie Man* (1943)**

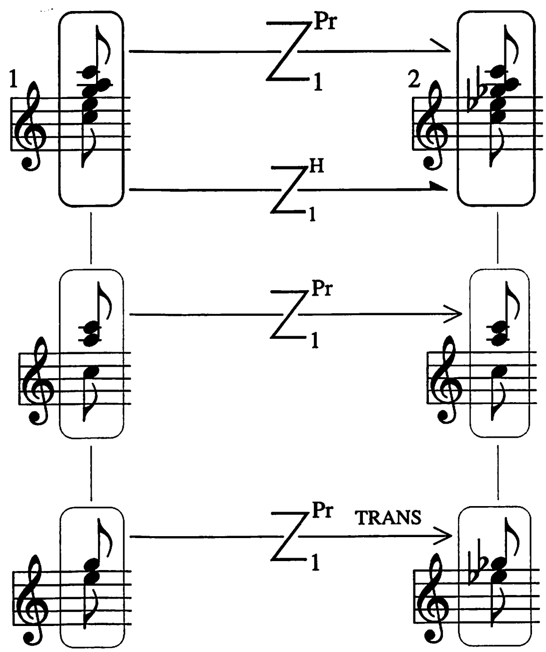


Figure 10.116
Compound transformation: the repetition of some values and the transposition of others.

Just as the extent to which the intervallic structure of a vertical pitch association may be altered by the addition, omission or alteration of material is very variable, so the potential effect of these processes on the way a chord is perceived harmonically is open to a wide range of variation too. It is quite possible for harmonies to be deemed imperfectly zygonically related where a value or values of pitch has been added, omitted or altered—see, for example, figure 10.115 (part ii).

Any of the intersociative transformations described above may be combined. Commonly, this involves the repetition of some values and the transposition of others; for instance, figure 10.116. Transposition may be at the octave. For example:

Chambonnières: *Les Pièces de Clavessin* (1670), *Livre Premier,* No. 18; *Gigue*

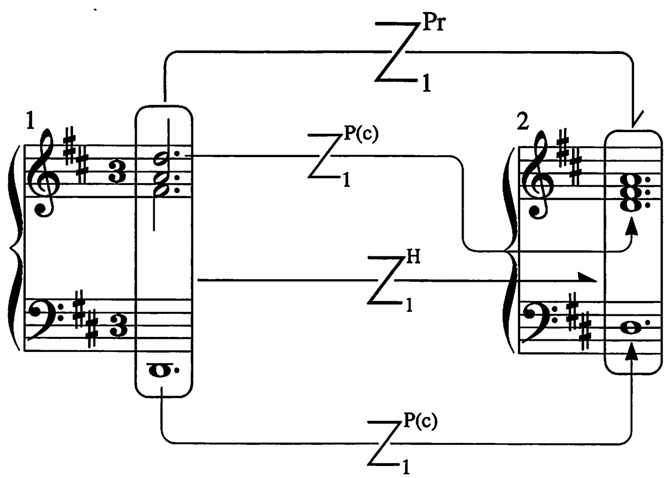


Figure 10.117 Compound transformation: the repetition of some values and transposition at the octave of others.

In fact, the definition of chordal pitch content in terms of pitch-class associations is an important feature of analysis in several styles. No doubt this is because the maintenance of pitch-classes to a large extent preserves harmonic value; the pair of associations shown in figure 10.117, for example, may be are imperfectly zygonically related in terms of harmony.

So much for primary organisation. Ordering simultaneous associations of pitch through secondary zygonic relationships is also feasible. As far as the compound perspect harmony is concerned, which can vary in a number of ways, secondary zygons can exist only between certain pairs of values whose differences are recognisably the same. This is conceivable, for example, where similar harmonies are transposed to the same degree.

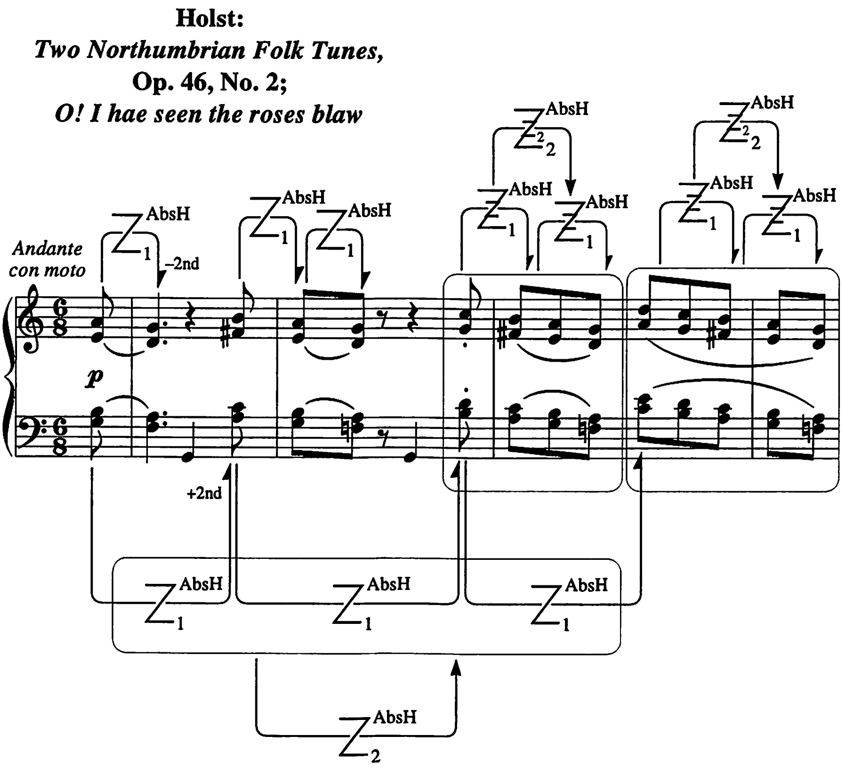
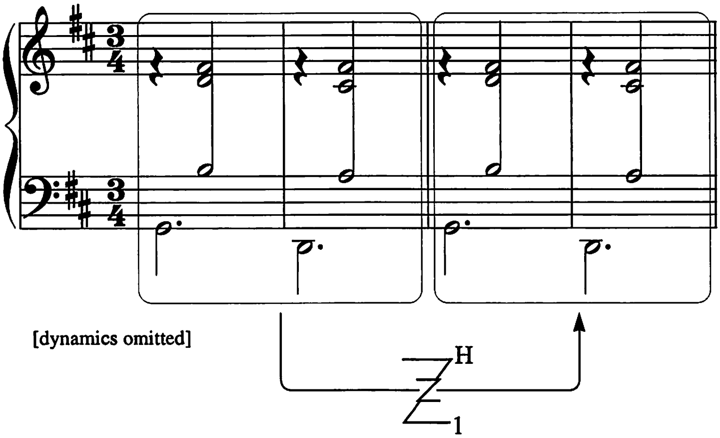


Figure 10.118 Example of the organisation of absolute harmony at the secondary level.

In conclusion, the possibility of the pitch associations of chords themselves forming canonically organised associations of higher orders should be acknowledged. Any of the means of orderly intersociative connection may be incurred. For example, a series of chords may be repeated, transposed or reversed (see figure 10.119).

Satie: *1.ère Gymnopédie* (1888)

Lent et douloureux (♩ = 66)



Hoddinott: *Divertimento*, Op. 32; *1. Overture*

(Maestoso)

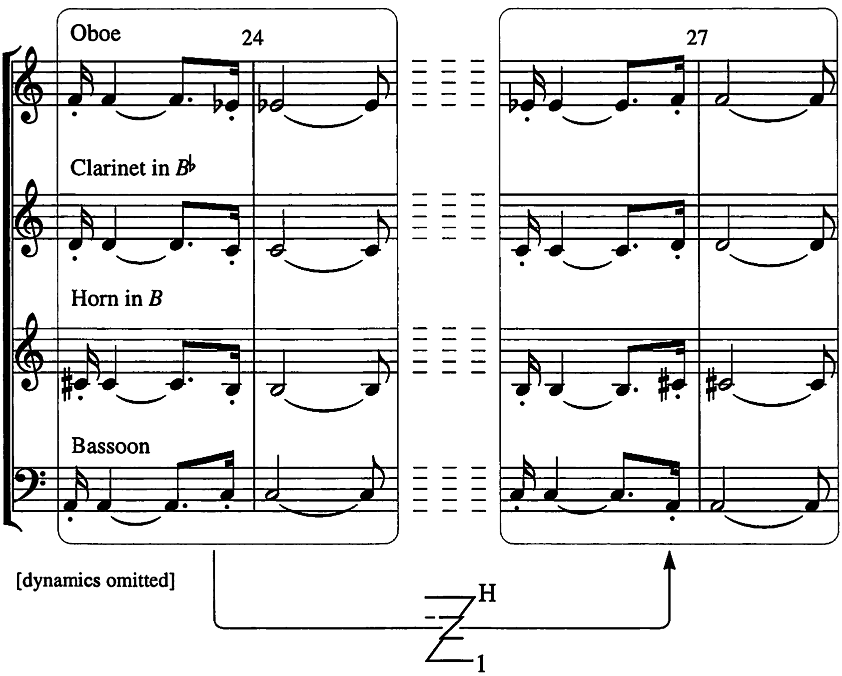


Figure 10.119 (part i) Examples of the repetition, retrogression and transposition of series of chords.

Wagner: *Tristan und Isolde* (1860); Prelude

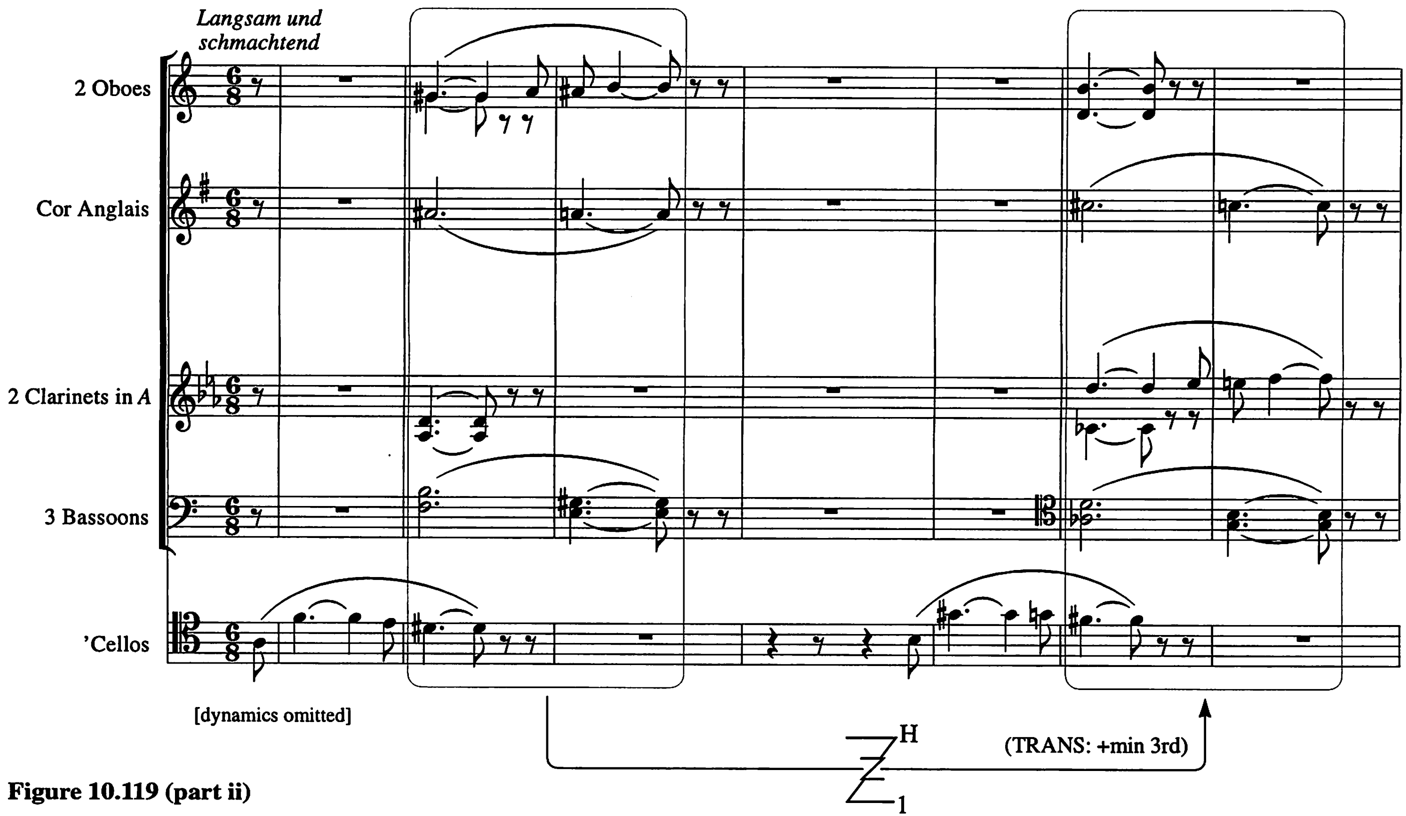


Figure 10.119 (part ii)

Pitch organisation in chords iii: the influence of the harmonic series; major and minor harmonies

Certain intervals that are frequently found in chords are the same or very similar to those that occur between the first few naturally occurring overtones (cf. pp. 459 and 460). However, this connection extends beyond the isolated octaves, fifths and fourths illustrated earlier (figure 10.8): major and minor thirds are often found too, and in combinations that reflect the layout of the harmonic series, strengthening the probability of extramusical imitation, whether direct or occurring through further, intramusical links. We now examine the relationships involved.

Typically it is portions of the lower end of the harmonic series that are imitated, sometimes involving two, three or four consecutive partials, although a good many vertical associations of pitch accord with intervallic patterns outlined by non-adjacent overtones. Other associations may be derived from the harmonic series through the octave transposition of one value or more. These three possibilities are exemplified in figure 10.120.

In addition to their potential extramusical zygonic connections, associations of the type identified may also be deemed to occur through intramusical imitation. In styles in which such associations are ubiquitous, vast networks of relationships may be thought to operate in the manner shown in figure 10.121. While the musical effect of any one strand in a complex of this kind is likely to be negligible, the network as a whole is highly influential.

Many associations of pitch that are conceivably derived from the harmonic series comprise a major third below and adjacent to a minor third, or octave complements of this pattern (see figure 10.120). Such combinations are often perceived as one compound value known as a **major** harmony. This can appear in three main forms, depending which note is in the bass: 'root position', 'first inversion' and 'second inversion'. Each type is subject to intramusical imitation through extensive zygonic networks (cf. figure 10.121). Certain relationships in these complexes may be more prominent than others on account of the specific structural context in which a given inversion occurs. Consider, for example, the tendency in some styles to conclude pieces on a root position major harmony, or the second inversion which characteristically introduces the Classical cadenza.

Various other patterns of intervals, which resemble the layout of certain higher overtones and extend the scheme of thirds underlying major harmony, also produce distinct harmonic percepts that have found frequent service in

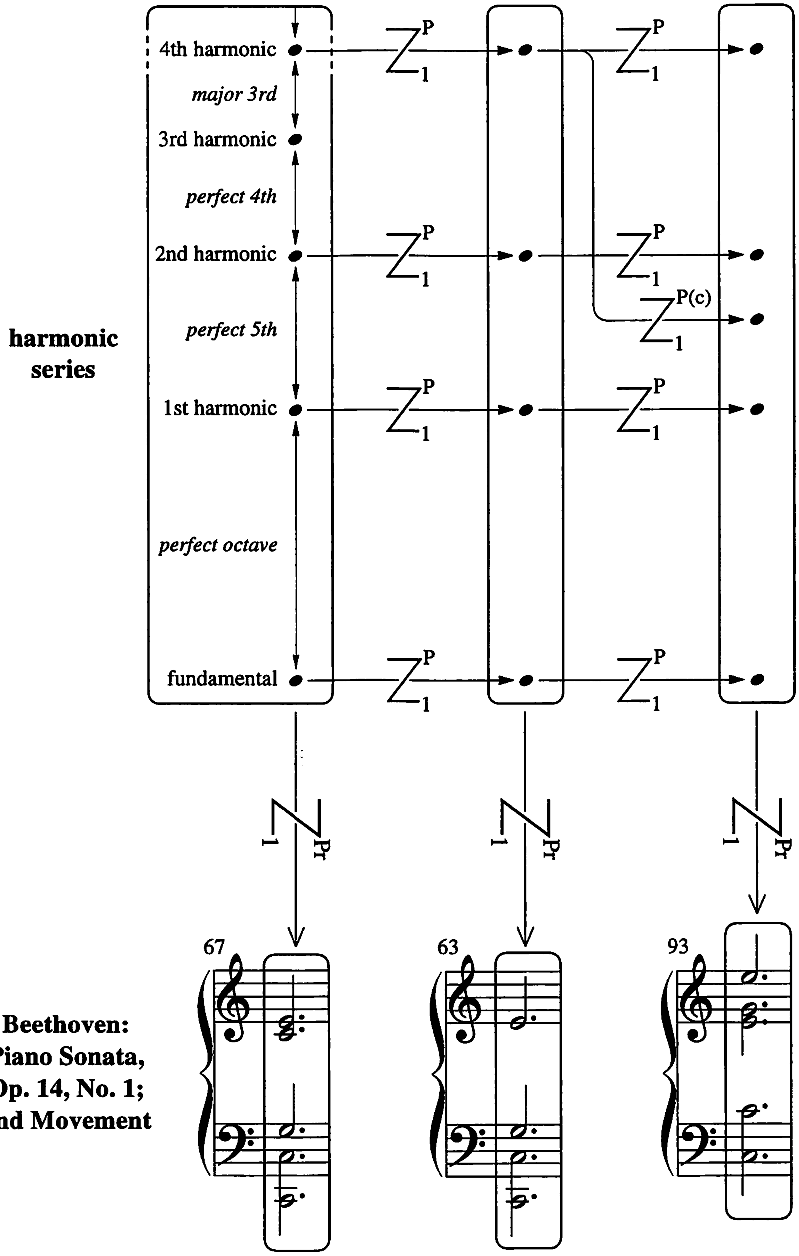


Figure 10.120 Examples of the influence of the harmonic series on the pitch associations of chords (cf. figure 115, part ii).

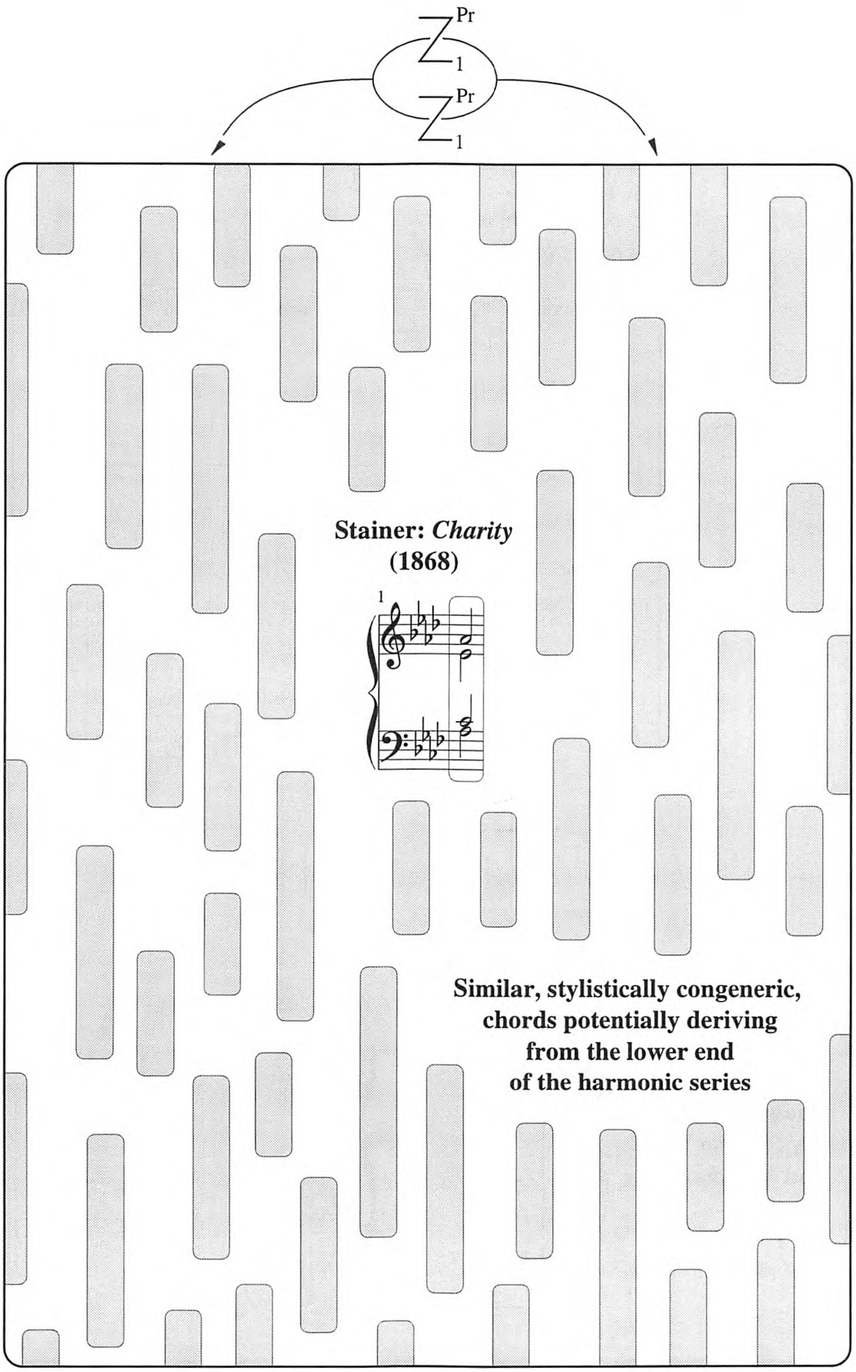


Figure 10.121 Intraoperative and interoperative imitation of chords whose pitch associations potentially derive from the lower end of the harmonic series.

Western music: 7th, 9th, 11th and 13th chords. Again, octave complementation means that inversions of these harmonies are conceivable. Moreover, material may be omitted without the harmonic identity of a chord being compromised. Hence a 9th chord is recognisable, for example, in first inversion with the root omitted, whilst a 13th may well be lacking its 5th, 9th and 11th degrees. Like simple major harmonies, then, each of these harmonic percepts represents a region in the harmonic domain rather than a unique point. They may be imitated intramusically, through perfect and imperfect zygonic relationships. For example:

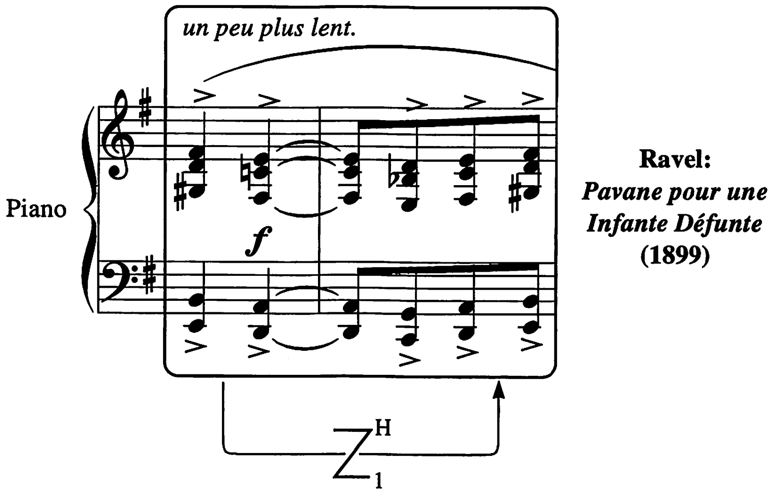


Figure 10.122 Association of identical 9th chords.

Other vertical associations of pitch may be obtained from the harmonic series through the alteration of material—one or more overtones may be inflected. Again, transformations such as this may be combined with octave complementation and the omission or addition of material. They may be subject to intramusical transfer. See figure 10.123. This is one way of interpreting the derivation of **minor** harmonies:[23] through chromatic inflection of the third degree; lowering it a semitone changes a 'major' third into a 'minor' one (see figure 10.124).

[23]Though by no means the only one: a minor triad is formed by harmonics 10, 12 and 15, for example.

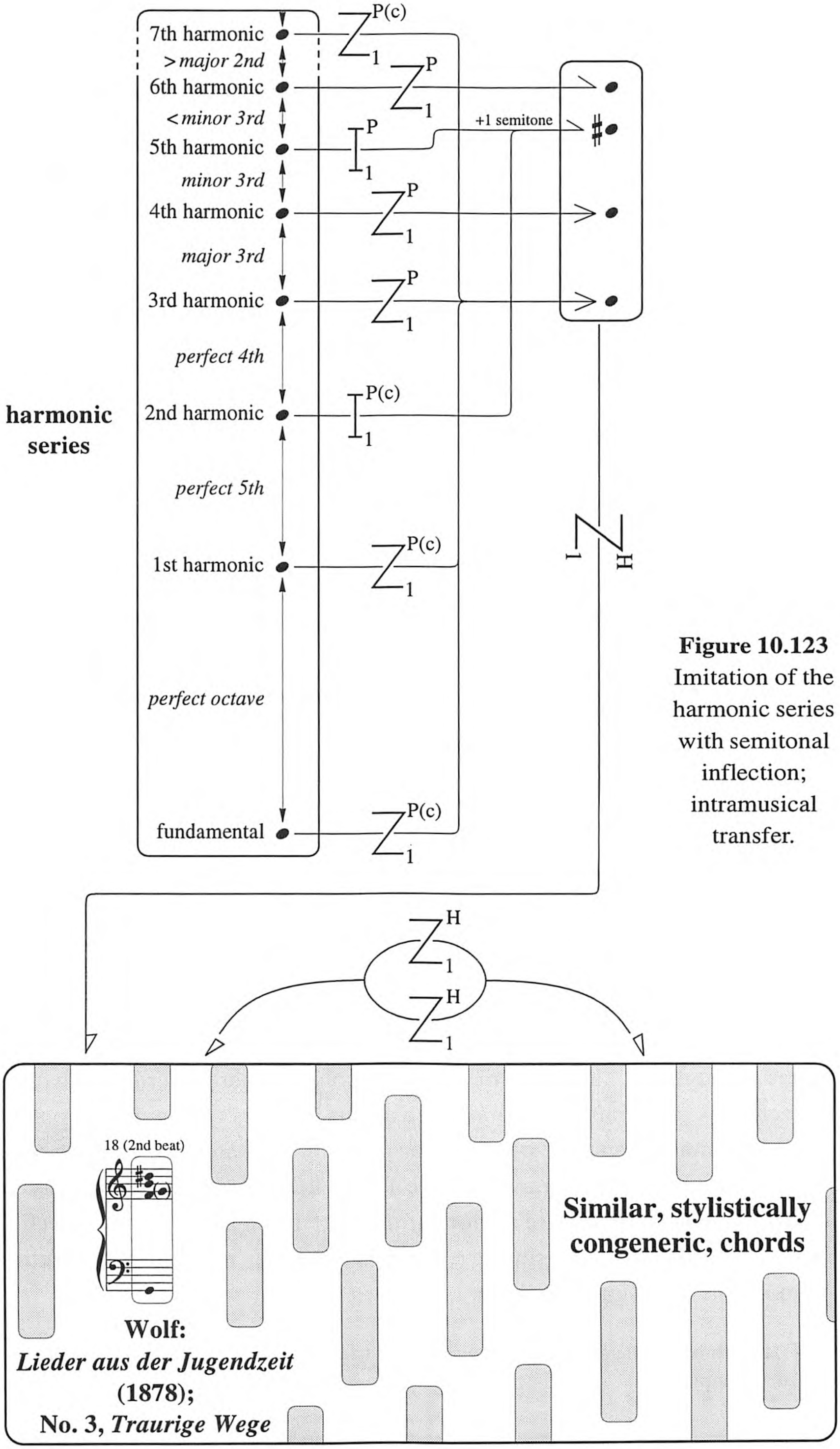
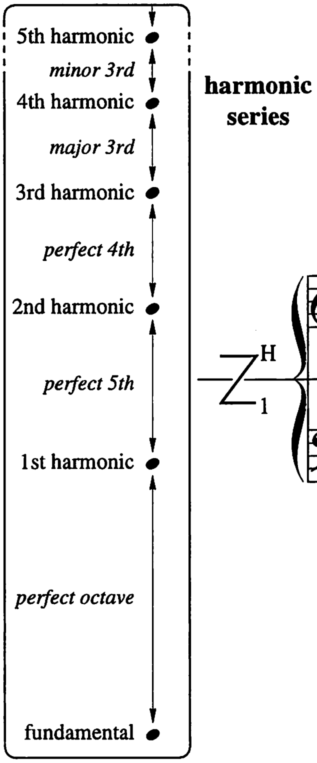


Figure 10.123
Imitation of the harmonic series with semitonal inflection; intramusical transfer.



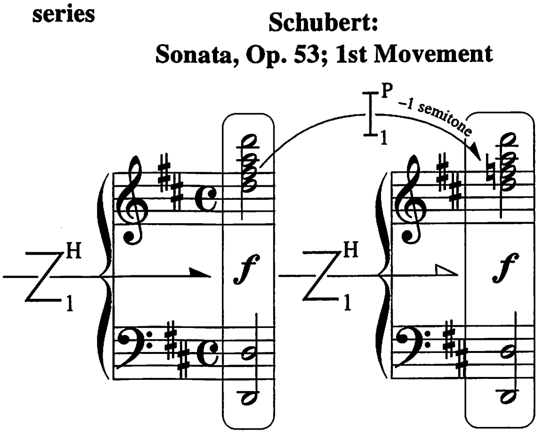


Figure 10.124 Chromatic inflection transforming a major harmony into a minor one.

Moreover, the pitch associations of major and minor chords share the same intervallic content, and may be related through inversion. The fact that this transformation is rarely recognised may be attributed to the fact that the harmonic effect of a major triad does not sound like that of a minor triad inverted. However, in the appropriate context, the inversion of the pitch content of chords can be aurally significant; see, for instance, figure 10.125.

The vertical pitch associations described in this section, constructed essentially from major and minor thirds, are said to form 'tertian' harmonies. It is generally acknowledged that these form the basis of all chords used in Western music in the period 1450–1900 (see Apel, 1969, pp. 373–374), as well as many others.[34] This suggests a model of ordering such as the following. (See figure 10.126.)

[34]Comparable constraints appear in other cultures too. See, for example, Harich-Schneider (1953, pp. 54, 55 and 64), who describes the tight harmonic organisation of Japanese court music.

Ockelford: *O Waly Waly,* Vocal Arrangement, 1983

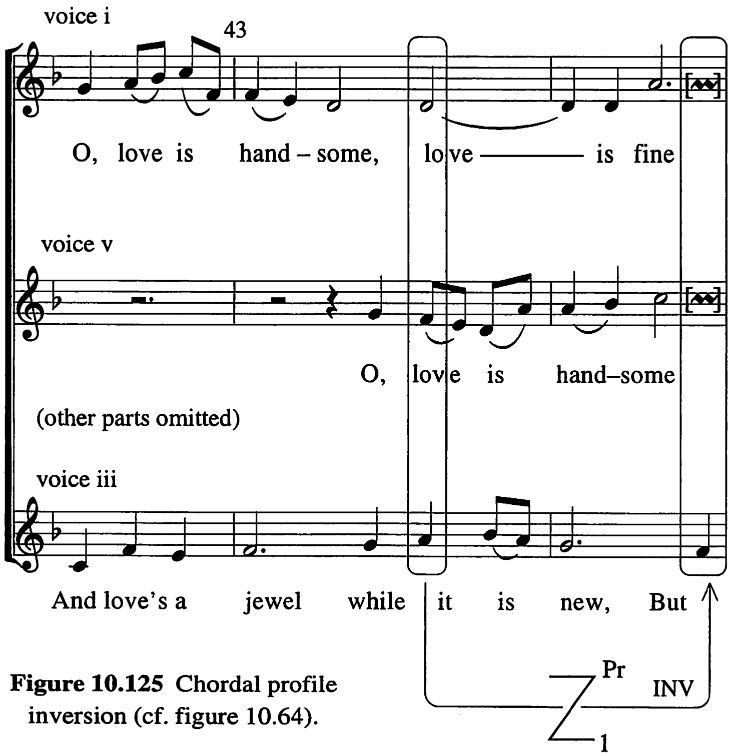


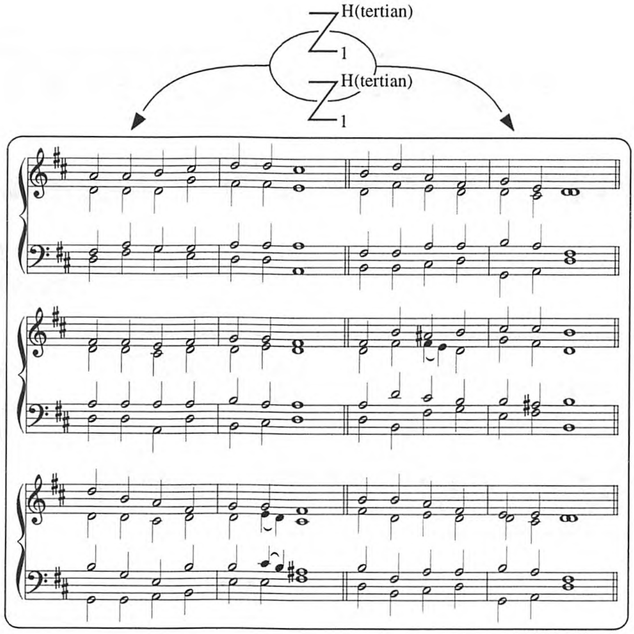
Figure 10.125 Chordal profile inversion (cf. figure 10.64).

However, as intramusical zygonic relationships of harmony potentially exist in such profusion, it would be difficult to attribute much significance to any one of them, even if perfect relationships only were taken into account. Certainly, it is unusual, within the period under discussion, for a harmony to stand out sufficiently from those around it to function as a structural sonority in its own right: generally speaking, *groups* of harmonies are required to generate sufficient individuality. There are exceptions, however. Boatwright, 1966, pp. 27–30, for instance, claims to have found an example in Mozart's minuet, K. 355, where, he suggests, the augmented triad functions as a 'harmonic motive'.[35,36] This implies the prominence of harmonic zygons such as those shown in figure 10.127.

[35]Consider also Wagner's 'Tristan' chord (see Nattiez, 1990, p. 219).

[36]Interharmonic zygonic relationships of noteworthy individuality may also occur interoperatively: for example, the major 13th chord (such as *c–b♭–e–a*) favoured by Chopin may be the ancestor of Scriabin's 'mystic' chord (*c–f♯–b♭–e–a*); cf. Longyear, 1973, p. 148.

Werner:
Ratisbon
(1815)



Stylistically congeneric pieces

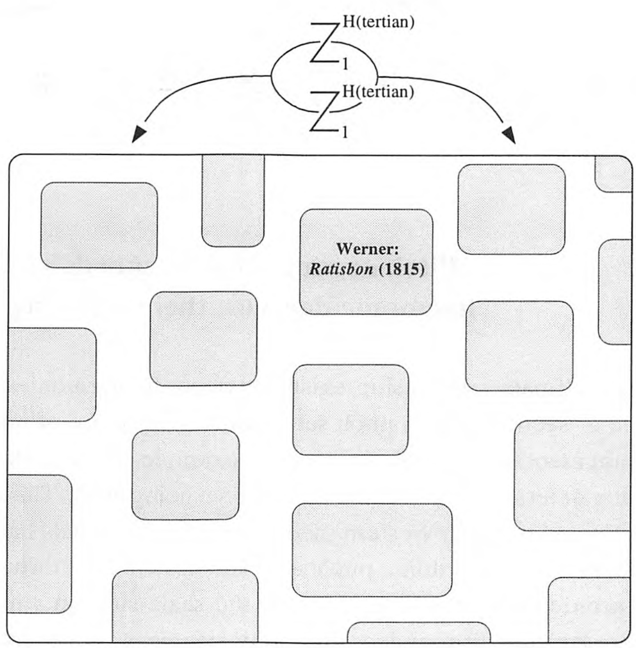
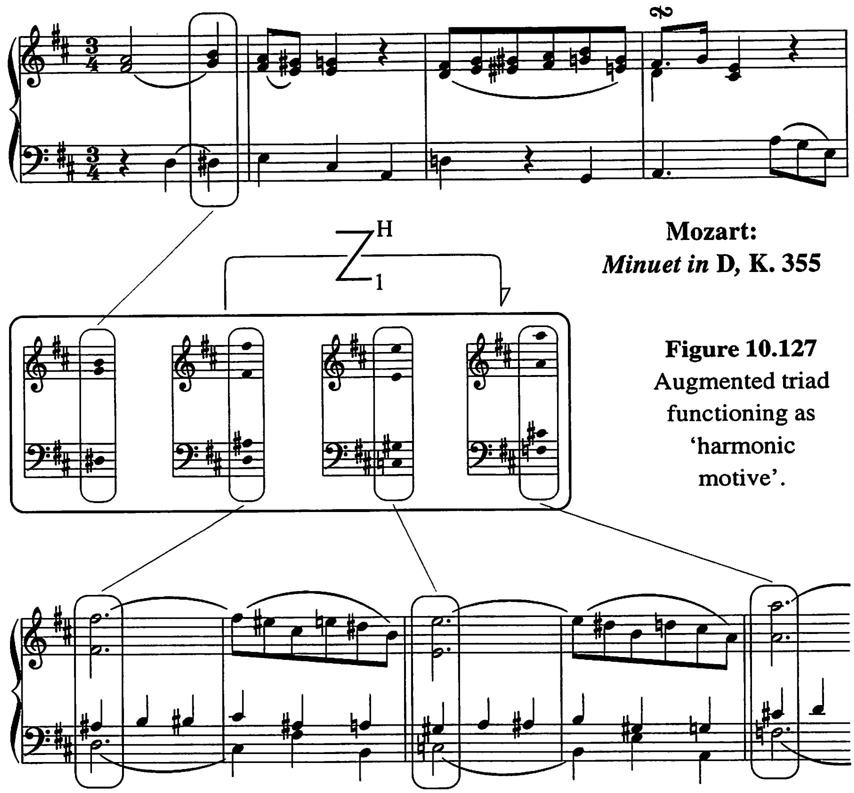


Figure 10.126 Intraoperative and interoperative imitation of tertian harmonies.



Mozart:
***Minuet in* D, K. 355**

Figure 10.127
Augmented triad functioning as 'harmonic motive'.

Pitch organisation in chords v: harmonic degrees; their ordering

An intimate relationship exists between the harmonies that appear in a piece or section and its pitch set: a limited selection of notes permits only certain associations to be formed, for example, while associations can, to a greater or lesser extent, define the pitch set being used. This close connection is reflected in much Western theory, which often labels harmonies in terms of their position within a pitch set. This is achieved through the notion of **harmonic degree**, which specifies the scale-step on which the root of a tertian harmony is founded. Harmonic degrees may be reckoned absolutely (in which case perspective values of pitch are taken into account) or purely relatively. Traditionally, they are labelled using Roman numerals, any elaboration on the basic triadic harmony being indicated, if so desired, through the addition of further Arabic numerals, sharps, flats or naturals, as necessary (see, for example, Forte, 1962, pp. 43–45).

Just as one pitch can operate simultaneously in two or more pitch sets, acting as a different degree in each, so a single harmony can take on different roles too. Hence, within the diatonic system alone, for example, a major triad can act as chord I, IV or V.

One harmonic degree, absolute or relative, may be considered to exist in imitation of another through the operation of a primary zygonic relationship, perfect or imperfect. However, with so little choice available, even given the harmonic variations possible on each degree, such relationships are potentially so numerous that it is difficult to attribute special significance to any that is not highlighted through repetition, for example, or perceived temporal adjacency. Their combined effect, however, is immensely powerful (see figure 10.128).

Repetition is also much in evidence in the transitions between successive harmonic degrees. Certain transitions have found more favour than others, to an extent that varies from one style to another. A number of attempts have been made to document these juxtapositions for didactic purposes. Piston, for example, in speaking of the common harmonic practice of Western composers of the eighteenth and nineteenth centuries (1941/1978) makes statements such as the following, concerning root progressions:[27,28]

> I is followed by IV or V, sometimes VI, less often II or III.
> II is followed by V, sometimes IV or VI, less often I or III. ...
> (p. 21)

In canonic terms, this again implies a high degree of organisation that is largely effective through constant systems of zygonic relationships, although it is possible that a progression may be singular enough to be reckoned to exist in imitation of a few others, or even just one. Normally, however, a succession of several harmonic degrees are required to furnish enough information to assure individuality, and for zygonic links to be musically

[27]Limited empirical confirmation in terms of listeners' expectancies is provided by Schmuckler (1989, pp. 128ff).

[28]As an indication of stylistic change, compare Piston's generalisations with a remark of Persichetti in the context of twentieth century harmony: "Any tone can succeed any other tone, any tone can sound simultaneously with any other tone or tones, and any group of tones can be followed by any other group of tones" (1961, p. 13).

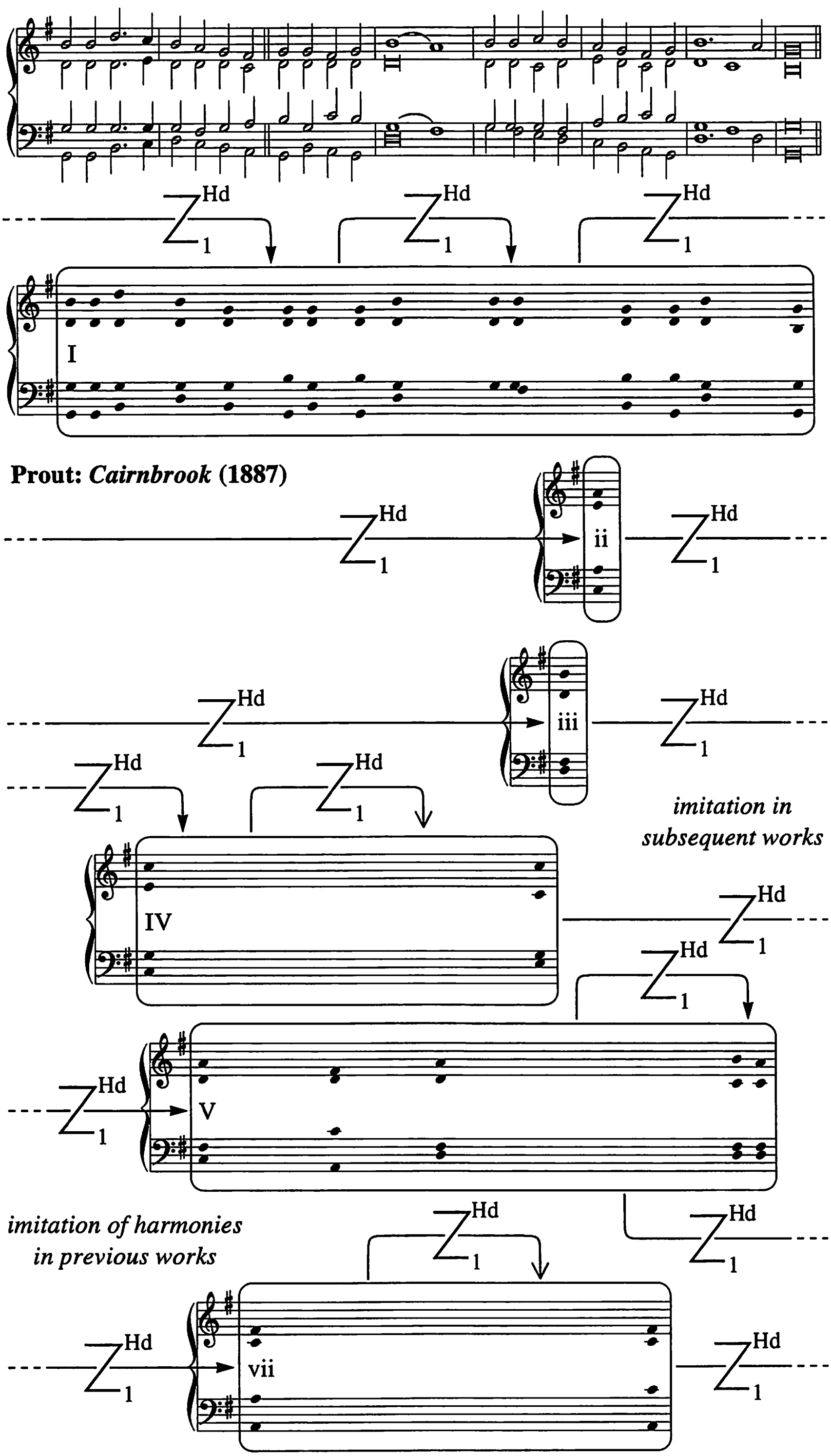


Figure 10.128 Zygonic relationships of harmonic degree.

significant in their own right. Such ordering has a long history. Take, for instance, the *chaconne*, as defined by Apel (1969, p. 141):[29]

> ... a continuous variation in which the "theme" is a scheme of harmonies ... .

Here, intraoperative ordering is implied as follows:

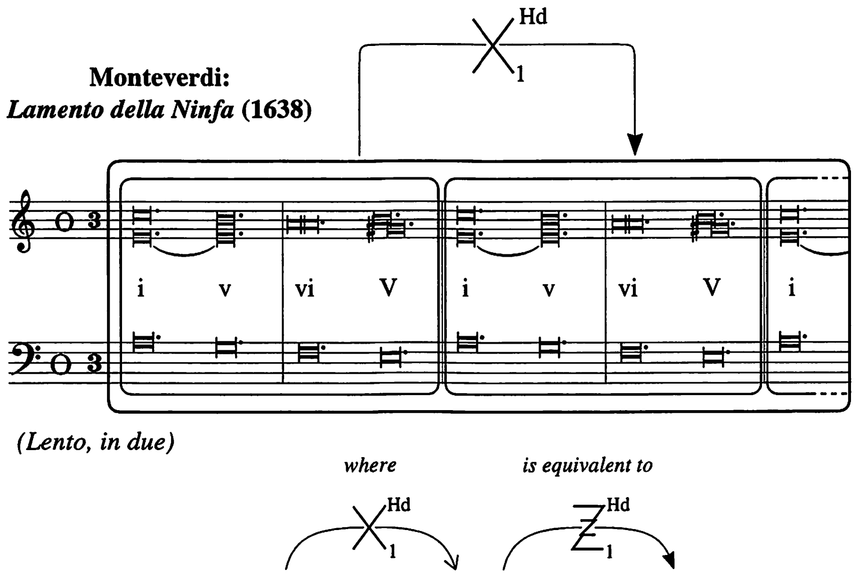


Figure 10.129 Constant system of primary zygonic invariants of harmonic degree.

Since, in Baroque times, the same harmonic ostinati were used time and again, interoperative zygonic constants must have been in operation too.

The perspect harmonic degree may also be ordered through secondary zygonic relationships. See, for instance, figure 10.130.

[29]As the author admits, not a definition that strictly accords with Baroque usage (see Bukofzer, 1947, p. 42).

Pachelbel (1653–1706):
Canon and Gigue for Three Violins and Basso Continuo

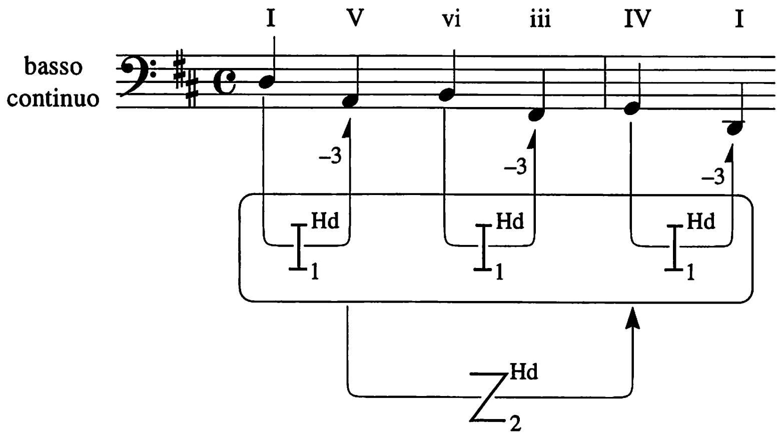


Figure 10.130 Secondary zygonic constant of harmonic degree.

Harmony on higher hierarchical levels; its ordering

In the same way that one value of pitch can be thought to elaborate on another, thereby extending its effect in time, so a value of harmony (or harmonic degree) can similarly be subject to 'prolongation', to use Schenker's term.

> Essentially, a given harmony is prolonged so long as we feel it to be in control over a particular passage. (Forte and Gilbert, 1982, p. 142)

In terms of the present theory, this procedure can be explained through the concurrent operation of separate associations of harmony. One, slower moving, serves as a 'background' upon which the others, whose members pass by more rapidly, weave a 'foreground' design. The integration of the two associative levels is achieved canonically: each background value appears at least once in a foreground association, effectively acting as a pivot, to which the remaining constituents are related through one zygonic means or another. See, for example, figure 10.131.

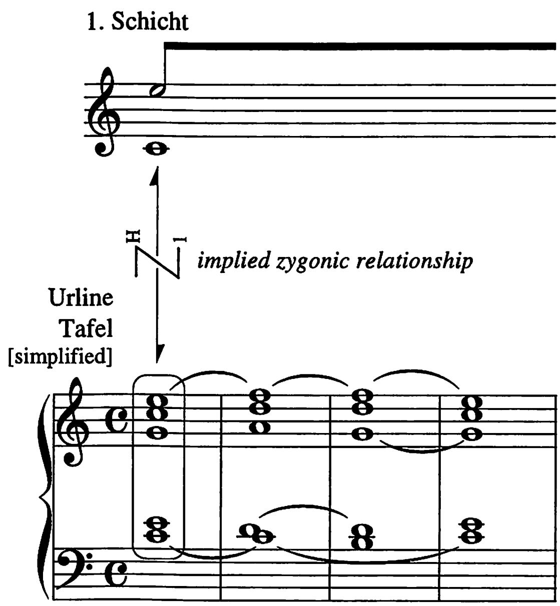


Figure 10.131 Implied zygonic relationship linking different levels in the harmonic hierarchy.

Bach: Prelude in *C* Major, BWV 846 (after Schenker, 1933/1969, p. 36)

The concept of harmonic prolongation may theoretically be extended to higher hierarchical levels too, whose audible limit is a matter of some contention. While Schenker (1935/1979) and many of his followers take the procedure to its ultimate logical extreme, reducing all so-called 'masterpieces' of the tonal era in the West to a succession of three chords termed the *Ursatz* (I–V–I), such efforts have subsequently been criticised by others since they do not appear to reflect how the works are actually heard by the vast majority of people (cf. p. 255). This, of course, can be taken as a demonstration of the fact that the cognition of musical order may vary considerably from one individual to another.

There is a close connection between the hierarchical harmonic structures referred to here and musicians' notion of **key**. This is because a sense of key arises from the perception of a pitch set being used according to certain constraints, familiar from previous usage—a requirement that successive harmonies can quickly fulfil (see Krumhansl and Kessler, 1982, p. 348), irrespective of the hierarchical level on which they are operating. It follows that a feeling of key, like the values of harmony that define it, can exist on

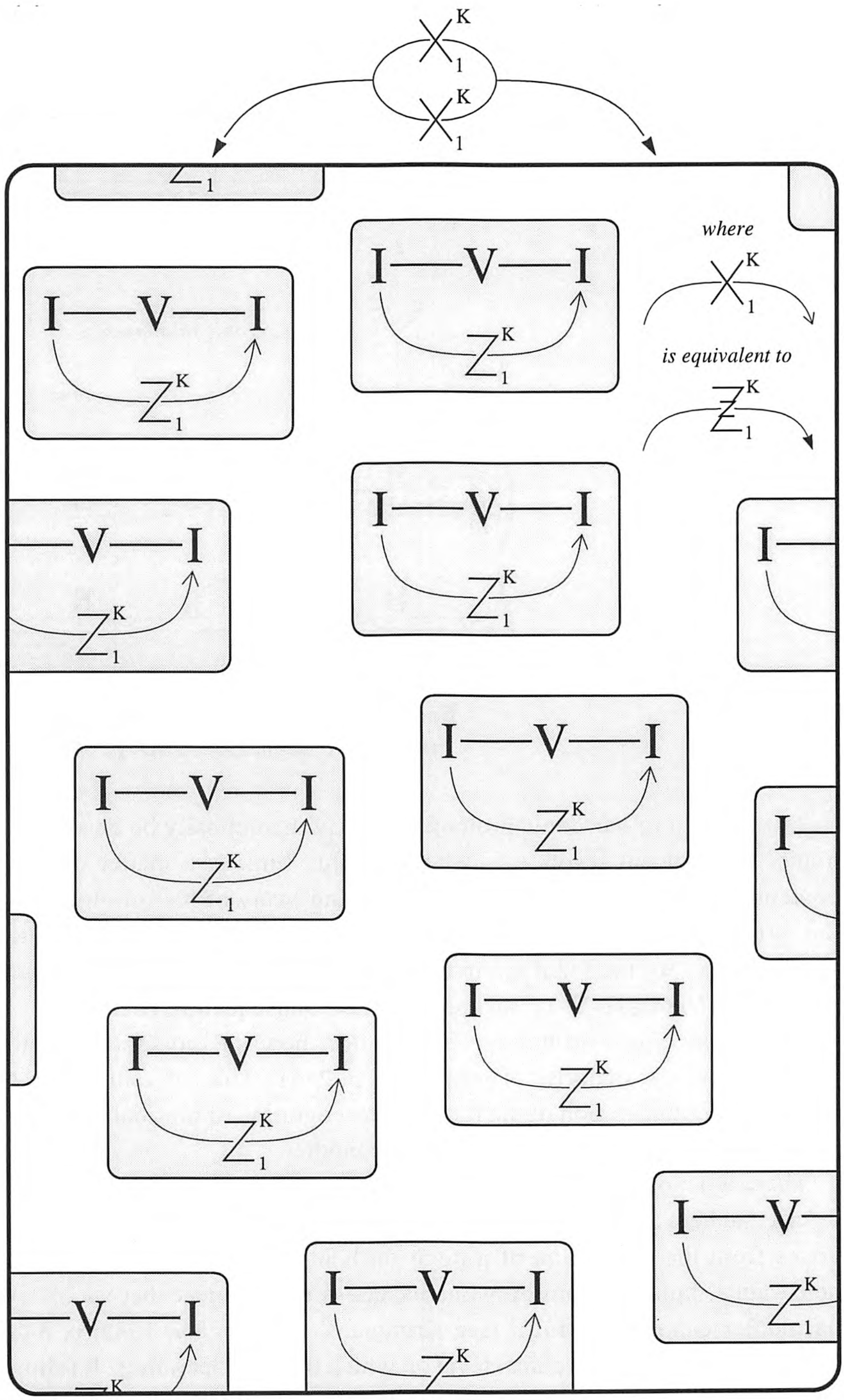


Figure 10.132 Intraoperative and interoperative zygons of key.

different perceptual strata too. Take, for example, Bach's chorale *Ich bin's, ich sollte büssen* (analysed by Schenker, 1933/1969, p. 32). The harmonic surface is coloured by a succession of what may be termed 'mini-modulations', to the dominant, the submediant and the supertonic. At a deeper level, however, these are heard as chromatic elaborations of a single key ($A^{\flat}$ major).

This multi-level view of key reflects different, but equally valid, ways of listening to the same piece. Its analytical advantages are clear, permitting, for example, the synthesis of Schoenberg's notion of 'monotonality' (1954/1969, p. 19) with the traditional concept of modulation, since the former may be interpreted as the disposition of key at the highest level, and the latter as its characteristics on a level nearer the musical surface.

Whatever their position with a hierarchy, harmony and key may be ordered through imitation. For instance, at the highest hierarchical level, many pieces begin and end in the same key, with a move to the dominant between. This implies both intraoperative and interoperative ordering as shown in figure 10.132.

Sonance; its ordering

There is a quality of the perspect 'harmony' that exists on a continuum, ranging from what may described as 'mellow' to 'harsh'. 'Mellowness' is traditionally equated with **consonance** and 'harshness' with **dissonance**. These are two opposite poles of what may be termed **sonance**.

A number of attempts have been made to define consonance and dissonance, to offer psychoacoustical and perceptual explanations of how they function, and to rank intervals according to their sonance (for discussion see, for example, Meyer, 1956, pp. 229ff; Apel, 1969, pp. 201ff; Davies, 1978, pp. 156ff). None of the theories is completely satisfactory, however, nor do the definitions that have been put forward produce consistent results, beyond the fact that intervals such as the perfect octave, 5th and 4th tend to be regarded as the most consonant, and major 7ths and minor 2nds are on the whole felt to be highly dissonant. When three or more notes are considered together, the situation is even less clear-cut. Take, for example, the augmented triad, made up of three consonant intervals which together sound dissonant. There is general agreement, though, that listeners' apprehension of sonance is subject to cultural influences and is affected by musical context.

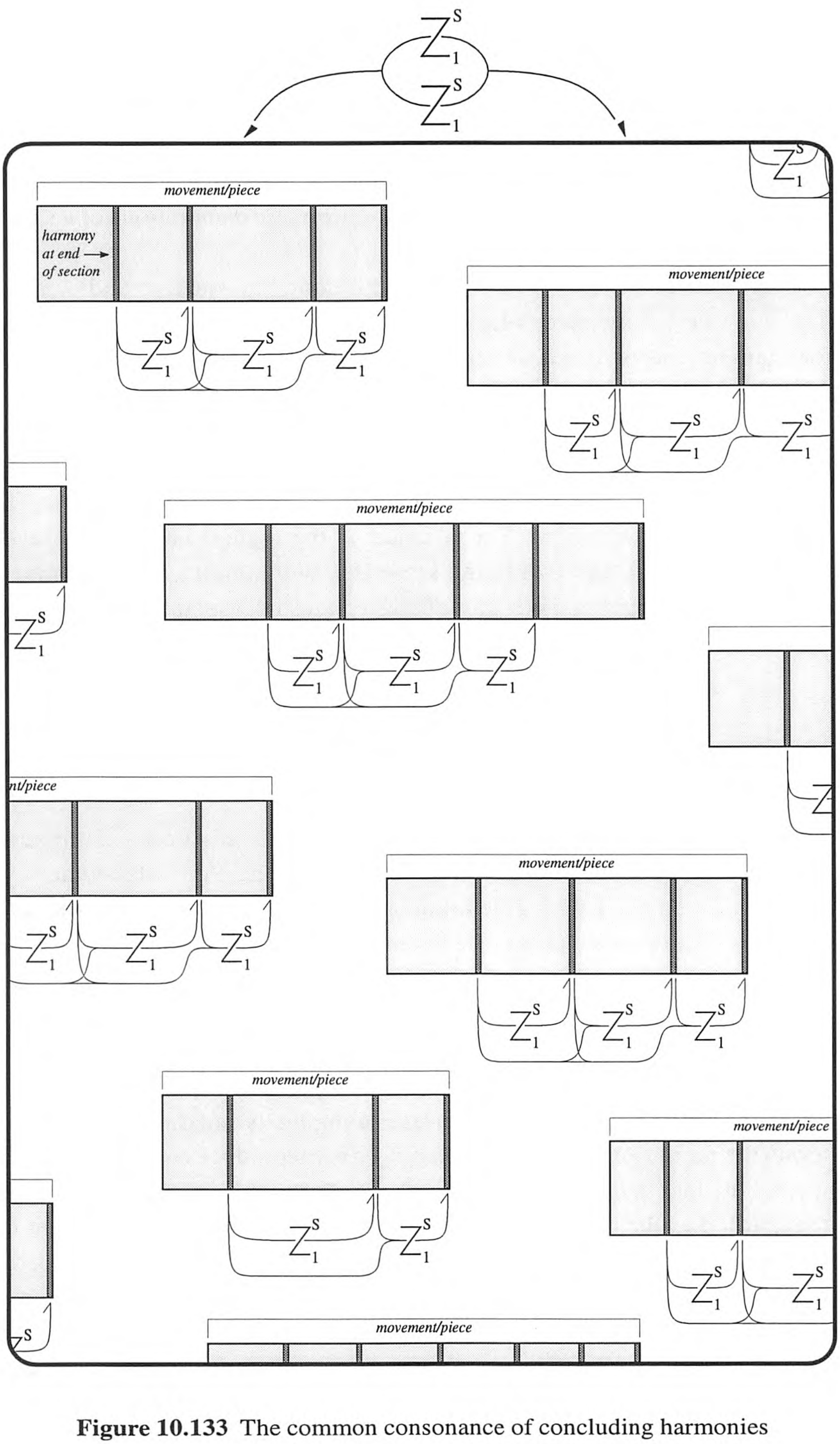


Figure 10.133 The common consonance of concluding harmonies linked through imitation.

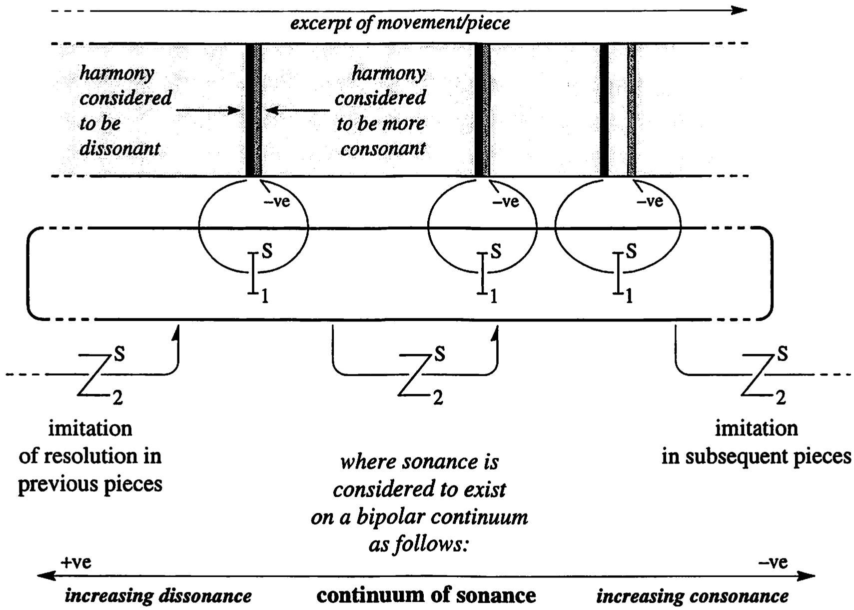


Figure 10.134 Intraoperative and interoperative imitation of the resolution of dissonance.

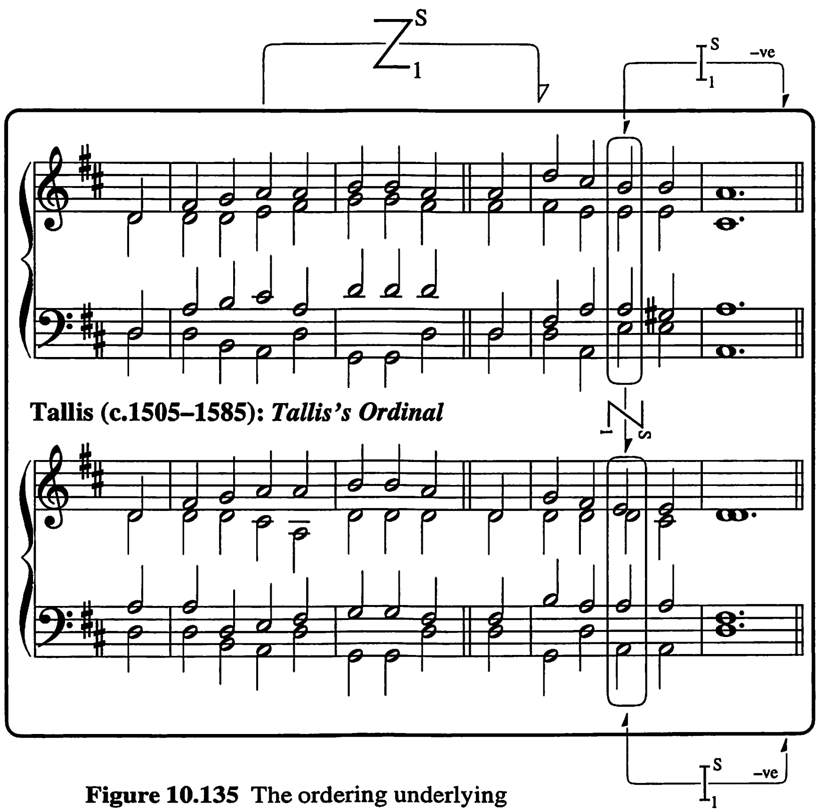


Figure 10.135 The ordering underlying a narrow range of sonance.

With such conceptual imprecision, it may appear that sonance is not worth considering as a factor in musical organisation. Yet consonance and dissonance are of profound importance in many styles, and are clearly subject to order through imitation.

For example, in the Western classical tradition of the 17th, 18th and 19th centuries, pieces (and, indeed, sections) almost invariably ended on a consonance, typically a derivative of the major triad. There are two ways of viewing this trait in zygonic terms: first, that the sonance of final harmonies are linked through imitation (figure 10.133); and second, that dissonant harmonies are always followed (though not necessarily immediately) by a chord that is consonant—the concept of 'resolution' (see figure 10.134).

In some pieces the range of sonance utilised is restricted to a narrow band. See, for example, figure 10.135 (cf. Knopoff and Hutchinson, 1981). Here, characteristically, the level of dissonance is elevated slightly in the cadential formula that is used, the contrast serving to enhance the conclusive effect of the final consonances in lines two and four.[30]

The interaction of the ordering of horizontal and vertical associations of pitch

The previous sections identified the two dimensions in which pitch can be imagined to exist—the 'horizontal' and the 'vertical'—and examined the ordering forces pertaining to each. In most music, however, the two interact, a phenomenon that is now investigated. We begin by considering how the disposition of chords may influence the pitch content of melody.

There are several circumstances in which a tune has been or may be constructed to sound with a given series of harmonies, from Baroque composers writing sets of variations over a harmonic ostinato such as the *romanesca,* to the contemporary jazz musician improvising on the blues. The nature of the relationship between harmony and melody differs from one style to another; here, observations will be confined, broadly speaking to Western tonal music.

Since a harmony is made up of certain pitch-classes, any of these may be used as melody notes. In canonic terms, this means that a performer or composer creating a new line over a given harmonic framework must

[30]Contrast with Danner (1985) for an analysis of Carter's *Canon for 3* (1971) in terms of 'acoustic dissonance'.

choose a pitch or pitches in imitation of one or more found in the chords presented, implying the utilisation of zygonic relationships such as those illustrated in figure 10.136 (part ii).

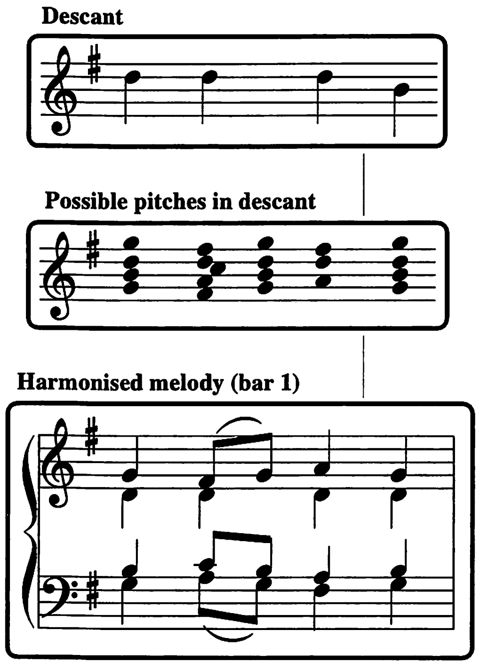


Figure 10.136 (part i)
Descant composed to given harmonised melody.

Kocher (1786–1872); arr. Monk (1823–1889); descant by Nicholson (1875–1947): ***Dix***

Here, additional limitations evidently played a part in the creation of the descant: for example, on only one occasion does it dip below the treble line and it never rises above fifth octave *g*; moreover, at no stage are the outer parts of the original hymn imitated in the new melodic line at the octave, fourth or fifth.

Clearly, the more pitches from a harmony that are transferred to the melodic line, the stronger will be the relationship between the two dimensions. This bonding is found in the many tunes that display 'broken chords', whose existence may be attributed to orderly intersociative connections. (See figure 10.137). Indeed, when arpeggiate figures such as these are played in certain contexts, the distinction between harmony and melody may be ill-defined. Consider, for example, accompanimental patterns such as the *Alberti bass*, which, although formed from a single line, really has the effect of rhythmised harmony. Or, take passages such as those found between bars 21 and 49 of Bach's *Chromatic Fantasia and Fugue*, BWV 903, in which there is a smooth transition from one dimension to the other—even an intentional blurring of the edges.

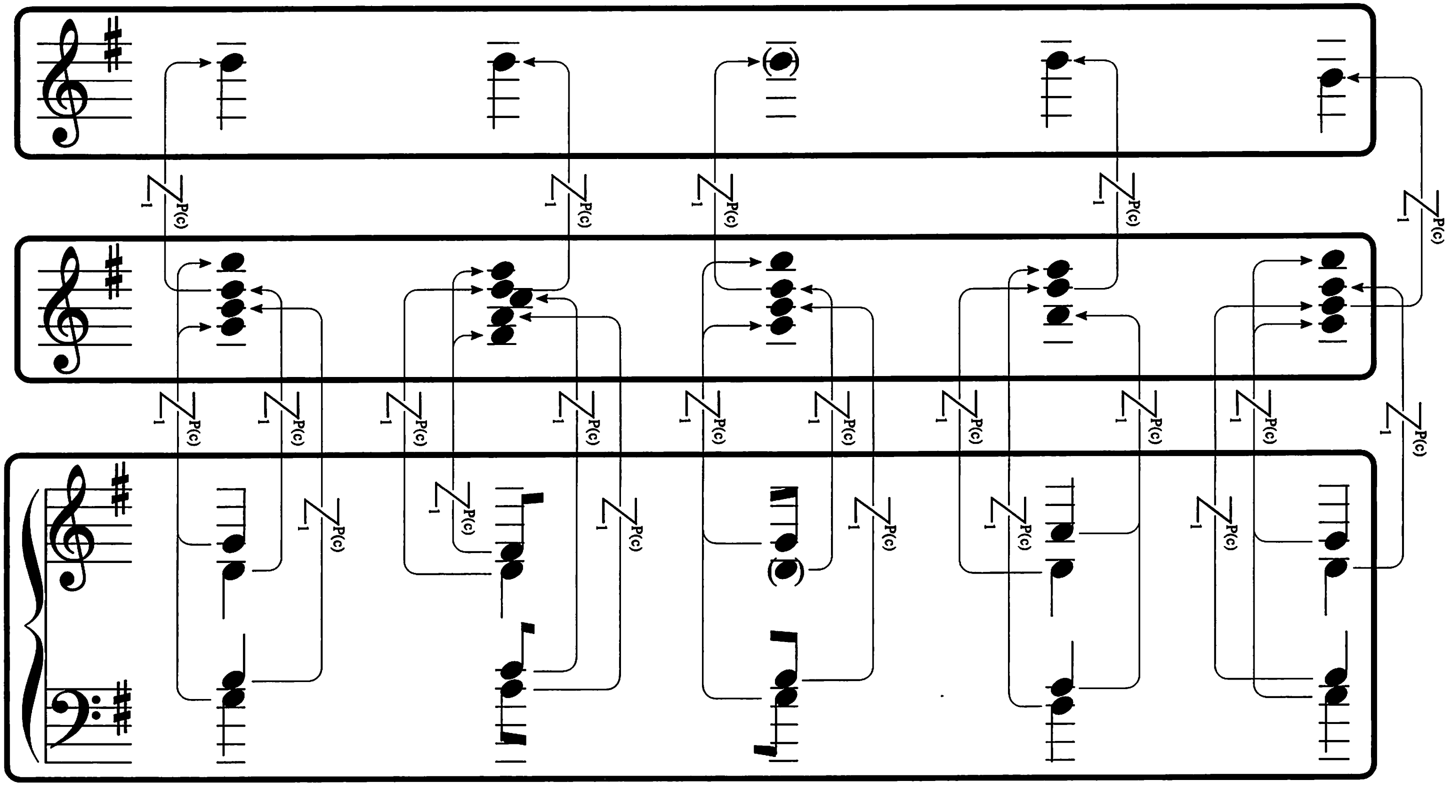


Figure 10.136 (part ii) Canonic interpretation of derivation of descant.

Mendelssohn: *Lied ohne Worte,* Op. 53, No. 3

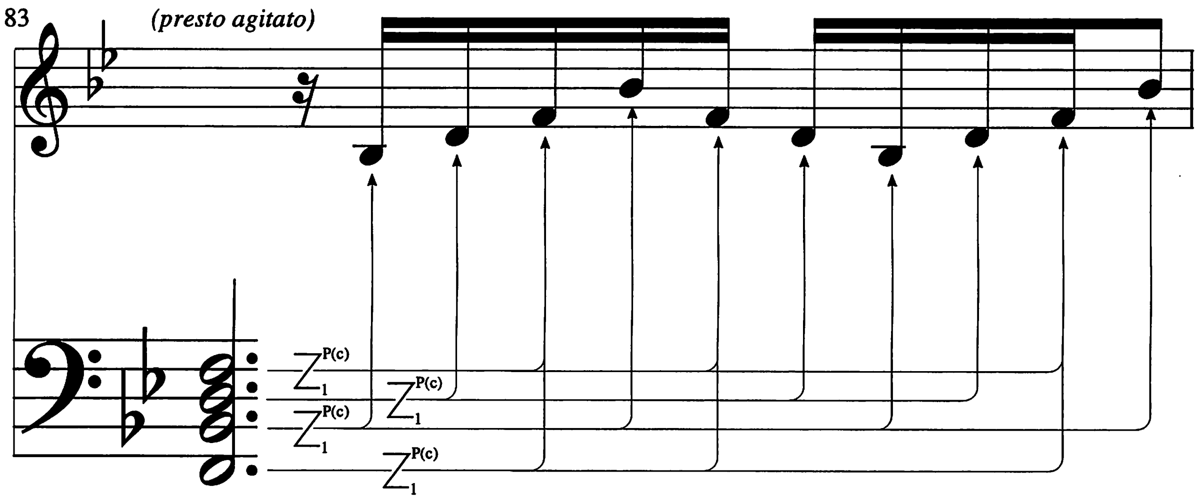


Figure 10.137 A substantial melodic fragment derived from a single chord.

In the example shown in figure 10.136, the addition of the descant leaves the harmonies unchanged. This need not be the case, however: a tune may elaborate on a harmonic structure in a number of different ways. For instance, the interval between two harmony notes may be filled with a pitch or pitches that move by step, or two harmony notes the same may be embellished with an intervening auxiliary one degree above or below them. A further possibility is the *appoggiatura,* an accented neighbour-note that resolves onto an adjacent harmonic member. The probability of features such as these occurring has changed over time. For example,

> accented passing tones occur in practically all periods of music history while the "free" appoggiatura was not much used before *c.* 1750 (Apel, 1969, p. 577).

The more unusual a process within a given style system, the greater the certainty with which its derivation may be traced through individual zygonic relationships. Conversely, the greater the frequency with which a given technique is used, the more surely can a further utilisation be ascribed to the imitation of an abstract model, constructed on the basis of many previous hearings—numerous specific examples become generalised in a syntactic principle which is subsequently applied to new situations (see figure 10.138.)

Melodic devices such as the one depicted can exert an influence on harmony beyond the immediate confines of the passages to which they pertain. This notion is implicit, for example, in the widely accepted theory of how the dominant 7th chord evolved, which proposes that the '7th' was initially a non-harmonic passing note, only subsequently becoming accepted as a harmony note in its own right (see, for instance, Piston, 1941/1978, pp. 231 and 232). This development may be expressed canonically as follows:

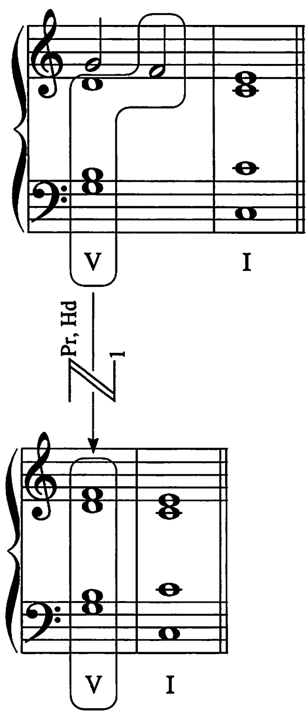


Figure 10.139 Presumed historical derivation of the dominant 7th chord.

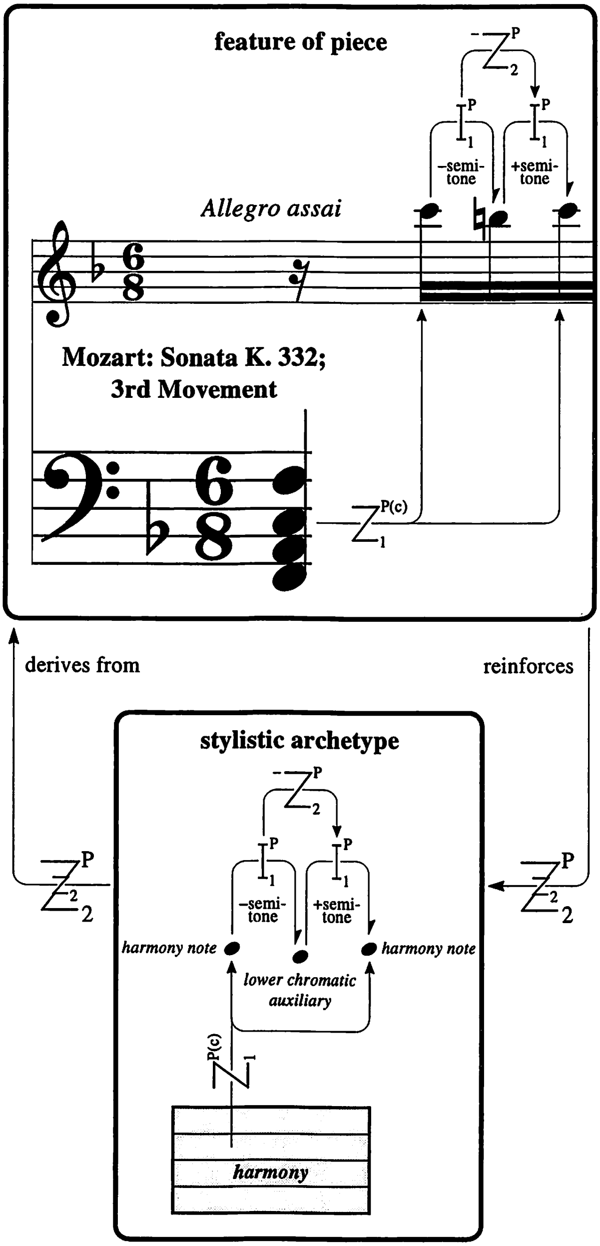


Figure 10.138 Melody elaborating on harmony according to given stylistic convention.

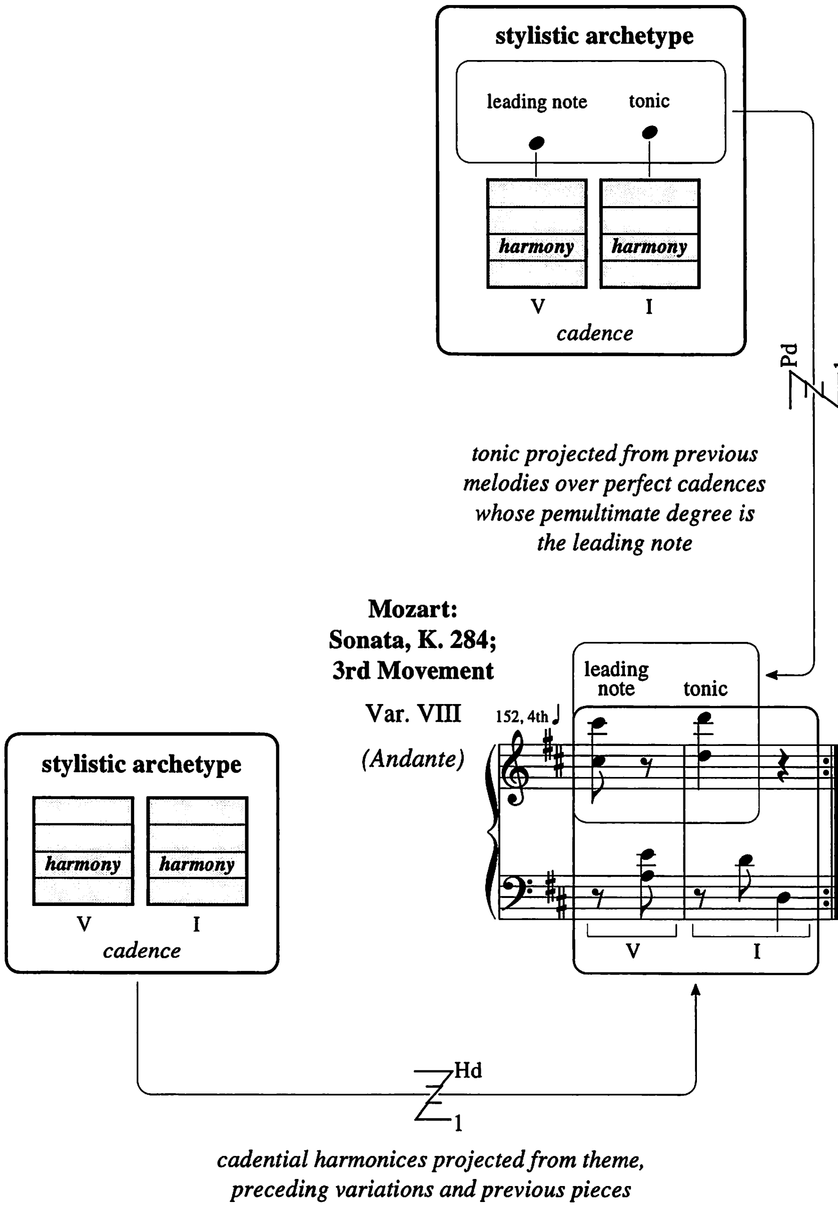


Figure 10.140 Leading note typically rising to the tonic in the context of a perfect cadence.

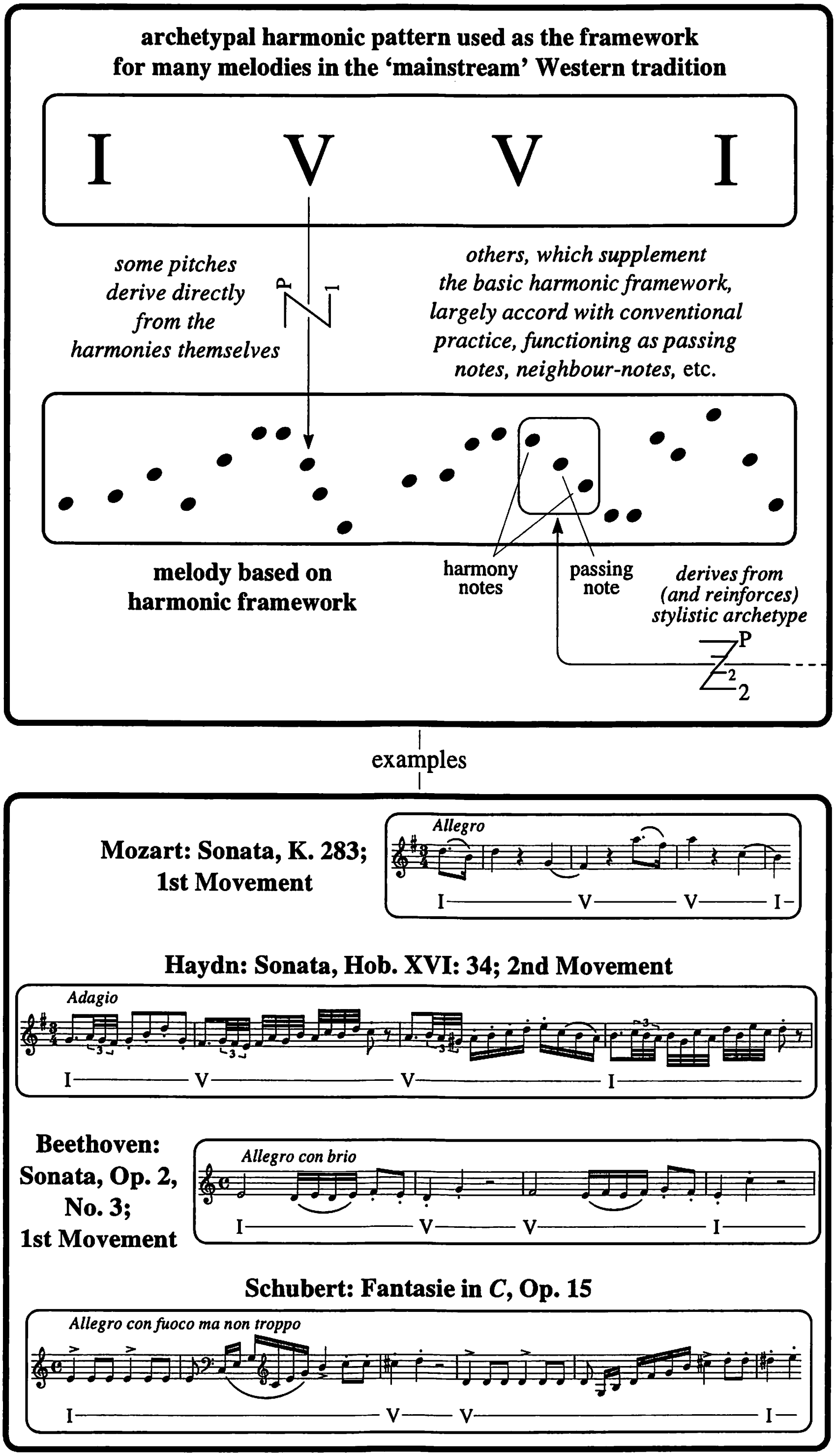
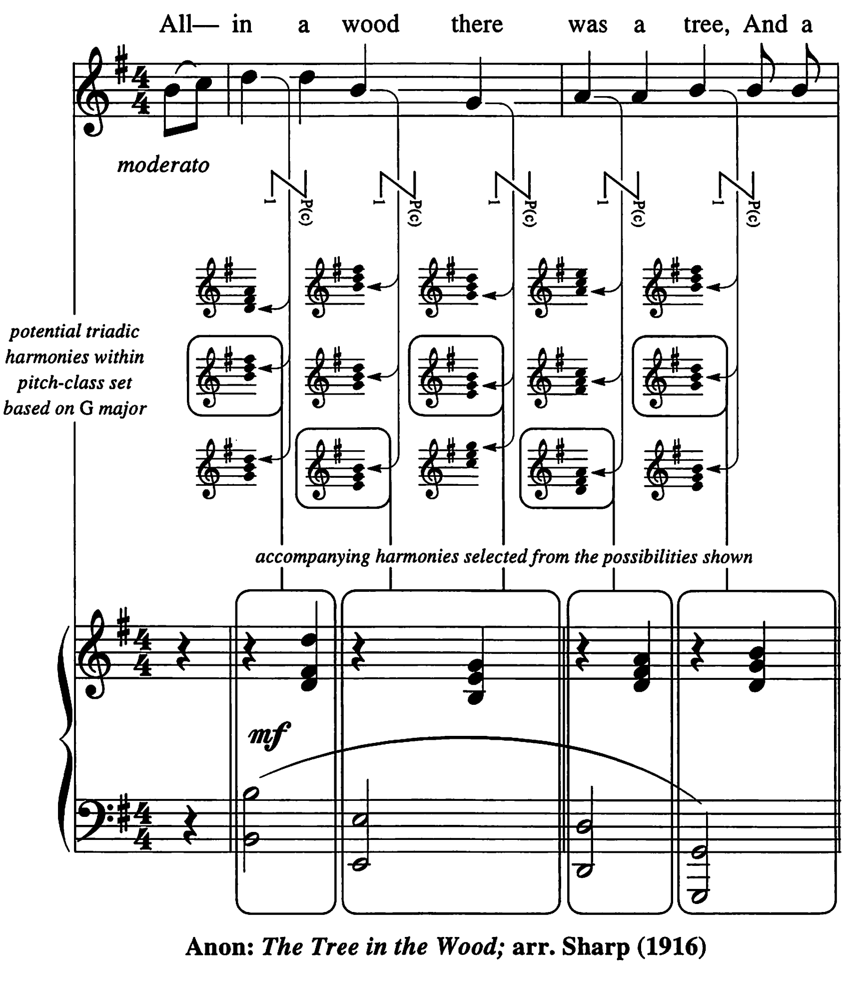


Figure 10.141 Melodies constructed on archetypal harmonic framework.

Given two successive harmonies and a melodic starting point in the first, composers have favoured some linear transitions more than others. For example, a leading note within the context of a V–I harmonic progression normally rises to the tonic. See, for example, figure 10.140.

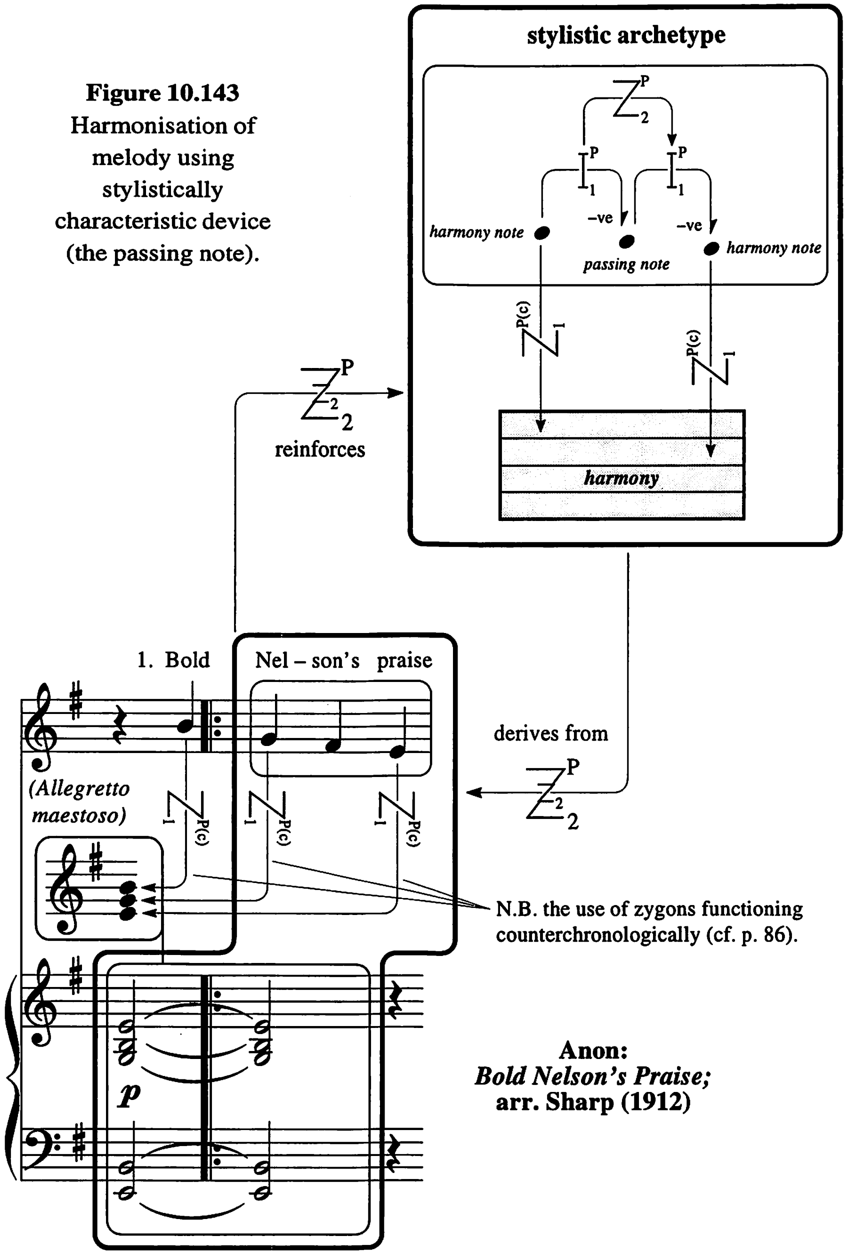
In summary: in certain styles, harmony has exerted a strict control over the disposition of pitch in melody. For instance, it would have been inconceivable for composers working in the mainstream Western Classical tradition to write tunes that did not conform to coherent harmonic patterns,



Anon: ***The Tree in the Wood;*** **arr. Sharp (1916)**

Figure 10.142 A given melody influencing its accompanying harmonies.

Figure 10.143
Harmonisation of melody using stylistically characteristic device (the passing note).



Anon:
Bold Nelson's Praise;
arr. Sharp (1912)

even if the melodies were never intended to be harmonised (cf. Apel, 1969, p. 517). And time and again, the same or similar harmonic frameworks were used to support different tunes. Consider, for instance, the passages shown in figure 10.141.

Next we examine how the pitch content of a melody can influence the disposition of harmonies that may be added to it. At the outset, it should be acknowledged that for a tune to be harmonisable according to the conventions of a particular style implies that certain constraints were operational in its construction. To harmonise a given note in a melody means that it must either belong to its proposed accompanying chord, implying zygonic relationships such as those shown in figure 10.142, or elaborate on its would-be harmonic support in one of a limited number of ways dictated by previous practice, which is again indicative of canonic ordering. See, for instance, figure 10.143.

Other factors are important too, such as the position the melody will occupy in the harmonic texture: will it form the top line, the bass, an inside part or even switch from one to another? Having the tune in the bass is the most limiting in chordal terms, since here, for a given melodic pattern, there are the fewest different harmonic models to emulate; that is, the smallest number of syntactically acceptable harmonic alternatives.

In the process of composition or improvisation, both melodic and harmonic forces may be at work. For example, a harmonic scheme may first suggest itself, followed by a fitting fragment of melody. Subsequently, this melodic motive may call to mind further successions of chords, which may be used on other occasions. Equally, the horizontal and the vertical components of pitch may well up from the subconscious together, melody and harmony apparently conceived as a unit. In such circunstances, the cross-dimensional control present must operate at a purely subliminal level.

We next investigate the interaction of the perspect harmony with the pitch sets of two melodic lines occurring at the same time. The control that one of these is imagined to have on the other can range from being complete to non-existent. Consider, for example, two melodies appearing together, whereby not only is the disposition of one felt to have no effect on that of the other, but their precise manner of combination is left to chance too. Clearly, in such circumstances, any values of harmony that occur will be ordered by the same apparently irrational forces that governed the juxtaposition of the melodic lines. This situation may arise unintentionally, as, for example, when two vehicles draw up together at a set of traffic lights, each driver listening to a different tune on his or her car radio, yet each within earshot of the other. It may be objected that such a scenario lies beyond the scope of the present discussion since two distinct pieces of music are involved, were it not for the fact that comparable effects have deliberately been wrought by some composers within the confines of a single work. Take, for example, Stockhausen's *Kurzwellen* (1968).

Other melodic combinations may be reliant on chance too, though to a lesser extent. For example, the content of two horizontal associations of pitch may be stipulated by the composer, but not the exact nature of the perceived temporal relationship between them. This is the case, for example, in passages in Penderecki's *Dies Irae*, 1967 (see, for example, *Lamentatio,* figure 13). Given such conditions, any harmonies that occur are partly predetermined and partly free. A rather different cocktail of indeterminacy and prescription is found in heterophonic passages, in which

> the norm itself is presented together with one or more deviants which ornament it, modify its melodic outlines, and play with its rhythmic structure. (Meyer, 1956, p. 234)

Here, vertical pitch associations are produced from a single tune with a freedom that is dependent on the nature and degree of improvisation that is felt to be stylistically acceptable.

Next we analyse how, within the harmonic context typical of Western tonal music, the pitch content of one melody can affect that of another occurring at the same time. We consider first the situation where one melodic part is prescribed, and another is to be allied to it. The line given will imply various harmonic frameworks that are deemed admissible within a particular style. The part to be added must conform to one or other of these, through zygonic relationships such as those illustrated in figure 10.144.

This description is incomplete, however, since it is a feature of many styles that one contrapuntal juxtaposition occurs more often than another, while others are rarely encountered, if at all. As an example, consider the infrequency with which consecutive ninths occur in the music of Mozart. The likelihood of certain forms of parallel movement depends upon the position of the parts in the texture. For instance, Handel seldom used successive fourths between the treble and bass lines, but commonly employed them between the top two parts. So how are observations such as these to be interpreted in terms of the present theory?

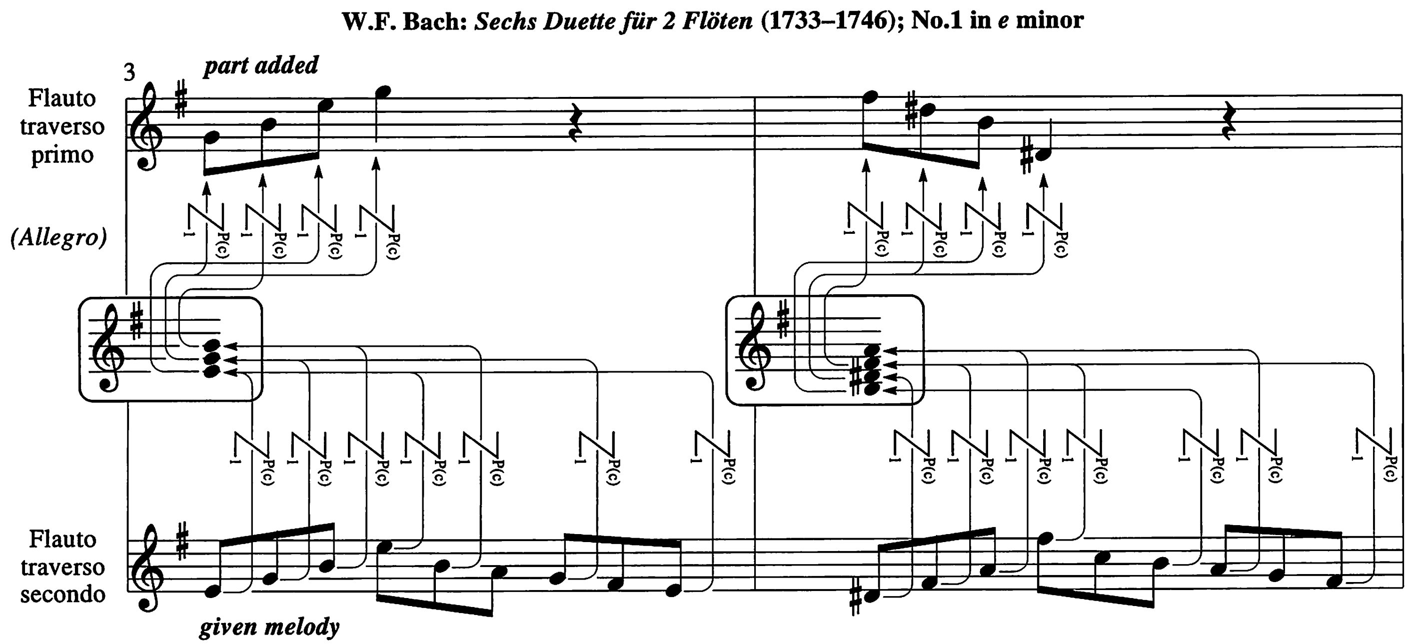


Figure 10.144 The addition of a counterpoint to a given melodic line showing zygonic links through the implied harmonic framework.

Consider that the style of a given body of music is no more than the sum of all its features. Hence for a composer to write a piece in a particular style,[31] it follows that she or he must emulate aspects of an extant work or works in that style, with a fidelity and comprehensiveness that depends upon the degree of conservation (or originality) that is desired. In fact, some differences must exist between the model or models and that which derives from it, otherwise the result would merely be the replication of pre-existing material: just as each piece differs from every other, so each creates its own, unique style system.

In canonic terms, this means that the composition of a stylistically conformant piece must involve a large number of proactive interoperative zygonic relationships. Not only are certain processes imitated, but also the approximate frequency with which they occur, and often their context. Hence, consecutive ninths could be used by a composer writing in the classical style, but only occasionally and on condition that one of the notes function non-harmonically (see Piston, 1949, p. 86). To help composers (and others) become familiar with stylistic norms such as these, the typical working practices of the great composers have been codified by theorists in the so-called 'rules of counterpoint', at least two versions of which exist (the 'strict' and the 'free'), according to which era they pertain.

It may be that a new part is to be added to a melody that is already harmonised. This may occur in the writing of a descant, for example (cf. figure 10.136). Here the limitations are even greater than those described above, since two of the three interrelated variables are given. Then, contrapuntal textures may well involve more than two lines. Since the manner in which each of these can be juxtaposed with every other is guided by principles similar to those outlined in the preceding paragraphs in relation to two parts only, it is clear that the constraints under which polyphonic passages are composed are often considerable indeed. For example, with a three-voice texture not only must the overall effect be harmonically coherent, but the principles of good part-writing (as laid down by stylistic convention) apply individually to parts 1 and 2, 1 and 3, and 2 and 3. With four parts, the composer must take into account six such pairs; with five, ten; and so on.

[31]Except in the creation of a pastiche, this may well not be a conscious decision, in which case the mental processes described here will almost certainly occur unwittingly.

As if these limitations were not sufficient, a great deal of counterpoint is further regulated by the use of one or more imitative devices; orderly intersociative connections of the types described on pp. 518ff. The effects of these in conjunction with rhythm are examined in chapter 11. Here, it is sufficient to observe that imitation determines both the horizontal and the vertical components of pitch. Hence composers writing imitative passages are constrained by the control imposed through the use of imitation, by the stylistic norms relating to part-writing, and by those pertaining to harmony.[32,33]

With three such forces acting concurrently in the act of composition, conflict is sometimes inevitable, and traditionally it is imitation that bends to accommodate the ideals of harmony and counterpoint, a fact that treatises on the subject make clear, time and again. For example:

> It may again be mentioned that imitation need not be exact as to interval, nor should a point of imitation ever be forced in at the expense of harmonic soundness and strength. (Lovelock, 1949, p. 36)

A rather different balance of power is evident in the serial techniques invented by Schoenberg: since this scheme accounts for the disposition of all the pitches in a texture by exerting complete control in the horizontal dimension, it inevitably has a profound effect on the vertical aspect of the music too. In fact, synchronous associations can be formed in three ways: through the simultaneous appearance of two or more consecutive members of a single row, through the coincidence of pitches pertaining to different series, or through a combination of these two methods. Not that this degree of control is sufficient for some critics, however, certain of whom detect an inconsistency between the rigorous organisation to which the linear aspect of music is subject and the relative freedom bestowed upon chords (cf. Stadlen, 1958).[34]

[32]The order present in the act of composition may be modelled more precisely according to specific circumstances. Consider, for example, writing a canon over a given harmonic framework (as Bach did in the *Goldberg Variations*, BWV 988). Here, the melody devised must fit with the chordal structure in two different places, as well as functioning as its own counterpoint.

[33]A different blend of coincident constraints impinge on writers of 'invertible' counterpoint. Here, the demands of good harmonic and contrapuntal practice have to be respected, whichever part is in the bass.

[34]In the work of non-serialists too, special relationships are sometimes found between horizontal and vertical associations of pitch. Consider, for example, the first movement of Bartók's 4th String Quartet, 1928 (see Perle, 1955, pp. 309ff).

Finally, consider that horizontal and vertical associations of pitch may be related at higher hierarchical levels. It has been suggested, for example, that

> in the Scherzo of Beethoven's Quartet Op. 135, the notes F–G–A of the opening phrase ... are tremendously expanded to form the basis of the harmonic structure of the middle section, in which the keys F, G, A follow each other in direct succession (Sessions, 1950, p. 49).

Similarly Rosen (1971/1976, p. 89), in speaking of Beethoven's *Appassionata* Sonata, Op. 57, states that the

> alternation of the keys of D flat major and C major is followed by the laconic motto of the single notes D♭–C in the left hand in measure 10, in which the appoggiatura which is the basis of the harmonic effect is presented thematically, its significance isolated and detached.

In each case, the zygonic implication is clear.

The concept of tonality; its ordering

This investigation of the order pertaining to pitch concludes with an examination of **tonality**, and the place of canonic control in its operation. We begin with the assertion that a piece or section thereof may be perceived to be 'tonal' if each of the pitch-classes or values of harmony (or both) from which it is constituted is used consistently in a manner that differs from the ways in which the others are employed, and is thereby felt to fulfil a unique function in respect of them (cf. Krumhansl, 1979, pp. 370 and 371).[35] This idiosyncratic utilisation of values can take a number of forms, which are now discussed, initially by considering pitch in a melodic context.

Some degrees tend to occur more often than others.[36] This is shown, for example, in the context of Western children's songs by Pinkerton (1956) and Francès (1958/1988, pp. 96 and 97),[37] although the fact that it is

[35]For other defintions of tonality, see, for example, Schoenberg, 1934/1975; Bukofzer, 1947, p. 12; Berry, 1976/1987, p. 27.

[36]Something that is widely acknowledged. See, for example, Nettl, 1973, p. 27.

[37]Francès (op. cit., pp. 102 and 103) also takes the rather more subtle measure of the durations for which different degrees are held. Again, an unequal distribution is found, although—surprisingly perhaps—the first and the fifth degrees do not on average occur more than the second and the third.

characteristic of musics across the world is indicated by the ethnomusicological concept of 'weighted scales' (see p. 156). Moreover, if the sequential locations of values are taken into account, the disparities in their frequencies of occurrence become even more marked. This is particularly apparent at the beginnings and endings of tunes—consider, for instance, the number that conclude on the tonic as opposed to any other degree—and has been the case, it seems, since ancient times: Sachs (1943, p. 42), for example, in examining several hundred three-tone melodies, found that

> only 8 per cent ended on the upper note, 39 per cent on the middle note, and 53 per cent on the lower note.

A further factor that contributes to the feeling of tonality is the unequal distribution of transitions between successive notes: that is, a given degree is more likely to be followed by some values than others. Pinkerton (op. cit.), for example, using the same sample of 39 nursery tunes that featured in the statistical analysis mentioned above, gives these probabilities for degrees following i: i...0.23; ii...0.13; iii...0.07; iv...0.02; v...0.10; vi...0.03; and vii...0.07.[38] Again, it would appear that such figures vary according to the sequential location of the interval involved. This is apparent from Simonton's (1984) study of the melodic structures of 15,618 classical themes (pp. 6–8): the probability of iv following v, for example, is 0.032 when the notes concerned are the first and second of a tune; 0.022 when they are the second and third; 0.029 when they are the third and fourth; 0.037 when they are the fourth and fifth; and 0.033 when they are the fifth and sixth. Furthermore, the likelihood of a particular degree occurring is influenced by the preceding interval, and once more, this manifests itself in Simonton's results (pp. 11 and 12). The probability of v ocurring as the third note in a theme, for instance, is approximately 0.05 when it is preceded by v–v, but drops to around 0.01 (one can assume from the data given) when it follows v–vi♭.[39] These statistics are, once more, affected by the sequential location of the values. Hence the probability of iii succeeding i–ii is something above 0.03 for notes 1, 2 and 3; >0.02 (but <0.03) for notes 2, 3 and 4; >0.01 (but <0.02) for notes 3, 4 and 5; and >0.02 (but <0.03) for notes 4, 5 and 6.[40]

[38] The probability of i being followed by a rest of more than one beat = 0.36.

[39] Transitions with lower probabilities than this are not cited.

[40] See also Butler (1989, p. 238): "*Any tone will suffice as a perceptual anchor—a tonal centre—until a better candidate defeats it.* The listener makes the perceptual choice of the most plausible tonic on the basis of style-bound conventions in the time ordering of intervals that occur only rarely in the diatonic set: that is minor seconds (or enharmonics) and the tritone."

Informal observation suggests that similar comments apply to higher hierarchical levels of pitch too, although detailed information is lacking. In Schenker's mind there was no doubt: his theory that all great works of the tonal era could ultimately be reduced to one of three versions of the so-called *Urlinie* (see p. 562) suggests that deep in the structure of such pieces each degree serves a unique function. And even if listeners' perceptual faculties rarely allow them to plumb such depths,[41] and whilst, intellectually, theorists may be troubled by the logic through which Schenker's 'universal' pattern was derived, the *Urlinie* at least affords an insight into the type of tight structural control that may lie below the surface of a large proportion of the Western repertoire.

So much for the constrained way in which pitch is used to create the feeling of tonality in melodies. With harmony the restrictions are even greater. For example, in his analysis of works by Bach, Mozart, Beethoven and Ellington, Francès (op. cit.) finds that chords I and V preponderate, accounting for between 70.7% and 93.6% of the total (p. 99). Again, these figures are affected by the sequential contexts of the harmonies concerned: for instance, pieces frequently begin with the tonic chord and almost invariably end with it. The matter of harmonic transitions has already been broached (see p. 589), and once more the observed tendency to make almost exclusive use of only a few combinations is heightened when their sequential locations are taken into account as well—consider, for example, the number of works the conclude with the progression V–I (a perfect cadence). Restrictive practices are a feature of harmony on higher hierarchical levels too. As noted in the preceding paragraph, Schenker holds the ultimate view in such matters, believing that all tonal compositions of worth have as their background the same succession of harmonic values: I–V–I (see pp. 593 and 594).

From these observations, it is clear that tonality evolved through imitation: evidently, composers saw fit to use the same juxtapositions of perspective and interperspective values of pitch and harmony time and again—and often in circumstances similar to those in which they had previously appeared.

We now examine the place of tonality in the listening experience. A crucial factor in musical audition is anticipation (see pp. 258ff), which

[41]Cf. Rosner and Meyer, 1986, p. 37: "Analysts such as Schenker (1956) and Lerdahl and Jackendoff (1983) may well produce hierarchical diagrams of quite long musical passages. But if 'higher' events exert increasingly tenuous perceptual influences, the psychological force of the outputs from such analytical machinery will dwindle quickly, whatever may be their value for the theory of music."

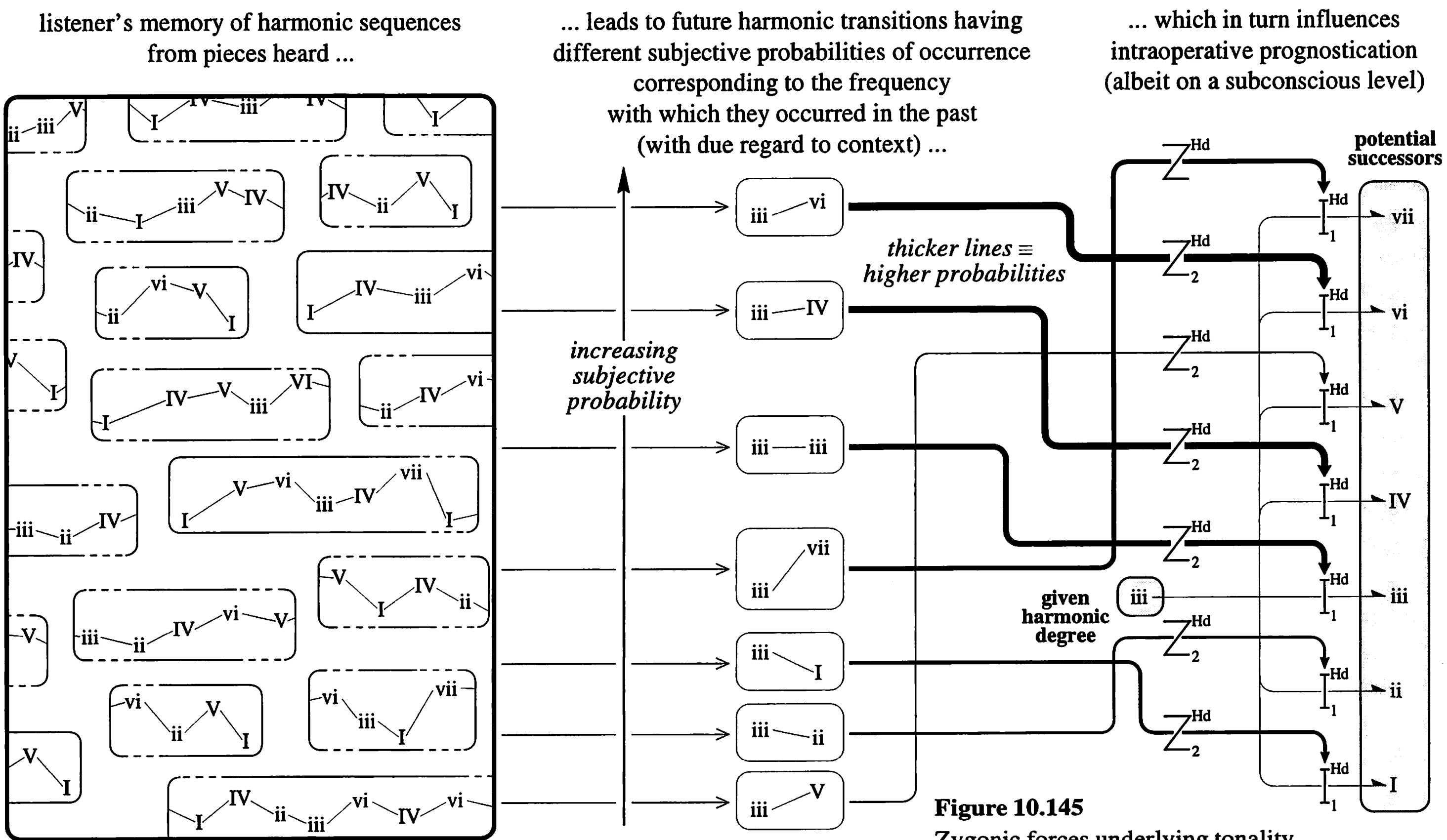


Figure 10.145
Zygonic forces underlying tonality.

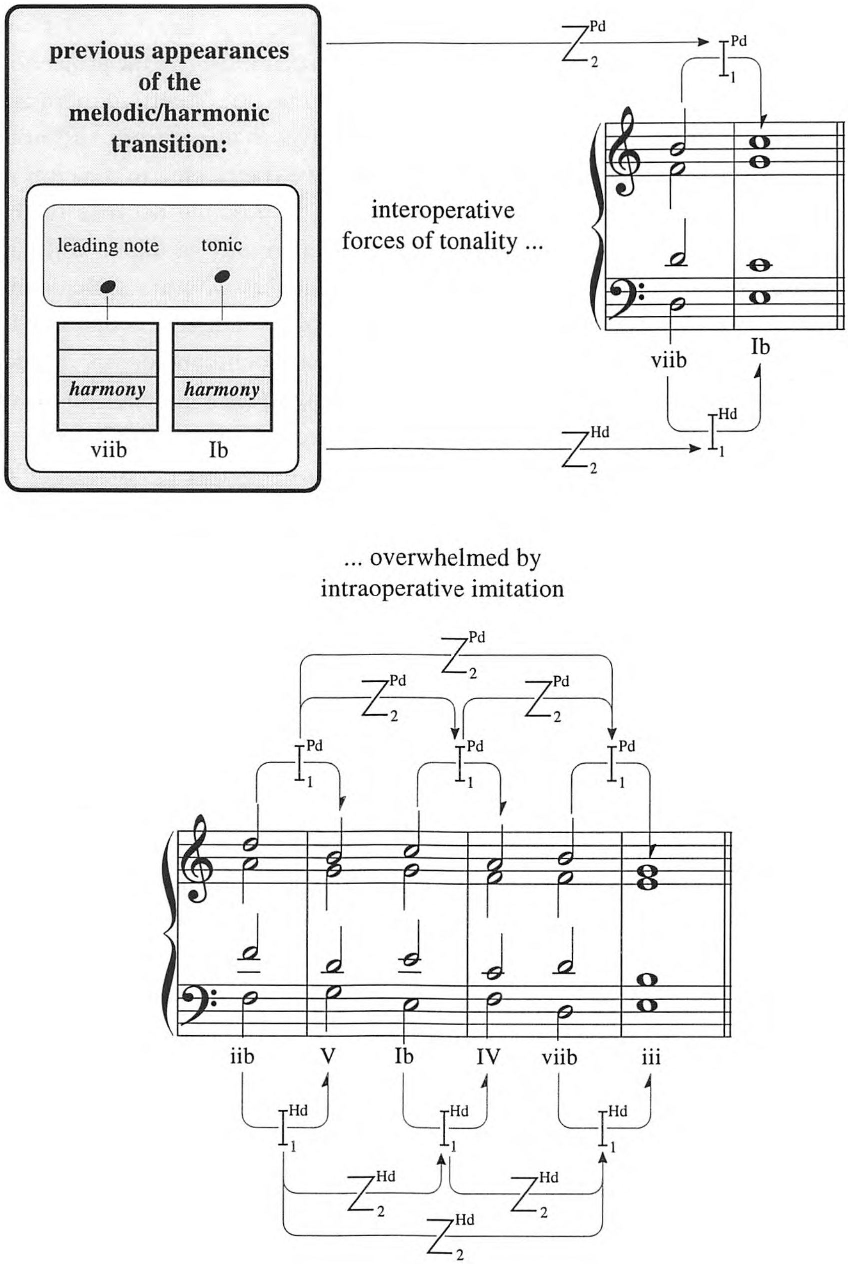


Figure 10.146 The tonal tendency of viib to be followed by Ib (and the leading note by the tonic) overwhelmed by local imitative forces.

derives from a listener's belief, albeit a subconscious one, that what has happened once will happen again. Anticipation occurs through the projection of proactive zygonic relationships, which may be interaudoperative (stemming from other works), interterauditive (hailing from different performances of the same piece) or intraauditive (pertaining to the current rendition). In tonal compositions, prediction is possible because of the unique function that each degree of pitch or harmony is felt to fulfil in relation to the others. This means that to listeners who are stylistically attuned, the presentation of a given value or values in a given context will arouse certain expectations as to probable modes of continuation (or, indeed, cessation), each with a likelihood corresponding to the frequency, in his or her experience, of past occurrence. Hence, according to Piston's table of usual root progressions (1941/1978, p. 21), upon encountering, for example, chord iii within, for instance, a classical sonata, a listener would expect to hear vi, although IV would also be a strong contender, and the possibility of I, ii or V should not be ruled out. Zygonically, such tonal projections may be considered to function along the following lines (see figure 10.145).

Such anticipation is based solely on the tonal forces imagined to be present. These may be qualified by felt tendencies of a more local nature, however, whether interholistic or intraholistic (see p. 261). Take, for example, viic. In isolation, the most probable resolution of this chord is I or Ib. In a sequence such as that shown in figure 10.146, though, the power of this general trend is overwhelmed by that of the zygonic relationships that operate in the immediate vicinity. The leading note, belying its name, falls to the dominant and is harmonised by iii (cf. Piston, op. cit., p. 305).

Conclusion

The relative length of this chapter is a reflection of the high level of pitch organisation encountered in many musical styles. Ordering almost invariably occurs in several different ways at the same time. Consider, for example, the stratification that characterises the 'horizontal' dimension of pitch, and the complex interaction between the 'horizontal' and 'vertical' axes, all subject to the quasi-gravitational pull of tonality in the background. These forces do not operate in isolation from other perspects, however, and it is to cross-modal issues that we now turn our attention.

11

The combined ordering of pitch and the temporal perspects

Introduction

This chapter examines the combined ordering of pitch and the temporal perspects. Non-canonic forces are considered first, followed by an investigation of cross-modal imitative control (pp. 625ff). Zygonic relationships of melody are a major area of concern, and a taxonomy of interfigurative transformations is presented (pp. 633ff). The independent ordering of profile and rhythm is also mentioned briefly (pp. 649ff). The organisation of configurations combining melody and harmony is examined (pp. 652ff), followed by an exploration of the perceived temporal possibilities of interfigurative relationships, which leads to a consideration of process and form (pp. 657ff). The interoperative transfer of configurations, processes and forms is investigated (pp. 695ff), and, finally, the extramusical influences that bear upon them (pp. 701ff).

Non-canonic forces affecting the coordinated ordering of pitch and the temporal perspects

First, we consider the circumstances in which the selection of value in one perspective domain can affect that in another, whether for physical or perceptual reasons. This is represented schematically in figure 11.1.

Pitch and the temporal perspects place a number of constraints on one another. For example, pitches demand a certain minimum duration, both

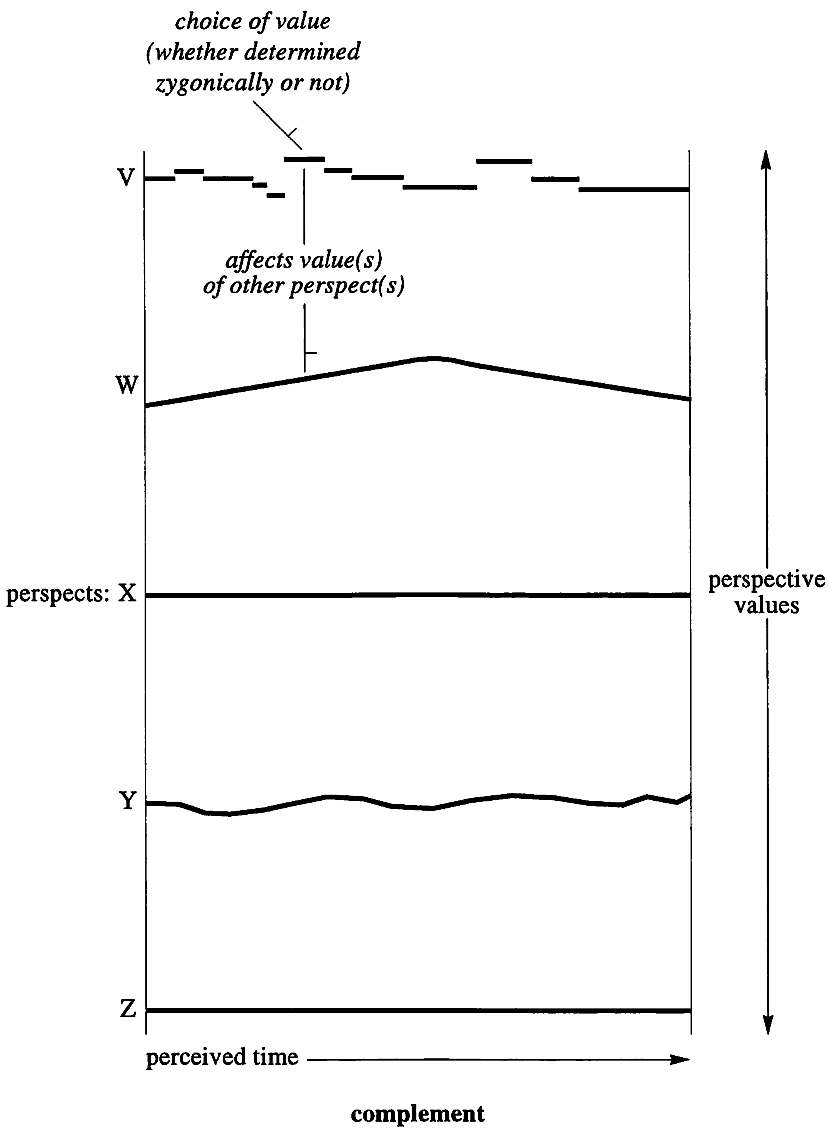


Figure 11.1 Cross-perspective ordering effect.

physically and perceptually, which varies according to value. Moreover, both performers and listeners can cope with consecutive notes only up to a certain tempo, beyond which technical or aural limitations prevail.

Several forms of cross-perspective restriction involve timbre. For instance, on a number of instruments, and with the voice, only single lines are available, generally speaking. On keyboard instruments such as the piano, only certain chords are possible for solo performers, while only particular double, triple and quadruple stops are available on a stringed instrument such as the violin (see, for instance, Forsyth, 1935, pp. 315ff). With certain instruments the effect of *legato* may be unobtainable between given pairs of pitches. Particular notes or intervals may be difficult or even impossible to play rapidly on some instruments, or in certain registers (depending partly on the skill of the performer). Conversely, order may be imposed through the desire to extend the technical prowess of the developing artist or to flaunt the mastery of the virtuoso, as in the *étude* (see also Kivy, 1984, pp. 26 and 27). The recognition that certain configurations of rhythm and profile are physically more suited to some instruments than others dates back in the West to the beginning of the Baroque period.

> The instruments ... gradually developed specific styles, notably the violin family, and to a lesser degree the wind instruments. Lute and keyboard music, too, became more idiomatic than before, and composers showed great resourcefulness in taking advantage of the peculiar aptitudes and weaknesses of the respective instruments. (Bukofzer, 1947, p. 15)

With some instruments, the influence exerted by performers' movements on the creation of melodic patterns is even more direct. See, for example, Baily (1985), and Blacking (1961):

> The most significant common factors of the *kalimba* tunes are not their melodic structures, but the recurring patterns of 'fingering', which, combined with different patterns of polyrhythm between the two thumbs, produce a variety of melodies. (p. 29)

The forces of order in operation here can be represented as follows:

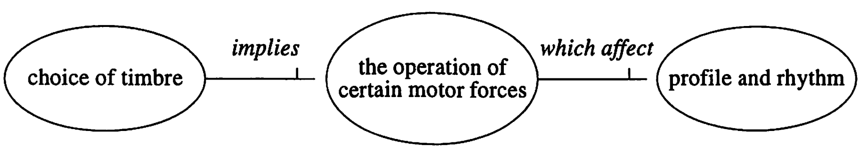


Figure 11.2 Underlying forces of order operating in kalimba tunes.

Loudness can affect the selection of pitches and values of the temporal perspects too. Consider, for example, that the soft, rapid repetition of notes on the piano was made possible only by the invention of the double escapement action by Érard (cf. p. 4). Even the perceived location of the sound source can have an effect. For instance, techniques involving the rapid interchange of parts such as 'hocketing' may well be difficult to bring off if performers are widely spaced. Finally, there are cross-perspective considerations involving perceived reverberation. Durations, for instance, are affected by the degree to which they echo; and playing or singing too fast in an over-resonant acoustic environment may well produce a muddled sound.

The range of possibilities available

Although these non-canonic factors ostensibly pose a considerable degree of pre-compositional constraint, in most circumstances composers are nevertheless faced with a broad margin of freedom in their choice of perspective values. Hence a given pitch can be allied with a wide range of durations, and *vice versa*. See, for example, figures 11.3 and 11.4.

Stravinsky: ***The Rite of Spring*** **(1913)**

57 Cb. solo (5) (♩ = 66)

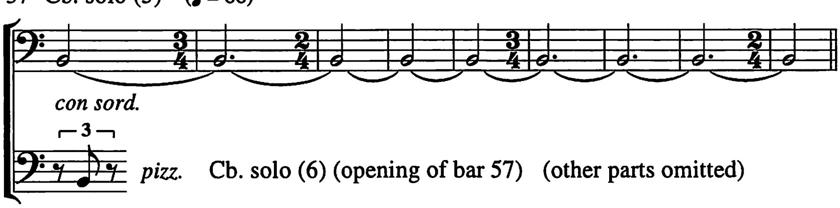


Figure 11.3 One pitch; widely differing durations.

Equally, an interval may be associated with many different interperspective values of prefix, and a given interperspective value of prefix linked to any interval. This principle extends to profile and rhythm too; given the same

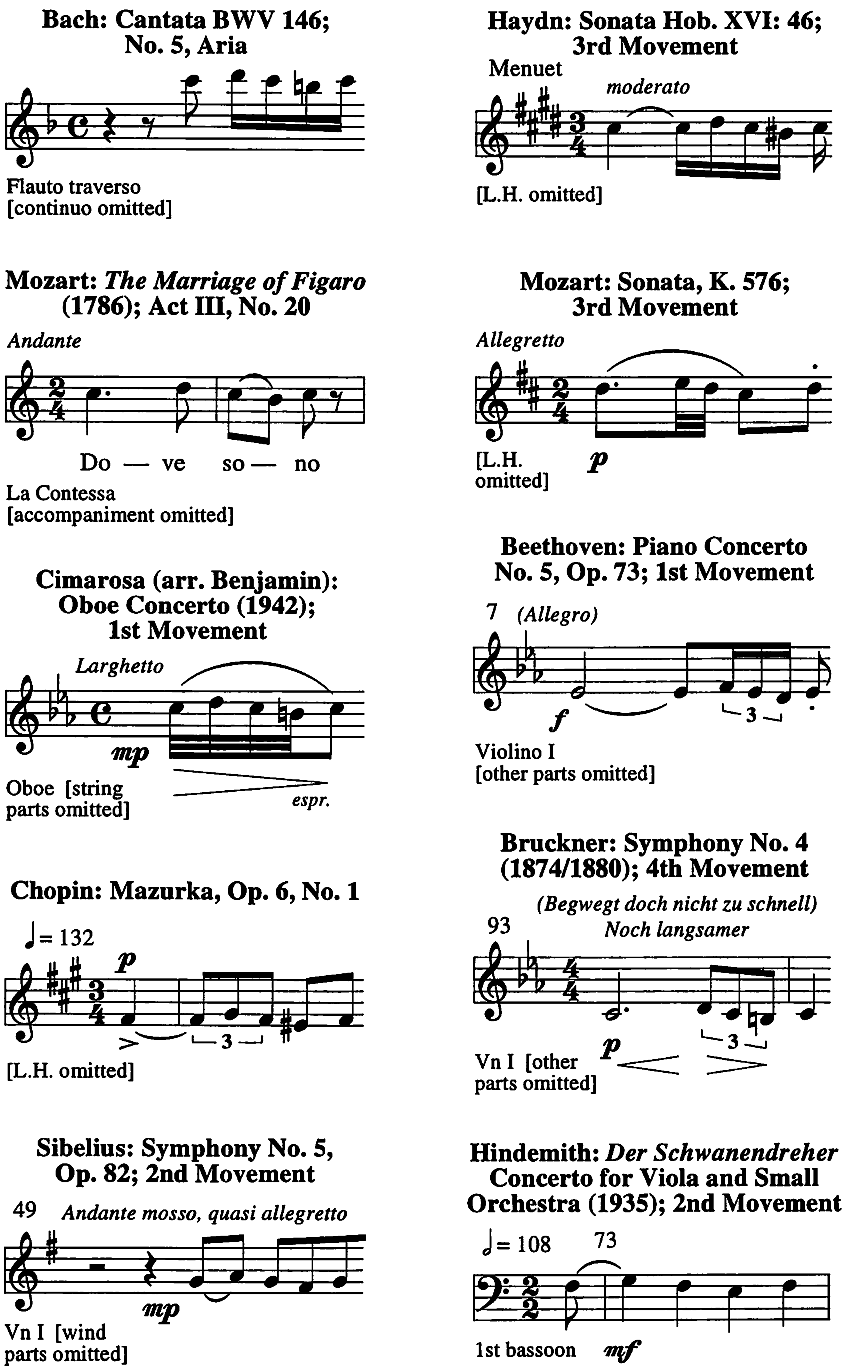
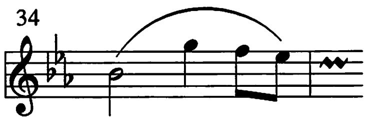


Figure 11.5 One profile allied to a number of different rhythms.

Haydn: String Quartet, Op. 20, No. 2; 2nd movement

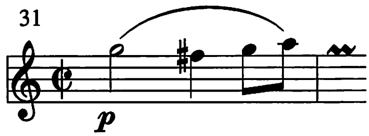
(Adagio)



Vn I [other parts omitted]

Schubert: Symphony No. 6; 1st Movement

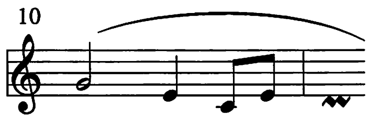
(Allegretto)



Fl I [other parts omitted]

Weber: *Der Freischütz* (1821); Overture

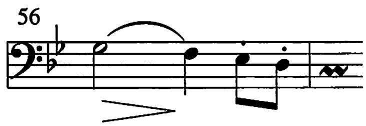
(Adagio)



Horn in *C* [other parts omitted]

Berlioz: *Symphonie Fantastique* (1830); 4th Movement

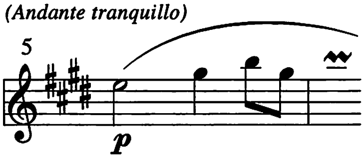
(Allegretto non troppo)



Celli and Basses

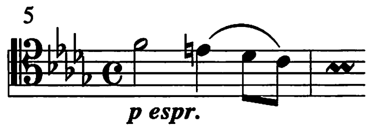
Mussorgsky: *Khovantschina* (1872); 1. *Prelude*

(Andante tranquillo)



Clarinet solo [other parts omitted]

Tchaikowsky: *Slavonic March,* Op. 31

(Moderato)

Fag. zu 2 [other parts omitted]

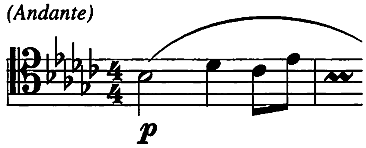
MacDowell: *Sea Pieces,* Op. 55; *Starlight*

(Tenderly)

Melody only [accompaniment omitted]

Stravinsky: *The Firebird* (1910); *Berceuse*

(Andante)



Fag. I solo [other parts omitted]

Figure 11.6 One rhythm allied to a number of different profiles.

Chopin: Prélude (1834)

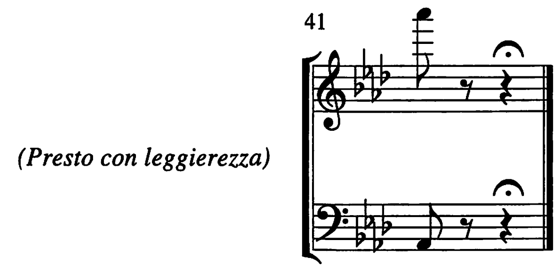


Figure 11.4 One duration; widely differing pitches.

number of protractions in each, a great number of alliances are possible, irrespective of the type or degree of internal order that either may (but need not) display.[1] The combination that is chosen is entirely dependent on the effect desired by the composer. See, for example, figures 11.5 and 11.6.

Cross-modal imitative ordering

We now investigate the cross-perspective ordering that has occurred and may yet occur between pitch and the temporal perspects. There are two basic forms this can take: cross-modal imitation, discussed in this section, and cross-modal coordination, examined below (see pp. 630ff).

Because the perspects pertaining to pitch are essentially quite different from those of perceived time, ordering can occur only with secondary relationships or those of higher ranks which entail the imitation of ratios, since these exist as abstract numerical concepts, independent of the perspects to which they refer (see p. 26).[2] This view does not accord with that expressed, for example, by Cone (1961, p. 452), who denies such relationships a place within the realms of music perception. However, some of the examples presented in this section suggest that such cross-perspective links can

[1]To exist at all, a profile must be associated with some rhythm, albeit a weak or even random affair. Conversely, a rhythm need not be pitched (or, at least, perceived as having a single pitch).

[2]For an extended discussion on the isomorphism of pitch and perceived time see Rahn, 1983, chapter 5.

indeed possess an intrinsic musical reality. It has to be admitted, though, that the cross-modal imitation of pitch and perceived time has been used very little in music to date, despite the numerous theoretical possibilities that exist. This may simply be because the ordering is not of the type that listeners generally expect to hear. Hence cross-modal canons may have a more substantial role to play in the future. Three possibilities are shown in figure 11.7.

Cross-perspective invariants are a feature of certain multiple serial techniques. Consider, for example, Babbit's proposals for equating pitch number with the point of initiation of a perceived temporal event (1962, p. 63). This may appear to be cross-modal coordination rather than imitation, since values of fix cannot directly emulate pitches. However, the way the scheme is devised means that secondary interperspective values of fix (calculated from the nearest preceding barline) do correspond absolutely to the ratios between intervals, indicative of a tertiary zygonic connection (see figure 11.8).

Cross-modal intersociative relationships can be free with regard to sequence. This means, for example, that pitch sets can be related to

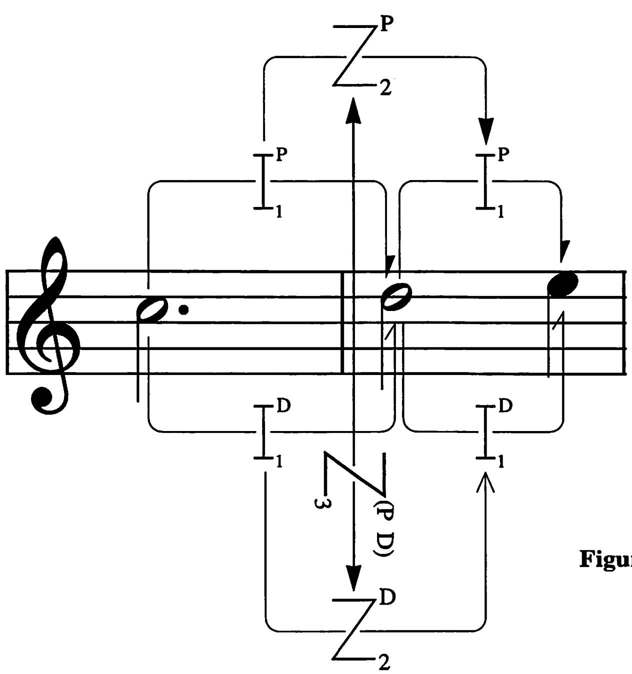


Figure 11.7 (part ii)

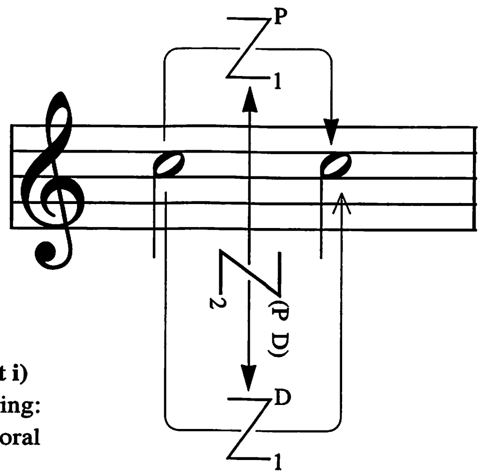
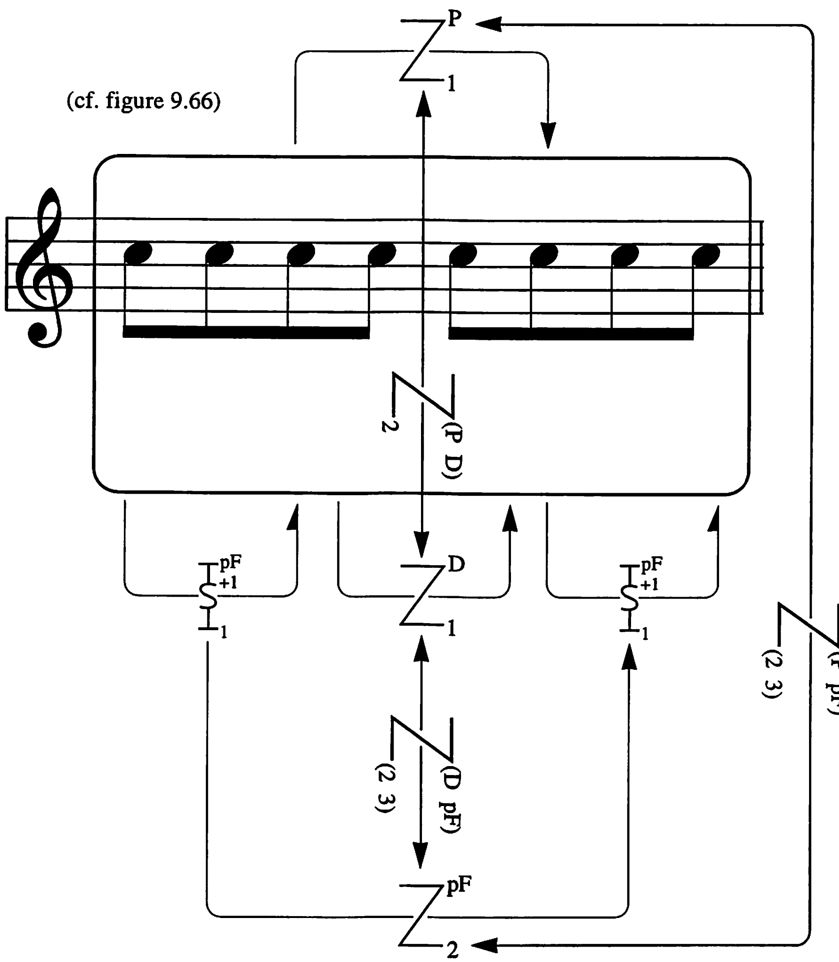


Figure 11.7 (part i)
Cross-modal ordering:
pitch and the temporal
perspects.

(cf. figure 9.66)



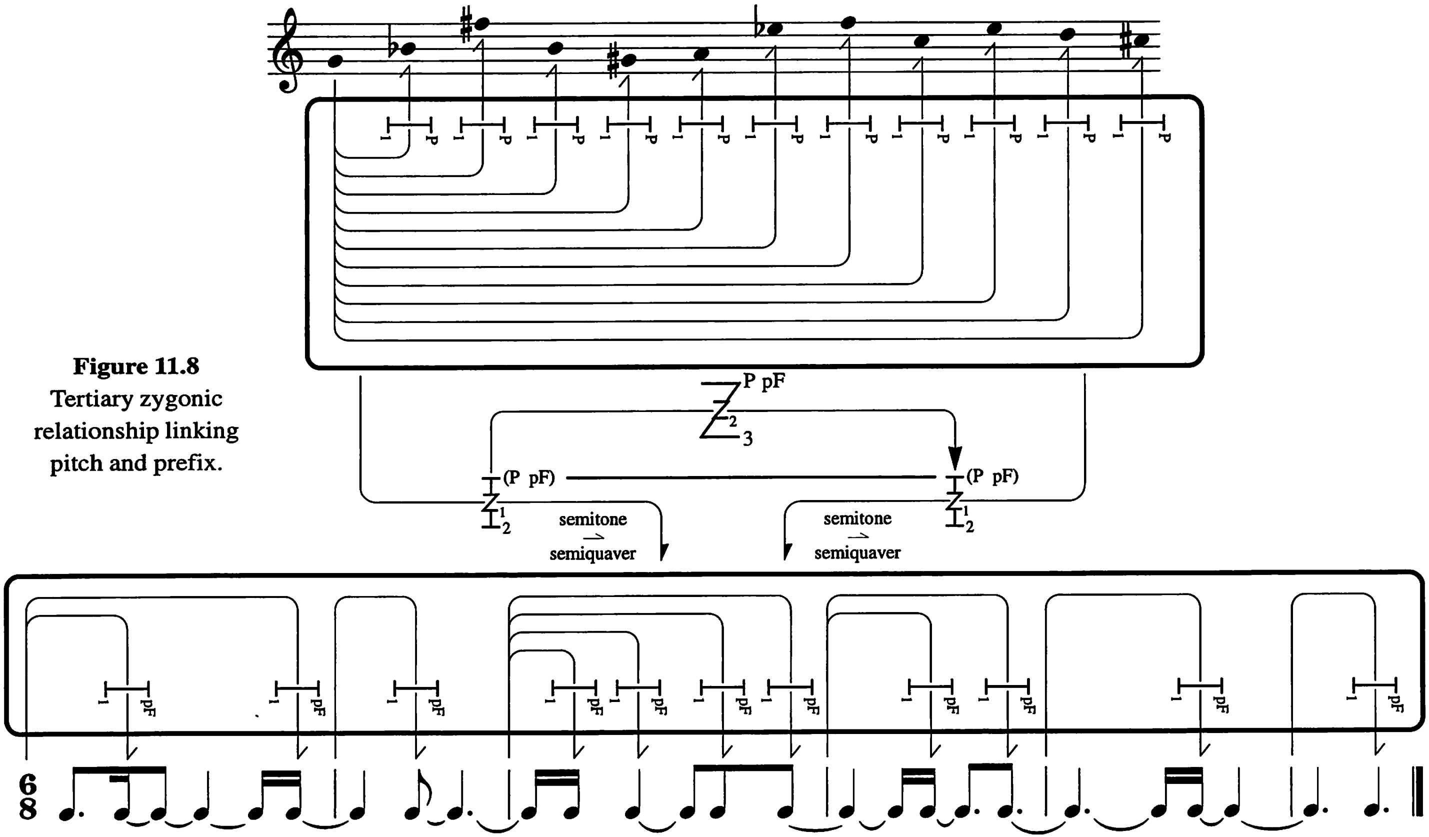
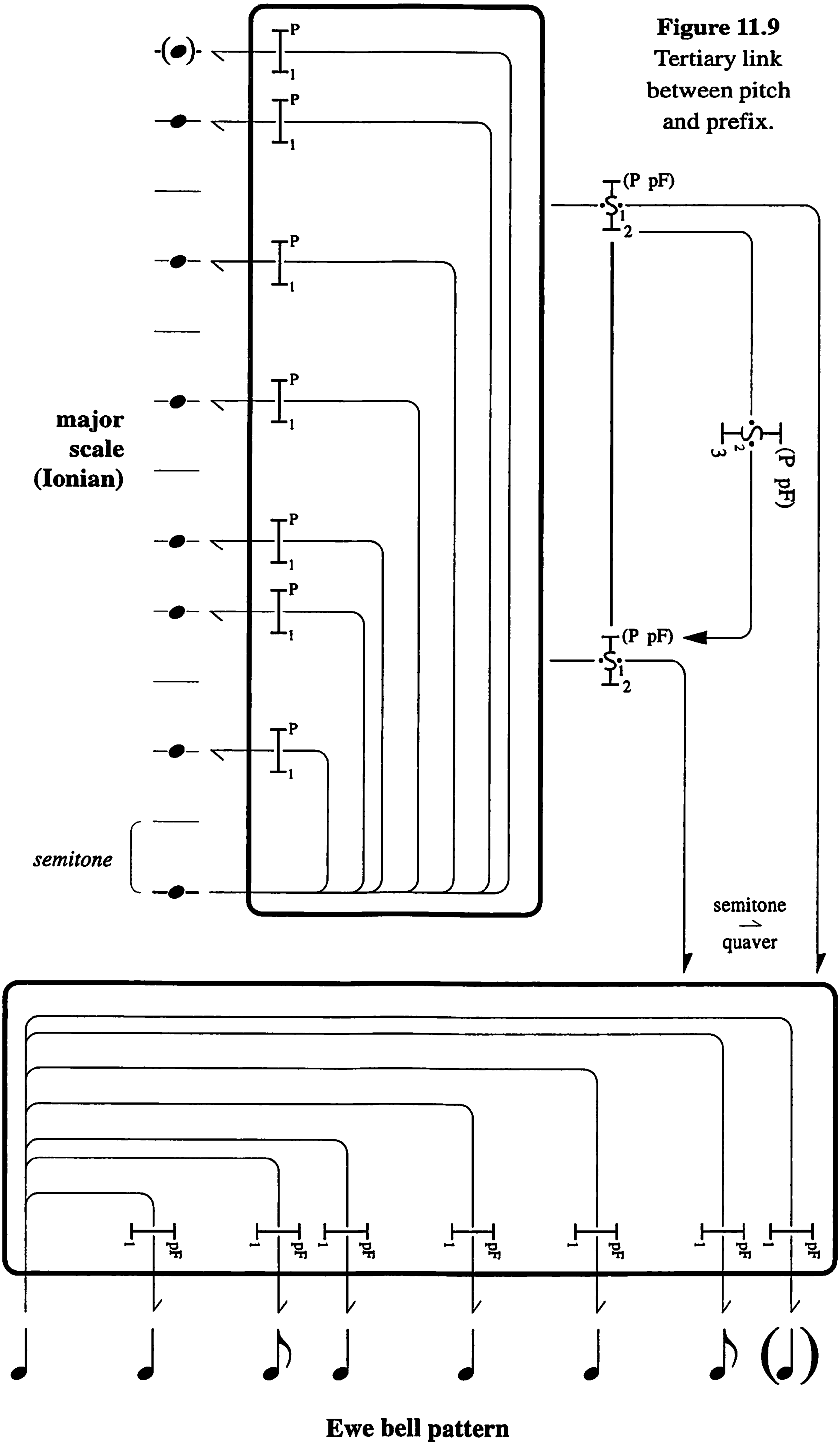


Figure 11.8
Tertiary zygonic
relationship linking
pitch and prefix.

Figure 11.9
Tertiary link between pitch and prefix.



durational sets or interperspective sets of prefix in an orderly way. Pressing's observations on the cognitive isomorphisms between pitch and rhythm in world musics (1983) can be viewed in this light, though here the relationships involved are non-zygonic since there is no feeling of implication in the cross-modal similarities that are observed. Among these are the fact that a predominant Ewe bell pattern may be equated with the Western major scale (p. 40)—see figure 11.9—though to what extent paired patterns like these are the result of a general cognitive process, as Pressing suggests (p. 38), is open to question.

The coordinated ordering of pitch and the temporal perspects; zygonic relationships of melody

Cross-modal coordination occurs when the values or groups of values pertaining to two different types of perspect appear together once, and then a second time, in presumed imitation of the first. In general terms, such an event may be interpreted through the operation of parallel primary zygonic relationships of different types:

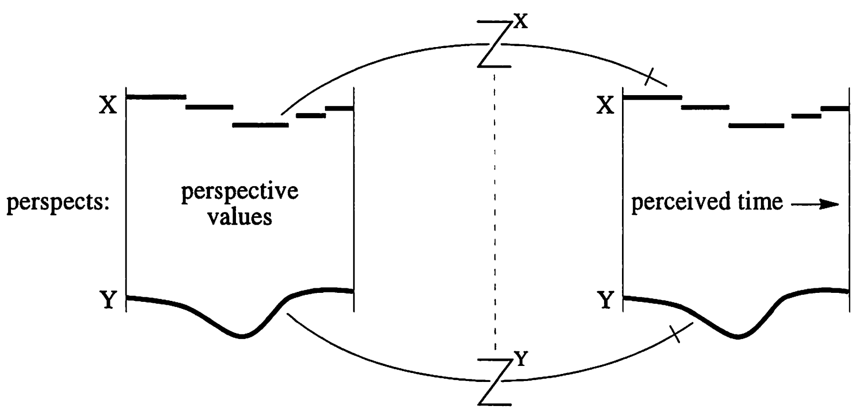


Figure 11.10 Cross-modal coordination occurring through parallel zygonic relationships.

An alternative explanation is conceivable involving relationships that are themselves cross-modal.

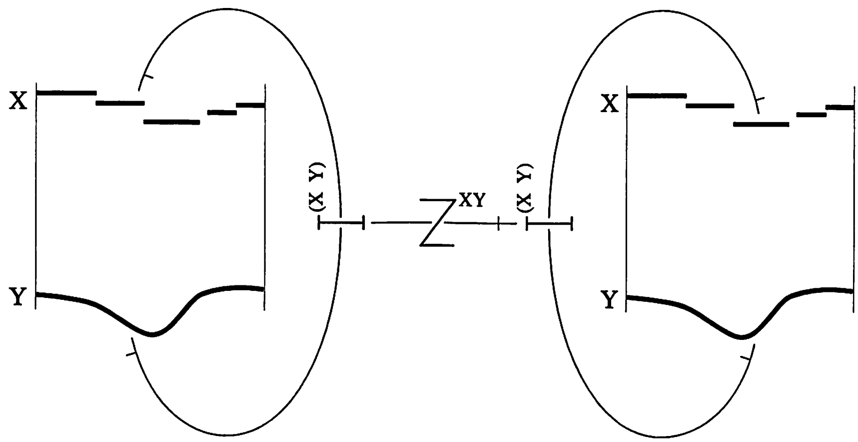
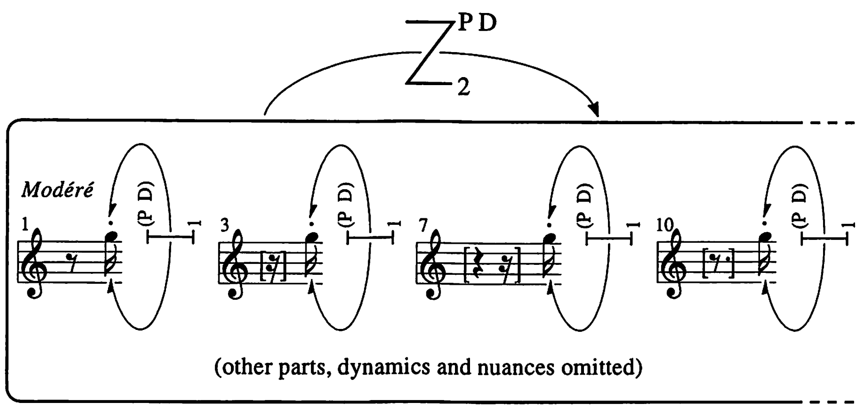


Figure 11.11 Alternative interpretation of cross-modal coordination.

On the whole, however, this seems to model cognition rather less strongly, although it may be viable in certain circumstances. For instance, given a number of different values, each appearance of a particular pitch may habitually be associated with a certain duration. This occurs, for example, in Messiaen's *Mode de valeurs et d'intensités* (1949–1950).



Messiaen: *Mode de valeurs et d'intensités* (1949–1950)

Figure 11.12 Cross-modal coordination using cross-modal relationships.

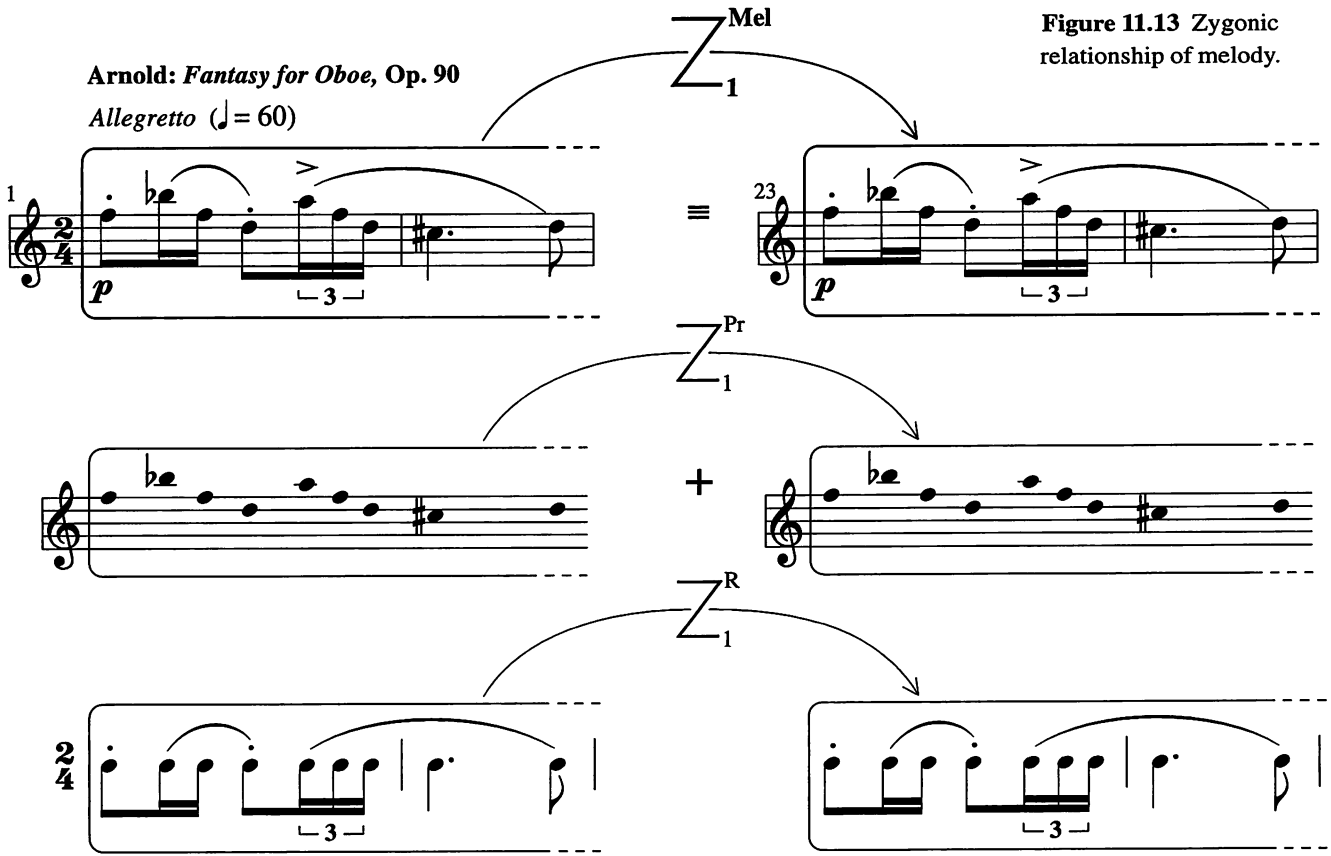


Figure 11.13 Zygonic relationship of melody.

Where a single part or strand in a texture is involved, parallel zygonic relationships between rhythm and profile may be regarded as being equivalent to one compound relationship of **melody** ('Mel')—or **line** ('Li') if the part concerned is not a melodic one. See, for example, figure 11.13. Like those linking rhythm and profile, such relationships are nominally relative.

Modifications in either domain may be indicated using the methods outlined on pages 398–433 and 518–547. As a matter of convention, when changes occur both to profile and rhythm, the former will always be detailed first. See, for instance, figure 11.14. It is to such modifications that we now turn our attention.

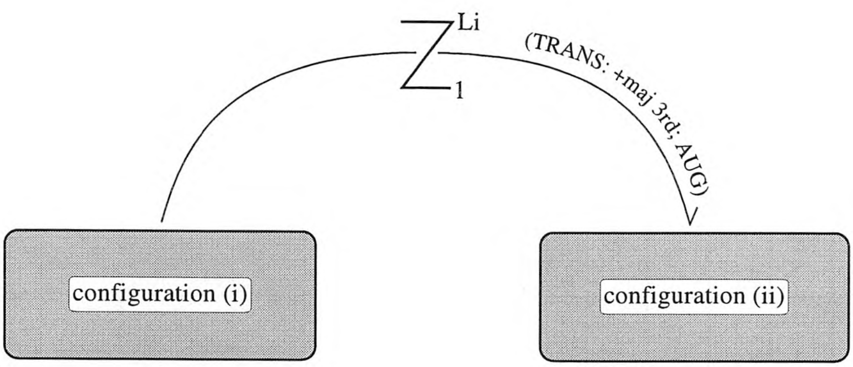


Figure 11.14 The symbolism of modifications both to profile and rhythm within a zygonic relationship of line.

A proposed taxonomy of melodic relationships

This section and the three that follow examine the forms that zygonic relationships of melody (or line) can take. The possibilities are outlined in figure 11.15, in which rhythmic variations (taken from chapter 9) and are shown along the horizontal axis, and modifications of profile (taken from chapter 10) are listed vertically. Just as any profile may theoretically appear in combination with any rhythm (provided they both form associations of the same size), so, in theory, either the rhythm of a configuration or its profile may be altered quite independently of the other, except where the addition or omission of material changes the number of notes, in which case

transformations of rhythm

reference number from chapter 9	–	(i)	(v)	(vi)	(ix)	(xii)	[p. 576]	(ii) (iii) (iv) (vii) (viii) (x) (xi) (xiii) (xiv)
primary values of prefix	repetition	repetition	x r	repetition	x r	+ d	– d	various
durations	repetition	x r	x r	repetition	x r	+ d	– d	various
relative metrical location	repetition	repetition	repetition	+ d	not maintained	not maintained	not maintained	various
description of transformation	repetition	articulative change	change of tempo	syncopation	augmentation *or* diminution	additive change	inversion	no simple description

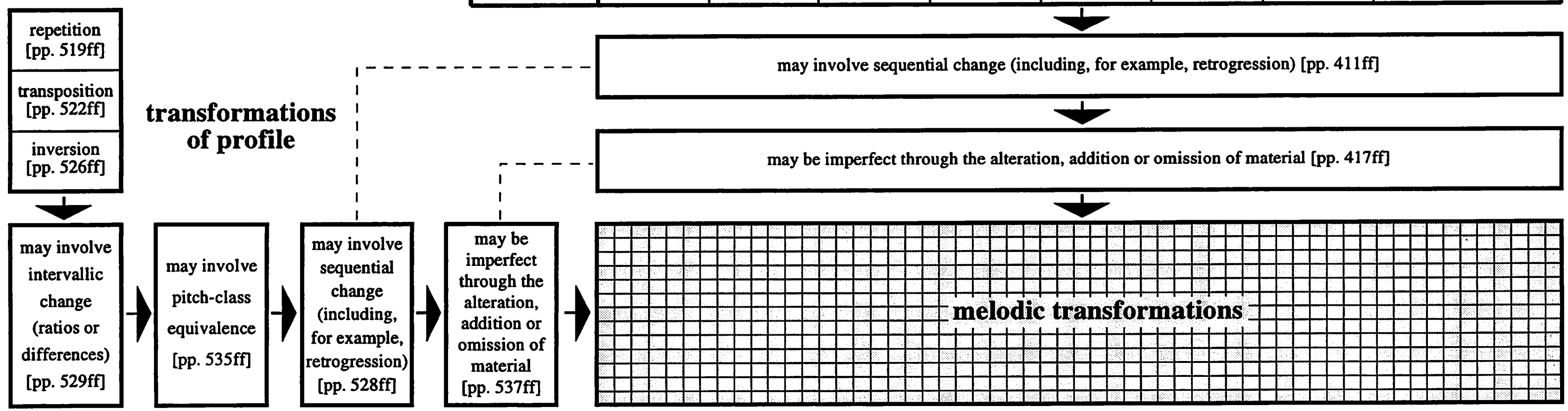


Figure 11.15 Outline taxonomy of melodic transformations.

cross-perspective interaction is inevitable. That is not to say, of course, that the perception of values in one domain is not affected by those in another: an association of pitches will sound quite different according to the nature of its perceived temporal disposition. There is a perspective 'cross-over' effect, whereby the greater rhythmic prominence of certain notes is transferred to the realm of pitch, and *vice versa.* Other perspects, such as harmony, figure crucially in the equation too.

Since the potential for interfigurative transformation is so vast, figure 11.15 of necessity presents a simplified version of affairs. For example, only the more familiar types of rhythmic variation are itemised, and in their simplest manifestations. Optional qualifications such as sequential change, and the alteration, addition or omission of material are listed separately. Profile is treated in a similar fashion: the three basic forms of relationship (repetition, transposition and inversion) are fundamental to the classification, which acknowledges the possibility of pitch-class equivalence, intervallic and sequential modification and—again—the alteration, addition or omission of material as potential adjuncts. Previous accounts of interfigurative development have been more limited in one way or another.

Consider, for example, Schoenberg's comments on motivic treatment and utilisation (1967, pp. 8–15). Although a few different melodic fragments and some of their possible transformations are quoted, the greater part of the chapter is taken up with the potential variants of a single motive based on a broken chord. Whilst the 105 examples cited are grouped according to type, no light is thrown on how the ordering in each case actually works, nor explanation offered of how the principles exemplified could be generalised to other configurations. Moreover, even accepting the unspoken constraint that the examples are couched in the Western musical vernacular of the 18th and 19th centuries, there are surprising omissions. For example, although minor chords do find a place in some of the different harmonic contexts in which the motive is illustrated, the possibility of a change of mode (that is, to *b♭* minor) is not considered.

In contrast, the classification presented by Coker (1972, pp. 83ff) is almost entirely concerned with the formulation of general principles, but is short on musical examples.[3] And despite the apparent intellectual rigour with which the taxonomy is conceived (for example, 'exclusion'—the equivalent of 'the omission of material'—is subdivided into six further

[3]A comparable 'nonexhaustive' list is provided by Moles (1958/1966, p. 154)

categories such as 'ellipsis' and 'synopsis', while 'inclusion' is split into seven, including 'interpolation' and 'corrective interjection'), again, there are omissions. For instance, the simple alteration of material, or its movement to a different location in the perspective domain (that is, transposition), are ignored.

Another means of classifying transformations is through the use of a continuum of configurative variation, beginning, at one extreme, with perfect repetition, and from there extending over an ever greater degree of mutation. Serafine (1983, p. 176), for example, adopts such an approach, identifying three stages along the path of interfigurative change: 'relative repetition' (ranging from identity to transposition, and changes in mode, tempo, accompaniment or dynamics); 'ornamentation' (implying the alteration of a musical event through the addition, overlay or superimposition of other events); and 'substantive transformation' (involving, for instance, the preservation of contour alone). This may be compared with Reti's fourfold arrangement (1951, p. 240):

1. *imitation*, that is, literal repetition of shapes, either directly or by inversion, reversion, and so forth;

2. *varying*, that is, changing of shapes in a slight, well traceable manner;

3. *transformation*, that is, creating essentially new shapes, though preserving the original substance;

4. *indirect affinity*, that is, producing an affinity between independent shapes through contributory features.

Other writers venture further along the continuum of change, and acknowledge the possibility of contrast. This is true, for example, of LaRue (1970, pp. 80–82), who divides the spectrum between similarity and difference into 'recurrence', 'development' (embracing all changes that derive clearly from the preceding material), 'response' (including continuations that give the antecedent-consequent effect), and 'contrast' (complete change).

The fact that these taxonomies differ so widely inevitably throws their validity into question, although it could be argued that since the transformation of configurations is such a complex affair, various models may be equally sound according to the analytical stance that is adopted in each case. A problem common to all, however, is the somewhat arbitary nature of the proposed divisions. In Serafine's model, for example, would the addition of material combined with a change of mode be classed as 'ornamentation' or 'substantive transformation'? And with Reti's categorisation, would it always be possible to say when 'varying' becomes 'transformation'? Then, with LaRue's version of affairs, is there a necessary difference between 'development' and 'response'? Perhaps the most basic distinction that should be drawn is that between variation and non-variation, a topic discussed in previous chapters (see pp. 430ff and p. 547). Lerdahl and Jackendoff (1983, pp. 52 and 53) provide further comment:

> When two passages are identical they certainly count as parallel, but how different can they be before they are judged as no longer parallel? ... It appears that a set of preference rules for parallelism must be developed, the most highly reinforced case of which is identity. But we are not prepared to go beyond this, and we feel that our failure to flesh out the notion of parallelism is a serious gap in our attempt to formulate a fully explicit theory of musical understanding.

Hopefully, the present work at least sheds more light on the issue.

Another factor to consider in comparing the classifications is from whose perspective they were drawn up, that of the composer or the listener. The problems such confusion can cause have already been aired,[4] and they become apparent in the current context when considering, for example, the question of retrogression. Reti, who describes the process as a literal repetition of shape, holds reversion to be a close form of imitation, whereas for Serafine, playing material backwards amounts to substantive transformation. From the composer's standpoint, Reti's position makes good sense, since retrogression demands, in logical terms, a minimal degree of change. However, as far as listeners are concerned, reversing material may well take it to the boundaries of what is recognisable and beyond. This is where Serafine's thesis—derived from the perspective of music psychology—comes in.

Other music psychologists too have considered the manner in which configurative transformations are perceived. A number of these are guided by the Piaget's principle of conservation, which:

[4]See pp. 393 and 394; also Cook (1987, pp. 220 and 221) for a discussion of how analysts may or may not be justified in considering issues of which most listeners are in practice unaware.

> refers to the ability to perceive or realize that something remains constant (is conserved) in spite of changes in other things .... This has been applied to music concepts in different ways, e.g., conservation of rhythm with change in tonal pattern and vice versa, conservation of meter with changes in rhythm (duration values), conservation of melody with changes in instrument, pitch level, harmony etc. (Gabrielsson, 1981, p. 53).

These ideas are bound up with the notion of cognitive development, which is of interest here, since implicit in the theory that has been proposed is the fact that its underlying mental processes must at some stage and through some means be learnt. Pflederer (1967), for example, proposes that children gradually acquire the capacity to recognise melodic features that are invariant. A review of this research is to be found in Hargreaves (1986, pp. 43ff). To the extent that the hypotheses formulated in the present work are well-founded, it is reasonable to assume that a developmental psychology could be written to outline their cognitive evolution.

Melodic repetition, absolute and relative, perfect and imperfect

Even with the simplified nature of the table in figure 11.15, it would still be impracticable within the current confines to illustrate all the interfigurative interconnections it sets out. The examples of transformations that follow, therefore, represent only a small sample of what is possible. Experience suggests that the vast majority of interfigurative ordering occurs through zygons of repetition, whether absolute or relative (and therefore embracing transposition and changes of speed), and perfect or imperfect (of rhythm or profile or both). It is to transformations of this type that this section is devoted.

Most straightforward of all is the absolute perfect repetition of both rhythm and profile. This form of ordering is virtually universal, and occurs with configurations of all orders, from motives to entire sections. See, for instance, figures 11.16 and 11.17. Similarly, the imperfect repetition of profile may be combined with the perfect repetition of rhythm—figure 11.18. Conversely, the perfect repetition of profile may be associated with the imperfect repetition of rhythm; see figure 11.19.

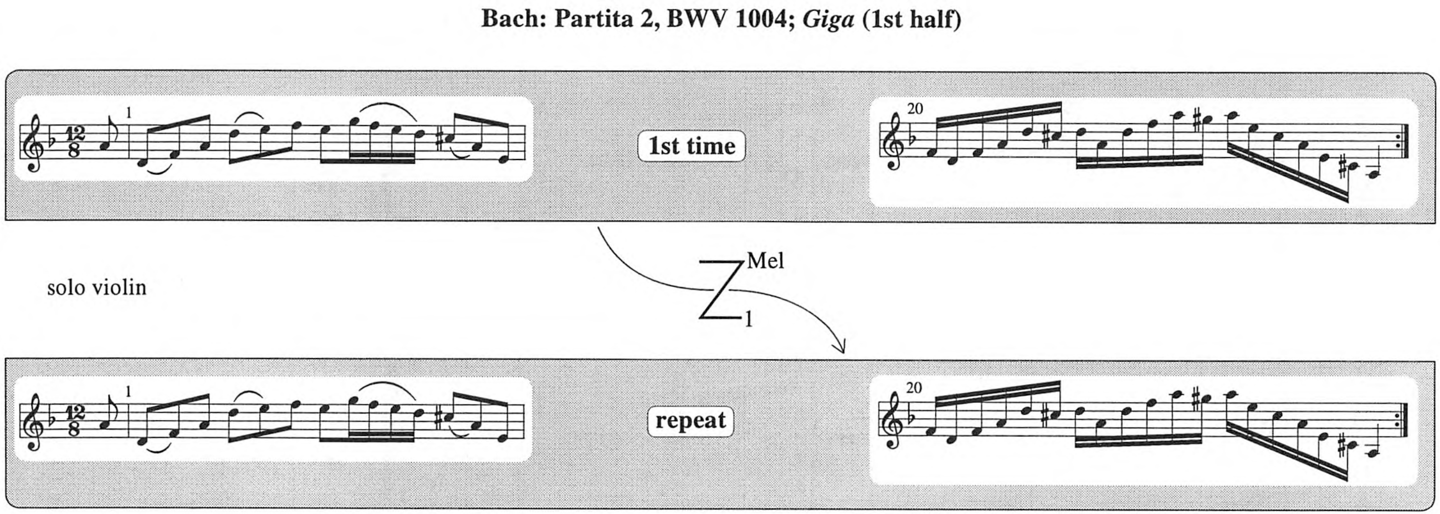


Figure 11.17 Melodic zygon linking a section and its repeat.

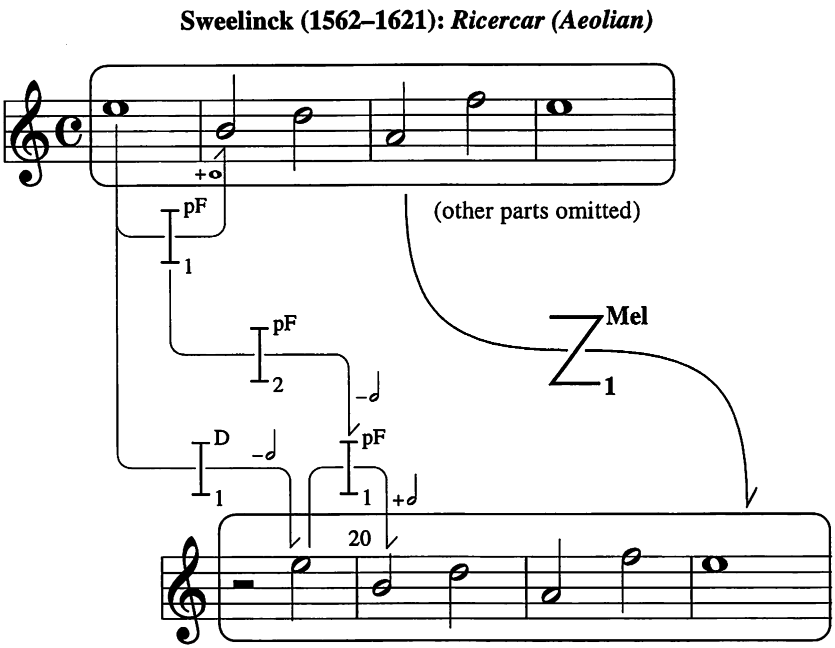


Figure 11.18 Melodic repetition, imperfect as to rhythm.

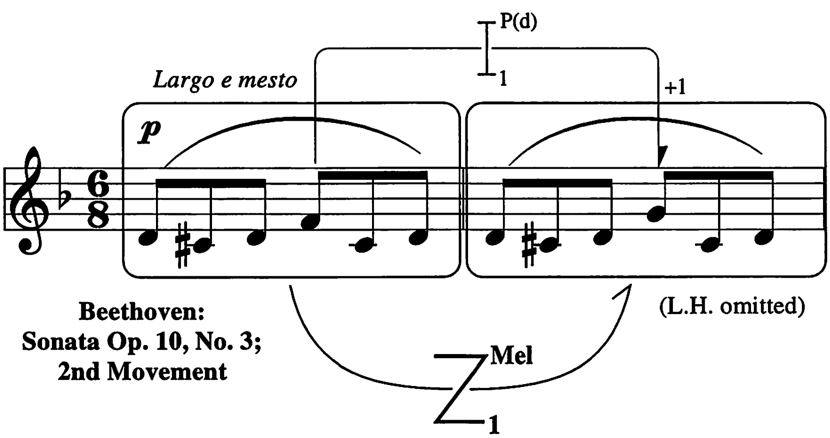
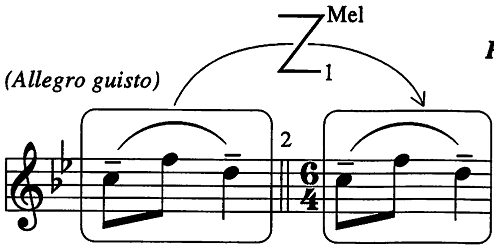


Figure 11.19 Melodic repetition, imperfect as to profile.



Mussorgsky:
***Pictures at an Exhibition* (1874);**
Promenade

Figure 11.16 Zygon linking repeated melodic motive.

The imperfect repetition of profile may appear in conjunction with the imperfect repetition of rhythm. The modifications in each domain may be discrete or they may be linked. See, for instance, figure 11.20 (parts i and ii).

The addition or ornamentation of material, as in figure 11.20, is one of the commonest forms of variation, transcending stylistic boundaries. See, for example, Apel, 1969, p. 892; Strangways, 1914, pp. 181ff; and Zonis, 1973, pp. 107ff. Rather less common is its omission of material:

Malipiero:
***Ritrovari* (1926)**

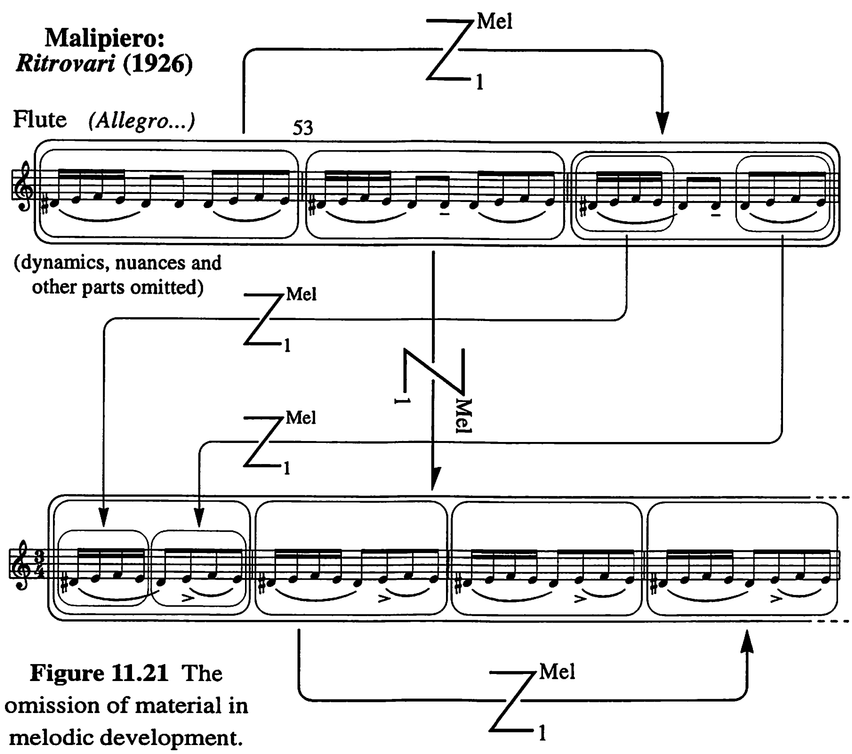


Figure 11.21 The omission of material in melodic development.

Mozart: Sonata, K. 309; 2nd Movement

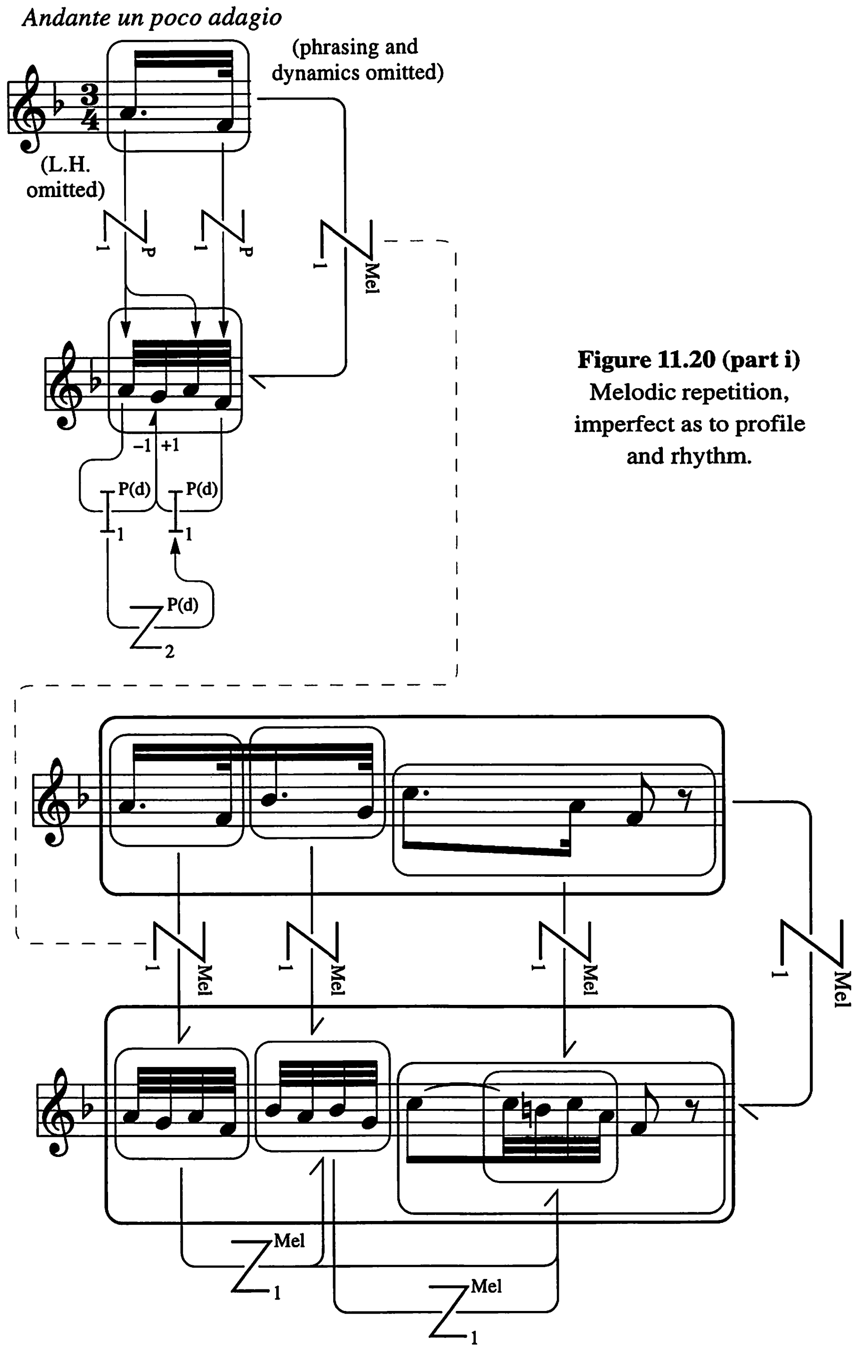


Figure 11.20 (part i)
Melodic repetition, imperfect as to profile and rhythm.

Mozart: Sonata, K. 309; 2nd Movement

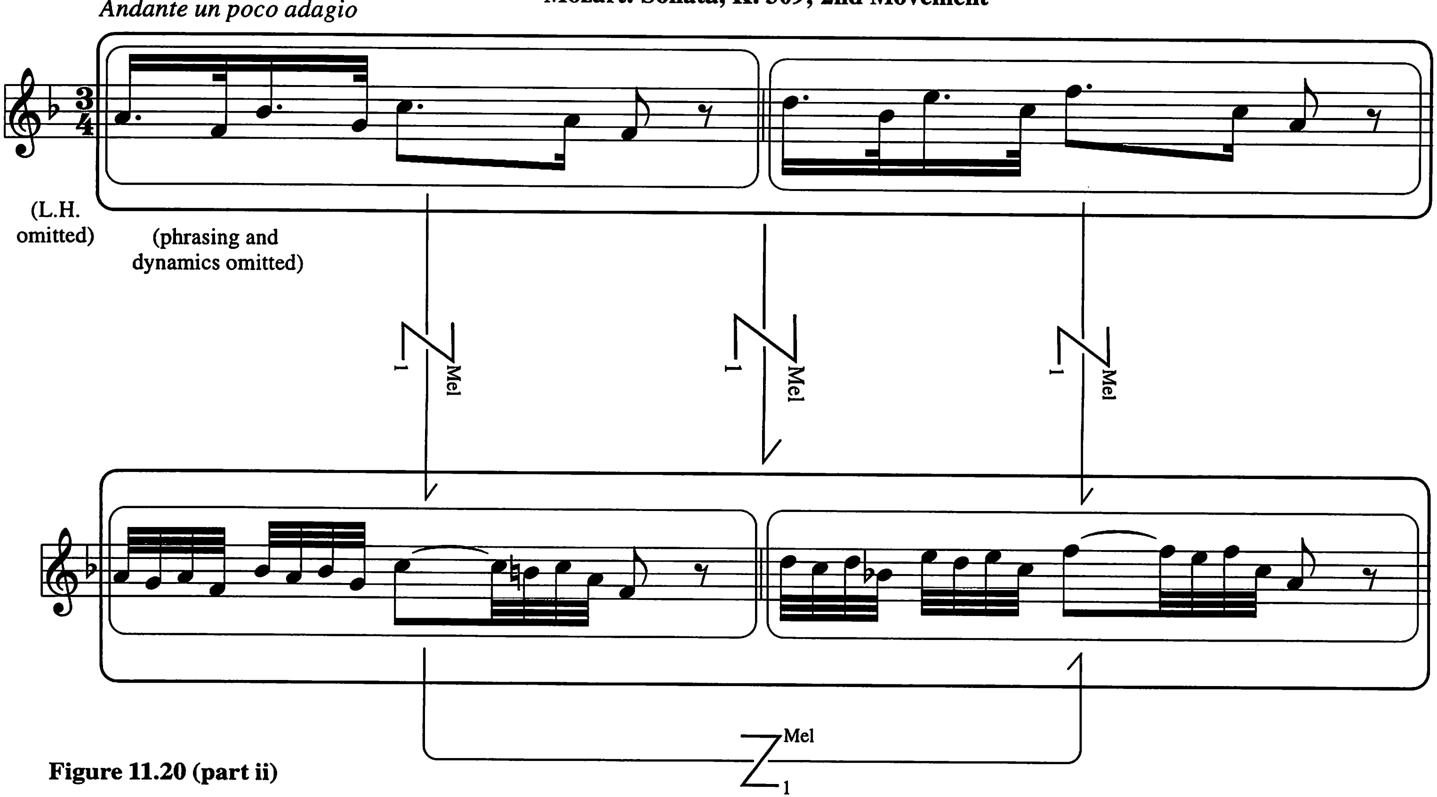


Figure 11.20 (part ii)

See also Nettl (1956, pp. 200 and 201), who describes the use of 'condensation' in European folk music; Schoenberg (1967, p. 58), who formulates the concept of 'liquidation'—the gradual elimination of characteristic features; and Reti (1951, pp. 85ff) and Rosen (1980, pp. 185ff), who discuss motivic fragmentation in Beethoven.

The combination of profile transposition with rhythmic repetition has been a stylistic universal from the earliest times (see, for example, Schneider, 1957, p. 15). Either feature, or both, may be perfect or imperfect:

Grainger and Johnson: *Fat and Greasy* (1936)

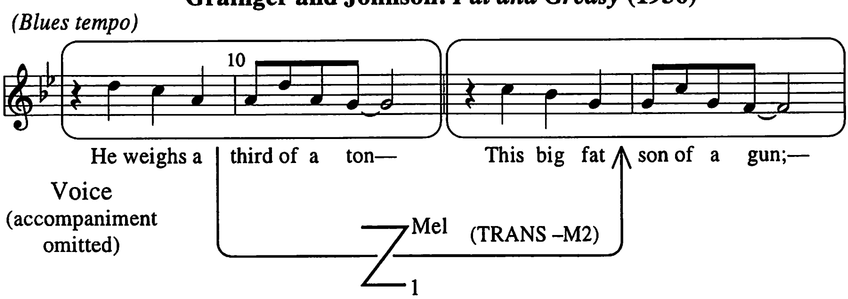


Figure 11.22 (part i) Melodic transposition: perfect in both domains.

Anon: Chippewa Owl Medicine Song

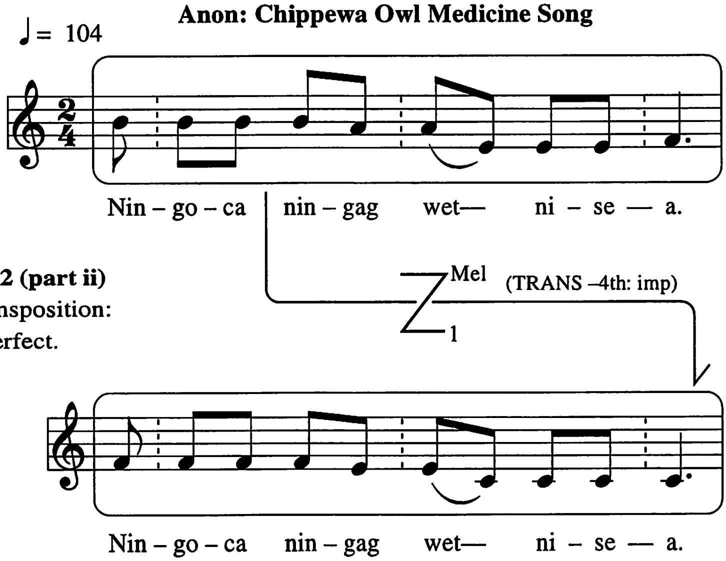


Figure 11.22 (part ii) Melodic transposition: profile imperfect.

Helm: Symphony (1958); 1st Movement

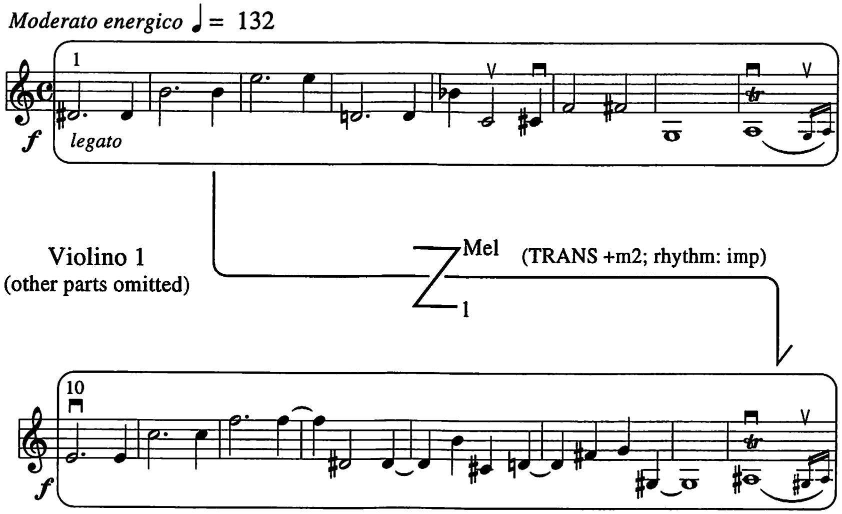


Figure 11.22 (part iii) Melodic transposition: rhythm imperfect.

Mozart: *Fantasie*, K. 475

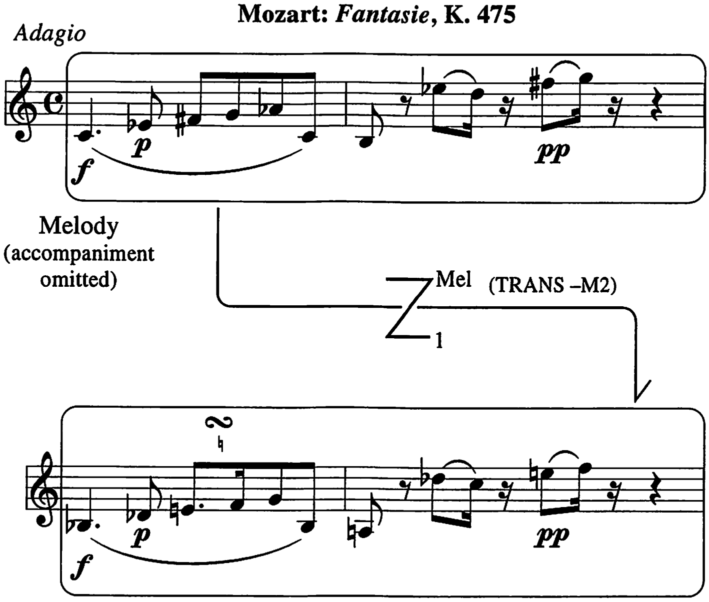


Figure 11.22 (part iv) Melodic transposition: imperfect in both domains.

Changes of tempo may be compositionally planned, and may be combined with repetition or transposition. Either rhythm or profile or both may be perfectly or imperfectly ordered. For instance:

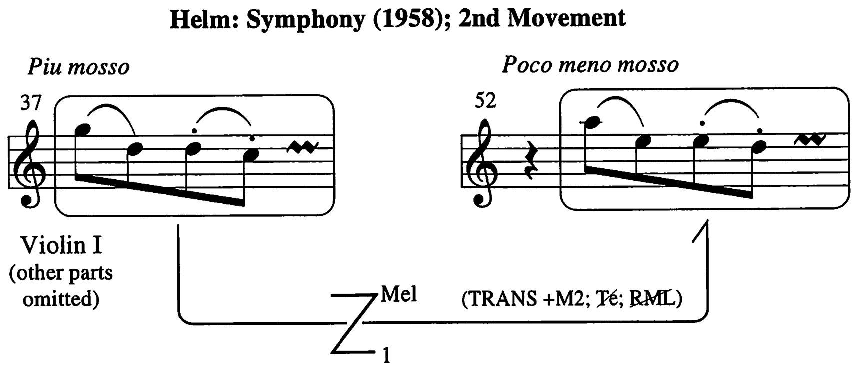


Figure 11.23 Transposition allied to a change of tempo.

Melodic inversion, retrogression, augmentation and diminution; compound relationships of melody

The combination of profile inversion and rhythmic repetition appears particularly at the motivic level, although more substantial examples are to be found too. See, for example, figure 11.24; also Walker, 1962, pp. 55ff; Apel, 1969, p. 423.

Profile may be maintained (whether as repetition or transposition) or inverted against the augmentation or diminution of rhythm (see Apel, op. cit., p. 63; cf. Yeston, 1976, p. 53)—figure 11.25.

Retrogression—of both rhythm and profile—is a further possibility. See, for instance, figure 11.26; also Reese, 1940, pp. 336 and 351; Keller, 1958; Walker, op. cit., pp. 50ff; Apel, op. cit., p. 728; Rosen, 1971, p. 94. Retrograde inversion of profile may occur with retrogression of rhythm, as in Hindemith's *Ludus Tonalis* (1942), where such a relationship links the *Postludium* with the *Praeludium*.

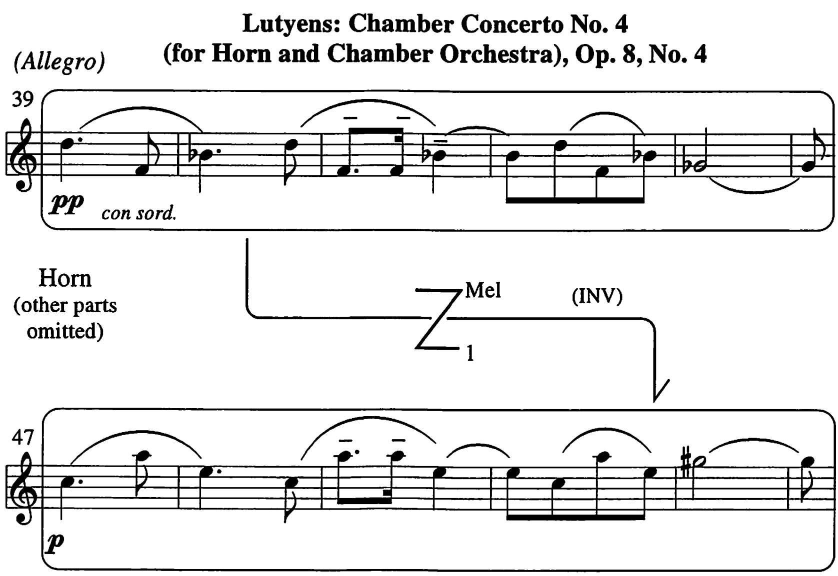


Figure 11.24 Melodic inversion.

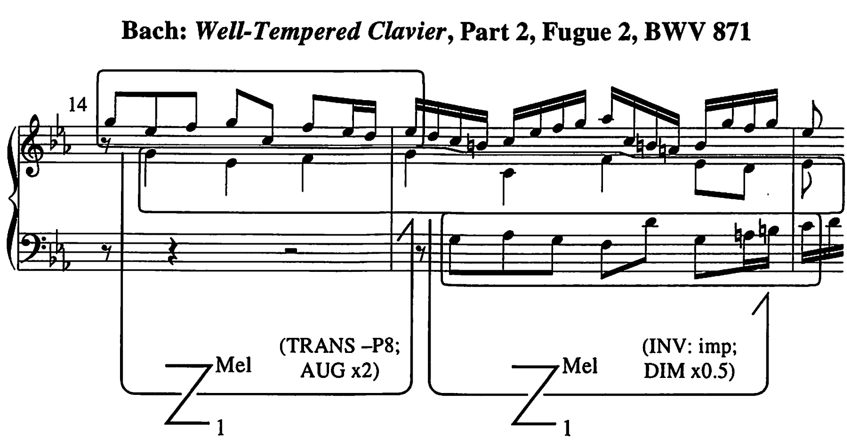


Figure 11.25 Augmentation and diminution combined with transposition and inversion (cf. figure 9.108).

Beethoven: Sonata, Op. 106; 3rd Movement

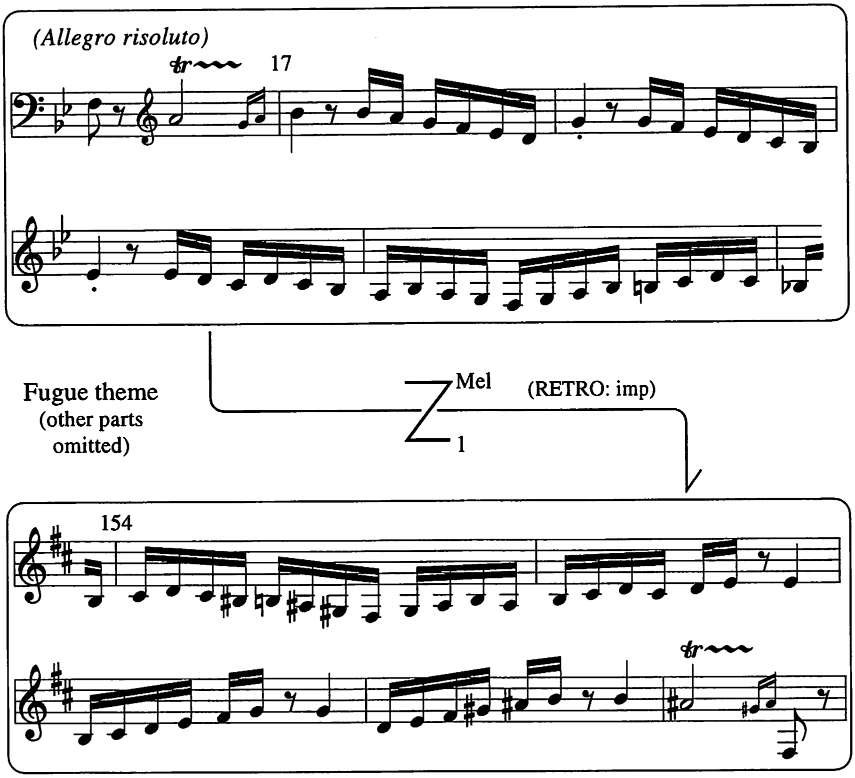


Figure 11.26 Retrogression of rhythm and profile.

Bartók: Improvisations on Hungarian Peasant Songs; No. 1

Molto moderato

L.H.
(R.H. omitted)

(phrasing
omitted)

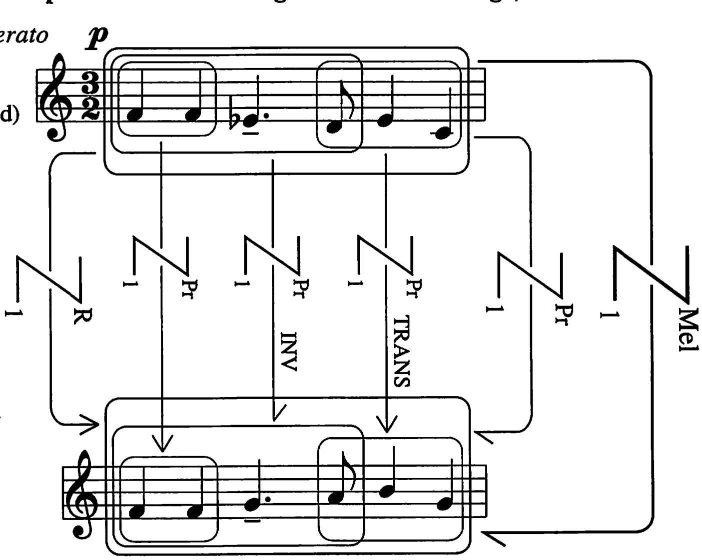


Figure 11.27 Compound melodic ordering.

Transformations may be juxtaposed or combined in any way to form compound relationships of melody. Commonly, this may involve differing degrees of transposition operating within a common rhythmic framework, although inversion may be involved too. See, for example, figure 11.27 (cf. figure 10.84).

The independent ordering of profile and rhythm

In the interfigurative relationships illustrated above, rhythm and profile are ordered, note by note, at the same time. This need not, however, be the case. For example, the two could be ordered separately, but kept within the same perceived temporal space. This occurs, for instance, when either rhythm or profile is retrogressed alone. See figure 11.28. Also conceivable is the retrograde inversion of profile set against sequence-maintaining transformations of rhythm, a technique used extensively in Webern's *Concerto,* Op. 24, for example.

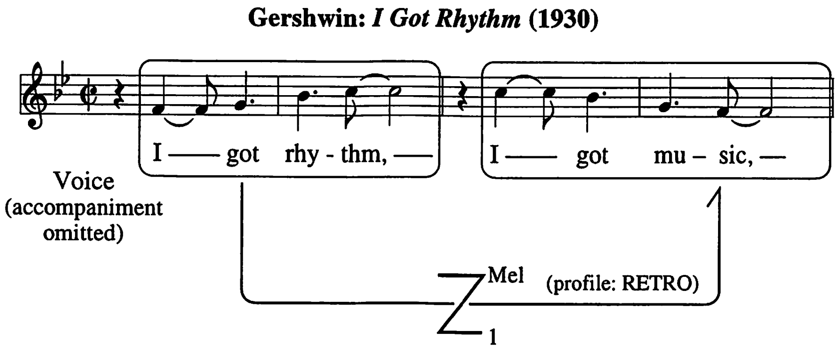


Figure 11.28 Retrogression of profile; maintenance of rhythm (cf. figure 10.66).

Alternatively, transformations may occur in which profile and rhythm are split in perceived time. The result may be associative imbrication. See, for example, figure 11.29. A further possibility is for rhythm to be ordered quite separately from profile. This is a form of what Serafine (1983, pp. 173 and 174) terms 'abstraction', that is:

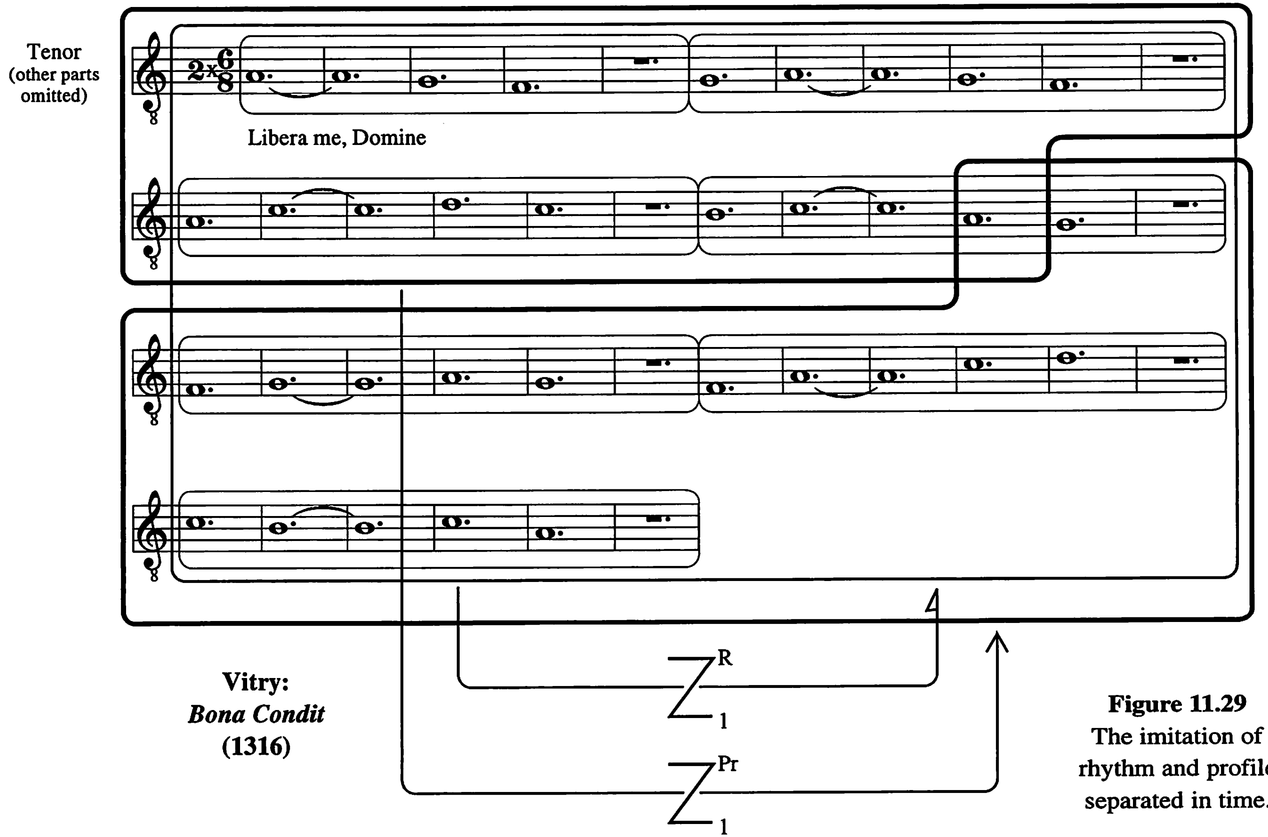


Figure 11.29
The imitation of rhythm and profile separated in time.

> the process by which some aspect of a musical event is removed or considered apart from its original context and is relocated elsewhere in the composition.

Rhythmic abstraction is well-established in music-psychological terms (see, for example, White, 1960; Pflederer, 1966) and occurs in many styles of music, from the most ancient (Sachs, 1953, p. 47; Schneider, 1957, p. 23) to the most modern (cf. Rufer, 1952/1954, p. 117). For instance:

Beethoven: Symphony No. 5, Op. 67; 3rd Movement

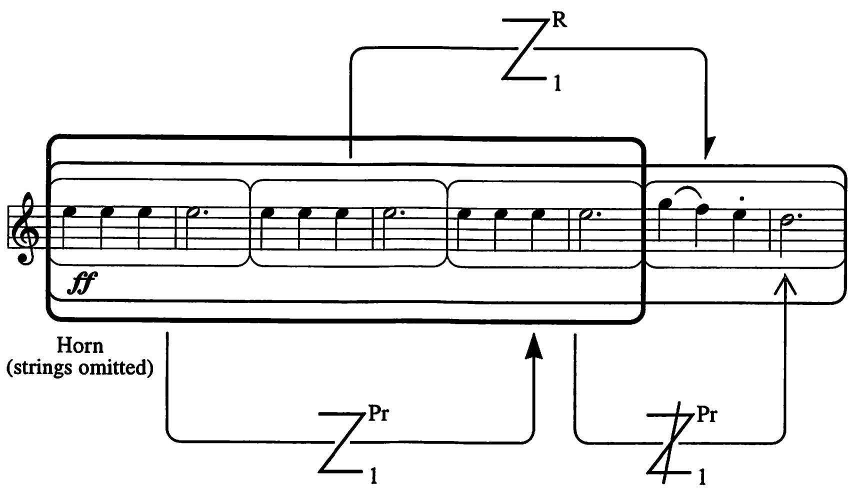


Figure 11.30 Rhythmic 'abstraction' (cf. Epstein, 1979, p. 75).

Although, according to White (ibid.), listeners are generally successful at identifying melodies on pitch information alone, the maintenance of profile in the absence of rhythm is noticeably less common than the isorhythmic techniques described above. According to Nettl (1956, p. 197), for example, the process is only rarely encountered in folk and primitive music. However, notable examples are to be found in music ranging from Berlioz's *Symphonie Fantastique* (1831) to Schoenberg's serial works (see figures 10.62 and 10.73; cf. Eschman, 1945/1968, pp. 116ff; Reti, 1951, pp. 75ff). See, for instance, figure 11.31.

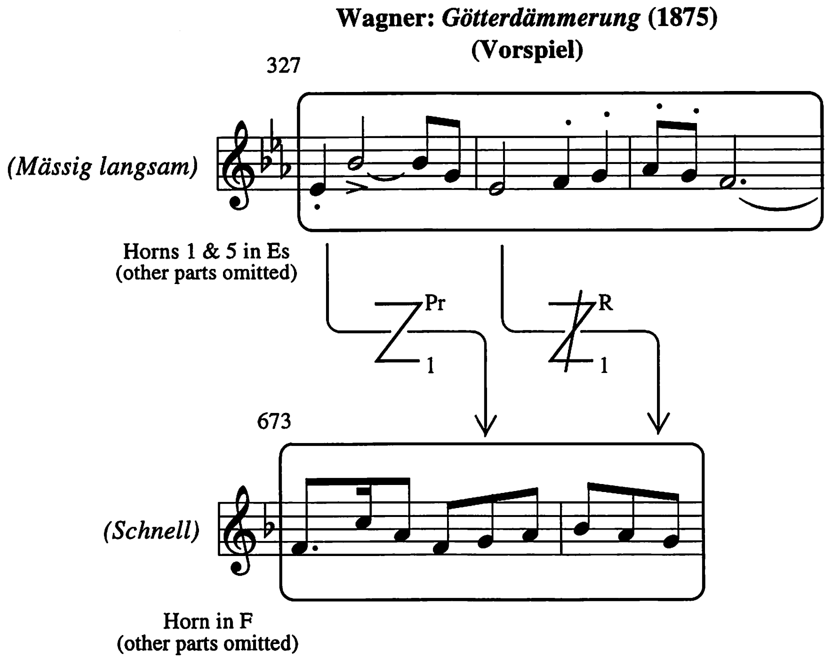


Figure 11.31 Abstraction of profile.

Harmonic rhythmic pattern—concept and organisation; configurations combining melody and harmony; syzygies and synapses

In the same way that profile and rhythm together constitute melody, so harmony and rhythm combine to form what may be termed **harmonic rhythmic pattern** or **HRP**. Theoretically, any association of harmonies may be linked with any rhythm, given the appropriate number of members in each (cf. pp. 622ff). Ordering may occur intrafiguratively through combinations of the forms of organisation outlined on pp. 398ff and pp. 577ff. A range of orderly interfigurative relationships is available too. See, for instance, figure 11.32.

Closely akin to the concept of HRP is the notion of **harmonic rhythm** (see, for example, Apel, 1969, pp. 369 and 370)—that is, the perceived temporal pattern of harmonic change. Here, contiguously repeated harmonies

McTell: *Streets of London* (1968)

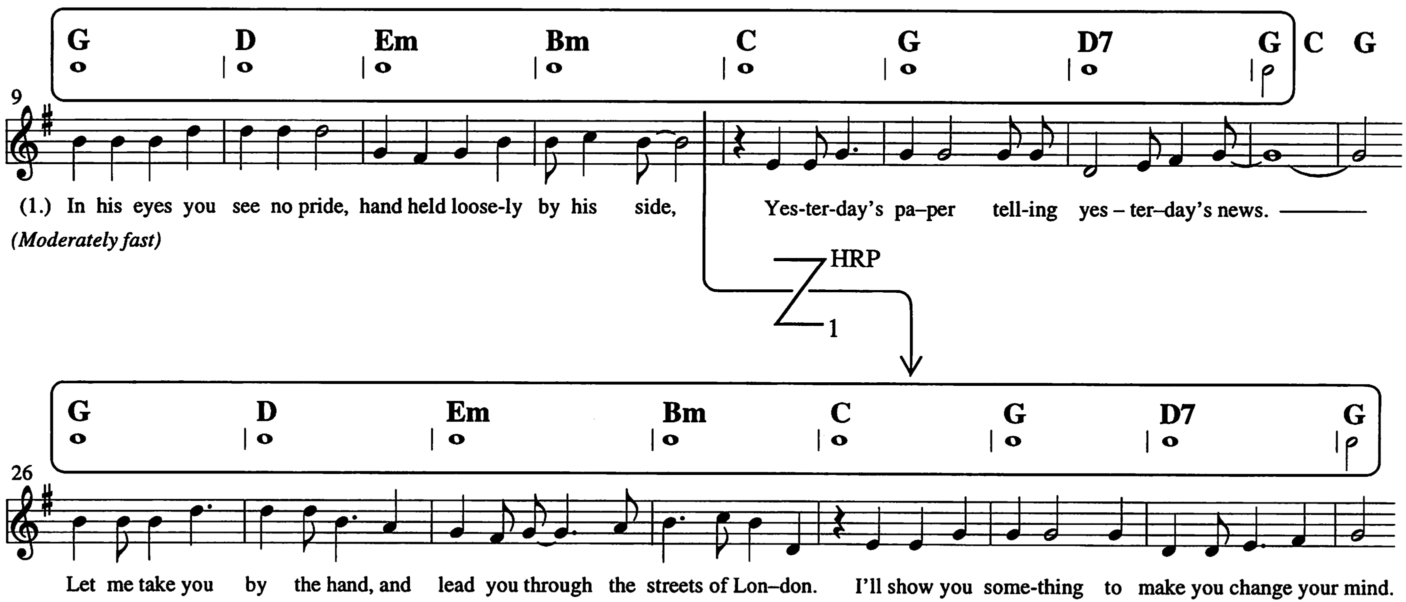


Figure 11.32 Zygonic relationship of 'harmonic rhythmic pattern' (HRP).

Mendelssohn: *Lied ohne Worte*, Op. 30, No. 3

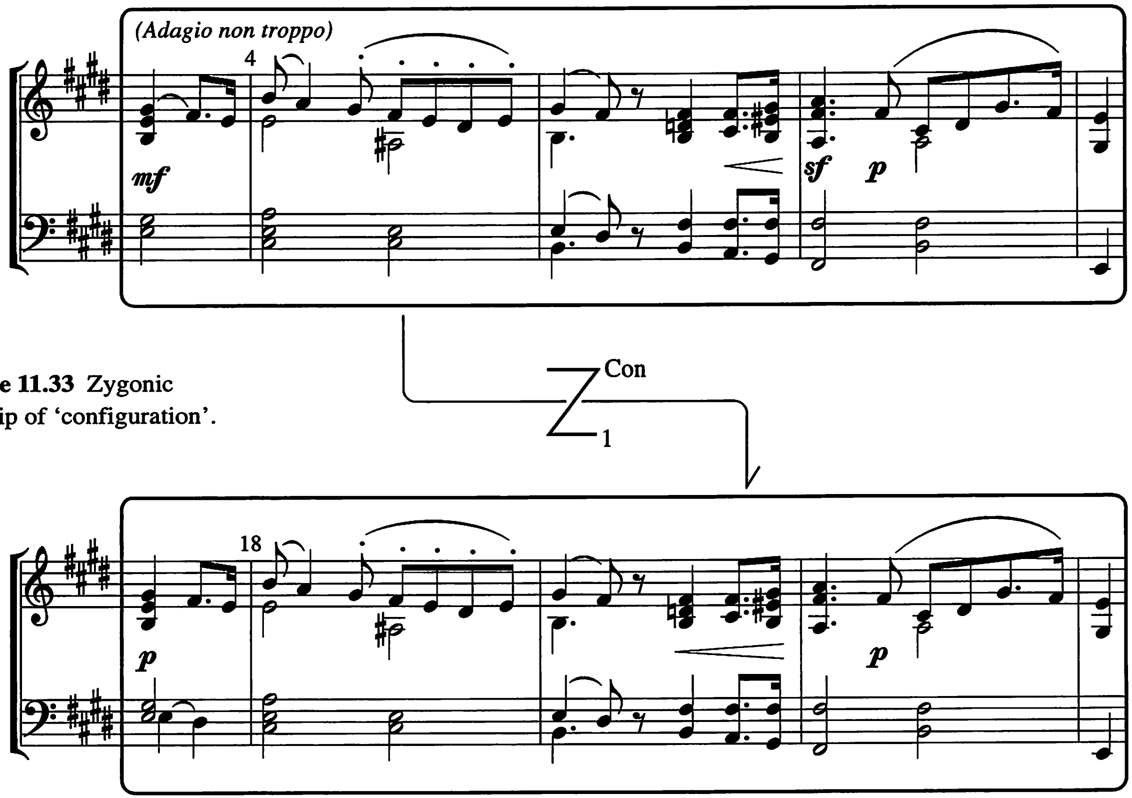


Figure 11.33 Zygonic relationship of 'configuration'.

are considered to be part of the same single duration. From an organisational point of view, harmonic rhythms may be treated as types of HRP.

It is often a fair reflection of musical perception—and is therefore analytically appropriate—to think of combinations of melody and harmony as single configurations. By extension, the relationships linking such passages can also be modelled as single cognitive entities, between the perspect 'configuration'. See, for instance, figure 11.33.

Relationships between configurations, whatever their texture—whether melodic, harmonic, or any combination of these—are of such fundamental musical importance they are recognised in the current theory as forming a distinct type of interperspective connection termed a **syzygy**.[5,6] This term is taken from the Greek 'syzygia' meaning 'coupling', derived from 'syn' (which means 'with') plus 'zygon'. It may be illustrated using a 'z' contained within an 'S'—see figures 11.34 and 11.35.

Similarly, a relationship between configurations whose zygonic status is undetermined may be termed a **synapse**,[7] from the Greek 'synapsis', meaning 'contact' or 'junction', illustrated using 'S' and 'I'.[8]

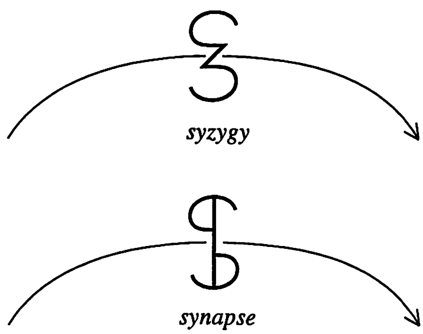


Figure 11.34 Symbolism of syzygy and synapse.

[5]The term 'syzygy' has already been used in a musical context by the composer Iliff as the title of a piece for oboe and piano (1968).

[6]Adjectival form: 'syzygial'.

[7]Adjectival form: 'synaptic'.

[8]It is worth noting that of the relationships described in this work, synapses and syzygies come closest to Meyer's notion of 'conformant relationships' (1973, pp. 44ff): "those in which one (more or less) identifiable, discrete musical event is related to another such event by similarity", since the 'events' Meyer refers to are configurations. Observe that implication is not a necessary feature of conformant relationships, however (cf. Ockelford, 1991, pp. 87 and 88).

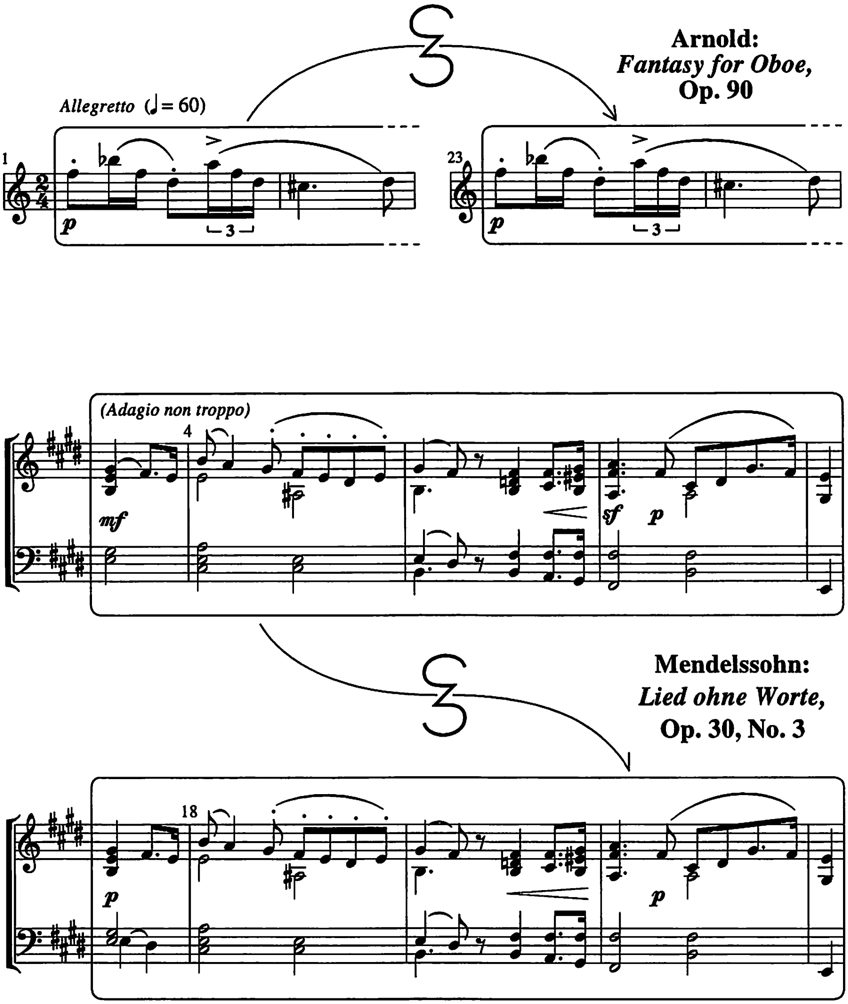


Figure 11.35 Examples of syzygies.

The perceived temporal possibilities of relationships between configurations—process and form

The interfigurative relationships described above may be of any perceived temporal disposition, linking configurations that are simultaneous, imbricated, contiguous or isolated.

The simultaneous repetition and transposition of configurations are both commonplace, underpinning techniques of composition and improvisation that extend far back into musical history (see, for example, Sachs, 1943, pp. 48 and 49; Meyer, 1956, pp. 234ff; Schneider, 1957, pp. 20 and 21; Apel, 1969, p. 383; Nettl, 1965/1973, pp. 149 and 150; Malm, 1977, p. 90). See, for example, figures 11.36 and 11.37. (Cf. also, for instance, figures 9.32, 9.121, 9.130, 9.131, 10.118 and 10.122.) Simultaneous inversion is encountered in a number of musical contexts too. For example, melody and bass lines are frequently linked in this way for short periods in pieces in the 'Classical' style:

Mozart: Sonata K. 283, 2nd Movement

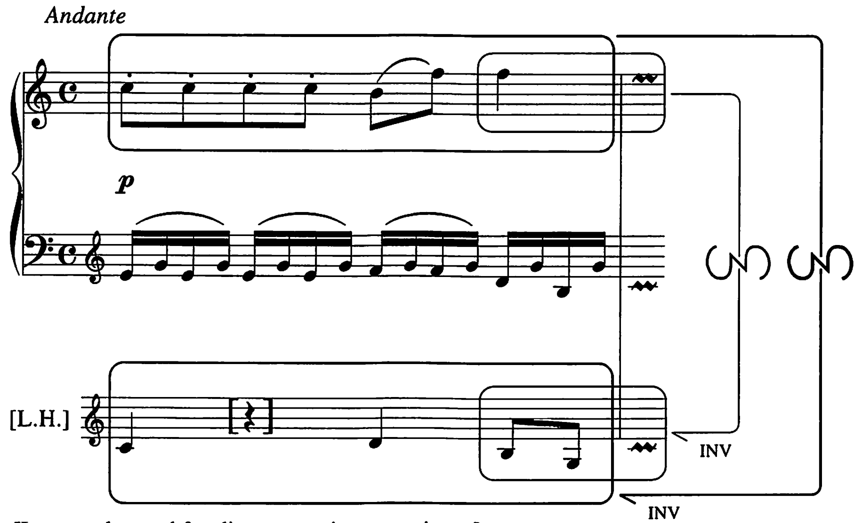


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Figure 11.38 Simultaneous inversion.

(See also figures 9.62 and 10.114, for example.)

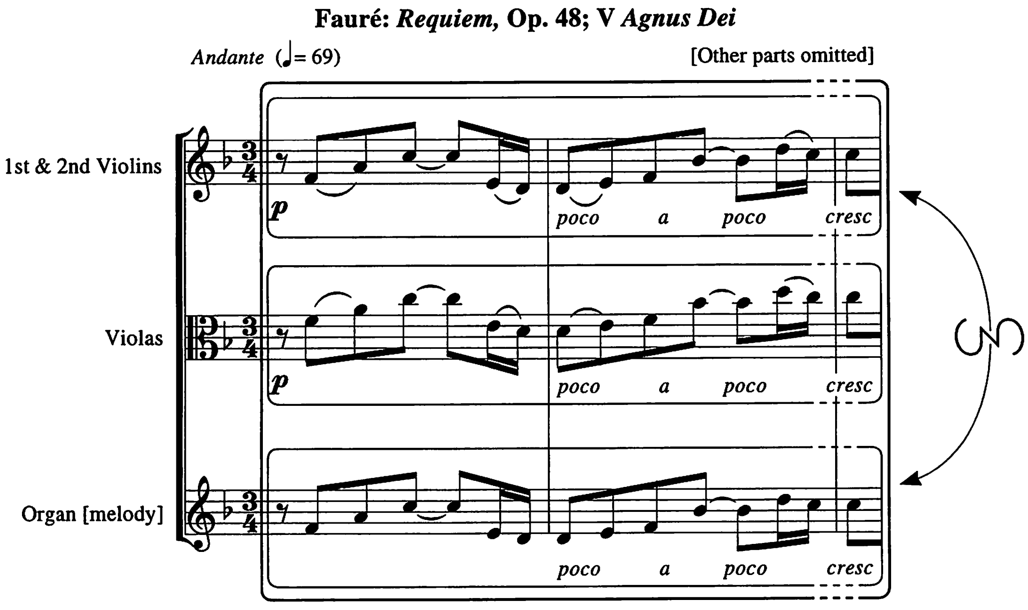

Figure 11.36 The simultaneous repetition of configurations.

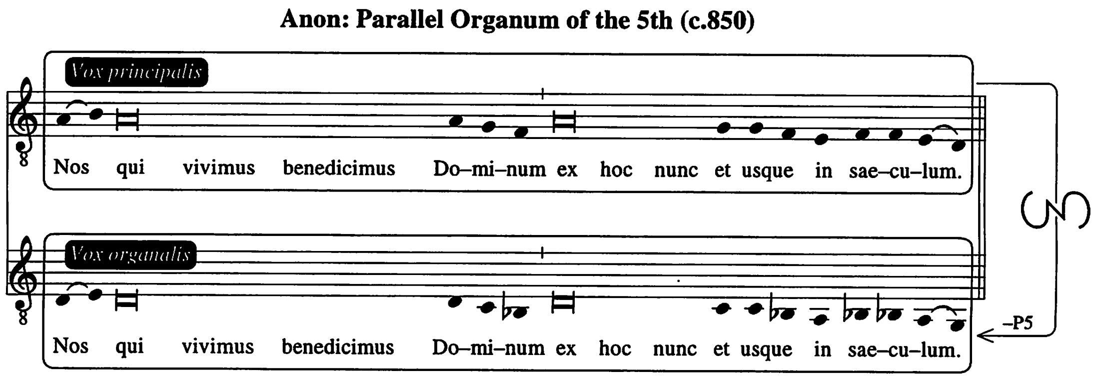

Figure 11.37 The simultaneous transposition of configurations.

Frequently, a rhythm is common to two or more parts in a texture, which are embedded within the same harmonic framework. This implies ordering along the following lines:

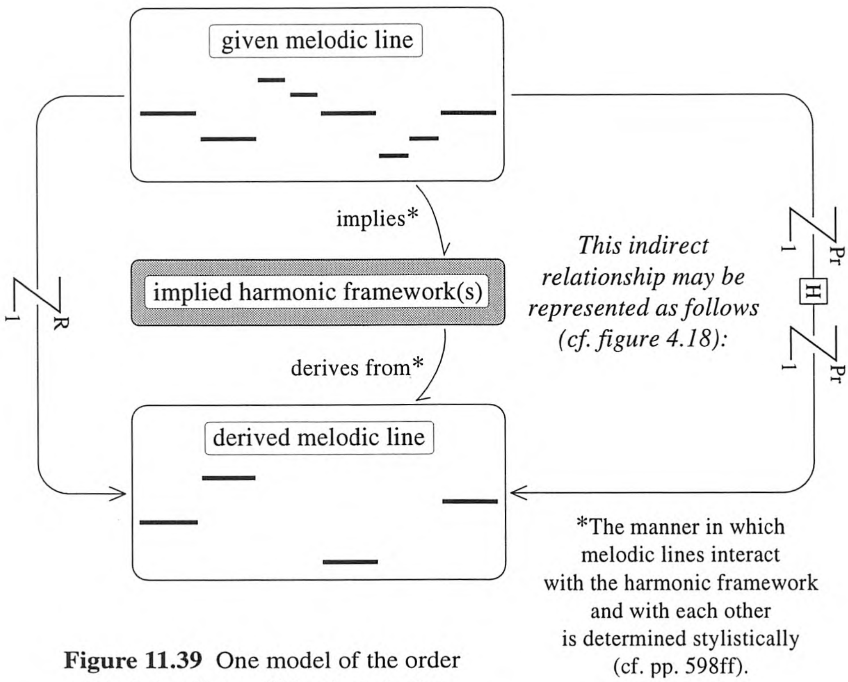

Figure 11.39 One model of the order underlying lines of identical rhythm embedded within the same harmonic framework.

See, for example, figure 11.40. Here it is assumed that the three lower parts derive from the top line. Rhythmic repetition is exact. In many passages, however, rhythm is repeated only imperfectly. See, for instance, figure 11.41.

A still looser form of connection may pertain in which simultaneous configurations share the same harmonic and metrical frameworks. This is illustrated in figure 11.42. The indirect derivation of rhythm (R) from a common metrical framework (M) is shown using a compound sign comparable to that indicating the relationship between profile and harmony. Observe that the polarity of these relationships is undetermined (cf. p. 309).

Finally, note that simultaneous rhythmic repetition may occur with no ordering of profile (figure 11.43). Similarly, in the absence of the organisation of profile, different rhythms may exist within the same metrical framework.

Anon: *Franconia* (1738)
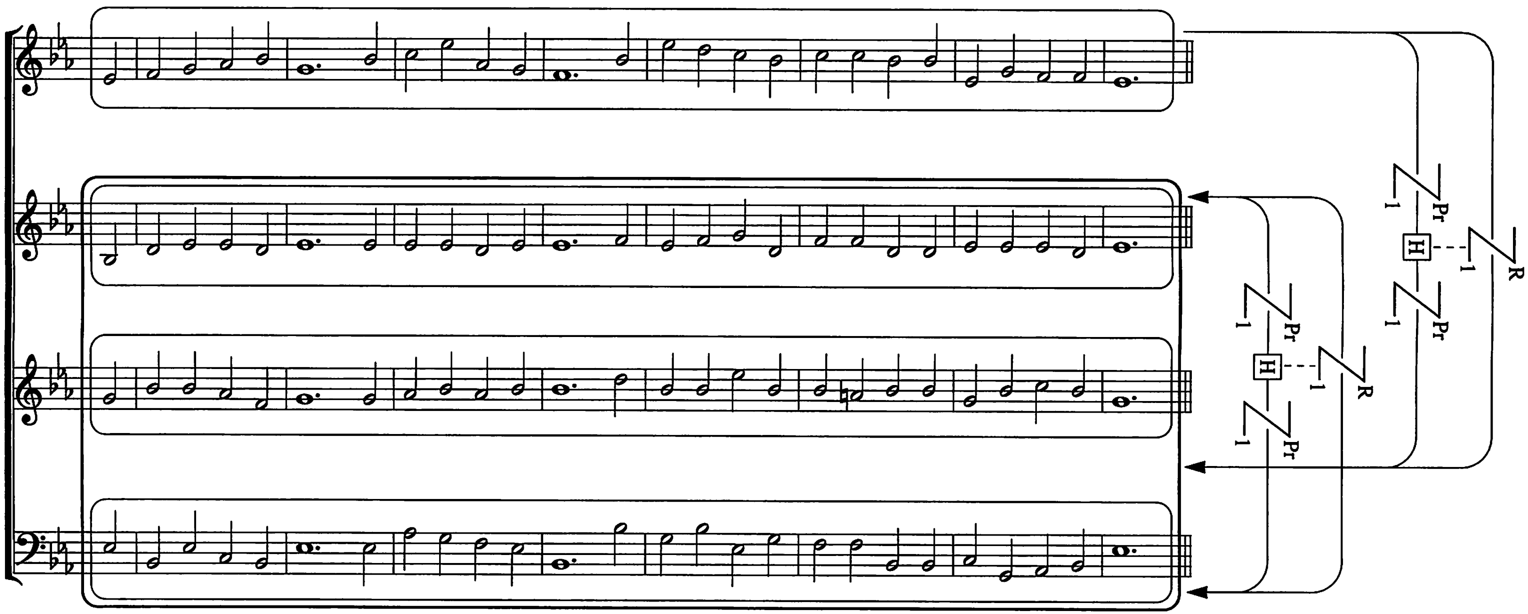
Figure 11.40 Simultaneous interfigurative ordering operating in a homorhythmic structure.

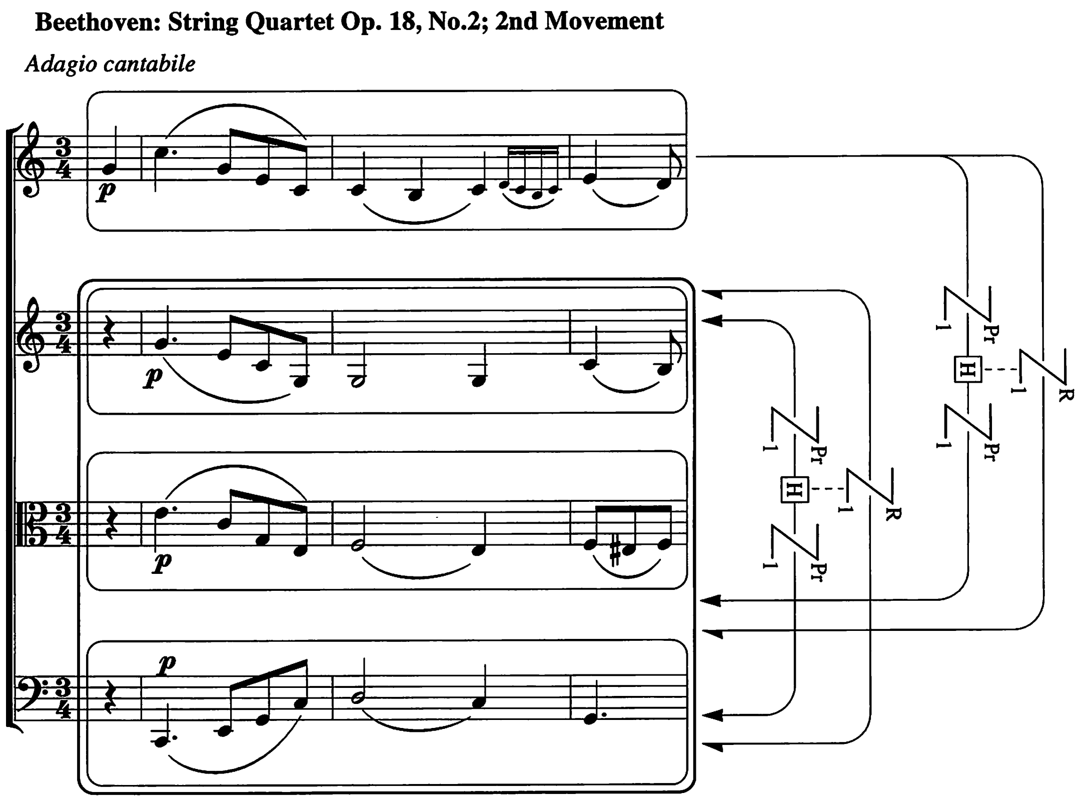

Figure 11.41 The order underlying an imperfect homorhythmic texture created within a single harmonic framework.

Beethoven: Sonata Op. 31, No. 3; 1st Movement

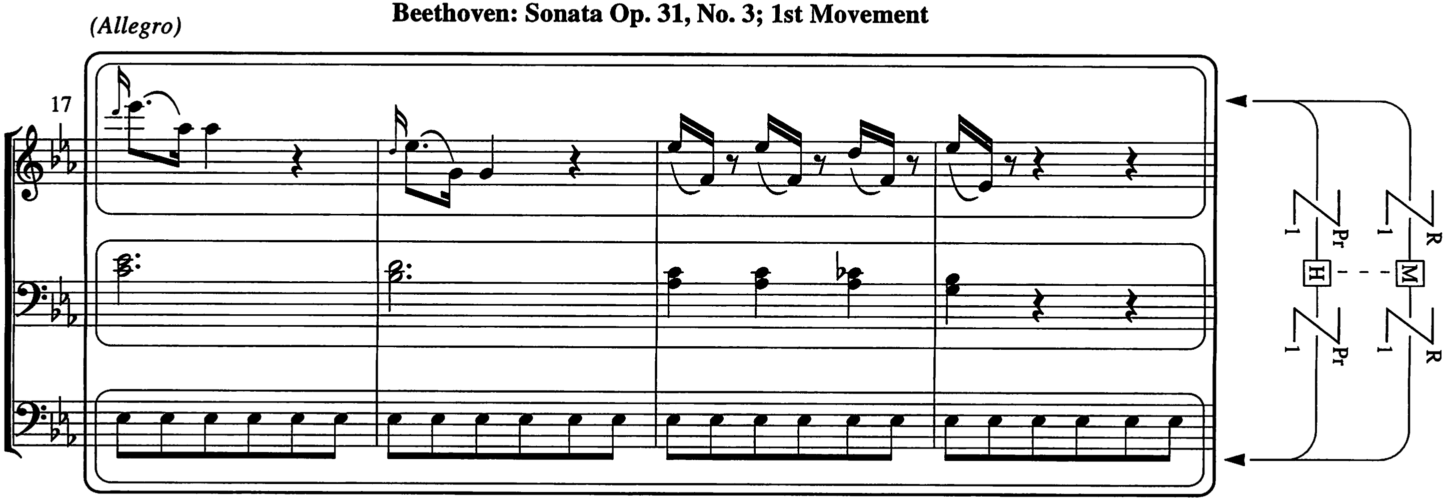

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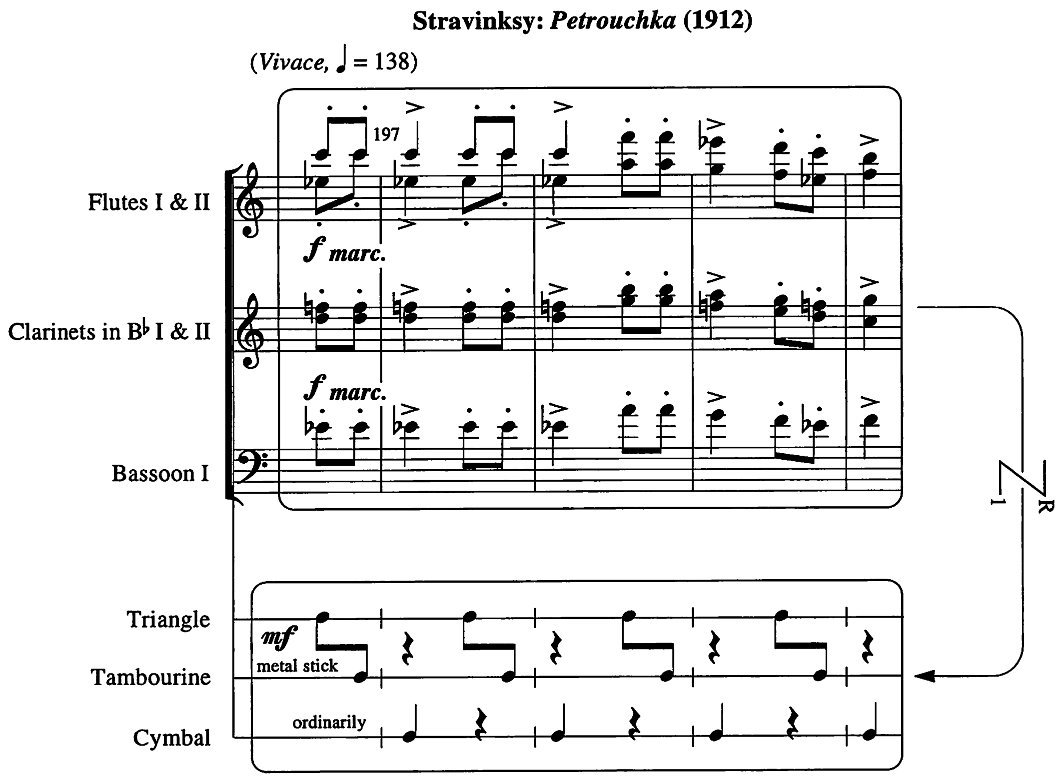
Figure 11.42 Configurations conceived within the same harmonic and metrical frameworks.

Figure 11.43 Simultaneous rhythmic repetition alone.



The number of parts in a texture may well vary, implying fluctuating conditions of configurative simultaneity. Each episode of configurative co-existence is typically characterised by the ordering engendered through shared harmonic and metric frameworks which is described above. *Direct* interfigurative links (involving, for example, repetition, transposition and inversion) of other perceived temporal dispositions may be superimposed upon this background.

For instance, with transformations that involve augmentation or diminution, configurative prefixture, suffixal and enclosure are conceivable. All three forms are combined in the following passage:

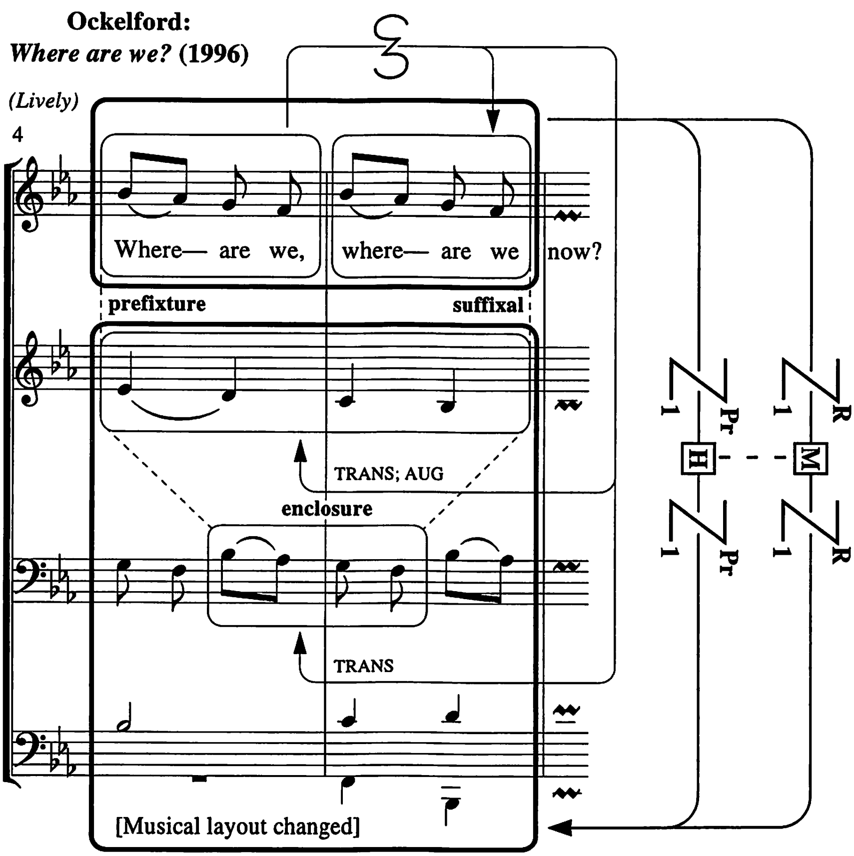


Figure 11.44 Configurative prefixture, suffixal and enclosure within a common harmonic and metrical framework (cf. figure 10.144).

See also, for example, Beethoven, piano sonata op. 110, 3rd movement, bar 160 (prefixture); Mozart, K. 309, 3rd movement, bars 199ff (suffixal); and Bach, fugue in *E*, BWV 878, bars 36 and 37 (enclosure).

Configurative imbrication may involve any transformation. Repetition and transposition feature in many styles, underlying a wide range of musical effects, including the 'canon' as defined in Western music theory (see, for example, Reese, 1940, pp. 303 and 304; Apel, 1969, pp. 124ff, 402 and 403; Nettl, 1965/1973, pp. 150 and 151; Crocker, 1966/1986, pp. 116, 117 and 130).

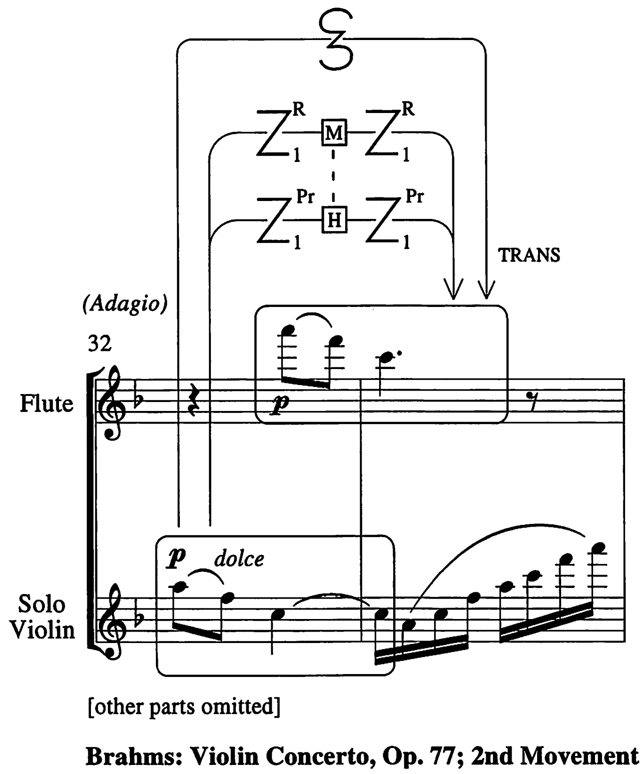


Figure 11.46 Imbricated transposition of configurations.

Anon: *Sumer is icumen in* (c.1310)

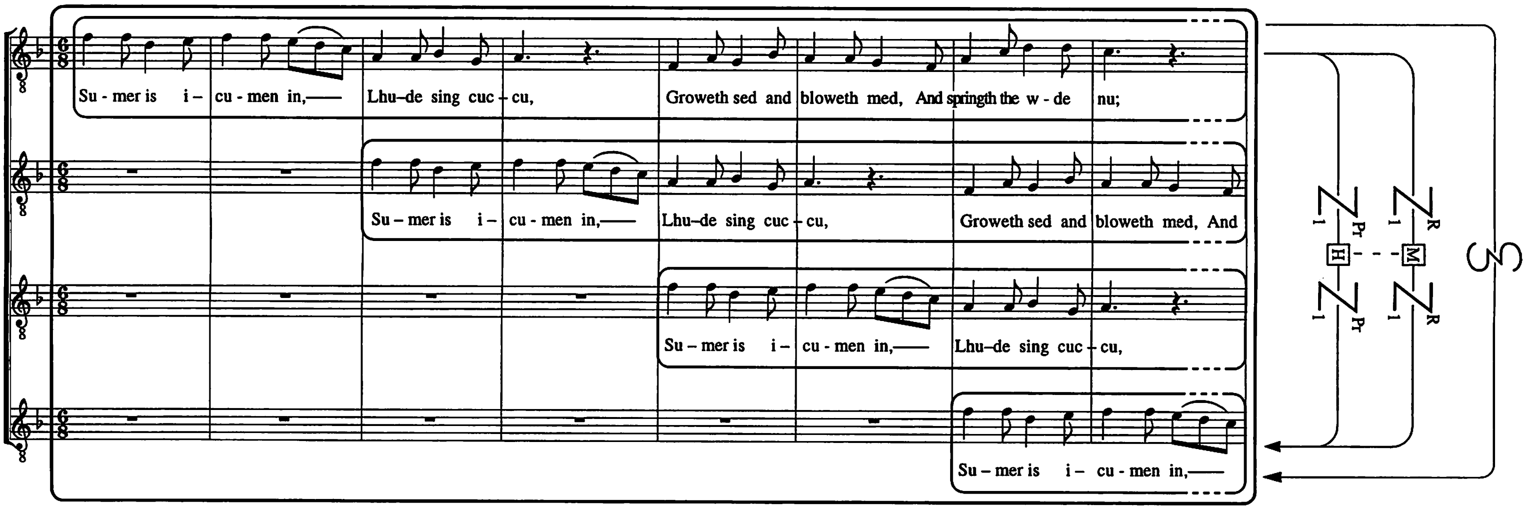
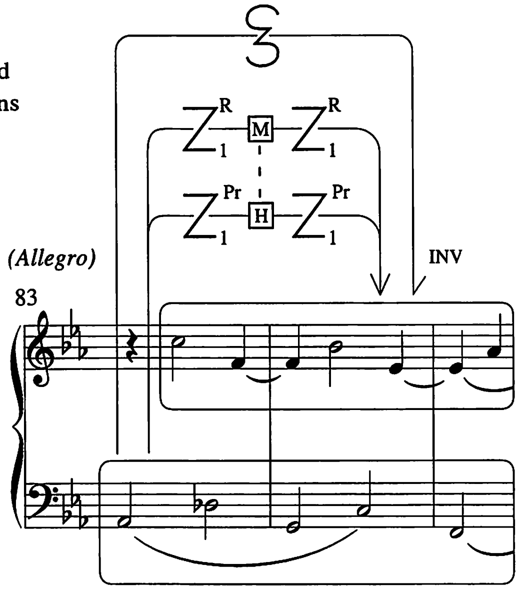


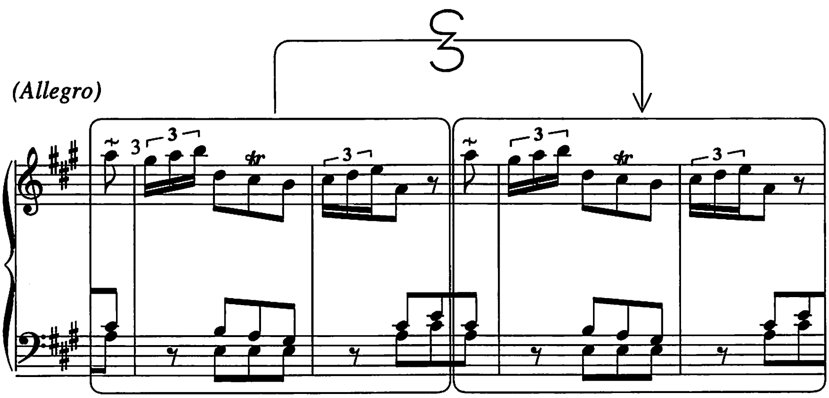
Figure 11.45 Imbricated repetition of configurations.

Figure 11.47 Imbricated inversion of configurations (cf. figure 11.25).

Beethoven: Piano Sonata, Op. 13; 3rd Movement



Contiguous configurations are likely to be linked in an orderly way in the domains of pitch and perceived time. The connection between them may involve the configurations in their entirety or any part of them (cf. p. 548), the following examples show (see also figures 10.59, 10.63, 10.65, 10.66, 10.87 and 10.88).



Haydn: Sonata in *A*, Hob. XVI: 5; 1st Movement

Figure 11.48 Contiguous repetition of configurations.

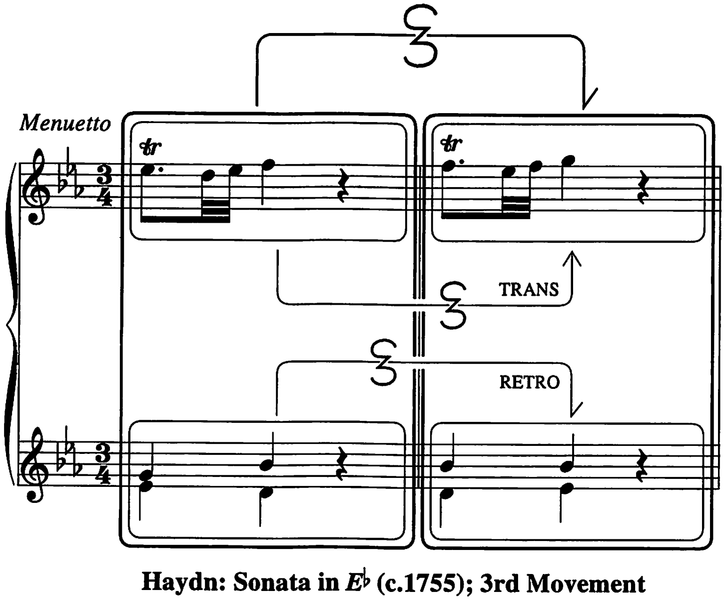


Figure 11.49 Imperfect syzygy linking contiguous configurations.

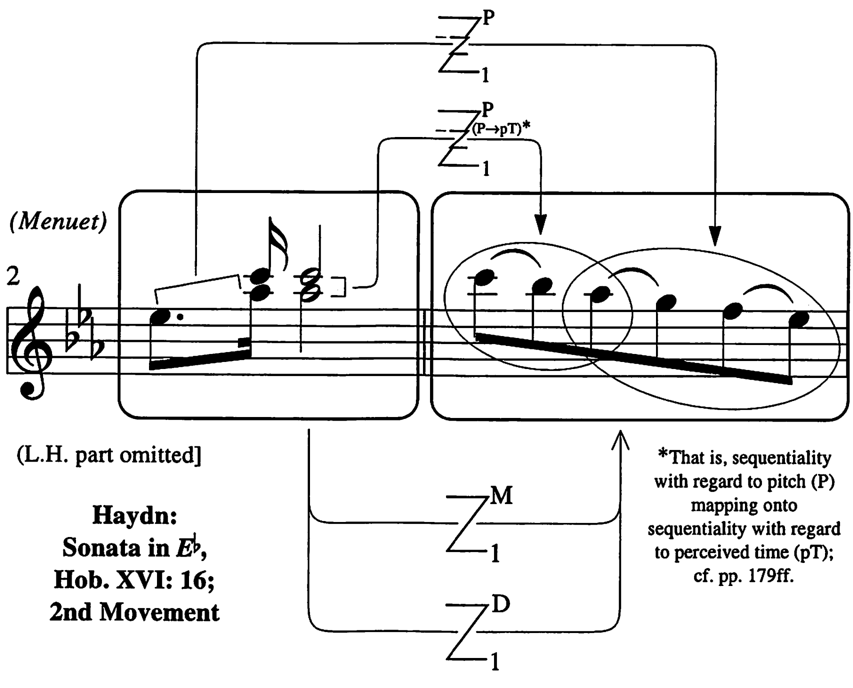


Figure 11.50 Contiguous configurative connection involving the discrete ordering of pitch and perceived time (cf. figure 10.78).

The same principles underlie relationships between isolated configurations—an orderly link implies the presence of repetition of one form or another—although for the relationship to have particular perceptual significance may well require an isomorphic link (see p. 401). For instance:

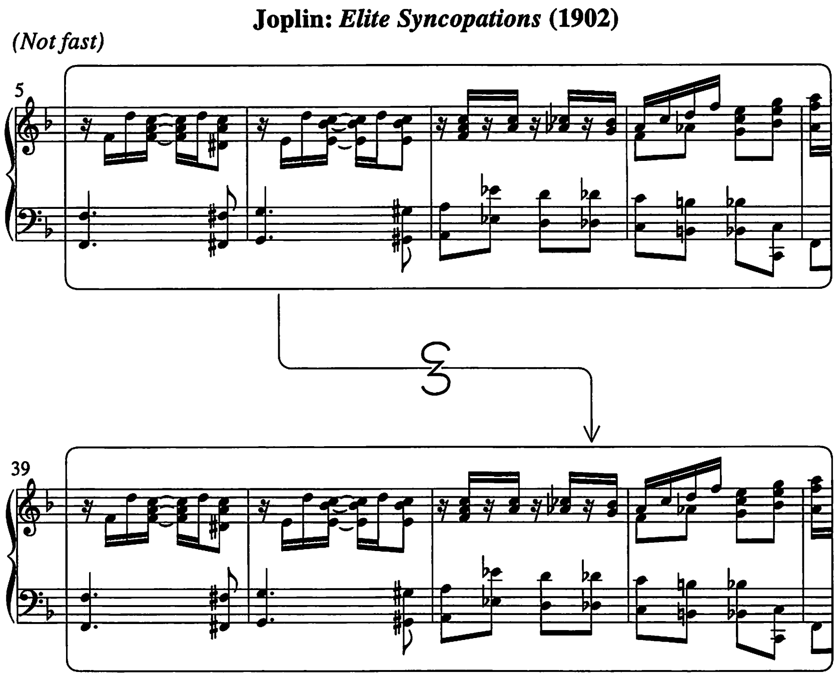


Figure 11.51 Isolated configurative repetition.

(See also figures 9.94, 9.98, 9.101, 9.105, 10.56, 10.57, 10.61, 10.71, 10.75, 10.85, 11.13, 11.22 (part iii), 11.23, 11.24, 11.26 and 11.52, for example.)

These examples and those that precede present a simplified version of affairs in the interests of the clearer explication of the ordering principles they depict; in reality, even the simplest interfigurative connection typically comprises numerous zygonic relationships of different types acting in a coordinated fashion. This is illustrated in the following analysis of the first 6 bars of the 3rd movement of Mozart's sonata K. 533 (see figure 11.53).

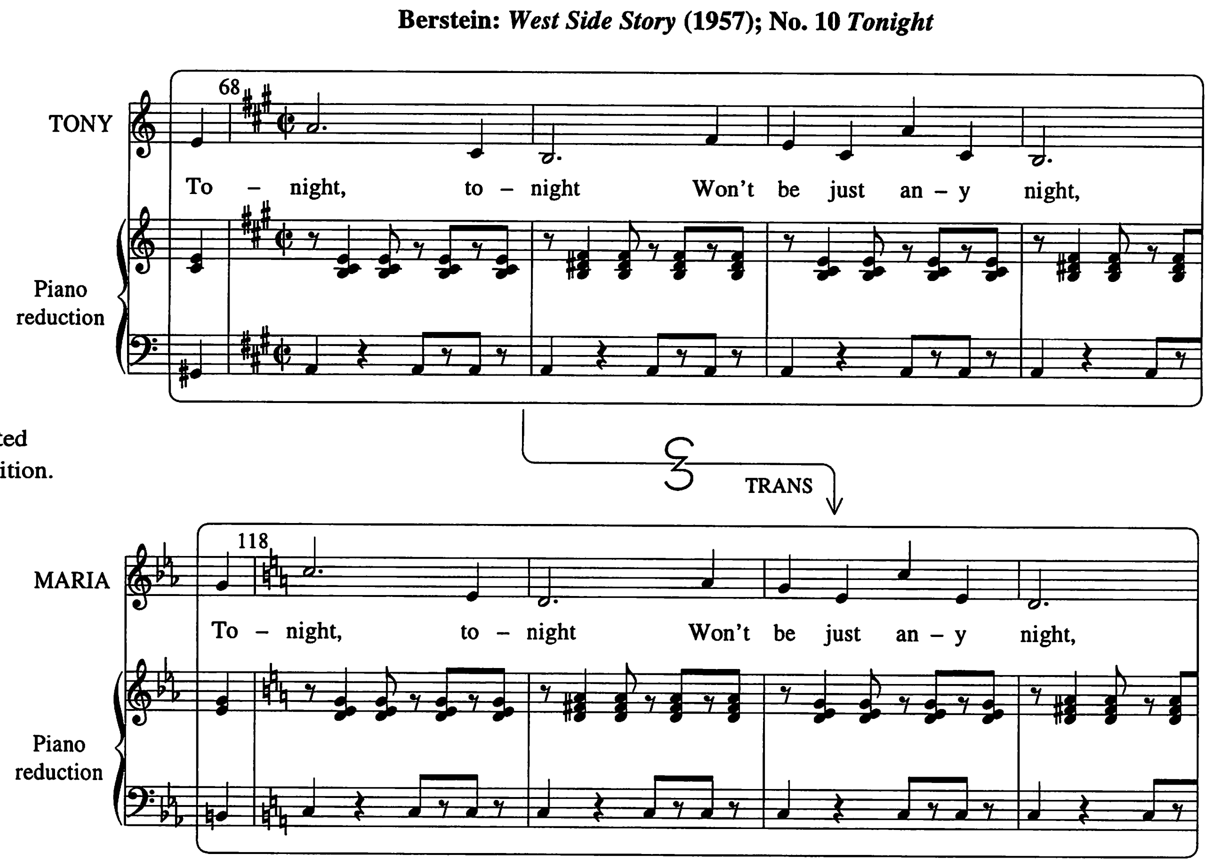


Figure 11.52 Isolated configurative transposition.

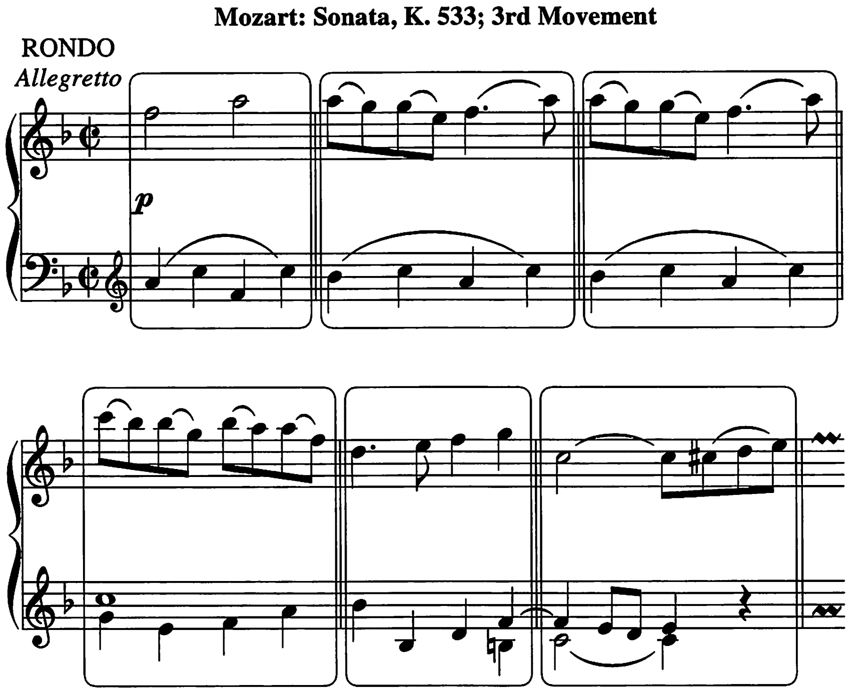


Figure 11.53 Opening bars of the 3rd movement of Mozart's sonata K. 533 regarded as comprising six configurations.

The present theoretical context means that only *intra*operative links will be considered, although a complete appreciation of the order present would require an awareness of the *inter*operative factors that were significant for Mozart and his listeners (cf. pp. 234 and 235; Gjerdingen, 1996). (In any case, the analysis has a certain musical self-sufficiency, since all components of the passage examined here must, by definition, be related coherently to one another for the excerpt to make complete musical sense.) Similarly, for the sake of brevity, neither is the orderly effect of the harmonic and metrical frameworks in which the configurations are embedded made explicit (cf. chapter 12).

Interfigurative organisation is inevitably rooted in intrafigurative design, and it is to this that we first turn our attention. The first configuration, for example, despite its apparent simplicity, is replete with internal order. Canonic theory predicts that at least some of the relationships illustrated below must subconsciously play a part in the listening experience of those for whom the passage makes musical sense.

Almost immediately, orderly links are established between the melody and accompaniment:

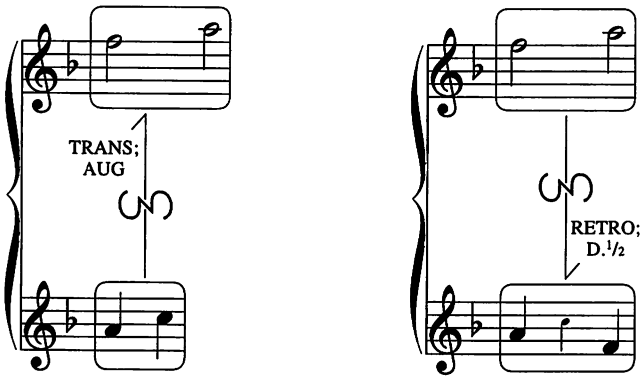
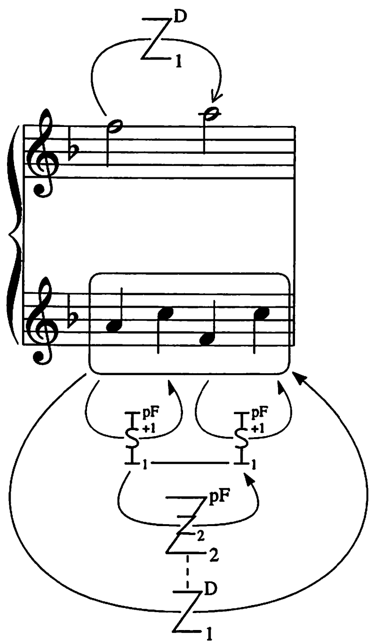


Figure 11.54 Opening imitation between melody and accompaniment.

Within each part, perceived temporal ordering exists as follows:

Figure 11.55
Perceived temporal ordering in bar 1.

(The coordinated ordering between prefixes and durations is not shown here; cf. pp. 372ff.)



The two crotchet *c*s of the accompaniment share an equivalent RML ('relative metrical location'—see p. 382) at the half-bar level, implying ordering as follows:

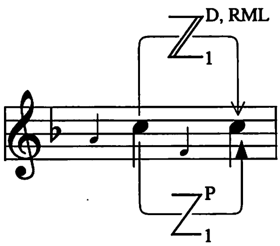


Figure 11.56 Off-beat *c* crotchets ordered through imitation.

Like those of bar 1, the contents of bar 2 also form a holistic configuration (see pp. 224 and 225). A number of interfigurative links bond this with the initial ideas presented in the first bar. Immediately, a primary zygon of pitch operates in the melody:

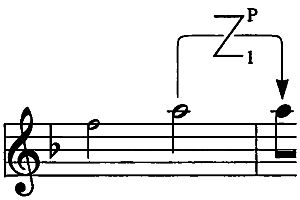


Figure 11.57 Primary zygon of pitch in the melody linking the first configuration with the second (cf. pp. 548ff).

The pitches that follow form an interlocking third with the opening interval of the melody, and may be considered to be derived through its inversion:

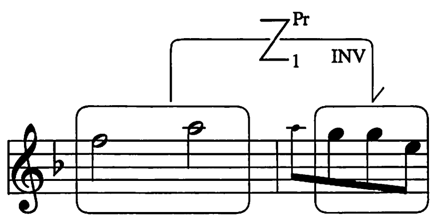


Figure 11.58 Melodic thirds linked through inversion.

Rhythmically, the group of quavers with which the RH begins bar 2 may be heard as a diminution of the four crotchets that make up the first bar of the LH, an understanding that is strengthened by the fact that this type of organisation has already occurred in bar 1 (see figure 11.54), implying rhythmic ordering at the secondary level.

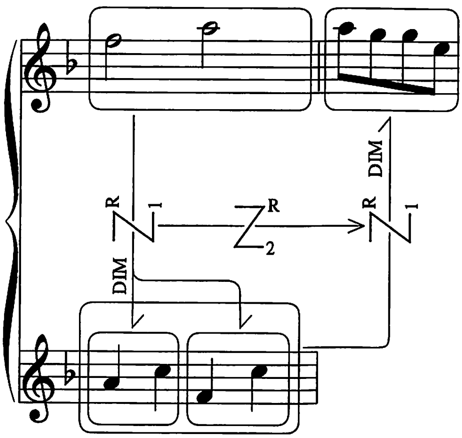


Figure 11.59
Rhythmic ordering through diminution.

The accompaniment of bar 2 is identical rhythmically with that of bar 1:

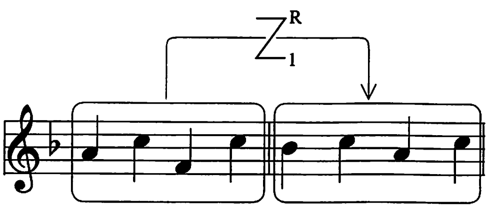


Figure 11.60
Rhythmic repetition in the accompaniment.

Moreover, the off-beat *c*s are maintained, forming an implied pedal.

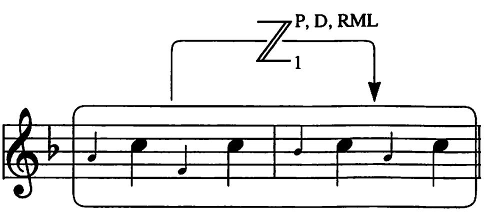


Figure 11.61 Repeated off-beat *c*s forming an implied pedal.

The accompaniment is bound motivically to the melody through inversion and transposition:

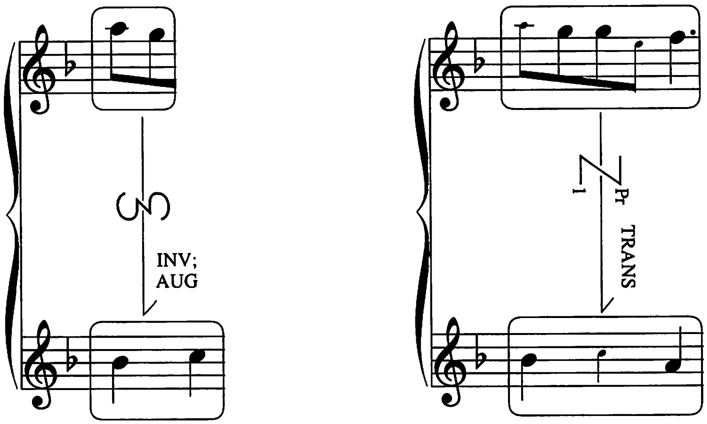


Figure 11.62 Melody and accompaniment linked through inversion and transposition.

Furthermore, the last two beats of bar 2 return to the profile with which the movement began:

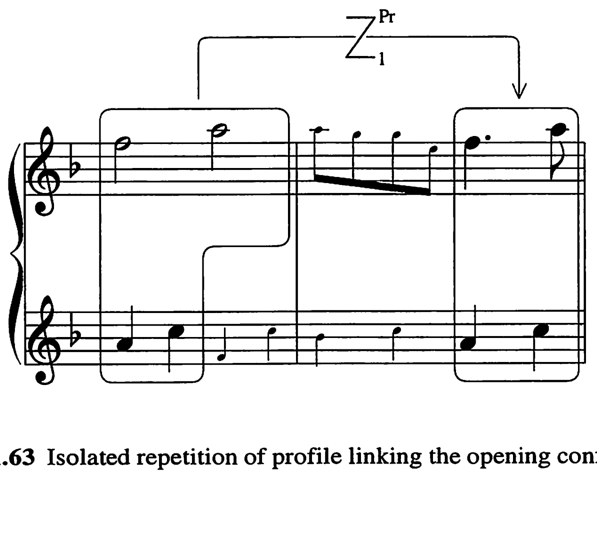


Figure 11.63 Isolated repetition of profile linking the opening configurations.

The two configurations are of the same duration.

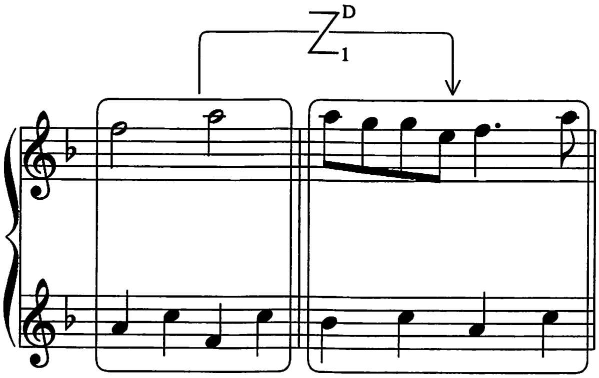


Figure 11.64 Interfigurative zygon of duration.

The third configuration (bar 3) is identical in content to the second:

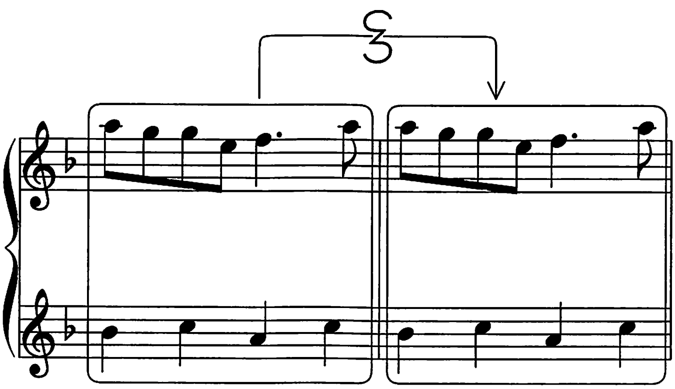


Figure 11.65 Syzygy linking the second configuration with the third.

Functionally, however, there are differences. Partly these are attributable to patterns which operate across configurative boundaries. For example, the off-beat ostinato continues as a major factor in the accompaniment, and the implication in the melody that the ascent from *f* to *a* will continue upwards to *c* is stronger than ever by the end of bar 3 (see figures 11.66 and 11.67).

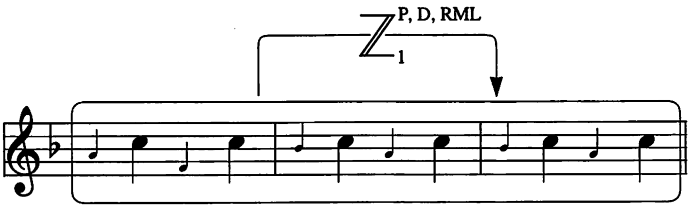



Figure 11.66 Continuation of implied pedal into the third bar.

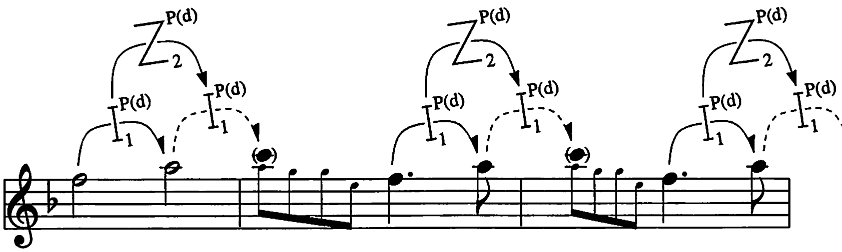


Figure 11.67 Implied ascent to *c*.

Both patterns are resolved at the beginning of the fourth configuration (bar 4). The repeated *c* crotchets of the bass lead to a semibreve...

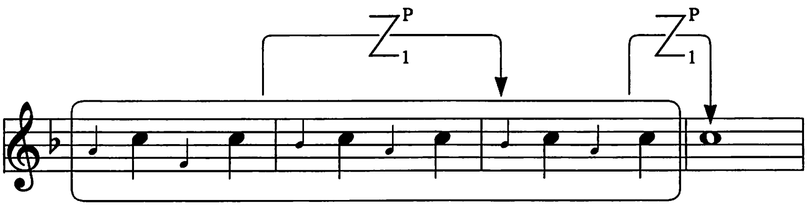


Figure 11.68 Resolution of ostinato.

...and the implied ascent to *c* in the melody finally occurs (figure 11.69).

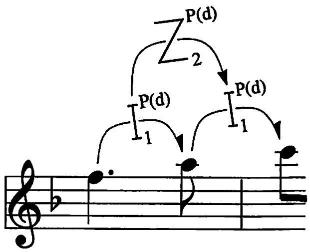


Figure 11.69 Ascent to *c* (implied at the secondary zygonic level).

The resolution of these two patterns leads to an increased rate of activity, however, as the four-quaver motive from bars two and three is transposed to form a descending sequence in bar 4.

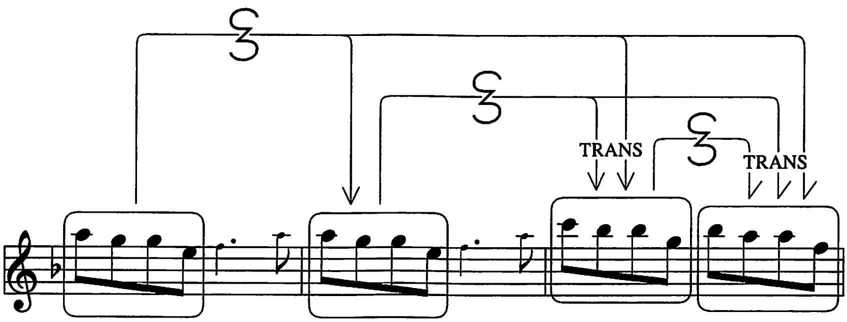


Figure 11.70 Development of the four-quaver motive in bar 4.

Motivic links with the accompaniment are made through transposition and retrogression.

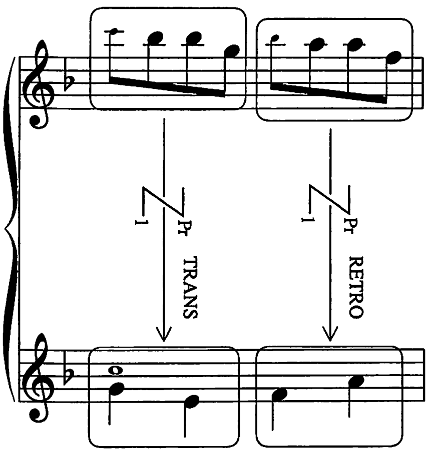


Figure 11.71 Zygonic links between melody and accompaniment.

The melodic transition *f a c* which links the third configuration with the fourth (bar 4) is balanced by the descent *a f d* which follows a bar later:

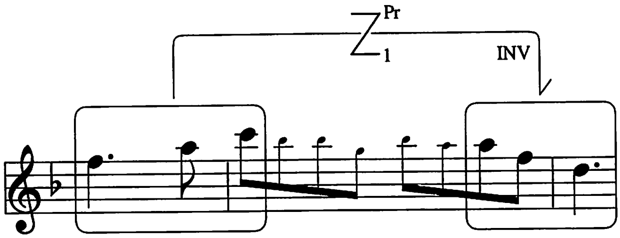


Figure 11.72 Melodic links through inversion of profile.

The steady succession of crotchets continues in the LH through configurations four and five.

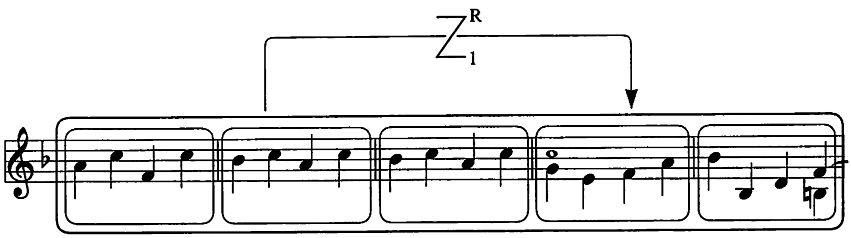
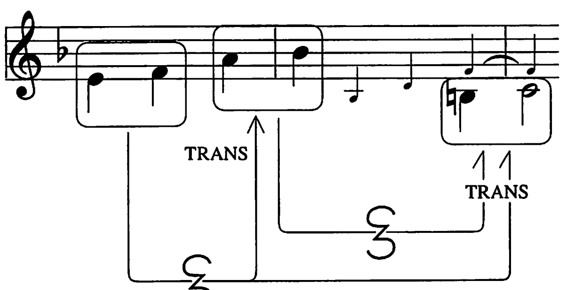


Figure 11.73 Rhythmic repetition in the accompaniment.

As well as patterns of thirds (see figure 11.71), minor seconds (bridging upbeats and downbeats) assume motivic significance in the accompaniment at this stage:

Figure 11.74 Semitone motive in the accompaniment.



Among the pitches in the RH, two patterns of particular importance emerge in the fourth, fifth and sixth configurations. These converge on the *f* with which the repeat of the melody begins.

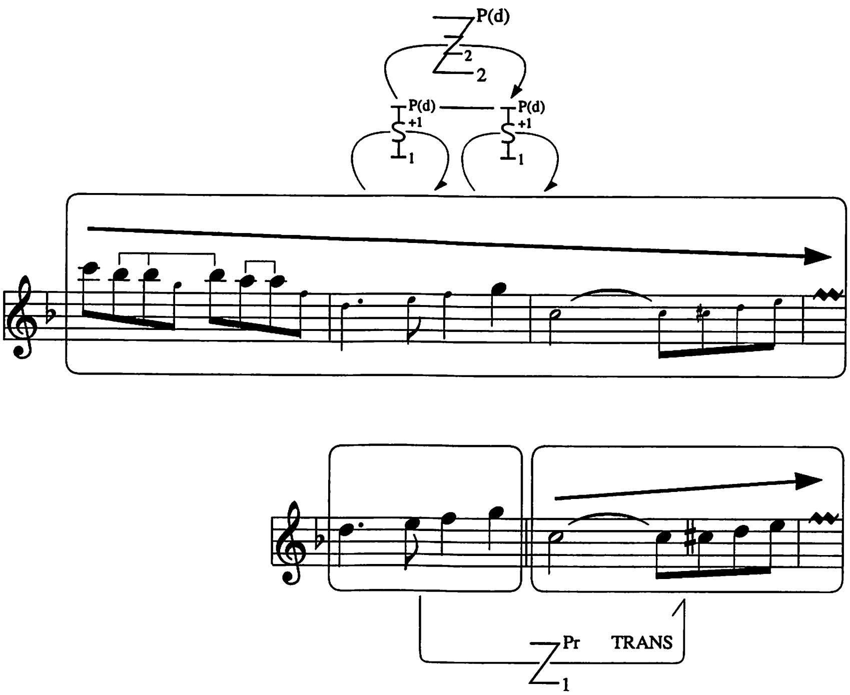


Figure 11.75 Convergence of ascending and descending lines in the first note of the repeat of the melody.

Despite this complexity, which is typical of music in a wide range of styles, common features are to be found in the way that configurations are linked one to another in an aurally coherent fashion. In considering such connections, music analysts often take into account only the highest order relationships operating in a given context—that is, those between the most substantial units of music that are present. Other relationships, linking smaller fragments of the perceived sonic fabric (such as many of those above) tend to be ignored.

The principal relationships between comparatively short configurations (of lower structural orders) are generally regarded in terms of musical **process**. Examples include 'ostinati', which are a feature of many styles, Chopin: Prelude Op. 28, No. 2

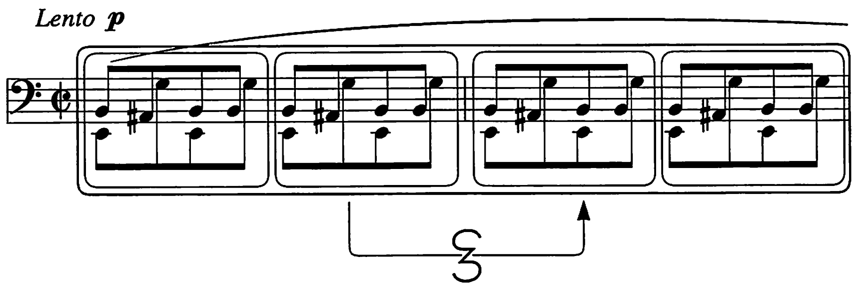


Figure 11.76 Successive repetition of contiguous configurations creating an ostinato.

Campion: *Never Weather-Beaten Saile* (1613)

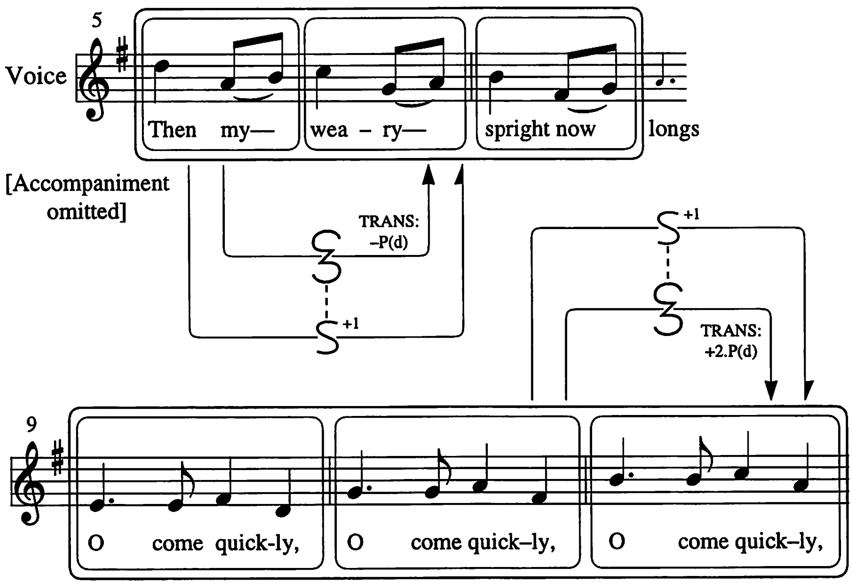


Figure 11.77 Successive transposition of contiguous configurations creating a sequence.

ranging from the ancient songs of the Botocudos of Brazil (see Sachs, 1943, pp. 32 and 33) to the music of the American minimalists of the 1960s (see Mertens, 1980/1983); and 'sequences', which are equally widespread (see, for instance, Schneider, 1957, p. 18; Daniélou, 1949, p. 100; Zonis, 1973, p. 107)—see figures 11.76 and 11.77. A further example is the process of fugal exposition (see, for example, Marpurg, 1806/1958). This involves configurative imbrication which typically conforms to a particular pattern of thematic relationships. In fugues of the Baroque period, for example, the *subject*, based around the tonic, is announced first, followed by the *answer* (on the dominant), accompanied by a *countersubject.* A further statement of the subject may follow, which may be heard in conjunction with the countersubject, and another presentation of the answer—again, with the countersubject. This implies the operation of a network of syzygial relationships along the following lines (see figure 11.78).

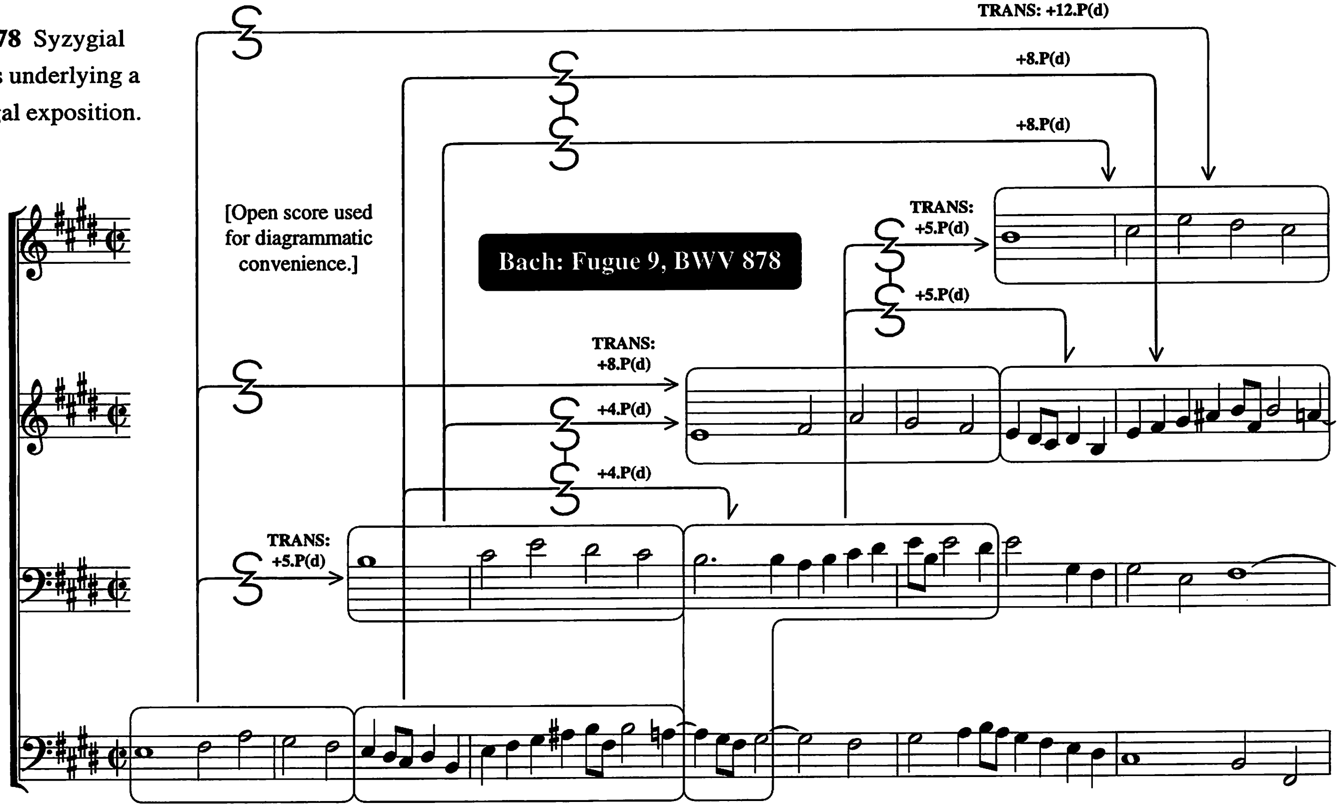
Between holons of higher orders, relationships between isolated or contiguous configurations, such as those illustrated in figures 11.76 and 11.77 are generally considered indicators of **form**. Logically, however, there is no difference between the organisational concepts underlying process and those underpinning form—it is merely a matter of scale. Hence, the principle of contiguous repetition that results in ostinati also produces strophic songs (see, for example, Nettl, 1965/1973, pp. 39ff; figure 11.79).[9]

Variation sets are derived in essentially the same way, but here the conscious and calculated use of imperfect repetition is fundamental. There are several means through which sets of variations may be contrived. For example, a line may be repeated (perfectly or imperfectly), implying a series of harmonic and metrical frameworks, against which a variety of designs are woven. The recurring configuration may appear anywhere in the texture, even on occasion transferring from one part to another. Inevitably, HRP ('harmonic rhythmic pattern'—see p. 652) is often maintained too, particularly when the line repeated is in the bass (cf. p. 608). Motivic links are commonplace. These forms of organisation are illustrated in figure 11.80, which depicts the variations on *Soll es sein* by Sweelinck.

Pieces such as this, based on contiguous repetition, form chain-like structures in perceived sound (A A' A" A'" ...). *Isolated* configurative

[9]Strophic songs in which there is a systematic rise in pitch in verse (for example, *I just called to say I love you*—Wonder, 1984; see figure 10.40) may be equated with sequences, since both the form and the process utilise contiguous transposition.

Figure 11.78 Syzygial relationships underlying a four-part fugal exposition.



Schumann: *Lieder-Album für die Jugend,* Op. 79; No. 13, *Marienwürmchen*

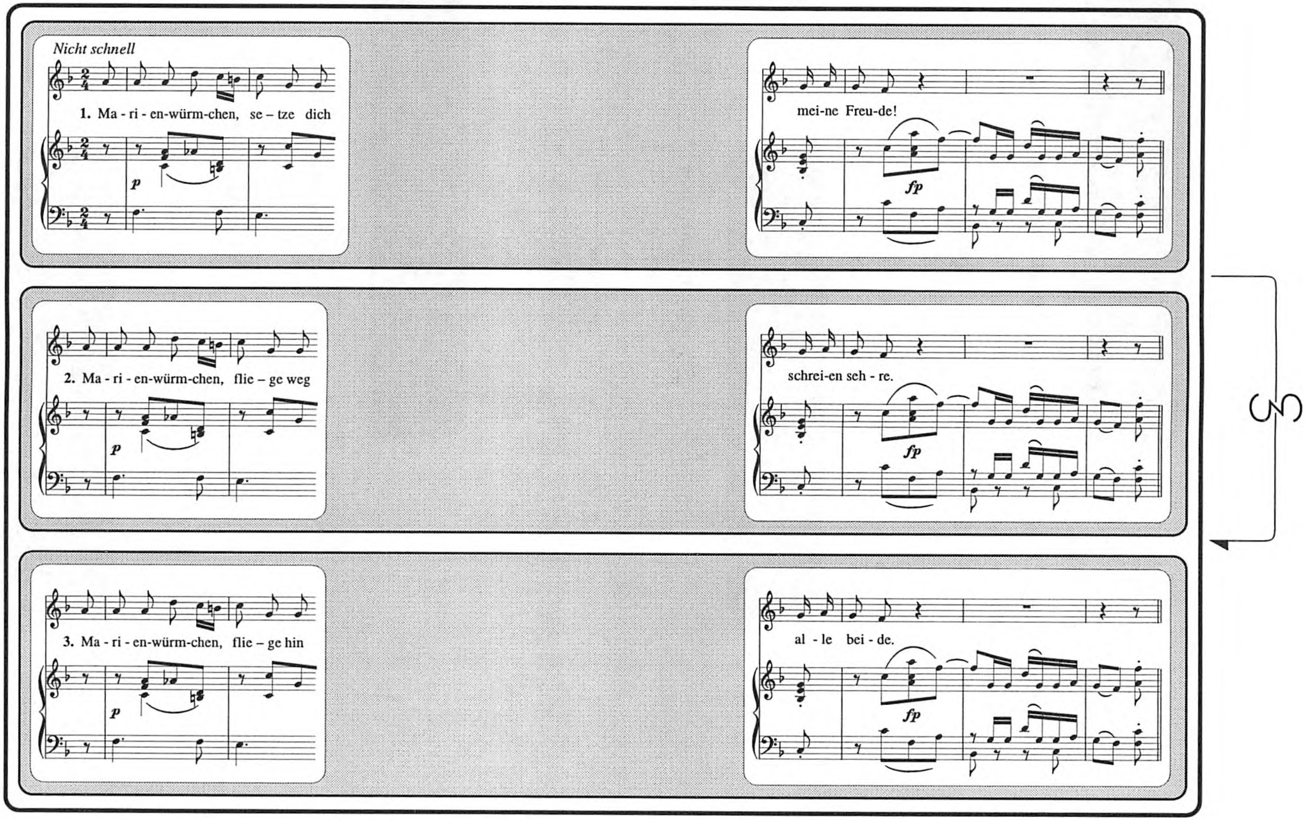
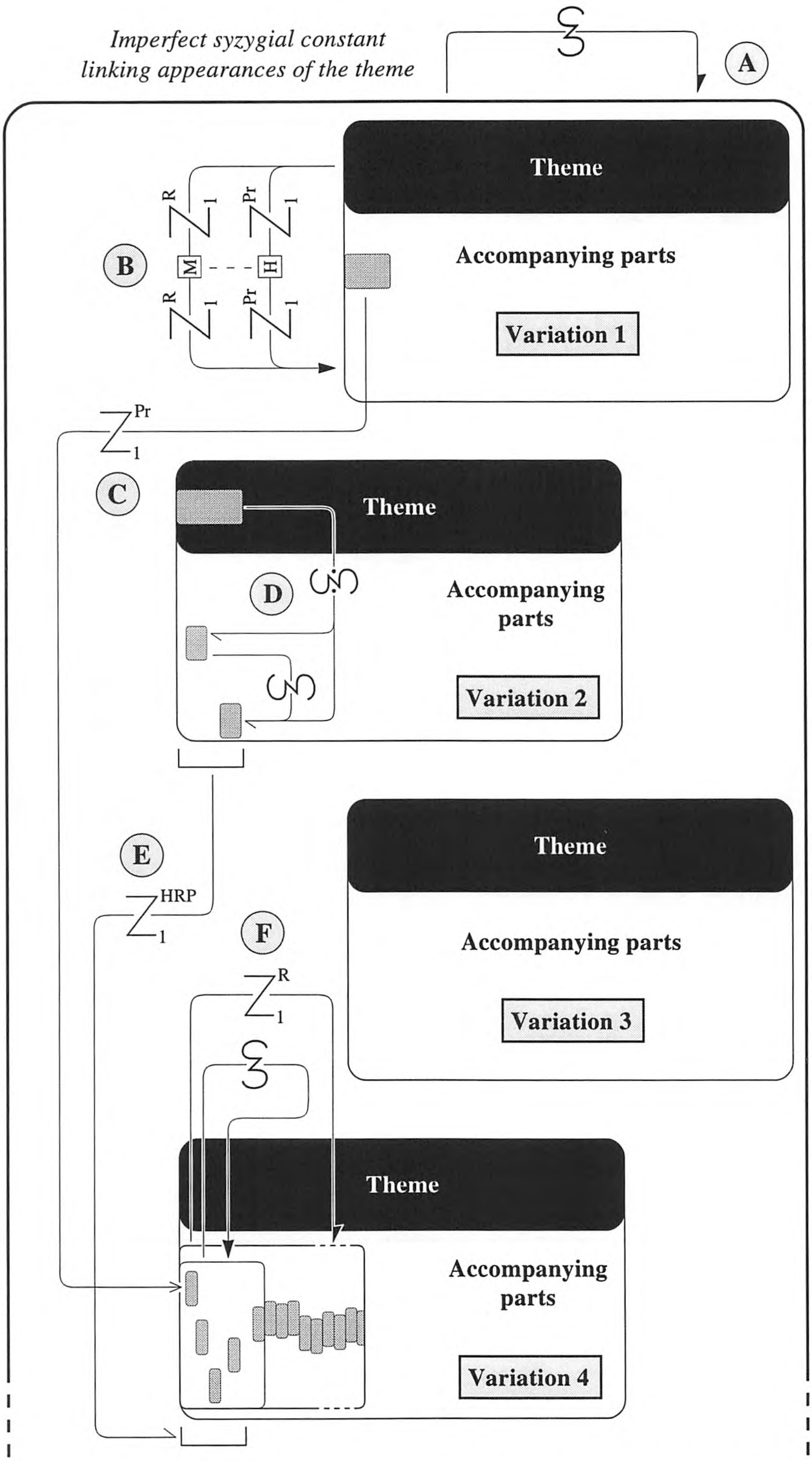


Figure 11.79 Contiguous configurative repetition in strophic song.



Sweelinck (1562–1621): ***Soll es sein*** **(8 Variations for Keyboard)**

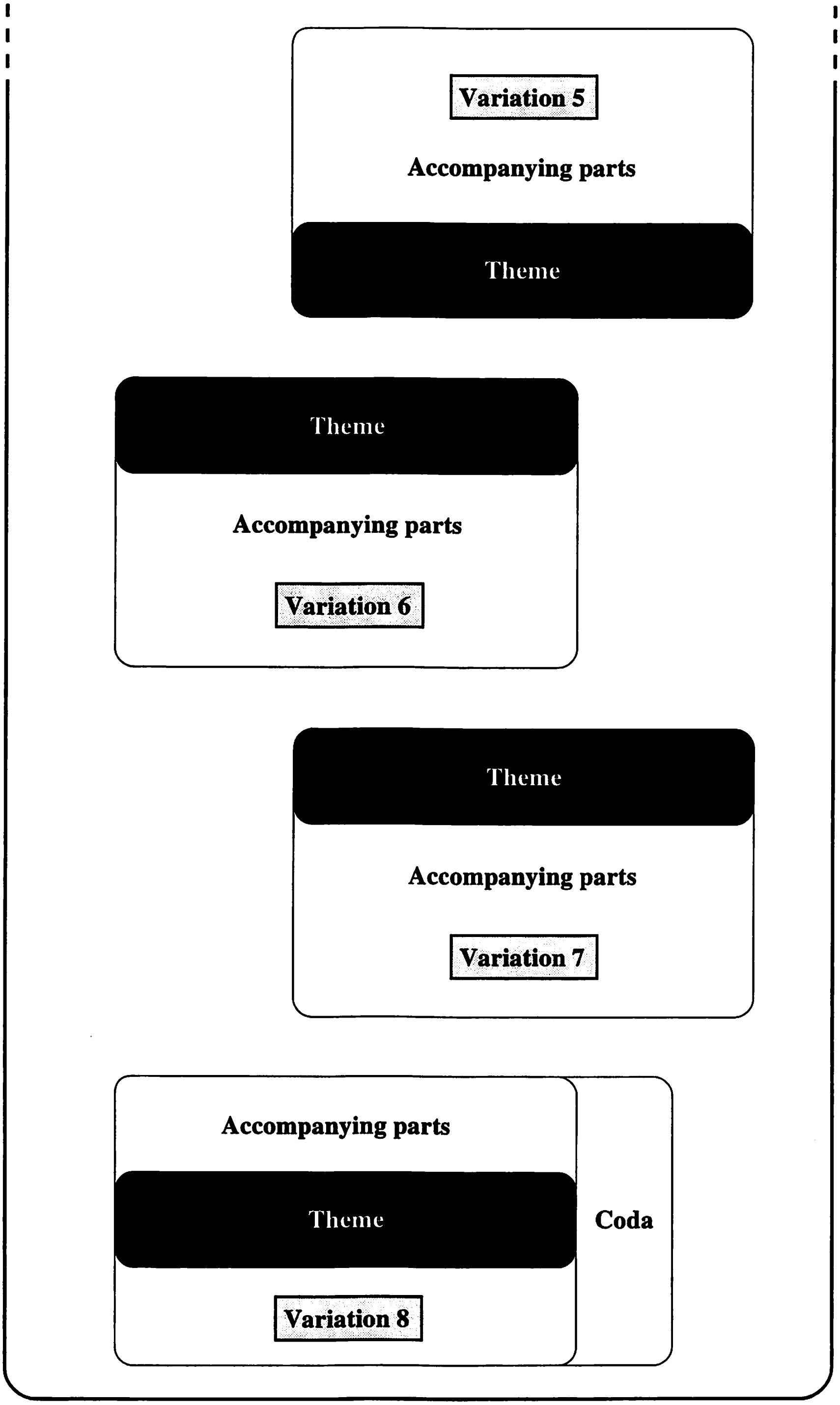
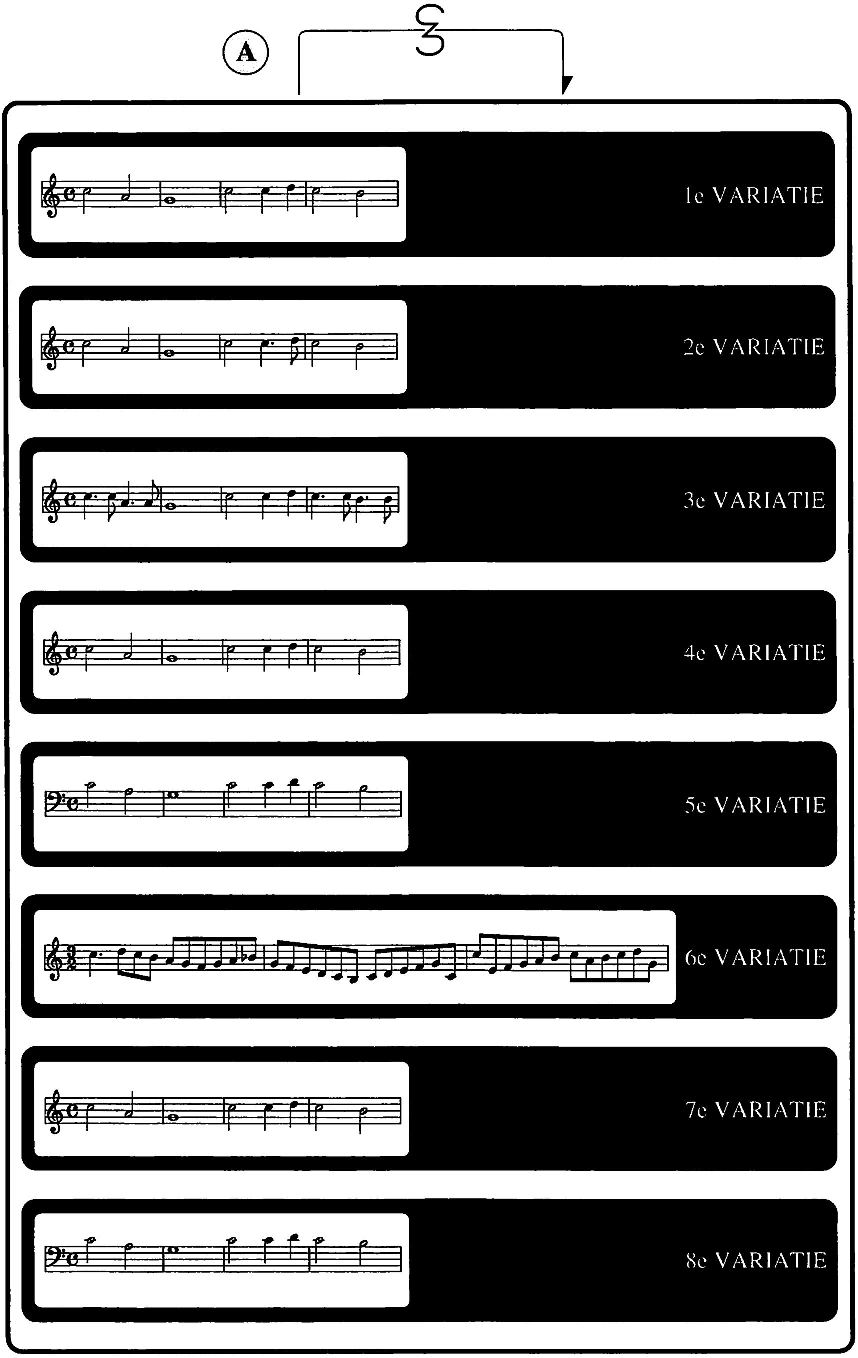


Figure 11.80 (part i) Indicative ordering present in variation set based on recurring theme.



Sweelinck (1562–1621): *Soll es sein* (8 Variations for Keyboard)

Figure 11.80 (part ii) Order underlying imperfectly repeated theme.

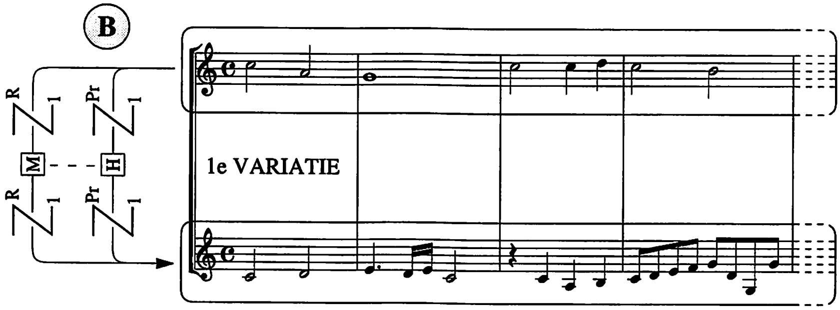



Figure 11.80 (part iii) Harmonic and metrical frameworks established by the theme.

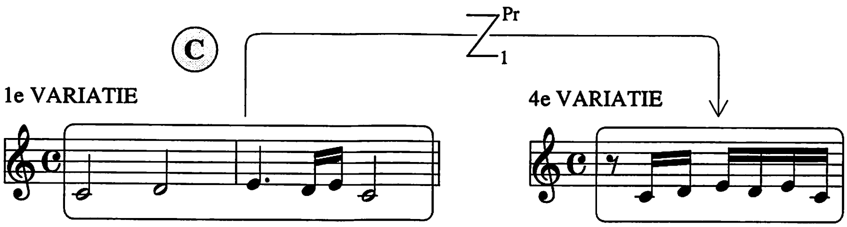


Figure 11.80 (part iv) Motivic link between variations in accompanying parts.

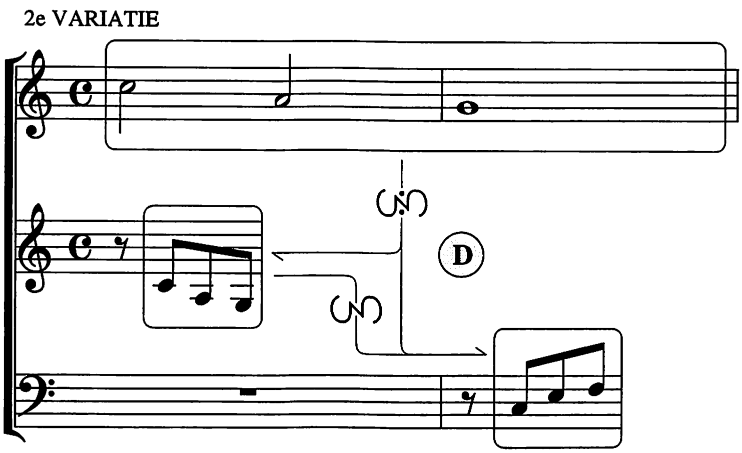


Figure 11.80 (part v) Accompanying parts derived from theme.

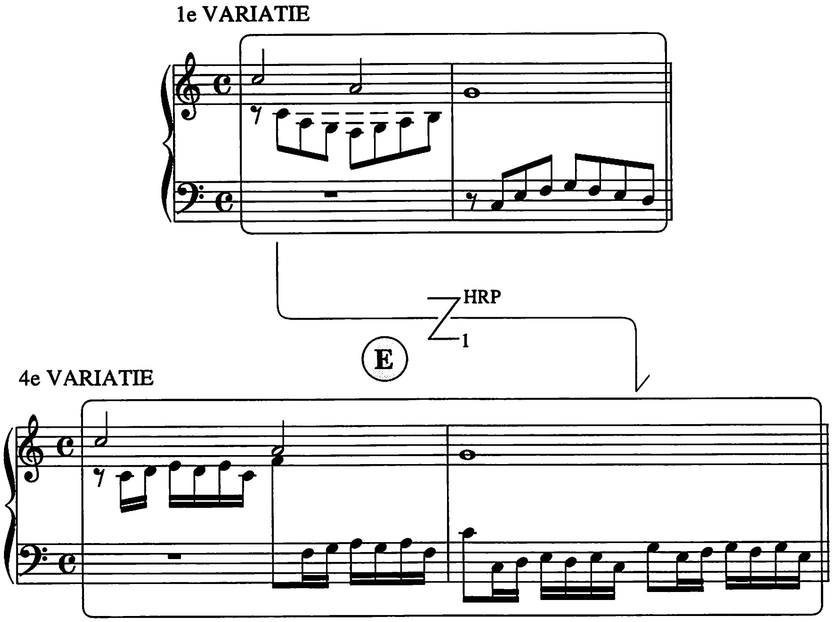


Figure 11.80 (part vi) Harmonic rhythmic pattern transferred from one variation to another.

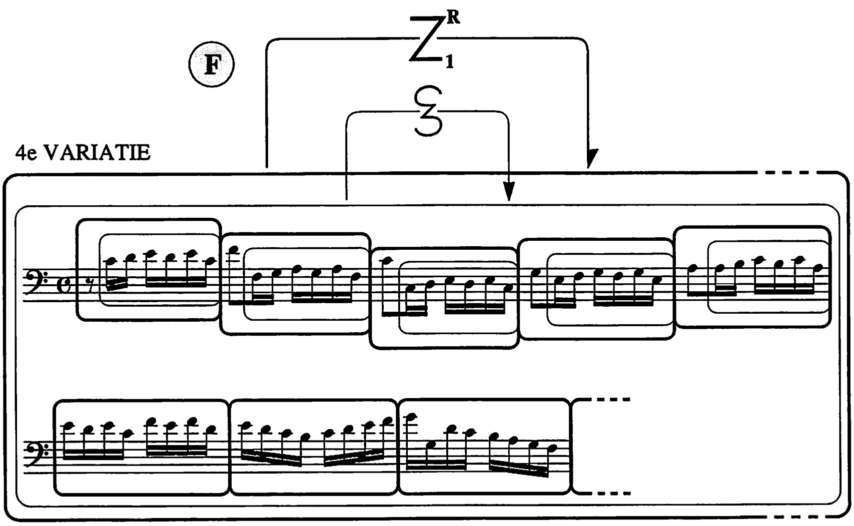


Figure 11.80 (part vii) Ongoing configurative and rhythmic relationships in accompanying part.

repetition produces a different formal archetype, frequently depicted as A B A (see, for example, Berry, 1966/1986, p. 44), in which 'B' represents a contrasting episode. This analogy can be misleading, however, since the fundamental requirement for music to be coherent as a whole means that zygonic relationships of different types invariably link one section with another. In the Classical *Minuet and Trio*, for example, a certain cohesion between 'A' and 'B' is typically achieved through the sharing of a common metre, similarity of tempo, and the use of closely related keys such as I and IV, or I and i (which differences also provide a basic level of contrast). Overlaid on this general background may be more specific connections involving any aspect of pitch and the temporal perspects, including profile, rhythm and combinations of the two. Hence links between shorter configurations may well exist alongside those pertaining to longer ones without compromising the capacity of these for determining form. See, for example, figure 11.81. Here, the trio functions as a distinct formal unit despite its numerous motivic connections with the minuet.

Similar principles apply in pieces which extend the notion of return—for example, through chaining, creating patterns such as A B A C A D A ... (the model upon which the rondo and a range of other forms are based)—and others, such as binary form (A B). In the Western classical tradition this is frequently articulated with a movement away from the tonic in the first half (most commonly to the dominant or, in the case of the minor mode, the relative major) and a return to it during the course of the second. Again, coherence is typically assured through a network of interfigurative links (cf. Berry, op. cit., p. 36). In some pieces these relationships are of a sufficiently high order to achieve formal significance. For example, there may be a recapitulation of the opening material in the second half. Typically, thematic restatements of this kind are linked with a return to the tonic, each type of reprise enhancing the effect of the other. See figure 11.82.

The interaction of high-order interfigurative and tonal relationships reaches its apogee in the Classical sonata, whose driving formal principle, according to Rosen (1971/1976, pp. 72ff; 1980, p. 25) is dissonance at the structural level. Specifically, material presented outside the tonic is conceived as dissonant, which is resolved by subsequent transposition to the home key. See, for example, figure 11.83.

Haydn: Sonata Hob. XVI: 9; 2nd Movement

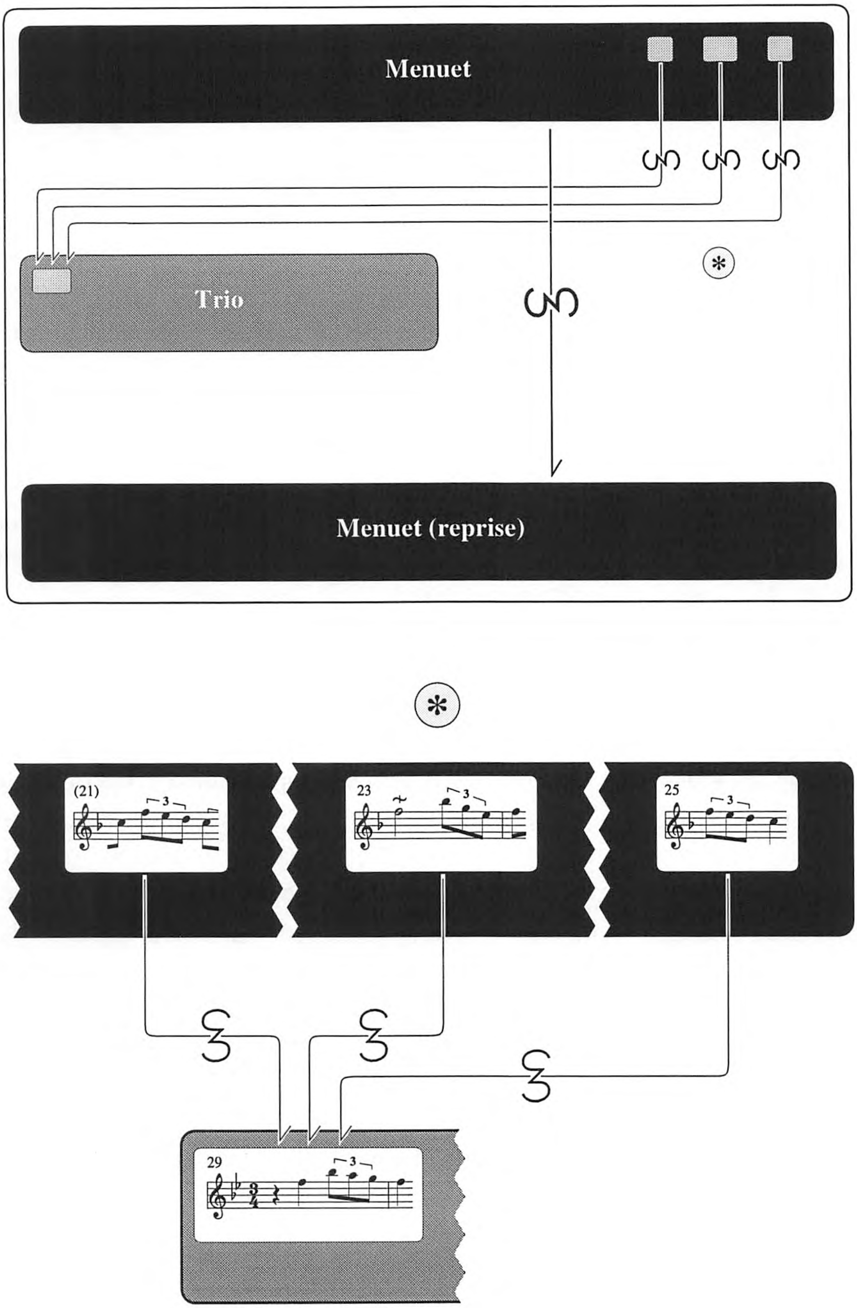


Figure 11.81 Indicative syzygial links (i) articulating formal sections and (ii) contributing to the musical coherence perceived between them.

Mozart: Sonata, K. 284; 3rd Movement

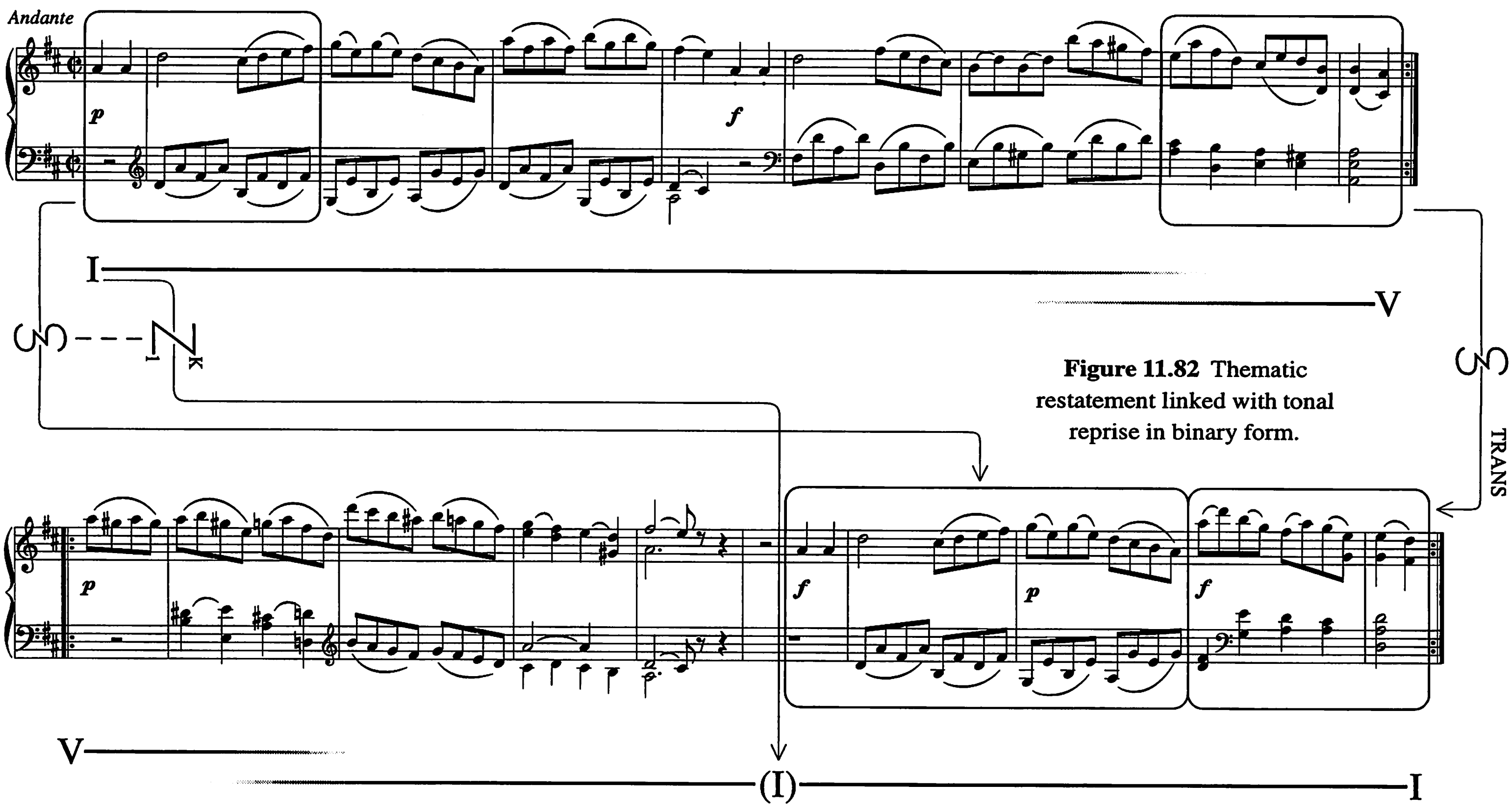
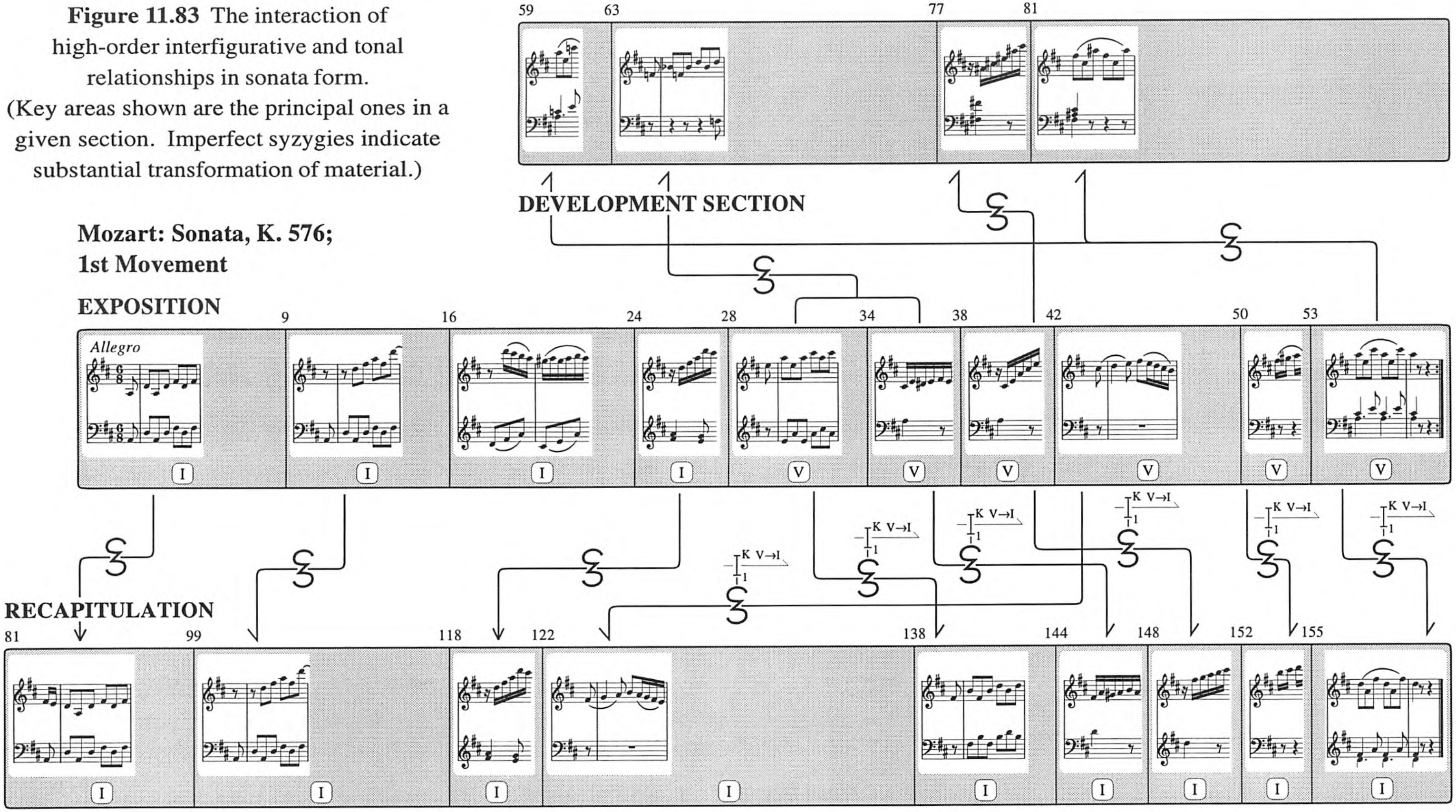


Figure 11.82 Thematic restatement linked with tonal reprise in binary form.

Figure 11.83 The interaction of high-order interfigurative and tonal relationships in sonata form. (Key areas shown are the principal ones in a given section. Imperfect syzygies indicate substantial transformation of material.)



The interoperative transfer of configurations, processes and forms

By far the most usual way of transferring material from one work to another is through the repetition of rhythm and profile together, implying the use of interoperative syzygies.).[10] Transposition and changes of speed are commonplace, reflecting the fact that the lasting impressions left by pitch and perceived time are largely relative. In either domain, the imitation may be perfect or imperfect on account of the alteration, omission or addition of material. Certain of these modifications may be intentional, while others may occur purely subconsciously, thanks to the vagaries of cognition and memory.

It is comparatively rare for one configuration to be linked to another through a unique interoperative bond. Usually, material that is transferred can be traced to a number of possible sources (cf. pp. 234ff). Hence interoperative syzygies are most frequently encountered in systems. The groups of notes involved are usually of the order of motives, whose anonymity is typically reinforced by what may be termed the 'chameleon' effect, through which values of loudness and timbre are changed where necessary to merge with those of the host passage. Observe that, from an analytical point of view, such excerpts are deemed to be linked through a 'general syzygial relationship', whose constituent strands may be direct or indirect and whose polarity is unspecified (cf. p. 309). See figure 11.84.

In circumstances like these, listeners—and, indeed, composers—do not normally make any conscious connection between models and imitation.

[10]Brief mention should also be made of interfigurative links between *movements*, a device which permeates many different pieces and styles, from Machaut's *Messe de Nostre Dame,* for example, (see Reese, 1940, p. 356) to Berlioz's *Symphonie Fantastique* (1830)—cf. also Bukofzer, 1947, p. 44; Rosen, 1971/1976, p. 37; Meyer, 1973, pp. 57 and 58. Certain theorists (notably Reti, 1951) have proposed that thematic connections between movements are a pervasive feature of masterpieces of the Classical period. In contrast, Berry (1966/1986, p. 151), suggests that the "relationship that we sense between or among movements of a large work may often be one of conditioned association." There are elements of truth in both positions: inevitably, given the stylistic limitations within which composers of the period worked, and since it was commonplace to borrow from a common stock of patterns in pitch and perceived time (see, for example, Gjerdingen, 1996), syzygial connections abound both interoperatively and intraoperatively. However, the links between the movements of a single piece may achieve a greater perceptual significance because of the proximity in perceived time of the material they relate and for sure, in some cases, on account of conditioned association incurred through repeated listening.

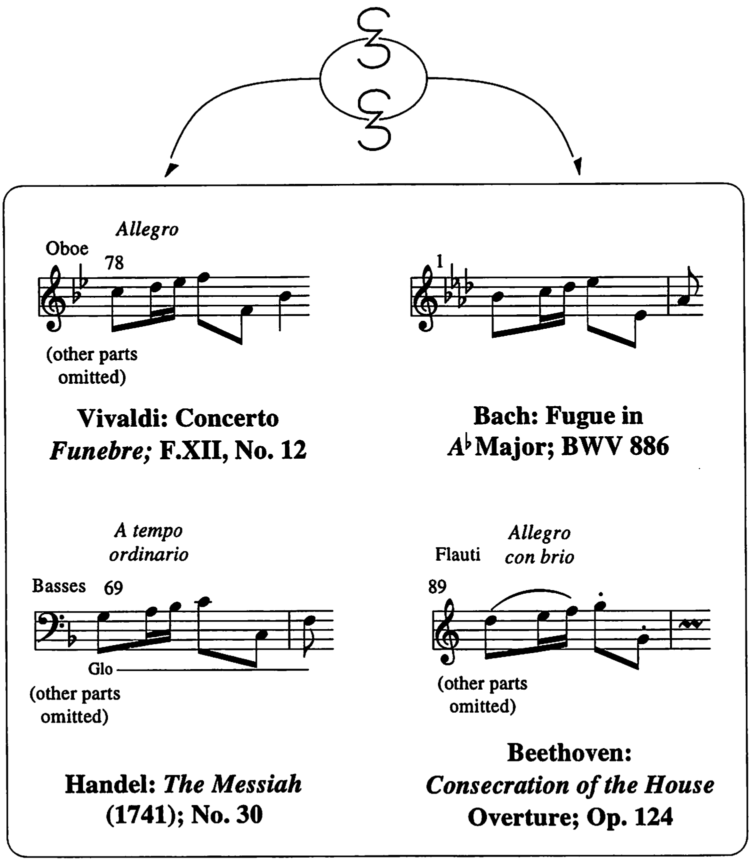


Figure 11.84 General syzygial relationship deemed to link motivic fragments interoperatively (cf. figure 7.17).

And yet we can assume that at some cognitive level links of this type are indeed forged. Otherwise, how is it that listeners can make sense of a new piece in a familiar style on first audition? Their efforts must be guided by an awareness of passages similar to those they are hearing in comparable, known pieces (cf. pp. 258ff). Unless the excerpts concerned were created alike by chance, interoperative imitation must have occurred, implying the operation of syzygies as described.

Other interoperative transfer of configurations may arise from a conscious decision on the part of composers. This may manifest itself in 'quotation', through which memories of an earlier piece are consciously evoked and set against the thoughts and feelings engendered by the new. Ballantine (1984, p. 74) describes the process thus:

> 1) An extraneous fragment is 'chosen'.
> 2) A dialectic—which may include a distortion of the fragment—exists between the fragment, with its semantic associations, and the new musical context.
> 3) The new context has primacy over the fragment, by providing the structure through which the fragment, its associations, and its interrelations are to be understood.

The technique has a long and varied history, ranging in Western culture from the quodlibets that appeared from the 13th century onwards, of which a well-known example is the final variation in Bach's *Goldberg Variations* (see Apel, 1969, p. 713), to a number of twentieth century works, ranging from Schoenberg's 2nd string quartet (which cites *O du lieber Augustin*) to Stockhausen's *Hymnen* (1969), which uses national anthems. The ordering involved may be perfect or imperfect, for, as Ballantine suggests, the configuration quoted may be modified by the demands of its new context. Clearly, the more characteristic or famous the theme that is cited, the more imperfect can the interoperative transfer be without its recognisability being compromised—see figure 11.85.

The essence of a passage such as this is the apposition of one set of musical connotations (from a previous piece) with another (from the present one): clearly, if a listener failed to recognise the quotation, or was ignorant of its source, the point would be missed. However, in other cases of interoperative transfer which use configurations of sufficient individuality to be distinguishable from the common motivic stock, the intention is not to re-kindle memories of another work with the purpose of establishing what may be termed an intraoperative-interoperative dialogue, but merely for the borrowed material to be treated as any other, and used freely in the new composition. The extent to which composers have felt able to treat extant musical matter in this way has been subject to considerable historical and geographical variation: what is regarded as the legitimate sharing of ideas in one culture may be deemed plagiaristic by another (see p. 243). Even within one society, the acceptability of a musical loan may vary according to its source. In the West, for example, there is a sense in which a tune belongs to its composer under the laws of copyright, and it is deemed an act

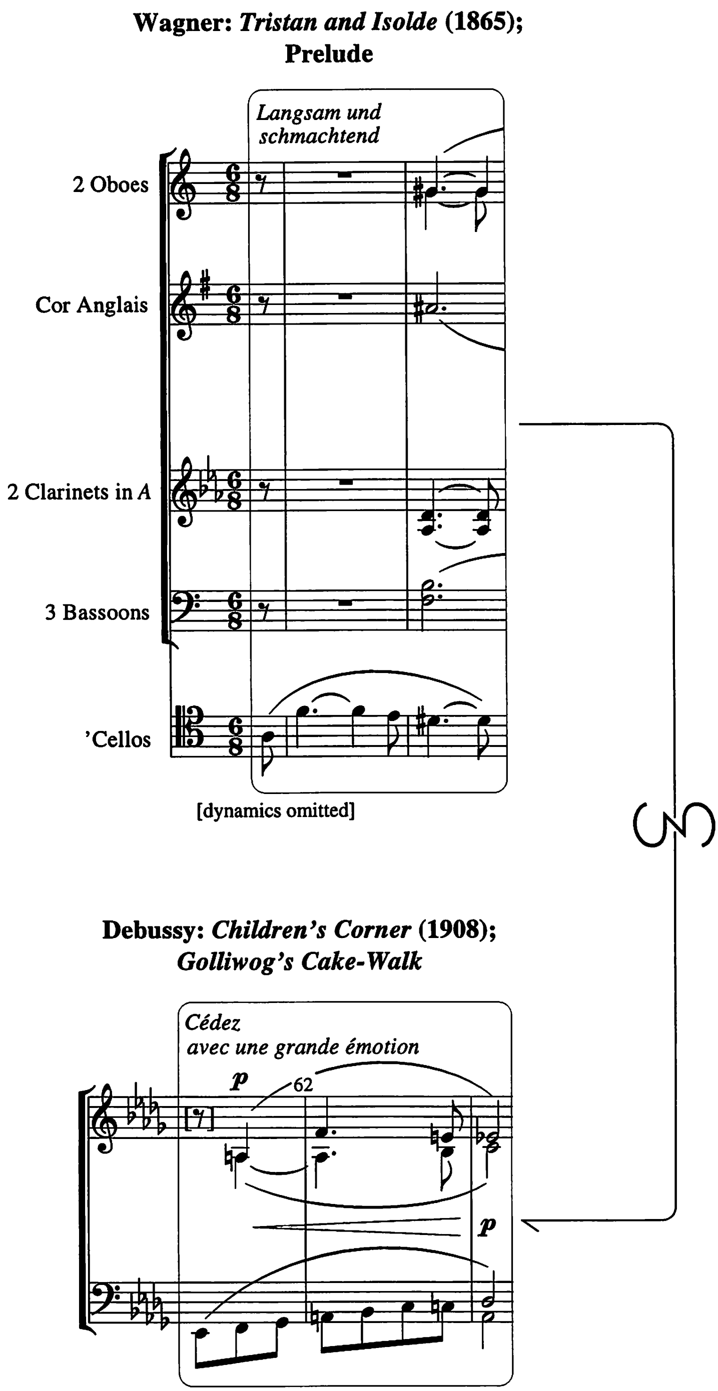


Figure 11.85 Quotation whose individuality allows a high degree of interoperative syzygial imperfection.

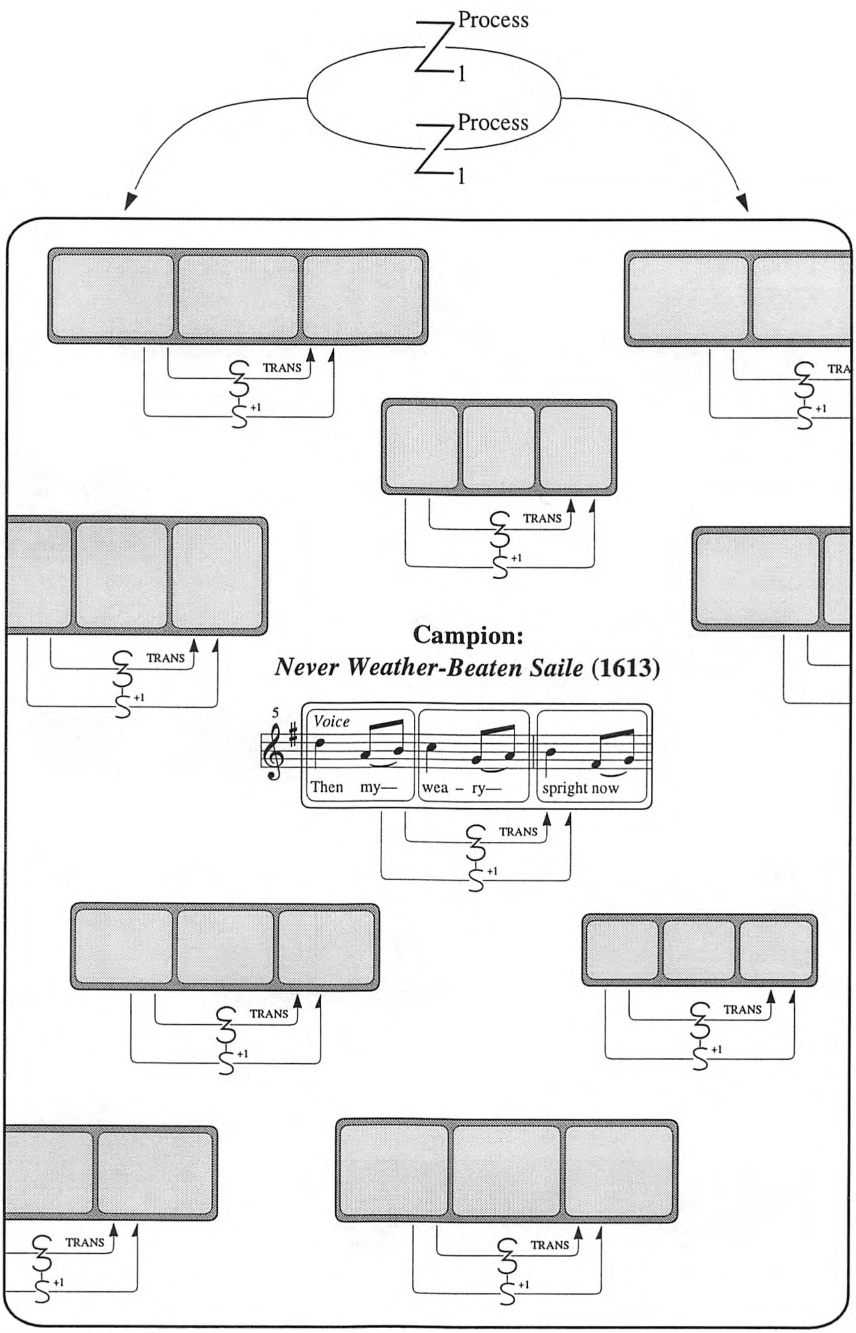


Figure 11.86 Interoperative imitation of descending threefold sequences in Campion's *Never Weather-Beaten Saile* and congeneric pieces (cf. figure 11.77).

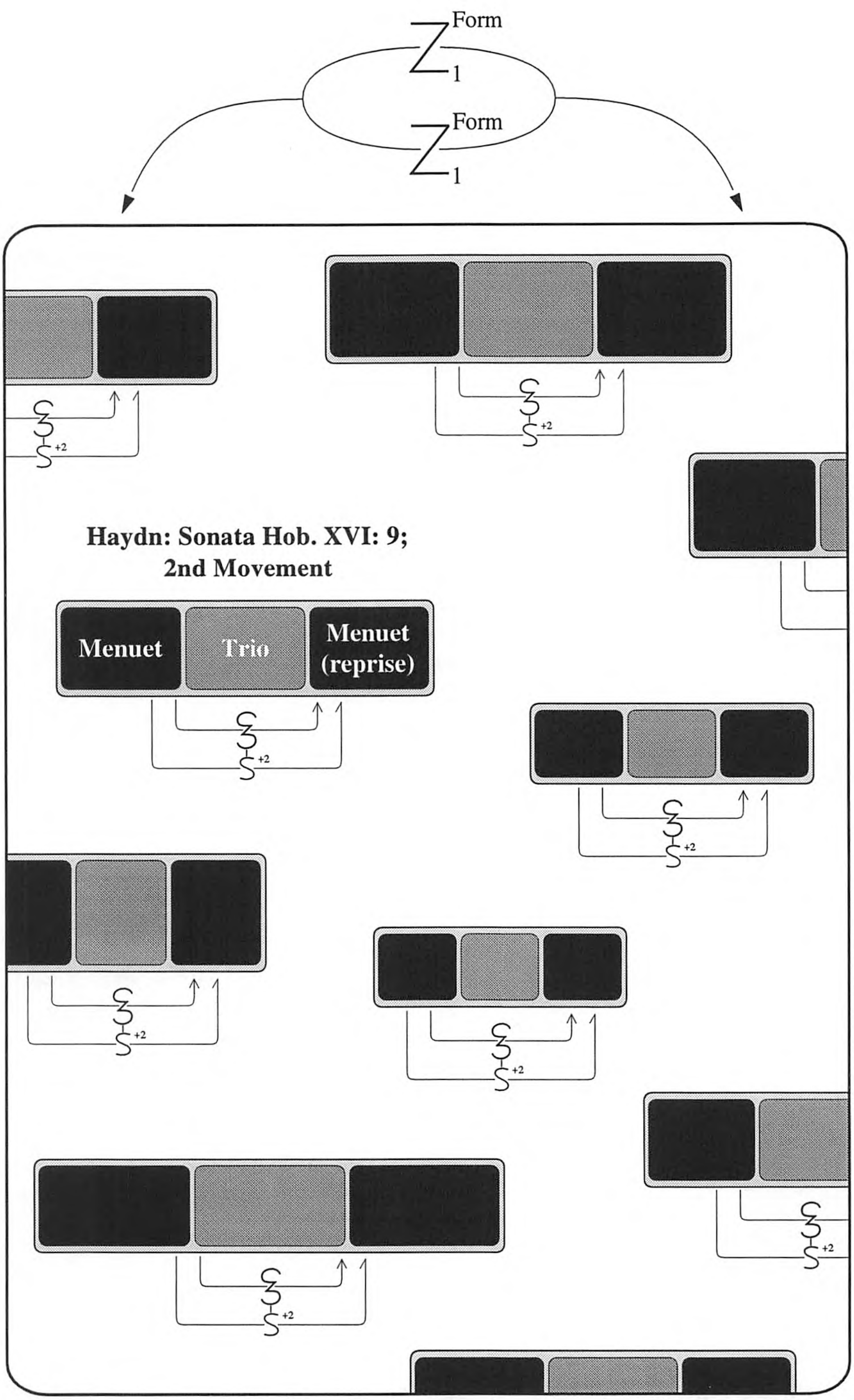


Figure 11.87 Interoperative imitation of ternary form between the minuet in Haydn's Sonata Hob. XVI: 9 and movements in congeneric pieces (cf. figure 11.81).

of larceny for another to make public use of it without his or her consent.[11] No such restrictions, ethical or legal, pertain to folk music, however, whose vast reserves may be tapped by anyone of a mind so to do.

In either case, whether or not it is demanded *de jure*, due extramusical acknowledgement of an acquisition may be made. Hence titles such as "*Variations on a theme by* ..." and "*A piano arrangement of ... by ...*" are commonplace.

These two descriptions give some idea of the potential range of interoperative ordering involved. On the one hand, a piece or movement may be built up using a theme derived externally as a chief source of material. Perhaps the most familiar manifestation of this is the set of variations on a given melody, although there are many other possibilities including, for instance, fugues on a predetermined subject. In each case, the borrowed material (at least in its initial appearance) makes up only a small porportion of the piece or movement as a whole. On the other hand, it is possible for interoperative transfer to occur that is a good deal more extensive than this. Take, for example, the parody Masses of the Renaissance (see Reese, 1954, pp. 239ff). Here the translocated configurations represent substantial portions of the works in question. Beyond this, the stage is reached where the resemblance between two items of music is so great that they can no longer be deemed separate entities, but, through adaptation or arrangement, different versions of the same thing.

Musical processes and forms may themselves be imitated interoperatively, as abstract concepts distinct from the material which defines them on any given occasion. Most processes and forms are common to many pieces, implying the agency of systems of zygonic relationships. See, for example, figures 11.86 and 11.87.

Extramusical influences on configurations, processes and forms

The derivation of configurations through extramusical imitation is a process that apparently reaches back into the realms of musical prehistory. In some cultures, the connection with a totem or mystic ancestor

[11] Implicit here is the question of when two tunes can be regarded as distinct and when one can rightfully be considered a derivative of the other. Cf. Davies, 1978, pp. 141–143.

> is established by the person concerned imitating the particular object which it is his duty to maintain, that is, his own totem. ... the essential part of the imitation is the simulating of sounds ... [and] of all the available means of imitation the human voice is far and away the best. ...
>
> ... If a man is capable of reproducing exactly the croaking of the frog or the hissing of the snake, it is because his mystic ancestor was the totem-god of the frog or the snake. When he imitates the voice of his totem with the greatest realism, he imagines he is obliterating the boundary between subject and object and identifying himself with the totem. Whoever croaks like a frog, is a frog. ... He becomes in fact a sound-symbol. This symbol, perhaps the oldest in the history of human culture ... is the voice of a dead ancestor, whose mystic body survives in the totem. The song represents the dead ancestor, or is itself the dead ancestor, who, together with all other ancestors, form the substance of the world. Vocal imitation is the strongest form of mystic participation in the surrounding world. (Schneider, 1957, pp. 9 and 10)

The imitation of natural sounds is an ingredient in the music of other cultures too, albeit one of rather less importance to the perceived sonic mixture as a whole. In the Western classical tradition, for example, the practice is widespread without being common. It seems that bird songs are most frequently the objects of musical illustration, doubtless on account of the particular affinity that exists here between art and nature (see Kivy, 1984, p. 25). Inevitably, given the rhythmic, tonal and technical constraints with which composers of this tradition had to contend, some calls are reproduced more faithfully than others. The cuckoo's is one to which a fair degree of realism usually attaches. See, for example, figure 7.16.

1948 saw the complete emancipation of extramusical imitation with the advent of Schaeffer's *musique concrète*. Here, for the first time, sounds from the world outside could be transferred directly into a musical context through the process of recording. Moreover, manipulation of the discs or tapes on which images of the sounds were stored enabled the easy realisation of transformations such as changes of speed (with concomitant degrees of transposition) and retrogression (see Griffiths, 1979, p. 12). Subsequent developments in the field of electronic music have meant that equipment is now readily available that can sample sounds and store them as parcels of digital information, in which form they can undergo any imaginable operation. With such facilities at their disposal, the only factor restricting composers today in the sphere of extramusical imitation is perceptibility.

Examples of the extramusical derivation of process include the use of canon (that is, imbricated repetition or transposition) as a metaphor for 'following' or 'leading' (see Kivy, 1984, pp. 9ff). According to Harris (1931, pp. 314ff), canon and a number of other musical processes, including inversion and contiguous retrogression, have clear parallels in art and nature, and may even have derived from their visual equivalents. Certain forms have extramusical precedents too. Harris (op. cit, p. 305), for example, finds a range of extramusical models—from animals to architecture—for 'mediate repetition', that is, the return to a first section after the appearance of intervening material: A B A. The rondo (A B A C A ...) may have arisen in imitation of the poetic form (see Schoenberg, 1931/1975, p. 265).

Conclusion

This chapter provides an overview of the combined ordering of pitch and the temporal perspects—by far the most significant perspective combination in music (cf. p. 4). It is shown that, while non-canonic forces impose certain limitations within this integrated domain, composers nevertheless have an immense range of material with which to work. Although cross-modal *imitation* offers certain possibilities, it is cross-perspective *coordination* that is more significant musically, and this is considered at some length.

The coordinated ordering of rhythm and profile underlies most melodic transformations, and a comprehensive taxonomy of orderly interfigurative connections is proposed, deriving from the ideas developed in chapters 9 and 10. These compound zygonic links are defined as 'syzygies', and their perceived temporal possibilities (first presented in a different context in chapter 6) are explored. This investigation leads naturally into a review of 'process' and 'form', and the order pertaining to them. Finally, combined interoperative and extramusical relationships of pitch and perceived time are considered.

12

Theory in action: an extended example

This chapter extends the line of thought initiated in chapter 11, seeking to integrate many of the ideas that are presented discretely in chapters 8 to 10. This is achieved through an extended example of zygonic theory in action, focussing on the first movement of Mozart's sonata K. 333 (cf. pp. 551ff), which is thought to have been composed in the autumn of 1783, in Linz and Vienna (Tyson, 1987, pp. 73ff; Mercado, 1992, p. 98). Throughout, attempts are made to contextualise the organisation that is discussed—to gauge its probable relevance to the composer, to subsequent performers, and to listeners, of varying musical experience. The aim is not to provide a comprehensive analysis of the movement, but to demonstrate how ordering through imitation is integral to every aspect of the musical fabric.

Although all aspects of the movement are structured according to the same fundamental principle—of order through imitation—this manifests itself in a wide variety of ways. At the most basic level, the values in some perspective domains form a consistent 'background', to a greater or lesser extent typical of many other pieces, against which other more detailed organisation occurs, which is more or less specific to K. 333.

For example, listeners would no doubt expect a moderate level of perceived reverberation to be maintained throughout the movement (indeed, for the duration of the piece). It may well be that environmental factors are responsible for this consistency, as they would have been in Mozart's time, but even today, when, in certain circumstances, continuous variation of perceived reverberation is possible through electronic means, the traditional uniformity is maintained. This form of background ordering is characteristic of performances in general, implying vast networks of potential interterpretive and interteroperative links (cf. pp. 244 and 249)—see figure 12.1. Despite these connections, the control of perceived reverberation rarely impinges upon the listening experience of most people, however (with the possible exception of professionals such as sound engineers). Exceptional values of perceived reverberation would rapidly rise to the perceptual foreground of most listeners, though.

Similar observations apply to the perceived location of the sound source, which is likely to remain constant throughout a performance. Again, this is a feature typical of other performances of the same work and of other pieces. Here, interauditive, interterauditive and interaudoperative primary interperspective differences are commonplace, however (cf. pp. 251 and 252), since the position of listeners relative to the perceived source of sound is liable to vary. See figure 12.1.

Timbre is uniform throughout the movement. Such uniformity is common to many pieces. Interterpretive relationships of timbre (between different performances of K. 333) may bear significant imperfection due to the evolving nature of the piano tone since Stein's 'fortepiano' which Mozart enthusiastically endorsed in 1777 (see, for example, Grover, 1976).

Loudness is prescribed within a small range (***p*** to ***f***), partly, no doubt, as a consequence of the dynamic limitations of the early pianoforte. Where these constraints are respected in contemporary performances, the entire movement may be reckoned to be ordered through an imperfect zygonic constant system. This is not, of course, to minimise the importance of the dynamic constrasts that *do* exist (see, for example the transitions between bars 42 and 43, and 138 and 139), but to acknowledge that only a relatively small range of values is used from an extensive perspective domain (cf. p. 280). Again, networks of zygonic relationships may be deemed to link different renditions of the sonata and performances of other stylistically congeneric works. See figure 12.2.

The first movement of K. 333 is subject to many forms of perceived temporal organisation. Fundamental to its existence as a perceptual unity is the fact that the movement occupies only a narrow slice of perceived time, and that all values of fix pertaining to a given performance can therefore be considered to be imperfectly zygonically related. Interterpretively, the durations of different performances may be zygonically linked too (see figure 12.3—the assumption here being that each performer, except Richter, was aware of at least one of the other recordings). This variation notwith-

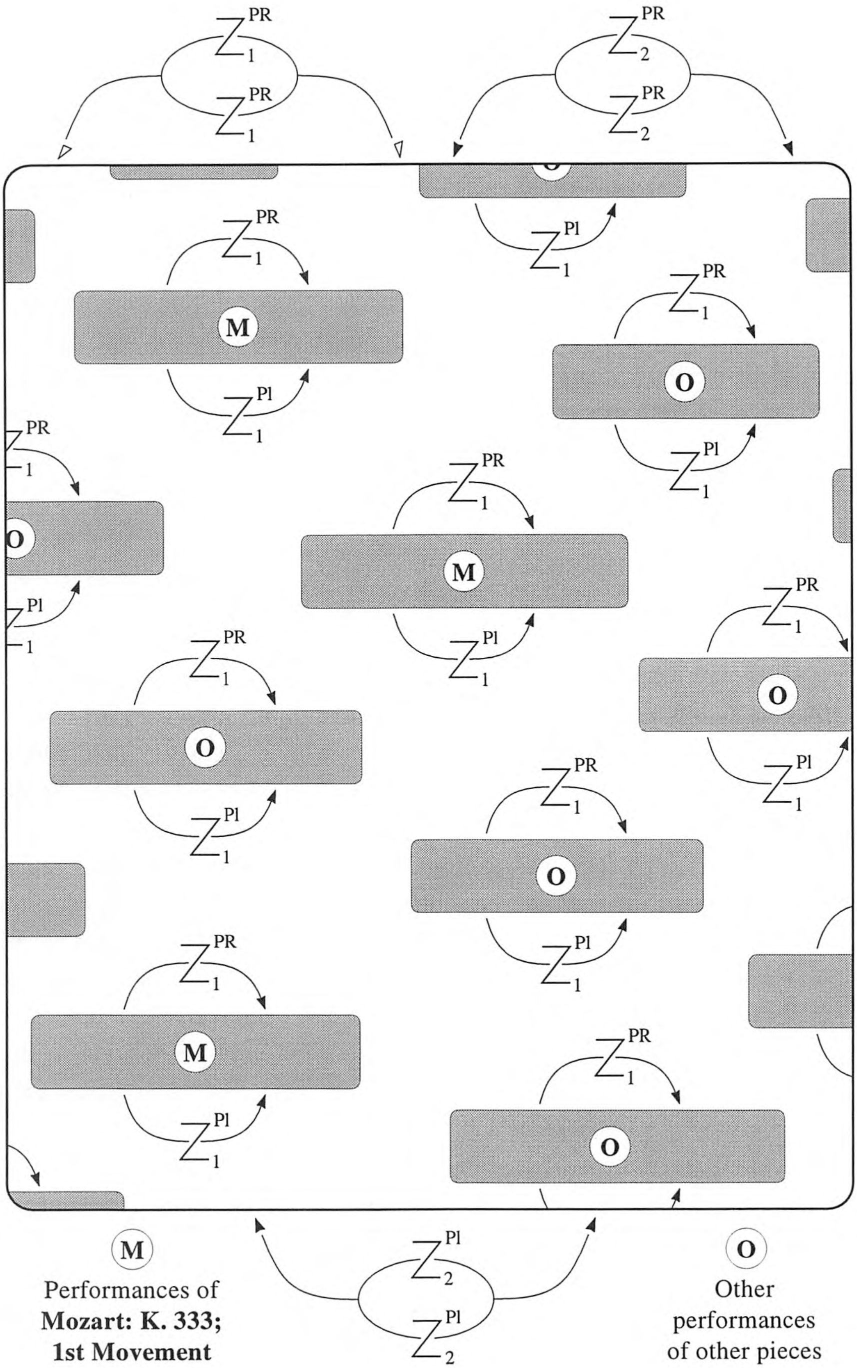
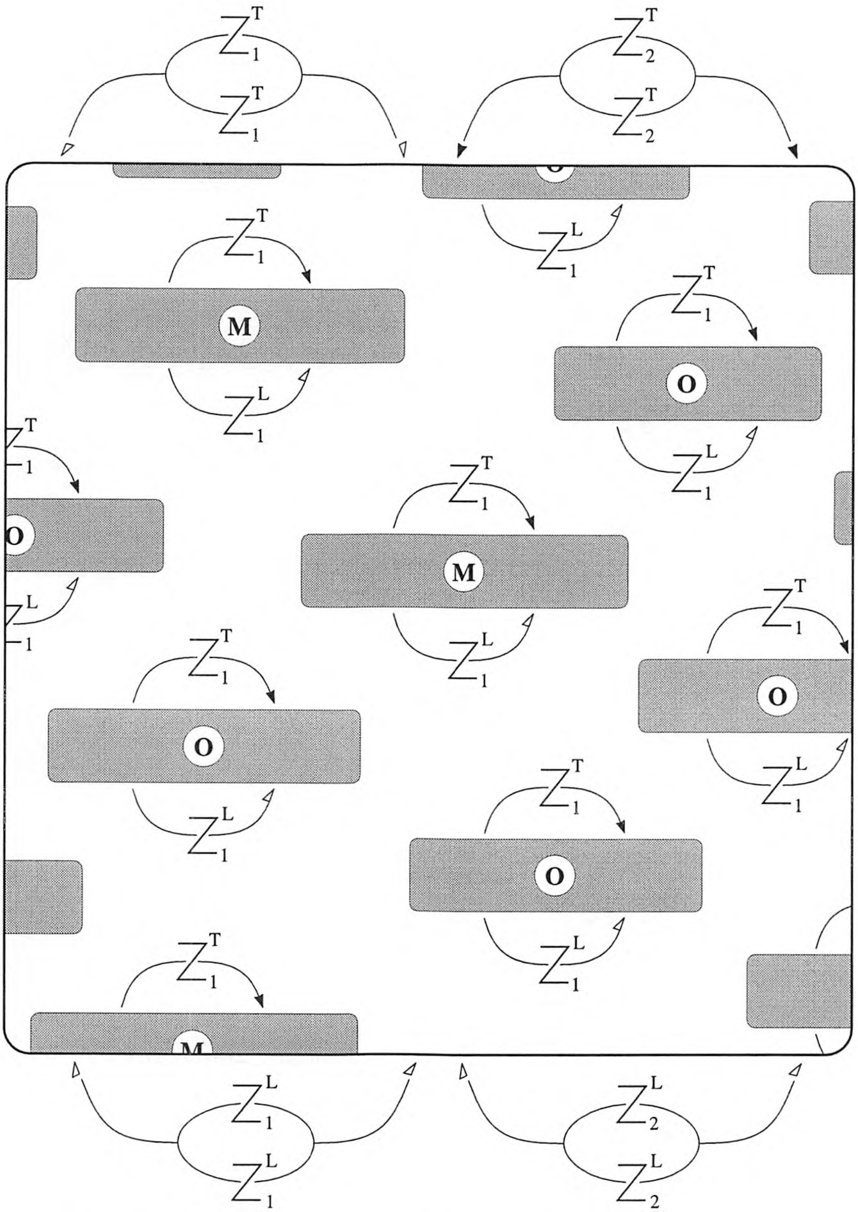


Figure 12.1 The ordering of perceived reverberation and plot pertaining to performances of Mozart's sonata K. 333, 1st movement.



(M) Performances of **Mozart: K. 333; 1st Movement**

(O) Other performances of stylistically congeneric pieces with similarly constrained dynamic envelopes (such as K. 331, K. 545, K. 570, K. 576, ...)

Figure 12.2 The ordering of timbre and loudness pertaining to performances of K. 333, 1st movement, and stylistically congeneric pieces.

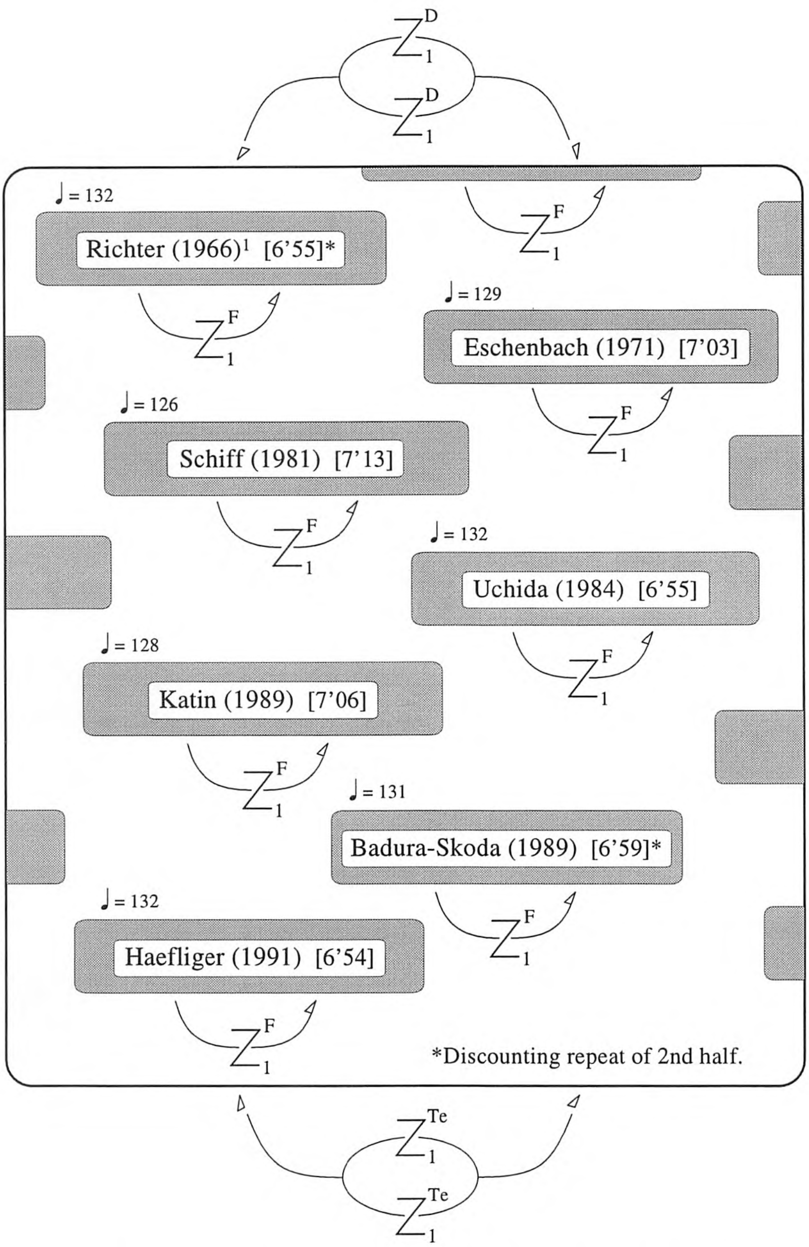
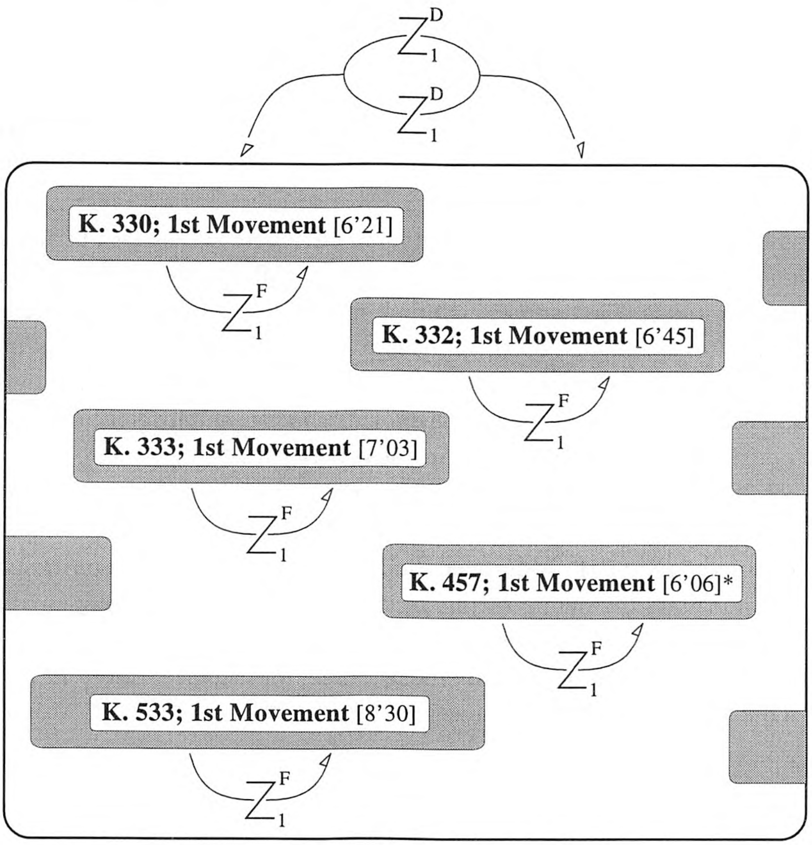


Figure 12.3 Intraterpretive zygonic relationships of fix, interterpretive relationships of duration, and interterpretive relationships of tempo linking different performances of the first movement of K. 333.

[1]Data taken from the following CDs: Richter—*Le Chant du Monde* (PR 254 026); Eschenbach—*Deutsche Grammophon* (419 452-2); Schiff—*Decca* (443 717-2); Uchida—*Philips* (412 616-2); Katin—*Olympia* (OCD 234); Badura-Skoda—*Astrée* (E 8684); Haefliger—*Sony* (SK 46748).

standing, the duration of the movement is broadly typical of a number of others from the same stylistic milieu.[2]



*Discounting 2nd repeat

Data from the recordings by Eschenbach (1971)

Figure 12.4 Interteroperative zygonic relationships of duration (and intraterpretive relationships of fix) in the first movements of Mozart sonatas.

[2]In fact, it is slightly longer than most other comparable movements by Mozart, for example. While these differences may well be significant in certain analytical contexts (and may even reflect ordering of different type, such as a gradual increase in length over a given period of stylistic development), it is worth stressing again that the aim here is to demonstrate the *similarities* that are present, and the perceived order that stems from these. The key issue is that, in comparison with the range of movement lengths that is conceivable, Mozart chooses a relatively restricted range of values (cf. pp. 448 and 449).

Inter-onset intervals (that is, the differences between adjacent values of prefix) vary according to performers' choice of tempo and use of rubato, but exist in round terms between 𝅘𝅥𝅰 and 𝅗𝅥 where ♩ = c.130 (cf. p. 326). Moreover, notes tend to follow each other without a cessation in perceived sound, and the longest silence lasts only for a ♩ (again, where ♩ = c.130); cf. p. 327. Hence intraoperative organisation is indicated as follows (see figure 12.5). Furthermore, since these features are typical of pieces in similar style, interoperative ordering can be considered to function along the following lines (figure 12.6).

An essentially regular beat, common to the whole texture (see p. 336), is maintained throughout the movement—cf. p. 330. Again, there are interoperative links. The tempo is within a range characteristic of other comparable movements (p. 333); see figure 12.7. Different performers may choose very similar tempi, indicating interterpretive imitation. See figure 12.3. Metre—𝄴—is constant. The choice of metre, and its constancy, may be considered to be derived interoperatively (figure 12.7).

RML (relative metrical location) invariably conforms to the framework illustrated in figure 12.8, in which bars are divided into a hierarchy of pulses based on the ratio 2:1. Moreover, the RML of notes is further constrained. To demonstrate the nature of this ordering, consider that, taking any two consecutive strata in the metrical hierarchy, notes may be 'on the beat (or sub-beat)' or 'off the beat (or sub-beat)'. See, for instance, figure 12.8.

This distinction may be represented thus:

● ←—— 'on the (sub)beat'
○ ←—— 'off the (sub)beat'

For example, at the level of ♩s: ● ○ ○ ○ ● ○ ○ ○
At the level of ♪s: ● ○ ● ○ ● ○ ● ○

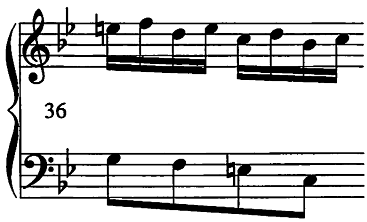



Figure 12.9 Representation of 'on the (sub)beat' and 'off the (sub)beat' at the different levels in K. 333.

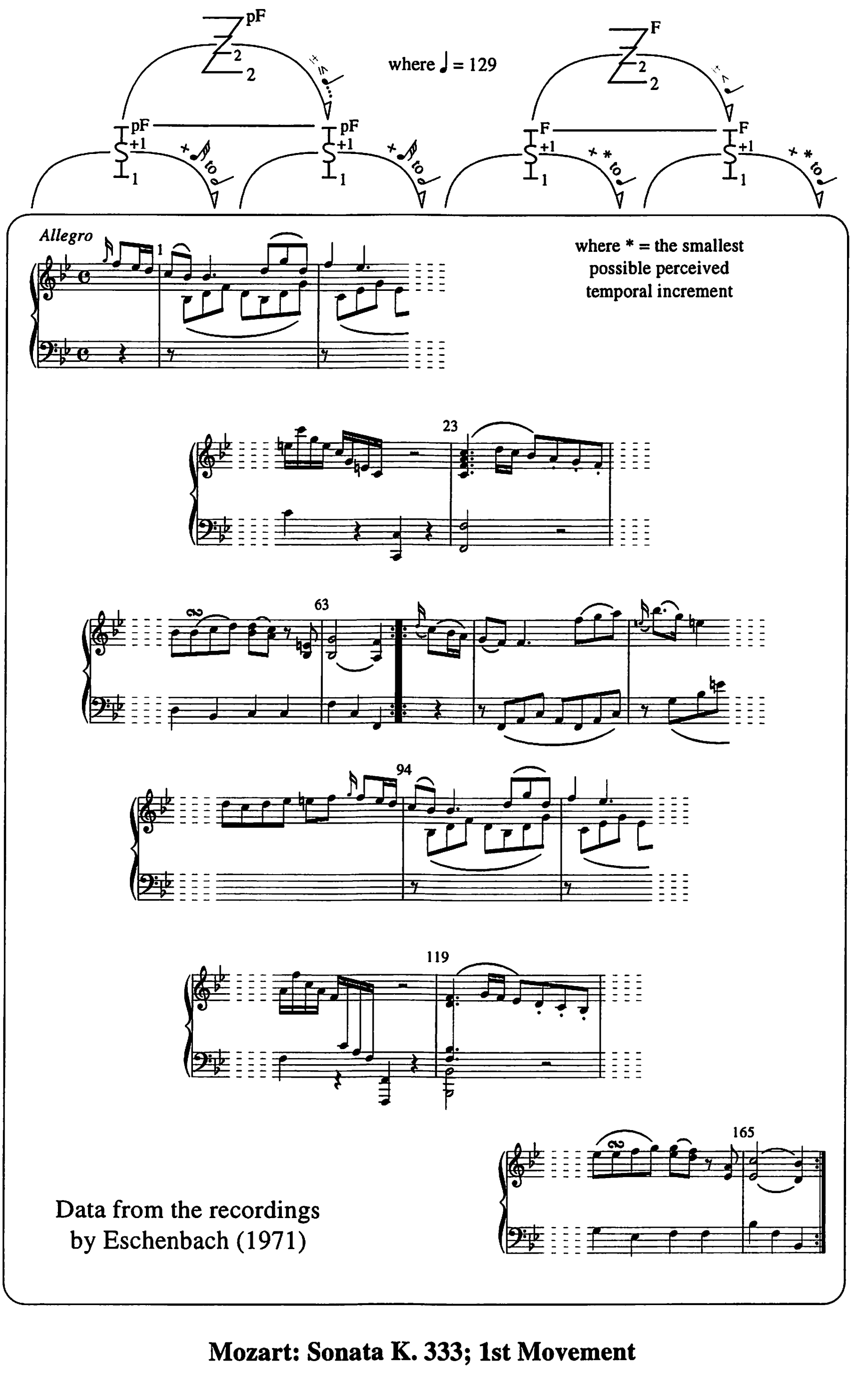
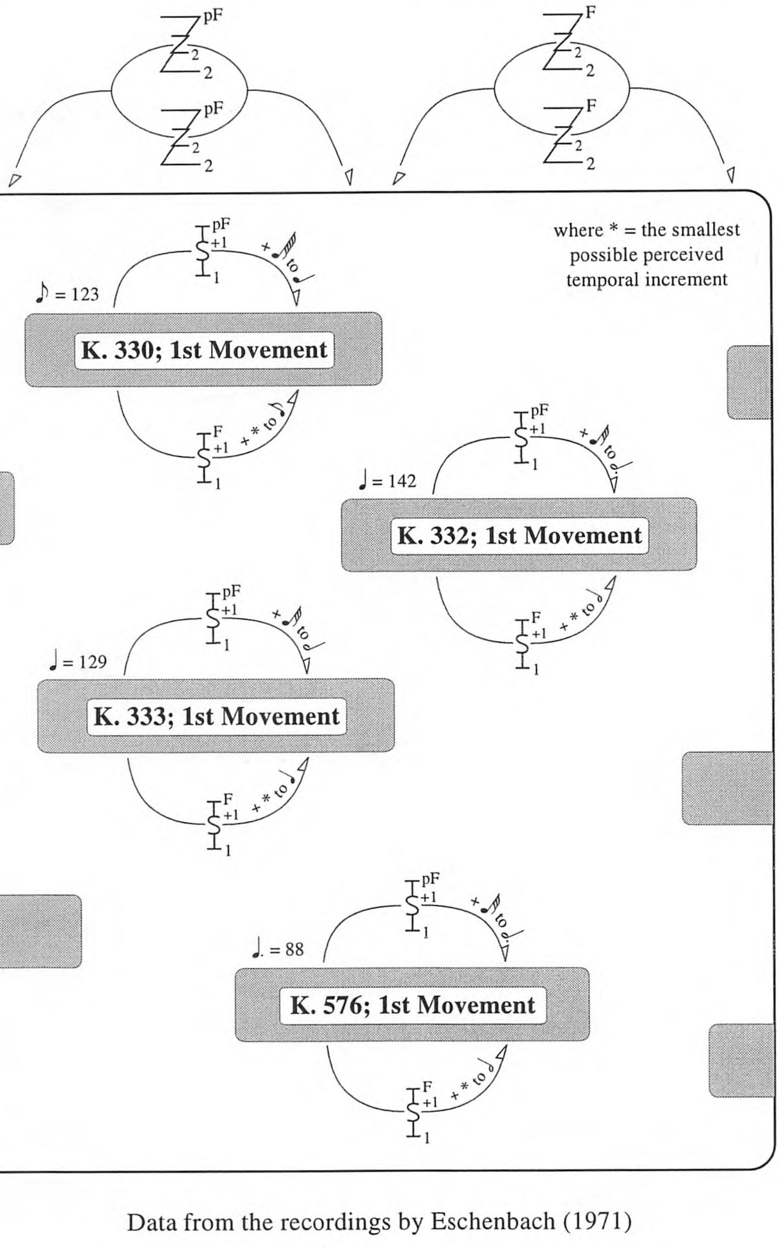
Mozart: K. 333; 1st Movement

Mozart: Sonata K. 333; 1st Movement

Figure 12.5 The intraoperative ordering underlying the fact that notes succeed one another within a narrowly defined range of interperspective values of prefix, and with little or no cessation in perceived sound.



Data from the recordings by Eschenbach (1971)

Figure 12.6 The interoperative ordering (in Mozart piano sonatas) underlying the fact that notes succeed one another within a narrowly defined range of inter-perspective values of prefix, and with little or no cessation in perceived sound.

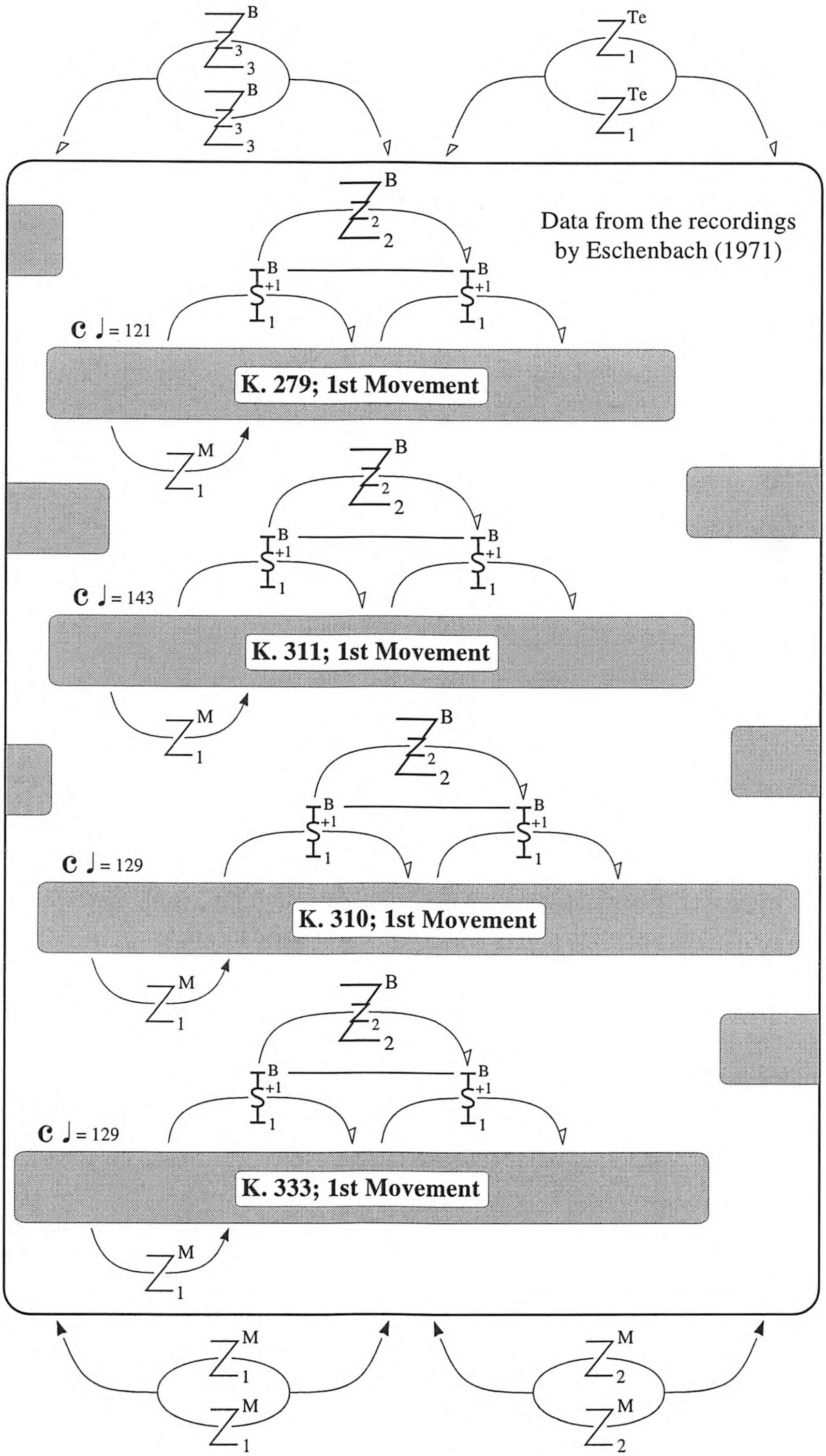


Figure 12.7 The ordering of beat, tempo and metre.

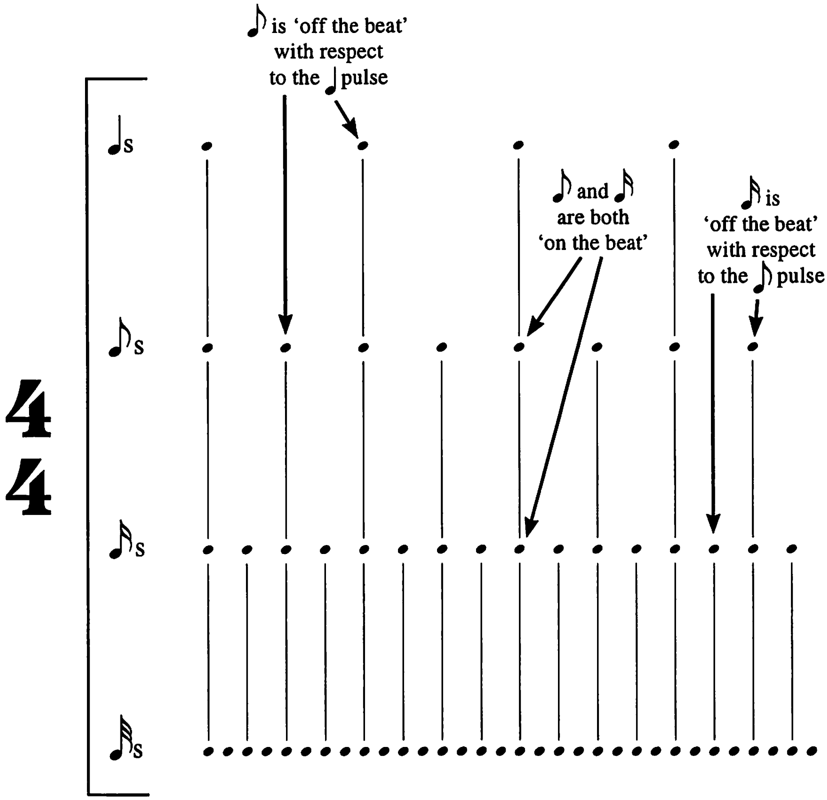


Figure 12.8 Notes that are 'on the (sub)beat' and 'off the (sub)beat', with respect to different pulses in the metrical hierarchy.

Without exception, in considering the texture as a whole, 'off-beat' notes (at any level in the metre) immediately precede or are followed by a note or notes that are 'on the beat' on a higher stratum in the metrical hierarchy. This principle applies up to and including the level of complete bars. That is, given an 'off-beat' note, one of the following models invariably applies:

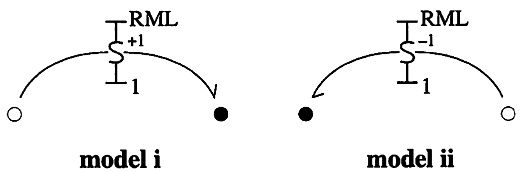


Figure 12.10 Notes that are 'off the (sub)beat' invariably precede (model i) or are followed by (model ii) notes that are 'on the (sub)beat'.

This feature may be deemed to be zygonically ordered, both intra-operatively and interoperatively (see figure 12.11).

The set of durations used in the first movement of K. 333 is as follows (observe that these correspond closely to the interperspective values of prefix between successive notes—cf. p. 372).[3,4]

duration	𝅘𝅥𝅱	𝅘𝅥𝅰	𝅘𝅥𝅮	𝅘𝅥𝅮.	♩	♩‿𝅘𝅥𝅰	♩.	𝅗𝅥
number of appearances (total **2682**)	164	1347	863	3	239	3	26	37

Values exist over a range of values; for example, from ♩ = 126 to ♩ = 132 in the performances listed in figure 12.3.

Figure 12.12 The set of durations used in the first movement of K. 333 (cf. figure 9.40).[5]

[3] The assumption here and in subsequent tables is that trills and turns are performed as demisemiquavers.

[4] In performance, each value represents a range of values (cf. p. 356).

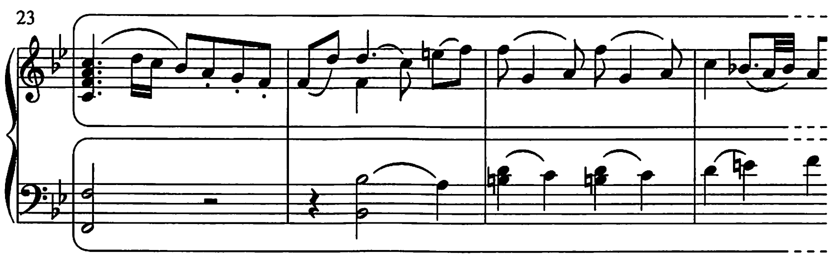
[5] These data, and those that follow, use the concept of perceptual 'streams' of sound—discrete linear strands in the musical texture. Each may contain 'harmonic blends' (comprising two simultaneous notes or more), as well as short periods of silence. For example, the following passage from the first movement of K. 333 consists of two streams, although the number of notes sounding at any one time fluctuates between one and six. As far as figure 12.12 is concerned, chords such as the first in the RH in the excerpt shown, constitute single components of the stream, and are therefore treated as individual durations.

Mozart: K. 333; 1st Movement

Figure 12.13 Two perceived 'streams' of sound in the first movement of K. 333.

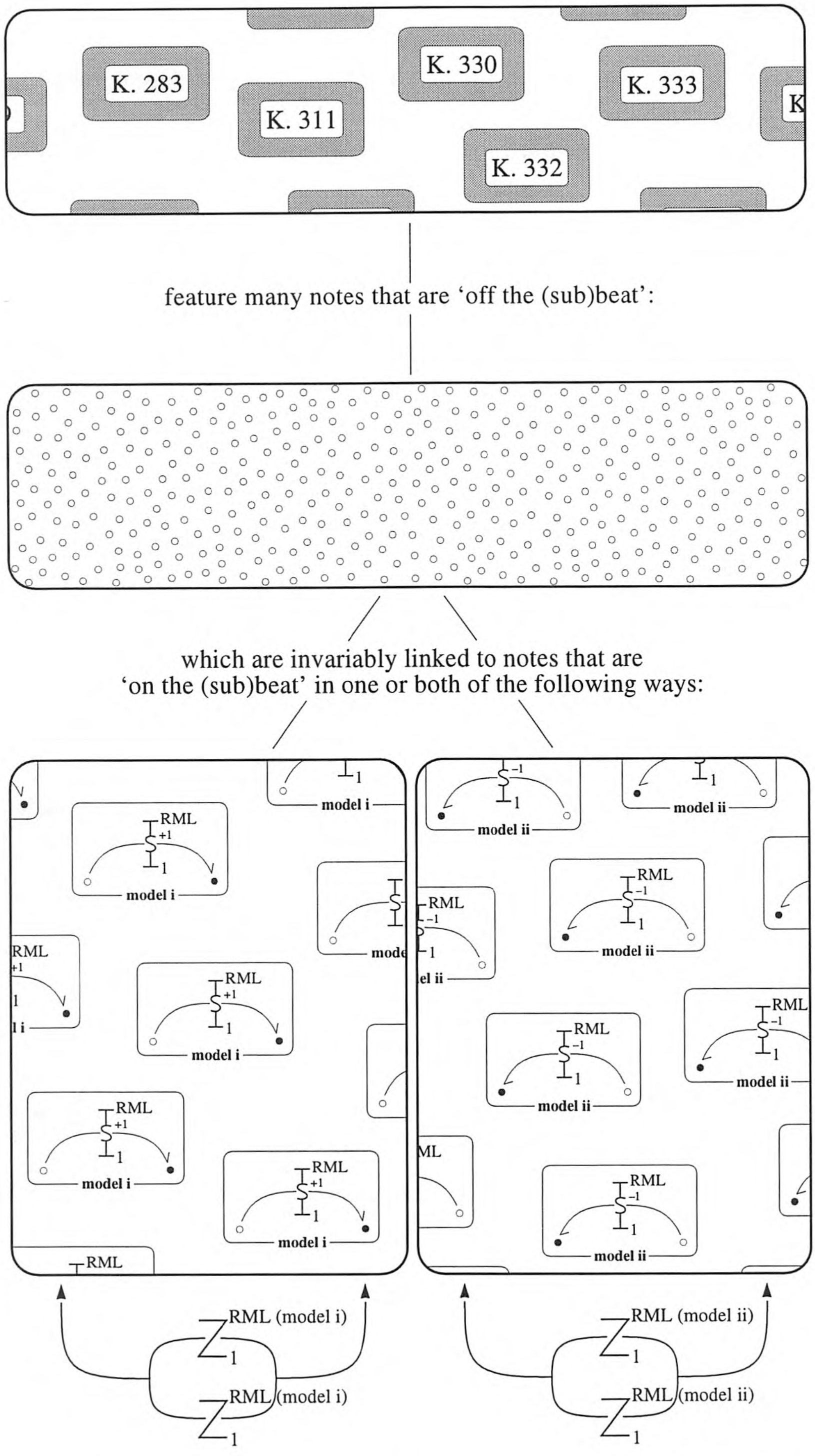


Figure 12.11 The intraoperative and interoperative ordering of RML in the Mozart piano sonatas.

The range of these values is limited (cf. figure 12.5) and the number of categories is small, implying intraoperative ordering of the following type:

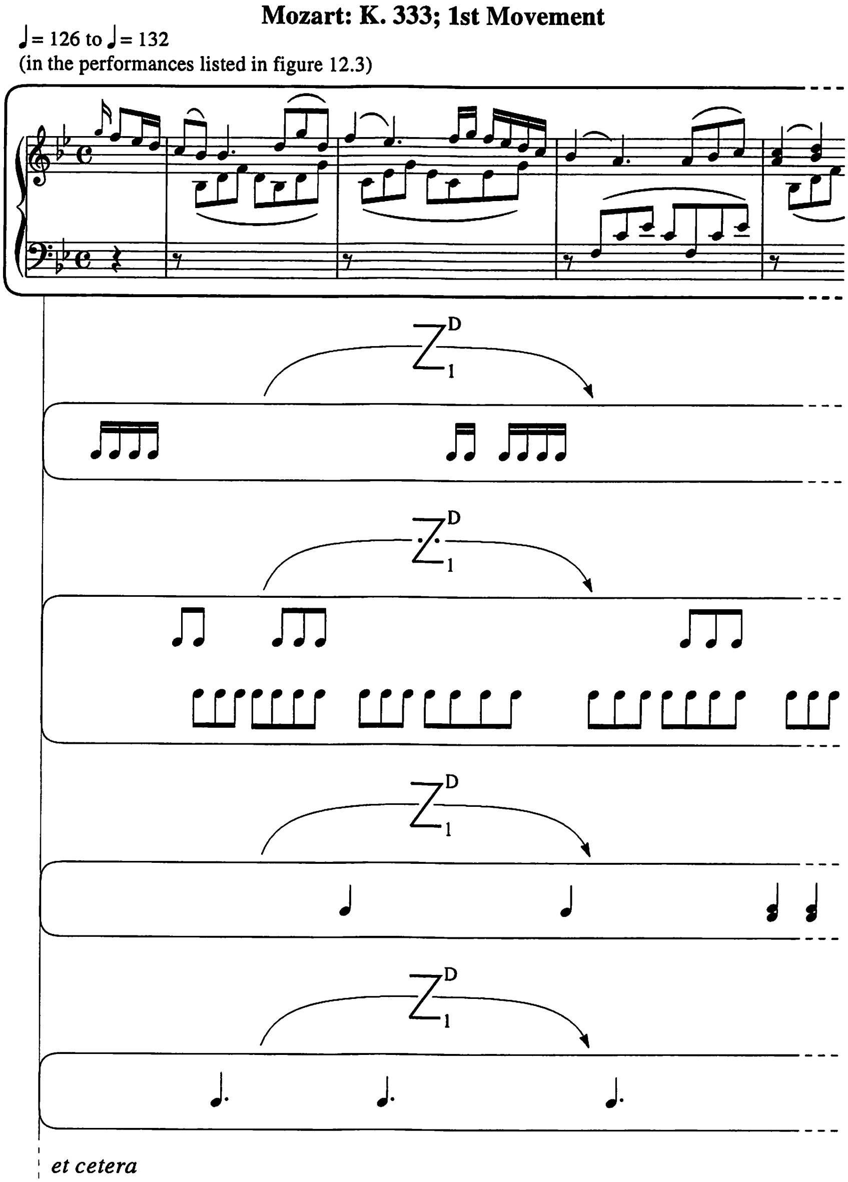


Figure 12.14 The intraoperative ordering of duration in K. 333 (cf. figure 9.41).

Both the range and number of durations are subject to interoperative imitation—see figure 12.15. The relative frequency with which these values appear is also characteristic of Mozart's style beyond the first movement of K. 333. For example, in this movement, and in the opening movements of K. 284, K. 310 and K. 311, 50% or more of all durations are 𝅘𝅥𝅯s, the next most frequently used duration is the 𝅘𝅥𝅮 (ranging from 12–32%), followed by the ♩ (8–9%), and the 𝅘𝅥𝅰 (5–7%). Together, these four durations make up 94–98% of the relative values that are used. Zygonic interoperative control is implied as follows (see figure 12.16).

Similarly, the distribution of inter-onset ratios (the ratios between adjacent primary interperspective values of prefix)[6] is tightly controlled, both intraoperatively and interoperatively. A given primary value of prefix is, by

[6]Again, these are taken to exist within separate rhythmic streams. For example:

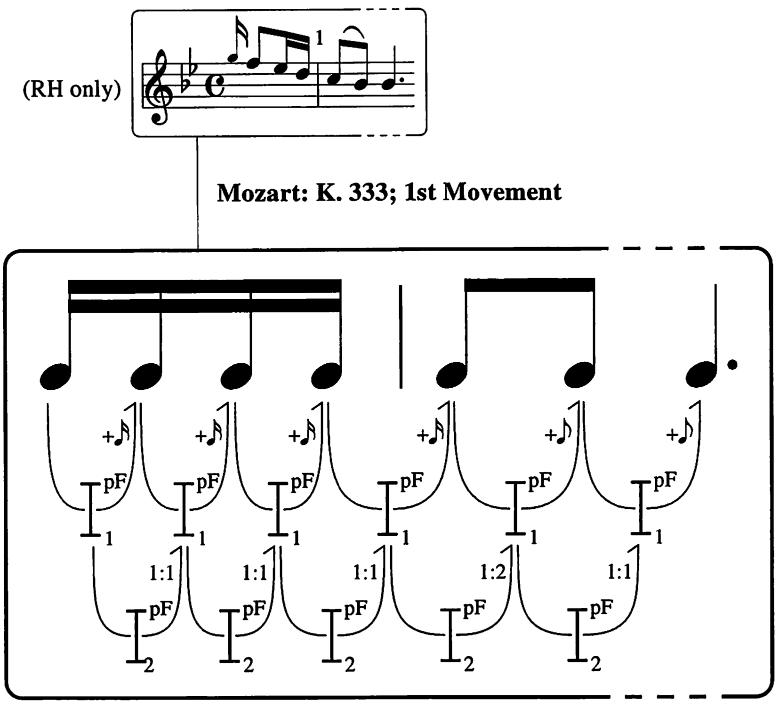


Figure 12.17 Series of inter-onset ratios between adjacent pimary interperspective values of prefix from the first movement of K. 333.

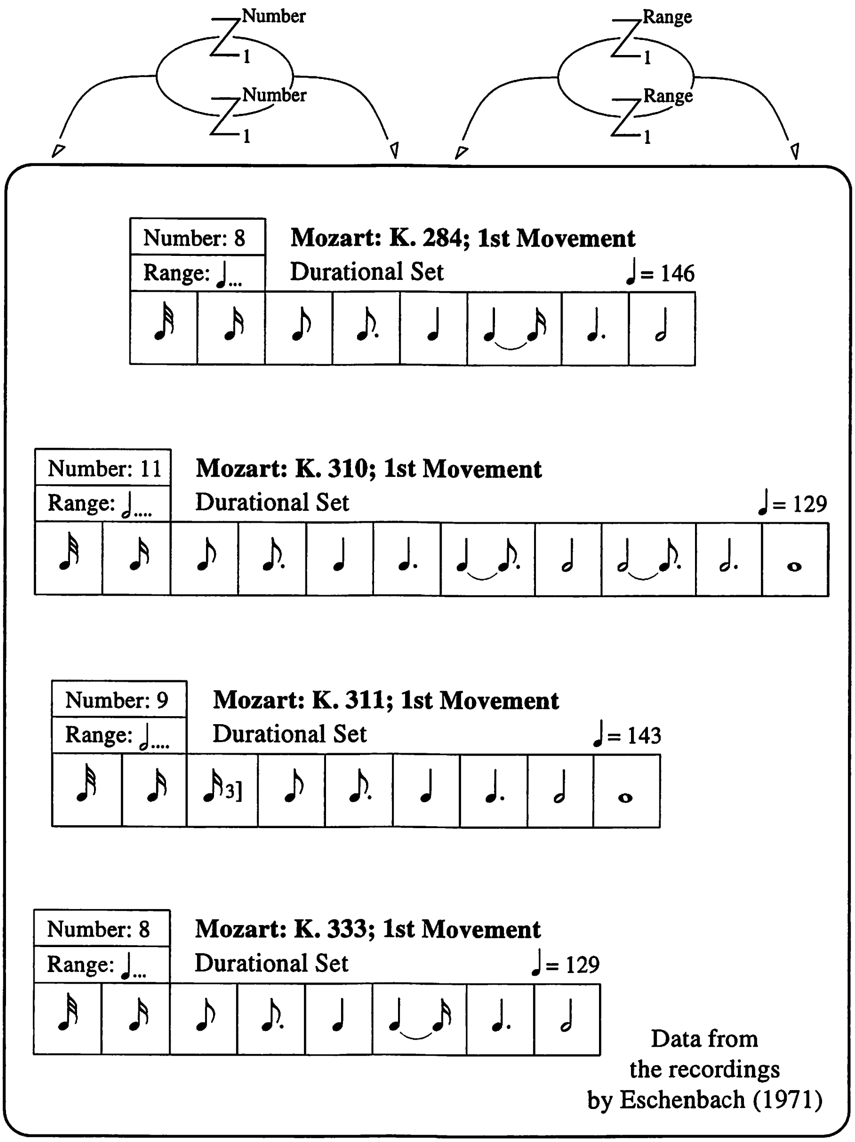


Figure 12.15 The interoperative ordering of number and range in the durational sets of the first movements of K. 333 and stylistically congeneric sonatas.

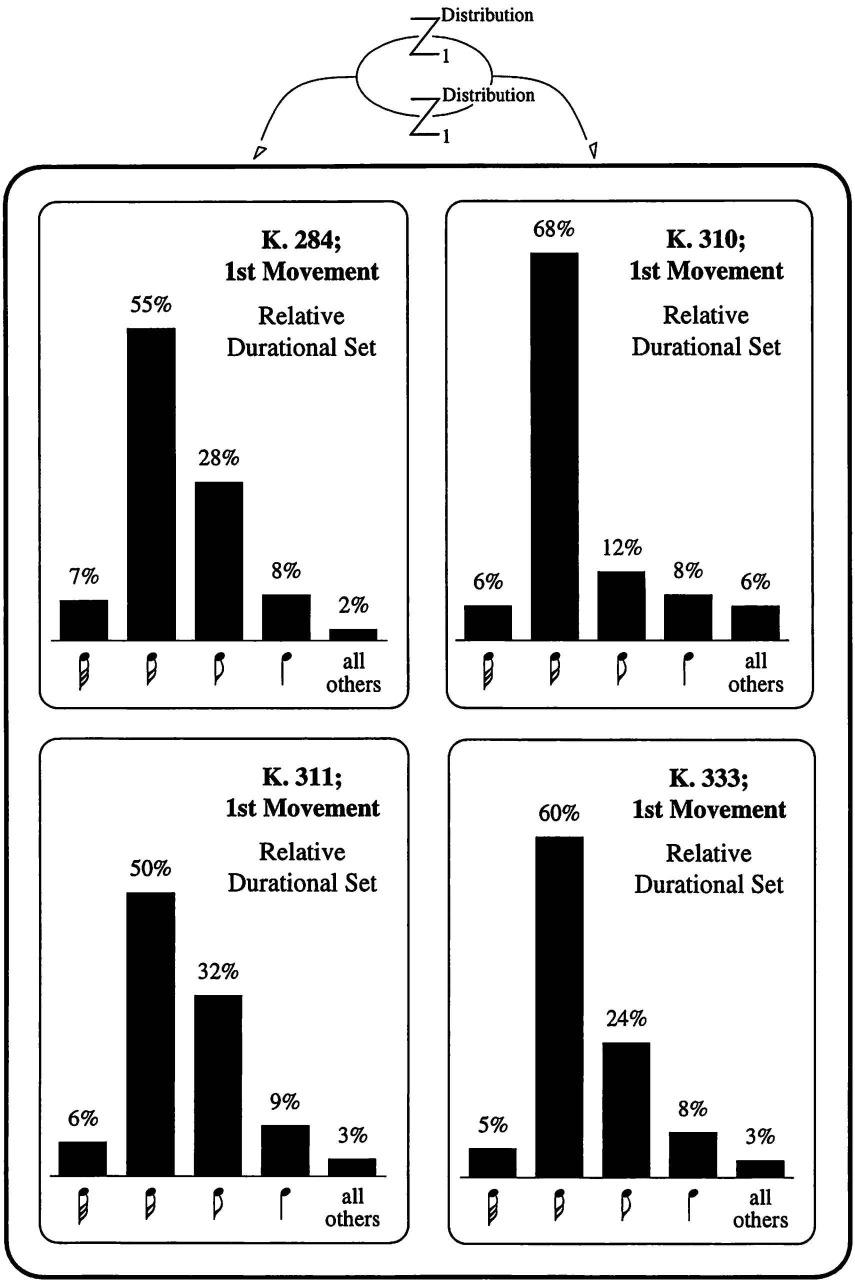


Figure 12.16 The interoperative imitation of the distribution of relative durational values in the first movements of K. 284, K. 310, K. 311 and K. 333.

a considerable margin, most likely to be followed by another the same (this occurs in just over 78% of cases).[7] The ratios 1:2 and 2:1 appear with the next greatest frequency (6% each). Only two other ratios are used in more than 1% of cases—3:1 and 1:4. Here are the full details:

inter-onset ratio	1:1	1:2	2:1	1:3	3:1	1:4	4:1
frequency of occurrence (%)	78.25%	6.27%	5.78%	0.97%	1.42%	1.64%	0.86%

inter-onset ratio	1:5	5:1	1:6	6:1	1:8	8:1
frequency of occurrence (%)	0.41%	0.86%	0.19%	0.34%	0.41%	0.71%

inter-onset ratio	9:1	1:12	17:1	1:32	2:3	3:2
frequency of occurrence (%)	0.07%	0.04%	0.04%	0.04%	0.37%	0.22%

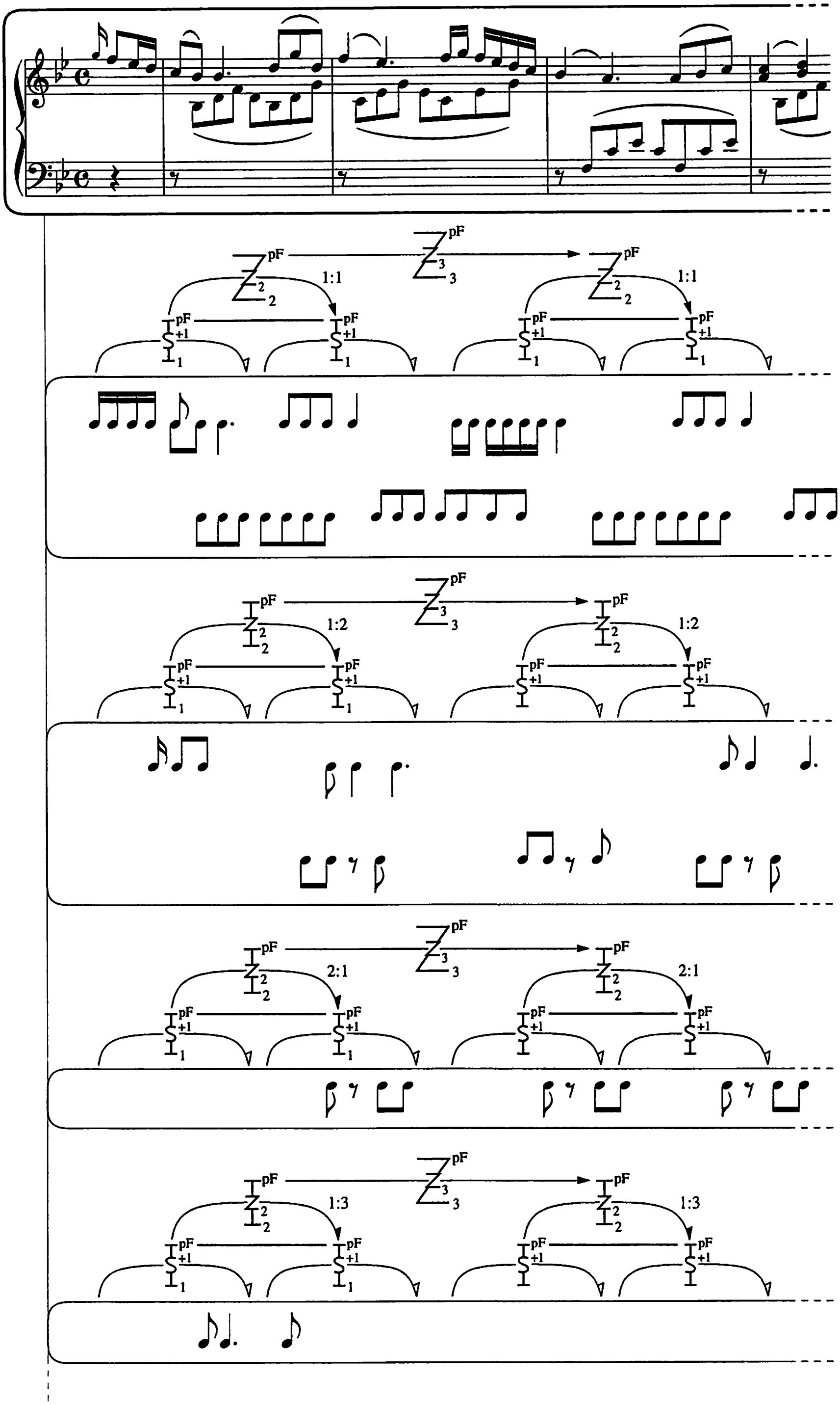
inter-onset ratio	2:5	5:2	2:9	2:17	4:3	4:5
frequency of occurrence (%)	0.34%	0.07%	0.07%	0.04%	0.15%	0.34%

Figure 12.18 Inter-onset ratios between adjacent primary interperspective values of prefix in the first movement of K. 333.

Hence, intraoperative order is implied as follows (see figure 12.19), and, since the distribution shown is typical of other pieces too, interoperative imitation is indicated—figure 12.20.

[7]Moreover, since the perceived temporal interval between adjacent prefixes tends to correspond to the duration pertaining to the first, it is most probable that a duration will be succeeded by one the same.

Mozart: K. 333; 1st Movement



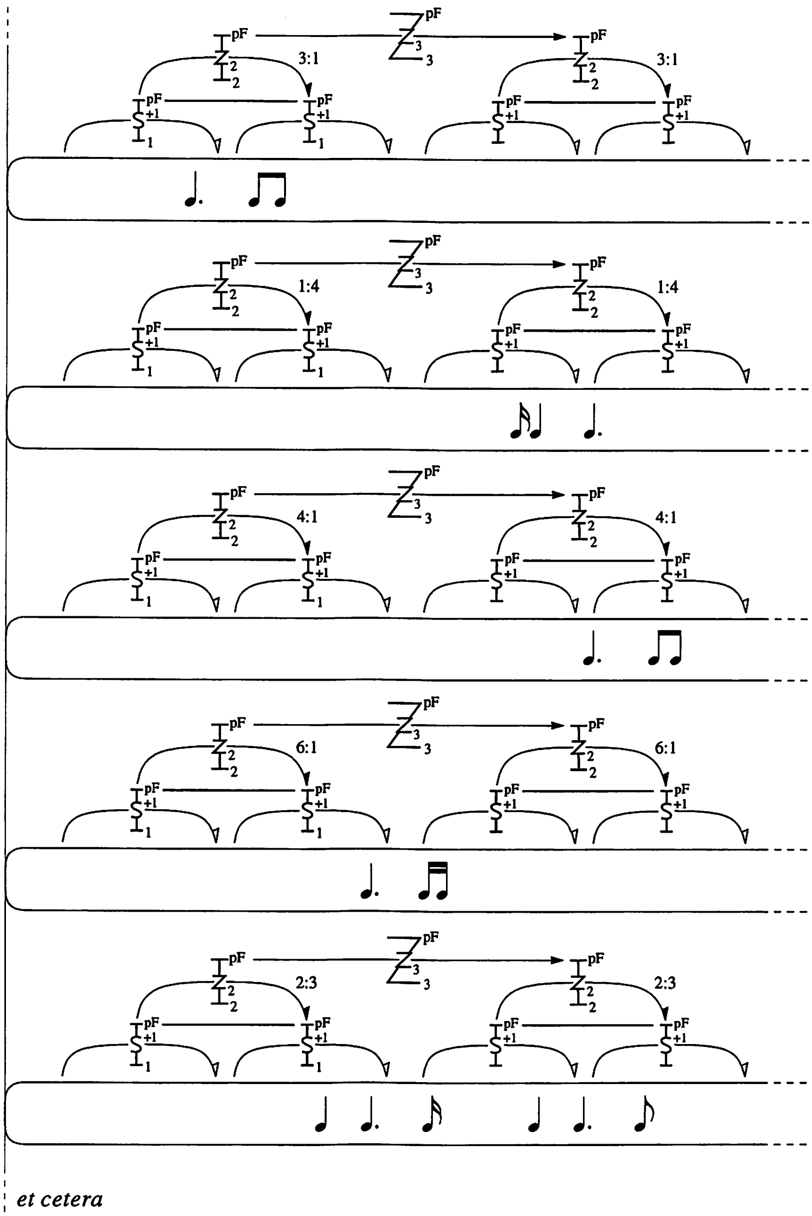


Figure 12.19 The intraoperative ordering of primary interperspective values of prefix in the first movement of K. 333.

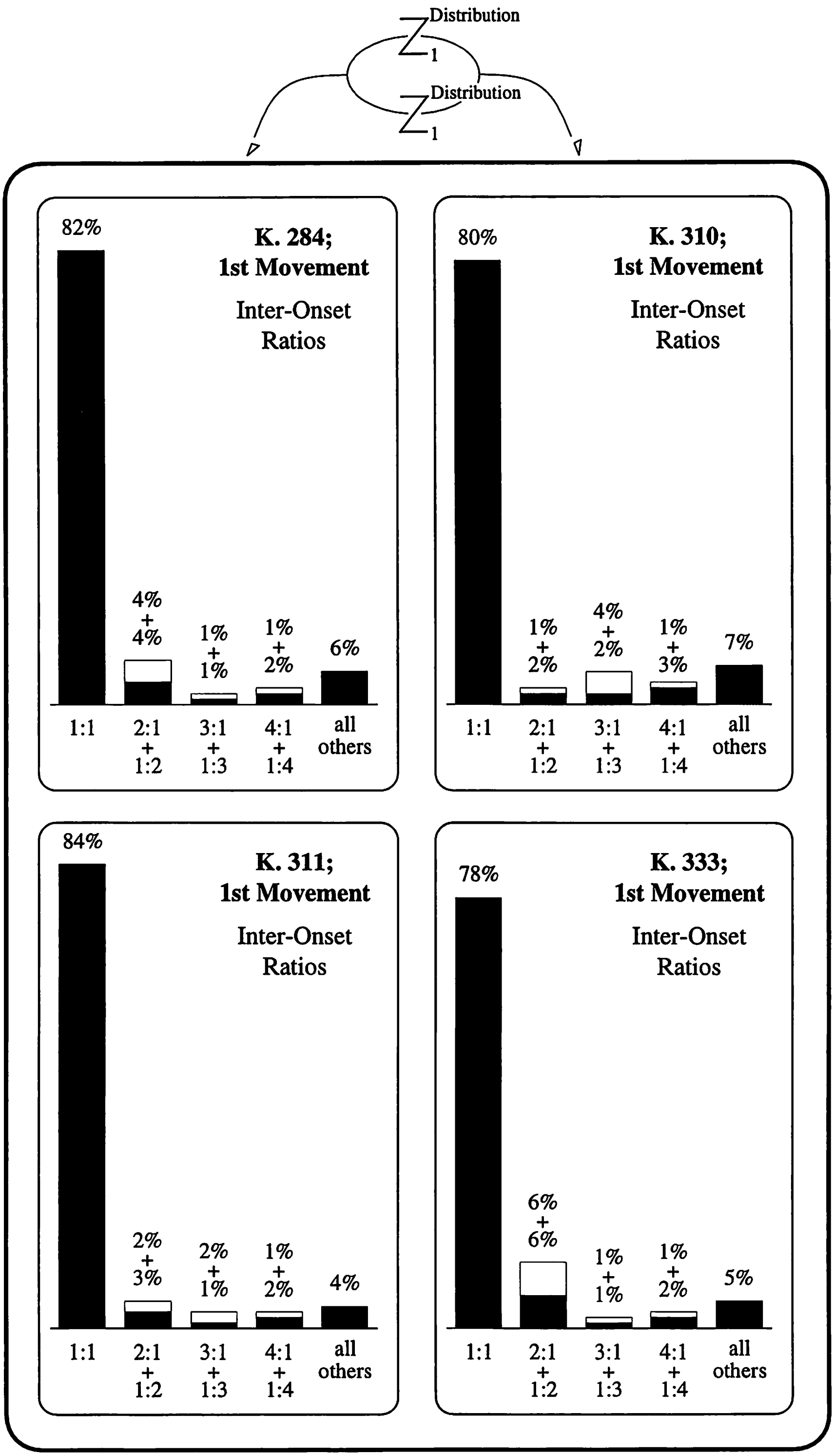


Figure 12.20 Interoperative imitation of inter-onset ratios.

The first movement of K. 333 largely runs with two parts sounding together (cf. footnote 5, p. 715), each hand typically delineating a discrete strand in the texture. This pattern is characteristic of many other pieces too, implying intraoperative and interoperative ordering through imitation:

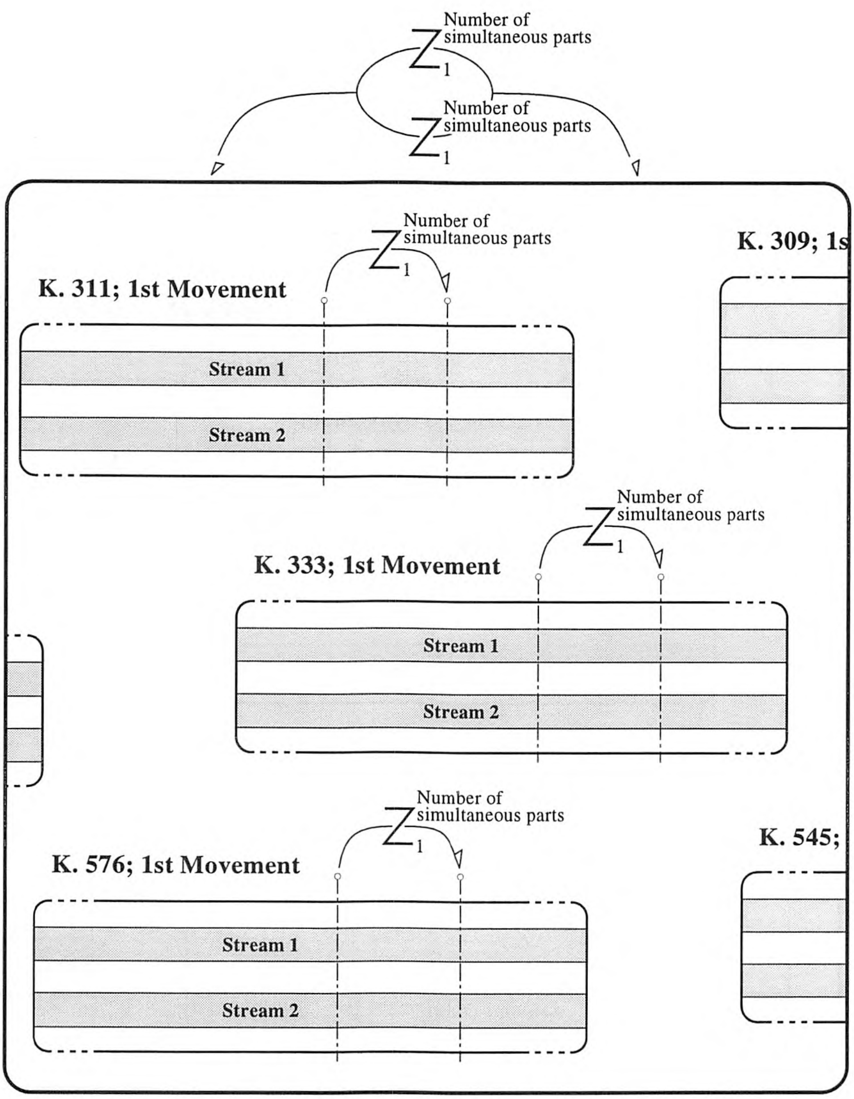


Figure 12.21 Intraoperative and interoperative ordering of the number of simultaneous parts in the first movement of K. 333 and other works.

In these two-part textures, the lines characteristically fulfil the roles of 'melody' and 'accompaniment'—the latter offering harmonic and rhythmic support to the former, which have greater immediate perceptual salience, and are typically the chief determinants of musical identity. At any given point, the melody is almost invariably above (that is, higher in pitch than) the accompaniment, implying zygonic control of the following type:

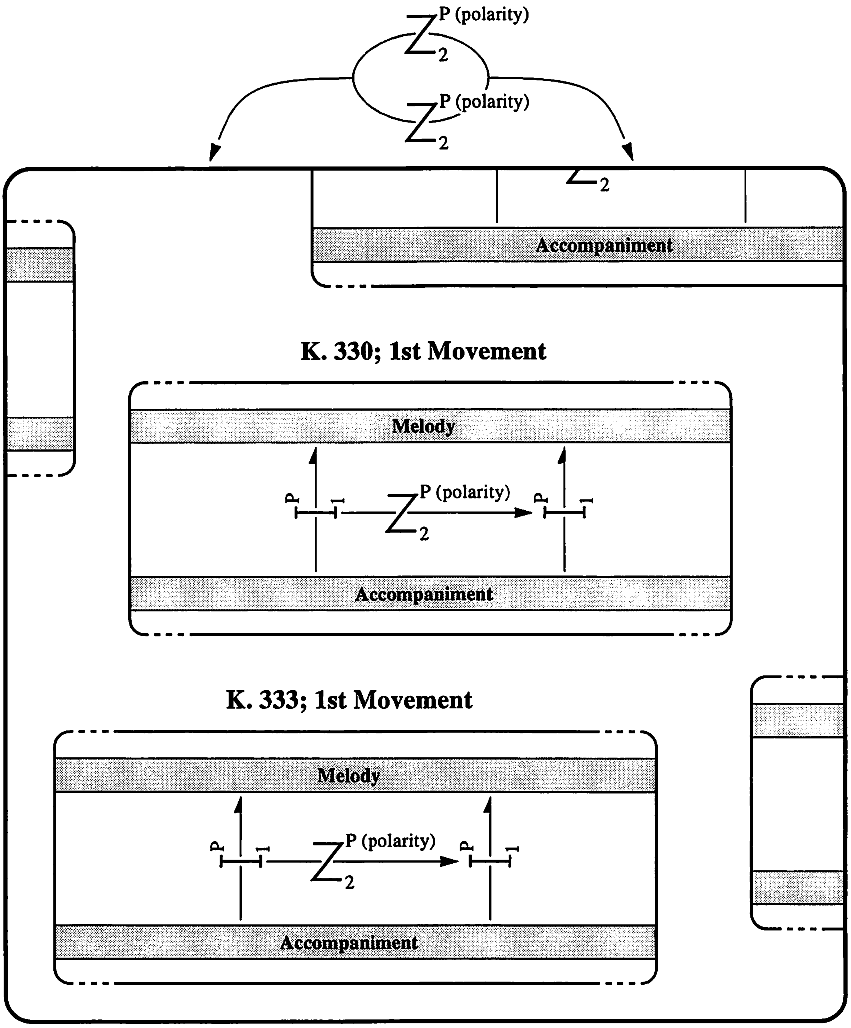


Figure 12.22 The characteristic relative disposition with regard to pitch of 'melody' and 'accompaniment' in Mozart's two-part textures.

The following pitches are used in the first movement of K. 333:[8]

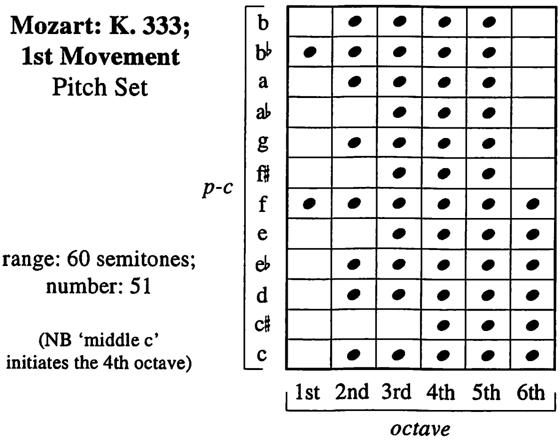


Figure 12.23
The pitch set of Mozart, K. 333, first movement.

Many of these values make a number of appearances,[9] implying the operation of intraoperative zygonic constant systems (see figure 12.24).

The pitch set is similar to those used by Mozart in other first movements of piano sonatas (despite their different keys). Hence interoperative imitation may be deemed to function as shown in figure 12.25. Observe that the resemblance between pitch sets is particularly marked in the 3rd, 4th, 5th and 6th octaves. The range is clearly influenced by the compass of the pianofortes available to Mozart (cf. p. 4).

The pitches used fulfil distinct functions which relate to the *B♭* major tonality in which the movement is cast (cf. pp. 613ff). Conceptually, and, for the composer, performers and suitably attuned listeners, *per*ceptually, a single pitch-class set underlies the entire movement. This may be represented as follows, in which diatonic and chromatic members are distinguished through notes of differing durations (cf. pp. 475ff); see figure 12.26. Widespread interoperative zygonic links may be deemed to function as shown in figure 12.27.

[8]Enharmonic equivalence assumed.

[9]All notes are uniform in pitch, implying further intraoperative and interoperative ordering (cf. pp. 452ff).

Mozart: K. 333; 1st Movement

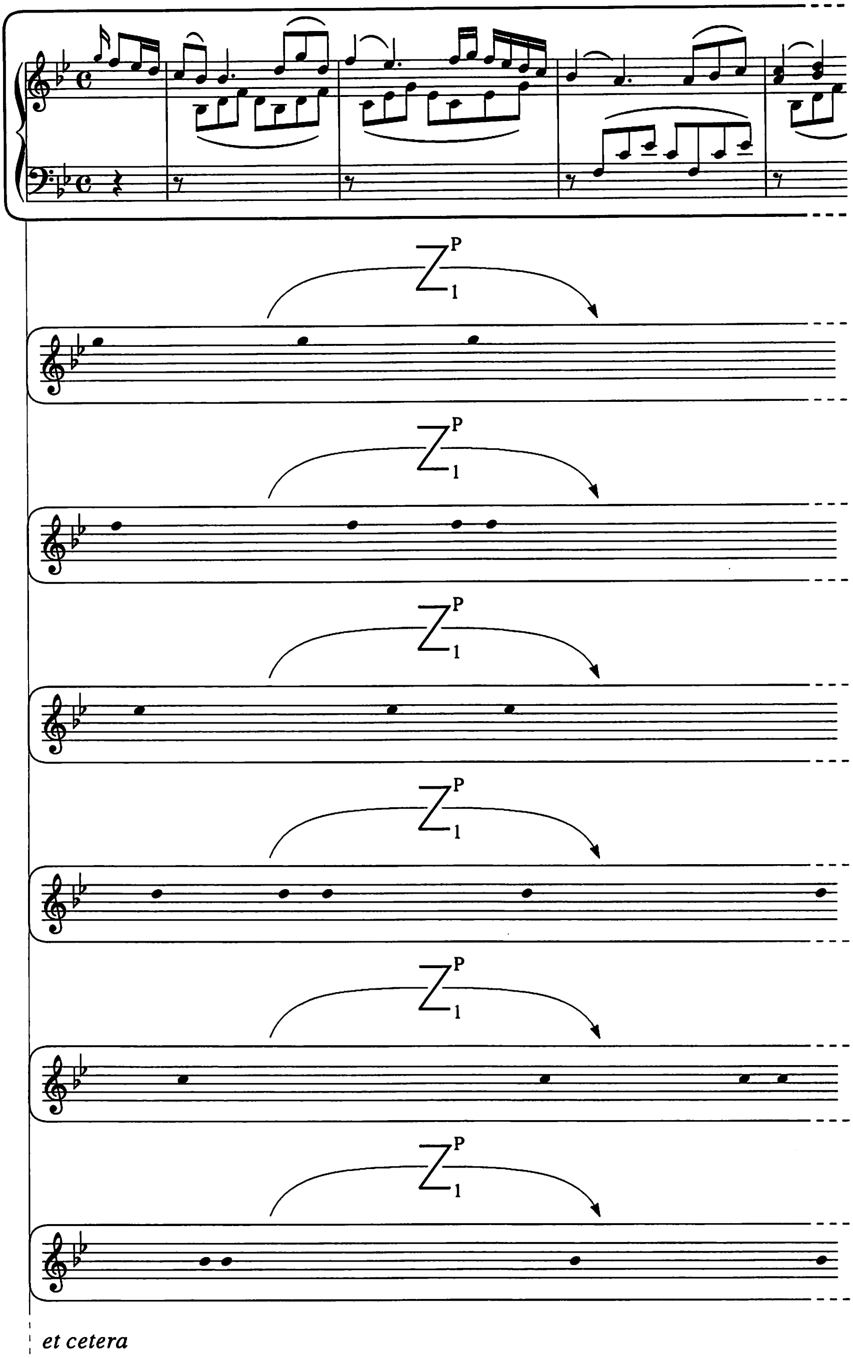


Figure 12.24 Examples of the intraoperative primary zygonic constant systems of pitch operating in the first movement of K. 333.

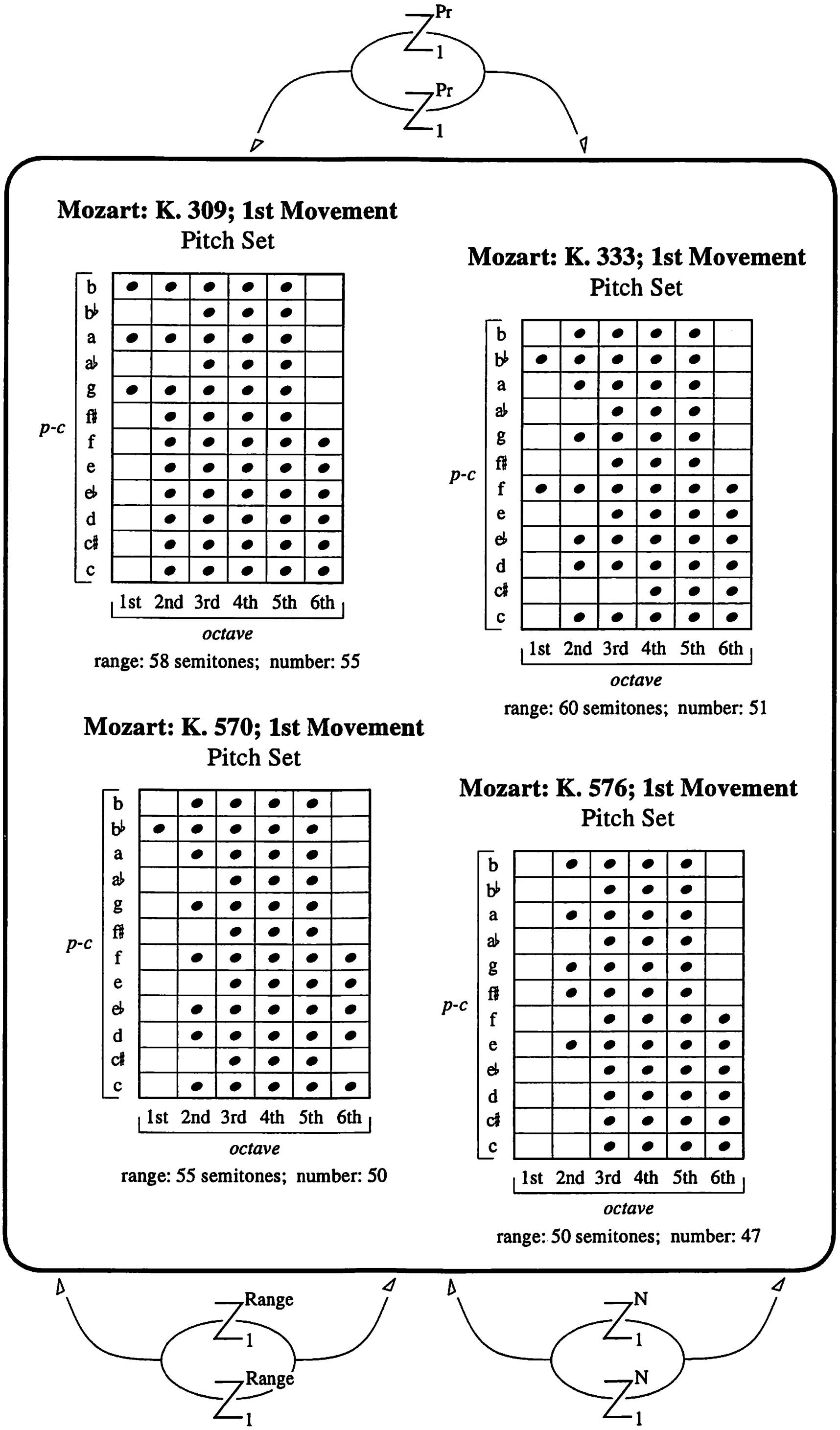


Figure 12.25 Interoperative imitation of the pitch sets used in the first movements of Mozart piano sonatas.

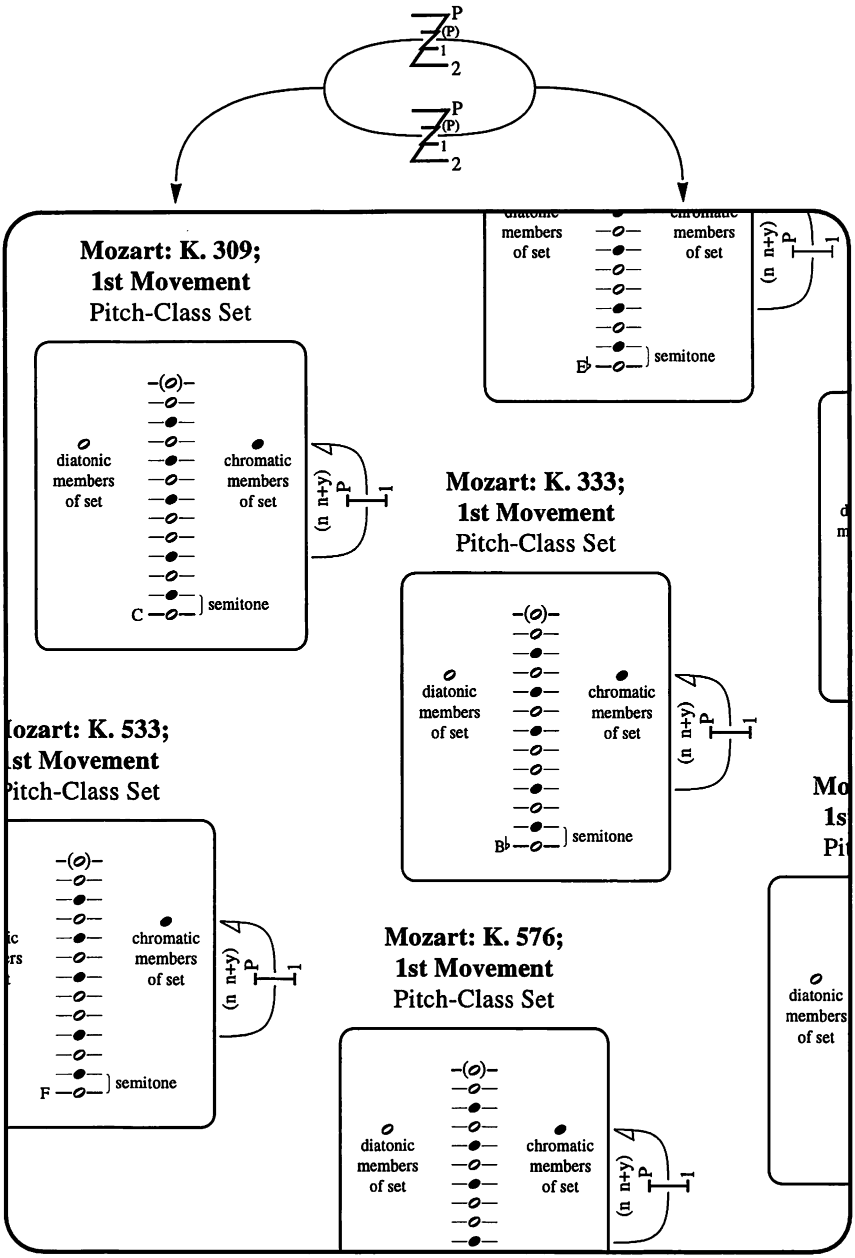


Figure 12.27 Interoperative ordering of pitch-class sets (cf. figure 10.45).

Mozart: K. 333; 1st Movement
Pitch-Class Set

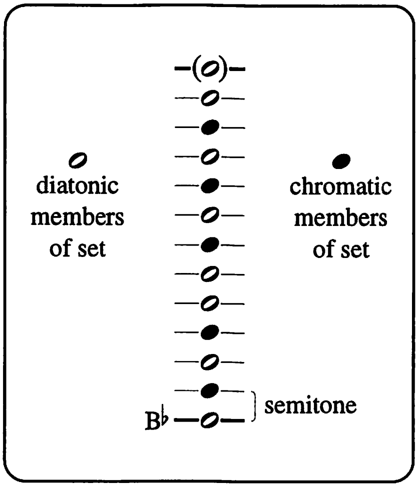


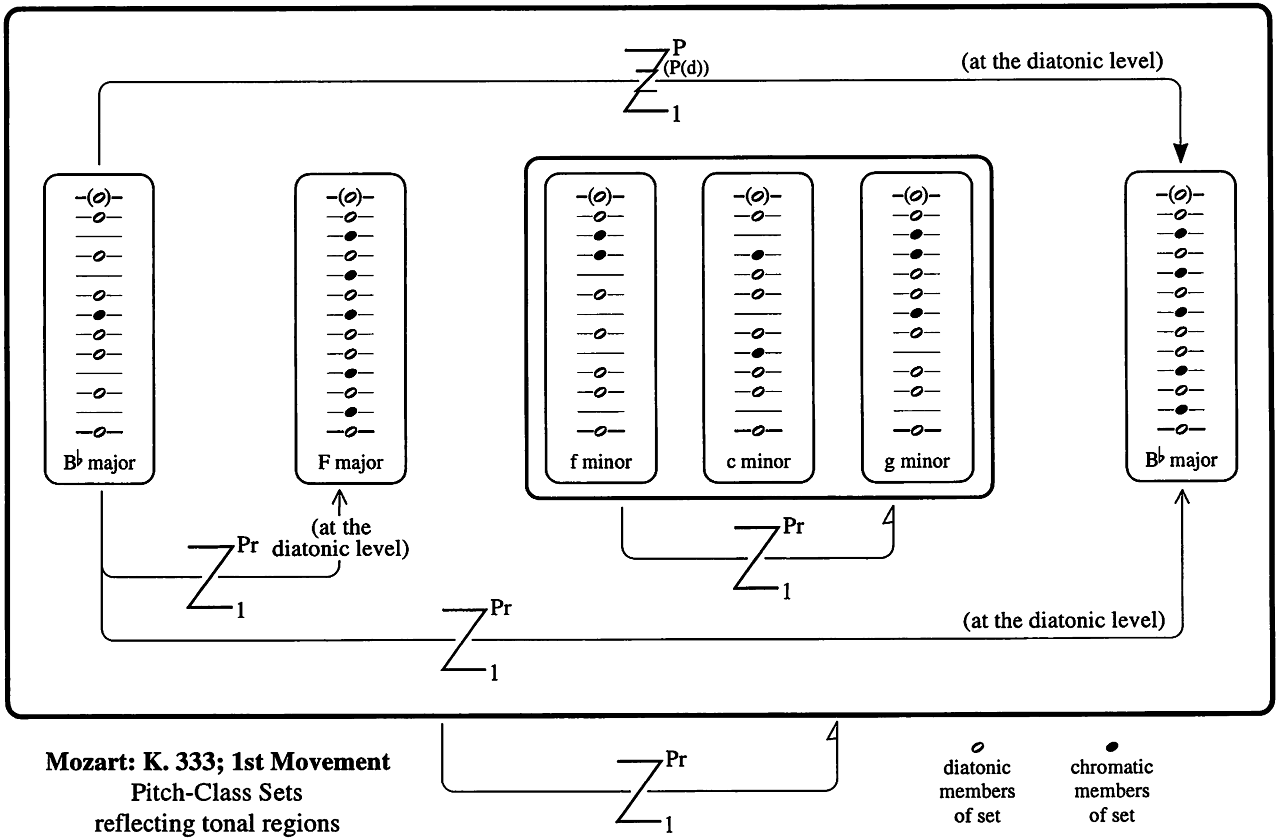
Figure 12.26 Pitch-class set of the 1st movement of K. 333.

It is possible to consider the movement as a series of pitch-class sets which reflect its changes of key. Intraoperative imitation is implied (see figure 12.28). Since this pattern of modulation is broadly typical of that found in many other pieces, interoperative links may be considered to operate as follows (see figure 12.29).

The intervals between adjacent notes in the melody (see figure 12.30) reveal substantial ordering in the movement as a whole. A little over 90% of the intervals used are a perfect 4th or smaller, and of the 43 different categories that appear, 10 occur on more than 2% of occasions (P1, m2↑, m2↓, M2↑, M2↓, m3↑, m3↓, M3↑, M3↓, P4↓) and account for around 88% of the total. Of these, M2s alone account for almost 39% of all melodic transitions. Hence, intraoperative ordering can be considered to operate as follows (see figure 12.31).

Moreover, the essential characteristics of this distribution are a feature of other pieces too, implying interoperative imitation of the following type (see figure 12.32).

Figure 12.28 Intraoperative imitation of pitch-class sets in the first movement of K. 333.



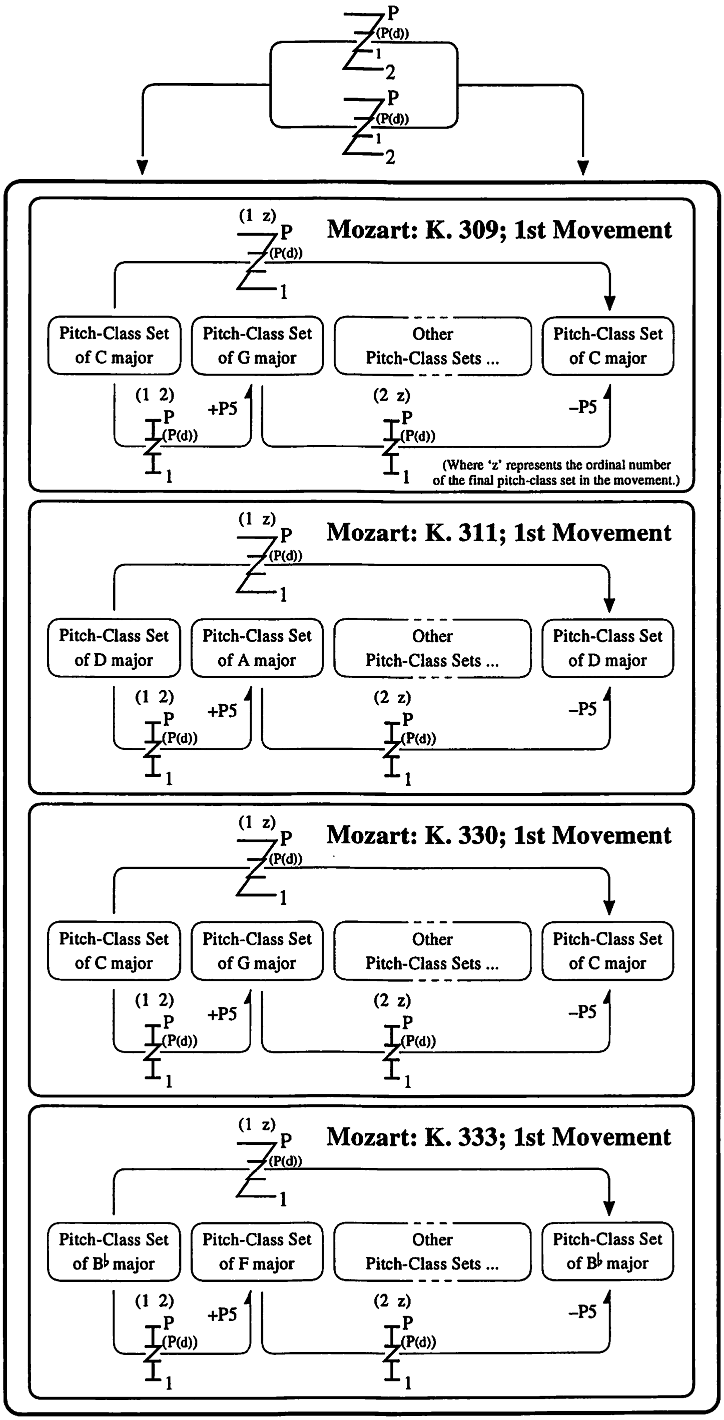


Figure 12.29 Interoperative imitation of pitch-class set transitions in Mozart piano sonatas.

interval	P1	A1↑	A1↓	m2↑	m2↓	M2↑	M2↓	D3↑
frequency of occurrence (%)	8.03%	0.88%	0.25%	10.48%	13.30%	14.55%	24.34%	0.06%

interval	D3↓	A2↑	A2↓	m3↑	m3↓	M3↑	M3↓
frequency of occurrence (%)	0.13%	0.06%	0.06%	5.14%	5.02%	2.01%	2.38%

interval	D4↑	D4↓	P4↑	P4↓	A4↑	D5↑	D5↓
frequency of occurrence (%)	0.13%	0.13%	0.82%	2.26%	0.06%	1.00%	0.13%

interval	P5↑	P5↓	m6↑	m6↓	M6↑	M6↓	D7↑
frequency of occurrence (%)	0.88%	0.63%	1.07%	0.38%	0.88%	0.38%	0.13%

interval	D7↓	m7↑	m7↓	M7↑	M7↓	P8↑	P8↓
frequency of occurrence (%)	0.13%	0.25%	0.44%	0.63%	0.69%	1.25%	0.56%

interval	M9↑	m10↑	P11↑	D12↑	D13↑	M13↑	P15↑
frequency of occurrence (%)	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.13%

Figure 12.30 Frequency of occurrence of intervals between adjacent notes in the melody of the first movement of K. 333.

Mozart: K. 333; 1st Movement

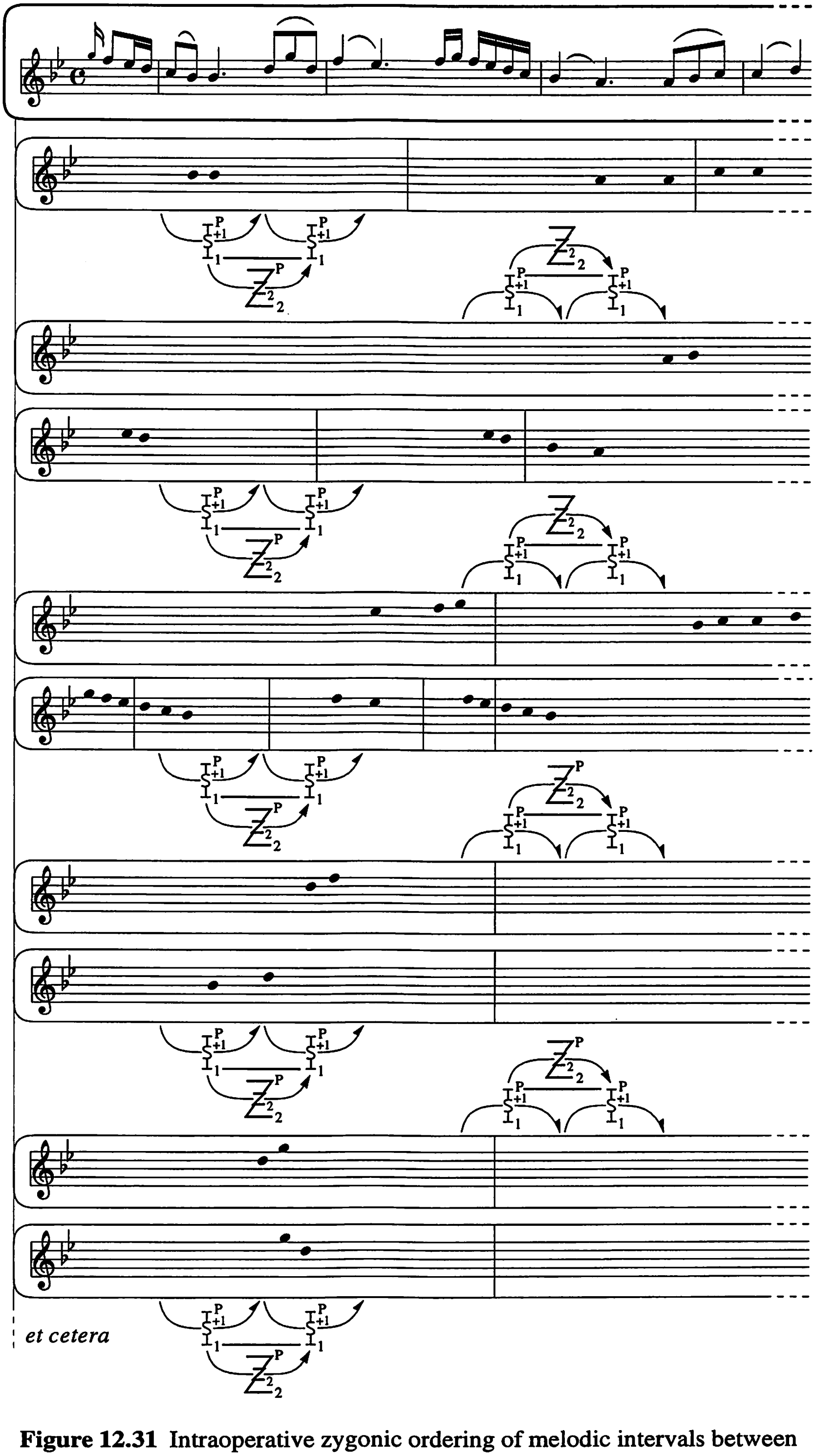


Figure 12.31 Intraoperative zygonic ordering of melodic intervals between successive notes in the first movement of K. 333 (cf. figure 10.11).

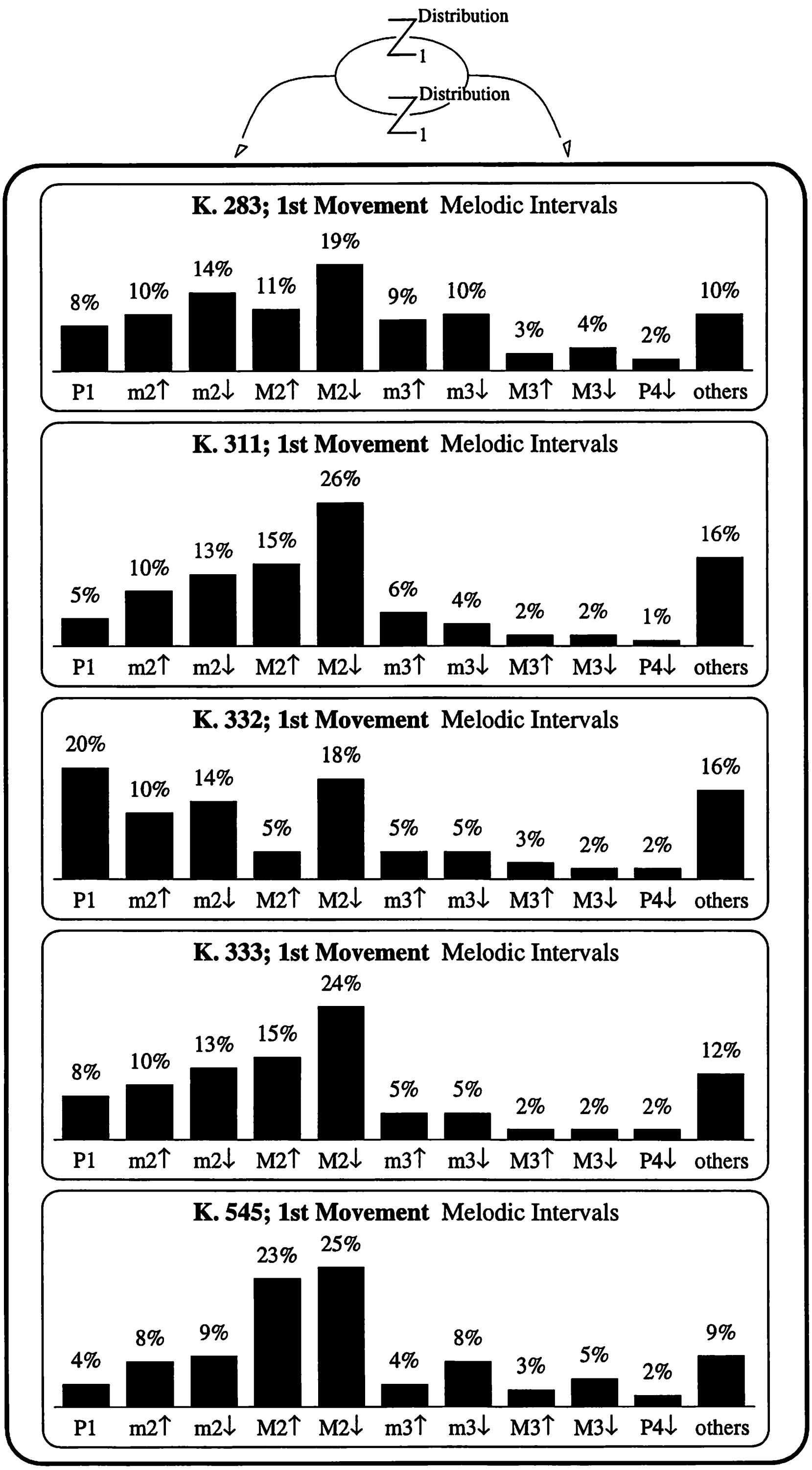


Figure 12.32 Interoperative imitation of adjacent melodic intervals.

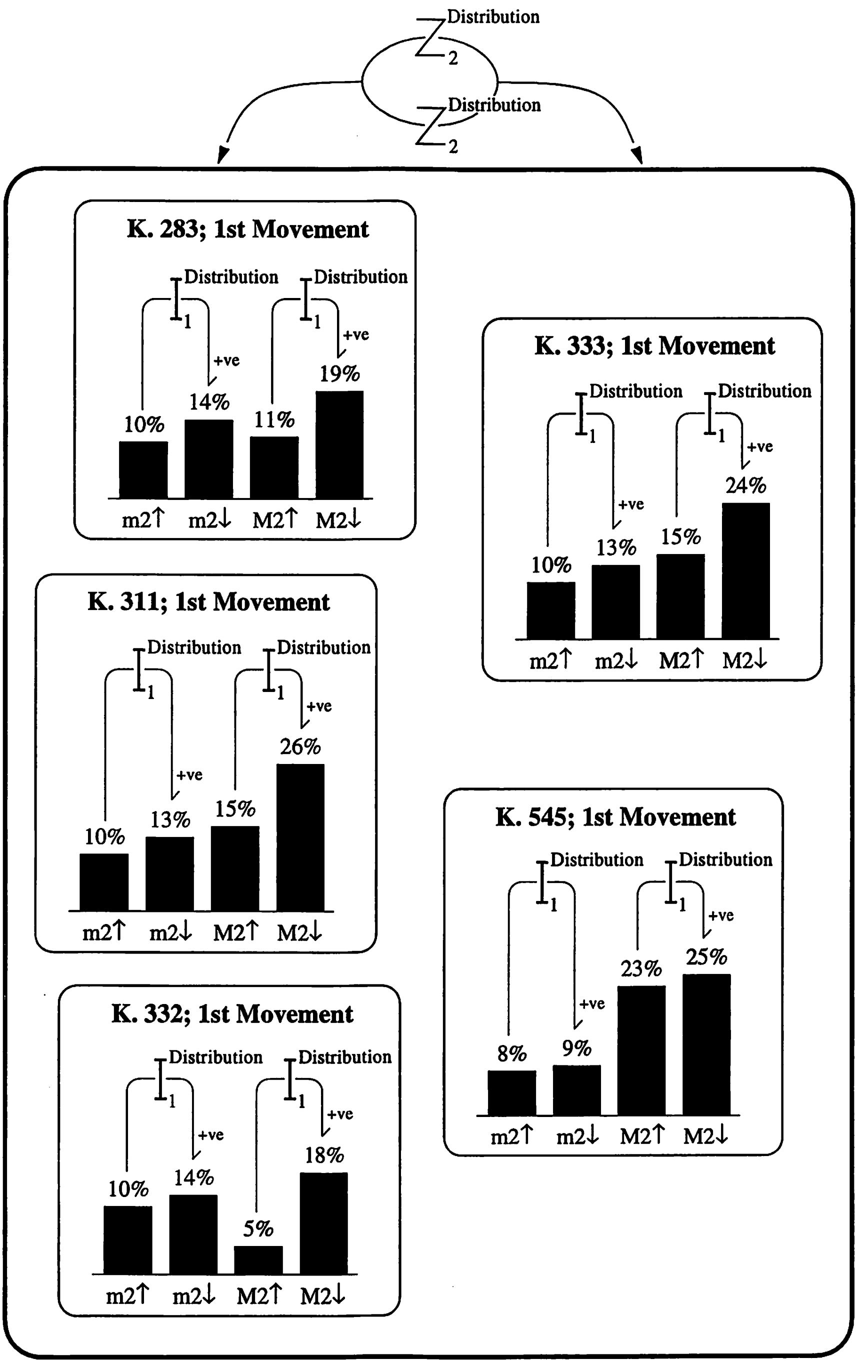


Figure 12.33 The interoperative order inherent in the tendency of melodic seconds to descend more frequently than they rise.

As well as sharing general similarities, these distributions have specific aspects in common. For example, major and minor 2nds consistently descend more than they rise (cf. Vos and Troost, 1989), suggesting imitative order thus (see figure 12.33).

Harmonically, the first movement of K. 333 is highly organised too. The underlying harmonies, discounting the ornamental effects created through the interaction of vertical sonorities with the horizontal movement of melodic lines, are entirely tertian in construction (constructed from major and minor thirds), a feature common to many other pieces—see pp. 585ff. Therefore, intraoperative and interoperative imitation are present on a large scale (cf. figure 10.126). However, Mozart's harmonic palette is more constrained even than this: the first movement of K. 333 is dominated with major and minor triads and 7th chords and their inversions. Hence primary zygonic constant systems of harmony exist of the type shown in figure 12.34. These smaller areas of imitation also extend interoperatively.

The ordering of harmonic *function* is indicated by the fact that chords built on four scale degrees[10] (tonic, supertonic, subdominant and dominant) appear 90% of the time. Moreover, harmonies constructed on the tonic and dominant account for 68% of the total.

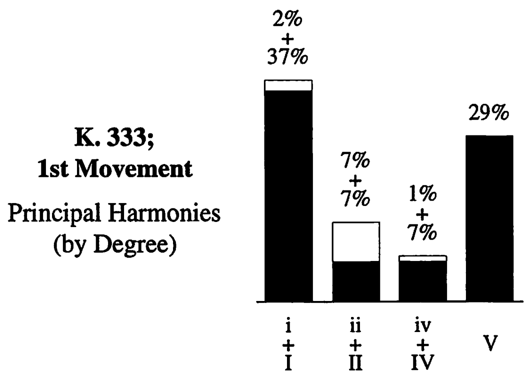
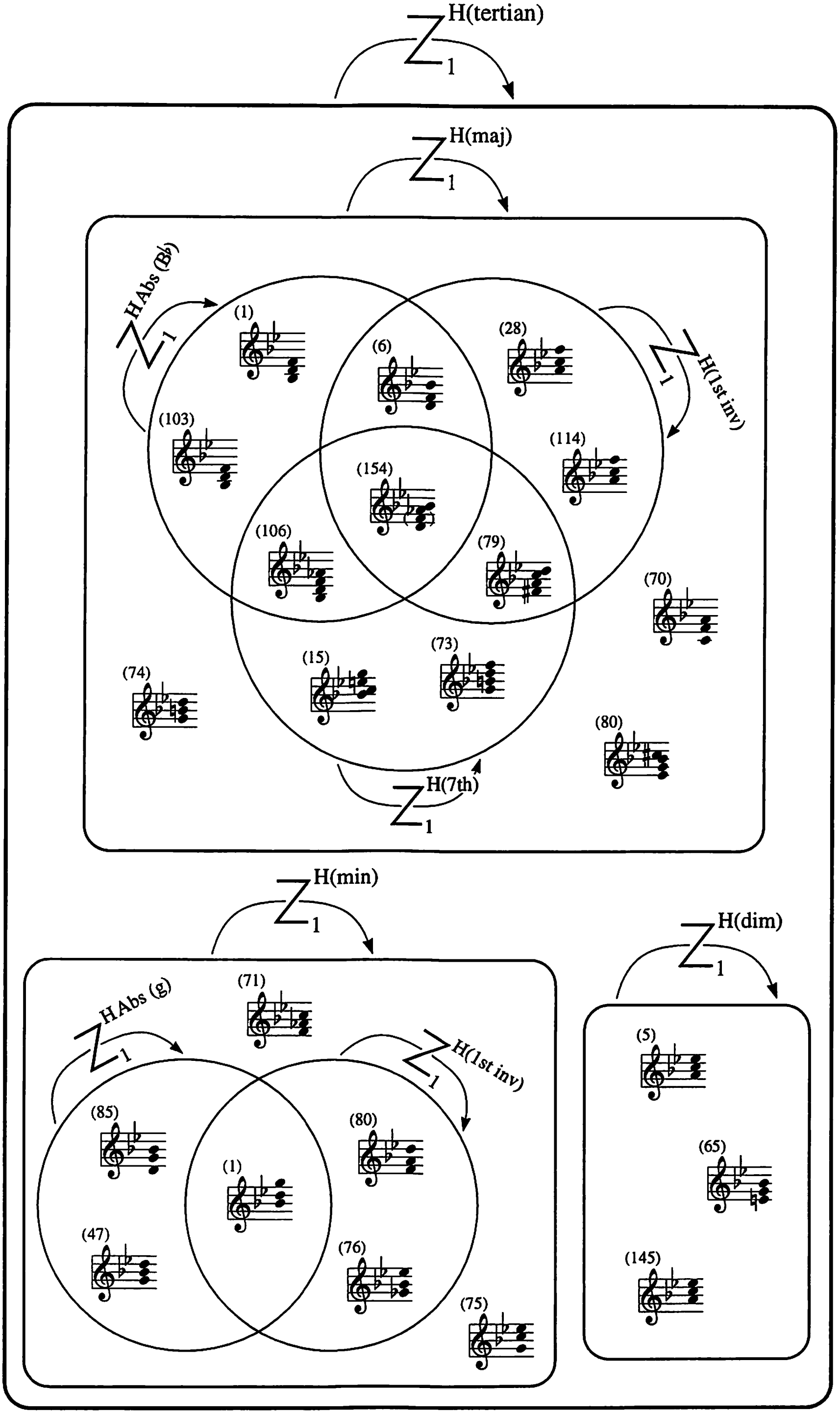


Figure 12.35 Distribution of principal harmonies (by degree) in the first movement of K. 333.

Primary zygonic constant systems may be deemed to exist along the following lines (see figure 12.36).

[10]Gauged with respect to local tonal regions. Hence absolute values may differ within a category.



Mozart: K. 333; 1st Movement

Figure 12.34 Primary zygonic constant systems of harmony in K. 333 (figures in brackets refer to bar numbers).

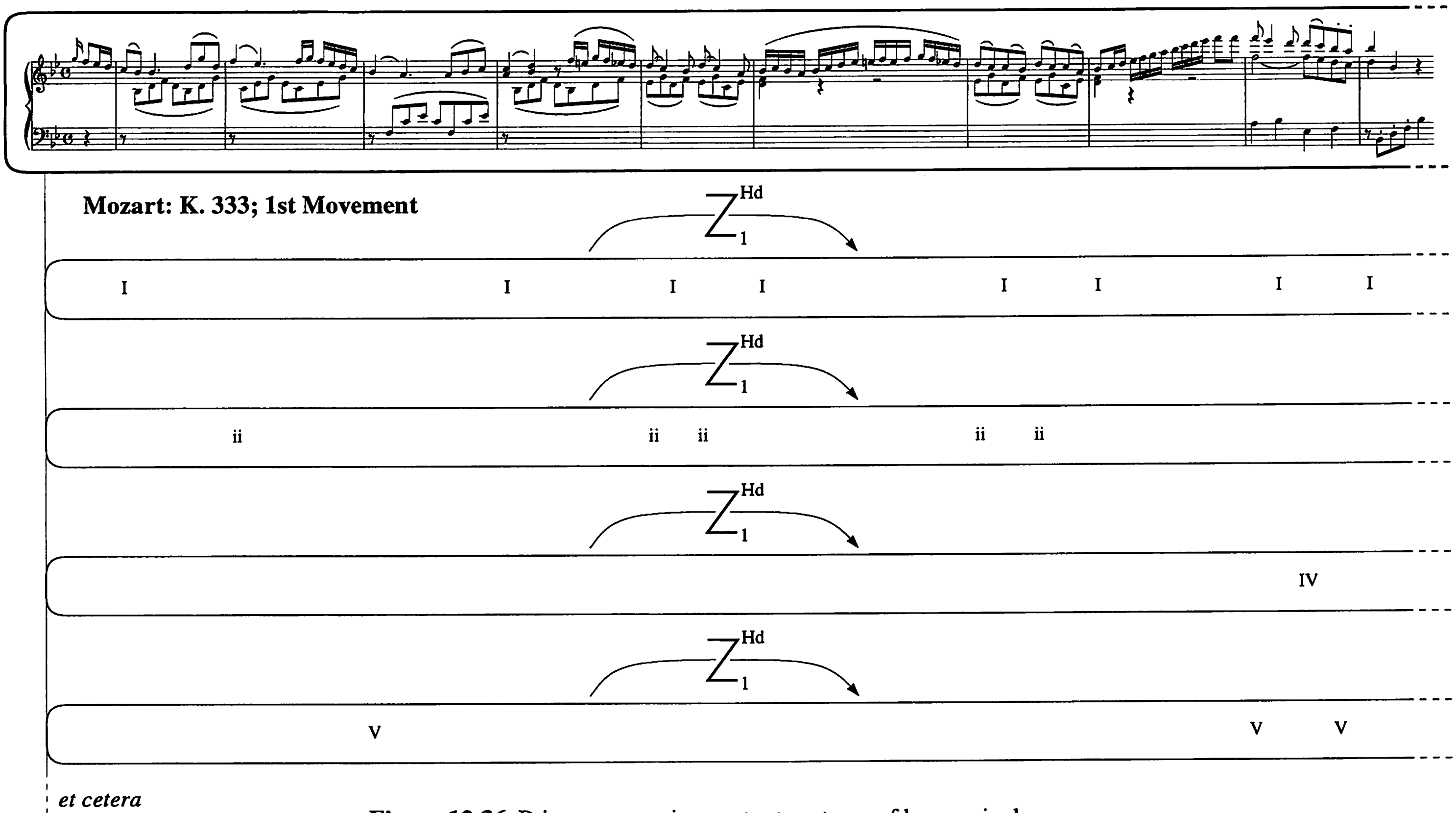


Figure 12.36 Primary zygonic constant systems of harmonic degree.

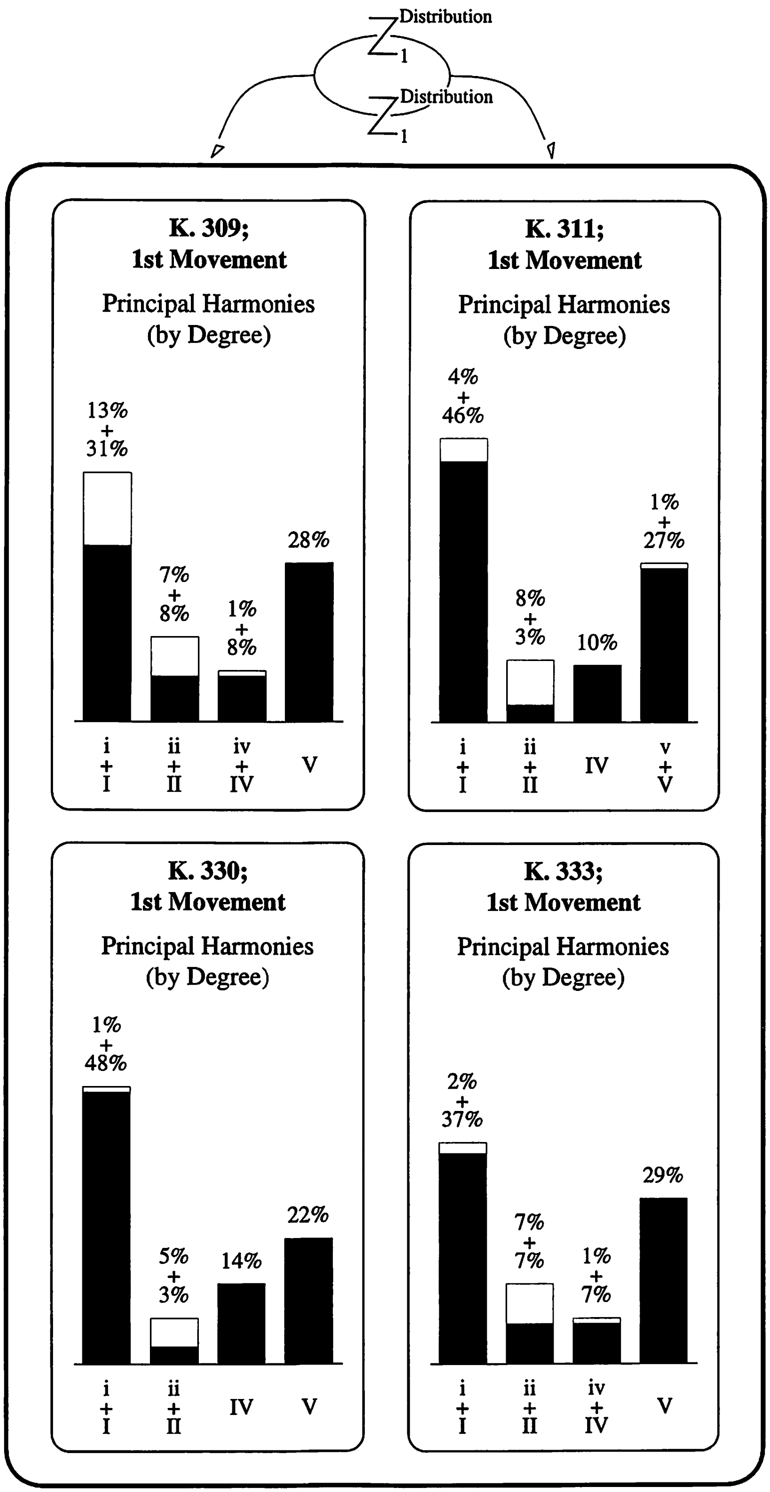


Figure 12.37 The interoperative zygonic ordering of harmonic degrees.

The distribution shown in figure 12.35 is similar to that in the first movements of other Mozart sonatas, suggesting the interoperative imitation illustrated in figure 12.37.

The transitions between successive harmonies are also controlled intra-operatively and interoperatively, as the following data indicate (see figure 12.38): transitions of +4 degrees or +5 degrees account for between 63% and 81% of all primary interperspective values.

The relative durations of tonal regions show marked interoperative similarities too. Hence ordering through imitation may be deemed to occur as follows (see figure 12.39).

There is an intimate relationship between melody and harmony, which can be interpreted in zygonic terms (cf. pp. 598ff). In the first movement of K. 333, over half the melody notes are consonant with the tertian harmonies with which they sound, functioning directly as the root, third or fifth of the chord (cf. figures 10.136 and 10.137). Dissonant notes are widespread too, although their use invariably conforms to one of a few archetypal patterns that closely define their permitted modes of operation, both 'horizontally' and 'vertically' in the musical texture. Examples in K. 333 include passing notes, appoggiaturas and chromatic auxiliaries (cf. pp. 602ff). These patterns are, without exception, underpinned by two distinct zygonic forces, one tying the dissonant note into the linear logic of the melody, and the other relating one member or more of the melodic line to the harmonic framework upon which it elaborates (cf. figure 10.138).

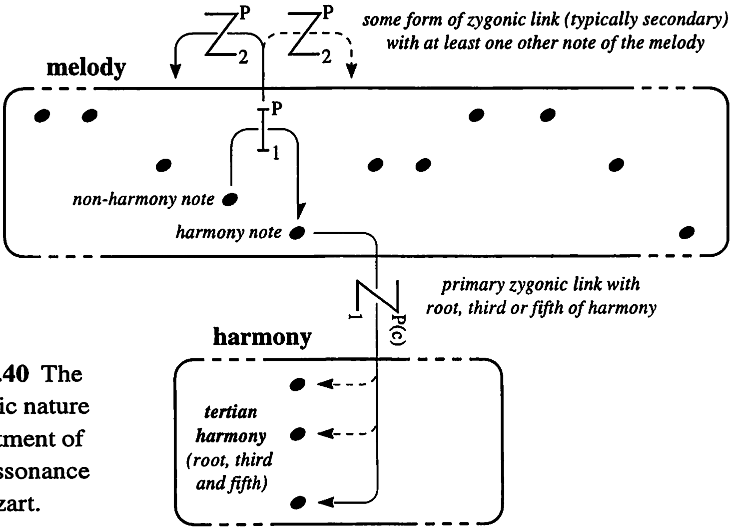


Figure 12.40 The dual zygonic nature of the treatment of melodic dissonance in Mozart.

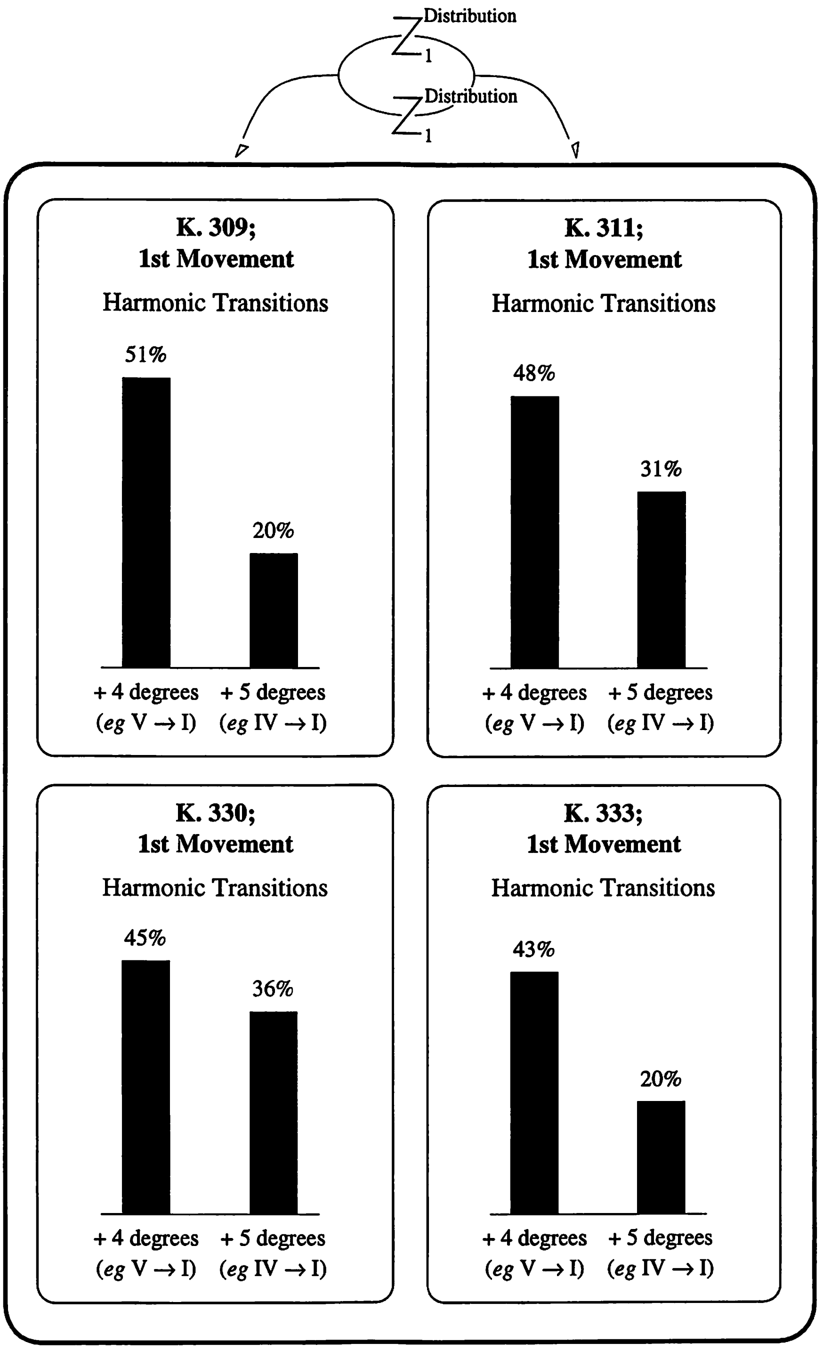


Figure 12.38 The ordering of transitions between successive harmonies.

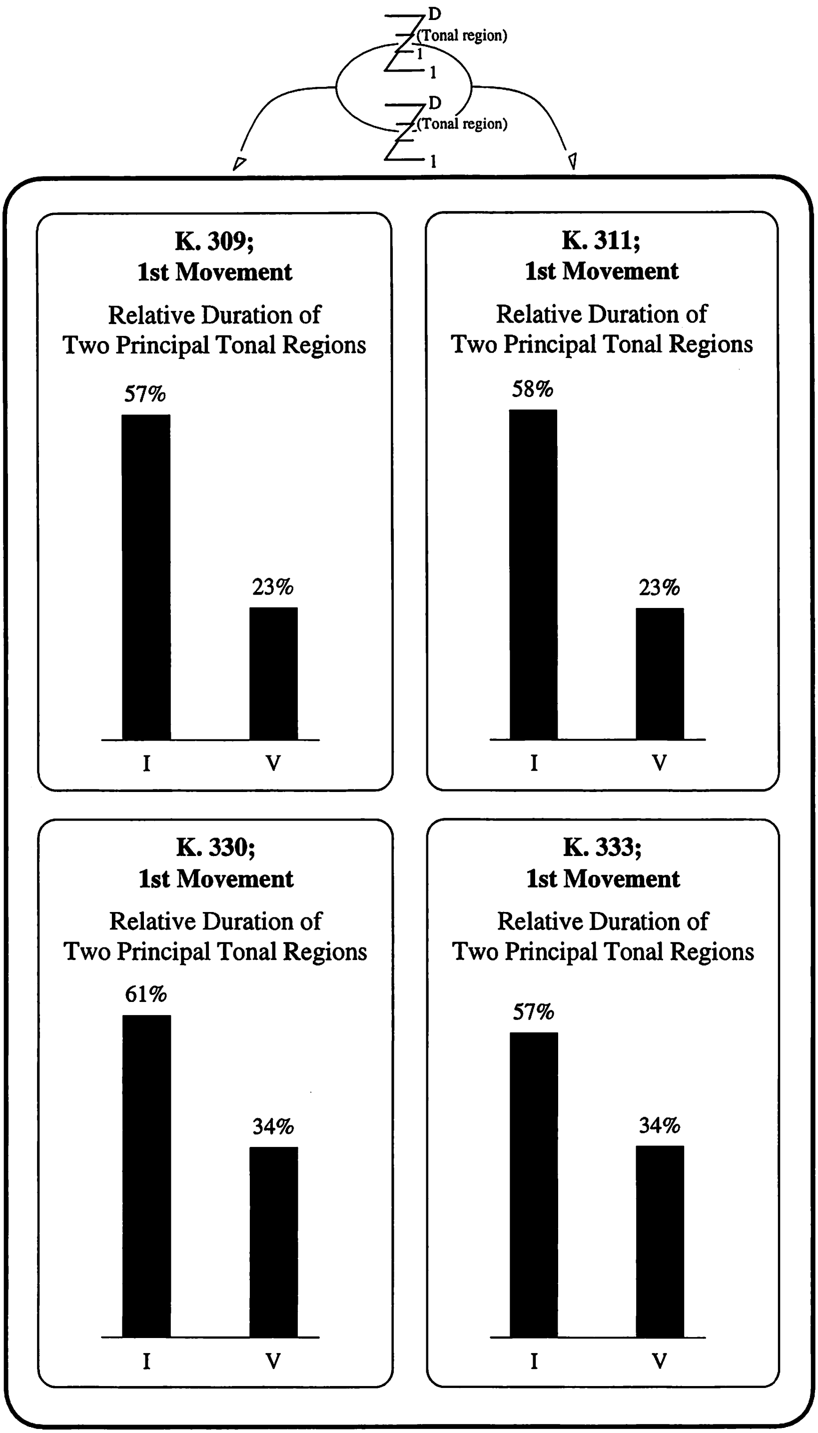
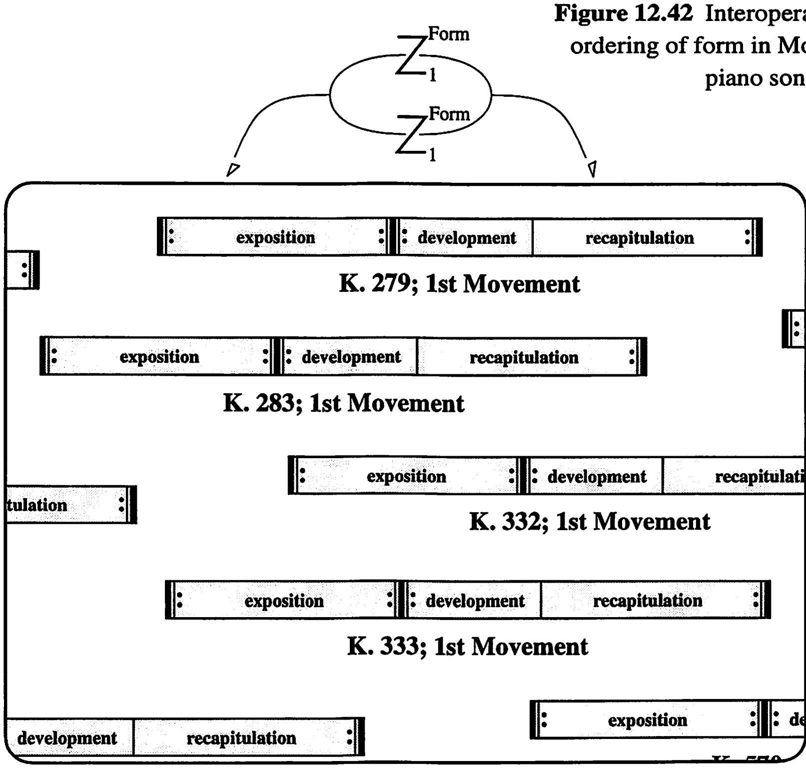


Figure 12.39 Interoperative ordering of the relative durations of tonal regions (cf. figure 12.29).

Finally, before examining the opening bars of K. 333 in some detail, we consider the interrelationship of themes and keys that define the form of the movement as a whole, and how this is ordered intraoperatively and interoperatively. The movement comprises two major sections, both of which are written with repeat marks (although, as the performances listed on p. 708 show, the second of these is frequently not observed). In music-analytical terms, the first section comprises the 'exposition', in which a number of themes are presented, and there is a general movement from tonic to dominant. The second section consists of the 'development', where material from the exposition is transformed thematically and tonally, followed by the 'recapitulation'—a return to the exposition, modified so that the transition to the dominant is replaced by an ultimate maintenance of the tonic. This, then, is a manifestation of Classical 'sonata form' (cf. Berry, 1966/1986, pp. 151ff), whose organisation may be defined in zygonic terms thus (see figure 12.41). Interoperatively, order through imitation operates along the follow lines:

Figure 12.42 Interoperative ordering of form in Mozart piano sonatas.



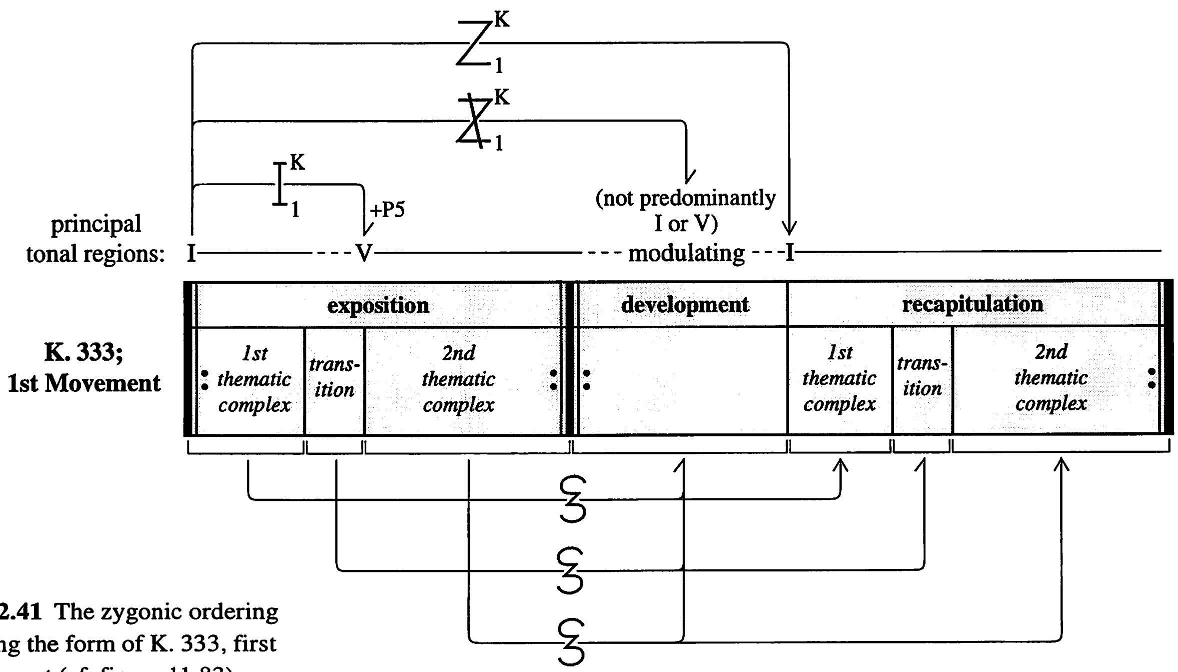


Figure 12.41 The zygonic ordering underlying the form of K. 333, first movement (cf. figure 11.83).

So much for the ordering forces active in the background of the first movement of K. 333. We now investigate how the more specific, bar-to-bar organisation functions within this framework, with particular reference to the opening.

Interoperatively, individual aspects of these initial bars have many potential antecedents (cf. p. 235). However, a number of distinct features[11] are attributable to J.C. Bach's piano sonata op. 5, no. 3 (one of a set with which Mozart is known to have been acquainted—see, for example, Roe, 1989, p. x), so constituting what may be regarded as one of K. 333's most immediate musical ancestors (see Einstein, 1946, pp. 130 and 131).

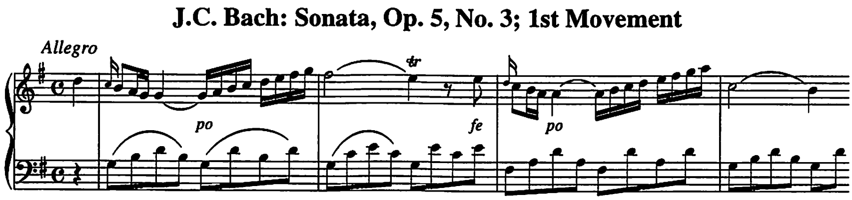



Figure 12.43 Potential source of material for the opening of K. 333.

For example, the harmonic rhythmic pattern and melodic phrase structure (cf. figure 9.135) of both openings are similar, suggesting zygonic ordering as follows (see figure 12.44). Then, there is a close resemblance between the descending pattern beginning the melodies:

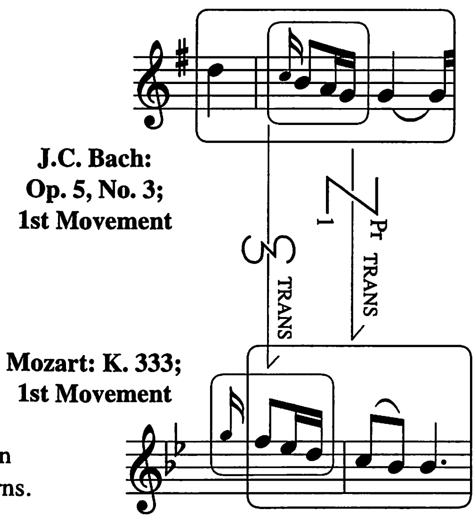
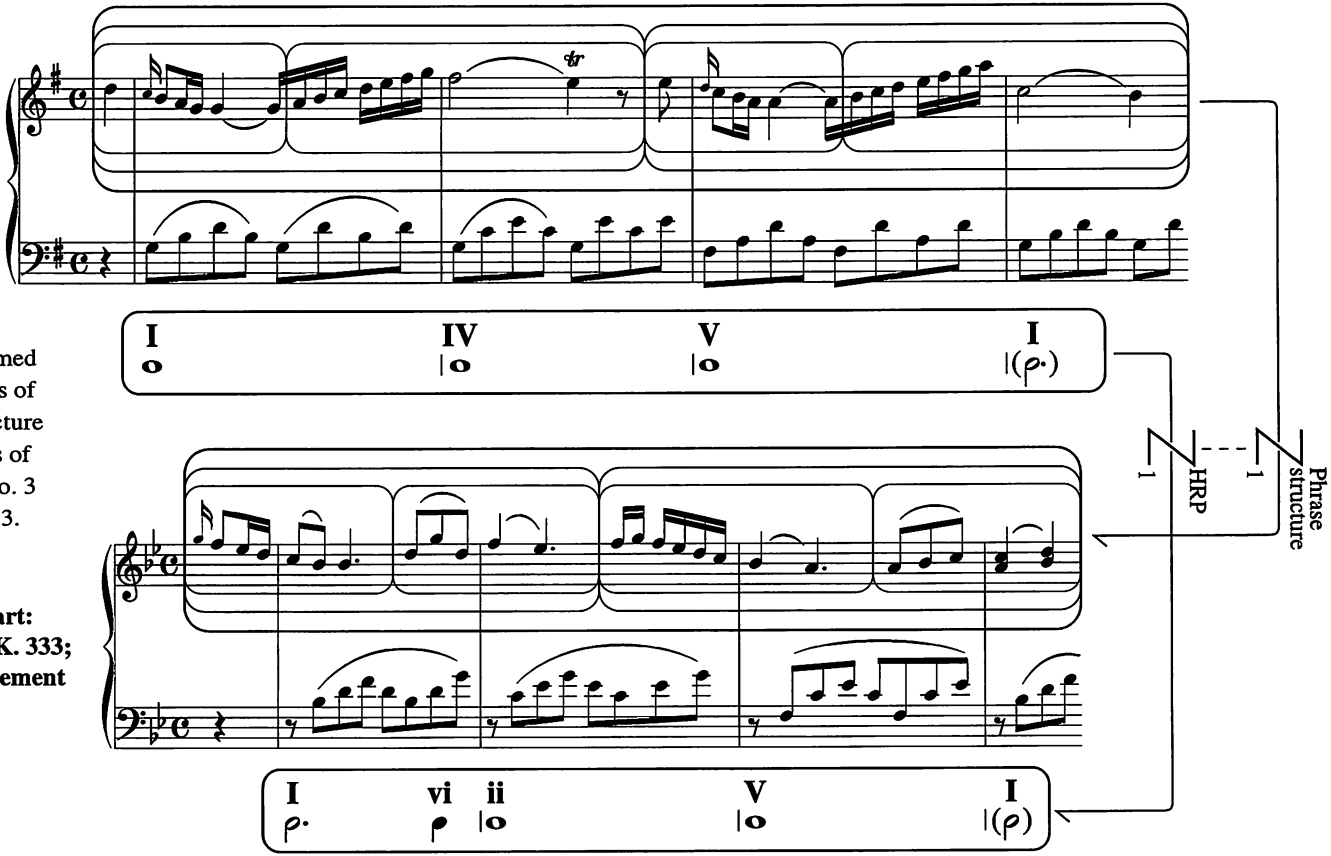


Figure 12.45 Zygonic links between the initial descending melodic patterns.

[11]More general similarities include tempo, metre, durational set and the primary interperspective values of prefix between adjacent notes that are used; primary interperspective pitch-class set and the pitch range; the number of simultaneous parts that appear and their function as melody over accompaniment.

J.C. Bach:
Sonata,
Op. 5, No. 3;
1st Movement



Mozart:
Sonata, K. 333;
1st Movement

Figure 12.44 Presumed zygonic relationships of HRP and phrase structure linking the openings of J.C. Bach's Op. 5, No. 3 and Mozart's K. 333.

There are imperfect syzygial links between the Alberti-style bass lines.

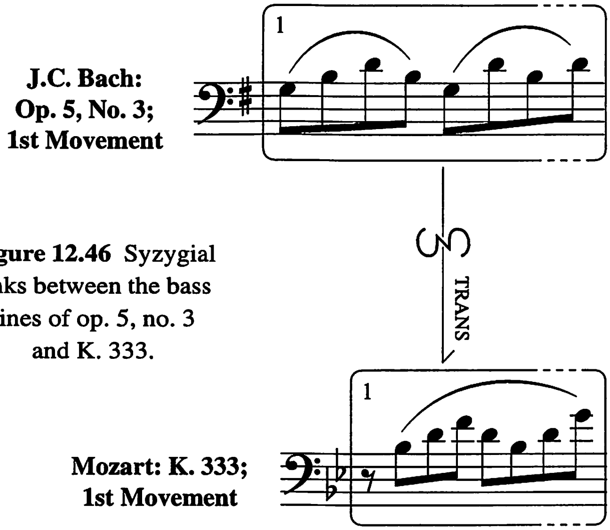
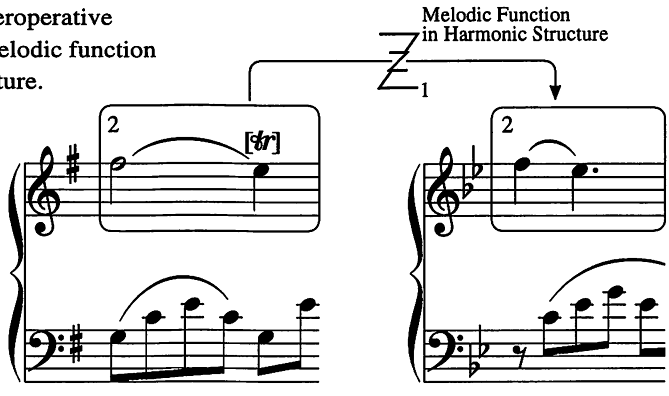


Figure 12.46 Syzygial links between the bass lines of op. 5, no. 3 and K. 333.

Appoggiaturas are an important feature of both melodies—suggesting interoperative ordering such as the following:

Figure 12.47 Interoperative zygonic link of melodic function in harmonic structure.



*Intra*operatively, the opening bars of K. 333 are replete with order too. The first phrase has the following harmonic design, which the melody and bass-line define, and to which they necessarily conform (figure 12.48).

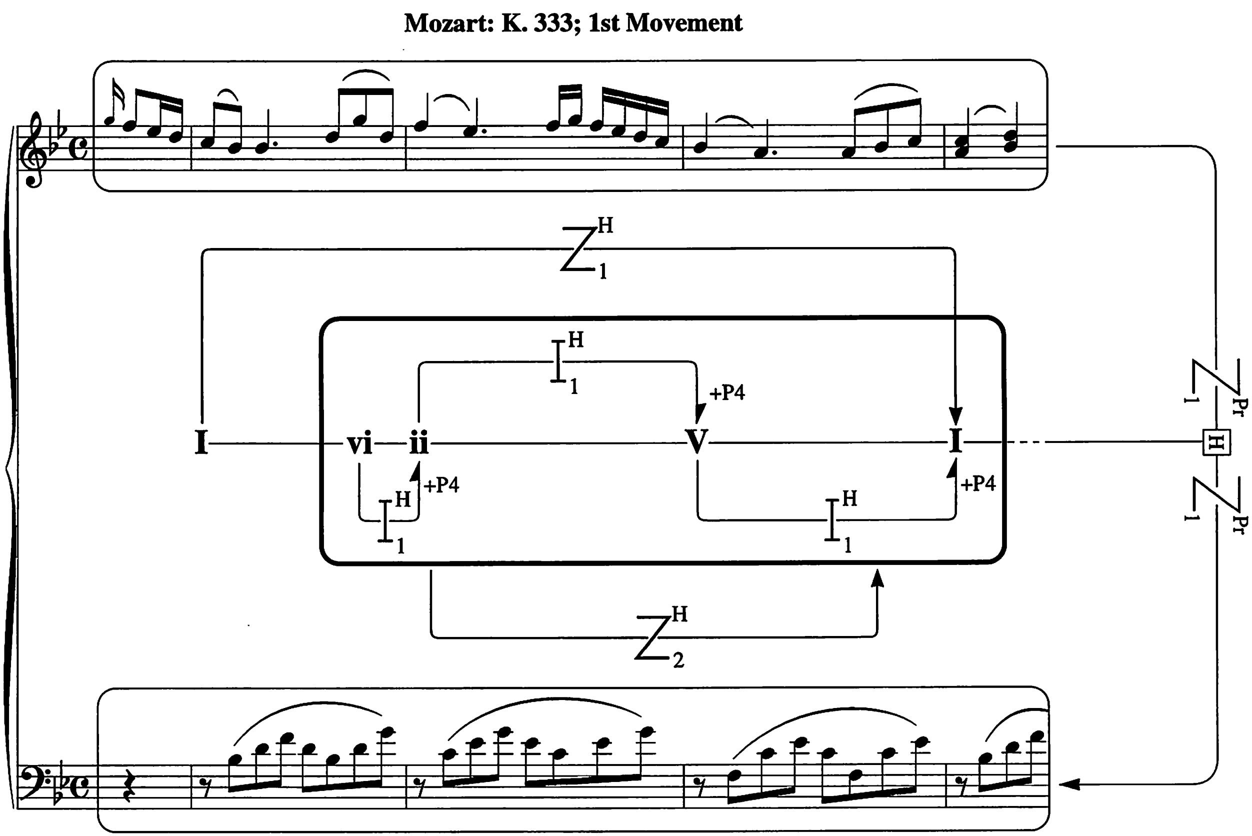


Figure 12.48 Harmonic ordering in the first four bars of K. 333 (cf. figure 11.39).

The opening melodic gesture is ordered in a number of ways. A secondary zygosequential zygonic constant system underpins its structure as a simple descending scale:

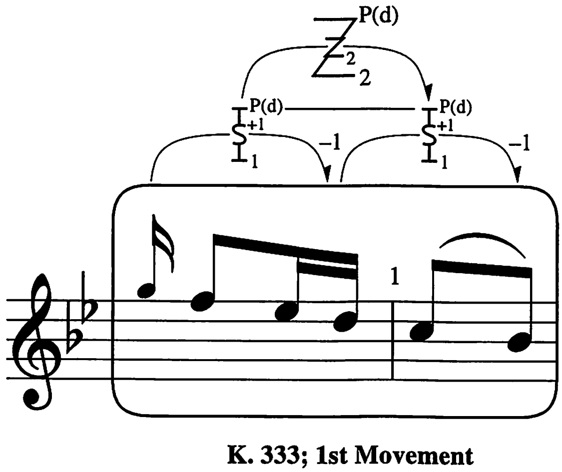


Figure 12.49 Secondary zygonic constant system underlying the opening melodic gesture in K. 333.

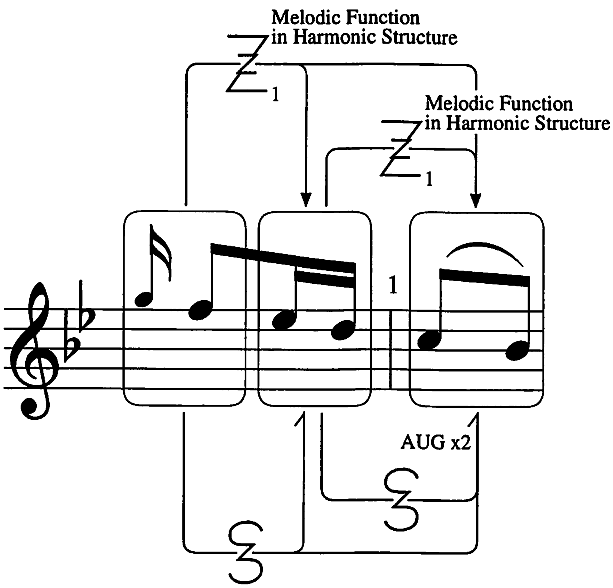
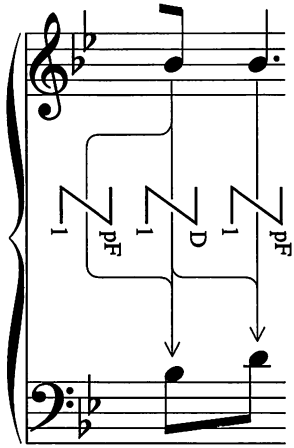


Figure 12.50 Other zygonic ordering in the opening descent.

The organisation is more complex than this, however: each pair of notes fulfils a similar function within the harmonic structure (a dissonance on the beat or sub-beat, resolving to consonance off the beat or sub-beat). Rhythmically, the third pair is an augmented version of the first two (see figure 12.50).

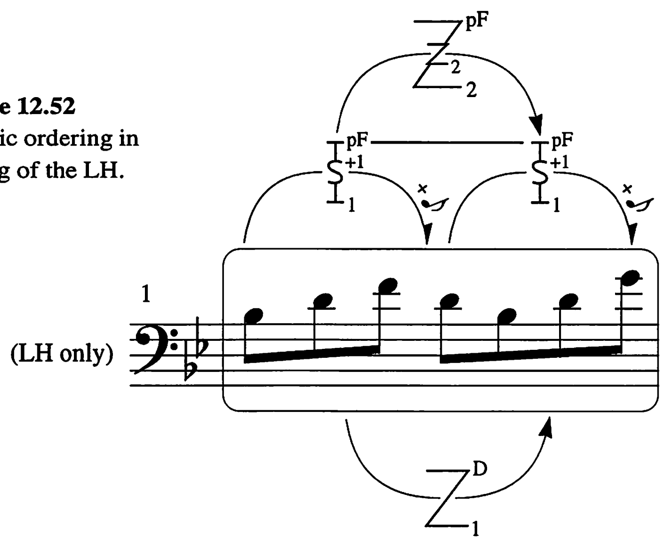
In perceived temporal terms, the beginning of the accompaniment derives from the melody ...

Figure 12.51
Perceived temporal derivation of the beginning of the accompaniment from the melody.



... thereby initiating a pattern of even quavers which is extended to fill the whole of the first complete bar:

Figure 12.52
Intrarhythmic ordering in the opening of the LH.



There is also a retrograde link of profile between the consonant notes of the opening melodic gesture, which outline a descending tonic triad, and the ascending figure in the LH:

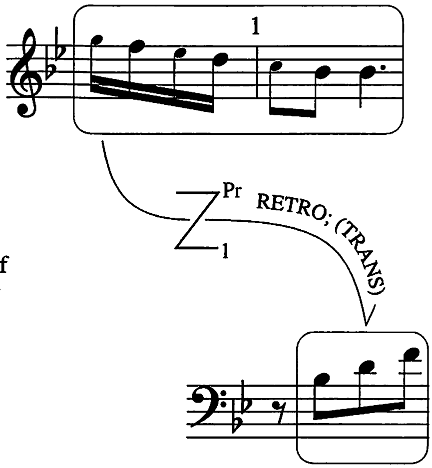


Figure 12.53 Retrogression of profile linking the opening of melody and accompaniment.

The use of retrogression continues in the accompaniment:

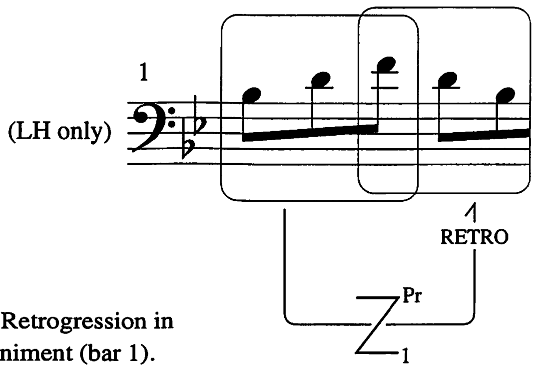


Figure 12.54 Retrogression in the accompaniment (bar 1).

Retrogression is important in the structure of the melody too:

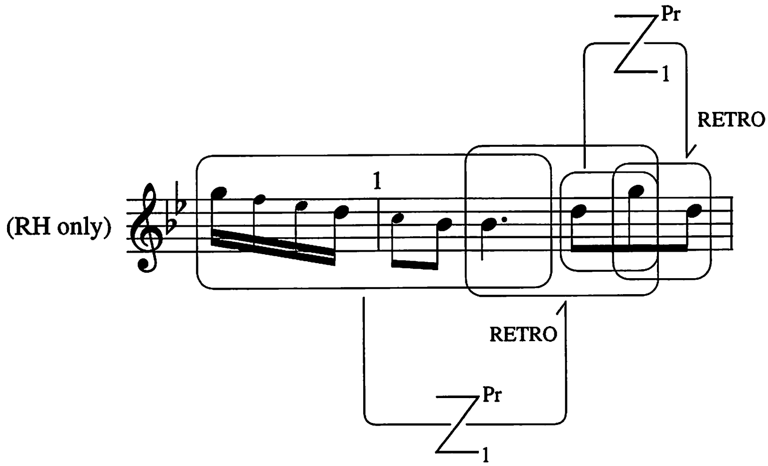


Figure 12.55 Retrogression in the melody.

The profile of the accompaniment is derived through imperfect repetition (which is attributable to harmonic influences—see figure 12.48):

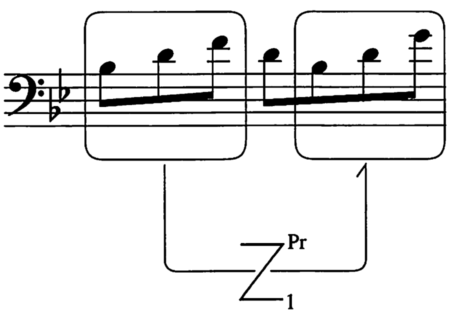


Figure 12.56 Imperfect repetition of profile in the accompaniment.

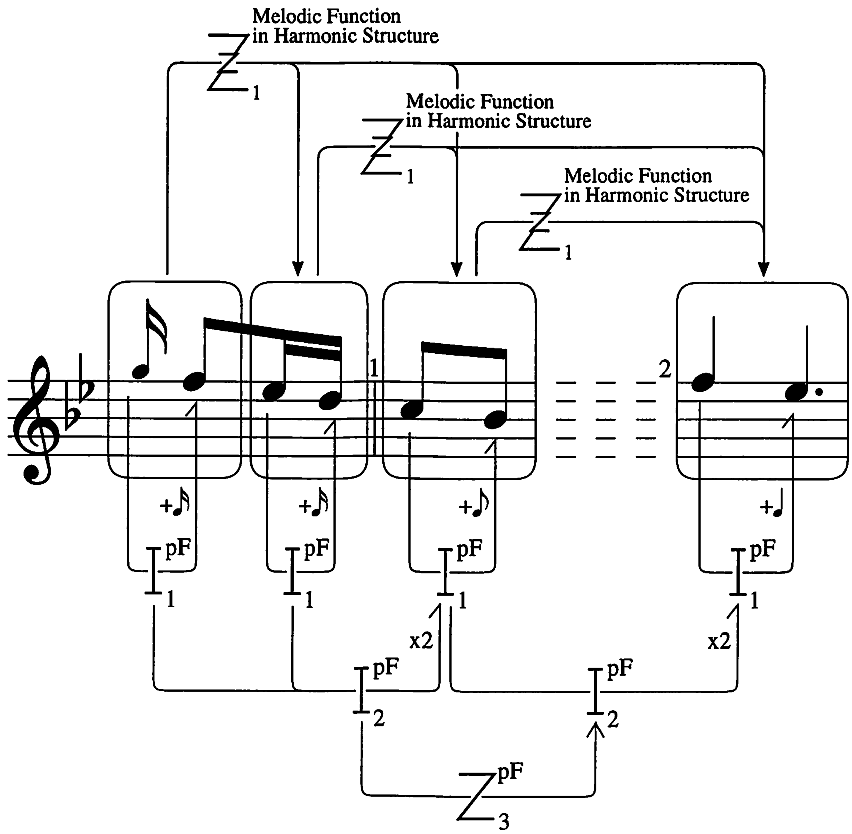


Figure 12.57 Continuation of pattern of paired notes, using augmentation.

The melody continues by extending the pattern of paired notes shown in figure 12.50—see figure 12.57. The *f* and *e♭* are also part of a descending motive that begins with the preceding *g*; they fill the gap left by this and the *d* that follows it; and they can be considered to be derived through intervallic inversion. See figure 12.58.

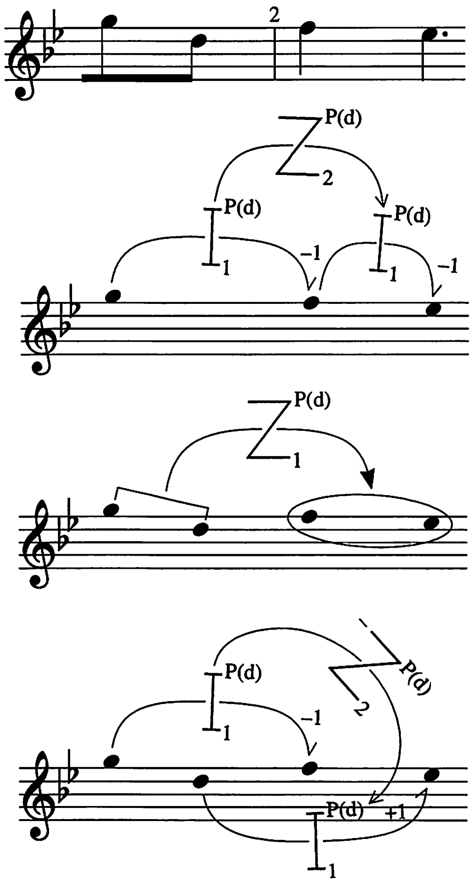
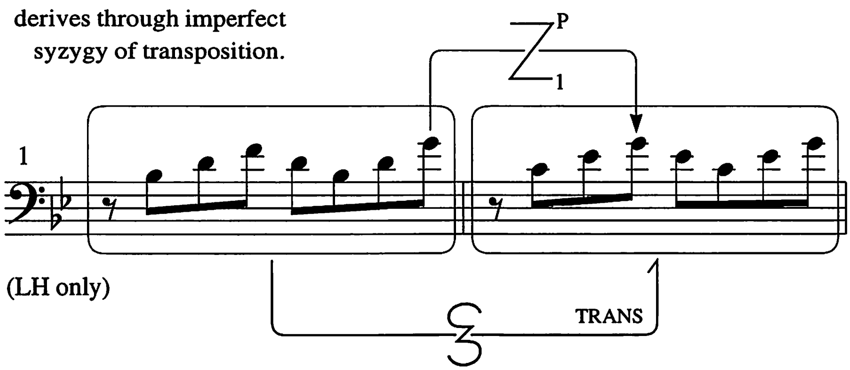


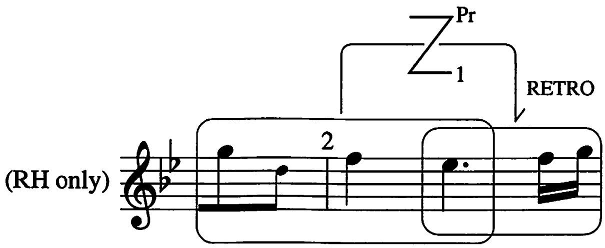
Figure 12.58 Melodic descent is derived in three ways.

At the same time, the accompaniment outlines the harmonic framework through an imperfect syzygy of transposition (figure 12.59).

Figure 12.59 Accompaniment outlines harmonic framework; derives through imperfect syzygy of transposition.



The next part of the melody is derived as follows:



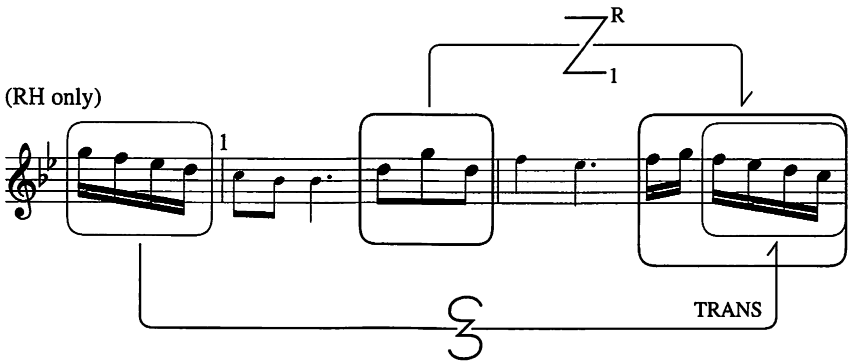


Figure 12.60 Derivation of the melody through the retrogression of profile, and rhythmic elaboration using the opening pattern of semiquavers.

Observe the three repeated 5th octave *g*s—a pattern that is extended in the bars that follow.

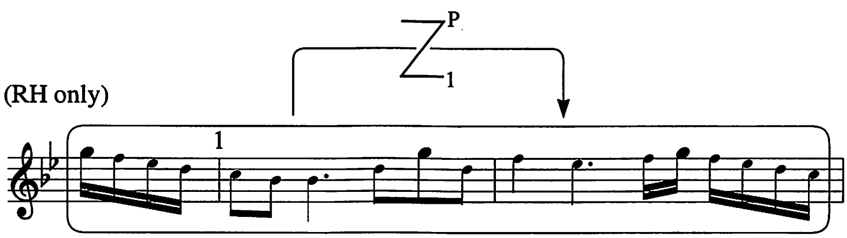
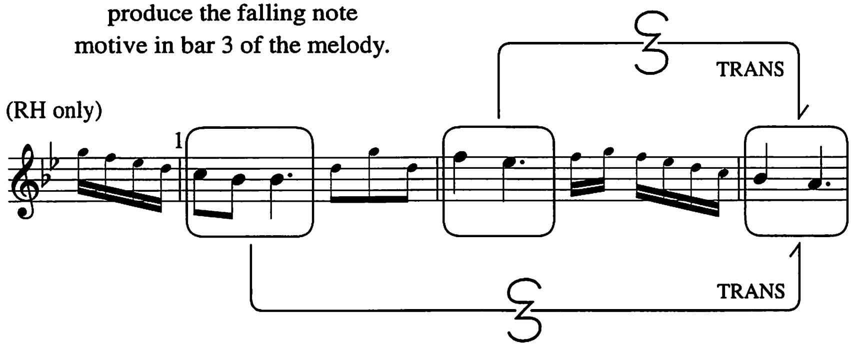



Figure 12.61 Primary zygonic constant system linking the three repeated *g*s in the melody.

Figure 12.62 Two syzygial links working together to produce the falling note motive in bar 3 of the melody.

The next two notes of the melody are derived thus:



Beneath the melody, the accompaniment continues to reinforce the harmonic and rhythmic framework with a further group of seven quavers:

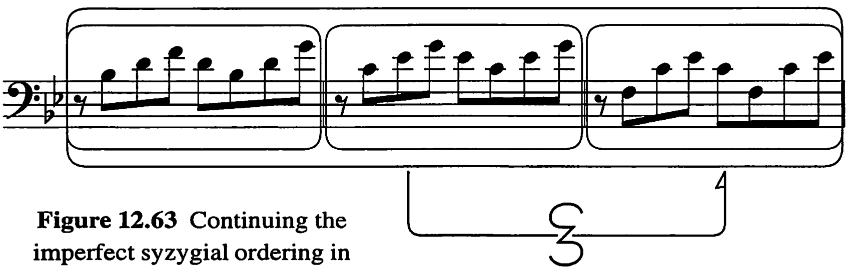
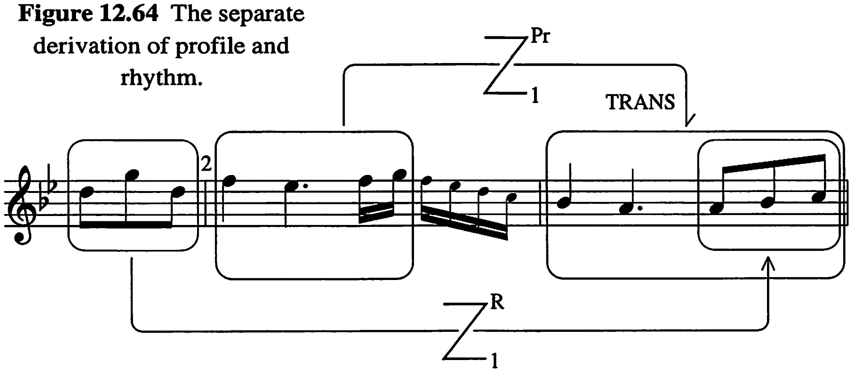


Figure 12.63 Continuing the imperfect syzygial ordering in the accompaniment.

The melody proceeds with transposition of profile and rhythmic repetition:

Figure 12.64 The separate derivation of profile and rhythm.



This is followed by inversion:

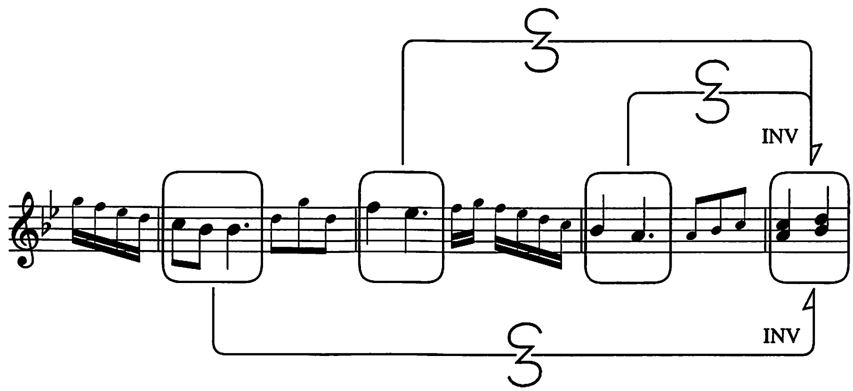


Figure 12.65 The use of inversion to conclude the first main section of the melody.

The pattern of quavers in the accompaniment is further extended, as the harmony returns to the tonic:

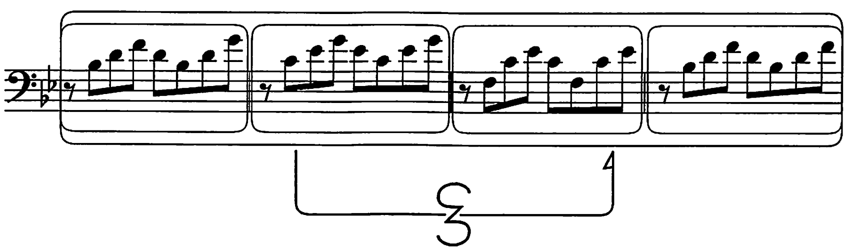


Figure 12.66 Further continuation of contiguous motivic development in the accompaniment.

The type of ordering illustrated in figures 12.49–12.66, through which adjacent material is tightly related, is characteristic of the movement as a whole, and, indeed, of other pieces by Mozart, implying further intraoperative and interoperative ordering (cf. 672ff). Longer range motivic connections are used too, enhancing the general feeling of coherence established through the background forms of organisation described in the first part of this chapter. For example, the opening melodic gesture and the theme that

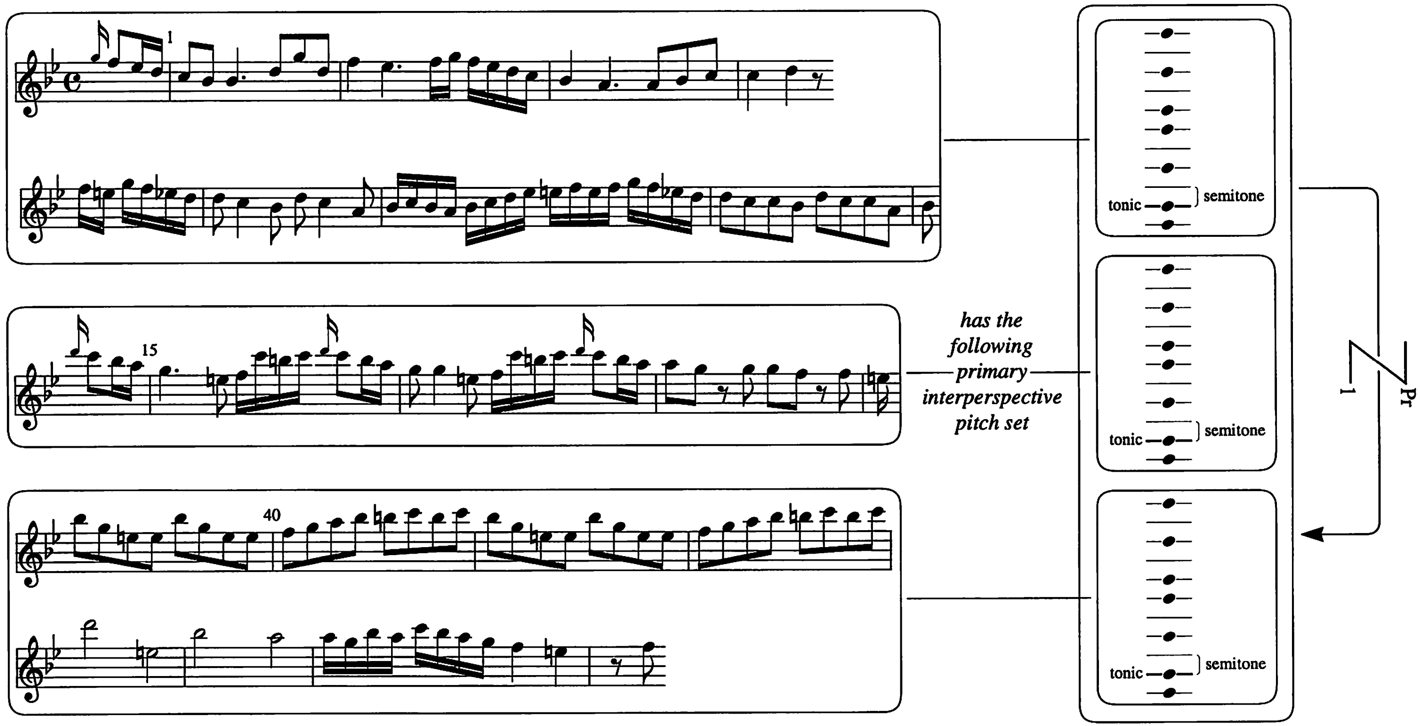


Figure 12.68 Examples of melodic passages from the first movement of K. 333 that adhere to the same primary interperspective pitch set.

initiates the second thematic complex in the dominant (bars 23ff) share significant similarities of profile.

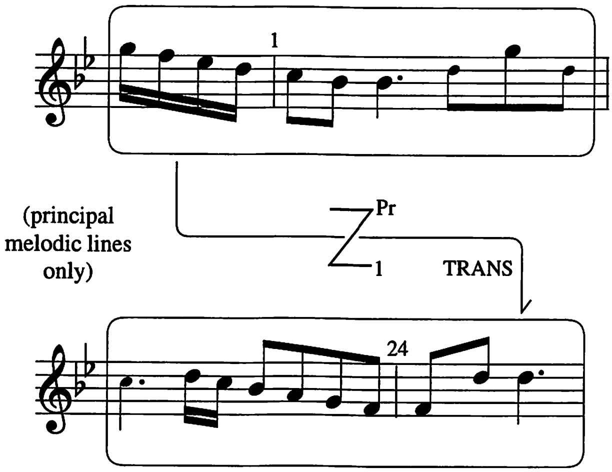


Figure 12.67 Similarities of profile linking material from the first and second thematic complexes.

More general links are in operation too. Consider, for example, the primary interperspective pitch set (extending diatonically upwards from leading note to submediant) to which many phrases conform; see figure 12.68.

What conclusions can be drawn from this examination of the first movement of K. 333? While it has not been possible to describe all the zygonic ordering that is present, the chapter offers a fair indication of the organisation that is predicted by the present theory to underpin the typical listening experience—albeit at a subconscious level.

Since the movement is wholly aurally coherent, in that it has no features that do not make intuitive musical sense, so *every* aspect of *every* note is zygonically ordered, often in several different ways. The texture is replete with imitative control. Moreover, K. 333 has extensive relationships with a wide range of other pieces, implying the existence of interoperative ordering on a huge scale. Finally, there is every indication that the nature of the organisation identified here in the context of a single movement is characteristic of music as a whole.

Conclusion

The purpose of this section is threefold: to summarise the hypothesis that lies at the heart of the present work, to revisit some of the evidence that is offered in its support, and to examine further potential avenues of enquiry.

The Cognition of Order in Music addresses the following issue: that, just by listening, music makes sense. No special knowledge or skills are needed. But how is this? How does music, the universal, abstract medium for conveying human thought, with the power to evoke a wide range of affective responses, actually *work*? In seeking to answer this question, a theory is developed which runs as follows.

Music is a form of communication. Successful communication requires that intelligible information be conveyed from a source to a receiver. Intelligibility demands order (cf. p. 1). Hence a meaningful message must be ordered in some way.

Music comprises perceived sound, which is both a necessary and sufficient medium for its existence. Hence, a piece of music may be 'self-contained' (cf. p. 71), making sense in its own right, without the need for additional artistic material or verbal explanation.

Effective music, then, through which composers and performers communicate purposefully with listeners, requires perceived sounds to be ordered in a way that is perceptible. Typically, musical order is detected subconsciously and intuitively: listeners 'get the message' without overt effort or thought, and with no formal music education or training, nor special knowledge of the work in question.

To understand how order in music operates, consider that perceived sound can be regarded as a system of variables, such as pitch, loudness, timbre and duration. Each variable or 'perspect' (p. 15) has many potential modes of existence or 'perspective values' (p. 16), whose range represents the freedom of choice open to composers. Conversely, each may be deemed to be ordered to the extent that its value is felt to be restricted in some way (see p. 68).

Given that pieces of music may be 'self-contained' (consisting only of perceived sounds) it is evident that at least one source of musical order—in its own right wholly sufficient for music to make sense—must lie within the perceived sonic medium itself.

It is my contention that this fundamental form of order resides in repetition: a perspective value will be reckoned to be restricted and therefore ordered if it is felt to exist in imitation of another (cf. pp. 70ff). The interperspective relationships (p. 21) through which such order is created or perceived are said to be 'zygonic' (p. 73). Many different types of zygonic relationship are identified in the course of *The Cognition of Order in Music.*

Through examining direct evidence (pieces of music), and indirect evidence (ideas about music), it becomes apparent that *all* intramusical order is ultimately attributable to repetition—to the operation of zygonic relationships. Moreover, the theory predicts that *every* aspect of coherent pieces of music are ordered zygonically. This prediction is corroborated by the numerous musical examples that are given. Observe, however, that there is no suggestion that this single concept is perceptually or even neurologically equivalent in all its many manifestations, but *logically* so (cf. p. 76).

Evidence in support of the theory, outlined in chapters 4–6, is presented, perspect by perspect, in chapters 8–10. Chapters 11 and 12 show how perspective ordering functions in an integrated way. Although hundreds of musical examples are cited, representative of a wide diversity of styles, in most cases, many thousands of others could have been selected to illustrate the same points. To reiterate: every piece is replete with zygonic order.

It follows that, if order through imitation, and therefore repetition, is in fact a feature of all aspects of musical structure, then this will necessarily be reflected in music theory and analysis: the presence of repetition, and its function as the agent of perceived musical order being acknowledged, if not explicitly, then by implication. This is indeed the case.

Consider, for example, the traditional notion of form, as espoused by writers ranging from Macpherson (1915) to Berry (1966/1986). Here, the concept of stereotyped structures such as A A' A'' A''' ... (characteristic of variation sets), A B A ('ternary' form) and A B A C A ... (the 'rondo') implicates repetition both within pieces and between them (cf. pp. 683ff).

Then, repetition is central to the various motivic-cum-thematic theories that have been propounded, in whose development the music and writings of Schoenberg have proved seminal. As the composer states unequivocally in his *Fundamentals of Musical Composition* (1967; cf. p. 10):

> A motive appears constantly throughout a piece: *it is repeated.* (p. 8)

> The repetition may be exact, modified or developed. (p. 9)

These ideas are taken to their logical extreme by a one-time pupil of Schoenberg, Reti, who demonstrates (1951), to his own satisfaction at least, that many works from the Western Classical repertoire are each built on a single theme, surface contrasts notwithstanding (cf. p. 636). Walker (1962, p. 79), working in the same tradition, states:

> The whole point of an inspired composition is that it diversifies a unity. On the other hand, the whole point about musical analysis is that it seeks to show the unity behind the diversity.

Although his approach is quite different, Schenker too acknowledges the part played by repetition, both at the level of motives and in the construction of large-scale forms, in his early treatise on harmony (1906/1954, pp. 4–19). This recognition carries over into the sophisticated models of musical structure that followed; in *Free Composition* (1935/1979) the question of repetition at deeper structural levels is aired in some detail (pp. 99ff). But of greater significance is the fact that zygonic ordering underpins the derivation, formation and operation of the *Ursatz*, the framework of relative pitches which Schenker considered lies in the background of all tonal masterpieces (see pp. 562 and 563).

Meyer's evolving reflections on musical patterning (1956, 1967 and 1973; Cooper and Meyer, 1960) variously involve repetition, most overtly in his notion of 'conformant relationships' (cf. p. 655),

> in which one (more or less) identifiable, discrete musical event is related to another such event by similarity. (1973, p. 44)

Although it is not stated openly, the concept is no less important, however, in the first chapter of *Music, the Arts, and Ideas* (1967), where the author's previously developed model of musical meaning is reviewed in the light of information theory (see, for example, Cohen, 1962). Meyer's thesis is this: that for the experienced listener, an incomplete portion of music generates certain expectations as to its continuation, which vary in probability according to the frequency of past occurrence (hence the significance of repetition). It is, we are told, deviations from the expected course of events that give rise to musical meaning.

Then, Meyer's subsequent theory of implication in music, definitively stated as follows:

> *Once established, a patterning tends to be continued until a point of relative tonal-rhythmic stability is reached.* (1973, p. 130)

is also susceptible to canonic analysis (cf. p. 262). Take the example from Bartók's 5th string quartet (1934) quoted by Meyer (op. cit., p. 115). Here, the organisation behind the ascending scale of pitches can be attributed to a secondary zygosequential zygonic constant system, and the felt tendency of the scale to continue implies the active extension of this system in the mind of listeners.

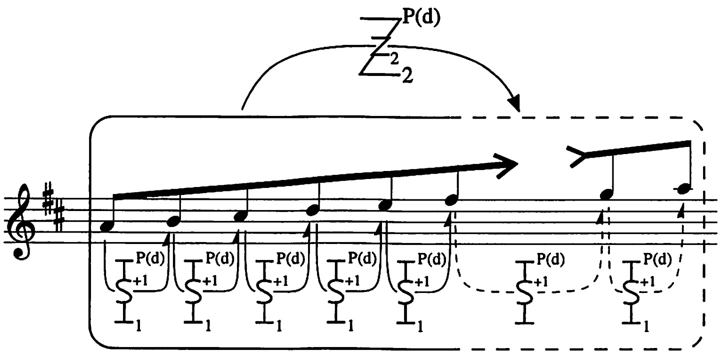


Figure C.1 Secondary zygonic constant system of pitch degree underlying the implicative patterning in Bartók's 5th string quartet (after Meyer, 1973, p. 115).

To the extent that 'points of tonal-rhythmic stability' are learnt phenomena, subconsciously acquired from the fact that many groups have previously concluded in the same way (cf. p. 229), so interoperative repetition is also implicated.

Other models of perceived musical structure involve repetition too: take, for example, Simon and Sumner's (1968) system of encoding musical patterns parsimoniously using preordained 'alphabets' and the operators 'same' and 'next'; Forte's method of atonal analysis (1973), which entails abstracting pitch-class sets and tracing the similarities between them; or semiotic analysis, to which motivic similarities are fundamental at the paradigmatic stage (see, for instance, Nattiez's 1982 study of *Density 21.5*—Varèse, 1936). As Ruwet says (1966/1987, p. 16):

> I shall start from the empirical appreciation of the enormous role played in music, at all levels, by repetition, and I shall try to develop an idea proposed by Gilbert Rouget:[1] "... Certain fragments are repeated, others are not; it is on repetition—or absence of repetition—that our segmentation is based. ..."

Finally, consider that repetition ('parallelism') accounts for four of the five preference rules underlying Lerdahl and Jackendoff's *A Generative Theory of Tonal Music* of 1983 (GPR 6, MPR 1, TSRPR 4 and PRPR 5), as well as being implicit in a number of others, such as GPR 5 (symmetry), for example. As the authors say (cf. p. 637):

> The importance of parallelism in musical structure cannot be overestimated. The more parallelism one can detect, the more internally coherent an analysis becomes, and the less independent information must be processed and retained in hearing or remembering a piece. (p. 52)

Bent and Drabkin (1987, p. 5) provide a useful summary:

> Analysis is the means of answering directly the question 'How does it work?'. Its central activity is comparison. By comparison it determines the structural elements and discovers the functions of those elements. Comparison is common to all kinds of musical analysis—feature analysis, formal analysis, functional analysis, information-theory analysis, Schenkerian analysis, semiotic analysis, style analysis and so on: comparison of unit with unit, whether within a single work, or between two works, or between the work and an abstract 'model' such as sonata form or a recognized style. The central analytical act is thus the test for identity.

As well as playing an implicit part in other theories of music and analysis, zygonic theory, its concepts, related terminology and symbolism, may prove a valuable tool in comparing and interrogating other models of musical

[1] 'Un chromatisme africain', *L'homme: revue française d'anthropologie*, Vol. 1, No. 3, September–December, 1961, p. 41.

functioning. Take, for example, the 'implication-realization' model of Narmour (for example, 1990, 1992). At is heart lies the claim (1990, p. 3) that

> the perceptual structures of melody rest on the realization or denial of two universal formal hypotheses:
> $A + A \rightarrow A$ (or $a + a \rightarrow a$);[2]
> $A + B \rightarrow C$ (or $a + b \rightarrow c$).
> (where $\rightarrow$ = implies)

That is to say: the presence of similarity implies the likelihood of repetition, whereas difference raises the expectation of change. Similarity and difference are gauged with respect to a 'syntactic parametric scale' (op. cit., p. 4). This hypothesizes that

> any pair of melodic pitches transmits separate intervallic and registral messages to the listener. ... it says, ceteris paribus, that small melodic intervals generate registral and intervallic implications of similarity ... [while] large intervals generate intervallic and registral implications of differentiation. (p. 5)

'Small' intervals are defined as the P1, m2, M2, m3 and M3; 'large' intervals are taken to the m6, M6, m7, M7 *et cetera*; 'threshold' intervals are those between: P4, A4/D5 and P5 (p. 78).

The notion that $A + A \rightarrow A$ (that is, 'duplication' or 'process') is derived from the *Gestalt* laws of similarity, proximity and common direction (op. cit., pp. 73ff; cf. pp. 224ff); the hypothesis that $A + B \rightarrow C$ ('reversal') has the status of a 'symmetrical construct' in Narmour's theory. As the author himself admits,

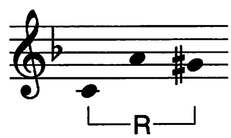
> little psychological evidence seems to lie behind the specific concept of reversal expostulated here. I believe that in time, however, psychologists will discover reversal to be an inborn cognitive mechanism commensurate with the bottom-up Gestalt laws—constantly operative in our input systems ... . (p. 150)

However, the theory of musical order propounded in the current work suggests otherwise. For future material to be implied from that presented

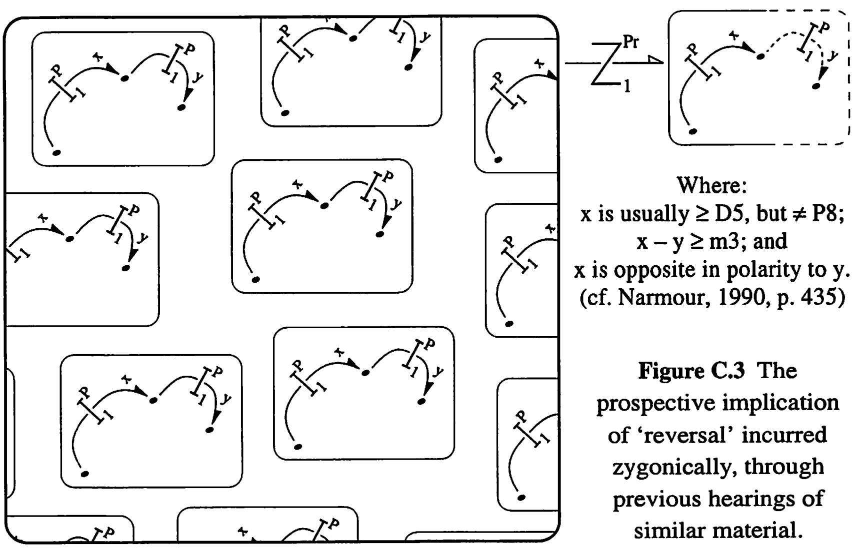
[2] Upper case letters refer to intervallic motion or registral direction; lower case letters refer to single elements such as pitches or durations. 'Registral direction' (the direction of movement from one pitch to the next) may be up, down or lateral. (Narmour, 1990, p. 439)

requires that it can be *logically derived* from it (through imitation). While this is unequivocally the case with Narmour's concepts of duplication and process,[3] whereby, for example, the two pitches *c* and *c* strongly imply a further *c* (through primary zygonic ordering), or *c* and *d* clearly hint at *e* (as a result of secondary zygonic ordering)—cf. Narmour, 1990, p. 75—the grounds for deriving, for instance, *g#* solely from a preceding *c* and *a*

Figure C.2 Registral and intervallic reversal (after Narmour, 1990, p. 154).



are far more tenuous, relying on imperfect ordering (cf. p. 237) or the notion of 'intervallic filling' (cf. p. 541). Hence it seems unlikely that projections of this sort are indeed the result of some innate cognitive processing mechanism. Why should they be? It seems more probable that they are learnt from previous occurrences of comparable events—through interholistic rather than intraholistic zygonic connections (cf. p. 242).



Where:
x is usually ≥ D5, but ≠ P8;
x – y ≥ m3; and
x is opposite in polarity to y.
(cf. Narmour, 1990, p. 435)

Figure C.3 The prospective implication of 'reversal' incurred zygonically, through previous hearings of similar material.

[3]In fact, this is *inevitably* the case, since they are derived from *Gestalt* principles, which are ultimately founded on repetition (cf. pp. 224ff).

Zygonic theory does not purport to be a system of composition, although its underlying concepts may be used to assist in the creative process. As composers strive for new ways of organising their materials, due attention to the hypothesis presented in *The Cognition of Order in Music* should at least ensure that the perceived sonic medium is purposefully and perceptibly structured (while offering no assurance of aesthetic quality). This said, the book is largely retrospective in outlook: cataloguing the types of organisation that composers have chosen to adopt to date, a taxonomy that is illustrated through a wide range of musical examples.

In many cases, however, extrapolation is possible: projecting potential means of future ordering on the basis of those already used. Some of these possibilities are hinted at in the text. They include, for example, the systematic organisation of perspects whose potential has hitherto largely been ignored by composers, such as perceived reverberation (see pp. 266ff), and the advanced zygonic control of factors such as sequence (cf. pp. 533ff).

It seems that the highest rank of interperspective relationship used in the creation of musical structures up to this point is tertiary—and this only in certain perspective domains such as prefix (see, for example, figure 9.78) and pitch (see, for instance, figure 10.14). The vast majority of ordering occurs through the imitation of perspective values themselves or the interperspective values that link them—that is, through primary and secondary zygonic relationships. However, it may be, in the appropriate contexts, that higher ranks of relationship will in the future prove a valid means for constructing meaningful patterns of perceived sound.

The connections between simple perspective values (see p. 17) have invariably taken the form of differences or ratios. This need not be the case, though: theoretically, abstract values can be related through any function. The challenge for composers is perceptibility (see, for example, Lerdahl and Jackendoff, 1983, pp. 2 and 298). There appears to be a logical problem too, since given any series of values (*a b c d*...), mathematical formluae can always be devised that relate in the same way *a* to *b*, *b* to *c*, *c* to *d*, and so on. Hence any three values or more can be considered to be zygonically related (see Weiss, 1968, p. 15). As Caws (1968, p. 105) says:

> It is sometimes thought to be a mark of a special kind of order if a mathematical function can be written that specifies the relations between the elements, but again a function can be written for any set of relations, simply because every set of relations *is* a function, of one sort or another. The concepts of order and

of mathematical function are exhibited—vacuously, it is true—by every state of affairs whatever.

Once more, the crucial thing, in terms of the present theory, is that the order should be *perceptible*. This may mean that complex sets of relationships, which are theoretically—though indiscernibly—orderly, are only reckoned to be so when the values to which they pertain are heard for a second time.

The more usual use of the concepts [order and mathematical function] arises if there is a *repetition* of some set of relations. (Caws, ibid.)

Although *The Cognition of Order in Music* makes extensive reference to relevant theories and findings in music psychology, and many of the concepts it develops are embedded within that discipline, the hypothesis that order in music occurs through imitation is directly supported by only a small amount of extant research: see, for example, pp. 139ff; Dannenbring, 1976; DeWitt and Samuel, 1990.[4] Neither is it the case that zygonic theory evolved through formal experimentation, but through careful consideration of the evidence that music itself offers, and through introspection. Hence, ideas are formulated and positions adopted that would now benefit from empirical scrutiny. For example, a variety of experiments could be undertaken in which certain perspective or interperspective values were omitted from passages, altered, or masked with others. Given listeners' capacity to make good the deficits or correct the perceived errors, the operation of proactive zygonic relationships in the minds of listeners would be inferred (cf. Dannenbring, op. cit.).

A further area of potential investigation concerns how the cognition of musical order develops in children (and others) as their ability to process structured sound grows through exposure to music and active involvement in music-making. Such research could build on the range of work already accomplished which acknowledges—overtly or by implication—the role of repetition in early aural development. Consider, for example, the findings of Dowling (1982, pp. 416ff) and Hargreaves (1986, p. 69):

The spontaneous songs of the 2-year-old tend to consist of brief phrases which are repeated over and over again. These phrases consist of notes with discrete pitches, and their melodic contours and rhythmic patterns remain more or less constant. The repetitions are likely to vary in pitch ...

[4]It is implicit in much other work, however: consider, for instance, *Gestalt* perception as it applies to music (cf. pp. 224ff).

Serafine (1988, pp. 171ff) shows how the recognition of melodic transformations (which involves the understanding of similarity and difference) takes a developmental route through childhood.

Ultimately, however, the most far-reaching implications of the zygonic model, developed here in an exclusively musical context, may reside in its links with cognitive psychology more generally. For example:

> A general principle that has emerged as fundamental to cognition is that the brain abstracts recurrent commonalities from the environment and encodes them in the form of schematic representations as a basis for future categorization and comprehension. (Bharucha, 1987, p. 2)[5]

Similarly, Coker (1972, p. 72), states that the

> most important relation found through attentive listening is that of *equality*, by means of which some kind of identity is displayed. The identity is discovered in musical experience when we think and feel 'it again' of a stimulus—whether 'it' is a single sonic or rhythmic property, a short gesture, or a large section of music. The mental act is one of recognition. And indeed, the recognition of identities is fundamental to thinking and to mental evolution.[6]

In summary, consider Bernstein's comments pertaining to bars 5–8 of the first movement of Beethoven's *Pastoral* symphony, op. 68:

> They are a striking model of the human brain in action and as such, a model of how we think. (1976, p. 169).

Other music-related disciplines too could be revisited in the light of the hypothesis set out in *The Cognition of Order in Music*. For example, the way in which zygonic ordering has evolved historically could be traced, either in general terms, or with specific reference, for instance, to a certain geographical area, composer's oeuvre, school of composition, genre, form or perspect. Such possibilities are adumbrated at a number of points in the preceding chapters (see, for example, pp. 292ff, pp. 472ff, p. 602). Then, many of the issues raised have aesthetic, logical and philosophical implications which could be pursued in more detail.[7] Finally, the book will be of interest and relevance to those working in music education and music therapy, since

[5]Cf. Rosch and Lloyd, 1978, pp. 73ff; Tversky and Gati, 1978, pp. 79ff.
[6]See also Lerdahl and Jackendoff, 1983, p. 53.
[7]Also compared and contrasted with other studies; see, for instance, Kivy, 1993, pp. 327ff.

the ideas presented probe basic functions such as perceiving, learning and responding to sound structured in musical contexts.

In conclusion, the possibility of applying zygonic theory in areas other than music should be acknowledged. Its potential relevance to other art forms—painting, sculpture, architecture, dance and poetry, for instance—has already been mentioned (see p. 114). Beyond this, the theory may assist in understanding and modelling other manifestations of repetition, occurring both synthetically and in the natural world (cf. p. 113).

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Composers, Performers, Works and Editions Cited

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Just listen, and music makes sense. No special knowledge or skills are needed. But how? How does music, the universal, abstract medium for conveying human thought, actually *work?* It is to this fundamental question that **The Cognition of Order in Music** is devoted.

The main findings are: that all forms of musical order—from the internal regularity of a single note to the large-scale tonal and motivic forces that drive the Classical sonata—occur through, or are ultimately dependent upon, repetition; that, in pieces that are wholly coherent, *every* aspect of *every* note is ordered through repetition—usually many times over; that the vast majority of repetition in music pertains directly to different manifestations of perceived sound or to the relationships that directly link these; and that, since all musical structure is founded on repetition, so all theories concerning music necessarily acknowledge its operation, whether overtly or by implication. In addition, a number of subsidiary themes are explored. These include perceived sound and its attributes, and the relationships that may exist between perceived sounds. A comprehensive new terminology and symbolism are developed to facilitate the investigation of these concepts.

The Cognition of Order in Music will be of particular interest to music theorists and analysts, those working in the field of music psychology or philosophy, music historians and ethnomusicologists, composers and performers, music teachers and lecturers, and music therapists.

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