Implication and expectation in music: a zygonic model

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ABSTRACT This article examines implication and expectation in music, taking as its starting point music-theoretical and music-psychological work ranging from the seminal thinking of Meyer (1956, 1967, 1973) to its development in the theories of Narmour (1990, 1992) and subsequent empirical and theoretical investigation by, for example, Schellenberg (1996, 1997), Von Hippel and Huron (2000) and Aarden (2003). Other psychological approaches, such as those adopted by Jones (1981, 1982, 1992) and Bharucha (1987, 1999), are considered too. The most important contemporary reference point, however, is Huron's latest extended thinking on expectation (forthcoming), which summarizes, consolidates and develops a wide range of theoretical and empirical work in the field. These diverse perspectives on musical implication and expectation are analysed using the 'zygonic' theory of musical understanding recently developed by Ockelford (for example, 1999, 2002, 2004, 2005a, 2005b). This holds that the cognition of structure stems from a sense of derivation arising from the presence of repetition in certain contexts. Using this framework, a new, composite theory of expectation in music is developed, which acknowledges the potential implications of three sources of regularity in music: patterns *within* groups of notes, and *between* them – as encoded in short-term memory and long-term, both *veridically* and *schematically*. Finally, the phenomenological relevance of the new model to 'typical' listening experiences is discussed, and the need for future empirical work is set out.

KEYWORDS: *cognition, realization, relationship, schematic, structure, veridical*

Introduction

In this article, musical implication and expectation are investigated using the 'zygonic' theory of musical understanding. Developed over the last decade or so, this argues that the creation and cognition of structure depend ultimately upon a sense of derivation engendered through the imitation of material, both within and between pieces (for example, Ockelford, 1993, 1999, 2002, 2004, 2005a). Zygonic theory – and, therefore, the current investigation – is interdisciplinary in nature, drawing on the individual intuitions that constitute the conceptual currency of music theory and analysis, as well as relevant empirical findings and thinking from the domain of music psychology (cf. Cross, 1998; Gjerdingen, 1999). The value of adopting a zygonic approach in seeking to further our understanding of musical implication and expectation is twofold. First, it can serve as a meta-analytical tool, enabling a range of contemporary theoretical and empirical work to be interrogated within a common conceptual framework. Second, zygonic theory enables a new, composite model of expectation in music to be propounded, which, it is believed, could inform future empirical work in this area.

The first step is to consider the implications for continuation that potentially stem from a *single* event, and the corresponding expectations that may be aroused in listeners. Zygonic analysis suggests that, on a first hearing, the possibilities of exact and approximate imitation yield a range of future outcomes that can reasonably be predicted, leaving listeners with only a general sense of what may occur next. This assertion is supported by a range of empirical work including that, for example, by Aarden (2003). Then, the expectations that may be induced by *two* units of perceived sound are examined through a review of Narmour's 'implication–realization' model (for example, 1990). Zygonic analysis reveals, again, that a range of logical projections is available – even greater than from one unit of perceived sound – and listeners are left, once more, with only a general feeling of what may ensue. This accords with the findings of Schellenberg (1997), who proposes a simplified model of expectancy in melody with only two factors. Indeed, the zygonic approach suggests further simplification still, leading to a single-factor model based on the principle of pitch proximity, which indicates that (and demonstrates how) listeners can infer a general sense of what is to come from a series of two notes or more.

This, though, is only part of the picture since, to listeners operating within a familiar stylistic environment, such broad-based expectations are typically tempered by schematic projections derived from the general regularities and patterning that characterize most musical textures (Bharucha, 1987). Even this dual account, however, fails to capture the more specific expectations that may be engendered in the course of listening to pieces (including unfamiliar ones), and these, it is proposed, come about through repetition between *groups* of notes, using short-term and veridical memory traces (cf. Bharucha, 1987, 1994). Through a phenomenological analysis of a single moment early in the recapitulation in the first movement of Mozart's Piano Sonata K333, these three implicative strands are drawn together into a composite model of expectation in music, utilizing the conceptual framework offered by zygonic theory. The model is subsequently used in an attempt to capture and explain the aesthetic effect of appoggiaturas and their resolution in the opening theme of the third movement of Rachmaninov's Symphony No. 2. This raises issues around the extent to which such modelling accords with the reality of the 'typical' listening experience: how, for example, the complex and multifaceted process of expectation that is identified can work alongside the potentially competing demands of past and current perceptual input. In conclusion, the need for further empirical investigation is discussed.

Implication and expectation in music

According to Schmuckler (1989: 111), 'Almost all contemporary music-theoretic analyses have adopted implicit or explicit ideas of expectation', and no theorist is more explicit than Meyer (1956, 1967), who postulated that the capacity of organized sound to generate expectancies in listeners is fundamental not only to the cognition of musical structure, but also to musical *meaning* in the form of emotional arousal. Meyer's ideas, rooted in gestalt perception and information theory, were subsequently developed by Narmour in his 'implication–realization' model (1977, 1990, 1992, 1996). This model has found support in recent empirical studies, though these have indicated that simplification may lead to little or no loss of its predictive power (Schellenberg, 1996, 1997; Thompson and Stainton, 1998). Moreover, Von Hippel and Huron's (2000) analysis of melodies from a wide variety of cultures has shown that Narmour's key principle of 'registral return' can be explained merely as a side-effect of constraints on tessitura. Nonetheless, the broad thrust of the theory retains its relevance in contemporary thinking. Aside from this, expectation features centrally in other psychological and music-theoretical approaches too (for example, Jones, 1981, 1982, 1992; Bharucha, 1999; Margulis, 2003, 2005).

Whatever their perspective, there is a consensus among writers that expectation works through a listener being able to predict, at any given moment, the future course of a piece of music based on his or her past experiences. These will comprise sounds that have just been heard, and may include previous hearings of the same performance (in the case of recorded music), earlier hearings of other performances, and other hearings of other pieces (Ockelford, 1999: 265). Curiously, most theoretical activity in the area of musical expectation has centred around the *first* hearing of a work, with the question of *repeated* hearings then having to be 'explained away' as a separate issue (see, for example, Meyer, 1967: 42ff; and Jackendoff's critique, 1991: 224ff). Yet, across styles and cultures, hearing pieces of music once is not the norm – indeed, according to Huron (forthcoming), 99 percent of all musical experiences involve works that the listener has heard before.[1] Certainly, one's first hearing of a composition is not generally the preferred one. There is evidence (summarized in Hargreaves, 1986: 110ff; Smith and Cuddy, 1986: 17 and 18) that the relationship between favourability and familiarity can typically be represented as an inverted 'U', whereby the pleasure that is felt in hearing a piece grows as a listener becomes better acquainted with it, and then falls back again as boredom figures more and more in the equation.[2] Hence the experience of multiple hearings should lie at the heart of a satisfactory model of musical expectation, which should also be able to account for the capacity of listeners to make some sense of a piece the first time it is heard.

Irrespective of its source, informed prediction, and therefore expectation, is possible because music is coherent – patterned in an orderly way – which, to a greater or lesser extent, implies predictable modes of continuation, both perceptually (to the intuitive listener) and logically (to the theorist attending with an analytical mindset). Hence, 'zygonic' theory (see, for example, Ockelford, 1999, 2002, 2005a, 2005b), which considers the implicative connections that may exist between perceived sounds, offers an ideal way of modelling musical implication and expectation in theoretical terms. The next section summarizes this theory.

Zygonic theory

Zygonic theory offers a model of how musical structure may be processed in cognition, something that typically occurs without the conscious awareness of listeners. The theory is interdisciplinary in nature: an epistemological hybrid in which the individual musical intuitions that typify approaches to music theory and analysis are informed by relevant thinking and findings appropriated from the domain of cognitive psychology (cf. Cross, 1998; Gjerdingen, 1999). The starting point is a reductionist one: music is considered in the first instance as a system of perceived sonic variables. Some, such as loudness, gauge qualities of sound as we apprehend them, while others detail its perceived location in time or space; some, like pitch, pertain to individual notes, while others, including tonality, are characteristic of a group. Perceptually, these variables pertaining to the 'auditory scene' of music (cf. Bregman, 1990) are complex and multidimensional in nature. Yet despite their diversity and complexity, such variables share a fundamental similarity in that they each have a number of potential modes of existence (termed 'values'), whose range represents the freedom of choice available to composers. Conversely, each may be deemed to be constrained or 'ordered' to the extent that its value is thought to be subject to restriction. The belief that such ordering is essential for composers and performers to be able to communicate purposefully with listeners lies at the heart of zygonic theory. While some of the causes of perceived sonic constraint may lie beyond a composer's immediate control (the selection of timbre may be determined by the availability of performers, for example, and a singer may be unable to reach a particular pitch), and while external influences (such as the cross-media effects of song-texts, for instance) often have a bearing, zygonic theory contends that most – and certainly the most important – perceived sonic restrictions in fact function *intra*musically, 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, if it is in some sense felt to *derive* from it. 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 it must be universally present (we may surmise), if only subconsciously, otherwise an orderly sequence of sounds would prove no more effective a means of musical communication than a random one, which is not the case.

The recognition of imitation (or derivation) is predicated on the presence of what may be termed 'interperspective relationships'[3] – cognitive constructs through which, it is hypothesized, incoming perceptual data are compared (cf. Krumhansl, 1990: 3). Interperspective relationships may be regarded as forms of 'link schemata' (Lakoff, 1987: 283), which inhabit the mental space pertaining to music processing (cf. Fauconnier, 1994[1985]; Lakoff, 1987: 281 and 282). Such relationships exist potentially between any aspects of musical events, in any perceptual domain. We may surmise that in most circumstances they are formulated unthinkingly, passing listeners by as a series of qualitative experiences. However, employing the metacognitive processes upon which music theory and analysis typically depend enables interperspective relationships to be captured conceptually, and they may be symbolized as shown in Figure 1. These relationships may be assigned values, some of which can be expressed as a difference or ratio, while others necessarily reflect the complex nature of the perspects to which they pertain.

In Figure 1, the two relationships are each symbolized through an arrow upon which the letter 'I' is superimposed, which stands for 'interperspective'. Superscripts indicate in each case the perspect concerned, represented by its initial letter or letters – here 'P(d)' for 'pitch (degree)' and 'O' for 'onset'.

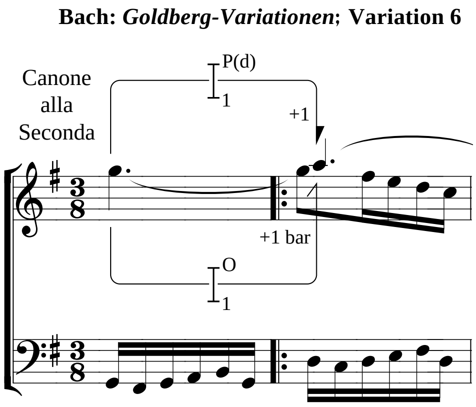


FIGURE 1 *Interperspective relationships.*

Relationships can be of different *levels*, with 'primary' relationships potentially linking perspective values, 'secondary' relationships connecting primaries, and 'tertiary' relationships offering a medium through which 'secondaries' may be compared (see Ockelford, 2002). The level of a relationship is indicated by the appropriate subscript (here, '1' in each case). Note that the value of the pitch-degree relationship (shown near the arrowhead as '+1') has two components, 'polarity' (which in this case is positive, showing the interval is ascending) and 'magnitude' (here, one scale degree). Together these reflect the interval of imitation of the 'canone alla seconda'. Similarly, the value of the relationship of onset (a 'primary interperspective value') shows the temporal direction and interval at which the imitation occurs (one complete bar ahead).[4]

Interperspective relationships through which imitative order is perceived are deemed to be of a special type which I term 'zygonic' (Ockelford, 1991: 140ff), from the Greek term 'zygon' for 'yoke', implying a union of two similar things. Zygonic relationships, or 'zygons', are represented through the use of the letter 'Z'. In Figure 2, the first primary zygonic relationship of duration reflects the derivation of the first note-length of the 'comes' from the corresponding value in the 'dux'.[5] The second zygonic relationship of duration and the secondary zygons of pitch degree and onset (indicated

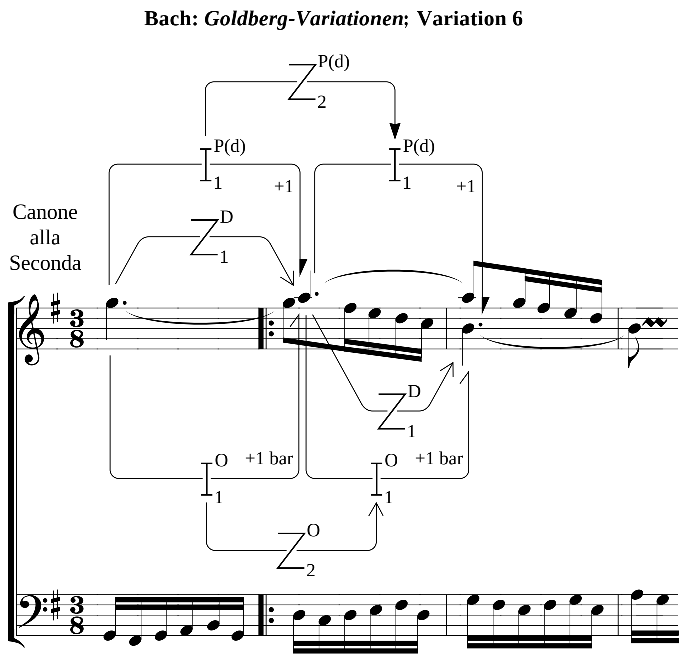


FIGURE 2 *Zygonic relationships.*

through the subscripts '2') show that events can serve both as model and imitation, since the third bar of the dux echoes the opening of the comes, each part therefore functioning as statement *and* answer.

Observe the use of *full* arrowheads, which signify relationships between values that are the same, and which are termed 'perfect'. *Half* arrowheads are indicative of difference (see Figure 1), and are used in a zygonic context to show approximate imitation. For example, the interval between the opening of the dux and comes (a tone) is copied '*im*perfectly' between the second entries of the motive that follow (a semitone) (see Figure 3).

Given the interdisciplinary nature of the current article, it is particularly important to be clear about the status of zygonic relationships (cf. Ockelford, 2005a). They are *hypothetical constructs* intended to represent aspects of the typically subconscious cognitive processing that can be assumed to occur when we attend to, create or imagine music – a supposition suggested by the structural regularities of pieces, which, as Bernstein asserts, offer 'a striking model of the human brain in action and as such, a model of how we think' (1976: 169). Certainly, the notion of a zygonic relationship can at best offer only a much-simplified version of certain cognitive events that may be stimulated by participation in musical activity. However, while simplification is necessary to make headway in theoretical terms, it is important to bear in mind that the single concept of a zygon bequeaths a substantial perceptual legacy, with many possible manifestations, not only potentially linking individual pitches, timbres, dynamics, durations and interonset intervals, but also prospectively existing between tonal regions, textures, processes and forms the same, over different periods of perceived time, and within the same and between different pieces, performances and hearings. Whatever their context, zygons, it is hypothesized, may function in a number of ways: reactively, in assessing the relationship between extant values, for example, or proactively, in ideating a value as an orderly continuation from one previously presented.

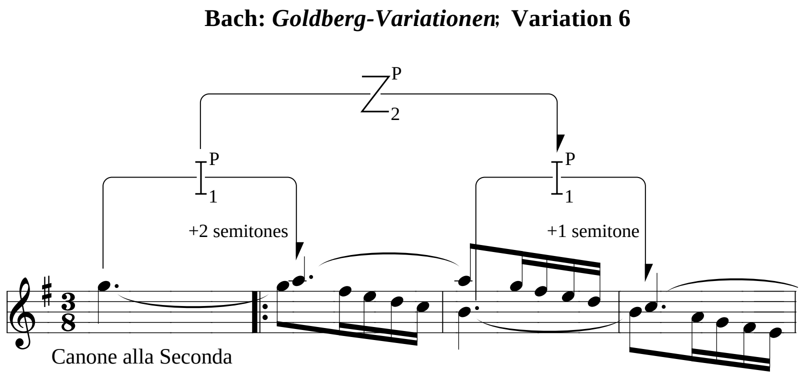


FIGURE 3 *Imperfect zygonic relationship.*

Given this variety, there is, of course, no suggestion that the one concept represents only a single aspect of cognitive processing. Hence, empirical evidence in support of the theory is likely to be drawn from a diversity of sources. Currently, for example, one can point to experiments in auditory processing (such as the 'continuity illusion', summarized in Bregman, 1990: 344ff) and work on expectation in a musical context, particularly that involving the perceptual restoration of omitted or obscured notes (for instance, DeWitt and Samuel, 1990), to support the presence of proactive zygonic-type processes (Ockelford, 1999: 123; 2004). There is general support for the theory, too, in the wide range of music-theoretical and analytical sources in which the fundamental importance of repetition in music is acknowledged. These are itemized in Ockelford (1999: 9ff, 71ff and 763ff). Similar acknowledgements are made by Borthwick (1995), as a background to the exposition of his metatheoretical framework to which the notions of identity (and non-identity) are central. From across the 20th century, relevant texts include those by such widely divergent writers as Selincourt (1958), Schenker (1979[1935]), Stravinsky (1942), Sessions (1950), Reti (1951), Zuckerkandl (1956), Meyer (1956, 1967, 1973), Chávez (1961), Ruwet (1987[1966]), Schoenberg (1967), Forte (1973, 1985), Rahn (1980), Lerdahl and Jackendoff (1983), Lewin (1987), Isaacson (1990), Nattiez (1990) and Morris (1995). Perhaps most pertinent to zygonic theory, however, is the assertion of Cone (1987: 237), made in relation to the derivation of musical material, that '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" . . .'.

In the sections that follow, zygonic theory is used initially to interrogate recent work in the field of music theory and music psychology in relation to implication and expectation, and subsequently to construct a new theoretical model, informed by relevant empirical findings where these exist.

Expectations stemming from a single unit of perceived sound

Notwithstanding the comments made above concerning the importance of repeated hearings, the most straightforward scenario to model comprises the expectations that are potentially stimulated by a unit of perceived sound, heard for the first time: what sense of continuation is this likely to arouse? That is, what can reasonably be predicted from what is heard?[6] The fact that such prediction is possible at all implies that future perspective values are somehow constrained – perceived to be logically derived from those present or in the past. According to the current theory, such constraint occurs through imitation and listeners anticipate what is coming through the (albeit subconscious) projection of zygonic relationships.

In musical contexts, anticipation has two distinct and equally important components: the future is about knowing *what* is going to happen (in terms of perspective values) and *when* (cf. Wittmann and Pöppel, 1999–2000: 13).[7]

The projection of 'what' can occur in any perspective domain except onset or the perceived location of the sound source. It can result from the ideation of perfect or imperfect relationships: the greater the degree of perfection, it is hypothesized, the surer the expectation. From a single value of onset, the projection of 'when' can occur only through an imperfect zygonic relationship (since in this domain perfection equates to simultaneity), corresponding to the fact that if a second value is to be musically pertinent to the first – if it is to constitute anything more than a further isolated perceived sonic experience – then it must occur within its perceived temporal ambit. Hence the musical implications and expectations that potentially stem from a single unit of perceived sound may be modelled zygonically in abstract terms as shown in Figure 4.[8,9,10]

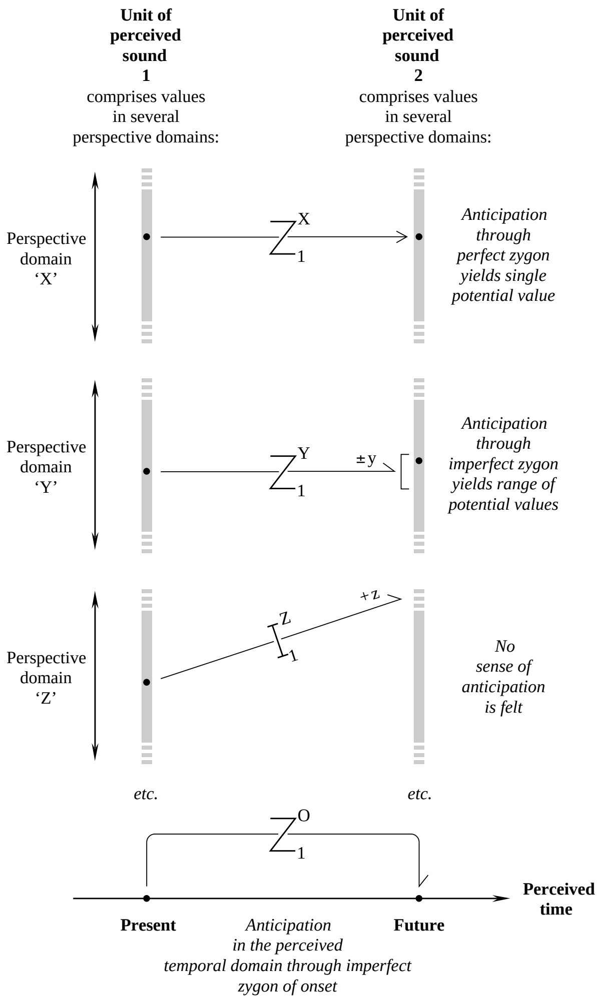


FIGURE 4 *Zygonic model of musical expectation stemming from a single unit of perceived sound.*

This shows expectation occurring through a perfect zygonic relationship in domain 'X', which yields a single potential value. In domain 'Y' a range of future values is implied through an imperfect zygon. No sense of contingency operates in domain 'Z'; that is, the second value cannot be anticipated on the basis of the first. However, the zygonic bonds that do exist between the two units of perceived sound are sufficient for one as a whole to be deemed to be derived from the other, and thus for the second to be anticipated *as a whole* on the basis of the first – something that occurs, we may suppose, through a form of auditory 'binding' (cf. Roskies, 1999; Huron, forthcoming). Hence prospective contrast is conceivable within an overall sense of coherence (cf. Ockelford, 2004: 57). Even without this freedom (if all domains were zygonically linked), from any given perceived sonic unit a diversity of possibilities exists that may be perceived as being contingent upon it: a theoretical position which, as we shall see, is supported by empirical evidence (cf. Figure 30 later). Take, for example, the single, short note that opens Schoenberg's *A Survivor from Warsaw.* Orderly continuations in all perspective domains can be predicted as follows (using perspective quanta typically associated with western art music of the first half of the 20th century) (see Figure 5).

Schoenberg's actual choice (also shown in Figure 5) was a perceived sonic event that lies well within the range of aural logic set out, and, in retrospect, one that offers a mode of continuation that is entirely coherent. However, there is no reason why this particular cluster of perspective values should have been predicted from the opening note in preference to a number of others. Hence, one has to question what the role of expectation in this, the initial hearing of the very opening of a piece is, beyond indicating in general terms likely future directions in each perspective domain. Of course, this is an extreme – and fleeting – scenario: one, it could reasonably be argued, that does not have much bearing on how implication and expectation typically work in music. Is it the case, for example, that prognostication is surer on the basis of *two* values, which provide more information, and potentially initiate *inter*perspective trends at the primary level?

Expectations stemming from two units of perceived sound

A ZYGONIC ANALYSIS OF NARMOUR'S 'IMPLICATION–REALIZATION' MODEL

Certainly, this is the view of Narmour,[11] as expressed in the 'two universal formal hypotheses' that underpin his 'implication–realization' model of melodic perception (for example, 1990). He postulates (1990: 3) that:

1. A + A → A (or, a + a → a); and
2. A + B → C (or, a + b → c).

Narmour unpacks postulate 1 thus:

> When form (*A* + *A*), intervallic patterns (A + A), or pitch elements (a + a) of a given melody are similar (*A*, A or a), the listener subconsciously or consciously infers some kind of repetition of pattern, element or form. (1990: 3)

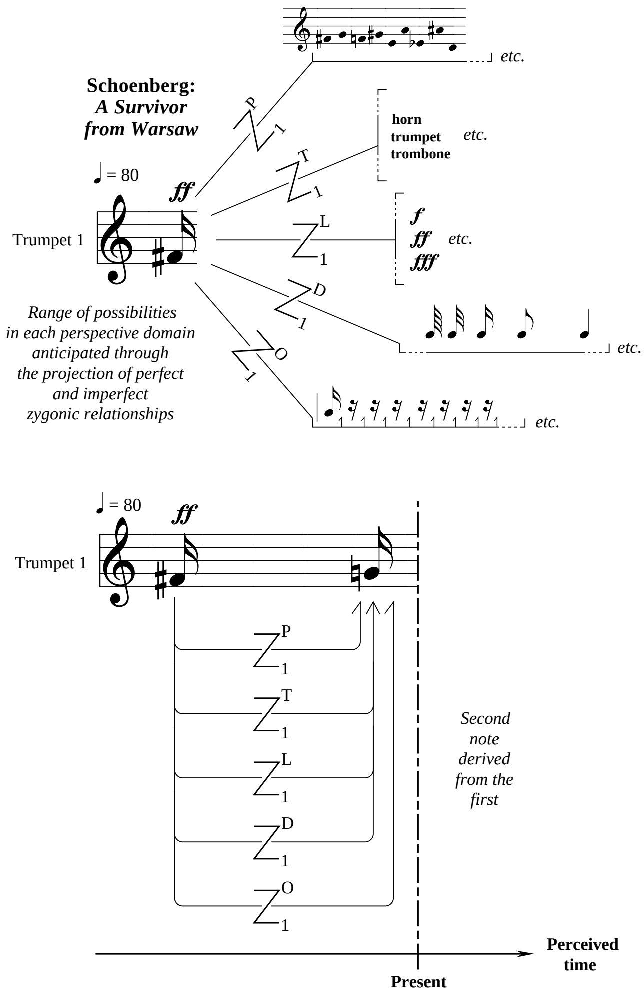


FIGURE 5 *Range of continuations in each perspective domain suggested by the opening note of* A Survivor from Warsaw, *and the option selected by Schoenberg.*

Postulate 2 translates:

> When form, intervallic patterns, or pitch elements are different (*A* + *B*, A + B, a + b), the listener subconsciously or consciously perceives some implied change in form, pattern or element (*C*, C or c). (1990: 3)

Postulate 1 is derived from the gestalt principles of similarity, proximity and 'common direction', and is applied by Narmour to three aspects of the domain of pitch: 'pitch specificity', 'intervallic motion', and 'registral direction' (which may be up, down or lateral – 1990: 75–6). In terms of the present theory, these three dimensions may be expressed as shown in Figure 6.

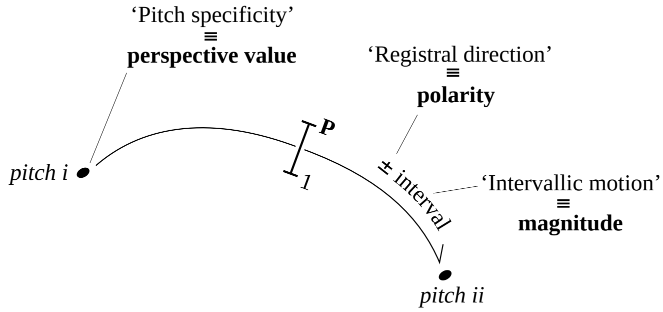


FIGURE 6 *Narmour's three dimensions of pitch in melody expressed in terms of zygonic theory.*

Each of these dimensions is capable of bearing implication. Take, for example, the repetition of two notes (say, C–C). Narmour hypothesizes that these imply:

> (1) the same pitch (= similarity; i.e., a second pitch like the first except for its temporal position), (2) the repetition of the same interval (= proximity; i.e., a third pitch the same unison distance from the second pitch as the second pitch is from the first), and (3) the same registral direction (= common direction; i.e., lateral or "sideways"). (1990: 75–6)

That is,

> all other things being equal, the listener will, on hearing the pitches C–C, subconsciously expect another C.

But is this all that he or she can reasonably be anticipated to expect? Recent empirical findings are discussed below. At this stage, we analyse whether the reasons for expectation set out by Narmour are accurate and complete on a *theoretical* level. In zygonic terms, Narmour's hypothesis can be interpreted as shown in Figure 7.

'Interval' and 'registral direction' are implied through a secondary zygonic relationship of pitch and 'pitch specificity' is implied through a primary zygon. In addition, note that temporal position is implied through a secondary zygon of onset. Putting these findings in the context of the zygonic model set out in Figure 4, which hypothesizes that a single value is sufficient to induce expectation, it is evident that pitch *iii* can additionally be derived directly from pitch *i*, although, of course, its onset will be related with a greater degree of imperfection to that of the first (see Figure 8).[12, 13]

Then, the model shown in Figure 4 proposes that anticipation may occur through *imperfect* zygonic relationships, and Narmour's hypothesis can be extended to encompass this possibility. This accords with the admission elsewhere in Narmour's theory that implication can result in *similarity* (and not just *sameness*). For example:

> If interval (A^0) composed of two proximate pitches lying on the same plane or in ascending or descending directions occurs ($a^0 + a^{1, 2, 3...}$), then the listener subconsciously expects the same interval (A^0) or a similarly sized interval (A^1) in the initial registral direction. (1990: 86)

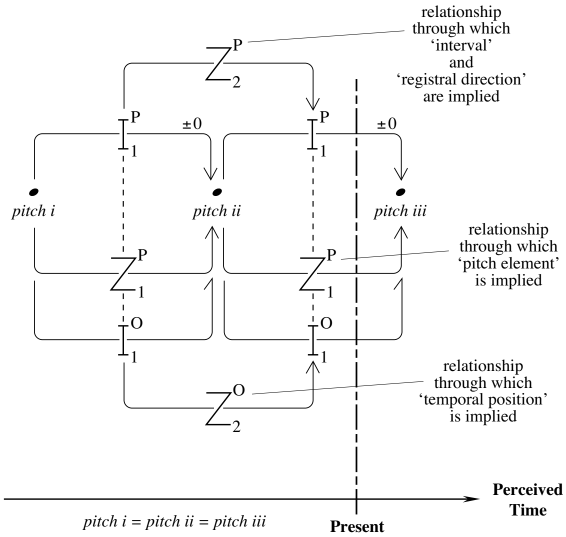


FIGURE 7 *Zygonic meta-analysis of the implications arising from two repeated pitches (after Narmour, 1990: 75).*

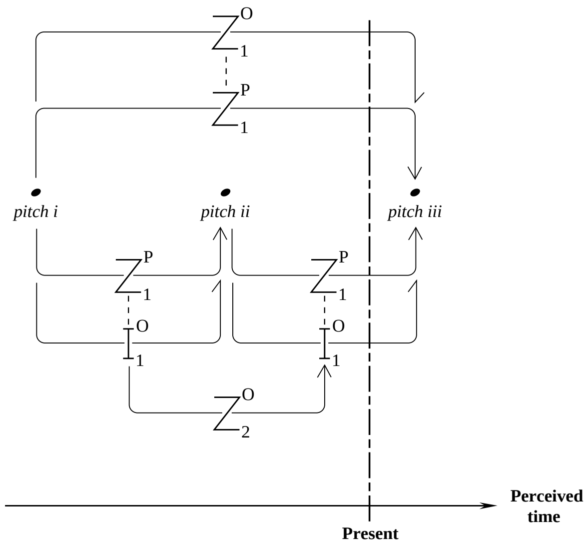


FIGURE 8 *Additional zygonic relationships linking pitch* i *and pitch* iii *implicatively.*

Where the initial interval is between identical pitches (**1**) (see Figure 9), surely it follows that this can imply – through an imperfect secondary zygon (**3**) – a relationship (**2**) (in either registral direction) between near-identical values? Moreover, similarity underpins Narmour's concept of 'near registral return' (aba^{1}), which occurs when 'a discontiguous pitch register nearly returns to the same register as the initial pitch' (1990: 131). This possibility, of imitation between discontiguous events, is captured in zygonic relationship (**4**).[14]

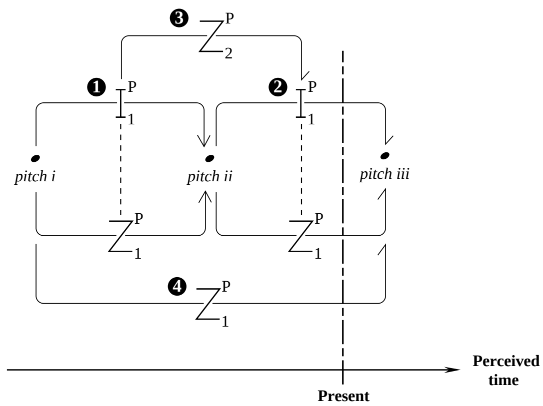


FIGURE 9 *Extension of Narmour's hypothesis through the incorporation of imperfect zygonic relationships.*

To consider what the construct a + a → a′ may mean in musical terms, consider, for example, the opening three notes of the theme of the second movement of Sibelius's *Karelia Suite.* Here, the third note of the melody is distinct from the first two, and the interval between adjacent scale steps that links them is of subsequent structural importance (see Figure 10). At the same time, however, the F, which, within the diatonic system is as close as it is possible to get to the preceding Es, clearly owes something of its derivation to them, and is well within the range of coherent continuations which they imply (cf. Figure 5).

Hence, two notes of the same pitch imply a *range* of future options. Just how far this range can extend depends on where the boundaries of imperfect zygonic ordering lie, although these cannot be determined in a hard and fast way, since the cognition of derivation is dependent upon context (Ockelford,

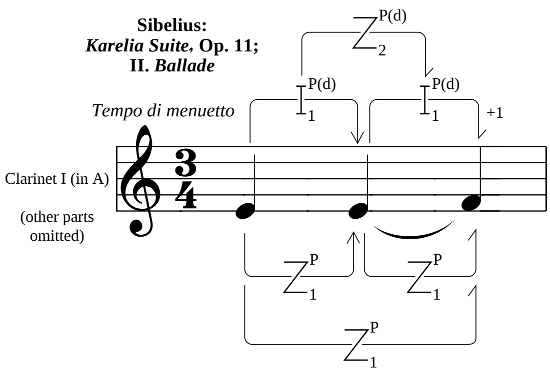


FIGURE 10 *Example of the construct a + a → a′ in the domain of pitch.*

1999: 92). However, broad markers can be put down based, for example, on Aarden's empirical work (2003: 49), which indicates, in general terms, that the strength of expectancy wanes with decreasing pitch proximity over the span of 11 semitones – with a pronounced reversal of this trend at the octave. Moreover, the tendency that Aarden identifies is broadly reflected in the cross-cultural distribution of intervals in music (Huron, 2001: 205). Hence, it seems reasonable to assume that the range of anticipation through imperfect imitation will, other things being equal, typically span at least an octave in either direction from the pitch concerned. Note, however, that Narmour regards similarity rather more restrictively than this – at most, up to a tritone from the given pitch (1990: 78ff).

A further scenario considered by Narmour is that of two *similar* notes, separated by a small interval, for example, C–D: what implications do they generate? The fact, according to Narmour, that there are three dimensions of pitch that are of perceptual relevance ('pitch specificity', 'intervallic motion' and 'registral direction') means that a number of continuations are implied. For example:

> Given C major, the E in the ascending pattern C–D–E, for instance, is, all other things being equal, a realization of an implication of registral direction (the ascent of C–D followed by the ascent of D–E), of pitch (E was implied, not, say, E♭), and the implication of interval (the M2 of C–D followed by the M2 of D–E). (1990: 75)

Zygonic analysis confirms that E offers one logical continuation of the interval C–D and its registral direction (see Figure 11).

However, the issue of pitch specificity (that is, E or E♭) cannot be resolved from the interval C–D alone, but requires a fuller intervallic context (afforded by previous material, or harmonically). As Narmour observes:

> though implication of registral direction (up or down) is as specific as that of iteration, the size of the interval and concomitantly the specificity of pitch are often not so clear, particularly in the absence of a contextually defined mode. But, regardless of the implicative specificity of pitch, when realization of registral direction (A + A), intervallic similarity (A + A), and pitch proximity (a + a) occur, we say that a process [P] takes place . . . [if] X – Y equals m3 or less . . . (1990: 99)

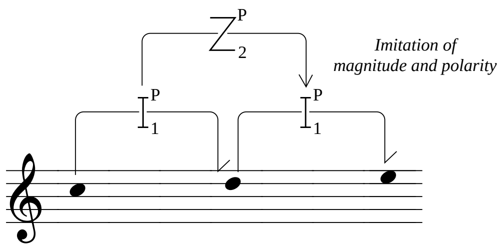


FIGURE 11 *Zygonic analysis of Narmour's anticipated implication from C–D (ascending).*

In terms of zygonic theory, this means that a primary interperspective value of pitch can imply a further primary interperspective value, provided that the difference between the two is a minor third or less (although idiostructural context can affect this – see Narmour, 1990: 81), as shown in Figure 12.

A further potential implication of C–D identified by Narmour yields the up-down pattern C–D–C, which is 'a realization of intervallic motion (M2 plus M2), but not registral direction (up is followed by down)' or pitch (C follows C–D instead of E)' (1990: 76). This is shown in zygonic terms in Figure 13.

Elsewhere (1990: 130), Narmour cites the pattern C–D–C as an example of 'registral return' (aba), which conceptually and symbolically implies the following zygonic connection (see Figure 14).

Again, imperfect repetition ('near registral return') is possible. Here, Narmour considers the boundary between similarity and dissimilarity to be 'when the difference between two intervals equals a plus/minus major second or less' (1990: 131). Figure 15 shows this in zygonic terms.

So much for the implications (and 'non-implications' in the form of registral return) identified by Narmour. Zygonic theory suggests other possibilities for logical continuation – that may but need not be realized. For example, the inversion of the ascending M2 may be rooted on the first C,

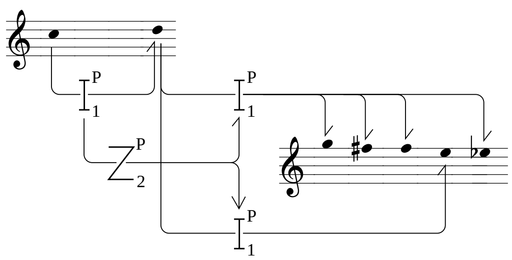


FIGURE 12 *Range of implicative possibilities stemming from an ascending major second (after Narmour, 1990: 99), expressed in zygonic terms.*

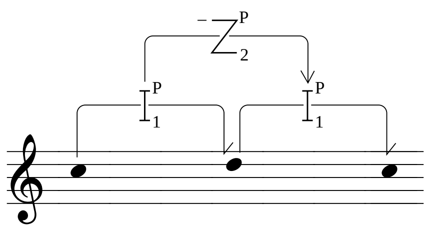


FIGURE 13 *Zygonic meta-analysis of Narmour's 'realization of intervalic motion . . . but not registral direction' (1990: 76).*

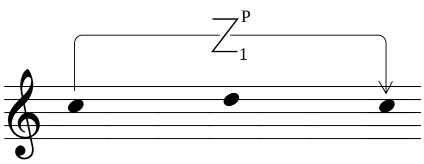


FIGURE 14 *Zygonic meta-analysis of 'registral return' (after Narmour, 1990: 130).*

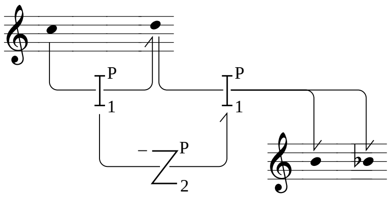


FIGURE 15 *Zygonic meta-analysis of 'near registral return' (after Narmour, 1990: 131).*

giving the following range of outcomes (assuming, for imperfect relationships, Narmour's limit of a M2 difference between model and imitation, although this constraint is not implicit in zygonic theory) (see Figure 16). Then, the first pitch, C, may imply a *range* of others that are similar, while the second pitch, D, may likewise suggest others that are similar or the same (see Figure 17). Lastly, the interval between the first pitch and the third may be an inversion of that between the second and the third, forming the sequence C–D–C♯ (or D♭) (see Figure 18).[15]

A third scenario depicted by Narmour is that of an initial 'large' interval, as framed, for example, by the pitches C–A (ascending). According to his second postulate (A + B → C), this initial difference implies change – specifically, melodic 'reversal'. This refers 'both to an implied change of registral direction and to an implied reduction in the size of the interval to

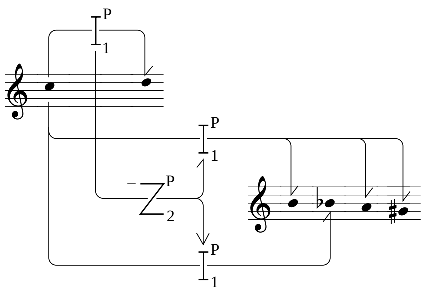


FIGURE 16 *Melodic inversion rooted on the first C.*

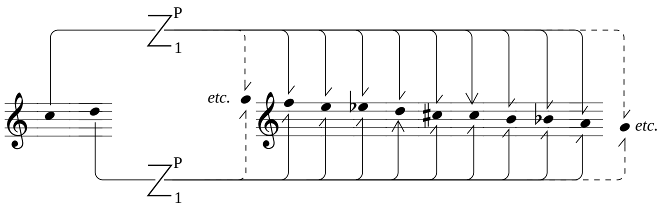


FIGURE 17 *Primary zygonic implications arising from the C and D.*

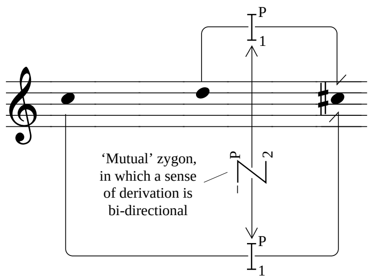


FIGURE 18 *Implication arising from inverse secondary zygon.*

follow. . . . for a satisfactory realization, the interval following the initial one must satisfy the definition of intervallic differentiation following registral change, namely, difference of a minus minor third or more . . .' (1990: 151, 153). Accordingly, there are seven possible realizations of reversal arising from C–A (see Figure 19).

However, this proposition is not supported in the current theoretical context, as zygonic analysis shows. Essentially, this says that an initial difference implies a further (and distinct) difference; or, in terms of the present theory, that one non-zygonic relationship implies another. This prospect can at least be captured conceptually and symbolically, though musically it is, of course, so open-ended as to be of little value (see Figure 20).

What *is* possible theoretically, though, is for the pattern of reversal (as defined by Narmour) itself to be imitated from a past occasion or occasions (see Figure 21).

However, this is something quite different from the hypothesis posited by Narmour: rather than the 'bottom-up' processing of an individual syntactic

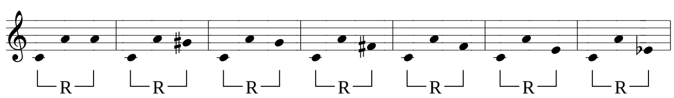


FIGURE 19 *The realizations of reversal arising from C–A (after Narmour, 1990: 154).*

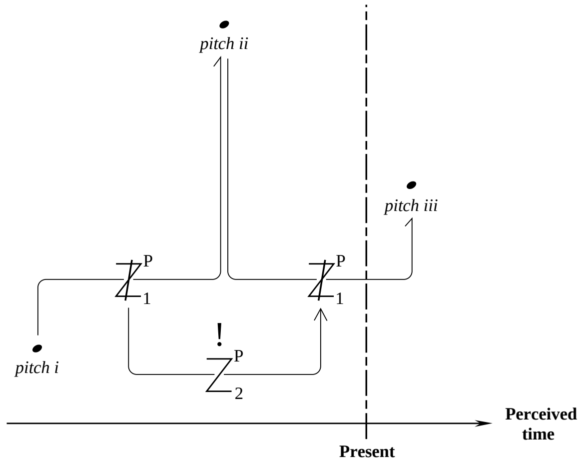


FIGURE 20 *Zygonic interpretation of Narmour's concept of 'reversal'.*

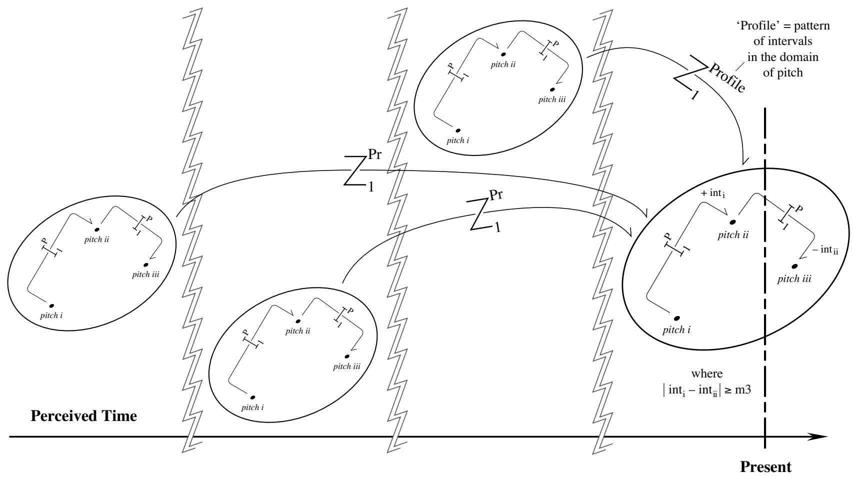


FIGURE 21 *Expectation of 'reversal' stemming from previous occurrences.*

primitive from an incoming signal, it is the 'top-down' processing of a conformant – albeit schematic – style structure (to paraphrase Narmour, 1990: 53). That is to say, zygonic theory suggests that 'reversal' is possible, but functioning as a schema rather than a syntactic primitive (1990: 55).

Expectation that occurs through organization of this type *between* groups is considered in some detail below. This apart, the interval C–A does, of course, bear potential *within*-group implication, which can be defined and analysed in zygonic terms. The closest such implication comes to Narmour's

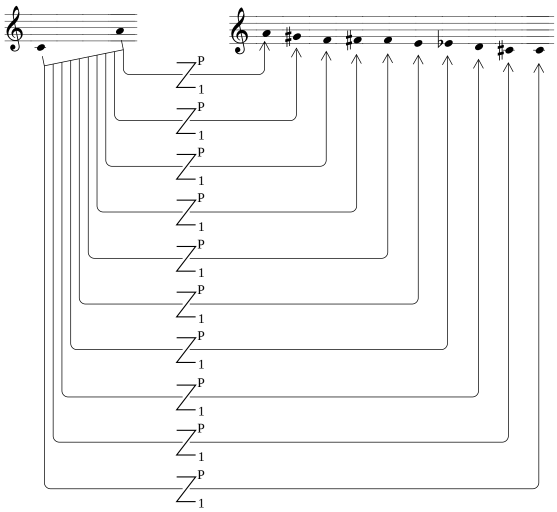


FIGURE 22 *Expectations arising from the principle of 'gap-fill'.*

concept of reversal occurs when the interval between the two pitches is held to be the silent expression of the imagined movement of a single value from the first location in the perspective domain (C) to the second (A) through melodic 'gap-fill'; cf. Gjerdingen (1994).[16] Hence, as they attend, albeit subconsciously, to the leap between the two notes, it may be that listeners mentally sweep over the range of values between the two – any of which can function implicatively through the active projection of a primary zygonic relationship. Given the discrete steps of the chromatic scale, the possibilities are as shown in Figure 22.

This series of potential realizations, extending down to D, C and C, has a greater range than the outcomes of 'reversal' identified by Narmour. In fact, these additional values, which fall within the ambit of registral return, are specifically excluded from Narmour's concept, since, in his terms, they represent a denial of intervallic motion ('magnitude' in current terminology). That is to say, if listeners are hard-wired, upon hearing an ascending major sixth, to expect a smaller, descending interval to follow, then to encounter instead a return to the first note (C) will come as something of a surprise (1990: 198). According to Narmour, it is only in retrospect that the sequence C–A–C can be heard as intervallic duplication. But is this logical? If an interval can be reckoned 'after the event' to have implied an imitation of itself, why should this possibility not be recognized prospectively? (That is not to say, of course, that such anticipation necessarily *would* be – particularly on a first hearing – but that it *could* take place.) Hence, implications for 'return' exist as shown in Figure 23, arising from primary and inverse secondary zygonic relationships.

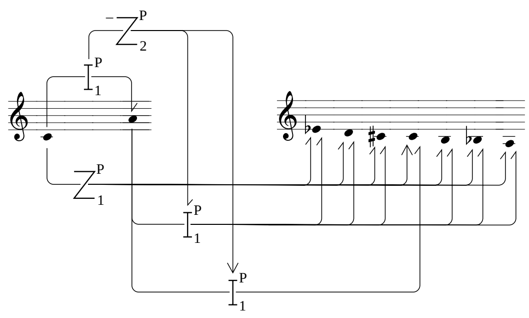


FIGURE 23 *Expectations arising from the principle of 'return'.*

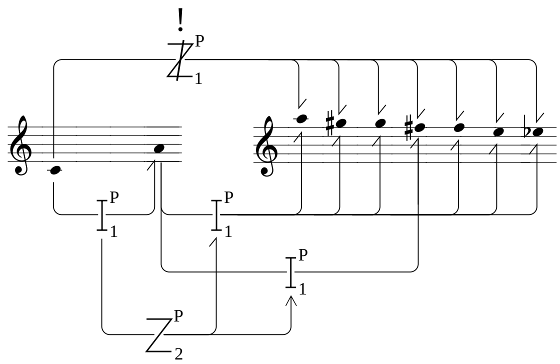


FIGURE 24 *Expectations through melodic 'process' from a large initial interval.*

Similarly, in the looking-glass world of reversal, Narmour interprets the three-note ascent C–A–F as a denial of intervallic motion *and* registral direction, although in retrospect this pattern can be heard as melodic 'process'. Again, however, it would seem reasonable to suppose that if an event can be recognized as having been implied once it has occurred, then it can also be felt to be implied *before* it happens. Hence, the implications shown in Figure 24 are possible too, although the particularly large leap between notes 1 and 3 of the sequence (where no primary zygonic connection exists) means, as we shall discover (see Figure 34 later), that these are likely to be relatively tenuous in perceptual terms.

Lastly, there are a number of additional implications suggested by zygonic theory: imitation of the first pitch or second pitches (C or A), perfectly or imperfectly (cf. Figure 17; see Figure 25); inverse imitation of the interval between the first pitch and the third, and the second pitch and the third (cf. Figure 18; see Figure 26) and imitation through inversion of the ascending interval (cf. Figure 16; see Figure 27). Observe, however, that this scenario entails a large interval between notes 2 and 3 of the sequence, and so once

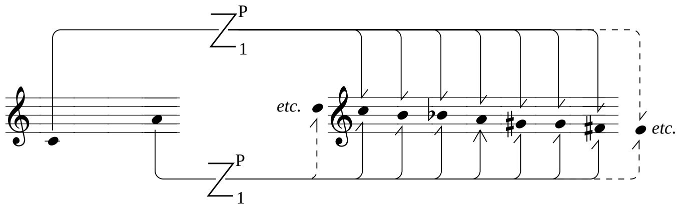


FIGURE 25 *Primary zygonic implications arising from C and A.*

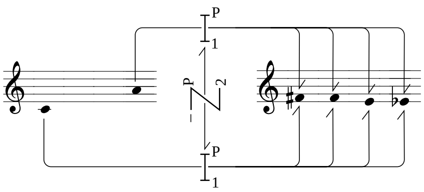


FIGURE 26 *Expectations potentially arising through inverse secondary zygonic relationships, linking primary relationships rooted on C and A.*

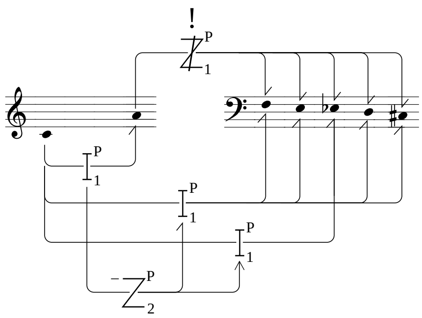


FIGURE 27 *Expectations potentially arising through inverse secondary zygonic relationships, linking primary relationships rooted on C.*

more (cf. Figure 24), while there is a logic to such organization, in most contexts it seems likely that the implication would be phenomenologically weak.

In summary, then, potential realizations in the domain of pitch predicted from two initial values (which may be the same, similar or distinctly different) deriving (a) from Narmour's model and (b) through zygonic analysis are as follows (see Figure 28). According to Narmour, two identical pitches yield one realization; two a tone apart offer eight; and two separated by a major sixth in excess of 16. In contrast, zygonic theory suggests one, five and four logical continuations respectively (utilizing perfect relationships only) and 25, 27 and 34 (through perfect *and* imperfect relationships) or, in the last case, 16, if those hypothesized to be perceptually tenuous are excluded.

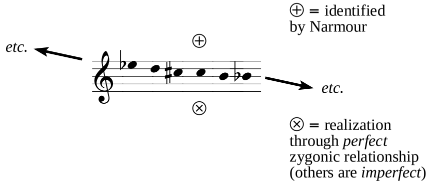
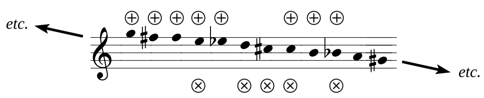
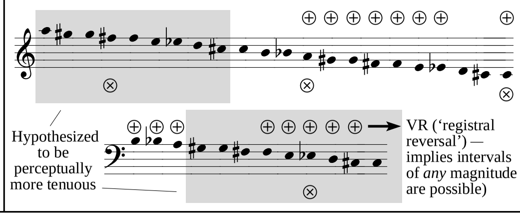
Implications arising from	Potential realizations	Sources		*Total* number of realizations	Number of *different* realizations			
		Narmour (1990)	*Current article*		Narmour (1990)	Zygonic (perfect)	Zygonic (imperfect)	Zygonic total
		p. 75	Figure 9	25	1	1	24	25
		pp. 75 99 130 131	Figures 11 12 13 14 15 16 17 18	27	8	5	22	27
		pp. 154 198	Figures 22 23 24 25 26 27	>34	>16	4 2	30 14	34 16

FIGURE 28 *Potential realizations from two pitches, derived from Narmour (1990) and zygonic theory.*

Clearly, whichever model one adopts, two pitches typically imply a range – sometimes a wide range – of subsequent values. Despite similarities in the models, there are key differences too, and it is pertinent to enquire which more faithfully represents cognitive processing. One approach to answering this question is to ascertain which model corresponds more closely to relevant empirical findings from the field of music psychology.

DISCUSSION OF EMPIRICAL EVIDENCE, AND A NEW, SINGLE-FACTOR MODEL OF EXPECTATION OF 'WITHIN-GROUP' EXPECTATION

The work of Schellenberg (1996; re-analysed in 1997) provides a useful starting point. Investigating the implication–realization model, his data lead him to develop a simplified model of expectancy in melody, with just two factors. The first principle is that of 'pitch proximity'. This states that 'when listeners hear an implicative interval in a melody, they expect the next tone to be proximate in pitch to the second tone of the implicative interval (i.e. they expect a small realized interval)' (1997: 309). This accords entirely with zygonic theory (cf. Figures 4, 5, 7, 9, 10 and 17). Figure 29 illustrates this in general terms.

Moreover, Schellenberg finds that when 'a melody departs from conjunct motion, smaller leaps in pitch are less unexpected than larger leaps' (1997: 311). That is to say, perfect or near-perfect repetition is perceived to be the most likely continuation from a given value, followed by larger differences, whose probability decreases as a function of their size. On the whole, this accords with the work undertaken subsequently by Aarden, cited above, although his finding that exact repetition was relatively unexpected (2003: 52–3) is not predicted by zygonic theory, nor does it tie in with the statistics of melodic intervals that are available cross-culturally (Huron, 2001: 25). The finding may, perhaps, have been a feature of Aarden's experimental design, given that the unison, despite being a single intervallic category, had equal status with all magnitudes of ascent and descent, each comprising many different classes of interval (see Figure 30).

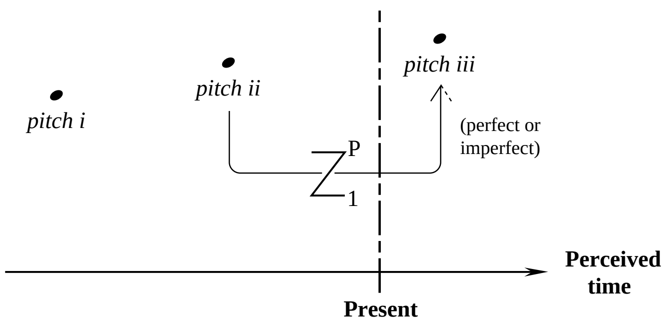


FIGURE 29 *Schellenberg's principle of pitch proximity expressed in zygonic terms.*

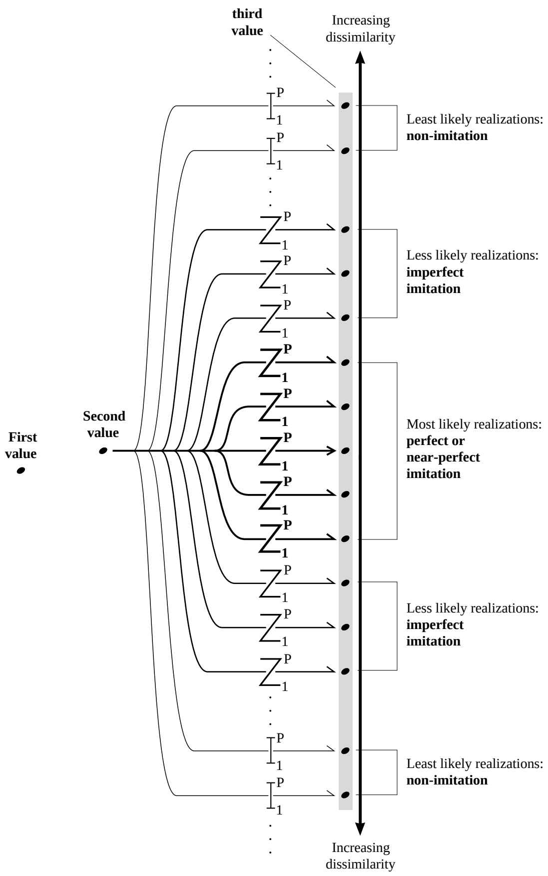


FIGURE 30 *Perceived probability of realization is hypothesized to correspond to closeness of imitation.*

Schellenberg's research leaves open the question of whether (as Narmour claims) the pitch-proximity principle stems from a hard-wired perceptual predisposition, or from a learned schema. Because small intervals are common in melodies, it seems reasonable to assume that listeners will learn to expect these are 'typical' (Huron, forthcoming). However, the fact that small intervals predominate across cultures (see, for example, Dowling and Harwood, 1986: 155ff; Ockelford, 1999: 460ff; Huron, forthcoming) also suggests an innate processing preference (Schellenberg, 1997: 310–11). It may well be that both forces play a role in expectation in the domain of pitch through proximity (see Figure 31).

Schellenberg's second principle is that of *pitch reversal*, which

> extends the pitch-proximity principle to relations between noncontiguous tones. In addition to expecting the next tone in a melody to be proximate in pitch to the tone heard most recently, the principle claims that listeners often

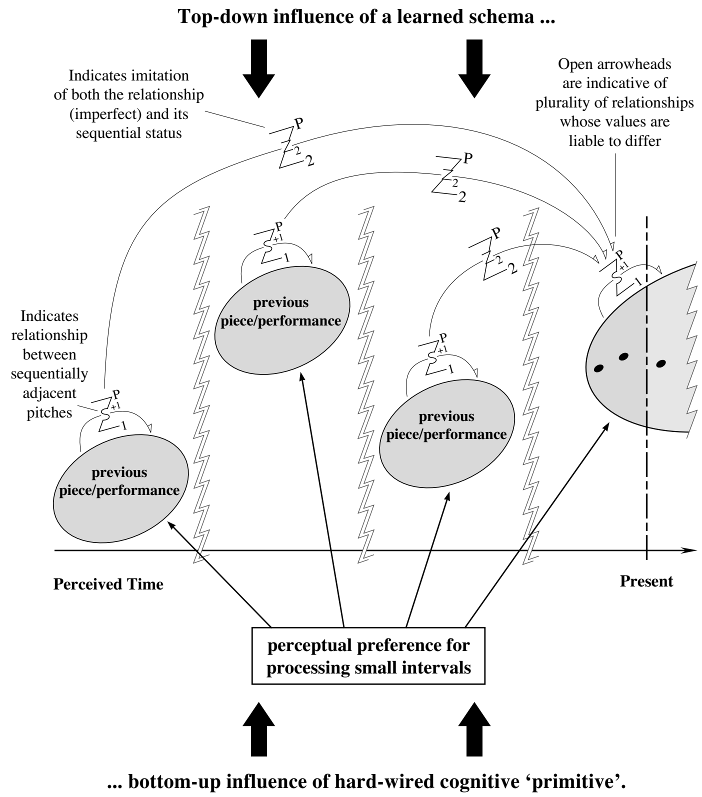


FIGURE 31 *Zygonic and non-zygonic forces at work in the expectation of pitch proximity in melodies.*

> expect the next tone to be proximate in pitch to the tone that preceded the most recently heard tone. In other words, listeners often expect the second tone of a realized interval to be proximate to the first tone of the implicative interval. Hence, the pitch-reversal principle describes expectancies slightly more global than those described by the pitch-proximity principle (Schellenberg, 1997: 312).

This is shown in zygonic terms in Figure 32.

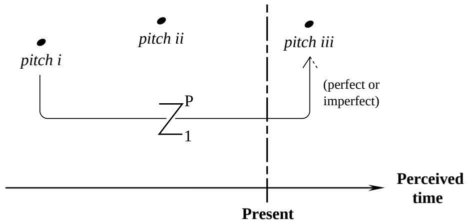


FIGURE 32 *Schellenberg's principle of pitch reversal expressed in zygonic terms.*

In terms of the present theory, the 'reversal' comes about since there is a tendency, through the zygonic force – a quasi-gravitational attraction – of the first pitch, to return to its value.[17] This effect is particularly noticeable through the expectancies that arise

> when a melody violates the pitch-proximity principle (i.e., when a large implicative interval is heard). Once the coherence of the melody has been 'threatened' by *disjunct motion* (a melodic leap), the principle asserts that listeners expect a reversal of pitch direction. If this expectancy is considered jointly with the expectancy for small intervals (as described by the pitch-proximity principle), the overall expectancy is for the resulting gap in pitch to be filled (i.e., listeners expect a change of direction *and* a relatively small interval). (Schellenberg, 1997: 312)

This balance of perceived forces, emanating from the first and second pitches, can be modelled zygonically as shown in Figure 33.

Again, as Schellenberg observes (1997), there could be other factors at work here, such as human vocal limitations (since, for example, a note following a large interval in a melody that does *not* change direction is more likely to exceed a singer's range – hence it would be relatively unexpected). Indeed, Von Hippel (2000) and Von Hippel and Huron (2000) have subsequently shown through the analysis of a large number of melodies that tessitura *is* a significant constraint on melodic design. They conclude that, in many cases, melodies change direction after a skip 'simply because they lack the space to do otherwise' (2000: 83). Further research (Von Hippel, 2002; Huron, forthcoming) has indicated that skip reversal is merely an artefact of regression towards the mean, which, through repeated exposure, experienced listeners have converted into an inexact but serviceable heuristic, whereby they expect a large interval to be followed by a change of direction.

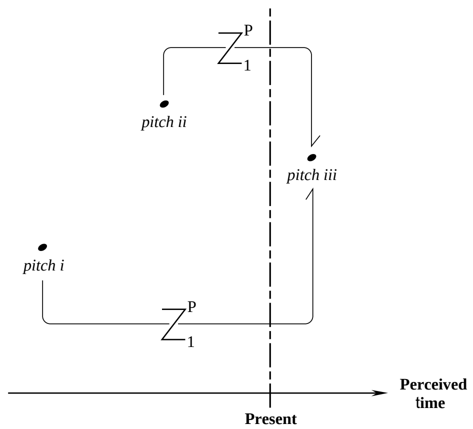


FIGURE 33 *Balance of imperfect primary zygonic forces from pitches* i *and* ii *implies a change of intervallic polarity and a relatively small magnitude.*

Furthermore, listeners will expect the new interval to be relatively small, simply because *most* intervals are relatively small. These principles tie in with the zygonic model set out in Figure 21.

Schellenberg's experiments, and those of Cuddy and Lunney (1995) which he re-analysed (1997), involved realizations deriving from a single implicative interval. However, given that the two principles that Schellenberg identifies – 'pitch-proximity' and 'pitch-reversal' – can be shown to share a common primary zygonic ancestry, as Figures 29, 32 and 33 illustrate, it is worth speculating whether, using the present theoretical framework, it would be possible to create a valid, single-factor model of within-group melodic expectation. This would pertain to a *series* of implicative values, and utilizes Schellenberg's finding that the expectation of pitch-proximity applies to *non*contiguous (as well as to adjacent) values. It would predict that expectation occurs through the extension into the future of proactive primary zygons from current and foregoing pitches, with a strength of effect, *ceteris paribus*,[18] proportional to their recency. Hence, it would accord with the principle of 'regression to the mean' identified by Huron and Von Hippel; indeed, it would provide the wherewithal for the cognitive extraction of the 'mean' from a series of notes. A simple version of this model, in which a range of values for an anticipated fifth pitch is implied from four that are presented, is illustrated in Figure 34. The thicknesses of the lines that depict the relationships are intended to give an indication of the relative potency of the zygonic forces – and hence the strength of the expectation – that is present in each case. Where expectations coincide, their effect is imagined to be cumulative.

Clearly, empirical work – or the further re-analysis of currently available data – is required to test the validity of this model. These findings notwithstanding, it is important to explore what function such a model suggests expectation may play upon first hearing a piece. At most, apparently, it can

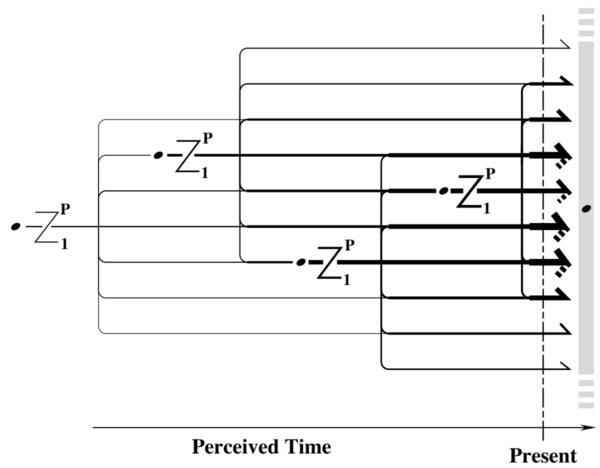


FIGURE 34 *General model of expectation within groups.*

offer listeners only a broad indication of what is to come. As Jones (1981) states: 'Expectancies, at least initially, . . . are continuous, rhythmically generated paths that allow us to guide our attention to approximately correct neighborhoods' (p. 571). Is this the whole story, though? Intuitively, while it accords with certain aspects of the experience of listening to a composition for the first time, it is often possible in the course of an unfamiliar piece to predict the nature of the sounds that are about to occur rather more precisely than the model in Figure 34 suggests. How is this greater precision achieved? I would suggest, principally, through the expectations that are engendered through the repetition of *groups* of notes. Such expectations involve projections from three values or more.

Expectations stemming from three units of perceived sound or more

The presence of three values from which to predict represents a threshold in musical expectation, since, while individual values can exceptionally function as self-sufficient motivic entities in their own right (see, for example, Ockelford, 1999: 152), typically at least two pitches are required to form a gestalt, with enough individuality to bear purposeful replication.[19] Hence, as well as affording the opportunity for general projection *within* groups (see Figure 34), three values may imply rather more specific continuation *between* them. See Figure 35 for an example.

A general model of projection between groups can be formulated as follows (see Figure 36). Imagine the first few values of a group of pitches ('**B**') are heard. Next, assume that the musical mind is constantly and proactively engaged in seeking meaningful relationships, not only within this group, but *between* this and others, whose traces are encoded in short- or long-term memory. Through this process of comparison, as the shape of **B** unfolds, it becomes apparent (through relationship '**m**') that this is similar to a series of perspective or interperspective values that have been heard previously ('**A**'),

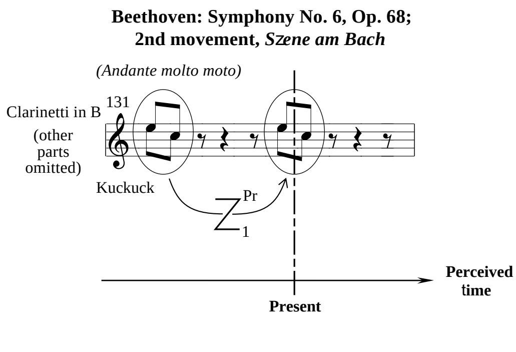


FIGURE 35 *Implication between groups occurring from three values.*

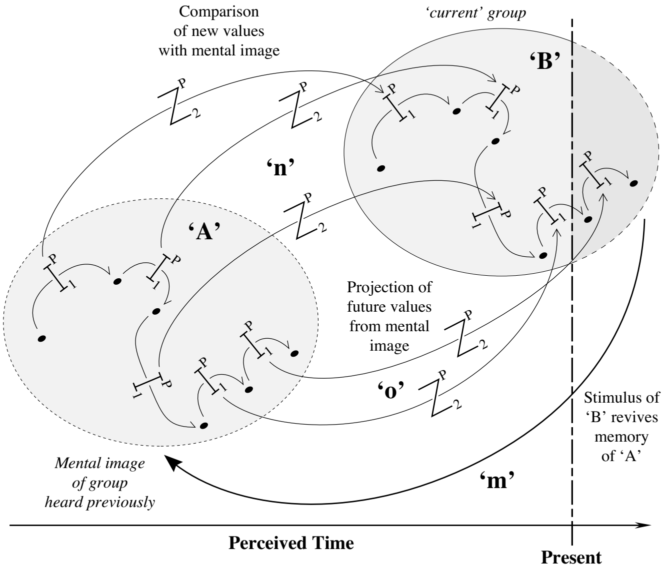


FIGURE 36 *General zygonic model of expectation between groups.*

and a mental image of that group is revived. This trace is then compared (at either primary or secondary level, which is depicted here) with the recently heard and incoming stimuli that constitute **B** (through relationships '**n**'). Significantly, in the current context, the memory of **A** also stimulates the listener to project likely future values of **B** (through relationship '**o**').[20]

This model suggests that expectation arising between groups of values is likely to be more prescribed than that stemming from within a group, and so be of greater service to listeners as they (subconsciously) strive to anticipate the future course of events during a piece of music. However, even projection between groups is far from straightforward, potentially occurring via a number of different routes (see Figure 37). In summary, it may derive from (cf. Ockelford, 1999: 265):

- other material or materials occurring within the *same* hearing of the *same* performance of the *same* piece;
- a *different* hearing or hearings of the *same* performance of the *same* piece (in the case of recorded music);
- a hearing or hearings of a *different* performance or performances of the *same* piece; or
- a hearing or hearings of a performance or performances of a *different* piece or pieces.

Groups vary enormously in length, ranging, for example, from the two notes of the cuckoo call in Beethoven's 'Pastoral' symphony (see Figure 35) to the entire movement. Similarly, the status of relationships between groups differs

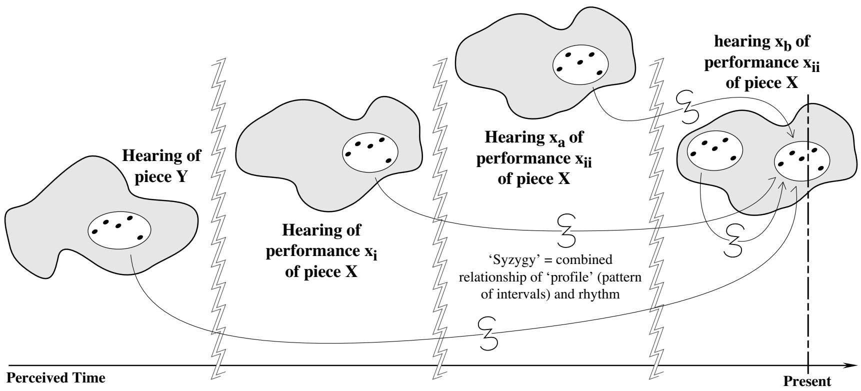


FIGURE 37 *Routes through which expectation between groups can occur.*

widely: contrast, for instance, those generated in the mind of the listener hearing the calls of Beethoven's cuckoo for the first time, amused and surprised, perhaps, and wondering how often the bird will sing, to those produced in the mind of the connoisseur listening to a favourite recording of the '6th' for the *n*th time, reinforcing his or her already consummate knowledge of this rendition of the piece.

It is hypothesized that any of the relationships shown in Figure 37 may be activated on a given occasion. Hence, their potential for interaction is virtually limitless. For example, different memory traces may reinforce or contradict one another. Aspects of two or more groups may combine (for instance, in a variation where a means of motivic transformation is applied systematically). Perceived implications may, but need not, be realized for a number of reasons: a chunk of material within a piece may well be modified on its reappearance, for example, or a listener may just misremember. A study of this area would constitute a major piece of empirical work, and here we will examine briefly only one issue: how expectation *within* and *between* groups interacts.

Our exploration of expectation within groups suggested that, at best, this can offer only a broad indication of what is to come. This imprecision undermines Meyer's attempt to formulate a methodology for analysing implication in tonal melody (1973: 114ff). His primary position (1973: 116) is that

> implicative relationships are like hypotheses which competent listeners entertain about the connections among musical events. To explain a melody . . . the critic must make these implicative hypotheses explicit. He must discover the patternings present in melody, and he must speculate – formulate explicit hypotheses – about how each of the patternings might be continued to reach the stability of relative closure, or perhaps silence: the end of the patterning. To do so, the critic will often perform a kind of mental 'experiment'. He will 'stop' the melodic flow at particular points and try to imagine what continuations seem probable.

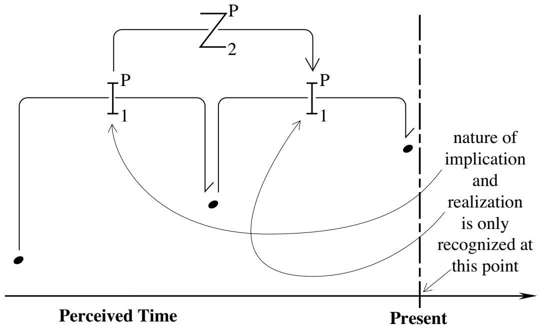


FIGURE 38 *Retrospective understanding of implication and realization.*

However, Meyer also acknowledges that

> Because patterns are seldom simple and 'single-minded', alternative consequents or continuations are as a rule implied by musical events. . . . We are specially liable to overlook or forget if the alternative consequent is separated from the implicative antecedent by time and the demands of contrasting, intervening events. In cases like these, implicative relationships may be understood largely, perhaps entirely, in retrospect . . .
>
> Most of the time a pattern can be fully comprehended and its internal relationships analyzed only by seeing what follows from it. (1973: 112–13)

Hence, it appears that while implication within groups is central to the musical experience, because of the practical cognitive difficulties of juggling so many alternatives that may exist at any one time, in reality the import of a passage in implicative terms can be understood only in retrospect once its associated realization is known,[21] as shown in Figure 38.

But does this position bear phenomenological scrutiny? Can implication still be regarded as implication when it is viewed in retrospect – or is the process in reality one of pattern *recognition*? For implication to function retrospectively would seem to imply mentally 're-playing' the relevant passage. This may be conceivable for Meyer's critic, who 'will study the composer's score to see whether any of the envisaged (alternative) continuations actually occur' (1973: 116). Here, there is time aplenty to contemplate and run, and re-run, the music in the mind. But what of the 'typical' listener, who listens to a piece in 'real time'? By the time an implication has been realized, the music will be moving on, affording no opportunity for reflection, since this would mean failing to attend to the next burst of perceptual input. How, then, can implication within groups work?

Zygonic theory suggests that this is possible when the anticipated course of patterning within a group is informed by relationships that operate *between* groups. This dual process effectively takes the uncertainty out of expectation within groups and enables such implications to function *pro*spectively. In general terms, the combined operation within and between groups can be modelled as shown in Figure 39.

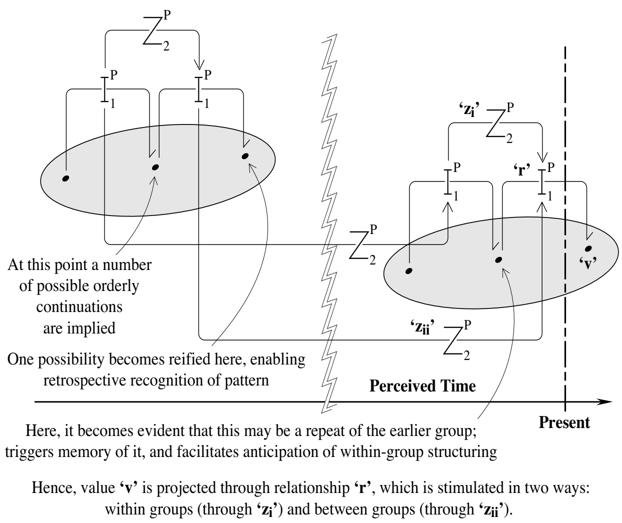


FIGURE 39 *Zygonic model of expectation within and between groups.*

There are a number of other ways in which relationships between groups can influence anticipation within them. One occurs through the tendency of pieces to use limited sets of perspective or primary interperspective values.[22] In the case of pitch, for example, the framework of the 'major mode', outlining pitch-classes separated by the ascending intervals *tone, tone, semitone, tone, tone, tone, semitone, . . .* is used (albeit with chromatic inflections) as the basis for a good deal of western music. Within such a context, 'expectations are generated automatically by the activation of learned, schematic representations that have abstracted typical relationships from the music to which one has had extensive exposure' (Bharucha, 1987: 4). Schematic expectations of this type can be modelled zygonically thus (see Figures 40 and 41). Figure 40 presents the scenario in which the opening notes of a piece suggest (in the experience of a particular listener) either or both of two primary interperspective sets of pitch 'X' and 'Y' as possible frameworks. Hence, there is potentially ambiguity in the process of schematic expectation. By the point t_{ii}, however (see Figure 41), the presence of further pitches has made the position clearer, and set 'X' emerges as the framework that is likely to be used, either contradicting, clarifying or confirming the previous expectation (cf., for example, Brown et al., 1994; Vos and Verkaart, 1999).

Schematic projection of this type can inform anticipation within groups as well as expectancies occurring 'veridically' within them, 'which are generated either by the activation of memory traces for specific pieces or by explicit prior knowledge of what is to come' (Bharucha, 1987). Expressing these possibilities in zygonic terms makes the balance of forces clear in each case. Figure 42 shows how expectation arising from two identical pitches which, through imperfect imitation, potentially suggest a large number of

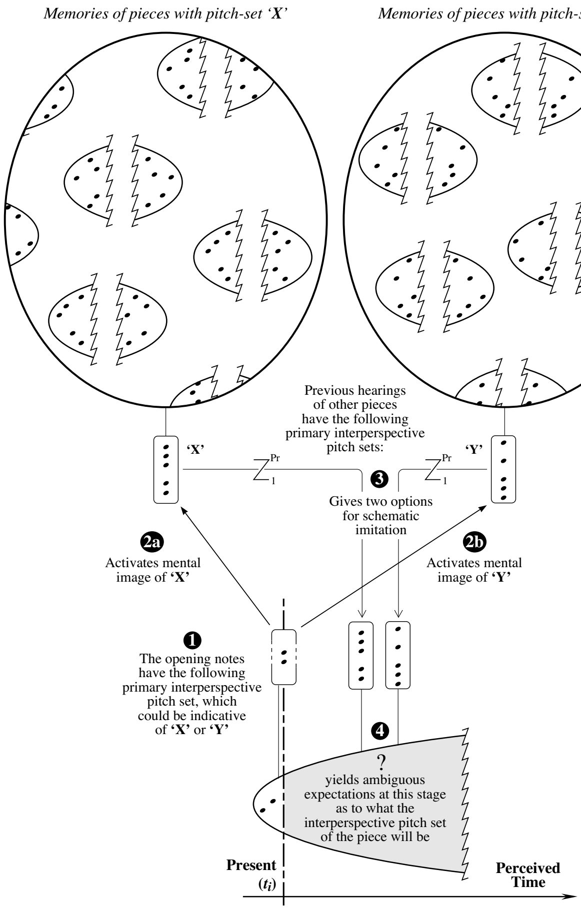


FIGURE 40 *Schematic expectation of primary interperspective pitch set (time t_i).*

microtonal values, is constrained within the context of a diatonic pitch set, yielding just three possibilities which lie in the intersection of the two sets. Conversely, Figure 43 illustrates how implication between groups is tempered by the presence in the background of a diatonic pitch set, which renders the expectation of otherwise perfect repetition imperfect.

In most musical contexts, perspective and interperspective pitch sets offer more than just a schematic framework upon which veridical expectations are hung. The manner in which their pitches are typically used is constrained too, offering further sources of implication. The factor of 'pitch proximity', for example, has already been noted (see Figure 31), and the work by Von Hippel (for example, 2000) suggests that not only the *sizes* of melodic intervals are predictable, but their *directions* as well. 'In general . . . intervals will retreat from the extremes of the tessitura and approach the middle: intervals that start on high pitches will proceed downward, and intervals that

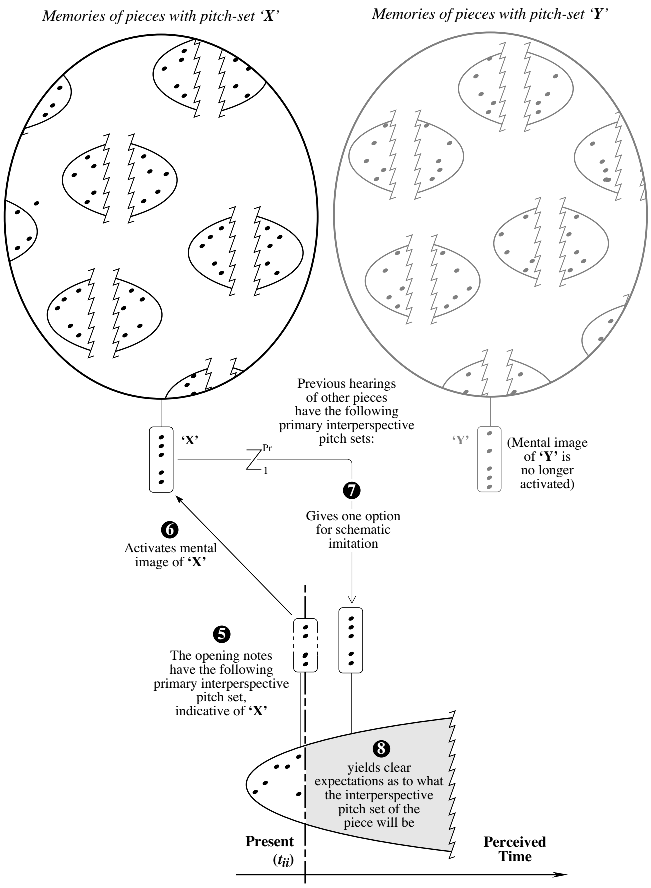


FIGURE 41 *Schematic expectation of primary interperspective pitch set (time t_{ii}).*

start on low pitches will proceed upward.' Moreover, 'interval sizes will vary depending on the melody's position in its tessitura. Near the middle of a melody's tessitura, the new definition predicts small intervals, but near the extremes, the new definition predicts relatively large intervals' (2000: 325). That is to say, both the magnitude and polarity of melodic intervals tend to be sensitive to tessitura (cf. Cross, 1995: 507) – a tendency, once more, that can inform expectation through the projection of zygonic relationships into the future.

The principle of pitch proximity, whether in its basic form or in Von Hippel's more refined version, offers listeners information that can be used to aid prognostication in the most general way. However, the typically asymmetrical nature of pitch sets means that greater specificity is possible, since values can be used idiosyncratically with respect to the unique position that each occupies within a set. This tendency, whereby pitches are felt to

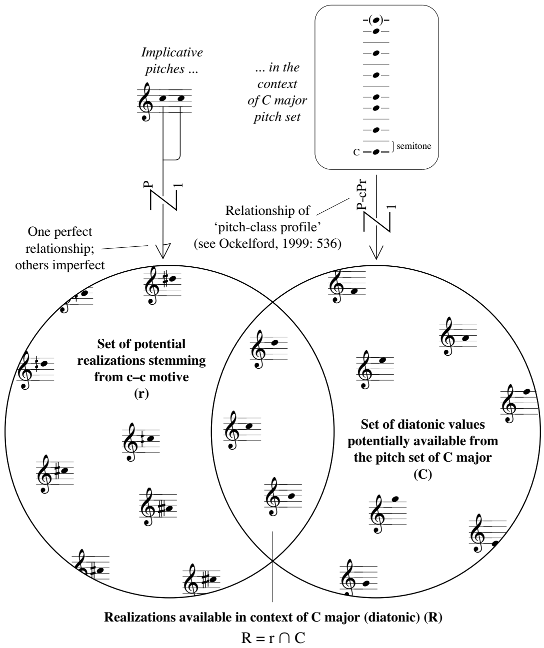


FIGURE 42 *Coincidence of schematic and within-group implication, resulting in limited expectation arising from the intersection of the two sets of possibilities.*

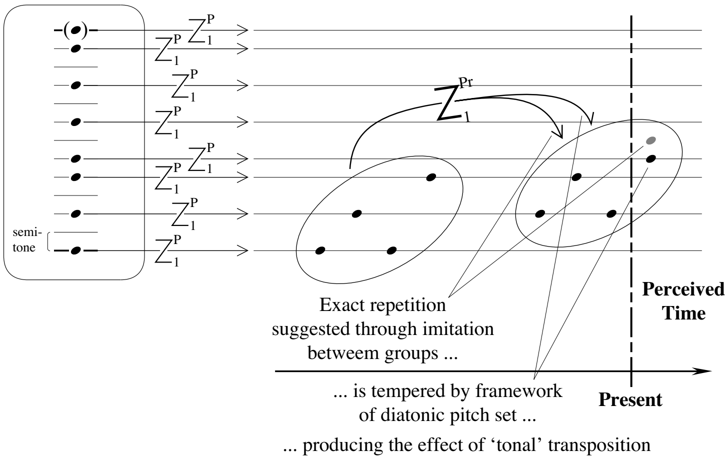


FIGURE 43 *Coincidence of schematic and veridical implication (between groups), resulting in 'tonal' transposition.*

fulfil distinct and recognisable functions in relation to one another, is characteristic of many styles, and has given rise to the notion of 'tonality' (though, for example, Vos, 2000: 404ff). There are a number of ways in which tonal schemata (whose precise nature varies from pitch set to pitch set and style to style) are engendered. One is through the relative frequency of

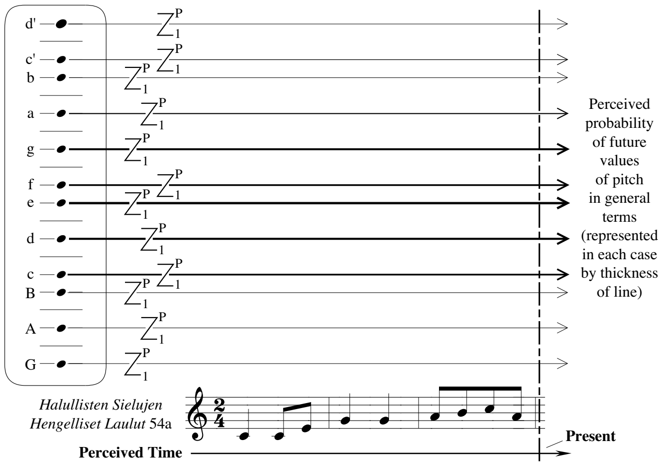


FIGURE 44 *Past frequency of distribution of values informs future expectation in general terms (after Krumhansl et al., 1999: 161 and 167).*

occurrence of values, a factor which a number of studies have shown is important in learning, perception – and expectation (for direct evidence, and comparisons with earlier work, see Krumhansl et al., 1999: 157ff). Most recently, Aarden (2003) has shown that *context* of occurrence of pitch-degrees is important too, and that the Krumhansl/Kessler 'key profiles' (Krumhansl and Kessler, 1982), which were developed through the probe-tone method (which requires that the musical passages in question *stop*), correspond more closely to the statistical profile of pitch degrees used to *close* melodies rather than to their general distribution (see also Huron, forthcoming). This subtlety notwithstanding, the fact that exposure to music in which the frequency distribution of values is reasonably consistent can translate into future expectation as to their future probabilities of occurrence, can be modelled zygonically as in Figure 44. Here, the thickness of lines used in relationships represents both the relative rate of past utilization of perspective values, and their felt probability of future recurrence. The model uses data from the study by Krumhansl et al. mentioned above (1999: 161), which was undertaken in the context of Finnish spiritual folk hymns.

More specifically, in tonal music, *transitions* between values have distinctive frequencies of occurrence too – see, for example, Pinkerton (1956) and Simonton (1984), whose study of the first five two-note transitions of over 15,000 themes from the western classical tradition revealed that 'a relatively small number of pairs account for the vast majority of transitions, and certain pairs dominate melodic structure' (1984: 5). In fact, he discovered that the four most commonly occurring pairs altogether make up over one-fifth of all two-note transitions. This finding has found support in the work of Huron (forthcoming), whose analysis of more than a quarter of a million pairs of notes in a corpus of Germanic folksongs found that the dyads $\hat{3}$–$\hat{2}$, $\hat{5}$–$\hat{5}$, $\hat{2}$–$\hat{1}$ and $\hat{4}$–$\hat{3}$ accounted for 18 percent of the total. This characteristic can inform expectation in the domain of pitch, as a number of studies show (summarized in Krumhansl et al., 1999: 162ff). There is strong empirical support for the theory that such expectation occurs through the creation and activation of neural networks, both in relation to individual pitch-degrees and harmonies. Nets of this kind are thought to 'learn' through exposure to large numbers of inter-event relationships and prime sets of expectancies according to the cognition of the events' distribution (see, for example, Bharucha, 1987, 1994, 1999; Bharucha and Stoeckig, 1987; Bigand and Pineau, 1997). This neuropsychological model captures and reinforces the previous intuitions of music-theorists such as Piston (1978[1941]: 21), who produced a 'table of usual root progressions', 'based on observation of usage' – anecdotal impressions which have indeed found qualified empirical support (Schmuckler, 1989: 128ff). So, according to Piston, upon encountering, for instance, chord iii within, say, a Classical sonata, an appropriately experienced listener would most strongly expect to hear vi, other things being equal, although IV would also be a strong contender, with I, ii or V being rather less probable. Zygonically, this can be modelled as in Figure 45, as a network of relationships of 'harmonic degree' ('H(d)') (cf. Ockelford, 1999: 616).

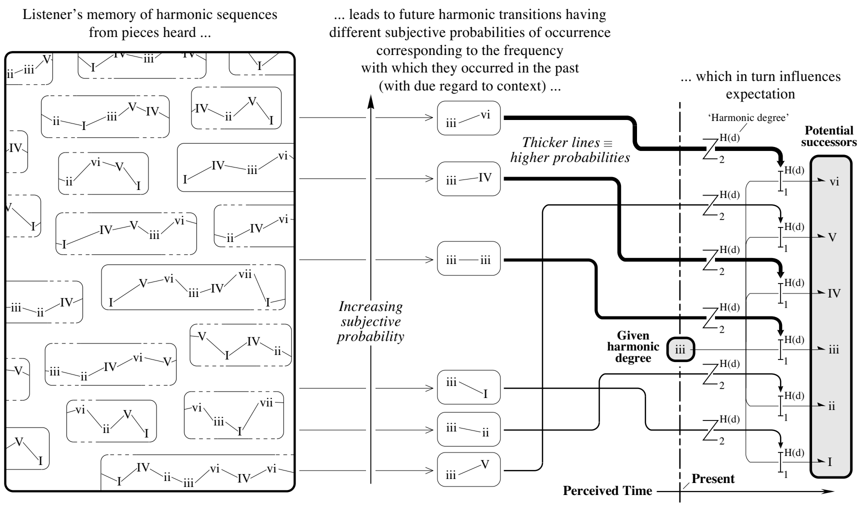


FIGURE 45 *Past frequency of harmonic transitions (from iii) informing future expectation (after Ockelford, 1999: 616).*

The interaction of general and specific expectations in music, with an example from Mozart's Piano Sonata K333

The demands of brevity and clarity have meant that this article has focused mainly on expectation in the domain of pitch and examined how zygonic constructs may elucidate the cognitive processes that underlie this phenomenon. However, anticipating what will occur on the basis of current and past perceived sonic input is, of course, much more broadly based than this. As Narmour (2000) observes:

> Iterative rules appear everywhere in music cognition, creating strong expectations. . . . There are many kinds of deduction. . . . Typical examples include melodic sequence, partial melodic sequence, and alternating melodic sequence. . . . Intervallic expansion and reduction in melody also involve higher-order abstractions. Various mirrored forms in music entail rule-mapping as well. . . . Listeners can likewise deduce additivity and subtractivity at work in harmony, tempo, texture, pace and dynamics. (p. 329)

In short, wherever aspects of music are orderly, expectation is possible; and, since music is replete with organization of relevance to listeners (see, for example, Ockelford, 1999: 704ff) so expectation pervades all areas of music perception. To demonstrate this in action – to give some impression of the complex, cumulative effect of expectation operating within and between perspective domains – we present a 'snapshot' of a single moment in the experience of listening to the first movement of Mozart's Piano Sonata, K333, frozen in time, to enable a comprehensive metacognitive analysis to be undertaken.

The point in time to be considered lies at the end of the first quaver of bar 94 – in formal terms, just after the beginning of the recapitulation. The performance was recorded by Eschenbach in 1971. The listener, we will assume, knows the sonata well, and is particularly familiar with Eschenbach's interpretation. Beyond this, he or she has a sound knowledge of Mozart's œuvre, especially his piano sonatas, and has a broad awareness of stylistically congeneric works. The issue, then, is what expectations can we reasonably assume to be in play at the juncture identified (see Figure 46)?

To answer this question, let us first return to the principle that in musical contexts, expectation is about anticipating the *what* and the *when* of perceived sound. As the illustrations above show, both factors exist on a continuum of specificity-generality, and together yield expectations which may be more or less determinate. So, for example, someone listening to the

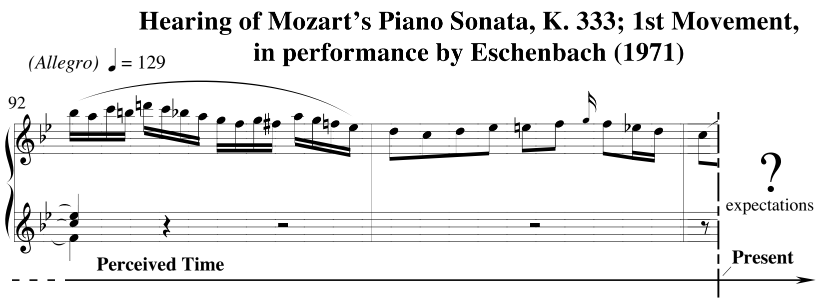


FIGURE 46 *What expectations are in play at this juncture, in the context described?*

recording of a piece with which he or she is very familiar may feel wholly sure that he or she knows *what* is going to happen and *when*. However, a listener encountering a work in unfamiliar style for the first time can be reasonably sure *when* events will occur (within a given range), since notes 'tend to follow one another without a cessation in perceived sound, or with only short breaks' (cf. note 10; Ockelford, 1999: 327), though not *what*, specifically, each of these will be. Conversely a person hearing a new piece in 'common practice' tonal style to which he or she is accustomed will intuitively have a good idea of *what* is going to occur in general terms (since pitches and interonset intervals tend to be used with prescribed frequencies), though not precisely *when* any of these will crop up.

It is generally accepted that 'specific' and 'general' expectations work together in music cognition, and research has been undertaken to suggest how the two psychological mechanisms may function in parallel, one complementing the other (see, for example, Bharucha and Stoeckig, 1987; DeWitt and Samuel, 1990: Jackendoff, 1991; Bharucha, 1994; Krumhansl et al., 1999). Expectations of differing specificity, arising from a variety of sources, can also be modelled zygonically to good effect; and to return to the case of our sophisticated listener, attending to the first movement of K333, the position can be summarized in zygonic terms as follows (see Figure 47). Clearly, the situation is complicated, since there are so many potential sources of expectation. In brief, *general* expectations may arise from the current hearing (through relationships labelled $\mathbf{G_i}$) and through memories of previous hearings of the same performance (through $\mathbf{G_{ii}}$ and $\mathbf{G_{a.i}}$), other performances of K333 (through $\mathbf{G_{iii}}$ and $\mathbf{G_{b.i}}$); and other stylistically congeneric pieces (through $\mathbf{G_{iv}}$ and $\mathbf{G_{c.i}}$).[23] Similarly, *specific* expectations may arise from the current hearing (through relationships labelled $\mathbf{S_{iii}}$) and through memories of previous hearings of the same performance (through $\mathbf{S_i}$ and $\mathbf{S_{a.iii}}$), other performances of K333 (through $\mathbf{S_{ii}}$ and $\mathbf{S_{b.iii}}$); and other stylistically congeneric pieces (through $\mathbf{S_{iv}}$ and $\mathbf{S_{c.iii}}$).

Despite its complexity, Figure 47 can offer nothing more than a highly simplified representation of the cognitive channels through which anticipation may flow – any, all or none of which may be activated at the point in time which is identified. For even expert 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' (Ockelford, 1999: 254). Furthermore, the plexus of fleeting mental operations through which music listening occurs will differ from one occasion to another.

Despite these obvious limitations, the model does offer insights as to the balance of anticipatory forces that will typically be in play. For example, it is likely that the axis of specific expectations arising from previous hearings of K333 (through relationships $\mathbf{S_i}$ and $\mathbf{S_{ii}}$)[24] and expectations stemming from the current hearing (through $\mathbf{G_i}$ and $\mathbf{S_{ii}}$) will predominate; and these relationships are highlighted in Figure 47. We may surmise that the

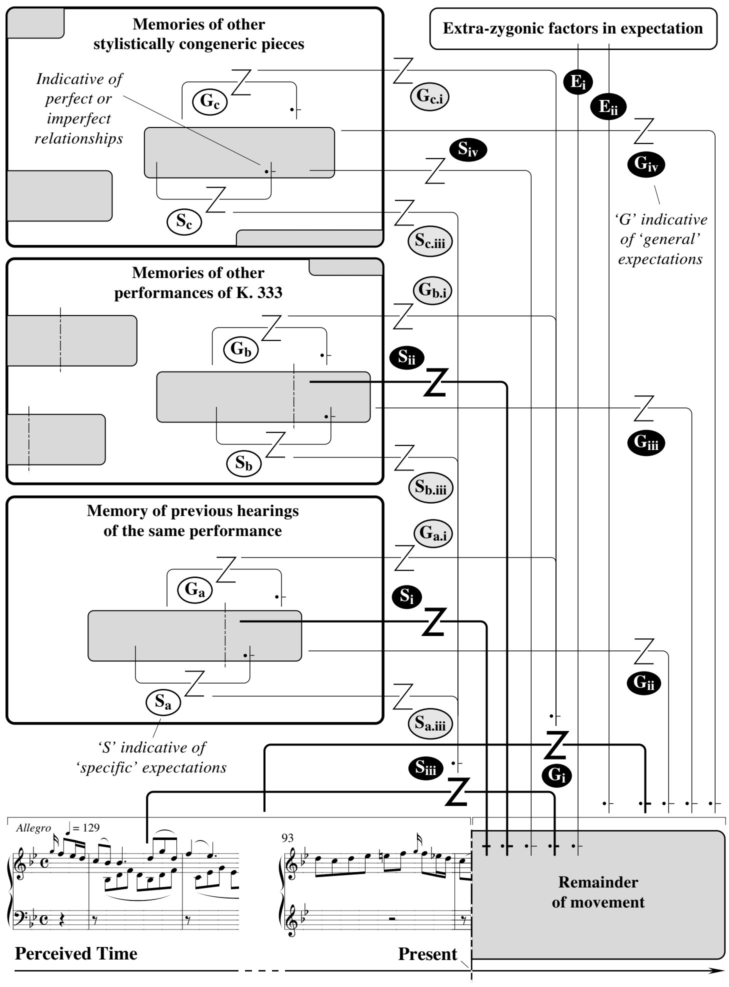


FIGURE 47 *Zygonic model of the expectations arising after the first quaver of bar 94 of the first movement of K333 ('expert' listener).*

interaction between these pairs operates along the following lines (see Figure 48). The memory traces from previous hearings exist in abstraction, as a mixture of interperspective and perspective values, whose fidelity to their model will vary according to the listener's perceptual abilities in the auditory domain. However precise the stored image is, it will be overwhelmed by the compelling effect of the current framework of perceived time, pitch, timbre, loudness, perceived location and perceived reverberation (see Ockelford, 1999: 266ff), and, chameleon-like (cf. Ockelford, 2005b), it will take on the general characteristics of the perspective background they offer. The listener may, but need not, be aware of this accommodation.

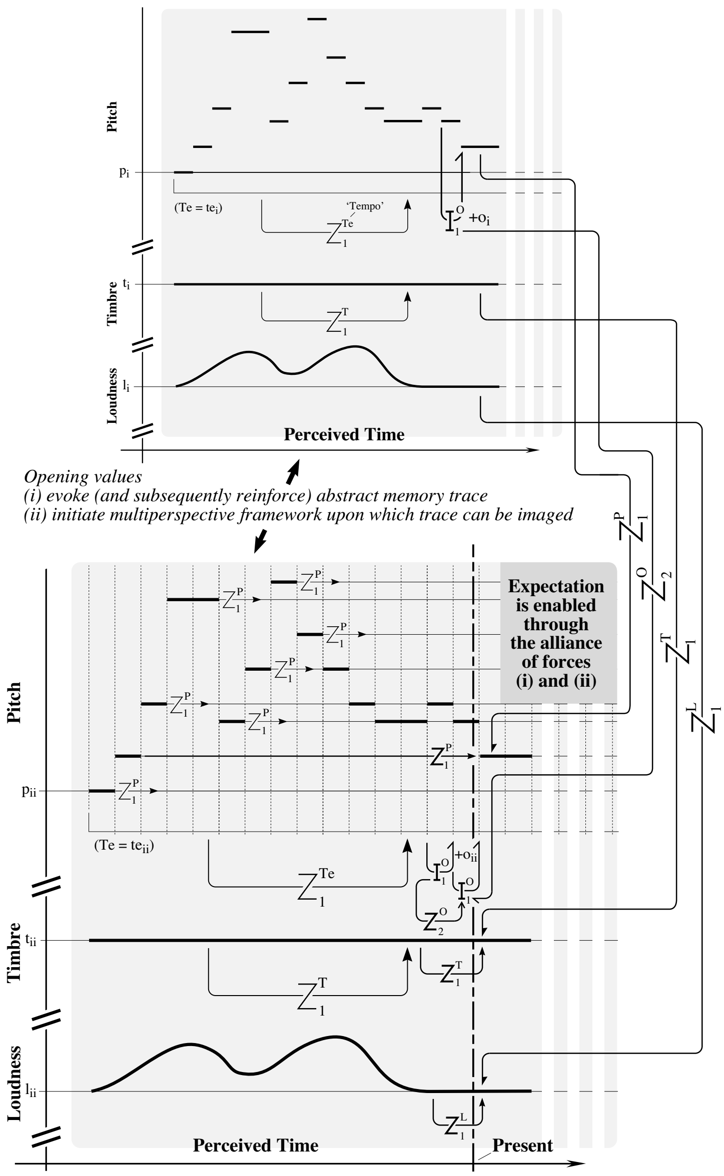


FIGURE 48 *Expectation arising through a balance of veridical and schematic zygonic forces.*

In terms of perceived time, this means that the remembered interonset intervals between notes and their durations will be mapped onto the grid formed by the regular beat and consistency of metre characteristic of the first movement K333 – the two sources of prediction combining in one expectation. Clearly, in the case of re-hearing the same performance, tempo (a percept drawn from the values of interonset intervals) will need no adjustment; with different performances, it is likely that some accommodation will be needed. Similarly, in the domain of pitch, the listener will, if necessary, wittingly or unwittingly, recast the memory of profile (the pattern of intervals) to conform to the current absolute values contributing to the framework of B♭ major (which may vary between performances), again, the two factors resulting in a single expectation.[25] With regard to timbre, adjustment may be required even with a further hearing of a familiar performance, due to the varying nature of sound reproduction systems and the acoustical environments in which they are situated, and loudness may be even more susceptible to variation between hearings.

The $\mathbf{S_i}$–$\mathbf{S_{ii}}$ combination interacts with expectation within hearings in other ways too, serving to reinforce specific anticipation occurring through $\mathbf{S_{iii}}$. That is, the within-group and between-group implications for continuation arising within the current hearing after the first half beat of bar 94 will combine with our listener's knowledge of how the piece has previously continued at this point – giving a cognitively irresistible feeling for what the future will bring (Figure 49).

The $\mathbf{S_i}$–$\mathbf{S_{ii}}$/$\mathbf{G_i}$–$\mathbf{S_{iii}}$ axis aside, expectation will, to a lesser extent, intuitively be drawn from other sources too. For example, *general* features of K333 and of other pieces, internalized during previous hearings, may inform anticipation (through relationships $\mathbf{G_{ii}}$, $\mathbf{G_{iii}}$ and $\mathbf{G_{iv}}$). These include:

- *The presence of a regular beat, its tempo, and the consistency of its hierarchical organization as 'metre'* (for example, in Eschenbach's 1971 recordings, the first movements of the following Mozart piano sonatas, all of which are in 'common' time (𝄴), maintain the same beat throughout and are performed at these broadly similar tempi: K279, ♩ = 121; K310, ♩ = 129; K311, ♩ = 143; K333, ♩ = 129).
- *The use of limited sets of relative durations and interonset ratios, and the relative frequency with which they occur* (for example, in the first movements of K284, K310, K311 and K333, 50–68 percent of all durations are 𝅘𝅥𝅯s, 12–32 percent are ♪s, 8–9 percent are ♩s, and 5–7 percent are 𝅘𝅥𝅰s – these four durations together making up 94–98 percent of the relative values that are used, whose distribution shares an 86 percent similarity across the four movements concerned;[26] with regard to interonset ratios (involving relationships between successive notes), 1:1 is by a considerable margin the most common, making up 78–84 percent of the total, with 2:1 and 1:2 accounting for between 3–12 percent, and all others totalling between 10 percent and 17 percent – their distribution sharing a 92 percent similarity across the movements).
- *A texture comprising two simultaneous streams of sound which function largely as 'melody' in the right hand and 'accompaniment' in the left* (a typical feature of music in the Classical style).

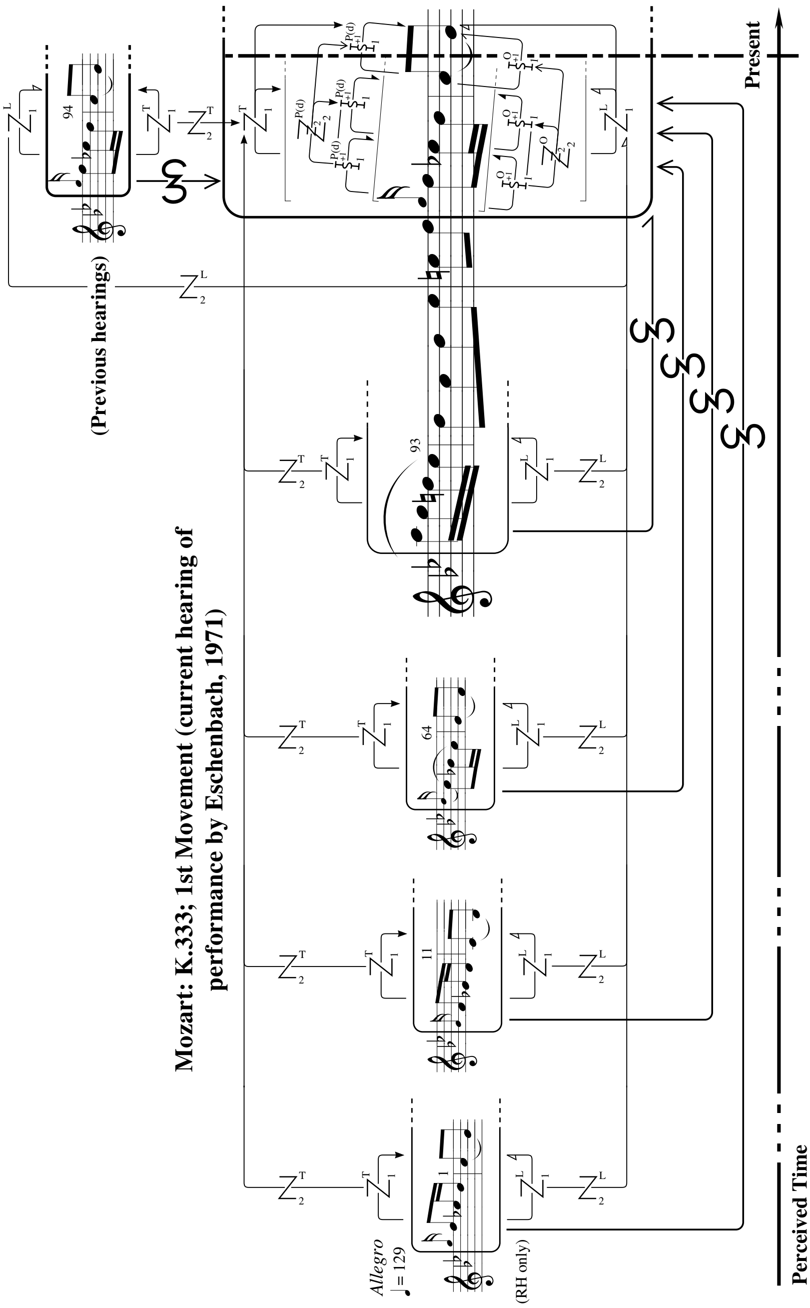


FIGURE 49 *Forces of expectation within a hearing and between other hearings reinforcing one another.*

- *The use of limited sets of pitches and intervals, whose range, size, and distribution of members are also constrained* (for example, in the first movement of K283, 88 percent of intervals between adjacent notes are a major third or less; in K311 the proportion is 83 percent; in K332, 82 percent; and K333, 86 percent – the distribution of intervals sharing a 77 percent similarity across the four movements).
- *The ubiquitous use of tertian harmony (that is, chords based on thirds)* (a virtually universal feature of homophonic and polyphonic western music of the period 1450–1900).
- *The distribution of principal harmonic functions and transitions* (for example, in the first movement of K309, tonic and dominant harmonies account respectively for 44 percent and 28 percent of the total, while transitions of +4 degrees make up 51 percent of all such intervals and transitions of +5 degrees 20 percent; in the first movement of K311, the proportions are 50 percent and 28 percent, and 48 percent and 31 percent respectively; in K330, the figures are 49 percent and 22 percent, and 45 percent and 36 percent; and in K333, 39 percent and 29 percent, and 43 percent and 20 percent – similarities of 89 percent and 75 percent respectively across the four movements).
- *The relative duration of tonal regions* (for example, in the first movement of K309, the tonic key prevails for 57 percent of the time, and the dominant for 23 percent; in the first movement of K311, the equivalent proportions are 58 percent and 23 percent; in K330, 61 percent and 34 percent; and in K333, 57 percent and 34 percent – a similarity across movements of 92 percent).
- *The manner in which melody and harmony interact – particularly with respect to the use of dissonance* (for example, in the first movement of K333 over half the melody notes are consonant with the harmonies with which they sound, functioning directly as the root, third or fifth of the chord concerned; and although dissonant notes are widespread too, their use invariably conforms to one of a few archetypal patterns, including passing notes, appoggiaturas and chromatic auxiliaries – defining features of the Classical style).

Clearly, observations and quanta such as these can only give an indication of the likely impact of statistical regularities on expectation in music, since, as Von Hippel (2002) and Huron (forthcoming) observe, exposure to regularities in music leads to the formation of schemata that only approximate to the stimulus patterns from which they derive. Moreover, even among a relatively homogeneous group, such as 'expert listeners', experiences are varied and we may surmise that differing degrees of familiarity with varying selections of pieces will yield subtly different perceived probabilities with which relevant stylistic features may subsequently be expected to occur. Nonetheless, the accounts of listeners suggest that there is sufficient commonality for a given piece of music to speak similarly to those broadly familiar with its style.

Exceptionally, *specific* expectations may be aroused through the memory of aspects of other pieces (through relationships $\mathbf{S_{iv}}$); consider, for example, that our expert listener may be familiar with the opening of the first movement of the Sonata, Op. 5, No. 3 by J.C. Bach – one of a set with which Mozart is known to have been acquainted (see, for example, Roe, 1989: x), so constituting what may be regarded as one of K333's most immediate musical ancestors (see Einstein, 1946: 130–1). Both specific and general expectation may be reinforced by the very fact that the underlying organization through which it occurs has itself been heard before (through relationships $\mathbf{S_{a.iii}}$, $\mathbf{G_{a.i}}$, $\mathbf{S_{b.iii}}$, $\mathbf{G_{b.i}}$, $\mathbf{S_{c.iii}}$ and $\mathbf{G_{c.i}}$). Examples include the fact that our listener will anticipate levels of loudness to have few abrupt changes, generally passing by in a stream of sameness or similarity, since this is typical of stylistically congeneric pieces; he or she will expect timbral constancy within melodies, since this is the norm for the late 18th-century; and he or she will look forward to themes being recapitulated in the tonic since this is a characteristic of the Classical style. Huron (forthcoming) notes that expectation such as the latter, which pertains to large-scale formal features, appears to operate through *conscious* mental processing, so functioning rather differently from expectations operating on a more local level, of which listeners are typically unaware.

Finally, one should not discount the significant role that extra-zygonic factors are likely to play in expectation – both general and specific ($\mathbf{E_i}$ and $\mathbf{E_{ii}}$). As Huron (forthcoming) puts it, 'How do listeners know what schema to start with? In the first instance, environment markers can provide useful cues regarding appropriate schemas'. That is:

> 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 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. (Ockelford, 1999: 256–7)

A new model of expectation in music; the issue of aesthetic response

In the course of the analysis and thinking presented above, the elements of a new, composite model of expectation in music have emerged, which may be summarized as in Figure 50.

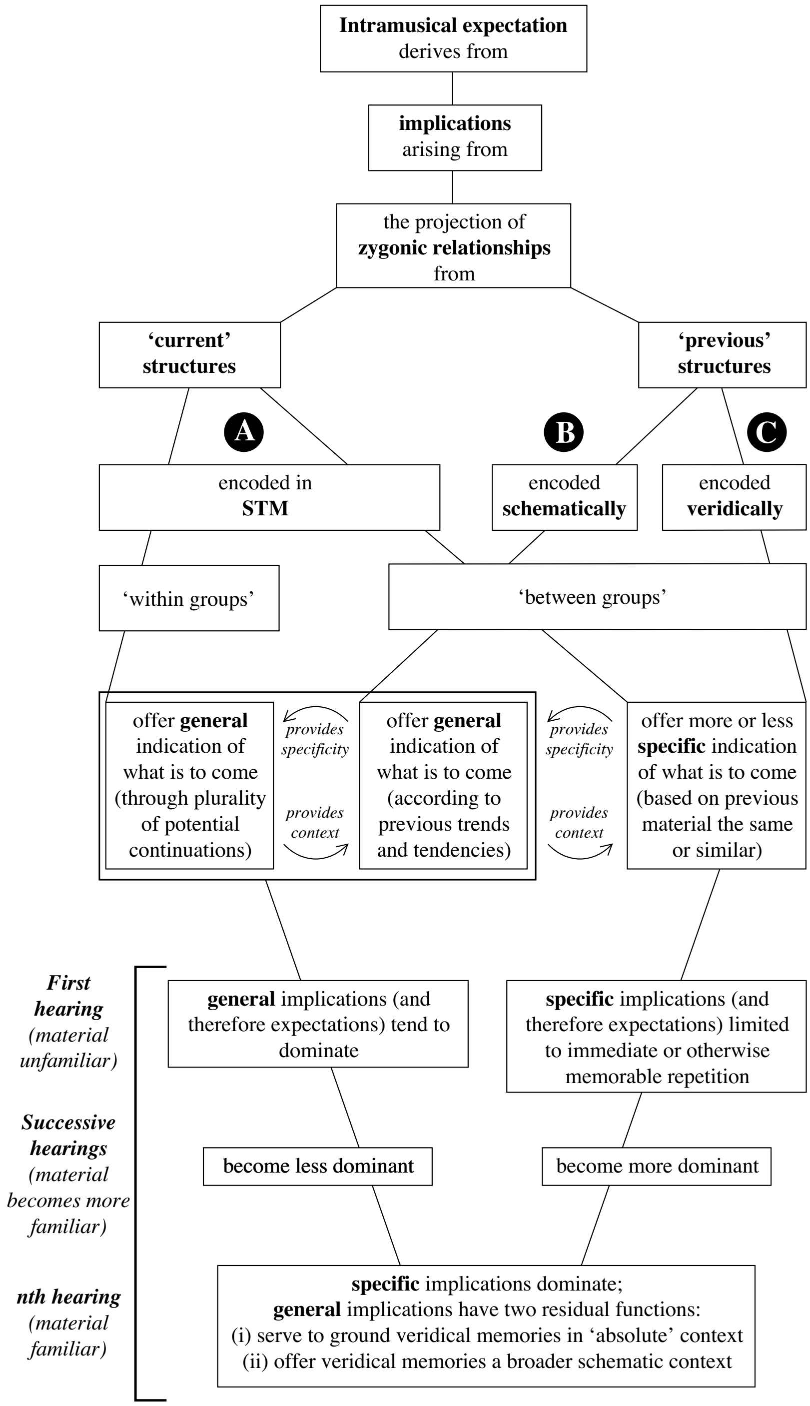


FIGURE 50 *Zygonic model of implication and expectation in music.*

It is proposed that expectation in music (which typically occurs subconsciously, and inevitably varies from listener to listener and from one occasion to another) occurs through the projection of zygonic relationships operating in three contexts: from 'current' structures (which form part of the present hearing process, are encoded in short-term memory, and operate *within* and *between* groups) (**A**); and 'previous' structures (which formed part of past hearing processes, and operate *between* groups). The latter may be encoded schematically (**B**) or veridically (**C**). Current 'within-group' structures can offer only a *general* indication of what is to come, since, as we have seen, all musical events have a plurality of potentially logical continuations. 'Between-group' expectation working within 'current' structures may be prompted by features that are particularly salient – brought about, for example, by repetition. Schematic information derived from structures heard previously offers a *general* picture of what the future may hold, according to heuristics based on past trends and tendencies. There is an interaction between **A** and **B**, whereby **A** provides a local context for the projections stemming from **B**, which in turn lend greater specificity to the implications arising from **A**. Veridical memory traces – **C** – offer a more or less specific indication of what is to come, depending on the degree of similarity of the new material, as it unfolds, with that heard in the past. **C** adds specificity to the implications deriving from **A** and **B**, which together provide the context in which expectations from **C** can be realized.

This basic model can be used to explore how the three forces of expectation that are identified interact in different circumstances, particularly as a listener becomes increasingly familiar with a piece. For example, with regard to the first hearing, we may infer that *general* implications (and therefore expectations) stemming from internal patterning[27] – **A** – and stylistic data – **B** – will tend to dominate, with *specific* implications and expectations limited, for example, to immediate or otherwise memorable repetition or variation of chunks of material, as found, for instance, in ostinati, recapitulations and sequential passages – **C**. With subsequent hearings, we may suppose that this balance gradually changes as veridically based expectations come to dominate more and more.

What role **A** and **B** have to play once a piece is well known, when much or even all of it can be anticipated accurately, is a complex one that has engendered some debate. It seems clear (as shown in Figure 48) that general forces of expectation deriving from current and previous material will continue to fulfil a function in providing a temporal, tonal, timbral and dynamic framework upon which short-term and veridical between-group memories can be hung, something that is particularly important for hearings of new *performances,* where the 'background' characteristics of the auditory scene may differ from that which is familiar. The ongoing cognitive function of expectation deriving both from certain immediate tendencies (a rising scale approaching the tonic, for example) and some schematically induced expectations (the general tendency of chord V^7 to be followed by I, for instance) is more contentious, however. What role can such expectations play when it is known through previous occurrences of the passages in question that the scale reaches the leading note, then falls back to the dominant, or that chord V^7 is in fact followed by vi? Surely the specific veridical memory traces render the more general implications redundant? Yet the relatively unexpected twists and turns in music that make such an impression on its first hearing *do* seem to go on playing a part in the enjoyment of a piece once it is well known – when the unexpected is no longer a surprise. How can this be?

In seeking an answer to this question, let us take a step back and return to the work of Meyer, whose seminal thinking over five decades has provided much of the stimulus for the theoretical and empirical efforts described and analysed in this article. An early proposition of Meyer's was that an affective response will be aroused when an expectation activated by a musical stimulus – a tendency to respond – is temporarily inhibited or permanently blocked (1956: 31). Since its original formulation some half a century ago, this thesis has stimulated considerable debate. A recurring concern has been how to reconcile the uncertainty purported to be necessary to stimulate affect (Meyer, 2001) with the matter of repeated hearings, since, as we noted in the introduction, one can perform or listen to the same piece of music many times and continue to enjoy it. Indeed, we typically react most strongly to music with which we are familiar (Panskepp, 1995: 172). Yet it cannot be the case for a piece that one has memorized, for example, 'that the ebb and flow of partially fulfilled expectations control one's enjoyment of it: every note is exactly what is expected' (Bever, 1988: 166). Meyer himself counters this argument in a number of ways (1967: 42ff). One to which he returns most recently is the 'willing suspension of disbelief', through which listeners supposedly enter into an aesthetic illusion, unwittingly (or even deliberately) ignoring their knowledge of a piece, and hearing it as if for the first time (2001: 352).

There are, however, a number of difficulties with this view. Consider, for example, the opening of the third movement of Rachmaninov's Symphony No. 2. Based on listeners' retrospective accounts, Sloboda (1991: 115) found this be prototypical of passages that provoke tears, in that it utilizes melodic appoggiaturas, and forms a melodic and harmonic sequence whose underlying chords descend through the cycle fifths to the tonic (see Figure 51). Sloboda believes that this finding and others similar offer some confirmation of Meyer's theory that affect stems from the creation and potential violation of expectancy within musical structures. But is this actually what the passage shows?

Take, for example, the appoggiaturas, which Meyer considers to cause 'affective expressive experience' since 'they delay (inhibit) the arrival of the expected and anticipated structural tone' (1956: 207). One can test this out by mentally replaying the first bar of the Rachmaninov movement, feigning ignorance of what should follow, in accordance with Meyer's proposition. What melodic continuations can reasonably be anticipated at this point? As we are discounting memories of previous hearings of the passage, there are two sources of predictive information that we are able to draw upon. The first is the opening material itself. If, for the sake of simplicity, we project only perfect primary and secondary zygonic relationships of pitch degree (see **A** in Figure 50) within the diatonic framework that is indicated through stylistic precedent (see **B** in Figure 50) – cf. Figure 42 – then seven theoretical possibilities are available as illustrated in Figure 51 (shown here with potential harmonizations).[28]

In fact, all these melodic options (situated in a range of harmonic, rhythmic and textural contexts) are taken up by composers working within the western Classical tradition, as Barlow and Morgenstern's (1948) *Dictionary of Musical Themes* reveals (see Table 1). There is, of course, no suggestion that the relative frequencies with which these series of pitch degrees occur translate directly into probabilities within an expectancy framework, through schematic memory and recall (**B** in Figure 50). Clearly, other factors would have to figure in any such equation, including the listener's degree of familiarity with the works concerned. The important point here is that since all the seven pitch degrees are identified as offering musically acceptable modes of continuation (judged both from the standpoints of logical analysis and historical precedent), it seems reasonable to assume that, on a first hearing at the moment in question, listeners'

TABLE 1 *Examples of melodic continuations following the opening i–ii–iii in the western Classical tradition*

Tonal degree following initial **i iii v**	Example from western Classical repertoire	Number of instances cited in Barlow and Morgenstern (1948)	Relative frequency
i	Bach: Prelude No. 9 in E Major, BWV 854	50	0.33
ii	Handel: Sonata in D Major, Op. 1, No. 13 for Violin and Continuo; 1st Movement	4	0.03
iii	Schubert: Sonata for Violin and Piano, Op. 137, No. 1; 1st movement	25	0.17
iv	Mozart: Symphony No. 40 in G Minor, K550; Trio	14	0.09
v	Haydn: Symphony No. 104 in D Major; Minuet	31	0.21
vi	Wagner: Parsifal; Overture	18	0.12
vii	Stravinsky: Capriccio for Orchestra (rev. 1949); 3rd movement	8	0.05
Totals		**150**	**1**

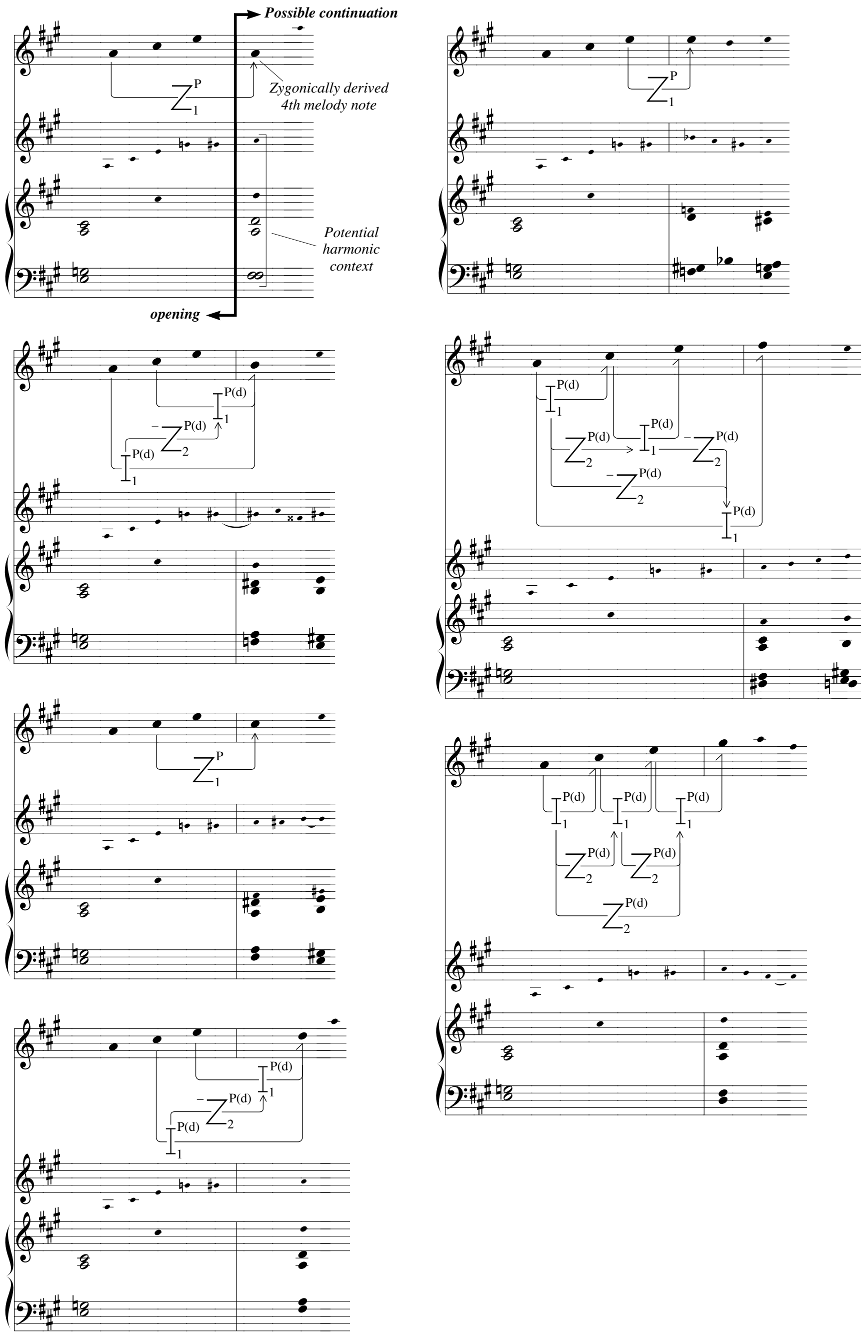


FIGURE 51 *Potential coherent continuations following bar 1 of the third movement of Rachmaninov's second Symphony No. 2.*

expectations should potentially embrace them all. Hence, in considering how bar 2 of the third movement of Rachmaninov's Symphony No. 3 may begin, a reasonable assumption would be that the fourth melody note is likely to conform to the major diatonic framework (with possible chromatic inflections) and be within an octave range of those preceding (cf. Figure 34).

Accordingly, there is no reason to believe (in the absence of empirical data) that the immediate 'structural tone' that Rachmaninov actually does employ – the fifth octave A – will be anticipated to the exclusion of any other. This implies a level of uncertainty which would surely *preclude the appoggiatura prospectively being felt to inhibit its arrival*.[29] Admittedly, within the 'common practice' style to which the symphony conforms, this G♯ has a perceived urge to resolve by step to the nearest diatonic consonance (the A) – see Huron (forthcoming) – but this effect (and any corresponding affect) will occur *as the discord is heard.* Hence, while expectation may well play a part in our aesthetic response at this (slightly later) point in the melody, it will derive from the stylistic tendency of appoggiaturas to resolve to neighbour notes, not from the preceding melodic context – the 'anticipation before the event' mentioned by Meyer. Before this (as the third note of the melody is heard) there appears to be *too great* a level of uncertainty to enable the theory of inhibited response to function. Conversely, once the resolution has been heard – in retrospect – the position is rather different: listeners may well appreciate (typically at a subconscious level) that the G♯ did indeed delay the arrival of the A, taking the melody on a circuitous route; but at this stage, clearly, there could be *no uncertainty*, since the events have passed.

Hence, Meyer's proposition that emotion and meaning in music stem through expectation from events around which there is an element of doubt appears to be in difficulty, even for a first-time listener. Moreover, the model set out in Figure 50 suggests that this thesis becomes even harder to sustain as the passage proceeds, since *between group* projections kick in: subsequent appoggiaturas *and their resolutions* are strongly implied through the sequential nature of what follows – secure predictions being enabled through primary and secondary zygonic invariants (series of relationships operating in parallel). A similar sense of inevitability – a teleological drive – characterizes the inner parts too (listen to the movement of the second violins, violas and 'cellos) and, crucially, the bass-line, since it bears the harmonic burden of the musical fabric as a whole. Here, at the bottom of the texture, the ascending third of the melody spanning bars 2 and 3 is mirrored in the descent from the fifth degree to the third, and concomitant transition from the dominant harmony to the mediant (see Figure 52).

In summary, then, it seems inconceivable that one could listen to these opening bars without *anticipating* the appoggiaturas with which they begin (after the first). To the stylistically competent listener, even if he or she is listening to the passage for the first time, there is little or no uncertainty as to the course of the melody once the sequence gets underway. Moreover (as we

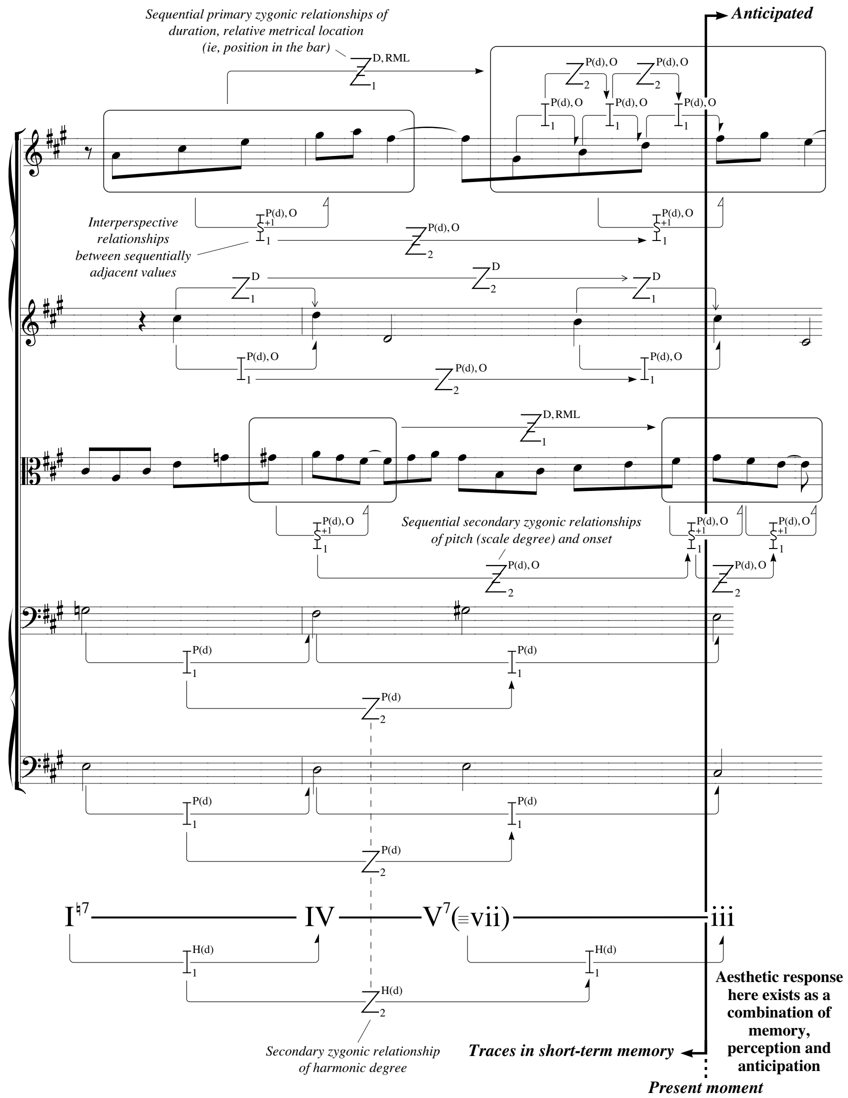


FIGURE 52 *The influence of preceding stimuli and relationships on aesthetic impact*

noted above) the first-time listener is the exception rather than the rule. So what is one to make of Meyer's theory? As Jackendoff puts it (1991: 224–5): 'Everyone has the experience of thinking "Here comes that beautiful place!" – enjoying it in the full knowledge of exactly what it is going to sound like, with both memory and affect fully engaged.' The problem with Meyer's argument is that it attempts to 'conflate enjoying a piece with not remembering how it goes.' However, Jackendoff (1991: 228) does offer the possibility of 'rescuing' Meyer's expectation theory, suggesting that violations of what is expected may occur on a subconscious level, involving a closed module for music-processing – a 'parser' – which in effect always hears a piece as if for the first time, thereby ensuring that affect remains intact (cf. Fodor, 1983; see also Margulis, 2005). Similarly, Schmuckler (1989) contends that

> expectancies are formed along the basis of ingrained 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 points, where unusual events occur. (p. 114)

Bharucha (1994) describes the position thus:

> Even when a piece has been heard often enough to be familiar, it cannot completely override the generic, automatic expectations. Surprises in a new piece thus continue to have a surprising quality because they are heard as surprises relative to these irrepressible expectations. (pp. 215–16)

Perhaps, then, Meyer's original assertion would be better couched in terms of expectation in music working through the *subconscious* (rather than the willing) suspension of disbelief.

To sum up: whatever the neurocognitive processes involved, reflection on the listening experience as set out in this article suggests that *being able to anticipate what is in stylistic terms the relatively unexpected enables us to relish it all the more*. This accords with Huron's hypothesis (forthcoming) that a key component in the pleasurable experience that music affords – its 'sweet anticipation' – is the succession of subconscious cognitive rewards that our ability to make correct prognostications offers. These are all ultimately enabled by repetition of one form or another, whether 'statistical' or 'specific', whose universal presence and function in music lies at the heart of zygonic theory. The link with this theory and aesthetic response is explored further elsewhere (Ockelford, 2005b).

Concluding thoughts; next steps

In conclusion, it is clear from the empirical work that has been undertaken that listeners are able to use the implications inherent in musical structure to make meaningful predictions, at any given point, as to the future course of events – and these findings appear to support the composite model of expectation presented above. Further experimental work could be undertaken to test certain of the underlying hypotheses and assumptions, particularly with regard to how the three strands of expectation that are identified interact in different ways as material becomes increasingly familiar. Beyond this, however, it remains unclear what role musical expectation actually plays in real-life listening situations. For example, is the anticipation of which listeners are clearly capable a preconscious part of the 'typical' listening process, or is it a capacity that is artificially highlighted through experimental conditions: a byproduct of music's supersaturation with repetition – and therefore implication – at all levels? Are multiple expectations in 'real time' a cognitive reality? If so, do these have a place in the cognitive processing of performers, for whom specific preparation for the notes that are to be played or sung is clearly essential? That is, do parallel processing and priming work together, and if so, how? And if expectation is indeed usually present in listening to music, then how in a phenomenological sense does it work alongside the immediate perceptual responses made to the sounds currently being heard, and the past experiences that may be projected into present consciousness (Husserl, 1964[1905–10; summarized in Miller, 1984: 120ff)? These questions currently lie at or beyond the boundaries of what is feasible to explore empirically. However, it is likely that by striving to answer them, our general understanding of the cognition of musical structure and our aesthetic response to it will be enriched.

NOTES

1. This is the case even in most styles that involve improvisation (where each performance is to a greater or lesser extent unique), since extemporised pieces are generally based on standard frameworks or formulæ, a knowledge of which is assumed in listeners. Huron (forthcoming) posits a continuum upon which pieces can be placed with respect to their identity as unique and distinguishable artefacts. How expectation works for *performers* is another matter, beyond the scope of this discussion (see comments in the final section).
2. As long ago as 1933, Verveer, Barry and Bousfield had reached just this conclusion, with the proviso that an 'intervening time interval . . . tends to enhance the pleasantness of subsequent repetitions' (1933: 134).
3. Interperspective': a term coined by Ockelford, 1991, to mean 'between *perspects*' (that is, '*per*ceived a*spects*') of music, used in contradistinction to the term 'parameter', which is reserved solely to refer to the physical attributes of sound. Hence, the perspect 'pitch', for example, most closely corresponds to the parameter 'frequency', though the connection between the two is far from straightforward (cf. Meyer, 1967: 246).
4. Observe that one arrowhead is open and one is filled – the former showing a link between *single* values, and the latter indicating a *compound* connection within or between 'constants' (typically, values extended in time) – implying a network of relationships the same. For a fuller explanation, see Ockelford, 1999.
5. In canonic or fugal textures, the 'dux' is the antecedent voice, and the 'comes' the consequent.
6. It is, of course, possible to imagine any perceived sonic event following any other, though in the context of music this is largely irrelevant, since a system in which all perspective values were reckoned to be equally likely (or unlikely) to follow one another – where nothing was perceived to be contingent on anything else – would be tantamount to chaos, incomprehensible, and therefore not 'music', in the generally accepted sense of the term. Even 'aleatory' music – in which perspective values are determined to a greater or lesser extent by chance – (as, for example, in Cage's *Variations I* (1958) and *Variations II* (1961)), and, ironically,

compositions whose values are in many respects controlled through transformations that are beyond the bounds of our auditory processing capacities (such as Boulez's *Structure Ia* (1951–2)), which may, at the first blush, sound chaotic, have sufficient regularity to cohere, at some level, as single extended entities in the domain of perceived sound. In *Structure Ia,* for example, contrasts between isolated sonic 'points' become the norm, and these follow each other within a narrowly defined temporal range. As Ligeti says (1960[1958]: 61): 'the structure . . . is seen to be something highly variable and chancy, comparable to the way the network of neon lights flashes on and off in a main street; . . . but as the separate lights flash on and off, they combine to form a statistical complex.'

7. *Where* – the perceived location of the source of sound – is also an important factor, but one that has rarely constituted an issue in studies of musical expectation, since it is generally constant or *visually* predictable during the course of a piece – though see Huron's comments (forthcoming) in relation to the spatial works of Giovanni Gabrieli; also Ockelford (1999: 274ff).
8. Note that units of sound of perceptible duration may engender expectation that occurs *within* their perceived temporal span – see Ockelford (1999: 121ff).
9. In reality, when listening to music, it is impossible to discount past experiences. At the most basic level, the very fact that orderly continuations have happened in this past means that these promote further rational prognostication.
10. Although imperfect relationships of onset may seem a tenuous basis on which to construct expectation in the perceived temporal domain, the fact that one note follows another within a relatively short period of time is a fundamental property of music. Indeed the clearest signal that a movement or piece has ended is an extended period of silence (cf. note 6 above and Ockelford, 1999: 322ff).
11. Narmour's model centres on *pitch*, and, due to limitations of space, a similar focus will be adopted in this article (with the assumption that implication and expectation work in comparable ways in other non-temporal perspective domains).
12. The importance of relationships between discontiguous notes is, however, acknowledged by Narmour elsewhere, in his concept of 'registral return' – 'aba' (see below).
13. Moreover, if one C is able to imply another through the gestalt principle of similarity, as Narmour states, then, by extension, why are *two* initial events necessary in the formulation of his first postulate (A + A → A, or a + a → a)? In fact, one is sufficient: that is, A → A, and a → a.
14. Note, however, that Narmour considers registral return to be a 'non-implicative pitch relation' (1990: 127). It is not clear why this should be so, since the concept of 'return' embodies the reiteration of an event already heard: that is, the second appearance of a note is reckoned to derive from the first – it is perceptually implied by it.
15. An unusual combination, though one that is found, for example, in Sousa's *King Cotton March* (1923), the opening of the third theme, where the first note is the dominant.
16. See also Cohen (1991), who demonstrated that opening fragments of Bach preludes were sufficient for listeners mentally to recreate the scalar frameworks that pertained to their respective tonalities.
17. Similar-sounding metaphors to those adopted by Larson (2002: 352), though used with different meanings here.
18. Inevitably, as Schellenberg makes clear (1997: 314), other factors, such as a melody's rhythmic and global pitch characteristics – including any tonal

implications that may be present – all almost certainly exert an influence. Moreover, local within-group patterning, operating through secondary or even tertiary zygonic relationships, is also liable to have an effect.

19. Even two values in the domain of pitch typically need to be teamed up with a distinctive rhythmic motive in order to function as a self-sufficient motivic entity, as the example in Figure 35 shows.
20. For a detailed consideration of how this type of analysis fits with contemporary research and thinking on motivic categorization in music – as reported, for example, in Deliège (1996), Deliège and Mélen (1997), Deliège et al. (1997) and Deliège (2001) – see Ockelford (2004).
21. This is not to argue against the existence of 'parallel processing' in music cognition (see Jackendoff, 1991: 214ff), whereby, at any given point in listening to a piece, a number of structural interpretations (each potentially bearing different implications) may be held in the mind – although only one of these is likely to permeate consciousness. As a particular passage unfolds, it is hypothesized (Jackendoff, 1991) that competing mental analyses are supported, continue to remain in abeyance or are 'pruned' if they prove incompatible with subsequent input. In my view, this model need not be understood in terms of retrospective implication, however, but of pattern recognition – albeit through the mind selecting from a number of simultaneously processed possibilities.
22. For a detailed exploration of perspective and interperspective pitch sets, and a zygonic account of their derivation, see Ockelford (1999: 472ff).
23. Just how these memory traces are built up, and what form they ultimately take is not clear, although listeners' accounts offer some indications. For example, after an initial hearing of the first movement of K333, it seems that we will typically be left with an overall impression of the music, and a series of fleeting traces that we find memorable: more or less accurate, more or less detailed, and more or less complete. Gradually, after successive hearings of the same performance, the picture becomes more complete and coherent until, eventually, a comprehensive representation may be constructed, enabling us to detect the slightest deviations from the original version. However, to what extent hearings of *different* performances of a piece are stored separately is unclear, although with sufficient exposure to a particular interpretation, it seems that this can develop a distinct memory trace of its own.
24. Clearly, the specificity of the expectations will depend on the fidelity of the memory trace in question.
25. Levitin's (1994) study suggests that many listeners store absolute pitch information to a high degree of fidelity in veridical memory (that is, in traces of specific musical fragments) – something which contrasts with the widespread *in*ability to remember absolute pitches in general terms (as in the percept of 'the key of B♭ major', for example). That is, in relation to the model set out in Figure 47, while the relationships $\mathbf{S_i}$ and $\mathbf{S_{ii}}$ may, in the domain of pitch, convey absolute information, this is far less likely to occur in the case of relationships $\mathbf{G_{ii}}$ and $\mathbf{G_{iii}}$.
26. Dissimilarity calculated as the sum of the average divergence from the mean in each (durational) category. Hence:

$$\text{Similarity (\%)} = 100 - \sum \left(\frac{\Sigma \left| x_i - \left(\frac{\Sigma x_i}{n}\right) \right|}{n} \right)$$

where x_i is the value of a given (durational) category in a piece, n is the number of pieces, and the sum of different categories under consideration in a piece = 100%.

27. It is reasonable to hypothesize that such expectations become better adapted as a work progresses (see Coons and Kraehenbuehl, 1958; Huron, forthcoming).
28. Assuming a tonality of A major; arguably, a first-time listener may hear the passage in D. In either case, the principle of general expectation outlined here would be the same.
29. In fact, the resolution is échapée-like; the structural tone arguably being the F♯ following the A.

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