UNIVERSITY OF SOUTHAMPTON

MUSICAL TIMBRE IN CONTEXT: THE SECOND VIENNESE SCHOOL, 1909-1925

A THESIS IN TWO VOLUMES

VOLUME I

LEE TSANG

SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF ARTS, DEPARTMENT OF MUSIC

SEPTEMBER 2000

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ARTS

MUSIC

Doctor of Philosophy

MUSICAL TIMBRE IN CONTEXT: THE SECOND VIENNESE SCHOOL, 1909-1925

by Lee Tsang

In most music analyses, timbral issues are rarely explored. The principal aim of this thesis is to put discussion of timbre on an equal footing with discussion of other parameters; a conceptual model of musical timbre is proposed and issues of terminology and perception are addressed. In order to place the timbre model into a theoretical framework, methodological contexts are investigated with a focus on recent performance analysis studies.

The methodological issues are drawn into suggestions for a theory of timbre for music analysis. Interrelationships between timbre and pitch are discussed from an auditory streaming perspective; Huron's voice-leading Principles (forthcoming, 2000) and Richard Parncutt's pitch salience algorithm (1993) are applied. A theory of timbral change is proposed with suggestions of possible governing principles.

The timbre model and proposed theory are absorbed into studies of music by Second Viennese School composers. In a study of Arnold Schoenberg's '*Farben*' (1909) and Berg's *Wozzeck* timbral issues are broadened into a discussion of (extra-)musical allusion and narrative. An extensive study of Anton Webern's *Five Orchestra Pieces* Opus 10 follows, situating timbre and pitch within a yet wider context; the study focuses principally on timbral and pitch links, refers to issues of sketches and chronology, and proposes an interpretation of Opus 10 from an extra-musical perspective. In conclusion, timbral perspectives are judged to offer much insight into the perceptibility of musical structures, providing a range of possible schemata for listeners; they are potentially useful for the analysis of a variety of musics.

CONTENTS

PREFACE

For a long time now, the manipulation of timbre has played an essential role in music: composers have sought for new sounds and new structures, and performers have striven to develop a unique voice, manipulating timbres in the name of interpretation; listeners' abilities to distinguish musical sounds have fascinated acousticians and music psychologists, leading to the development of new technologies, new experiments and new perceptual models in attempts to describe the phenomenon. Given timbre's status in musical activities, it is surprising to find that those who talk about music—mainstream musicologists, especially music analysts—have, on the whole, resisted serious engagement with timbral issues.

There are a number of reasons for this resistance. Compared with other musical parameters, the possibilities for variation seem vast, and adequate description is elusive. Other parameters, such as pitch or rhythm, are relatively easy to describe, because suitable vocabularies have developed. These vocabularies develop according to cultural conditioning and are sometimes associated with technological advances; equivalent vocabularies may not exist in other cultures. For instance, our notation of pitch reflects the equal-tempered scale system; equal-tempered scales are not inherent to our understanding of pitch—they are the direct result of keyboard instrument development. By contrast, the Debarčani (a Yugoslav peasant community) have a 'highly developed' vocabulary for describing timbral relationships, but a far less accurate vocabulary for describing pitch relationships (Cook 1990: 238 in reference to Marshall 1982: 170).

Another reason for the lack of engagement with timbral issues is that the foci of many Western analytical studies are often too narrow. Rarely does the application of theories by Schenker, Forte, Reti and others lend itself to observations of how musical parameters interact and shift emphasis. The fault here lies in the application, not in the theories themselves, which are explicitly concerned with limited aspects of the total musical phenomenon. Too often, analysts gloss over, or indeed miss out altogether, important points of interest which the employed techniques cannot accommodate. The difficulties of incorporating a systematic study of neglected parameters (not just timbre, but related 'parameters' such as dynamic, phrasing, articulation, and texture) are, nevertheless, understandable, not least because an established theory or method is lacking.

Research for this thesis started out as an exploration of timbre, and I had grand ambitions of devising a complete theory of timbre which could be implemented in the analysis of many types of music: instrumental, vocal, electroacoustic, non-Western, and so on. It soon became clear that this goal was somewhat overambitious. More significantly, I began to question the desirability of such a goal; the function and interpretation of timbre varies according to context and using a single analytical method is unlikely to be the best way to address timbre in different contexts.

Since musical timbre is not a discrete phenomenon, I have assessed recent timbre research from a contextual perspective (Chapter 1). The principal aim here is to develop a suitable vocabulary for timbral description. The basic conceptual framework that is proposed focuses on the correlation between physical and perceptual aspects of sounds; although I have carried out no new experimental work, I invoke the existing literature and re-analyse some existing data. The framework put forward, which applies to most types of music as heard by Western listeners, does not draw upon the physiological intricacies of the auditory process, which have been adequately covered elsewhere (e.g. Goad 1994) and lie beyond useful application to music-analytic contexts.

In Chapter 2, I raise many issues that have an impact on timbre perception and representation. However the main thrust is not about timbre per se: I address issues of theory and methodology, principally from the perspectives of current approaches to orchestration analysis and performance analysis. The performance analysis focus is principally meta-methodological; current approaches raise useful questions about the aims of music-analytic inquiry and the importance of context.

Building upon many of the issues raised in Chapters 1 and 2, Chapter 3 proposes a theory of timbre. The study, which is illustrated with examples from Arnold Schoenberg's '*Farben*', explores interrelationships between timbre and pitch through an application of Richard Parncutt's pitch salience algorithm (1993) and a discussion of Huron's voice-leading Principles and Derived Rules (forthcoming, 2000). A theory of timbral rhythm is proposed with suggestions for possible governing principles.

By offering new ways of thinking about timbre hitherto overlooked in musicology, I aim to put timbre on a more equal footing with other parameters. I have, however, consciously avoided limiting my perspective to timbral matters. My music analyses in Chapters 4 and 5 are musicologically orientated—they are not acoustical or psychological studies. Too little attention to other points of interest would be to the detriment of effective and useful interpretation.

Timbral matters are, nevertheless, a major focus. The ideas in the earlier chapters are absorbed into, and developed in, the analytical approaches that are adopted in my studies of well-known works by Schoenberg and his pupils Alban Berg and Anton Webern. I have chosen works by the Second Viennese School in order to provide the thesis with coherence: each composer's compositional style is distinctive and yet was highly influenced (at least up until 1925) by personal and professional relationships with the other members of the School. As I will demonstrate, these composers became increasingly aware of timbre's role as a possible structural determinant in the so-called 'Expressionist' phase.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Professor Anthony Pople of the Universities of Southampton and Nottingham for his tremendous support and guidance throughout the PhD; my advisor, Professor Nicholas Cook (Southampton) for extensive and invaluable feedback; and Dr Deborah Mawer of Lancaster University, who helped supervise the project during 1996-1997.

I wish to express my gratitude to the many people who facilitated access to materials, recommended various articles and offered other helpful advice. Dr Richard Parncutt of Graz University supplied his pitch salience algorithm and offered advice on various psychoacoustical matters; John Pritchard (Lancaster) helped with computer applications; Brian Francis (Lancaster) offered advice on mathematical aspects of the thesis, particularly statistics and three-dimensional scatterplots. Access to and advice on Webern's materials was provided by Dr Neil Boynton (Lancaster), staff of the Pierpont Morgan Library in New York, and Dr Felix Meyer, Johanna Blask and others at the Paul Sacher Stiftung in Basel. Dr Ronald Woodley (Lancaster), Bethany Lowe (Scarborough/Southampton) and Victoria Vaughan (Southampton) provided me with their unpublished writings. Nathan Helsby provided invaluable help with German translations and, with Peter Elsdon and Björn Heile, acted as a springboard for many of my ideas; other staff and postgraduate students at Southampton offered enthusiasm and responded constructively.

Access to materials was provided by staff at various libraries, including the Hartley Library of Southampton University, the British Library, Lancaster University Library, Cambridge University Library, the Robinson Library of Newcastle University, the Music Department Library of Cardiff University, the University of London Library, the Birmingham Conservatoire Library and the Barber Institute of Fine Arts at Birmingham University.

Musical examples have been reproduced with the kind permission of Peters Edition Ltd, London (Schoenberg's *Five Orchestra Pieces* Op. 16), Universal Edition and

Alfred A. Kalmus (Berg's *Five Orchestral Songs* Op. 4, and *Wozzeck*; Webern's *Five Orchestra Pieces* Op. 10), Carl Fischer, Inc., New York (*Orchestra Pieces* 1913/14 and *Three Orchestral Songs*), the Pierpont Morgan Library (Webern's unpublished 'Opus 6' version of Op. 10), and the Paul Sacher Stiftung (sketches of Webern's Op. 10).

I wish to express gratitude for support of a more pastoral nature. In addition to many of those mentioned above, I thank the late Dr Bernard Harrison (Lancaster) for his helpful advice and enthusiasm for the project during its early stages, and Peter Johnson and my other colleagues at the Birmingham Conservatoire for their patience. Special thanks are due to Philip, Mum, Josh, Charlotte and other members of my family for their patience and understanding.

LIST OF FIGURES

Chapter 1

A Conceptual Model of Musical Timbre

1.0 Introduction

Terminology is a familiar problem for timbre researchers. Not only is the description of specific timbres difficult—an accurate definition of the term 'timbre' is, itself, a cause for debate.[1] In this chapter, I do not intend to provide an extensive account of the familiar arguments against current definitions, but will raise issues that help us to construct a basic conceptual model of musical timbre for musicologists.

Many researchers refer to the following definition of timbre by the American Standards Association (1960, 1973):[2]

> Timbre is that attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar.
>
> NOTE: Timbre depends primarily on the spectrum of the stimulus, but it also depends upon the waveform, the sound pressure, the frequency location of the spectrum, and the temporal characteristics of the stimulus.

This definition is problematic, because it does not adequately convey the sense that timbre is a multidimensional, perceptual attribute. It emphasises the effect of spectrum, waveform and so on, but a sound's physical constituents should not be confused with timbre: frequencies and waveforms are physical, pitches and timbres are perceptual. This was the point that Gerald Balzano (1986) made when he questioned the validity of using Fourier analyses as mathematical metaphor for perceptual attributes of sound. One of the problems is that listeners may perceive as identical tones that have non-identical spectral components (David Worrall 1997). Another is that Fourier analyses omit important information; they do not reflect fluctuations in the tone over time, and they focus often on only harmonic components of a sound's spectrum.

---

1 Stephen Malloch (1997), Gregory J. Sandell (1997) and many others have contributed to this debate. See also Gerald Balzano (1986) and A. J. M. Houtsma (1997) for contrasting views on timbre's relationship with pitch.

2 Sometimes referred to as the American National Standards Institute (ANSI) definition (1973).

Timbre and Pitch

Many tones have components that lie outside or are deviations from an 'ideal' harmonic spectrum (see Figure 1.1).

These 'inharmonicities' play a significant role in perception of both timbre and pitch. Broadly speaking, a tone consisting principally of harmonic components is likely to be perceived as pitched; if the spectral components do not conform to the 'ideal' spectrum (e.g. they are stretched), the pitch will be perceived as less focused than if the components do conform. A tone consisting principally of inharmonic components (e.g. a snare drum tone) is, therefore, likely to be perceived as non-pitched.

Timbral 'geometry'

Timbre and pitch are, it seems, 'mutually dependent' (Houtsma 1997), but their conceptual/perceptual 'geometries' are distinct (Balzano 1986: 300-1). Whereas the conception of timbre is multidimensional, pitch has just a single governing order relation—higher to lower—and special relationships, termed 'octave equivalence' (and in Western tonal music, the 'circle of fifths'), exist amongst certain pitches.[3] In most Western musics, specific pitches may be assigned to discrete categories such as 'A', 'B', 'C#', 'D'—so a slight shift along a pitch continuum is likely to have an enormous effect on one's interpretation of pitch relationships. Conversely, it is unlikely that a discrete system of categorisation for timbre could ever exist. For instance, if we construct a 'perceived inharmonicity' continuum (see Figure 1.2a), there isn't an obvious way of dividing sounds that are perceived as 'inharmonic' from those that are not.

If we divide the continuum arbitrarily in the middle, a sound y, which is just to the right of the division, is clearly differentiated from a sound x, which is at the far left (see Figure 1.2b). On the other hand, if, in a musical context, it is replaced by a sound y', which is just to the left of the division, this is unlikely to have much effect on our interpretation, as little perceptual difference exists between y and y' (see Figure 1.2c). In most cases, the important point would be that the y timbres are 'semi-inharmonic' in contrast to x, which is harmonic.

3 Pitch height, octave equivalence and the circle of fifths may, nevertheless, be represented as a three-dimensional model (see Houtsma 1997: 106-7).

Timbral Vocabulary

The complexities of timbral geometry raise issues about timbral vocabulary. Problems of timbral vocabulary have been investigated in a number of empirical studies, e.g. Gottfried von Bismarck (1974) and Roger Kendall and Edward C. Carterette (1993). These studies were motivated by discontentment with the common practice of using general terms, such as 'flute' or 'strings', to describe timbral phenomena. However, discontentment with these terms is not always justified: when discussing the overall timbral structure of a musical work, they are useful because identification of instrument type and family is an important associational feature of timbre perception. The terms become less practicable when discussing instrumental combinations, but, as many orchestration analyses illustrate, it is useful to describe the effect that a particular instrument might have on a sonority. Most difficulties arise when conveying a particular timbral sensation through the use of instrument names alone. For the purposes of detailed timbral analysis, it is often necessary to pinpoint the dimensions of individual timbres so that the unique sensation of their combination may be most adequately described. The following discussion of timbre dimensions focuses on terms that are likely to have a widespread perceptual validity.

1.1 Timbre dimensions

Stephen McAdams and other researchers at IRCAM (1995) have recently devised a psychoacoustical model based on listeners' responses to synthesised musical instrument timbres (pitched at Eb4).[4] Some of the timbres were instrument hybrids (see Figure 1.3), which were created by combining the spectra of two instrument timbres. (For instance, the 'parent' timbres of the vibrone are the vibraphone and trombone.) Eighty-nine listeners of varying musical ability took part in the experiment; they were asked to rate the dissimilarity of the timbre pairs. The researchers found that listeners distinguished timbres according to three main criteria, and that these can be correlated with quantitative measurements: rise time, spectral centroid and spectral flux. Each criterion is represented as a dimension of 'timbre space' (Wessel 1979) within which timbres are represented as points (see Figure 1.4).

[4] David Wessel et al. (1987) developed these timbres; others in the field have also used them, e.g. Carol Krumhansl (1989), Giovanni de Poli and Paolo Pandroni (1997), and Stefano Balliello et al (1998).

1.1.1 Rise time and Spectral flux

McAdams et al found that listeners' responses correlated very well with Jochen Krimphoff et al's (1994) calculation of 'rise time', which is the time it takes for a sound to reach maximum amplitude starting from a 2% threshold of the maximum amplitude. The distribution of tones within the dimension seems to validate psychoacoustically the principle that the shorter the rise time of a sound's attack portion, the more incisive the perceived attack; the shortest times are to be found in tones that we usually regard as having incisive attacks: vibraphone, harp, oboleste (a hybrid of oboe and celeste) and guitar.

'Spectral flux' correlated significantly with listeners' responses. It is calculated by comparing adjacent time windows of spectra;[5] the greater the degree to which the amplitudes of the harmonics vary over time, the greater the spectral flux.[6] The problem with this measurement is that it is not easy to transfer the quantitative value into a qualitative conception.[7] However, on analysing the data in the model, I found that many of the tones were grouped within the rise time and spectral flux dimensions according to their instrument families.

Perceptual grouping of instrument families

'Rise time' and 'spectral flux' are greatly influenced by modes of excitation. This is not surprising: when an instrument is excited, the energy of the resultant tone's spectral components constantly changes. In Figure 1.5, I have listed the various tones, grouping them according to excitation type. Each group is classified as being excited either impulsively **(I)** (i.e. by striking or plucking etc.) or continuously **(C)** (i.e. by bowing or blowing air etc.).

---

5 See Krimphoff (1993) for more details.

6 These aperiodic microfluctuations of amplitude are quite distinct from vibrato, which is a periodic variation of frequency and/or amplitude over time.

7 This difficulty is something that Pierre Boulez (1987: 161) has acknowledged. He feels that such difficulty invalidates the use of quantitative measurements when talking about music.

Grouping Criteria

Notice that the grouping of timbres is not the same in both figures. My grouping criteria differ according to the dimension, because each dimension deals with a different portion of the tone. For instance, in the rise time dimension the guitar and harp are grouped together because both timbres are excited in the same manner (plucked string). In the spectral flux dimension, they are separate, reflecting the considerable differences in resonance caused by the physical dissimilarities of the instruments.[8]

The criteria are also flexible because some tones cause ambiguity. Although 'impulsively'- and 'continuously'-excited sound sources are easily distinguished within the rise time dimension ('impulsive'—short, 'continuous'—long), hybrid tones (see Figure 1.3) blur the distinction between the excitation types (see Figure 1.5a).

For instance, the guitarnet (guitar and clarinet) and striano (bowed string and piano) have rise times that are more rapid than their continuously-excited 'parent' timbres, but less rapid than their impulsively-excited 'parent' timbres. This has to do with the way these hybrids have been created; the continuously-excited features dominate the onsets of these tones, and for this reason I have grouped them with their continuously-excited 'parent' timbres. My own listenings to the tones confirm the validity of these groupings; the positioning of hybrids in relation to their parent timbres reflects the dominant parent timbre.[9]

At the extremes, the division into families within the spectral flux dimension appears fairly neat. Notice that the tones with the most flux (bowed and plucked (guitar) string) are those that we might perhaps describe as 'grainy' and those with the least (double reeds and middle/low brass)[10] seem more 'solid'.[11] Some tones are, however, not grouped: the clarinet because it denotes the only true single reed instrument (the 'steady state'/decay portion of the guitarnet is dominated by the 'parent' guitar) and,

---

[8] Note, however, that the synthetic harp tone is not a true representation of a real instrument tone; the decay after the initial attack is too rapid.

[9] The tones used in the experiment are in the public domain. See Poli and Pandroni (1997b).

[10] Krimphoff et al (1994) point out that Krumhansl (1989) reaches the conclusion that these brass instrument tones have significant 'spectral flux'. Her use of the term does not, however, refer to fluctuations during time; it refers to irregularity in the global (averaged) spectrum (see Krimphoff for more details).

as noted above, the harp because of the unique physical construction of its 'source' (which affects the 'resonance'). There are also some overlaps between 'impulsive' (keyboard and plucked string) tones and 'continuous' (high brass and single reed) tones.

In contrast to the spectral flux dimension, the rise time dimension distinguishes fairly clearly between impulsively- and continuously-excited timbres. Nevertheless, the rise time and spectral flux dimensions are similar in that their highest values are dominated by impulsively-excited timbres (or by hybrids which have a dominant impulsively-excited 'parent' timbre), confirming that such timbres tend to have both rapid rise times and significant fluctuation in the steady state/decay. The opposite does not necessarily occur for (hybrids dominated by) continuously-excited timbres; the string tone, for instance, is an example of a timbre which fluctuates considerably, but has a fairly long rise time.

Although in general, most hybrids in the space are positioned somewhere between their two 'parent' timbres, one should note that the trumpar has less flux than either the trumpet or the guitar. In this case, when the spectra of the 'parent' timbres were fused, their different fluxes may have cancelled out to produce a timbre of lower flux. If it is possible for hybrids to be affected in this way, it is worth investigating whether or not spectral flux is cancelled out in conventionally blended unison timbres. If the 'cancelling out' only occurs in hybrid timbres, it may explain partly why hybrids and unison timbres do not necessarily sound the same.[12] On the other hand, it could prove to be a significant contributor for good blend in both hybrids and simultaneous timbres.

Flux and jitter

Although the above family groupings are a promising interpretation of the rise time and spectral flux dimensions, one should note that the spectral flux calculation does

---

11 I am not, however, suggesting that flux alone contributes to these sensations.

12 Another reason for the difference between unison and hybrid timbres in musical contexts is the subtle differences in loudness between the tones of a 'unison' timbre; the loudnesses of parent hybrid timbres may also vary, but are more easily controlled. I discuss the perception of combined timbres in more detail in Chapter 3 (see p. 52).

not account fully for the distribution of timbres within its dimension;[13] the correlation is significant, but there may be other measurements/physical parameter(s) that can account for the distribution more accurately.

In recent experiments, Dubnov et al (1995) found that the physical characteristics of real instrument tones may be grouped into instrument families according to the degree and rate at which the tones' waveforms deviate from 'ideal' waveforms (jitter). The use of higher order statistics (HOS) to view the data makes it difficult to interpret the family groupings according to a single criterion, but the groupings are similar to those that we often consider to facilitate good blend. For instance, one of the representations displayed the groupings and distribution outlined in Figure 1.6. Notice the relationships between instrument groups: the French horn bridges the gap between the trumpets-trombones group and the saxophones; the bassoon bridges the gap between the saxophones and the contrabassoon-bass-clarinet group, and so on. These findings have yet to be correlated with listeners' responses.

Interestingly, the Dubnov et al distribution of instruments correlates well with the groupings of the McAdams et al rise time dimension (compare Figures 1.5 and 1.6): lip reed followed by overlapping double and single reed; double (and single) reed overlapped by strings (the correlation breaks down here because the flute does not feature in the McAdams et al model). The groupings correlate well also with those in the McAdams et al spectral flux groupings, but less so with the distribution within this dimension.

It is, however, dangerous to read too much into a comparison between McAdams et al and Dubnov et al data, because the stimuli of the experiments differ in an important respect. The McAdams et al tones, though representing basic characteristics of musical instrument tones, are easily identified by the listener as synthesised—they are not really accurate representations of real instrument tones.[14] Their obvious artificiality does not, however, detract from the psychoacoustical reality that the

---

13 This caveat does not necessarily apply to the other dimensions, which were very well correlated with calculations for rise time and spectral centroid.

14 My subjective listenings of these tones confirm this. The tones can be accessed from Poli and Prandoni (1997b).

principal means of distinguishing the tones are reflected in the measurements with which the McAdams et al dimensions are correlated.

Despite the perceptible artificiality of the McAdams et al tones, both models give psychoacoustical validity to the common practice of describing timbral proximity according to familial connections. The differences between models and group overlaps suggest that timbral links between families are numerous, and some of the more interesting groupings, e.g. violin-oboe and viola-cello-flute (Dubnov et al), suggest that we may wish to redefine the families themselves.

'Impulsiveness' and 'Continuousness'

According to those who believe that perception is tied up in the 'underlying dynamics of physical processes' (Balzano, 1986: 312; see also Stephen E. Handel, 1995: 426; and John M. Hajda et al, 1997: 264-5), the perceptual distinction between 'impulsively'- and 'continuously'-excited tones is easily recognised by most listeners. The McAdams et al rise time and spectral flux dimensions support this idea: the broad distinction between excitation types seems to have been well observed. However, the data may not fully support a claim that listeners regard all impulsively-excited tones as having shorter rise times than continuously-excited tones; many types of impulsive tones (e.g. gongs, bass drum) were not included in the McAdams et al study, and, as explained earlier, the tones that were used are not always representative of real instrument tones. On the other hand, experience (and my own informal investigations) tells us that listeners probably do regard most 'impulsive' attacks as shorter.[15]

The characteristics of 'impulsiveness' (short rise time, sudden dip after point of maximum amplitude, short decay or long decay with considerable spectral fluctuation) and 'continuousness' (long rise time, steady state that is relatively even after point of maximum amplitude, short decay) might be considered as having a good negative correlation. The terms cover a bundle of characteristics, but do not necessarily present the same problems as descriptive terms like 'richness' (a term

[15] The perceptibility of rise times (particularly of continuously-excited tones) is likely to differ according to context. For example, when a tone is presented against a textural backdrop, the global amplitude level of that textural backdrop may mask the attack portion of the tone. Moreover, Roger

favoured by Kendall and Carterette (1993b: 490)), which may be interpreted in different ways and are dependent on the listener's understanding of what they stand for:[16] at a basic level, the meanings of 'impulsiveness' and 'continuousness' are clear cut in a timbral context—they refer specifically to how sounds are produced.

The notion of 'impulsiveness' may, nevertheless, be applied to some tones produced by continuously-excited instruments. For example, when 'continuously-excited' tones are played staccato, the intensity after the initial attack decreases rapidly; this places greater perceptual emphasis on the attack portion of the tone. Interestingly, David Luce and Melville Clark Jr. (1965: 197) found little significant difference between the durations of attack transients for isolated short and long continuously-excited tones;[17] the 'impulsiveness' or 'percussiveness' of staccato continuously-excited tones may, however, have less to do with the note duration, and more to do with attentional focus on the 'extraneous noise(s)' that often occurs during the attack portion.[18]

By the same token, some impulsively-excited tones have 'continuously-excited' characteristics. For instance, the perceived global amplitude level of a tam-tam or gong tone may decrease slightly after the initial attack, but it then increases fairly rapidly as the vibrations move towards the perimeter of the disc (though for gong tones, the vibrations are principally within the central portion of the disc). Contributing to the sensation of increased global amplitude is the pumping of energy into 'modes of progressively higher frequencies' (Neville Fletcher, 1994). For gong tones, increased tension in the central portion of the disc results in a pitch glide of up to a minor third. Since the ear's sensitivity generally increases according to frequency/pitch height (see Figure 1.7), the perceived loudness also increases. After reaching a peak, the highest frequencies decay and the perceived global amplitude level decreases, often taking many seconds to reach inaudibility (Fletcher, 1994). Tam-tam and gong tones may be described as pseudo-continuously excited because

---

B. Dannenberg and Istvan Derenyi (1998) found that a trumpet tone played as part of an ascending scale has a point of maximum amplitude that occurs later than that of isolated staccato tones.

16 For instance, 'richness' may be used to describe inharmonicity, vibrato, 'chorus' effect, harmony etc, but not all listeners would regard the term as appropriate to describe these phenomena in the specific contexts in which they occur.

17 Note, however, that Luce and Clark's durations of 'attack transients' and measurements such as Krimphoff et al's 'rise time' (the time it takes for a sound to reach maximum amplitude) are not necessarily synonymous.

18 Attack portions of instrument tones are often inharmonic (Dannenberg and Derenyi, 1998).

they produce a *crescendo-diminuendo* and a smooth frequency/pitch modulation—effects that are usually associated with continuously-excited tones.

This idea that a continuously-excited tone may be considered 'impulsive' and *vice versa* suggests that to divide timbres as categorically impulsive or continuous is an artificial division and that it is far better to describe timbres in terms of 'impulsiveness' and/or 'continuousness'. The distributions of timbres within the dimensions of the McAdams et al model support such a notion, particularly where the electroacoustic-inspired hybrid timbres are concerned. In electroacoustic music there are often no actual excitations or sound sources that can be identified—only 'virtual' ones (see Luke Windsor 1995: 89-90). The ambiguity of virtual sound sources suggests that 'impulsiveness' and 'continuousness' may be perceptually mapped onto the same continuum.

Given the ambiguity of excitation in virtual/hybrid sound sources, it may be useful to merge these excitation types onto a single continuum also when describing acoustic music.[19] In practice, however, a single impulsiveness-continuousness dimension may not always facilitate timbral description. In some music it is difficult to determine whether a tone is more impulsive or more continuous than another—it could of course be both. For instance, a long harp tone is more impulsive (rapid attack) and more continuous (sustained) than a staccato trumpet tone. In this case, one may find it easier to describe the timbres in terms of two separate, but complementary dimensions that focus on different portions of the tones. But such a division may not always be necessary; an alternative reading could take a more holistic, contextual perspective. If the sustained harp and staccato trumpet tones were combined, the trumpet tone would be functioning 'impulsively' (it would be 'punctuating' the sonority) and the harp tone would be functioning 'continuously' (it would be sustaining the sonority).

[19] Note that the perceptual fuzziness of 'impulsive' and 'continuous' dimensions is likely to be influenced by the medium through which the music is experienced. For instance, live performance and video offer visual cues that may emphasize the distinction between the modes of excitation.

1.1.2 On describing the 'steady state'

In contrast to most terms used to describe attack and decay portions of tones, descriptive terms for the steady state are numerous and are generally derived from our visual and tactile senses e.g. 'rich', 'rough', 'bright', dark, pale etc. A term that is more obviously related to aural senses is 'nasal', and this term is closely connected with our experience of voice production. Kendall and Carterette (1993b) have used this term to distinguish wind instrument tones. Their use of the term seems justified in the sense that the method of producing sound on a wind instrument is closer to that of the voice than to that of any other acoustic instrument. However, it becomes very difficult to use 'nasality' to differentiate between sounds which bear no relation to that sort of tone production (e.g. triangle and bass drum).[20] It is like asking: 'Which is more grey: pink or yellow?'

Although it was this sort of problem that led the German psychoacoustician Bismarck (1974b) to suggest using a *Schärfe* ('sharpness' or 'brightness') continuum for steady state tone differentiation, Kendall and Carterette (1993a) found that 'sharpness' was not the best scale for wind instrument tones. They attribute this to the ambiguity caused by the English usage of the term (Kendall and Carterette 1993a: 456). In English, the term 'sharp' is often used in relation to pitch height notation (#) (Terhardt 1991); other times, it is used to describe attack quality. In some contexts, the term 'sharp attack' (and 'impulsive') may refer to the overall amplitude envelope, implying a rapid attack, prominent point of maximum amplitude, and (fairly) sudden dip in amplitude. However, these are unlikely to be the meanings that concerned Kendall and Carterette's subjects (experimentees). For them, the ambiguity lay in what 'sharpness' (and 'brightness') in the steady state portion really means.

In psychoacoustics, the terms 'sharpness' and 'brightness' have very specific meanings that are defined by mathematical formulae. (Kendall and Carterette's subjects were not made aware of these meanings, so it is not surprising that they did not use them to differentiate the timbres in the experiment.) The calculations are

[20] Kendall and Carterette (1993b) have only used 'nasality' as a means of differentiating wind instrument dyads.

intended to measure similar things, but they can be clearly distinguished: the 'sharpness' measurement takes into account ways in which the ear processes sound;[21] the 'brightness' measurement (spectral centroid) does not. The distinction suggests that, from a perceptual perspective, the 'sharpness' measurement may be superior to the 'brightness' measurement because it is not based on only acoustical information. However, 'brightness' measurements have been well correlated with both 'sharpness' (Sandell 1997) and listener's responses in (dis)similarity rating tasks (e.g. John Grey 1977: Krumhansl 1989; Krimphoff et al 1994; McAdams et al 1995).

The good correlation between listeners' responses and the calculation suggests that 'brightness', defined quantitatively, may be a useful term for qualitative differentiation of steady state tone portions. The term still requires clarification, however. We need to know more about the perceptual implications of spectral centroid, and why it correlates with qualitative conceptions of 'brightness'.

'Brightness'

In the McAdams et al model (see Figure 1.4), the spectral centroid measurement correlated negatively very well with listener's responses. Using Krimphoff et al's measurement (1994), McAdams et al calculated the average amplitudes of the harmonics over the duration of each tone; this enabled them to find the 'centre of gravity' (centroid) of the resultant global harmonic spectrum. A sound with a high centroid is generally perceived as 'brighter' than a sound with a low centroid.[22]

The distribution of instrument names within this dimension of the model is sometimes misleading because of the artificiality of the tones used in the McAdams et al experiment (see Figure 1.8).

For instance, the clarinet tone is insufficiently bright and the bassoon tone is too bright, being insufficiently differentiated from the trumpet tone. A possible explanation, which could account for these discrepancies, might be the transference of

---

[21] See Bismarck (1974) and Pamela Goad (1994) for extensive studies of this measurement.
[22] Brightness is, however, affected by dynamics and register (see pp. 16-18).

spectra amplitudes from different tessituras to Eb4. For instance, high clarinet tones are likely to consist of fewer and weaker upper spectral components than low clarinet tones; if the range and strength of components is transferred to a lower pitch, such as Eb4, the centroid will be lower than one would expect, and the tone will sound insufficiently bright. The same principle applies to the bassoon tone, but the other way round; the engineers may not have taken into account the tone being in the instrument's upper register.

These impressions can be corroborated with acoustical data from Sandell's SHARC Timbre Database (1997).[23] Real instrument tones pitched at Eb4 have the following centroid frequencies: trumpet—c.2250Hz, Bb clarinet—c.1975Hz, bassoon—775Hz. Another McAdams et al tone which is insufficiently representative of a real instrument is the piano tone; it sounds as though it is produced on a dull, poor quality piano. Unfortunately, there are no data in the SHARC database with which to corroborate this impression.

The spectral centroid dimension features some other surprising results. The oboleste (dominated by celeste), harp and vibraphone are instruments that we might normally expect to sound 'bright', but according to the dimension they have relatively low centroids.

The synthetic harp tone does sound bright, but only at the point of maximum amplitude. The centroid (which is taken from the averaged spectrum over time)[24] is probably fairly low because the sudden dip in amplitude results in a sudden drop in high frequencies. A real harp tone is likely to sustain the higher frequencies for

---

23 The database features analyses of a wide range of real steady state continuously-excited instrument tones and some impulsively-excited tones. The tones are taken from the McGill University Master Samples (MUMS), a library of compact discs produced by Frank Opolko and Joel Wapnick. The SHARC database and MUMS tones are resources used principally by acousticians and psychoacousticians. For more details about users, see the archive of SHARCLIST postings (email discussion list) at http://www.parmly.luc.edu/lwgate/SHARCLIST/htmlarchive/ .

24 By contrast, Sandell divides his tones into frames, finds the average of those frames which are within 25% of the maximum amplitude, then finds the frame that most closely resembles that average; the spectral centroid is then calculated from this representative point of the tones. Sandell's centroids for impulsive timbres are likely to be higher than in Krimphoff's, because the calculation only takes the average of the highest frames. However, the database features very few impulsive timbres. I should point out that there is no actual difference between the Sandell and Krimphoff calculations, though the numerical results do differ—Sandell finds the centroid as a harmonic frequency; Krimphoff finds it as a harmonic number.

longer. The subjects in the experiment were not aware of any specific criterion to listen out for (they were not told to compare the brightnesses of the tones), which suggests that they took probably the whole of the tone into consideration when comparing it with other tones. In real musical contexts, listeners are perhaps more likely to focus on the brightness of the attack, especially if the harp tones are presented in a context where other sonorities are not particularly bright.

The vibrone tone is, like the harp tone, affected by a clear dip in amplitude and perceived brightness after the point of maximum amplitude. This may explain why it has a centroid lower than either of its parent timbres. Other hybrids (e.g. trumpar) are not positioned between parent timbres, but may be explained in terms of the principle of combined spectra, which was suggested in reference to spectral flux (see p. 7).

The oboleste tone (dominated by celeste) is only slightly affected by a dip after maximum amplitude. The tone is a little dull, but the positioning within the dimension seems fairly appropriate—the celeste is in its lowest range here. Similarly, the sound and position of the vibraphone is appropriate. It is in a low register (bottom third of range), sounding bell-like, but sonorous, as though played with soft mallet heads (causing a muted effect). My expectation that celeste and vibraphone tones would be bright may be attributed to my experience of hearing the instruments being exploited most often for the brightness of their higher registers in musical contexts.

Despite the surprising results and discrepancies in tone synthesis, the correlation between my qualitative evaluation of brightness and the differentiation of tones within the McAdams et al dimension is consistent with qualitative judgements of spectral centroid height made by other researchers (e.g. Sandell 1997). The good correlation has convinced me that spectral centroid height is useful for informing qualitative evaluations of brightness, and that brightness evaluations based on centroid height estimations may be a useful way of ensuring that one is describing brightness differences which are perceived by other listeners. However, estimating centroid height requires careful evaluation of various factors, such as register and dynamic.

Brightness and register

Sandell's data (1997) verifies that, when sounds are produced from the same source, spectral centroid and pitch height are generally well correlated. The correlation begins to break down when we compare sounds from different source types—some tones which differ in pitch may have equivalent spectral centroids.

The extent to which listeners regard tones with equivalent centroids as equally bright requires investigation; if Sandell were to arrange the tones of the SHARC Timbre Database in rank order of spectral centroid values, the networks of possible equivalent tones could provide the basis for such an investigation. From a musicological perspective, the rank orderings would, however, be notional because performers are able to manipulate the timbral characteristics of a tone, and different instruments of the same type may occupy different positions within the brightness dimension. The representative instrument tones of the Sandell data would not occupy absolute positions, but would sit within brightness 'windows', which have fuzzy boundaries. Given the fuzziness of these boundaries, the results of a psychoacoustical investigation may be musicologically redundant.

Although the Sandell database is an extensive resource, which includes instrument centroids across entire ranges, it omits some important (particularly impulsively-excited and vocal) instruments. The incompleteness of the database means that there are many possible comparisons for which there is currently a lack of corroborative quantitative evidence.

Some comparisons may, nevertheless, be informed by evidence from other sources. For instance, Jonathan Dunsby (1995: 73-4) has raised the issue of musical 'illusion' in reference to the second song of Schumann's *Dichterliebe*; he suggests that the tenor part, which is the bass line, is heard but not perceived as lower than the piano part (see Figure 1.9).[25]

---

[25] As most musicians are aware, tenors sing an octave below pitches notated in treble clef.

What we hear and what we perceive may be more closely aligned than Dunsby suggests. Differences in formants (strong resonant frequencies)[26] and/or spectral centroid height may make 'identification' of the register of the tenor's tones difficult. We do not have data confirming that a tenor has a higher formant than a piano, or that the tenor C#4 tone has a spectral centroid higher than or equivalent to the piano's C#5 centroid; however, W. F. Rogers (2000) has pointed out that singers tend to have formants in the region of 2500-3000Hz (nearer 2500Hz for males according to Bloothoft and Plomp (1986)) and that orchestral sounds tend not to be as strong in this region. He suggests that this is why operatic tenors can be easily heard over an orchestra.

We know from experience that tenors produce tones in the mid-upper range of the voice by 'tuning into' the upper resonances. They do this by focusing on resonance in the 'mask' (the face) rather than allowing the sound to get bogged down in the 'chest' voice. The effect—the registral illusion—might be different, or at least less pronounced, if the same line were sung by a bass voice that is not 'in the mask', as the formants are likely to be weaker and spectral centroids are likely to be lower.[27]

This example demonstrates how knowledge of non-centroid factors and instrumental/vocal technique may inform qualitative evaluations of brightness. It suggests that registral illusion is a robust indicator of relative tone brightness, that register in music is not a simple phenomenon, and that timbre plays a much more important role in pitch perception than musicologists usually recognise.[28]

---

[26] Dunsby does not refer to formants here, but he does mention them elsewhere (e.g. Dunsby 1995: 67). His definition of 'formant' may be rooted in definitions made by researchers such as Wayne Slawson (1968): 'timbre of steady-state musical sounds is primarily determined by the absolute frequencies of their first two resonances (formants)'. Here, the term could be confused with the idea of the resonances 'forming', which seems to be Dunsby's meaning; Dunsby refers to the formant as 'the beginning of the note', comparing 'gentle and indistinct' vocal tones with the 'crisp formant' of oboe tones (67). But this is the effect of the rise times of these tones—not the absolute frequencies of the resonances, which is what Slawson and others are really referring to. These strong resonances help provide timbral consistency within instrumental and vocal ranges. For example, they help us to recognise that low and high oboe tones belong to the same instrument. Whereas considerable research into vowel formants has been undertaken (in linguistics), little work has been done on musical instrument formants.

[27] Moreover, if the words of the song were omitted, the voice part may be even more likely to be heard as a bass-line. The presence of words—or indeed the singer himself—have the effect of making this line perceived not so much as registrally above or below, but more distinct from the piano material. When listening to a song, the words are usually the listener's main focus of attention.

[28] Incidentally, Dunsby (1995: 73) raises another interesting point about *Dichterliebe*, No. 2 when he suggests that, despite the obvious difference between the true legato of the voice and the 'melodic,

Dynamic and brightness

Dynamic differences are perhaps an even more complex correlate of brightness differentiation than register. As we have already established, the brightness of a tone is dependent upon the strength of upper spectral components relative to lower components. This means that there is a clear distinction between turning up the volume on a stereo and playing an instrument louder (varying dynamics). Turning up the volume has little or no effect on brightness, because the relative weight of spectral components remains the same. Playing an instrument louder does have an effect because the player must exert greater force and/or modify how or where she exerts force. For instance, when changing from *p* to *f*, a string player will often bow faster and increase emphasis on upper harmonics by playing closer to the bridge.

Brightness is also affected by differences in sensitivity to certain frequencies, which is why the 'sharpness' measurement takes into account the audibility threshold (see Figure 1.7).[29] In particular, the ear is most sensitive to frequencies between c.3000-c.4000Hz, which suggests that tones with significant spectral energy in this region are likely to be perceived as brighter than those without.

The effect of dynamics on brightness depends greatly on the type of instruments involved. Derenyi and Dannenberg (1998) explain that trumpet and other wind instruments sound brighter when played louder because 'the amplitudes of higher harmonics grow faster than the amplitudes of lower ones'. Moreover, in a number of informal tests at McGill University, researchers have found that the effect of loudness on perceived brightness is much greater for impulsively-excited instruments (brighter when louder) than for continuously-excited instruments (Wapnick 1997).

---

mechanical decay of piano notes', both tenor and piano are 'smooth and in a sense equivalent melodic textures'. This 'illusion' of equivalent smoothness may well come about from our knowledge that the piano can, and often does, play much less legato, and that there are other instruments that are inherently less capable of producing a true legato than the piano (e.g. harpsichord).

[29] The calculation is an averaging of loudnesses across critical bandwidths of the inner ear over time (see Goad 1994: 25). A critical bandwidth is the frequency difference (Hz) required for two simple (pure) tones to sound completely separate; or, to put it another way, the frequency difference required for a sound not to be perceived as masking another (Bregman 1990).

Blend

Both musicologists and psychoacousticians are faced with a difficult task when weighing up the brightnesses of tones with different pitches and dynamics.[30] Such differences have major implications also for blend. Some general principles about tones of equal loudness may offer guidance, nevertheless. As Sandell has pointed out (1995), tones that have low centroids blend best; the greater the difference between centroids of non-unison tones, the worse the blend; however, the worst blend for both unison and non-unison tones occurs when all centroids are high. When discussing music in context, we can invert this idea, asking whether the blend is 'poor' because the sonority combines bright and dull tones, or because it combines all bright tones.

1.1.3 'Specificities'

I have shown that the dimensions in the McAdams et al timbre space account for common perceptual qualities amongst instrument tones. However, there are aspects of the timbres that cannot be accounted for by the three common dimensions.[31] These aspects, which often play a key role in making a timbre distinctive, are called 'specificities' (McAdams et al 1995). They may be divided into two types: those that are intrinsic to the tone and those that are extraneous. Examples of intrinsic specificities include 'hollowness' (e.g. in the clarinet), inharmonicity, roughness, and vibrato width and speed. Extrinsic specificities include the sound produced by a fingernail on a guitar string, the returning 'clunk' of a harpsichord jack, inharmonicity caused by 'surface noise' etc. Such sounds, which are often a result of the excitation process, are not a feature of the 'intended' resonance and yet they are characteristic of the sound source.

Blend and salience

Each of the intrinsic and extraneous specificities of a tone functions as a separate dimension. As with all other dimensions, their significance varies according to context, and some play important roles in determining blend and sound source

---

[30] Exploration of the effects of tone lengths, dynamics, and pitch ranges on orchestral instrument tones is underway as part of an extensive project at IRCAM (McAdams: private communication [1997]).

[31] Even though the 'specificities' exist outside the space, their removal from the model would cause the distinguishing characteristics of the 'specific' dimensions of each timbre to be absorbed into the three dimensions. The removal affects the acoustic parameters 'centroid' and 'flux' in that the parameters do not correlate so well with their respective dimensions; thus, the model is more difficult to interpret (see McAdams et al 1995).

salience. For instance, in Figure 1.10, timbres *a* and *d* have vibrato, whereas *b* and *c* do not.

Since vibrato tends to cause a sound to stand out from a texture that is made up of non-vibrato sounds (Goad 1994), one might therefore deduce from the vibrato dimension that timbres *a* and *d* are likely to be more prominent than *b* and *c*. It also suggests that *a* and *d* may fuse more effectively with each other than with *b* and *c*, because vibrato often helps a sound to be fused perceptually with other vibrato sounds (Goad 1994).

Other important 'specificities' that affect blend include roughness and inharmonicity. Although they function outside the three common dimensions of the McAdams et al model, it is perhaps misleading to describe them as 'specificities' because, to a certain extent, they affect most instrument tones.

Roughness is defined psychoacoustically as the sensation caused by pairs of frequencies beating in the same critical band.[32] Critical bands of low frequencies are much wider than those of high frequencies;[33] this explains why low instrument tones tend to sound rougher than high ones, why a major fifth played in the bottom range of the piano is much more dissonant than one played in the upper register, and why individual tones of close intervals are more difficult to isolate in a low register than in a high register.

Inharmonicity affects blend because inharmonic components tend to stand out from a texture consisting principally of harmonically-related components. Conversely, harmonically-related components may stand out from a texture consisting principally of inharmonicities.

---

[32] The sensation is caused by rapid amplitude fluctuations. In order to be perceived as roughness, the time intervals between fluctuations must be less than 30ms; if greater than 30ms, individual fluctuations will be heard as separate events (Terhardt 2000). For a definition of critical bands see this thesis, fn. 29 (p. 18).

[33] My terms 'low' and 'high' refer to the perceived pitch height as opposed to low and high values in Hz.

Extraneous noises can also affect sound source salience. When most wind or string instruments are played in their uppermost tessituras, they tend to lose their most distinguishing timbral characteristics. This suggests that the instrument types may be in closer proximity within certain dimensions and/or some specificities may play a less significant role. The physical difficulty of playing at uppermost extremes may, however, increase inharmonic content resulting in extraneous noise and/or unclear pitch; some players are able to minimise such inharmonicities, giving the impression that the tones fit comfortably within their range. In the context of a chord consisting principally of harmonic instrument tones, a tone with extraneous noise and/or unclear pitch is likely to stand out more than a clearly pitched tone without extraneous noise.

It could be difficult to rate the salience of such extraneous noises quantitatively. For instance, an instrument tone, which is part of a chord, may have an extraneous click during its initial attack. The actual loudness of the click may be equal with the loudness of the tone itself, but the click may not be perceived as loud as the tone; it is likely to be partially masked by the loudness, inharmonicity, and roughness of the attack portions of all of the tones in the chord. The masking effect of inharmonicity and roughness depends upon the extent to which the spectral components of the click are in the same bandwidth as those of the tones.

From a music analyst's perspective, the usefulness of such a quantitative measurement (which would surely be more complex) is moot. The important point is that even though the click may be partially masked because of inharmonicity and loudness, it still increases the likelihood that the listener's attentional focus will be drawn to the sound source.

1.2 Conclusion

The principle of thinking about timbre as a dimensional model certainly seems useful, though it would be a mistake to regard any study of isolated tones as telling an absolute perceptual truth. Johan Sundberg (1982) has claimed that 'changing stimuli are easier to process than quasi-stationary stimuli', which suggests that recognition/identification of instrument tones' defining characteristics may be easier in context than in the laboratory.

When it comes to describing timbre in musical contexts, there are essentially two types of dimension that we can use. One might describe these as 'analytical' and 'holistic'.

'Analytical' types, such as 'brightness', focus on facets of timbre that can be expressed as a quantitative value. The quantities themselves are superfluous and difficult to pinpoint for timbres in context; more important is the qualitative evaluation of a timbre's general position within a dimension in relation to other timbres.

'Holistic' types, such as 'impulsiveness-continuousness' or 'vibrato', cover a bundle of characteristics. Even ambiguous terms, such as 'richness', may be used if the context seems appropriate; timbres shift within a number of dimensions simultaneously to different degrees, so a single term that can convey these concurrent shifts may prove convenient. However, the meaning of such terms will often require clarification by pinpointing the dimensions or components of the dimension that most contributes to the effect. Only then can our discussions of timbre in musical contexts become more sophisticated.

One of the most important points about timbre in musical contexts is the issue of variety; pieces that lack variety are likely to be deemed unsatisfactory by most (Western) listeners. Ensuring sufficient fluctuation within the common dimensions of the McAdams et al model could be considered a fundamental principle of good orchestration (of Western music); in particular, tone brightness and spectral flux are essential components of those all-important nuances—expressive dynamics (*crescendi* and *diminuendi*). Other dimensions need not fluctuate much at all. Many pieces in the repertory, which we are likely to accept as being well orchestrated, are devoid of, for instance, 'hollow' timbres; such 'specificities' are often exploited as special effects. However—and this is an important point—it is entirely possible that, in a piece or section of a piece, a specificity (even extraneous inharmonicity) becomes the main or one of the main dimensions within which timbres may be best differentiated. We are likely to bypass this relationship between a musical context and its principal timbre dimensions if the 'common' dimensions of the current model are used prescriptively.

Chapter 2

Methodological Contexts

2.0 Introduction

Some musicologists oppose the idea that psychoacoustical models are appropriate for music theory (e.g. Nicholas Cook 1990: 154-5; 1994; private communication). They complain that such models do not reflect how we listen to music—breaking down sounds into their constituent parts is like listening to music under aural test conditions (Cook 1990: 154); the process of perceiving information is distinct from the perception/sensation itself. One cannot deny the logic of this stance. Cook is right when he points out that it may be ludicrous to deconstruct the 'swoosh of the harp, the violin scale' and so on, when such events have 'global precedence' in the musical context (155).

However, if a musicologist were to deconstruct tones or to describe the perceptual process, (s)he is not necessarily intending to describe a conscious series of perceptual acts which occur during normal music listening. As I suggested in Chapter 1, being able to isolate aspects of an event is important in musicological writing: some harp 'swooshes' and violin scales are played differently in different contexts and can have different perceptual effects according to those contexts. Perhaps the harp swoosh directs our attention to the brightness of a wind chord, or perhaps the harp sonority remains our focus of attention as it is allowed to decay into silence; perhaps the violin scale merges into a texture made up of sounds that have similar brightness, or perhaps it becomes increasingly prominent because its tones are brighter than the rest of the texture. In order to describe such phenomena accurately, we reflect upon what we hear—we listen more 'musicologically' (Cook 1990: 154). Once we have reflected, we rarely hear the same music in quite the same way—our observations filter into subsequent more 'normal' listenings.

For the above reasons, I do not regard using basic principles of psychoacoustical models in music theory as an example of the 'unstructured leakage' between music psychology and music theory which Eric Clarke (1989) warned against. However, the gap that Clarke spoke of is a danger in many musicological studies that venture into music psychology territory. In this chapter, I focus principally on performance analysis studies as a means of addressing from methodological perspectives some of the dangers that the gap presents; many of the issues raised have a bearing on the development of theories and methods for timbral analysis.

2.1 On 'the gap' between music psychology and music theory

Recent 'leakage'

Recent examples of 'unstructured leakage' between music psychology and music theory can be found in David Epstein's *Shaping Time: Music, the Brain and Performance* (1995). Reviews of this book by Robert Adlington (1997) and Anthony Pople (1997) show that Epstein satisfies neither the rigours of music theory nor those of empirical studies. Pople points out that Epstein's aim is essentially to provide advice on how to perform specific musical pieces (1997: 1). Use of empirical studies to inform interpretative decisions would seem to be a legitimate way of achieving this aim. However, as Adlington explains (1997: 161), Epstein's discussion of empirical evidence is selective: when the evidence goes against his hypotheses, Epstein simply brushes it under the carpet.

Epstein is not alone—convenient oversights are rife in studies of this sort. Even more recent performance analysts, such as Sarah Martin (1996), Victoria Vaughan (1998), José Bowen (1999b) and Bethany Lowe (1997; unpublished), acknowledge but disregard or skate over perceptual issues in their discussions of empirical data. The problem seems to be a lack of awareness that perceptual issues are fundamental in the methods they are using.

Such a charge might be levelled at John Rink's recent work. In a study of Chopin's *Nocturne in C# minor*, Op. 27 No. 1, Rink fashioned graphs depicting a performance 'Knowledge Structure' (1998). I will discuss this study in some detail as it raises a number of fundamental issues about perception, and is one of the few recent approaches to performance analysis that are not based on data generated from recordings.

Hierarchical models

Rink's study of Chopin's Opus 27 No. 1 develops ideas explored in his study of Liszt's 'Vallé d'Obermann' (1999). As in the latter study, Rink offers 'a graphic representation of the music's ebb and flow, its "contour" in time, determined by all active elements (harmony, melody, rhythm, dynamics etc.) working either independently, in synchrony, or out of phase with one another to create the changing degrees of energy and thus the overall shape' (1999: 234). His graphic representation of Opus 27 No. 1 is illustrated in Figure 2.1. It consists of a hierarchy in which the highest level consists of 'Form' followed by 'Tonality', 'Main Tempi', 'Dynamics', and 'Plot', respectively; the mid-level consists of 'Character', 'Texture' 'Rhythmic essence', 'Pitch essence' and some 'mid-level considerations of timing [e.g. notated rits, ralls and accels.] ... and dynamics (e.g. notated hairpins)'; the low level consists of 'Articulation/technique' and 'low-level considerations of timing, dynamics, rhythm, harmony, pitch etc.'.

Rink's hierarchisation of the piece's 'active elements' is quite problematic. For instance, it suggests that 'Main Tempo' changes dictate at a higher level than 'Dynamics' or 'Texture' his conception of form. I would suggest that a clearer impression of the basic form is reflected in the changes of texture. Moreover, the marriage between 'Form' and 'Tonality' would seem to be far better correlated with the combination of changes in the mid-level parameters 'Character' and 'Texture' than in the 'Main Tempi' graph.

The real purpose of this 'Knowledge Structure' is not entirely clear. If it is intended to be a model for how other performers should conceive the piece, the format is extremely limiting. It is difficult to see from the graphic representation how 'low-level' considerations such as unnotated dynamic and tempi changes might influence the form at a fundamental level—in fact, some performers might regard such considerations as 'higher level'. Rink might argue that to do this would be at odds with the notated tempi and dynamics, but some musicologists, such as Mark Tanner (1998), maintain that diverting from the score can sometimes be desirable for conveying a sense of form (a traditional Schenkerian position).

Perceptual networks

When we prepare a piece for performance, our conception of the piece is constructed from networking musical ideas rather than categorising them completely in order of significance. The same networking process occurs when we perform or listen to music; the aural or performative experience is itself likely to require many shifts of attentional focus;[1] only on a very local level can certain musical ideas/parameters be regarded as more significant than others. This idea—that our aural and conceptual networks reflect (and are the product of) our neural networks—is perhaps obvious to psychologists, but as Rink's study exemplifies it is rarely upheld in music-theoretical models.

On using perceptual models

Cook argues that a perceptual model consisting of 'multiple cognitive frameworks' and involving shifts between strategies 'from one moment to the next' is 'totally inappropriate' for music theory (Cook, 1994: 89). He claims that 'it cannot challenge our pre-formed responses because it sets out to reproduce them' (Osmond-Smith, 1989: 92), and that 'the aim of music theory is to go beyond perception' (Cook, 1994: 89). He argues that

> ... when a theorist analyzes a piece of music, she is taking up an interpretive stance in relation to it. She is following through the implications of a particular way of thinking about it. She is aiming, perhaps, to change the way people experience the music.

But this is not really an argument against perceptual models; it is an argument against 'theoretical constructs' that are 'devoid of critical content' (Osmond-Smith 1989: 92). Perceptual models cannot be used to 'reproduce' the perceptions of all listeners—they can provide only an impression of specific listeners listening in a specific way. If a model aims to represent what is perceptible rather than what all listeners perceive all of the time, it can be an effective tool for arguing a particular critical stance. Moreover, differences between global (i.e. averaged) data and individual listeners' responses are often the most interesting and revealing aspects of perceptual data; these differences can be used to 'challenge our pre-formed responses'. I agree with Cook that the job of music theory is 'to go beyond perception', but the theorist can only really 'change the way people experience the music' if what (s)he proposes is perceptually viable.

---

[1] Glenn Gould would surely agree with this. He believed that 'the ideal way [to perform] ... is to assume that when you begin you don't quite know what it is about. You only come to know as you proceed' (Page 1987: 287; Dunsby 1995: 39, 46; Cook 1999: 16). The 'exploratory' approach that he describes is essential for conveying a sense of spontaneity.

If we accept this premise, part of music theory's job may be to explain how the way of perceiving or way of performing that a model proposes challenges or supports specific theoretical stances. In practice, a model might be used as a template against which recorded performances may be compared and/or on which future performances may be based. Such uses of the model might at first seem naively idealistic, but, unlike score-based 'ideal' performances, the model is not 'pragmatically unworkable' (Johnson 1999: 55)—it has a perceptual basis (this suggests that it is potentially practical). Some might say that such approaches smack of the idealism of Narmour, who, as Cook puts it (personal communication), builds into his discourse the concept of theorist as 'arbiter of performance'. The problem with Narmour was that he used a model as a basis for saying what performers *must* or *must not* do—and it is the arrogance of this stance that Cook quite rightly challenges (1999: 240). The bottom-up approach of using a model as template or basis for performance need not be implemented in such an authoritarian fashion; the extent to which the performer is subordinated to the theorist (the effect of the theorist being 'arbiter of performance') depends entirely on how the model is integrated into the theorist's argument. There is nothing wrong with a model that points to the success of a performance from certain specific perspectives; the model may represent just one (or some) way(s) in which various aesthetic criteria might be satisfied. In other words, we can surely use a model to say 'this is how the piece *could* be played/heard/conceived' and, by the same token, 'this is how people *might* play/hear/conceive the piece', accepting that there are certain aspects about the performance that the model does not map.

Notation and 'the gap'

'Ideal' representation of a performance (whatever that might be) can change according to the type(s) of listener, the availability of resources, and so on. Such criteria are often bypassed in most music-theoretical models; too often scholars make generalisations about their models' universal application rather than discussing the specific circumstances that are likely to give rise to the described musical experience(s).

Rink's 'Knowledge Structure' is no exception. Rink may not have referred to this model as 'ideal' and he may not have promoted its general applicability, but without a caveat about its specificity, such views might be thought implicit. The model is highly specific in that it can be regarded neither as Rink's conception of the piece nor as a reflection of the performer's conceptual process: the graphs are specifically a notated version of how Rink actively perceives his conceptual framework of the piece. His conceptual framework is something intangible because it is made up of not only conscious but also unconscious ideas; his act of perceiving is in this case a largely conscious, 'analytical' process; finally, his notation is a system developed for showing his perception of his conception in visual form—as such it is limited to conveying only those things that are notatable. These are not discrete categories: the act of perceiving may influence Rink's conceptual framework and the act of notating may influence both his conceptual framework and his perception of it. Such loop-like relationships cause difficulties for ascertaining the extent to which Rink's notated framework may be regarded as his conceptual framework.

Experimental research

My reservations about Rink's 'Knowledge Structure' should not be regarded as an attempt to devalue his approach, but his position on perceptual issues needs greater clarification if the bridging of the gap between analysis and performance is really to be achieved. Cook believes that Rink's approach is 'insufficiently grounded in analytical method' (1999: 14). One could take this criticism a step further by suggesting that the greatest weakness of Rink's approach (and indeed in the work of Epstein and others) lies in the gap between perception and music theory. The key to bridging this gap may lie in the creation of perceptual models that may be verified both through intersubjective experiments that focus on musical performances and psychoacoustical experiments.

However, there is a potential problem with intersubjective data because it is impossible to know exactly which parameters subjects are responding to. Cook has suggested (private correspondence) that we do not need to know what these parameters are if the consistency of the results is sufficiently 'robust' to function as a 'reliable basis' for analytical comparisons. I agree with this in principle, but as I hope to demonstrate in a discussion of tempo analysis techniques, understanding musical details is often important, even in analysis of large-scale form. If we are ever to understand how subjects perceive musical details, understanding the role(s) of the parameters becomes a real issue. Psychoacoustical findings may help us to develop that understanding, and, where appropriate, may be usefully brought in to support the musicological argument.

Admittedly, it is difficult to see how a psychoacoustical and intersubjective approach might be applied to Rink's 'Knowledge Structure' as it stands. A possible 'intersubjective' development could take the form of an experiment featuring various performers defining their conceptual frameworks of the same piece according to Rink's criteria and graphic format. Such a comparative study is unlikely to reveal how performers conceptualise music, though it might provide useful insight into the psychology of notation, perhaps saying something significant about performers' abilities to notate their conceptions of musical pieces in a restricted format.

2.2 Computer-assisted analysis

Issues of 'notation' or representation affect also computer-assisted performance analysis. In this section, I explore some of the problems of interpreting computer-generated data.

2.2.1 Dynamics

Sforzando

Rod Johnson's *Sforzando* program (1997) measures global amplitude levels (i.e. overall loudness levels) of recorded music to every 1/50th of a second. As a music-analytic tool, it would appear to be useful for observing changes in dynamic.[2] The program claims to measure both acoustical amplitude levels (linear scale) and listeners' perceptions of amplitude levels (logarithmic scale).

The logarithmic scale is the most useful for the music analyst, because it takes into account the fact that the ear's sensitivity to changes in amplitude greatly affects perceived loudness:

[2] Indeed, since the average listener cannot, according to Terhardt (2000), detect individual amplitude fluctuations much faster than 33 cycles per second, the degree of accuracy this program offers does at first seem more than adequate (see Chapter 1, p. 20, fn. 32). The program's capacity for modification of graphic resolution also seems useful.

> This scaling system corresponds most closely to human perception of amplitude, offering great sensitivity to changes at low amplitude, with much less sensitivity to changes in higher amplitudes (Weber's law). This is the system used in the conventional measurement of amplitude, in bels and decibels (dB).

Johnson describes one of the programs limitations. He states that 'the minimum y value [of the logarithmic scale] may not represent silence', because it only displays the range of amplitude in the recording; he suggests that one can overcome this by using the linear scale 'to see the minimum value in context'.

There is, however, a problem. The analyst may be able to use the linear scale to identify points of silence, but she cannot use it to show the relationship between silence and perceived sound. Whereas the frequency equivalent to the bottom pitch of a modern piano requires a Sound Pressure Level (SPL) of over 60 dB (A0 = 64.5dB) to be just perceptible,[3] the A above middle C requires less than 10dB (A4 = 6.97dB, see Figure 2.2). Although these frequencies at these SPLs are both likely to be perceived by the listener as barely audible, the actual SPL difference would be shown very clearly on the *Sforzando* linear scale.[4]

Tone brightness may also contribute to the discrepancies in the correlation between perceived loudness and amplitude levels of complex tones. The ear's sensitivity to high frequencies causes bright tones to be perceived as louder than 'dull' tones (see Chapter 1, p. 18), but this will not be represented in the data if global amplitude levels of dull tones are as high as those of bright tones.

Aside from these issues, Johnson's program is limited to providing an impression of only global amplitude levels. In-depth computer analysis of musical dynamics requires a program that is far more sophisticated, because music listening often relies on picking out streams (such as lines in a fugue), and each of these has an amplitude level that may differ from that of the other streams. Ideally, the program would take into account the audibility threshold, be able to estimate how listeners are most likely

---

3 Of course, the audibility of an actual A0 piano tone (as with any complex tone) depends also on the strength of its spectral frequencies.

4 I should point out that the data do take into account Weber's law: 'the change in a stimulus that will be just noticeable is a constant ratio of the original stimulus' (Britannica.com Inc.: 1999).

to parse textures, and to determine amplitude levels for individual streams.[5] In the absence of such a complex program, performance analysts could usefully tackle these rarely-explored issues of stream salience on a theoretical level;[6] moreover, even with the availability of the suggested program, a convincing reflection of the listener's perceptions is likely to remain elusive, lying somewhere between the results for individual streams and the global effect.

MIDI-based programs

A number of MIDI-based programs have also been designed for measuring 'dynamics'. Examples of these include Peter Desain and Henkjan Honing's POCO (1992) and Victoria Vaughan's *Software for Performance Analysis of MIDI Music* (SPAMM, 1998). Such programs have been used by music psychologists such as Eric Clarke (1995) and Bruno Repp (1995); they generate data via a MIDI keyboard rather than from recordings, so the advantage that these programs have over *Sforzando* is that one is able to identify the amplitude levels of individual tones and then follow the amplitude levels of a line embedded within a texture (Clarke 1995). This does not, of course, solve the problem of how the tones are grouped perceptually into streams, though if the data took into account the audibility threshold, the analyst could conceivably use the data as the basis for such a discussion.

2.2.2 'Tempo'

Sforzando and the MIDI programs also measure timing fluctuations in performances. The *Sforzando* timing feature is based on the same principles as James Davis's *Tempo* (1994) program. In both *Sforzando* and *Tempo*, the analyst listens to a recorded performance and measures its 'tempo' by tapping out the main beats or bars; the data are represented as a line graph. Analysts use this method of data collection often as a means of providing objectively verifiable data to support their own subjective responses to the music. In principle, such graphic representation of temporal phenomena is useful, and it is to be expected that the graphs can be only partially representative of the aural experience. Unfortunately, the graphs are often so

[5] One of the difficulties is that the program would need to differentiate between amplitude fluctuations that are perceived as timbral (spectral flux) and amplitude fluctuations that are perceived as loudness.

[6] Some issues of stream salience are discussed in Chapter 3.

impoverished that it is difficult to apply them in any meaningful, in-depth analysis. As I will demonstrate, a number of recent music analysts have failed to heed Desain and Honing's (1992: 38) warning about this 'dangerous' method of data collection, which 'lulls its users into a false impression that it has a musical and psychological reality'.

When do you tap?

Cook (1995: 109, 114) and Lowe (unpublished: 4) have noted the difficulties of predicting where beats occur when tone onsets do not coincide with them. Lowe regards such discrepancies as negligible—a view that is shared by other synchronization tapping analysts (e.g. Sarah Martin, 1996; Bowen 1999a). They say that the data are only 3-5% inaccurate.

However, the 3-5% deviation figure should be considered with care; consecutive pre-beat and post-beat deviations of 3-5% would result in distances on a tempo line that are up to 6-10% longer or shorter than if there is no deviation. This means that a line which is 10% longer than a 'no deviation' line is over 22% longer than a line which is 10% shorter than a 'no deviation' line. Such differences have damaging implications for analyses based on comparisons between graphs.

Other factors may significantly affect the reliability and interpretability of the data. The tests for accuracy were based on piano tones or computerised sounds with rapid rise times (e.g. Carolyn Drake et al 1991); it is not clear how the analyst should respond if tone rise times differ. Luce and Clark (1965) found that the attack transients of typical wind and string instrument tones can vary by as much as 0.092 of a second: short cor anglais tones have the shortest at 0.008 of a second, and short violin tones have the longest at 0.1 of a second. When ♩=120, the difference is almost the length of a semiquaver.[7]

This significant difference raises the question of whether the analyst should tap at the initial point of excitation or when the sound reaches maximum amplitude. For tones that are played with a particularly incisive attack, most listeners would probably try to

[7] The McAdams et al data suggest even more extreme examples of short and long rise times (e.g. the rise times of horn and vibraphone tones), but the perceived durations are not given specific temporal values.

tap at maximum amplitude, because the slight reduction in amplitude that usually occurs after the amplitude peak provides the perceptual cue that generally means the attack portion of the tone is complete.[8] If the piece consists only of tones with incisive attacks, fluctuations in the degree of error are likely to be fairly small.

The real problem arises when the same piece features tones with a noticeably slow rise time. Horn tones are notoriously problematic in this respect, because they can give the impression that the beat is delayed (much more than the Bristow et al (1987) synthesised horn tone suggests).[9] Whether the listener hears this as an 'expressive' delay or an 'unintended' delay, which is then conceptually quantized to where the beat 'should have been', is a moot point: it depends upon the acoustics of where the performance takes place, the listener's musical experience and attentional focus, whether the sound is heard on a recording or in the concert hall (visual cues could affect judgement), and so on.

Moreover, for a tone that begins *niente* and continues with a *crescendo*, there is no obvious amplitude peak. In order to produce an effective *niente* tone (clarinettists are particularly good at it), the player of an (acoustical) instrument must initiate excitation for a short period before (s)he expects the tone to be perceptible: on recordings, probably even more than in the concert hall, this point of excitation is extremely ambiguous. Sensitivity to the amplitude levels of *niente* tones is, therefore, likely to cause considerable variance in the reaction times of listeners' perceptual-motor tasks. *Niente* tones may be extreme examples of tones that cause beat ambiguity, but they are not as rare as one might think: there are many instances, particularly in slow music, where the only tones that coincide with the beat emerge from an orchestral texture as though *niente*.

Finally, if two musical streams are supposed to synchronize, but are perceived as asynchronous, on which criteria should the beats of one stream be chosen over another? If Luce and Clark's cor anglais player and violinist initiate excitation at exactly the same time, the points at which their tones reach maximum amplitude will

---

8 Gordon (1984) has studied the difference between actual excitation and perceived excitation—the 'perceptual attack time' (PAT).

be divergent, and the violinist's entry will be perceived as late; on a recording, however, the oboist could equally be perceived as being early (it depends on the (ir)regularity of pulse in the context). The divergence would be even greater if the cor anglais player does slightly anticipate the intended point of excitation.

Desain and Honing (29) point out that asynchrony occurs regularly in ensemble playing—'the leading voice takes a small lead of around 10 ms (Rasch 1979)'. This is different from non-intentional asynchrony. The leading voice may be anticipating in order to facilitate auditory streaming (i.e. to make itself heard as distinct from the other parts). Moreover, in early recorded performances (e.g. by Rosenthal, Paderewski, and many more) asynchrony is often much greater than 10 ms—it is a standard means of conveying expressivity (see Robert Philip 1992).

Where asynchrony is not too pronounced and is not used as an expressive effect, a possible factor supporting synchronization tapping tasks is tappers' experience as performers; performers listen to their own playing, feel the beat, and compensate for temporal lapses. However, one cannot rely solely on the tappers' judgements whilst they are involved in the task. As 'performers' they are at a disadvantage—there are no visual clues to aid the ensemble. In order to facilitate self-assessment, programs could incorporate a facility that enables tappers to play back an extract that has registered their tappings in the form of electronic impulse tones. This would be particularly useful for assessing accuracy of tricky passages, such as when there are sudden tempo changes, and for tappers who may have little experience of observing their own perceptual-motor responses, such as non-instrumentalists.

Moroever, experimental work that tests the accuracy of data generated from a variety of musical contexts is necessary. The experiments that have investigated the accuracy of synchronization tapping have thus far been based on simple, expressionless music (e.g. Richard Parncutt 1994; Piet G. Vos 1994) or expressive piano music (e.g. Drake et al 1991), where all the streams are well synchronised, the tones almost always occur on beats, and durations of tone rise times vary little.

---

9 See Figure 1.5a for the relative length of a synthesised horn tone rise time according to psychoacoustical modeling (McAdams et al, 1995).

Synchronization tapping versus MIDI-based timing programs

Desain and Honing (1992) have suggested that the omission of between-beat timing fluctuations may prove extremely misleading. One has only to think of rubato in performances of Chopin's music to find an example of the problems one might encounter. If the tempo in the left hand is almost consistently heard as equal beats, as writings on performance practice seem to indicate it should (e.g. see Philip 1992: 43, 47, 221), an 'accurate' beat-tapping graph will simply reflect this equality and not the interesting timing fluctuations that occur in the right hand.

By contrast, MIDI-based programs that measure timing overcome the problem of between-beat timing fluctuations, because every note is accounted for; their data are, nevertheless, generated from the actual excitations or onsets of tones as opposed to listeners' perceptions of tempo, and the programs exclude the analysis of timing (as well as of dynamics and articulation) in most non-keyboard works. There are a number of non-keyboard devices (e.g. drum pads) that provide MIDI function, but it is virtually impossible to get MIDI data for orchestral repertoire. The MIDI analyst is, moreover, limited to studying only those performers who are willing to participate in empirical work. Synchronization-tapping timing studies are regarded as having the advantage here in that the availability of many recordings facilitates data comparisons of many different performances.[10]

Temporal nuance: implications for large-scale structure

All of the above suggests that music analysts must consider carefully which modes of inquiry and repertoire will benefit from computer-assisted analysis. Most of those who currently use synchronization tapping are aware that their investigations should not rely on small temporal fluctuations (e.g. Cook 1995: 114). They assume, however, that they are on safe ground when using the broad shape of the graphs to reflect large-scale structure. Lowe's recent work (1997, unpublished) is an example of why such assumptions may be dangerous.

Lowe has recently compared recordings of the first movement of Sibelius's Fifth Symphony; on the whole, her study does not suffer unduly from the problems of rise

---

[10] However, note my earlier point that such comparisons of data are particularly susceptible to increased error margins (see p. 34).

time and asynchrony raised earlier. According to Lowe, performances of this movement of the symphony conform to one of two different interpretations:

(i) a 'one-movement' form in which the tempo line is represented as an upward curve, indicating a smooth acceleration (see Figure 2.3a).

(ii) a 'two-movement' form in which there are obvious tempo changes marking the beginning and end of the transition between the movements (see Figure 2.3b); the second movement begins at bar 138.

She concedes that there may be some hybrid performances that combine the two patterns.

There are two problems that arise from Lowe's graphs. First: her caricature template of the one movement form is misleading because it irons out any changes in the significant transitory bars (107-138). Surprisingly, she claims that the tempo map of Alexander Gibson's performance with the London Symphony Orchestra (1960) illustrates an archetypal one-movement interpretation (1997, unpublished: 12) (see Figure 2.4). Second: it is impossible to tell from the general shape of the graph if an interpretation is a 'one-movement' or 'two-movement' type, because a structural division may be made by means of an agogic accent (and dynamic emphasis) to mark the beginning of the new movement. A structural agogic accent is likely to be indistinguishable from the other small fluctuations of the tempo line.

Lowe's aim, which is not entirely clear, seems to be to ascertain which conductors choose a one-movement interpretation and which ones choose a two-movement interpretation. Her reliance on the sychronization-tapping data oversimplifies this task. If we want to know what a conductor intended at the time of recording, we need more documentary evidence to support the analysis. And even if we know which interpretation the conductor intended, it may not be the structure that the listener perceives. If Lowe is to offer convincing conclusions about the perception of musical structure (though she has made it clear that this was not the purpose of this study (private corespondence)), her data should be correlated with subjects' responses to the recordings.

Pulse, note values and perceived tempo

On the one hand, tempo analysis requires a more holistic perspective (i.e. taking into account the context, including dynamics, rhythm, instrumentation etc.) and, on the other, a more penetrating view of what tempo really is. Tim Howell (1998, 1999, 2000) has recently demonstrated that Jean Sibelius's music can be simultaneously 'static and dynamic, slow and fast-moving' (1999). For instance, he explains that in the Seventh Symphony (bars 209ff), the activity in the strings is perceived as a fast tempo against the slow rate of change in the brass. This is a relationship between tempo and rhythm, which is not peculiar to Sibelius—a famous early nineteenth-century example occurs in Hector Berlioz's *Symphonie Fantastique*. In bars 174ff of the finale, the dotted minims of the *Dies Irae* provide a slow pulse, and crotchets and quavers of the witches round provide a quicker pulse (see Figure 2.5). This perceptual sensation of different simultaneous tempi is made possible by the listener's ability to segregate the sounds into different streams; the timbral differences between the streams (winds and brass versus strings and timpani) and the differences in the rate of timbral change (tone onset) enable segregation.[11]

Differences in pulse may also occur within a single stream. For instance, in 4/4, the notated main beat value is usually regarded as the crotchet, but the actual main beat value can easily switch from crotchet to minim to semibreve: the marking of ♩=120 at the top of a score indicates a fairly fast tempo, but if the piece (or a section of the piece) consists mainly of minims, the perceived tempo is likely to be a rather stately 60 main beats per minute (bpm), and if it consists mainly of semibreves, the perceived tempo is likely to be a very slow 30 main bpm. A piece could, therefore, consist of sections of different tempi without ever deviating from the notated metronome mark. Lowe misses this point entirely when she suggests that the tempo of the first movement of Beethoven's *Eroica* Symphony may be expressed as a straight line (60 bpm) on a graph. Whilst the opening of the first movement may be felt in one-in-a-bar (though the conductor may still conduct in three (as a subdivided one-in-a-bar)), bar 65 features a change in character caused by the vivace ♩♫ rhythm of the violins, with supporting punctuation (♪| ♩ ♩) in the winds and timpani; it encourages a clear

[11] In other pieces, the principal timbral change rate is not necessarily the same as the rate of tone onset. I discuss issues of auditory stream segregation in more detail in Chapter 3.

three-beat pattern and has the perceptual effect of a shift to a faster tempo (see Figure 2.6).[12]

Whilst the above differences in pulse are based on simple ratios, many twentieth-century works feature frequently-changing time signatures or simultaneous tempi which have pulses that are not related in any simple sense (e.g. Charles Ives's *The Unanswered Question*). All of these temporal issues are entirely bypassed in synchronization-tapping data.

Representation

I have shown that data generated from the programs discussed cannot be regarded as an accurate reflection of listeners' perceptions. In particular, the data of synchronization-tapping programs, which reflect perceptual-motor responses, represent something that lies uneasily between the acoustical and the perceptual. They provide information that is related to tempo in terms of real time as opposed to perceived speed; as such, their measurements may be more closely aligned to acoustical phenomena. However, the extent of the divergence between the acoustical and the perceptual depends entirely on context: if the piece consists only of equal-weighted crotchets and tones with rapid rise times, the acoustical and perceptual maps of its tempo would probably be well-correlated. Such pieces are, however, very rare.

The question of pulse uncovers a fundamental flaw in interpreting the synchronization-tapping data as tempo, but it raises other possibilities. The graphs could conceivably be used to demonstrate tappers' interpretations of pulse, and this could result in some quite interesting comparisons between recordings and/or listeners. If this is what the tapping programs are to be used for, the resultant graphs would have to be interpreted in a different way. The graphs would be crude caricatures of possibly subtle effects that the conductor might be conveying ((s)he might slip unobtrusively out of one beat pattern into another). Moreover, for some listeners, the differences in a particular performance might seem quite marked, for

[12] I should make it clear, however, that the perceptual effect of a three-in-a-bar pulse is not inherently faster than a metronomically equivalent one-in-a-bar; a 'heavy' three-in-a-bar pulse may be perceived as more laboured (and, therefore, slower) than a 'light' one-in-a-bar pulse. The effect depends upon relationships between individual bars and hypermeasures (the relationships between downbeat emphases). Further investigation into this phenomenon is beyond the focus of this thesis.

others they might be almost imperceptible. The 'inflexibility' of the graphic representation should not be regarded as too limiting; the graphs may be considered in the light of data gathered by other means (e.g. well-phrased questionnaires) which help the analyst to evaluate the certainty with which interpretative decisions are made. Clearly, this area is fertile ground for future experimental work.

2.2.3 Timbre

Thus far, I have focused on some fundamental perceptual issues about notionally non-timbral studies. There are, however, a few performance analysis studies that focus specifically on timbre.

Stephen Malloch (1997) has recently attempted to revive a form of analysis that was first proposed by Robert Cogan (1984). Cogan used spectrographs (photographs of sounds) to show the 'sonic design' ('acoustic outline') of recorded works. Malloch has extended this principle by using programs (written by A. Murray Campbell) to measure sharpness, roughness, (in)harmonicity (called 'cepstrum' analysis), 'timbral width', 'timbral weight' and 'timbral pitch'. He defines timbral width as the extent to which energy is concentrated within a specific region of a spectrum (a 'focused/diffuse' scale), changes in timbral weight as the frequency shifts of the loudest spectral band (low bands sound 'heavier' than high ones), and timbral pitch as the dominant frequency region of a sound.

Whilst the Campbell-Malloch programs are acoustically based, the spectrographs are 'A-weighted', which means that they reflect more closely how we perceive sound than graphs generated from unweighted Sound Pressure Levels (Malloch 1997: 48). However, as Bergitta Berglund and Thomas Lindvall (1995) have noted, the limitations of A-weighting include the following:

> Not only does A-weighted sound pressure level underestimate the impact of the low-frequency components of noise (Goldstein, 1994), but it is also strongly dependent on the exposure pattern with time. For sounds that exceed 60 dB the reliability of A-weighting decreases.

An even more serious problem from a music-analytic perspective is that, as with the dynamics and synchronization-tapping programs, streams are indistinguishable—the data of these programs provide information only about global features/aggregates. For instance, it is difficult to determine which components of a texture are the main sources of roughness or sharpness within an aggregate.

The generalised nature of the data means that there is a real difficulty in showing the relationships between timbre and other parameters, such as pitch. Timbral pitch is limited in its usefulness because it applies to just a frequency region, which is indicated by a 1/3 octave band number (see Figure 2.7). The 'centre frequency' of the band number may not apply to any specific pitch, and even when it does, it may not indicate the most prominent pitch of tones in close proximity. Such ambiguity suggests that the program is unreliable for isolating specific sound sources.

Malloch's choice of pieces for analysis is, nevertheless, well suited to the tools that he is using. He analyses György Ligeti's *Atmosphères* and Witold Lutoslawski's *Jeux Venitiens*. Both pieces are unusual in that they consist generally of a textural homophonic or polyphonic backdrop—in the case of *Atmosphères*, a 'single mutating texture' (Malloch, 158)—through which the strongest tones and streams penetrate. Acoustical data can often reflect fairly adequately the presence of prominent tones and streams in such contexts.

But not all pieces that may be described as 'a single mutating texture' can be analysed adequately using these techniques. For instance, Schoenberg's Op. 16 No. 3 '*Farben*', often erroneously thought to be a single chord that undergoes various timbral transformations, may, to a certain extent, be regarded as a 'single mutating texture'. If Malloch had produced graphs of this piece, his data would be of limited use, principally because they cannot distinguish the voices of the canon, which generates the pitch structure. Some might argue that we should not expect the Campbell-Malloch programs to reveal aspects of pitch structure—they are designed to facilitate analysis of only a limited aspect of the total musical phenomenon. This is true, but, when these programs are used as the only means of analytical inquiry, the interpretation is likely to be musically impoverished because important perceptual and structural relationships between timbre and pitch are neglected.

Timbre dimensions

Malloch's use of quantitative measurements to reflect timbral sensations is useful from the perspective of non-recordings-based analysis. In particular, the notions of timbral width and timbral weight provide useful additions to the dimensional timbre model discussed in Chapter 1. If these dimensions are to be incorporated into a non-recordings-based analysis, further investigation into the phenomena may facilitate discussion of sonority comparisons.[13] Useful investigations could include generation of data indicating individual instrument tone distribution within a 'focused/diffuse' dimension, and the relationship between the notions of focused/diffuse timbre and pitch salience. Moreover, timbral weight may be less important than the degree and rate of timbral weight fluctuation within a tone; generation of data indicating timbral weight fluctuation may be particularly useful for comparing different types of bell and gong tones, since this sort of fluctuation is often one of the defining characteristics of such tones.[14]

2.3 Orchestration analyses

The gap between music perception and music theory is not just a problem in performance analysis. Perceptual issues are often relevant, but neglected, in conventional orchestration analyses. One of the most recent examples of such analyses is Richard S. Parks's (1999) comparative study of orchestration and musical structure in Debussy's *Prélude à l'après-midi d'un faune* and Benno Sachs's chamber ensemble arrangement (1921) of the *Prélude* for Schoenberg's Society for Private Musical Performances (1919-23).[15]

---

13 For instance, the correlation between these quantitative dimensions and listeners' qualitative evaluations could be usefully supported with experimental evidence.

14 Malloch (1997: 52) has demonstrated that timbral weight fluctuates throughout the duration of a bell tone, and Fletcher (1994) has investigated aspects of gong and bell tones from perspectives related to timbral weight and timbral pitch; see also this thesis, Chapter 1, p. 10.

15 For historical accounts of the Society, see Willi Reich (1971: 117-28) and Joan Allen Smith (1986: 81-102).

2.3.1 Texture and dynamics

Analogies

Parks uses visual analogies to help elucidate his ideas about musical texture. Sometimes these analogies, like conventional approaches to describing timbre (see Chapter 1, p. 4), are inappropriate or unclear. For instance:

> The obvious way to relate instrumental forces to intensity is to co-ordinate them in tandem by pairing 'louder' with more instrument groups, 'softer' with fewer, which we might liken to modifying visual perspective on a subject by means of a camera lens of variable focal length, through which we may zoom in on, or away from, our subject' (58).

By suggesting that loud passages with more instruments are like a 'zoomed in' picture, Parks fails to consider fully the listening process. From a listener's perspective, soft passages with few instruments may, indeed, be perceptually more 'distant' than loud passages with many instruments, but they are often also more 'intimate'. Broadly speaking, timbral nuances are perceived more easily in soft passages than in loud passages; thus, the soft passages may be said to encourage one to 'zoom in' on detail and loud passages may be said to encourage one to 'zoom out'.

'Groups' and 'parts'

Parks discusses (58) textural and dynamic effects in Debussy's original also in terms of numbers of instrument groups and parts. This approach to texture description is a common practice in orchestration analyses.[16] As an analytical principle, it lacks a perceptual basis.

The main problem relates to Parks's definition of instrument groups and parts. His 'groups' refer to instruments of the same type, but his criteria for determining 'type' may require greater consideration. For instance, there are rationales for his distinction between different types of double reed instrument (cor anglais and bassoon are regarded as different groups) and for his grouping of all strings as a single group; however, one could argue that this blanket grouping of strings does not account fully for the striking timbral differences between first violins and double basses—these instruments' tones often occupy very different regions of the brightness dimension.

---

[16] For instance, Gregory Woodward (1986: 57-61) approaches texture in this way in a study of Webern's *Five Orchestra Pieces*, Opus 10.

Also contentious are Parks's criteria for identifying 'parts': he regards multiple string instruments playing in unison as one part (e.g. violin I or, if *divisi*, half of violin I), but often regards other multiple instruments playing in unison as separate parts. For instance, he counts twelve parts at bar 48, which means that he counts the four unison horns as two parts (1 and 2; and 3 and 4); similarly, at bar 50, he counts unison flutes and harp as three parts (flute 1; flutes 2 and 3; harp 2), making a total of eleven parts for that bar.

Parks's analysis of texture would benefit greatly from careful consideration of auditory streaming. His current approach is governed by music publishers' notational practices—if all unison instruments of the same type were notated on a single stave, his calculations would have been significantly different.

2.3.2 Analytical expectations and aims

Stripped of its façade of precision and throroughness, Parks's point about texture is rather unexceptional: the number of instrument parts increases and decreases in tandem with the dynamic shape. This example of orchestral *crescendo-diminuendo* is what one might expect to find in a standard undergraduate-level orchestration textbook.

Another unexceptional point, which Parks labours somewhat, concerns the careful retention of 'overlapping entrances and exits ... throughout the arrangement'. Whilst instrument dovetailing is a characteristic of Debussian orchestration, it is not peculiar to Debussy—it is another standard technique of (particularly late nineteenth-century French) orchestration. The technique facilitates smooth transitions between instrument lines—it provides bridges between different regions of timbre space. One can reasonably expect an arranger to observe these overlaps.

Schoenberg and the Society for Private Musical Performances

According to Joan Allen Smith (1986: 83, quoted in Parks 1999: 52), Schoenberg believed that the purpose of the Society's arrangements was 'to hear complicated works clearly presented, divorced from their coloristic properties'; the pianist Stefan Askenase (letter to Smith, 27 July 1973) claims that Schoenberg felt 'that a work could be better judged without an orchestral decoration ... one could better find out what it really contained of musical quality'. The implication here is that Schoenberg did not regard orchestration as intrinsic to 'musical quality'. Given Schoenberg's well-documented desire for a theory of *Klangfarbenmelodie* (Schoenberg 1911/1978: 421-22), it would be most surprising if he really did hold such a view. Schoenberg's published comments about piano transcription reflect a view of arrangements that is more in line with his aspirations for timbral theory:

> A sculpture can never be seen from all sides at once ... the piano reduction should only be like the view of a sculpture from one viewpoint' (1923) (Schoenberg 1975: 349, quoted in Parks: 52).

Sachs

Parks's conclusion seems to be that the essence of the *Prélude's* 'orchestral decoration' was not stripped away in Sachs's arrangement, that Sachs preserves the relationship between the orchestration and the musical structure (72-73). Parks suggests that Sachs's arrangement contradicts Schoenberg's (but, more accurately, Smith's and Askenase's) 'published comments to the effect that he [Schoenberg] regarded orchestration as compositional decoration rather than essence' (72-73). However, Parks points out a number of instances where Sachs does not observe Debussy's overlappings and entries. He does not address why such differences between the original and the arrangement exist and often neglects the perceptual effect on the structure caused by the arrangement's new instrumentations. For instance, in bars 4-5 of the original, the harp glissando is followed by a horn solo (see Figure 2.8); in the arrangement both the glissando and the motif are played on the piano. This new timbral similarity between the glissando and the motif may affect the perceived salience of the motif and, in turn, the status of the motif within the large-scale structure.

Engagement with these issues could have highlighted what Sachs wished to draw out of the original. It could have usefully thrown light on the question of whether or not the arrangement may be judged as a work in its own right—whether it involves re-creative interpretation of the material or is simply a transposition of parts from one group of instruments to another.

2.4 Conclusion

In this chapter, I have shown that recent performance and orchestration analysts are insufficiently sensitive to perceptual issues and do not always adopt clear interpretative stances. Their work is often insufficiently grounded in theory, showing little or no signs of critical engagement with aesthetic issues. This paucity is symptomatic, perhaps, of the current fashion in music analysis to shun 'prescriptive' writing in favour of 'descriptive' writing. Analytical inquiry might be more useful if it were to propose models that focus on the music's potential to be conceptualised / performed / heard in specific ways. The models need not be prescriptive; they may be used as templates—as points of departure for interpretation.

If we are to use models as templates, we ought to take into account what is perceptually (and practically) possible in specific musical contexts, and to be sensitive to issues of representation and notation. A model based on networking processes may offer the necessary flexibility to reflect listeners' capacity to change attentional focus, and also the potential to take into account musical details, which can be important for analysis of large-scale form. Tools or methods (technological or otherwise) should only be used to tease out the problems for which they have the capacity—there are specific questions and contexts to which they are best suited. In short, if we are to avoid interpretative pitfalls, music—not methods—should direct our approaches to analysis.

Chapter 3

Towards a theory of timbre for music analysis

3.0 Introduction

In this chapter, I propose a theory of timbre for music analysis, illustrated with examples from '*Farben*', the third of Schoenberg's *Five Orchestra Pieces*, Opus 16 (1909). The theory is subject to development, opening up new areas for musicological investigation. Implementation of the tools and methods discussed here will not dominate the rest of this thesis, which is concerned principally with integrating ideas about timbre into more conventional musicological questions about the music of the Second Viennese School.

I will draw upon two main sources of music perception research: Richard Parncutt's psychoacoustical approach to harmony (1989) and David Huron's perception-based voice-leading theory (under review, 2000). These studies lend a certain degree of objectivity to the proposed analytical techniques. However, since personal hearings can never have objective status, my references to 'the listener' should be regarded as just a methodological convenience. Before discussing Huron's and Parncutt's studies, and their relevance to timbre, let us first establish a few basic structural features of '*Farben*'.

'Farben': aspects of structure

'*Farben*' is a 'fugue'[1] in which a three-note motif acts as the subject and various other ideas constitute countersubject material. Figure 3.1 outlines the main sections, and Figure 3.2 shows (a) the canon subject and (b) the main non-canonic ideas. Note that the recapitulation is a retrogression of the canonic material of the exposition, and that, according to the pitches within the canon, the coda begins in bar 39: all voices begin moving together, and from bar 40, the subject of the fugue in retrograde is played simultaneously in all voices (see Figure 3.3).

The canonic movement of the subject is embedded in a continuous succession of five-voice chords in which the rate of instrument change almost continuously exceeds the rate of pitch change. Figure 3.4 shows the rates of instrument and pitch change in bar 26. To the two instances of pitch change, there are sixteen modifications to the instrumentation! It is this feature of '*Farben*' that has prompted many musicologists to take a closer look at the piece's orchestration.

[1] Schoenberg described the piece as a 'fugue' in his lectures (according to his pupil Rudolf Kolisch, in Smith 1986: 146).

Timbral serialism

Peter Förtig (1969) suggests that serial techniques may underlie the instrumentation, but whereas he is unable to identify this aspect of the piece's composition in any detail, Jan Maegaard (1972) and Charles Burkhart (1973) attempt to demonstrate how the instrumentation of the climactic bars 26-29 is quite explicitly serial.[2] Both Maegaard and Burkhart have identified a succession of twelve distinct instrumental combinations as constituting a 'row'; Figure 3.5 shows the constituents of this 'row' according to Burkhart (1973: 159).

The term 'serialism' implies that a row undergoes transposition, inversion and retrograde inversion, but there is no evidence to suggest that such techniques are employed in '*Farben*'. Burkhart does, nevertheless, point out a retrogression of the exposition in the recapitulation and a retrogression of the instrumental combinations of bars 25-27 and 28-29 in bars 27-28. Although such structures are far from serial, the instrumentation of bars 25-29 should be regarded as historically significant: the concept of retrogression was by no means new to the twentieth century, but the process of ordering instrument combinations in the described manner and presenting them in retrograde was indeed new.

The aforementioned processes should not be referred to as 'timbral' because it is the instrumentation that is ordered, not the sound sensations themselves. Burkhart has, quite rightly, avoided use of the term, because his theory does not accommodate distinctions amongst timbres generated from a single source. Even if a composer does choose to treat instrumentation serially, a great deal of scope for timbral organisation would remain. In contrast to serialisation of instrumentation, serialisation of timbre is an extremely complex issue—to begin with, how can one define notions of timbral 'inversion' or 'transposition'?[3] 'Retrograde' timbres might perhaps be expressed by having sonorities played backwards, so that each 'decay' grows towards its respective 'attack'. But if this is the most plausible definition of timbral retrograde, a theory of timbral serialism is perhaps inevitably confined to the realm of electroacoustic composition.

---

2 According to Burkhart (1973: 166), this 'serial ordering' is indicated in Schoenberg's short score of the piece.

3 Later, I will discuss a possible definition of timbral transposition, but in a non-serial context (see p. 69).

In the following proposed timbral theory, I will demonstrate how discussion of timbre's interdependence with other parameters, such as pitch and rhythm, is far more pertinent to an analysis of '*Farben*' than pursuing erroneous claims of timbral or instrumentation serialism. The theoretical framework addresses two important perceptual phenomena: auditory stream salience and timbral change rate. These are complementary aspects of the structure of '*Farben*' which will help us to judge the perceptual salience of the canon.

3.1 Auditory stream salience

Albert Bregman's extensive research into *Auditory Scene Analysis* (1990) divides auditory streaming into two types: 'primitive', which is 'pre-attentive', and 'schema-based', which involves 'hearing out'. Bregman's distinction seems to correspond to Cook's characterisation of 'musical' (notionally non-analytical) and 'musicological' (analytical) listening, which I alluded to in Chapter 2 (see p. 25). However, if we develop Bregman's terminology a little further by treating his listening types as separate (but well correlated) continua—pre- to high-level attentiveness and no schema to flexible and then strict schema—it offers a way of describing approaches to listening that are perhaps preferable to Cook's terms. When listening to music, most listeners do not occupy the extremes of attentiveness and schema continua. 'Musical' listening is not pre-attentive—it is 'attention-driven' (if the listener is not attentive, she would hear and regard musical sounds as background or intrusive 'noise'); this is a flexible schema. Musicological listening often involves stricter schemata, which in turn require a more acute attentional focus. Focusing on a specific partial of a sonority is an example of an extremely strict schema which requires a very high level of attention. Sometimes we perform this sort of listening task in aural classes in order to teach students about perception and acoustics; the extent to which it is 'musicological' listening depends on how it is contextualised. Moreover, Cook might define as musicological the act of 'hearing out', but the process is equally valid in non-musicological contexts (when the listener's intention is 'musical').

This suggests that the listener's perception of the canonic voices in '*Farben*' depends entirely on whether or not (s)he adopts an appropriate schema. As with the perception of any homophonic writing,

> … the amalgamated partials of [each] constituent chordal tone don't really form a stream *per se*, but rather form a *potential* stream that is realized only with a shift of attention (from chord to chordal tone). (Huron 1991.)

On shifting attention, the listener hierarchises locally streams and events,[4] taking into account where sources lose their identity as streams and become subsumed either into other streams or into the background.

Chimeric percepts

Where a source is subsumed into a stream, it may 'colour' the sounds from a more prominent source. One might perceive a multiple-source stream as originating from only a single source; timbre researchers sometimes call such perceptions a 'chimeric percept' (Bregman) or a sensation derived from a 'phantasmagoric instrument' (Boulez) or 'virtual source' (McAdams).[5] In terms of timbre space, a chimeric percept is likely to occupy a position somewhere between the 'parent' sources, but the perceptual isolation of the 'parents' may be inherently easier than is the case with hybrid tone parents (see my discussion of hybrids, pp. 6-7). Of course, the extent to which chimeric percept parents may be isolated depends upon the nature of their relationship. For example, two unison tones ('parents') are likely to draw the listener's attention towards a strong chimeric percept and away from their characteristics as individual tones, but tones that are separated by an interval have greater potential to draw the attentive listener towards the characteristics of individual tones.[6] If the listener were engaged in 'primitive'/pre-attentive listening (s)he would perceive only a single percept, being insensitive not only to isolating the parent tones, but also to many of the characteristics that define the chimeric percept. In attentive listening, the weaker sensations, which have the potential to be focused on, contribute to the global sensation of the sonority.

As with hybrid timbres (see p. 6), the location of the chimeric percept is determined by the relative prominence of the parent timbres. Judging the prominence of parent timbres is useful

---

4 The importance of flexible hierarchy was discussed in Chapter 2 pp. 26-8.

5 The term 'chimeric percept' is preferable to 'phantasmagoric instrument' and 'virtual source' because it does not carry the baggage of the term 'instrument' and is not so easily confused with true 'virtual sources', such as instrument hybrids or electroacoustic tones that do not have a specific instrument affiliation.

6 Moreover, the effect of spectral centroid on blend suggests that the chimeric percepts of combined bright/high tones are likely to be weaker than the chimeric percepts of combined dull/low tones (see Chapter 1, p. 19).

in music analysis; judgements can be informed by comparing the percept and parents according to timbral dimensions. However, if the parents have different pitches, one should take into account also pitch salience. As Huron (under review, 2000) points out:

> ... pitch is typically regarded as a subjective impression of highness or lowness, [but a] more fundamental feature of the phenomenon ... is that it provides an internal subjective label—a perceptual handle—that represents a bound collection of partials likely to have been evoked by a single physical source.

In other words, pitch facilitates stream segregation, which means that pitch salience estimations may help us to identify the sources/streams that are likely to be most prominent.

3.1.1 Parncutt's pitch salience algorithm

One can estimate pitch saliences by using Parncutt's pitch salience algorithm (1992). The algorithm, which is based on Parncutt's psychoacoustical approach to harmony (1989), determines the prominence of pitches in chords and other aggregates by calculating the sum of amplitudes for each of the harmonic components in 'typical' complex tones. Parncutt (1989: 89) defines such tones as resembling 'a harmonic template, whose components form an idealized harmonic pattern', where the perceived weight of each harmonic 'becomes progressively less' the higher the harmonic (see Figure 1.1). The results can have perceptual validity because they take into account the audibility threshold.

For instance, Figure 3.6 demonstrates how register affects pitch salience; pitches that are most salient are closest to the optimal value 1.00. As separate tones, the pitches Bb1 and A2 are close to this optimal value (in both cases 1.03), but as combined tones (Bb1-A2), the A (0.95) is by far the strongest pitch (Bb is 0.14). When transposed up three octaves (Bb4-A5), the pitches become far more equal (Bb 0.61; A 0.75), and if transposed up a further two octaves (Bb6-A7) or higher, the Bb (0.80) dominates (A is 0.43).

If one takes the premise that pitch is a sound source's 'perceptual handle', one is likely to perceive a Bb1-A2 sonority as an A tone coloured not only by weak Bb spectral pitches, but also by the timbral attributes of the Bb1 sound source (it is the principal source of the Bb spectral pitches). An example of the resultant chimeric percept occurs in *Wozzeck* (bars 187ff): a bowed col legno double bass solo Bb1 is perceived as 'colouring' a cello A; most available recorded performances (e.g. Abbado 1989, Dohnányi 1991, Barenboim 1994, Metzmacher 1999) are consistent with this perceptual emphasis. The Bb-A pitches may be heard as equal only if the double bass plays significantly louder than the cello.[7]

Pitch saliences of the 'Farben' canon

In musical contexts, Parncutt's algorithm is limited in that it takes into account neither dynamic level differences nor the distinction between aggregates and the groups of sound sources that might constitute separate streams within those aggregates. Whereas it offers a certain degree of objectivity, the interpretation of the data is based almost solely on the author's listening experience. Despite these limitations, the program can help us to establish, by determining the extent to which the pitch saliences correlate with pitch changes, the extent to which the voices of the canon in '*Farben*' are inherently salient at appropriate points.[8] The data may be used as a pitch salience template; when perceptual cues cause different pitches to be noticed, the salience of a pitch may be attributable to particular timbre dimensions.

The algorithm was applied to all vertical sonorities that occur in '*Farben*'. The results for bars 1-11 are shown in Figure 3.7. In the first sonority, the E of voice 2 is the most salient, whereas the A of voice 1 is the second most salient. In bar 4, voices 1 and 2 are almost equally salient; this is the point at which voice 2 moves and, significantly, voice 1 is about to begin moving. In bar 5, voices 2 and 1 still have, respectively, the most and second most salient pitches; the third most salient pitch happens to be the G# of voice 4, which is about to move to the A in the following bar. However, in bar 6, the salience of A is very low; the sonorities of this bar are dominated by the interval of a fourth in the upper two voices, which is made possible by a pitch change in voice 1. The third most salient pitch is the B of voice 3, which is about to move to the C in the next bar. In bar 7, the most salient pitch is indeed the C and the fourth in

7 Of course, any dynamic increase in the double bass here would result in a corresponding shift in the chimeric percept's timbre space location from close to the cello tone to nearer the double bass tone.

8 The program may be used also to calculate the extent to which a progression from one chord to another might be perceived as 'consonant' or 'dissonant'. This use of the terms 'consonance' and 'dissonance' should not be confused with consonance/dissonance of individual chords. Parncutt adopts the principle that the more frequency/pitch components that a pair of sonorities have in common, the more 'consonant' the progression. For example, C4-E4-G4 and F#4-A#4-C#4 are consonant chords that have a 'dissonant' relationship when they are juxtaposed; a pair of chords that consist of all twelve notes of the chromatic scale from C4 to B4 have an optimal 'consonant' relationship—they have exact 'pitch commonality' (Parncutt's term). Use of this function of the program is beyond the remit of this thesis; it is most useful for addressing harmonic questions rather than timbral/streaming ones.

the upper voices remains prominent. The salience of the G is very low, suggesting that, although in bar 5 we may have been alerted to the fact that some movement is about to feature in voice 4, according to the calculations it proves very difficult to hear out the movement itself (bars 6-7). The listener may, with some effort, be able to follow the line through, nevertheless, particularly if there is a very slight adjustment of balance (as in Rattle 1989).

However, without such an adjustment, the results seem to suggest that the listener is going to be more aware of the returning fourth in the upper two voices than the pitch change in voice 4. Indeed, the Eb and Ab prove to be the most salient pitches throughout the rest of the first section. Bar 8 is consistent with previous patterns, with the moving pitches (Bb and C#) having significant salience values. Interestingly, in bar 9 the salience values of the moving pitch B in voice 5 are generally rather low. One might interpret this in a way which is similar to the perception of voice 4 in bars 5-7: the fact that voice 5 has moved is considerably less important than the fact that we have arrived at a transposition (down a semitone) of the initial chord; one of the main characteristics of that chord is the prominence of the perfect fourth in the upper voices.

Interestingly, in bars 7-10, the material that is outside the canon is, according to the results, not particularly salient. This 'countersubject' material can, however, prove quite noticeable in most performances. Our results suggest, therefore, that other auditory cues are the cause of the discrepancy. The attacks of the two-note motives do not coincide with the attacks of instruments in the canon, and a sense of motion follows with an attack on the second note of the motif; other distinguishing factors include the slight impression of 'hollowness' caused by the absence of some low even-numbered harmonics in the clarinets, and the emphasis of upper harmonics caused by muting in the trombone. A tone's isolation or a sudden shift within timbre space can, it seems, act as a perceptual 'magnet'; and if the listener's attention is drawn towards particular sound sources, it follows that the likelihood of noticing their pitches is greatly increased. This inverts Huron's notion of pitch as 'perceptual handle': in certain contexts, timbre dimensions provide a 'handle' for pitch perception.

The development and recapitulation sections of '*Farben*' yield Parncutt results that may be interpreted in a fashion similar to those of the exposition. In cases where canonic movement does not seem to be perceptible, the listener's attention may be drawn to a more significant idea, such as non-canonic material or (as in the exposition) the perfect fourth interval. Indeed, in bars 36-44 the pitches of the same interval are almost always the most salient (see Figure 3.8). From bar 38 onwards, this may not be surprising because the original five-voice chord is reiterated. Surprising or not, this aspect of the sonorities, along with the two-note motif (bar 38), serves to merge the recapitulation into the coda. This perceptual fusion of the sections may be understood as a higher level application of the dovetailing or overlapping feature which is characteristic of the chords in the canon.[9]

3.1.2 *Huron's voice-leading Principles and Derived Rules*

Application of Parncutt's algorithm is certainly useful for judging auditory stream salience in certain contexts. Stream perceptibility may be informed also by other means. For instance, Bregman found that streaming is affected by pitch proximity, temporal proximity, timbre and related factors such as (in)harmonicity, intensity, and spatial positioning of sources. Huron subsumes these ideas into his perceptual theory of voice-leading (under review, 2000). His approach to voice-leading is interesting because it provides a theoretical framework that bridges a gap between timbre perception and pitch notation.

Huron suggests that eleven perceptual principles are relevant to voice-leading: (1) 'toneness', (2) 'temporal continuity', (3) 'minimum masking', (4) 'tonal fusion', (5) 'pitch proximity' (6) 'pitch co-modulation' (7) 'onset synchrony', (8) 'limited density', (9) 'timbral differentiation', (10) 'source location', and (11) 'structural tonality'. Huron's definitions of these principles are provided in Figure 3.9. These Principles ('P's) are based on experimentally-determined facts ('A's) from which Huron derives a set of twenty-six voice-leading Rules ('DR's).[10] These Rules are provided in Figure 3.10; some of the Rules (DR18-DR23) are derived from combinations of facts.

Huron's theory is subject to revision. There are some obvious inconsistencies, such as an extra 'rule' ('corollary' (C)) for DR11,[11] and the omission of names for DR24, DR25, and DR26;

---

9 One of the main reasons for the lack of perceptual distinction between the recapitulation and the coda seems to be that the non-canonic ideas divert the listener's attention, because they are timbrally more noticeable than the canon itself.

10 Huron uses 'D' (for 'derived rule') rather than 'DR'; however, I have used 'DR' consistently throughout this thesis in order to avoid confusion with the pitch D.

11 Unlike Huron, I have not treated C3 as a separate rule; the Rule numbering system of Figure 3.10 is,

nevertheless, even in their present state, the Principles and (to a lesser extent) the Rules provide a useful source of reference and notational shorthand for corroborating stream salience judgements. Where appropriate, they are integrated into various aspects of this thesis.

'Farben'

Huron's voice-leading Principles and Derived Rules support the stream saliences suggested in my earlier interpretation of Parncutt data. The '*Farben*' canon complies with the principles P1, P2, P5, and P6. All tones are clearly pitched (Toneness, P1); the sound sources are continuously excited and the ('intermittent') sound source changes are dovetailed (no intervening silence) (Temporal Continuity, P2). Pitch changes in the canon are within van Noorden's 'fission boundary' of two semitones or less, and the rate of change is usually slow (Pitch Proximity, P5). Voices do not move in synchrony in the same direction except in the coda (Pitch Co-modulation, P6). Here, all canonic voices move together and in the same direction, causing the perception of a single stream that contrasts with the rest of the canon and encourages attention to focus on the non-canonic material.

The canon conforms to a lesser extent to Principles P2, P4 and P8. Minimum Masking (P2) is not fully achieved in that the smallest intervals lie within the middle (between the third and fourth voices) rather than top pitch range of the chords. However, Parncutt's algorithm is a much more sophisticated way of determining the impact of masking within critical bands than Huron's very general rule, because it takes into account specific pitch combinations. As I demonstrated earlier, the results of the Parncutt application suggest that Schoenberg's choice of pitches ensures that relatively strong harmonic components draw the listener's attention to the canonic voices that are moving or are about to move.

The canon does not comply fully with P4 because there are some pitch relations (octaves and perfect fifths) which may contribute to Tonal Fusion. For instance, in the exposition, there are perfect fifths in bar 5 (voices 1 and 2) and bar 7 (voices 4 and 5), and an octave in bar 7 (voices 3 and 5). However, the impact of such pitch relations is minimal because they are transient and not combined with Pitch Co-modulation (P6).

---

nevertheless, consistent with Huron's system.

In the canon, there are usually no more than three canonic voices moving at any one time; in this sense, '*Farben*' complies with the Limited Density Principle (P8).[12] When non-canonic material occurs, more than three streams are possible, but many of them are likely to be perceptually grouped because they satisfy various other Principles. For instance, the different sound sources playing the two-note motif are grouped as a single stream because of their Onset Synchrony (P7), Tonal Fusion (P4, perfect fifths) and Pitch Co-modulation (P6). However, at the textural accumulation (bars 28-29), there are many variations in the number of simultaneous pitches, the rate of pitch change greatly increases, sound source change is very frequent, the distinction between the two-note motif and the canon subject becomes unclear, and there are parallel *sul ponticello* viola and cello chromatic scales. The perceptual effect is slightly disorientating, with many sources sounding equally important. Rather than isolating the three most prominent streams, the listener is perhaps most likely to perceive most streams in the background, focusing on only one stream at any one time (usually the brightest streams and/or those with greatest intensity). The components or identity of that stream will, of course, tend to change frequently, and will depend greatly on the performance.[13] In the available recordings, execution of '*Farben*' differs most during this passage; the quiet dynamic of all instruments, frequent entries and exits cause the orchestral balance to be highly sensitive to nuances, resulting in a multitude of possible streaming effects.

The '*Farben*' canon complies least with the Principles P7 and P9. The impact of Onset Synchrony (P7) is obvious. Timbral Differentiation (P9) is often insufficient, because there are some timbral overlaps between voices. For instance, in the exposition, the alternating chords feature a bassoon tone for voice 4 in the first half of the bar, and a slightly higher bassoon tone for voice 3 in the second half of the bar; voices 1 and 2 are both played by flutes. The remaining principles Source Location (P10) and Structural Tonality (P11) bear little relevance to '*Farben*'.

---

[12] According to Huron (1989), Andrew Gregory (1990), and others, listeners have the capacity to follow up to only three streams at any one time, perceiving any additional streams in the 'background'.

[13] The background elements are unlikely to fuse into a single stream. Huron makes this point in reference to schema-based listening approaches to heterephonic textures.

One might think that a ratio of Huron's Principles provides an indicator of potential stream perceptibility. According to the above analysis, the Principles compliance ratio full:partial:none:non-applicable is 4:3:2:2—a ratio that seems to support strongly the notion that the canon is perceptible. However, some Principles and combinations of Principles can have a greater impact than other (combinations of) Principles. The combined perceptual effect of Onset Synchrony and lack of Timbral Differentiation is so powerful that it balances the combined effect of all of the Principles that promote the streaming of the canonic voices. For many listeners who are unaware of the canon, the combined effect encourages listeners to focus first on the 'vertical' aspect of the sonorities, and second on the linearity of the chord succession. This hearing of the canon as a single stream of chords is induced also by the '*Farben*' title (translated often as 'Chord-Colours').[14]

Whereas Huron's Principles seem useful, his Derived Rules are sometimes misleading. For instance, the Tonal Fusion Rules DR6, DR7, and DR8 are obsolete: the fourth Rule, DR9, subsumes them and is equivalent to the Tonal Fusion Principle, P4. Moreover, other Principles do not have Rules. In particular, Huron seems to have overlooked Rules that do not emphasise voice-leading as a pitch phenomenon, falsely giving the impression that they are not as relevant to pitch perceptibility as his other Rules. For instance, Huron could have derived from his general discussion of the Timbral Differentiation Principle (P9) at least two distinct Rules:

(i) ... timbral differentiation seems to be preferred in situations where the composer wishes to draw attention to a particular line of sound against a background of other sounds. That is, *timbral differentiation may be the primary means for choreographing foreground / background effects* [my emphasis].

(ii) Iverson (1992) has shown that timbral cues that contribute most to streaming are highly correlated with similarity judgments. That is, *listeners are most likely to link ... sonic events that share similar tone colors* [my emphasis]; conversely, listeners tend to segregate sonic events whose tone colors are quite different.

[14] One should note that it was only after persuasion from C. F. Peters edition that Schoenberg conceded to provide titles in 1912. The title was later changed to 'Summer Morning by a Lake' for the 1949 version; the implications of this title are discussed in Chapter 4.

A more fundamental problem than the absence of Rules is Huron's current definition of P9, which inadequately conveys the issue of foregrounding elements (i) (see Figure 3.9).

Huron could develop his theory by providing flexible ranking of streaming Principles. Such developments might be quite complex; they should take into account the differences between specific aspects of the Principles and the extent to which certain combinations of those aspects might be likely to have a greater streaming effect than other combinations. Moreover, Huron could clarify by specifying scenarios the rank orderings for Source Location (P11). As he acknowledges, the effect of Source Location can be variable. It is likely to vary not only with the Principles with which it is combined, but also on other factors, such as global loudness levels (e.g. onstage sound sources played *forte* may mask off-stage sound sources).

3.2 Timbral Rhythm in Theory and Practice

This study has thus far focused principally on the interdependence of timbre and pitch. The rest of the chapter explores timbre from a temporal perspective, specifically its change rate and 'rhythm'. Although a theory has not yet been developed to account for the phenomenon of 'timbral rhythm' as a perceptual phenomenon, a number of studies on rhythm and meter have discussed relevant issues.

Of all the theories of rhythm and metre, Fred Lerdahl and Ray Jackendoff's (1983) has generated the greatest response from the music psychology community. In an experiment that sought to confirm the Grouping Preference Rules of their theory,[15] Irène Deliège (1987: 352) found that instrument change (Deliège's Rule 7 (of 8))[16] had a particularly high degree of salience. The rules with the second highest degree of salience were register change (R3) for non-musicians and dynamic change (R4) for musicians; the rules with the third highest degree of salience were proximity of attack point (R2) for non-musicians and phrasing by slur or rest (R1) for musicians. Changes in articulation (R5), note duration (R6) and contour (R8) had much lower saliences for non-musicians, but changes in articulation (R5) were significant for musicians.

---

15 Rules that establish the 'formal structure of grouping patterns' according to listeners' intuitions. See Lerdahl and Jackendoff (1983: 36-7, 43-55).

16 Deliège uses the term 'timbre change', though her experiment tested instrument change.

Deliège's findings elevate instrument change from the parenthetical status it holds in Lerdahl and Jackendoff's study.[17] Her study supports the case for a theory of timbral rhythm, because the highest and second highest saliences of grouping criteria were essentially based on timbral changes. (This is consistent with my suggested Huron Rule P9 (ii).) The other saliences suggest that rules of proximity (R1 and R2) are secondary grouping criteria.

3.2.1 The Guidelines

The principal aim of a theory of timbral rhythm might involve determining textural and timbral divisions within a piece and associating each segment with the most salient characteristics of particular sound sources and/or timbral dimensions. Guidelines for achieving such an aim could include the following:

(i) Divisions may be made on a number of levels. Each level varies according to the degree of detail.

For example, at one level, bars 26-29 of '*Farben*' may be taken as a single textural segment (see Figure 3.3). Determining the relative significance of timbral events becomes difficult because the rate of instrument change is so frequent; the segment may be appreciated purely for its 'collage' effect. On the other hand, a slightly more analytical approach to listening may cause one to notice individual timbral features, which may then facilitate the division of the segment. A possible subdivision might occur at bar 28, where the previously unheard *sul ponticello tremolo* effect is played on 'cellos and violas. Beyond this, however, much smaller divisions would probably be necessary, and distinguishing between them may, in perceptual terms, be inappropriate.[18]

(ii) The divisions are often affected by type of change.

In other words, changes that have similar characteristics, or emphasise a particular aspect of a timbre dimension (such as a succession of incisive attacks), may be grouped as a segment.

---

[17] In Lerdahl and Jackendoff's study (1983: 46), rules of change are labelled a-d, but 'timbre change' (instrument change) is not assigned a label.

[18] The divisions will depend on stream salience. As mentioned earlier (p. 58), the highly variable possibilities for streaming in this passage of '*Farben*' depend greatly on the performance. See also Guidelines x and xi.

(iii) The divisions are often affected by subtlety of change.

Some changes are more distinctive than others. A particularly dramatic timbral event is likely to mark a division between segments at all levels. Although the attacks of tones usually suggest that a timbral change is perceptually significant, cut-off points can prove equally indicative. The end of the exposition provides a subtle and yet striking example of this (see bars 9-11).

(iv) Timbral dimensions should be assessed in order to determine divisions.

Dimensions are based on the basic conceptual model discussed in Chapter 1. Specification of dimensions that most contribute to divisions may be useful.

(v.a) Representing a segment as a specific time unit may facilitate discussion of a level.

At most levels, a time unit may be expressed as a note value (such as a quaver or crotchet), though at an extreme foreground level, an arbitrarily selected numerical time unit (e.g. 0.1 seconds) may be necessary in order to facilitate discussion of minute timbral details within the three portions of a sonority: 'attack', 'steady state' and 'decay'. Use of numerical time units at all levels would be particularly appropriate if the theory was applied to music that has a perceptually ambiguous or indescernible metrical pulse. Examples of such music may include electroacoustic compositions and pieces that feature frequent changes of tempo and time signature. For ease of interpretation, the units may be represented graphically as free-floating blocks.

In an acoustic piece, and with the aid of a score, it is usually possible to account for most timbral changes at foreground level by taking as time unit the smallest note value in the piece. Figure 3.11 shows the rate of timbral change in bars 1-11 of '*Farben*'; the semiquaver has been taken as the time unit. At this particular foreground level, the rate of timbral change is equivalent to the rate of instrument change. In order to account for the timbral changes later in the piece, the most extreme foreground level of the analysis could take the sextuplet demisemiquaver as the smallest unit (bar 29). Although it may be possible to determine the duration of a *staccato* semiquaver in terms of such demisemiquaver sextuplets,[19] the detail would give an unnecessary impression of complexity. Moreover, the extent to which there should be a gap between a pair of *staccato* tones is moot. As I suggested in Chapter 1 (see p. 10), where continuously-excited instruments are concerned, *staccato* is an indication to play in an impulsively-excited manner. It is an articulative indication that refers principally to the attack of the tone; it suggests an immediate 'decay' which either produces a silent gap because the instrument stops resonating before the next attack, or gives the impression of a silent gap because the tone becomes very quiet during the excited or resonant 'decay'. The extent to which there is a gap is also partly dependent upon tempo i.e. faster tempos may reduce the likelihood of a gap.

If the listener's conceptualisation of durations is informed by experience with notated music, it is likely that a perceived *staccato* semiquaver will be conceived as a semiquaver rather than as a shorter value followed by a rest. In other words, the conceptual (and ultimately the perceptual) distinction between a *staccato* tone and a non-*staccato* tone is primarily one of timbre, not duration.

(v.b) *At a background level, a single bar-length or more may suffice and main sections may be articulated usually by specifying the most distinctive timbral events in the piece.*

In '*Farben*', the most 'vivid' moment is commonly acknowledged as bar 31 (Burkhart 1973: 150). From an aural perspective, the preceding textural accumulation is not as striking as the sudden textural decrease marked by the spread chord in celeste and harp in bar 30 and the ensuing activity of piccolos, celeste and harp (bar 31).

(vi) *At all levels, the timbral segment is usually a multiple of the time unit. As in conventional rhythm notation, ties may be used to connect time units in order to account for the appropriate duration of the segment.*

As in Figure 3.11, if the unit is a semiquaver, the segment may be a semiquaver or quaver, or dotted quaver and so on. To create a level for every note value in the piece may, however, be impractical. For this reason, triplet quavers and quavers or semiquavers may function on the

---

[19] If three sextuplet demisemiquavers are equivalent to a semiquaver, a staccato semiquaver may be equivalent to approximately two sextuplet demisemiquavers.

same level. This is only appropriate if, for example, triplet quavers occur occasionally within a quaver or semiquaver context. If triplet figuration is common, a separate level for triplet quavers may be necessary.

If a segment overlaps into the next bar (see Figure 3.12), it would usually be shown with a tie. However, ties may not always be the most efficient way of defining a segment, especially in music that features different metrical systems running simultaneously. For example, in bars 670-80 of Alban Berg's *Wozzeck* (Act II, scene iv), the brass and snare drum cut across the 3/4 time signature as though they were in 2/4 (see Figure 3.13). These chords are heard collectively as a separate stream within the global texture. The perceived distinction between the '2/4' and 3/4 material is facilitated by obvious timbral differentiation (Huron's P9) and the positioning of the instruments (P10): the pseudo-impulsive brass chords (2/4) and impulsive snare drum strikes are played in the pit; the tavern band with its varied mix of continuously-excited, impulsive and pseudo-impulsive tones (3/4) play on stage.[20] As far as notation is concerned, it would be appropriate to reflect the distinct metrical systems in these bars.

(vii) The timbral segment functions as a time 'window' in which certain characteristics of the timbres contained within it are distinct from those of the adjacent segments.

Figure 3.11 shows a level in which the first two semiquavers of bar 2 of '*Farben*' are insufficiently distinct to be distinguished as separate time windows; instead, they merge to form a larger segment, which is a quaver in duration.

In the context of the *Wozzeck* scene discussed in Guideline vi, the '2/4' brass chords characterise bars 670-80 to such an extent that it would be appropriate to group them as a single segment (see Figure 3.13). The pseudo-impulsive brass sonority is the most consistent element within those bars; as such, it helps to contrast with the textures and timbres of the surrounding context.

---

[20] This is an example of different simultaneous tempi, as discussed in Chapter 2 (see pp. 39-40).

(viii) Stresses (-) may be placed above a note or segment to indicate timbral distinctiveness/textural emphasis.[21]

For example, in the opening bars, the timbral change on the fifth quaver is likely to be the most noticeable (see Figure 3.11), for a number of reasons: there are more instruments playing at this point than at any other point in the bar—in a sense it is the textural 'highpoint' of the bar; this highpoint differs from the first quaver of bar 2 in that the fairly bright combination, which includes the tones of cor anglais and trumpet, comes into prominence, whereas during the first quaver of bar 2 it is fading out to make way for the rather less bright combination of flutes, clarinet, bassoon and viola.[22]

In the suggested background level of bars 26-32 of '*Farben*' (see Figure 3.12), the spread chord, textural decrease, and the entries in bar 31 are the most distinctive moments. Stresses have, therefore, been placed above these bars. Whilst Burkhart's description of the triplet figure as 'the most vivid short event in the piece' (1973: 150) is partly due to the figure's unique rhythm,[23] it is the brightness of timbre, rhythmic clarity and repetitious pitch alternation within a short time frame that makes the figure stand out from its immediate context.

(ix.a) Horizontal brackets may be used to link segments where the change results from voices dropping out of the texture.

I have used the bracket to link an attack with the segment that follows the cut-off point (see Figure 3.11); for example, if the note is a dotted crotchet, the bracket extends to the fourth quaver.

(ix.b) Extensive overlapping of horizontal brackets (such as that which occurs in the exposition) *is generally a good indication of subtle timbral changes.*

---

21 Lerdahl and Jackendoff (1983) and Benjamin (1984) use the term 'phenomenal accent' to describe a stress or emphasis caused by timbre. I prefer to use the terms 'stress' or 'emphasis' because they avoid the associational baggage of the musical accent symbol (>).

22 Egon Wellesz, who was a contemporary of Schoenberg, also perceives the second chord of the first bar as 'somewhat brighter' (1925, 1970: 123).

23 The triplet rhythm can, nevertheless, be regarded as the culmination of an idea that develops during the climax. Note the introduction of triplets in bars 26 (beat 3) and 28 (beat 3), and the tremolo sextuplet semiquavers in bar 29 (beat 4).

(x) Stream salience should be estimated as a means of determining the level(s) to which the listener's attentional focus is most likely to be directed.

This may be achieved by judging textures according to tone distributions within timbre space and/or data generated by Parncutt's pitch salience algorithm and/or Huron's voice-leading Principles. The perceptually most salient streams are likely to feature the most salient timbral changes. Relatively non-salient streams that interact with or are momentarily perceptually more salient than the 'main' stream(s) are likely to cause rhythmic variations within a level or may direct a listener briefly to another level.

(xi) Timbral segment and stream salience should take into account schema-based listening and performance types.

Most music analysts' principal interests lie in various schema-based approaches to listening (see earlier, p. 51). If necessary, the analyst should clarify which schema(ta) the listener adopts, even when certain listener types (e.g. non-musicians/musicians) have been specified. For instance, schemata may be based on a single timbre dimension (such as brightness), or pitch relationships, or a specific level of timbral change rate. Such schemata are rather less flexible than most 'attention-driven' schemata (switching freely between pitch and other factors according to perceptual salience) which listeners usually adopt.[24]

The appropriateness of schemata may vary according to performances. For instance, a stream segregation schema is particularly problematic when applied to the textural accumulation passage in '*Farben*' (bars 28-29, see discussion of Guideline i). Such a schema is rather less problematic in the exposition, though here stream perceptibility is affected by brightness differences between the alternating chords. David Wessel (1978, 1979, 1999) found that differences in brightness cause adjacent tones to be perceived as separate streams (see also my suggested Huron rule P9 (ii), p. 59). The extent to which listeners make such perceptual divisions is dependent partly upon the rate of change: rapid alternations in brightness are more likely to cause stream division than slow alternations.[25] In most performances of '*Farben*', brightness differences between the alternating chords of the expository bars (the second chord

---

24 Musicians are often more likely than non-musicians to adopt pitch-relationship-based schema, particularly during 'aural test' conditions (Beal 1985: 411).

25 This is in keeping with Körte's third law of apparent motion in vision (Körte 1915). See Huron (under review, 2000) and Albert Bregman (1990).

is brighter, see Guideline viii) do not usually cause a stream division, because the differences are subtle and the rate of change is sufficiently slow for a single stream to be perceived. The consistent timbral differentiation means that alternate chord linking and stream segregation is, nevertheless, possible. Such segregation is likely to be much more pronounced if the performance is relatively fast and is poorly balanced, with each of the second chords played significantly louder (and therefore brighter) than the first chords.

(xii) The dominant features of the various levels may be combined to provide an impression of the listener's shifts of attentional focus.

In Figure 3.14, five levels of timbral rhythm are combined and arrows indicate shifts of attentional focus from one level to another. In bars 1-3, the main focus of timbral change happens on the second level, the timbral emphasis being on the second minim of each bar; this is due to brightness in the second instrumental combination. One is more likely to notice the crotchet tread of the fifth voice in these opening bars than in the rest of the exposition, perhaps because the crotchet on the second beat is the first obvious timbral change after the attack of the initial chord. However, the listener may not notice the first and third crotchets of this voice because they coincide with the minims, which are the main focus of attention; it is possible that the listener switches between these levels, maintaining a sense that two levels are functioning simultaneously, one subordinate to the other. In bars 4-6, the listener may be alerted to the pitch changes which draw attention to the sonorities at the beginning of each bar; whilst the fairly 'background' first level occupies the perceptual foreground, the second level may adopt a subsidiary role. In bar 7, the bass clarinet entry momentarily introduces into the foreground a more rapid rate of change and in the following bar, a pitch change alerts us to timbral changes on the first level. The double stress in bar 9 indicates the most distinctive timbral event so far, perhaps owing much to the brightness of the muted trombone in this context.[26] In bar 10, the minims may become the main focus, because a pitch change does not occur at the first level. In bar 11, the stress and square brackets indicate that the brightest timbres of the preceding sonority are cut off first, resulting in a striking timbre change early in the bar.

---

[26] Grey (1978) found that muting caused trombone tones to be perceived as brighter than most orchestral wind and string instrument tones of equivalent pitch.

Some Implications

In response to the above guidelines, Cook has suggested (private correspondence) that there could be 'different simultaneously active (and hence not strictly hierarchical) levels' of timbral change. This is certainly a possibility if the listener adopts a stream-segregation-based schema (see Guideline xi) for music that has an ambiguous or indiscernible pulse, and is extremely likely for music that features 'different simultaneously active' tempi, such as Ives's *The Unanswered Question* or *Central Park in the Dark*. When faced with such complexities, the analyst may need to consider carefully the practicalities of conveying musically meaningful information and this may entail rethinking the analytical notation, particularly the relationship between time unit and timbral segment.

Cook has suggested also that the regularities of timbral change may, in Christopher Hasty's terms (1997: 84-95), have 'projective potential' (the potential to be perceived as metre), and if such a thing as 'timbral metre' exists, it could be unrelated to the main metre. If we understand 'main metre' to mean a *perceptible* (as opposed to notated), multi-parametrical, integrated metre, it seems unlikely that a timbral metre could be unrelated: timbre cannot be easily separated from the factors that ultimately cause changes in timbre, such as dynamics, pitch (register) and harmony. Moreover, both main metre and timbral metre can be influenced by notated metre (or metre that is directly reconstructable from the score) because a listener's conceptualisation of notated metre can influence his/her perception.

That is not to say that timbral, main and notated metres are exactly the same. There is perhaps greater scope in atonal music for divergent metres because timbral variety need not have the traditional role of highlighting rhythmic ideas, such as motives and/or themes and is not so constrained by notions of harmonic rhythm. Moreover, the lack of conformity between 'compositional grammar' and 'listening grammar' that Lerdahl complained about (1988: 231-59) suggests that notated metre is removed from main metre (and timbral metre) in much twentieth-century repertoire even further than in tonal music. On the other hand, with conceptualisations of notated metre further out of the picture, the listener's focus is almost entirely on the metre of the timbre-influencing parameters (dynamics, pitch, etc); this means that the integration of timbral and main metres in atonal music may be even greater than in tonal music.

Where textures consisting of concurrent (non-)hierarchically related streams are concerned, each stream has a metre that is timbrally-defined, but also multi-parametrical and integrated: the stream metres are 'main' metres, and the listener does not necessarily integrate them into a 'global' main metre (see Guideline vi). Depending on performance type and the listener's schema, the chords in the exposition of '*Farben*' may or may not be integrated into a 'global' main metre. If one links alternate chords (see Guideline xi), the resultant streams have identical, but separate, 'metres' (each stream and each onset begins on a 'downbeat'). However, the relationship between these streams is such that, when the initial onsets are separated by a minim, the 'metres' slot together, enabling the listener to perceive a regular chord alternation within a single (global) main metre.[27]

Superimposed metres have the potential to affect tempo perception (see Chapter 2, p. 39) and/or give rise to formal/structural devices, such as canons. The 'alternate-chord' streams in the exposition of '*Farben*' may be perceived as 'canonically' related, because they are rhythmically (and metrically) identical, superimposed with staggered entries, and the second stream is a 'transposition' (in Wessel's terms, a timbral 'analogy') of the first. The chimeric percepts of the streams' sonorities are situated within different areas of timbre space and their pitch changes cause shifts that are within common timbre dimensions (e.g. brightness), in the same direction and approximately to the same degree.[28]

If we understand the notion of timbral/stream 'transposition' in this sense, the pitch canon that is embedded within the 'alternate-chord' streams is itself 'timbrally' canonic. Within each of the 'alternate-chord' streams, each of the five canonic voices is timbrally both 'unique' (separate sound source) and consistent (though see my discussion of Huron's P9, pp. 59-60), and each pitch ascent and descent corresponds to a slight increase and decrease in brightness. If this is a valid example of a 'timbral' canon, it has implications for most standard pitch-based canons, which have sound-source consistent voices.

[27] In Guideline vi, I discussed metres that are not so simply related.
[28] Conceivably, other timbral transpositions are possible by shifts that are not motivated by pitch change.

Throughout this study, I have suggested various schemata that the listener may adopt in order to enrich his/her perception of '*Farben*'. I have demonstrated how aspects of auditory streaming and timbral rhythm may play important roles in those schemata. The perceptibility of pitch and 'timbral' canons, timbral rhythms, and timbral metres is dependent upon the listener's capacity for imagination; the listener is able to switch between and modify the various schemata. This suggests that a perceptual reading, no matter how flexible, will always fall short of how listeners really perceive music. Nevertheless, if the schemata that the analyst proposes do have a perceptual basis, they may help the listener to develop his/her essential role in the 'constitution of the musical artwork' (Cook 1990: 17).

Chapter 4

Allusion in '*Farben*' and *Wozzeck*

4.0 Introduction

In Chapter 3, I demonstrated how data from Parncutt's pitch salience algorithm, Huron's voice-leading Principles, and timbral rhythm guidelines provide a sound basis for a theory of timbre for music analysis. Whereas my discussions focused principally on perception of contiguous sonorities/textures, most of my discussions of timbre in this chapter will focus on gestural and motivic networks, showing how manipulation of timbre dimensions may lend structural coherence to disparate events. The networks require the listener to adopt specific schemata, which call for often fairly high levels of attention.

The study begins with a discussion of timbre's role in the perceptual networks of '*Farben*'. It will broaden to encompass issues of influence, allusion, narrative and autobiography. Possible links between Schoenberg and Berg will be drawn, particularly in relation to '*Farben*' and Berg's *Wozzeck*.

4.1 Schoenberg's '*Farben*'

4.1.1 Networks

In Chapter 1, I suggested that timbres may be distinguished most often according to rapidity of attacks and decays, and brightness. The following analysis of '*Farben*' supports these findings: differences within impulsiveness-continuous and brightness dimensions highlight aspects of the piece's structure.

Where the relationship between the five-voice (pitch) canon and the non-canonic material is concerned, differences of impulsiveness-continuousness are particularly significant. The canon consists of continuously-excited tones. Set against this backdrop, the impulsively-excited tones in the piece are likely to be perceptually linked simply by virtue of their 'impulsiveness'. The non-canonic material that is not 'impulsive' may be characterised usually as pseudo-impulsive. For instance, where the two-note motif is concerned (see Figure 3.3, bar 9), the first note is staccato and the second note is usually performed as though it were a slow decay, fading into the canonic texture (e.g. Barenboim 1995, Craft 1995, Rattle 1989, Zender 1997); the *diminuendo*/decay effect is employed so that the figure is the leading voice only until the end of the *Hauptstimme* marking.[1] In this opening section, the motif diverts attention from the canon's steady rate of instrument change. In bars 26-30, on the other hand, the sustained tone of the two-note motif can be regarded as one of the most continuous and stable elements amidst an array of rapid instrument changes. Since there are no *Haupstimme* markings here, there is a case for maintaining a consistent dynamic level throughout the duration of the sustained notes.

As the textural accumulation reaches a climax, the 'continuousness'-'impulsiveness' distinction between canonic and non-canonic ideas becomes fuzzy. In bar 29, a motivic link between the three-note canon subject (ascending minor second and descending major second) and the two-note motif (descending major second) is made perceptible through the rhythmic diminution of the canon subject. The contrabassoon, third trombone (muted), fourth trombone (unmuted) and *pizzicato* double bass combine the canonic and non-canonic ideas.[2] Rhythmic modification of the canon subject caused by elongation of the first and third notes facilitates isolation of the two-note motif in the contrabassoon line. The double bass solo plucks each pitch change, further drawing attention to the two-note subcomponent. Rhythmically-modified versions of the canon are played firstly by unmuted fourth trombone (D_3-Eb_3-Db_3) and secondly by muted third trombone (Db_3-D_3-C_3). Doubling the muted third trombone pitches in the second half of bar 29, the unmuted fourth trombone's semiquavers restore equal note values to the canonic idea. The combination of the *legato* contrabassoon and trombone lines and the doubling of the pitch changes by *pizzicato* double bass fuses the ideas of continuous and impulsive timbres at the height of the piece's textural accumulation. In bar 29, the two-note motif can be heard in the three solo *arco* double basses. This may be perceived as in stretto-like dialogue with the impulsive two-note motifs embedded in the canonic lines.

Timbre plays a role in linking also non-canonic ideas; interestingly, many of these developments occur in the Coda (bars 39-44), drawing together ideas from each of the piece's earlier sections (see Figure 3.1). In bars 39-40, the two-note descending motif is again heard in

---

1 Schoenberg used *Haupstimme* markings in the 1949 version; these are now supplied in the most recent edition of the 1922 version.

2 Incidentally, a plucked string instrument tone is far more inharmonic than a bowed string tone; the harmonicity of the bowed tone is caused by the continuous excitation, which 'resets' the harmonics each time the string is 'pulled back' (Robert Scott: private communication, 1996). The inharmonicity of the plucked tones contributes to a global increase in inharmonicity which occurs at the textural climax of the piece.

the basses (a reference to the Exposition), but this time it is doubled by the harp. Although having a different rhythm than the end of bar 24, the impulsive quality of the harp attacks is reminiscent of the previous timbre (a reference to the Development), though certainly not as bright because the register is lower and it is not doubled by celeste. The gesture is also the same: whereas in bars 24-25 the descending demisemiquavers lead into a chord of artificial string harmonics, in bars 39-40 the semiquavers lead into a chord played on *sul ponticello tremolo* strings. The fact that the *sul ponticello* effect places emphasis on the upper harmonics of complex tones may provide a perceptual link with the artificial harmonics in terms of the brightness dimension,[3] though the effect is perhaps more overtly a reference to its only other appearance—bars 28-29 of the climax.

The timbral links between motives do not stop there. The crotchet tread associated with voice 5, which has been absent in the Recapitulation, is reintroduced by the linear octave descent in the harp (bar 41); the lowness of register reinforces the link with the fifth voice. In drawing attention to its absence, this crotchet tread may be perceived as an 'allusion' to the Recapitulation. (The principal allusion to the Recapitulation is the pitch retrogression of the canon.) This bar is linked also to the First Bridge Passage. In bar 12, the harp provides a bright attack for each note of a broken chord, and a note or notes of the chord are each time sustained by a different instrument, or combination of instruments; in bar 41, the harp's notes are sustained by 'cello, tuba and contrabassoon, respectively. Bar 12 is apparently the first instance in Schoenberg's works of what Robert Craft has described as 'a new application of the *Klangfarben* idea' (Craft 1995: 11)

Peter Förtig (1969: 209) has suggested that a link exists also between the C# notes of the harp in bar 41 and the piccolo Bs in bars 16-17, but provides no explanation for his claim. However, if the harp figure is extended to include bar 42, the link becomes apparent: the rhythm of the attacks is identical to that of the piccolo in bars 16-17. By extension, bars 41-42 are linked to the Second Bridge Passage, because the triplet quavers (bar 31) have an obvious

---

[3] Artificial harmonics are most easily produced when bowing close to the bridge. Since research has shown that bowing close to the bridge emphasises the upper harmonics (Campbell and Greated 1987: 213), it follows that the artificial harmonics, which are complex tones, are likely to have strong upper partials. A psychoacoustical study by Grey (1977) confirms that listeners perceive the brightness of a *sul ponticello* cello tone as brighter than a 'normal' cello tone (and, as we would expect, a *sul tasto* tone is the least bright).

timbral association with the repeated Bs idea of bars 16-17; in both cases, the bright, impulsive quality of the celeste provides colour and emphasis to the middle of the piccolo line. A spread celeste chord in bar 43 reinforces the link with the Second Bridge Passage. This distinctive sonority is characterised by an initial rapid succession of impulsive attacks that cause a perceptible rapid increase in brightness during the attack portion. In bar 30, it marks the cessation of the fifth canonic voice crotchet tread (which is greatly obscured in the preceding bar) and the end of the textural climax of the Development. In bar 43, its function is reversed: it marks the full resumption of the crotchet tread as the principal rate of timbral change in the fifth voice (the crotchet tread in bars 41-42 is only partial).

Although the above analysis is by no means exhaustive, I have demonstrated that isolation of certain dimensional aspects of individual timbres is clearly important for facilitating the articulation of timbral links amongst the various musical ideas in '*Farben*'. These links are structurally interesting as they stand, but they have even greater musical meaning if framed within an extra-musical context.

4.1.2 A secret programme

The principal extra-musical factors that affect the meaning of '*Farben*' concern episodes in Schoenberg's life. According to Stuckenschmidt (1974: 94), Schoenberg was profoundly affected by various events in the early 1900s, particularly Mahler's departure from Vienna in 1907. He began painting in 1905/1906, and by 1907 was using the activity as a form of escapism. His seclusion eventually brought about a crisis in his marriage.

Both Schoenberg and his wife Mathilde began to receive painting lessons from the young painter Richard Gerstl. [4] Gerstl grew close to the Schoenbergs and, in 1908, rented a studio in their house so that they could paint together more easily. The arrangement seemed mutually beneficial: Schoenberg was taught the basic principles of painting and his 'unconcerned attitude to the technical' (Hahl-Koch 1984: 168) influenced Gerstl's independence.[5] However, in the summer of 1908, they spent a family holiday at Gmunden that was to reveal the extent

4 Gerstl was the first 'Fauvist' painter in Vienna.

5 In a handwritten memorandum '*Malerische Einflusse*', 11 February 1938 (see Hahl-Koch 1984: 167), Schoenberg would later dismiss such claims, believing that Gerstl mistakenly assumed that the 'miserable appearance' of his paintings was 'intentional'.

of Schoenberg's marital crisis. Schoenberg discovered that Mathilde and Gerstl were having an affair.

That these events impacted on Schoenberg's Opus 16 (as indeed on *Erwartung* (1909), the Second String Quartet (1910), and *Die glückliche Hand* (1911-1913)) is often acknowledged, but the extent of the impact is rarely discussed in any detail. Alan Street's (1994) discussion of the musical implications of these events is perhaps the most thorough.

Street raises the possibility that Opus 16 may be read as an auto-/psycho-biographical narrative. Conceding to a request from his publisher, C.F. Peters, in 1912, Schoenberg provided titles for the pieces; he felt that his titles were sufficiently obscure so as not to give away too much.[6] Nevertheless, in the context of the Mathilde-Gerstl affair the titles 'Premonitions' (No. 1) and 'The Past' (No. 2) have obvious connotations. The implications of the title '*Farben*' (No. 3) are more difficult to ascertain, but Street suggests that the revised title for the 1949 version of the piece—'Summer Morning by a Lake (Colors)'[7]—refers to Schoenberg's 'point of repose' (Street 1994: 178) when overlooking Lake Traunsee at Gmunden. Since painting played a central role in initiating the affair, it seems fitting that Schoenberg's creative response is an aural painting of the Traunsee landscape.[8]

Street links the discovery of the affair—an 'essential turn from ignorance to knowledge'—to Aristotle and the plot of tragic drama (179). The '*Peripeteia*' (No. 4), which follows '*Farben*', is a 'reversal of fortune' that may refer to Schoenberg's (mis)'fortune'; after the affair was out in the open, Mathilde left Schoenberg, and like many other intellectuals of the time, Schoenberg considered commiting suicide.[9] But the piece's turbulence suggests that this '*Peripeteia*' may be more likely to refer to Gerstl, whose 'fortune' is more genuinely 'reversed'. Amongst others, Schoenberg's pupil Anton von Webern persuaded Mathilde to

[6] Diary entry, 27 January 1912 in Willi Reich (1968: 51-52).

[7] This title dates from 1925 (Street 1994: 169).

[8] According to Kolisch in Smith (1986) and Malcolm Macdonald (1976), Schoenberg admitted that the ascending demisemiquaver motif was a 'jumping fish'.

[9] Important figures who committed suicide include three of Ludwig Wittgenstein's brothers (Hans, d.1903; Rudolf, d.1904; Kurt, d.1916), the poet Georg Trakl (d.1914), and Otto Weininger (d.1903) (Jelena Hahl-Koch 1984: 201).

return to Schoenberg for the sake of the children (Macdonald 1976: 7).[10] She did eventually return, and Gerstl committed suicide (4 November 1908).

This reading of '*Farben*' may be developed: specific musical ideas may pertain to the protagonists and events of the affair. Street suggests that the revised title 'Summer Morning by a Lake' is 'an allusion to the figuration of desire [for Mathilde] through liquid tropes'; an idea that is in keeping with the nineteenth-century practice of alluding to notions of desire and femininity through 'images of fluidity'. If this idea is valid, the continuous movement of the canon might be said to represent Mathilde; moreover, in the Exposition, the alternation between, and interlocking of, streams characterised by different instrument combinations (see Chapter 3, p. 69) might represent the duality and interaction of the Mathilde-Schoenberg relationship, the potential for fusion and streaming conveying perhaps the potential for both unity and disunity in the relationship.

Such attribution of the autobiographical to musical ideas may be taken even further. The two-note descending motif, see Figure 3.2b (i), which contrasts with the canon, may function as a *leitmotif* that represents Schoenberg, or perhaps what Schoenberg did wrong. It leads into the subtle, but dramatic timbral event of the First Bridge Passage: a cessation of both regular instrument group alternations and pulsations (fifth voice), followed by staggered tone cut-offs that leave suspended a four-note sustained chord played by solo celli—a desolating effect.[11] The isolation of solo celli is particularly significant, because the cello is an instrument with which Schoenberg is closely associated.[12]

The First Bridge Passage marks a turning point; the vivid 'new application of the *Klangfarben* idea' (see p. 74)[13] initiates the canon's timbral transformations (now no longer alternations) that might represent the burgeoning of the Mathilde-Gerstl affair; the non-canonic material of the Development (see Figure 3.2b, ii, iii, and iv) might even represent Gerstl. The appearance

---

10 Interestingly, Webern has a strong connection with the Opus 16 pieces; in 1912 he arranged the work for two pianos (see Chapter 5, p. 93).

11 For implications and notation of Timbral Rhythm, see Chapter 3, p. 62, Guideline iii.

12 He played the instrument. The solo cello may be associated also with the Man in *Die glückliche Hand*, which is another of Schoenberg's works of this period that is about a love triangle (see this Chapter, p. 75-6).

13 In Rattle's performance (1989), this is particularly vivid: Rattle's tempo is slower in this bar, resuming the original tempo when the canon proper resumes. By slowing down, Rattle facilitates perception of the details of the different timbral characteristics of each note of the broken chord.

of the Schoenberg (two-note) *leitmotif* during the retrogression of instrumental combinations (see Figures 3.3 and 3.5) denotes perhaps Schoenberg's request for Mathilde's return. The subsequent embedding of the *leitmotif* within the canon is in keeping with the desire to be united with Mathilde, and its occurrence during a textural accumulation and dissolution of the texture perhaps links it to Schoenberg's emotional breakdown.

The most 'vivid' moment in the piece (see p. 63), which follows in the Second Bridge Passage, is a conflict between Schoenberg's *leitmotif* and bright piccolo tones (triplets), which are characteristic of the (Gerstl) Development. This turning point (Mathilde's decision?) leads to the retrogression of the canon, which may represent Mathilde's return to Schoenberg. However, the absence of the pulsating fifth voice here is perhaps significant: Mathilde returns, but the relationship is lifeless. Moreover, the lack of dual, interlocking streams (alternating instrument-combinations) is consistent with the notion of a relationship that lacks convivial interaction.

In the Coda, reflective allusions to the earlier non-canonic and canonic material are in keeping with the introspective nature of Schoenberg's 'point of repose'.[14] After linking the initiation of the affair (First Bridge Passage) to Gerstl (a piccolo motif, Figure 3.2b, ii) (bars 41-42), the spread celeste chord and resumption of the pulsating fifth voice, suggest perhaps that, having dealt with the issues that instigated the Mathilde-Gerstl affair, the Schoenberg-Mathilde relationship is revived.

4.2 (Auto-)biography, Secrets, and Berg's Anxiety of Influence

My narrative reading of '*Farben*' may seem rather indulgent; however, latent associations between (auto-)biographical events and specific musical ideas/structures are typical of Second Viennese School composers.[15] Schoenberg alludes to music's capacity for harbouring secrets in his diary entries (28 January 1912):

> ... one can say everything in [music], so that *he who knows understands everything* [my emphasis]; and yet one hasn't given

---

[14] Unlike some musical developments, they are not 'teleological'. I will discuss examples of teleological developments in Chapter 5, particularly in reference to Opus 10 No. 2 (see pp. 117ff).

[15] In Chapter 5, I will demonstrate how secret programmes may be harboured also in Webern's compositions.

> away one's secrets—the things one doesn't even admit to oneself. (Trans. Walter B. Bailey.)

Such comments seem to support the notion of a hidden programme in '*Farben*'; the idea that 'he who knows understands everything' suggests that those close to Schoenberg may have been at least partially aware of the encoded messages.

Sketches of Berg's *Chamber Concerto* (1923-25) support this hypothesis. They reveal annotations that refer explicitly to the Mathilde-Gerstl affair (Jarman 1997: 170), and the music features structures that are similar to those outlined above. In particular, the middle movement of the work (subtitled 'Love' in the sketches) is a palindrome; a timbrally unique moment marks the point of reflection (the solo piano makes only one appearance in the movement (bars 358-63), chiming 12 times on a low C#), and the subsequent retrogression conveys Mathilde's return to Schoenberg.

However, Berg's motives for making such allusions to Schoenberg's domestic life may not have been always charitable. For instance, Pople (1997: 152) suggests that, in *Wozzeck* II/iii, Berg criticizes Schoenberg's reaction to Mathilde's unfaithfulness. The main protagonist (Wozzeck) accuses his mistress (Marie) of having an affair with another man (the Drum Major); Berg transposes ideas to generate specifically the pitches A-Eb, which correspond (in German) to Schoenberg's initials (A. S.). Whether or not this parallel is a criticism is unclear, because we sympathise with both Wozzeck and Marie. However, we sympathise with Marie because of her need for a supportive lover/husband; Wozzeck's inadequacy in this capacity might be read as analogous to Schoenberg's problem.

Pople points out that 'another private joke at Schoenberg's expense' occurs at I/iv (bar 520) (see Figure 4.1): the Doctor refers to the regularity of his pulse ('my pulse is beating its usual sixty'), and Berg makes an allusion to the opening '*Farben*' chord (transposed up a semitone). The exact nature of the joke is, again, not entirely clear. The allusion is further acknowledgement of the link between the 'pulsating tempo' of '*Farben*' and the notion of life-giving force, because the moderate tempo (♩ = 60, each beat marked by a *Haupstimme* staccato cor anglais tone) gives rise to a principal rate of timbral change that corresponds to the *Mäßige Viertel* (moderate crotchets) of '*Farben*'.[16] Whether or not one perceives this as a joke, the important point here is that the reference to '*Farben*' is framed within the context of passing time, life and, by implication, mortality—issues that, as will be discussed later, have great significance for Berg.

Berg's anxiety of influence

Berg's mixed feelings about Schoenberg are symptomatic of what Harold Bloom calls the 'anxiety of influence'.[17] Although composers such as Brahms, Wagner and Mahler influenced Berg, one can find traces of real neurosis about Schoenberg's influence in the correspondence:[18]

> I shall be dedicating the new pieces for orchestra [*Three Pieces*, Opus 6] to Schoenberg. As my teacher he has long been due for a large-scale work dedicated to him by me... [He] was my inspiration for it, not only through my listening to his own pieces for orchestra [Opus 16] (*but remember, mine don't derive from them, they will be utterly different* [my emphasis]) but because he urged and advised me to write character pieces. (Letter to Helene, July 1914; trans. Gruhn 1971: 159.)

In a letter that revealed a rift in his relationship with Schoenberg, Berg made it quite clear that he had set out specifically to please his mentor (letter to Schoenberg, late November 1915). Berg nearly always sought to assert his creativity in a way that would meet with Schoenberg's approval. One of the ways that he achieved this was through 'wilfully revising' and 'distorting' the work of others, including Schoenberg's techniques. Such wilful revisionism is, in Bloom's terms, an act of 'misreading' that the artist must carry out in order to situate his/her work in relation to history.

16 Both tempi lie within the low tactus range: 60-84 beats per minute is 1-1.4Hz). (In III, bars 109ff, Berg suggests that a *Mäßige* tempo is 80 beats per minute.) According to Vijay S. Iyer (1998), the lowest tactus rate is approximately 1.2 Hz (the highest rate is 3.3 Hz).

17 Harold Bloom is a literary theorist. His work (1973, 1975, 1988) has been applied to music principally by Straus (1990) and Kevin Korsyn (1991). Bloom suggests that misreadings may exist even if one cannot specify the passages or works that are 'misread'—they are not necessarily perceptible. Investigation of such phenomena lies, however, beyond the scope of this thesis; I focus primarily on links where resemblance is perceptible.

18 Schoenberg's official tutelage with him ended some years before the pieces were written.

Berg's anxiety of influence may have been compounded by Schoenberg's reaction to the *Altenberg Lieder*. Schoenberg disliked aspects of the songs because he felt that Berg was overzealous in his use of 'new means' (letter to Berg, 14 January 1913):

> I find some things disturbing at first, namely the rather too obvious desire to use new means. Perhaps I'll come to understand the organic interrelationship between these means and the requirements of expression. But right now it troubles me.

These songs feature allusions to Schoenberg's works. The crux of Schoenberg's objection might have been a lack of understanding about the 'organic interrelationship' between the 'requirements of [structural and textual] expression' and Berg's 'misreadings' of new Schoenbergian techniques.[19] On the other hand, Schoenberg responded very positively to some passages, which suggests that he might have approved of the 'misreadings'. He might have perceived Berg's 'wilful revision' and 'distortion' of Schoenbergian techniques as 'organic' developments that would help to secure his (Schoenberg's) position within history.

4.3 '*Farben*' misreadings in the *Altenberg Lieder*

In the *Altenberg Lieder*, Berg makes various allusions to Schoenberg's work, and some of the most interesting timbral effects are 'misreadings' of '*Farben*'. In keeping with his depiction of the Doctor's 'pulse' in *Wozzeck*, he seems to misread '*Farben*' as a Time *leitmotif*.

Passing Time

Different instrument combinations playing a single chord seem to represent passing time. In *Altenberg Lied* No. 3 (see Figure 4.2a), this occurs in the opening bars, where twelve solo wind instruments play a twelve-note chord (based on the notes of the chromatic scale: C#2-G#2-D3-G3-A#3-D#4-F#4-A4-C5-E5-F5-B5). As in '*Farben*', the tempo indication is *Mäßige Viertel*, though the principal timbral changes occur every semibreve (the chord reiterations are effectively in 4/4 against the voice that is in 3/4) rather than every minim. The text of the song refers to a 'point of repose' that, in the context of this instrumentation, seems to allude to Schoenberg's contemplations when overlooking the Traunsee before and after the

[19] Arved Ashby (1998: 226) claims that Schoenberg (letter to Berg 14 January 1913) took issue with certain playing and singing techniques, misleadingly citing as examples effects such as harmonic glissandi, timpani glissandi and bowed col legno. However, in his letter to Berg Schoenberg does not mention such techniques; the techniques that he discusses feature in his own *Gurrelieder*; he describes how one should execute *Sprechmelodie*.

discovery of Mathilde's affair. In the context of the affair, the references to a careless approach to domestic life and the sudden ending of both (that) life and life's dream(s) are particularly poignant.

> *Über die Grenzen des All blicktest du sinnend hinaus.*
> [Beyond the boundaries of the universe you still thoughtfully gaze!]
> *Hattest nie Sorge um Hof und Haus!*
> [Never had a care about hearth and home!]
> *Leben und Traum vom Leben—plötzlich ist alles aus*
> [Life and the dream of life—suddenly all is gone ...]
> *Über die Grenzen des All blickst du noch sinnend hinaus!*
> [Beyond the boundaries of the universe you still thoughtfully gaze!]

In the following song, dovetailed instrument groupings (playing the chord F#-Eb-C#-F) occur during a reference to waiting (No. 4, bars 9-15; see Figure 4.2b):

> *Nichts ist gekommen, nichts wird kommen für meine Seele—*
> [Nothing has come, nothing will come for my soul—]
> *Ich habe gewartet, gewartet, oh, gewartet!*
> [I have waited, waited, oh, waited!]
> *Die Tage werden dahinschleichen, und umsonst wehen*
> [The days will drag on, and in vain]
> *meine aschblonden, seidenen Haare um mein bleiches Antlitz!*
> [my ashblond, silken hair blows around my pale countenance!]

The sense of loneliness and the reference to a restless soul in limbo are in keeping also with the proposed narrative reading of '*Farben*'. However, this limbo may be read not just as a reference to Schoenberg's sense of defeat that Mathilde will not return; it is perhaps also an allusion to Gerstl, because limbo/purgatory is the penance of those who commit suicide.

Klangfarben 'crescendi': Change

Bar 12 of '*Farben*' is another influential timbral effect (see Figure 3.3). This 'new application of a *Klangfarben* idea' may be described as a *Klangfarben* '*crescendo*'. In a sense all *crescendi* are 'timbral', because an increase in loudness often modifies the timbral characteristics of a sonority (see Chapter 1, p. 18). However, an increase in the strength and spread of spectral components may be achieved also through increasing the number of parent timbres contributing to a chimeric percept.

Berg seems to allude to the '*Farben*' '*Klangfarbencrescendo*' during the final line of *Altenberg Lied* No. 3 (see Figure 4.2a). Sustained tones 'natural harmonic' tones of divisi strings) are doubled by impulsive, slightly inharmonic tones (bell-like celeste tones), building up to create an ethereal effect. The timbral shifts are more unidirectional than in the '*Farben*' *Klangfarbencrescendo*, because all of the sustained tones belong to the same instrument family; the sonority may be perceived not just as a broken chord that the strings sustain, but as a finely graded increase in brightness.

In the narrative reading of '*Farben*', the '*Klangfarbencrescendo*' denoted a significant change—the burgeoning of the affair. At the end of *Altenberg Lied* No. 3, the change is that life is over. The ethereal sonority seems to refer to the contemplation of 'change' (perhaps alluding to the turning point that initiated the development of the Mathilde-Gerstl affair). Moreover, the references to the soul and the ending of life have connotations of death; read from this perspective, the song may allude to the afterlife, which is represented in song No. 4 (see earlier).

4.4 Depictions of Time, Change and Fate in *Wozzeck*

The concepts of Time and Fate have long been acknowledged as significant dramatic themes in *Wozzeck*. In this section, I will discuss how Berg manipulates timbre to convey these ideas, showing also how the concept of *Klangfarbencrescendo* is developed and how the '*Farben*' Time *leitmotif* may offer further insight into Berg's anxiety of influence.

4.4.1 Klangfarbencrescendo in Wozzeck

Wozzeck features a most striking *Klangfarbencrescendo*. In contrast to the *Klangfarbencrescendo* of '*Farben*', the cumulative effect is created through staggered entries on a single note (B3) and the initial attack of each tone entry is non-impulsive (see Figure 4.3, bars 109-14). This *Klangfarbencrescendo* may be perceived in a variety of ways. For instance, the listener may adopt a 'pointillist' schema, hearing the timbral changes as a non-pitch-varied *Klangfarbenmelodie*. On the other hand, the *Klangfarbencrescendo* sonority may be perceived as a succession of tones that fill out different aspects of the aggregate spectrum. This schema is similar to conventional chord perception, though there is greater potential for fusion. The lack of impulsiveness for each tone entry contributes to this potential for fusion;

some of the tones, which are marked *pppp*, have the capacity to emerge *niente*, which means that their perceptual salience depends solely upon the qualities of their steady state portions.

Gradual fluctuations in the saliences of instruments may be attributed to various specificity dimensions. For instance, the progression from 'clarino' bass clarinet to chorus Bb 'chalumeau' clarinets shows greater expansion within the hollowness dimension (chalumeau tones sound more 'hollow' than clarino tones). The sonority retracts from hollowness as a different dimension comes to the fore: the progression from clarino bass clarinet to chalumeau clarinets corresponds to an increase in 'nasality' or 'reediness' that is followed by a steeper increase on the oboes' entry.[20] The sonority retracts from reediness on entry of three bassoons and bass tuba—a chimeric percept that draws the sonority towards the region of timbre space occupied by brass instruments (see Chapter 1 on spectral flux and jitter).

One could describe such gradual shifts within dimensions as organic—the sonority increases in 'mass' as it spreads throughout timbre space. As it develops, brightness increases, partly as a result of the overall increase in dynamic levels, and partly because the sonority begins with tones that have limited upper partials (solo muted horn and muted string). These tones are followed by tones that have stronger upper partials, a strong fundamental and some missing partials (solo bass clarinet and clarinets). The final entries are tones that have more partials and stronger upper partials (chorus and unmuted instruments).

The gradual increase in the number and strength of upper partials increases the spectral centroid height of the aggregate. This increase is a robust global trend, but a certain degree of gradual fluctuation occurs. For instance, the four trumpets' entry (bar 112) is likely to be the brightest entry,[21] but is followed by tones that have lower centroids. In the following fermata bar, the trumpet tones are likely to cut through the texture; trumpets in F are known for their great carrying power and their tendency (more than any other type of trumpet) to dominate the orchestra (Adler 1989: 300).[22]

---

20 Reediness may be a phenomenon that results from formants (see p. 17).

21 The trumpet has one of the very highest spectral centroids in the McAdams et al model (see Chapter 1, pp.13-14).

22 Note that Cogan's spectrograph (see p. 85 and Figure 4.4) does not show such amplitude nuances.

Berg (1929) regarded this *Klangfarbencrescendo* as 'of greater dynamic and intensity' than a version, which follows, that is played by the full orchestra in different registers and supported by percussion. This view may be attributed partly to the global amplitude of the initial entries, which is far lower in the first *crescendo*. However, the perceptual difference between the *crescendi* is not so much the dynamic range; it is a difference in the dynamic level of the opening entries (the first crescendo starts at a far lower global amplitude). The first crescendo's 'intensity' is perhaps related to this difference.

The second *crescendo* (or *Klangfarbencrescendo*) achieves its intensity through different means. Cogan has produced a spectrograph analysis of these bars, which shows effectively the gradual global increase in the number of upper partials in both *crescendi* (see Figure 4.4). The percussion of the second *crescendo* fills out many of the upper partials and even shows the loss of lower frequencies at the height of the climax. This reflects how, as the sonority progresses, the second crescendo increases in inharmonicity and brightness far more than the first crescendo.

Timbral rhythm

The differences between the *crescendi* relate also to timbral rhythm: in the first crescendo the phenomenon is structurally significant. In a lecture on *Wozzeck* (1929), Berg pointed out that the instrumentation of this passage was ordered canonically: the strings play the rhythm that is begun by the winds a crotchet earlier. This canonic treatment of streams reinforces the link with '*Farben*' (Exposition; see pp. 66-7, 69). However, the sustaining of tones throughout the passage reduces the impact of timbral differentiation (P9) on the perceptibility of the streams and some of the timbral differences amongst winds may be greater than the differences between individual winds and strings.

Canonic perception may be difficult also because the perception of timbral rhythm (instrument change level) is obscured by the ambiguous (*niente*) initial onsets of the strings and clarinets; however, hollowness in the steady state portion of the clarinets' tone(s) is likely to make the entry perceptually salient.

Although the canonic relationship between wind and strings may be difficult to perceive from a timbral perspective, the canon subject's rhythm is perceptible in the winds. The string tones are the least salient tones not only because their onsets are unusually subtle. The differences between the instrument types are perhaps the least pronounced of any conventional instrument family; they are likely to be perceptually grouped (principally because of close proximity within spectral flux and jitter dimensions). Moreover, the members of this instrument family are most evenly distributed throughout the *Klangfarbencrescendo*.

Various factors contribute to the salience of the wind entries. The muted horn emerges from silence (bar 109). The bass clarinet is more 'hollow' and brighter than previous entries. (It is in the clarino register; see also Sandell data Chapter 1, pp. 13-14.) The four clarinets' chalumeau tones are more distinctively hollow than the bass clarinet clarino tone, and are further distinguished by the chorus effect. The unmuted horns doubled by solo viola are brighter than the opening muted horn, and their lack of 'hollowness' contrasts with the preceding 'hollowness'; they are perceptually more distinct also because of the chorus effect. Where the four oboes are concerned, B3 tones are notoriously difficult to produce at a *pppp* dynamic even for a single oboist—four oboists are likely to compound the problem; the result is likely to be a particularly incisive, 'thick and heavy' tone (Adler's term)—a 'solidity' that may be attributed to the limited spectral flux. Similarly, the four trumpets are likely to have difficulty producing a *pppp* or *niente* attack; they may be salient also because of the unusually high brightness and distinctive waveform jitter (see pp. 7-8 and Figure 1.6) of their tones. The bassoons of the bass tuba and three bassoons entry may produce a perceptibly incisive attack. Where the four trombones are concerned, the absence of 'reediness' contrasts with preceding entries, and the difficulty of producing a unison *niente* may result in a noticeable attack (though the violas may reduce the impact of this attack).

Although wind instrument tones are the most salient, the wind tones that are doubled by strings are likely to be in the middleground because the doubling facilitates blend with the (background) strings. The emergent timbral rhythm is an exact augmentation of the rhythm heralded by the timpani in bars 114-115 (see Figure 4.5), and the most salient tones (oboes and trumpets) convey the relative strengths of the rhythm's accents as they might be convincingly executed: the oboes occur on a syncopation and the trumpets emphasize the first note of the ♫♩ rhythm.

4.4.2 *Fate and Time*

In keeping with other instances of *Klangfarbencrescendi*, the *Wozzeck Klangfarbencrescendo* depicts change; it is part of an orchestral interlude that occurs during a scene change, but has greater structural and dramatic significance than a simple bridging of two scenes.

In the scene that precedes the interlude (III/ii), Wozzeck murders Marie. The scene is an 'Invention on the note B'. This pitch has peculiar significance for Berg: it is part of the tritone B-F, which Berg associated with Fate. In the interlude, the emergent timbral rhythm is the rhythm on which the next scene (an 'Invention on a rhythm') is based. The organicism of the *Klangfarbencrescendo* and the linking of the B and the rhythm convey the sense that the murder of Marie puts Wozzeck firmly on the road to his Fate. Marie's final cry for help (B) has yet to be resolved, and Wozzeck's Fate is now driven by the rhythm, which Jarman (1997: 43) suggests is 'a striking and effective symbol of Wozzeck's suppressed consciousness of the crime'.

Wozzeck's attempts to 'suppress his consciousness' (and his conscience) might be represented also timbrally. In III/iii, the honky tonk piano is associated with the idea—a perceptual association that is facilitated by cultural factors.[23] The sound of the honky-tonk piano has a direct meaning for the listener, because it is recognised as a pub piano. Its directness of meaning is exploited as a perceptual cue for scene setting: Wozzeck is in a tavern—a place associated with forgetting about one's troubles. Berg's use of the instrument to provide music for dancing and little else strengthens the perceptual link.

---

[23] Clarke (1997) has suggested that such associations may be more relevant to the direct perception of musical timbres than has previously been realised.

As I will demonstrate, the honky-tonk piano links show that, throughout III/iii, there is a tension between Wozzeck's attempts to put Marie's murder out of his mind, and his remembering and eventual confrontation of the idea. In bars 143ff, Wozzeck sings, alluding, ironically, to I/iii. His song begins with the same rhythm and pitches as Marie's lullaby (I/iii, bars 372ff), the accompanying distinctive snare drum tones linking to the Drum Major's march of the earlier scene. These allusions seem to suggest that Marie's affair with the Drum Major is ingrained in Wozzeck's subconscious.

In bars 148-153, the pianist is not playing the polka, but is instructed to act as though he is attempting to find the accompaniment to Wozzeck's song. He does, however, only play octave F#s—pitches that avoid the resolution of the B of the previous scene and interlude. This idea of a lack of resolution is reinforced by the canonic relationship with the rhythm in the triangle strings and harp. This is the first instance in which the honky-tonk piano integrates into the orchestra.

Wozzeck breaks off his song before the expected rhyme 'Todtenbahr', which, as Erika Reiman suggests (1998: 238), would remind him of Marie's death. Reinforcing this point, the honky-tonk piano slips rather forcefully from an F# to an F and the B-F tritone is heard in timpani, reflecting how Wozzeck is suddenly reminded of the murder. He soon suppresses these thoughts; springing up from his chair, he calls Margret and dances a few steps. The honky-tonk piano begins the polka again; a backdrop of horns may be heard, with a low F# pedal on trombones further representing Wozzeck's attempts to elude thoughts about the murder.

The honky-tonk piano next appears with yet more new material—it provides the accompaniment for Margret's song (see Figure 4.3, bars 168ff). At the mention of unsuitable clothing for 'serving girls', Wozzeck reacts explosively and the horns enter forcefully in a blaze of Eb minor. This Eb minor chord and pedal seems to be a clear reference to II/iv (bars 589ff) (see Figure 4.6); the link is made in terms of both pitch and timbre. In the earlier scene, Marie dances with the Drum Major, and Wozzeck is consumed with jealousy. Andres sings a song, which has references to flirting, and a tam tam crashes on an Eb minor chord, which is heard on trumpets and trombones. In the context of the present scene, the Eb minor chord on horns seems to suggest that Margret's flirtations suddenly remind him of his jealousy.[24]

We do not hear the honky-tonk piano after Margret's song, but its timbre is alluded to immediately after Marie questions Wozzeck about the blood on his hands (bars 187ff). At this point Wozzeck sings the rhythm in canon with bowed col legno solo double bass and cello. Wozzeck's 'suppression of consciousness' is most vividly depicted here. His rendition of the rhythm is identified with the 'avoidance' F# tones, because it occupies the same metrical position as the honky tonk piano F#s. Moreover, the bowed col legno strings and honky tonk piano octaves chimeric percepts may occupy similar regions of timbre space. The *col legno* attack may mimic the honky-tonk piano's impulsiveness at this very quiet dynamic (*ppp*), and the double bass's colouring of the cello A (see pp. 53-54) increases inharmonicity and roughness, which may allude to the honky tonk piano's out-of-tuneness.[25]

The lower strings chimeric percept is a virtual sound source; it is a timbral distortion of the honky tonk piano that reflects Wozzeck on the brink of submitting to his consciousness. In addition to this psychodramatic function, Berg's reasons for using a virtual sound source may have been practical. Whereas the spatial location of the honky-tonk piano may cause difficulties of integration with the other orchestral sonorities (the honky-tonk piano is on stage, the orchestra is in the pit) (P11), the surrogate honky-tonk piano may be drawn gradually into the orchestra. Each time the 'pedal-like' bass line rises a whole tone, instruments are added, mimicking Wozzeck being drawn to the scene of the crime. The scene climaxes with sopranos calling out 'Blut' (blood) on B and the 'pedal' on the enharmonic Cb (bar 211). Wozzeck's voice is appropriately 'drowned out' at this point (see Figure 4.3).

At bars 202-212, the honky-tonk piano may be used to help the chorus to pitch its notes, but Berg clearly indicates that its timbre must be inaudible to the audience. One may interpret this as the honky-tonk piano now being fully absorbed into the orchestra. At this point, the whole

---

24 My reading of Wozzeck's attempts to forget are generally in keeping with Rieman's interpretation of tonality as representing 'unreality', escapism and avoidance; however, the blaze of Eb minor is an example of something that Wozzeck cannot avoid—it is a memory of a 'real' event. In view of this, it may be more appropriate to think of tonality as tied up in states of human consciousness.

25 If played without vibrato this would increase the perception of roughness. See Goad (1994) on vibrato as facilitating blend, and this thesis, p. 20.

tone ascent of the surrogate honky-tonk piano reaches full circle—it is modified by the chromaticism Ab-A-Bb in the bass; as the pitch-circle closes on the return of the Bb-A interval, the curtain falls quickly and the scene changes. The circularity of octave equivalence conveys the sense of returning; the dropping of the curtain here has the effect of cutting off the continuity of the whole-tone ascent 'circle'. Perle (1967: 55) has noted its dramatic significance, describing it as 'premature' 'to heighten the conclusion' of the scene. On the one hand, it seems to convey the notion that the wheel of Time continues to turn; on the other, it implies finality—a premonition of a more tragic submersion of Wozzeck, which is soon to transpire.

In the next scene (III/iv), Wozzeck goes in search of the knife to get rid of the evidence. A 'machine' of superimposed ostinati (clarinets, horn, and flute) represents the sounds at the lake (see Figure 4.7a).[26] This machine relates to the superimposed alternating streams and the different rates of instrument change of canonic voices 1-4 (crotchets) and 5 (minims) that occur in '*Farben*'. Moreover, when Wozzeck throws the knife into the lake (III/iv, 259-64), a harp chord initiates regular alternations between winds and brass—a timbral oscillation that is perceptually analogous, and certainly alludes, to the timbral alternations in '*Farben*' (see Figure 4.7b). Worried that the knife has not gone far enough, Wozzeck wades into the lake, and then tries to wash Marie's blood from his hands. He drowns; his final utterance, 'Blut' (blood) on F resolves Marie's final cry for help (B) (see Figure 4.7c).

In bars 289-93, the Captain and Doctor hear something at the lake. A link with the previous scene is made here: bowed col legno strings and rising chromaticisms are a reminder of Wozzeck being submerged by the crowd (see Figure 4.7d). These legato bowed col legno strings are timbrally further removed from the honky tonk piano than the rearticulated virtual honky tonk piano tones of the previous scene; nonetheless, they support the idea that the absorption of the virtual honky tonk piano into other sonorities mimics Wozzeck's death by drowning.

[26] The term 'ostinato machine' was first coined by Derrick Puffett (1996) in relation to Debussy's *Ibéria*, No. 2 of the orchestral *Images* (1905-12). He also notes that the orchestral prelude to Berg's *Altenberglieder* is another example of an ostinato machine (5).

A final allusion to '*Farben*' and the lake occurs in bars 302-13; the ostinato machine now consists of four layers (see Figure 4.7e). In the context of Wozzeck's drowning, the machinistic '*Farben*' allusion seems to represent the immutability of Time in the face of Death.[27]

A symbolic murder

Bloom's notion of the anxiety of influence offers a peculiarly ironic twist to the musical allusions outlined above. Bloom suggests that the anxiety of influence is inextricably tied up in the Oedipus complex; the artist's misreadings are 'symbolic murders' (Straus 1990: 14) that (s)he must perform in order to 'clear space' for her/his work. In the light of Berg's misreadings of '*Farben*' and the link between Schoenberg and Wozzeck in the confrontation scene of the opera (II/iii), one might read the '*Farben*' allusions in III/iv as a symbolic drowning of Schoenberg in Lake Traunsee! The extent to which this was an intentional joke is moot.

[27] There are other possible connotations. In a discussion of the 'Marsch' from the *Three Pieces*, Puffett (1997) links Berg's use of ostinati to the 'treadmill'—'an ultimate symbol of human futility'. As has been documented elsewhere, the *Three Pieces* are closely linked to *Wozzeck*; Berg wrote them in 1914, soon after seeing Georg Büchner's play Woyzeck, which Berg was to adapt into *Wozzeck*.

Chapter 5

Webern's *Five Orchestra Pieces*, Opus 10

5.0 Introduction

Schoenberg's Opus 16, which had clearly a profound influence on Berg, influenced also Webern, notably in his approaches to multipiece composition. Webern wrote a set of his own orchestral pieces in 1911 and, as noted earlier (p. 77), wrote an arrangement of Schoenberg's Opus 16 for two pianos (1912) before embarking on a different set of pieces in 1913. Webern's involvement in the Schoenberg-Mathilde-Gerstl affair (see pp. 76-7) may have made him particularly sensitive to the extramusical design of Opus 16; his own pieces are just as programmatic. The projects of 1911-13 led eventually to the publication of the *Five Orchestra Pieces*, Opus 10 in 1923.

This chapter is an extensive study of Opus 10; it provides an example of how timbral perspectives may be drawn into a broad musicological framework. My timbre and pitch analyses will take into account extra-musical and autobiographical issues that are in keeping with the issues of allusion and narrative approaches to musical structure that I raised in Chapter 4. Before discussing the individual pieces in turn, I will outline some background information as a means of situating the pieces within their historical context: in particular, issues of chronology are important in suggesting or supporting both structural links between the pieces and their relationship to extra-musical events, and so it is with these issues that I begin.

Aspects of chronology

During 1911-13, Webern wrote a total of eighteen 'aphoristic' orchestral pieces, including the orchestral song '*O sanftes Glühn der Berge*'. According to Webern's letters, the 1911 set consisted of seven 'chamber' pieces for orchestra[1] and the 1913 'set' consisted of eleven pieces for a larger orchestra (see Figure 5.1).[2]

Only two of the 1911 pieces are extant. In a letter to Nicolas Slonimsky (14 January 1937), Webern revealed their dates of composition: Opus 10 No. 1, 28 June 1911; and Opus 10 No. 4, 19 July 1911 (Slonimsky 1971: 117). The fact that they were originally intended as part of the same work suggests that the pieces are related. Their relationship, which will be discussed in more detail in later analyses, may rely partly

[1] Letter to Schoenberg, 23 August 1911 (Moldenhauer 1978: 195).
[2] Letter to Schoenberg, 22 December (Moldenhauer 1978: 196).

upon their positions within the chamber pieces set. The positioning of Opus 10 No. 1 is unclear, though we know that it was probably the first of the pieces to be written;[3] in my discussion of the piece, I suggest that it may have opened the 1911 set (see Section 5.1, pp. 99-100). The positioning of Opus 10 No. 4 within the set is made explicit in an early version, which states 'No. 5 of VII *Kammerstücke*' (see Figure 5.2).[4] These positions (opening piece and post-central piece) are preserved in the Opus 10 grouping.

Of the eleven orchestral pieces of 1913, only nine are extant: Opus 10 Nos. 2 (13 September), 3 (8 September) and 5 (6 October),[5] the orchestral song '*O sanftes Glühn*', and five pieces that were eventually to be published posthumously as *Orchestra Pieces (1913)*. An undated ink copy of a largish group of (at least six) pieces features Orchestra Pieces 1-4 (see Figure 5.4a). Orchestra Piece 5 exists as a short score pencil sketch with instrumentation markings (dated 2 December 1913); the Moldenhauers (1978: 196) believe it is the last of the 1913 pieces to be written. Since these pieces were originally conceived as belonging to a single set, the following speculative reconstruction of the Orchestra Pieces ink copy may offer insight into Webern's grouping criteria.

5.0.1 The Orchestra Pieces ink copy: a reconstruction

The Orchestra Pieces ink copy features movement numbers and page numbers (see Figure 5.4a). The Roman numeral labels 'III', 'IV', 'V' and 'VI' clearly indicate the intended sequence of the pieces. However, the page numbers for Orchestra Piece 4 ('V') are missing. Webern would probably not have interrupted his numbering of the manuscript sheets; the absence of numbers suggests that the current fifth movement was inserted after the third, fourth, and sixth were written and that either a different piece or an earlier version of Orchestra Piece 4 was originally in its place.

---

3 Over a week after writing the piece, Webern informed Schoenberg (6 July 1911) that he had written the first two pieces (Moldenauer 1978: 194).

4 Hans and Rosaleen Moldenhauer (1978: 736-37) have erroneously catalogued as 'Orchestra Fragments' of 1913 (unpublished) early ink sketches of Opus 10 No. 4 (see Figure 5.3). (The later ink copy 'No.5 of VII *Kammerstücke*' resembles more closely than the sketches the published version.) Many of the other fragments are so incomplete that we cannot really regard them as the orchestral pieces that Webern wrote about in his letters. Some of them are clearly sketches of orchestral movements, but others are simply melodic fragments with or without piano 'accompaniment'. These fragments are related to the 1913 pieces that were written in 1913, which have collectively been published as the posthumous *Orchestra Pieces*.

5 Dates provided by Webern in his letter to Slonimsky, 14 January 1937 (Slonimsky 1971: 117).

In a letter to Schoenberg, dated 12 October, Webern stated that the fifth of a group of six pieces was the orchestral song '*O sanftes Glühn*', which suggests that the same piece may have been the original 'V' of the ink copy (see Figure 5.4b). However, one cannot be certain that this was the case because the ink copy was written after the letter; when he wrote to Schoenberg, Webern was only in the process of writing his sixth piece. At least eight pieces (Orchestras Pieces 1-4, the orchestral song *O sanftes Glühn*', and Opus 10 Nos. 2, 3 and 5) had been completed by the time that he wrote the ink copy.

As he wrote more pieces, Webern encountered problems with large-scale structure. His criteria for ordering the pieces in the ink copy were probably quite clear at least before he had written out the pieces that followed the sixth. But, as the annotations in the score suggest, the nature of the material that he produced in the subsequent pieces prompted him to rethink the sequence of the first six pieces.[6] The ordering problems eventually led him to abandon the idea of a large grouping.[7] Instead, he formed from Opus 10 Nos. 2, 3 and 5 and the orchestral song '*O sanftes Glühn*' a four-piece work called 'Opus 6' (see Figure 5.5). The (proposed) positioning of '*O sanftes Glühn*' as a post-central piece in both the Orchestra Pieces ink copy and 'Opus 6' suggests that the song's role in these multipieces may be similar to that of the post-central piece in Opus 10 (Opus 10 No. 4) (see Sections 5.3 and 5.4).

The missing pages

There is much circumstantial evidence to suggest that versions of Opus 10 Nos. 2 and 3 were the original 'I' and 'II' of the ink copy. For instance, Webern wrote to Schoenberg (10 September 1913) soon after writing the first of the 1913 pieces (Opus 10 No. 3). He informed Schoenberg that the idea of writing 'a series of movements belonging to each other' was at the forefront of his mind, and a few days later he completed the second piece (Opus 10 No. 2). In my later analyses I suggest that Opus 10 No. 2 was written specifically to precede immediately Opus 10 No. 3 (see Figure 5.4c).

6 The annotations suggest that the insertion of Orchestra Piece 4 occurred probably before Orchestra Piece 2 was modified from 'VI' to 'V' and then labeled with a circled '4' in pencil (later deleted).

7 Letter to Schoenberg, 22 December 1913 (Moldenhauer 1978: 196).

In the Orchestra Pieces ink copy, the pencil labelling of '(II)' without deletion of 'III' supports this idea, because the pieces may be regarded as constituting a whole.[8] Moreover, the number of bars per page in Webern's other neat ink copies suggest that their inclusion in the set was possible. In the 'Opus 6' grouping, the copies of Opus 10 Nos. 2 and 3 take up six pages. If the same pieces spanned the same number of pages in the Orchestra Pieces ink copy, the first two pages might have been taken up by the main title and instrument list.

The musical content of 'III' (Orchestra Piece 1) offers further evidence. The fragmentary textures of the piece provide a striking contrast with the layered ostinati of Opus 10 No. 3 (see Figures 5.6a and b). Webern may have regarded this contrast as an important criterion for the final Opus 10 grouping, because, texturally, Opus 10 No. 4 is very fragmentary (see Figure 5.6c). However, the textures of Opus 10 No. 4 differ from those of 'III' in that they seem to refer more obviously to superimposed ostinati. In being placed immediately after Opus 10 No. 3, Opus 10 No. 4 conveys more effectively the sense of fragmenting the Opus 10 No. 3 layers.

The above reconstruction of the ink copy suggests that the positioning and textures of Opus 10 No. 4 provide the necessary link between the 'VII *Kammerstücke*', the 1913 Orchestra Pieces ink copy, 'Opus 6' and Opus 10. However, Webern's reason for choosing textural fragmentation as a grouping criterion may not be just musically motivated—it may have an extra-musical basis.[9] The following extra-musical issues have a bearing on all five of the Opus 10 pieces.

5.0.2 Extra-musical issues

Webern's memories about his mother provided the creative stimulus for him to begin the 1913 orchestral pieces; the first of the pieces—Opus 10 No. 3—was written the day after the anniversary of his mother's death (7 September 1906). The abrupt death of Webern's nephew (Theo Clementschitsch) in the summer of 1913 not only further intensified these memories (Moldenhauer 1978: 82); it prompted Webern to write a stage-play in the following October.

---

8 On the other hand, Webern may have considered replacing with Opus 10 No. 5 the first two pieces. Opus 10 No. 5 has many ideas in common with Nos. 2 and 3 (see Section 5.5.).

9 I discuss this specific case in more detail in Section 5.4.

The play is entitled *Tot* ('Dead'). It is a psychological drama set in the Alps and features four characters: a father, a mother, a boy apparition (representing their dead child), and an angel. Moldenhauer (1978) has summarised the various scenes of the play, which I have tabulated in Figure 5.7. As I will discuss in my analyses, these scenes are closely related to the (extra-)musical content of Opus 10. Ideas raised in the play seem to have had an important bearing on the final grouping of the pieces.

The earliest known version of the Opus 10 grouping was a chamber ensemble arrangement written in 1919. In this arrangement (labelled 'Opus 7, No. 4'), Webern attached titles to each of the pieces: '*Urbild*', '*Verwandlung*', '*Rückkehr*', '*Erinnerung*' and '*Seele*' (see Figure 5.8). The arrangement, which was catalogued by the Moldenhauers, is now lost, so we are unable to speculate about whether timbral differences (and other changes) might explain why the titles were deemed appropriate for the arrangement, and not for the publication of the orchestral version. From the evidence we have, we might assume that Webern did not want to (mis)direct his listeners: titles are open to interpretation and can be misleading; without them, his music can speak for itself. Perhaps even more strongly than Schoenberg (see p. 76), Webern may have felt that his titles also offered too many autobiographical clues:[10] he only ever performed the arrangement for the Society for Private Musical Performances (30 January 1920, Vienna). Whatever the reason for the omission, we can regard the titles as an integral part of the composition; they may reveal some important clues to Webern's grouping criteria, because they suggest certain important relationships between the pieces.

I will now explore the Opus 10 pieces in detail. The analyses feature perceptual links amongst timbres, pitches, rhythms and motives that are to a certain extent based on my schema-based hearings of current recorded performances. These subjective readings are not, however, simply an amalgamation of my perceptions of various recorded performances; as in Chapters 3 and 4, they are based on close scrutiny of the

[10] Webern had a history of dropping titles that have autobiographical/programmatic associations e.g. 'Langsam, marcia funebre' from the fourth of the *Six Pieces for Orchestra*, Opus 6 (Moldenhauer 1978: 126).

score and informed by what I believe to be possible according to my other listening and performing experiences. Needless to say, I do not expect listeners to be able to hear all of the structures that I outline in any one listening—the complexity of these structures is probably beyond even the keenest listener. However, given sufficient attentional focus, and a sufficiently 'accurate' performance, individual links or patterns should become perceptible.

5.1 No. 1, '*Urbild*'

When Webern began his 1913 pieces, he informed Schoenberg that he was writing 'a kind of symphony' (10 September 1913). However, his idea of writing 'a kind of symphony' was not new; it was almost certainly in mind when he wrote his first set of orchestral pieces in 1909, the *Six Orchestral Pieces*, (published) Opus 6. As is often acknowledged, the *Six Orchestral Pieces* (particularly the funereal fourth movement) have more than a hint of the symphonic Mahler about them. Mahler was a highly influential figure in the lives of the Second Viennese School composers, and he seems to have inspired Webern to write the 'VII *Kammerstücke*'; Webern began working on the pieces during the summer after Mahler's death (May 1911).

In this analysis of Opus 10 No. 1, I will explore a sense of the arrangement title '*Urbild*' (see Figure 5.8) that is in accordance with Mahler's view of musical development (1905):

> Just as in nature the whole universe has developed from the primordial cell, from plants, animals and men on to God, the Supreme Being, so also in music a larger structure should develop from a single motive, in which is contained the germ of everything that is yet to be. (Trans. K. Bailey, 1998.)

Mahler's advocation of organicism was embraced wholeheartedly by Webern; Webern's notebooks state clearly his belief that 'the whole development should ... be fashioned from a single motive', and that 'variation is the most important factor in a musical work' (1905).

As I will demonstrate by tracing timbral, intervallic and motivic organicism in Opus 10 No. 1, Webern's balancing of seemingly contradictory generators of musical structure—organicism and symmetry—reflects his conception of 'Nature',[11] the sublime and the metaphysical. All of these ideas are implicit in the term '*Urbild*'; Christopher Wintle's (1995) translation of '*Urbild*' as 'Ideal'[12] conveys the sense of the organic 'Original Form' as 'Creation'. These religious connotations tie in with Webern's intention to write 'a kind of symphony', as they are in keeping with Mahler's assertion that 'the symphony must be like the world. It must embrace everything.'[13]

Unlike Mahler's approach to musical development, the religious connotations of Webern's '*Urbild*' lie beyond the idea of 'Creation'. In the final scene of *Tot*, the father expresses his hope for mankind's transcendence—a return to the 'exalted state' that mankind experienced before God sent the Flood. Quoting a passage from Emmanuel Swedenborg's *Vera religio*, the father yearns for the time when men might once again communicate with angels and all 'earthly experiences' can be 'in direct communion with the divine' (Moldenhauer 1978: 201; see also Figure 5.7). If the title of Opus 10 refers to the 'ideal' or 'original' state that mankind is said to have experienced, one might interpret the piece's organicism and overlapping entries as a dialogue between man and the angels.[14] Some of its bright timbral effects, such as string and harp harmonics, celeste and glockenspiel tones and so on, might even be regarded as allusions to the divine beings themselves.

These senses of '*Urbild*' and the likelihood that Opus 10 No. 1 was the first of the orchestral pieces that Webern wrote in 1911 (see p. 94, n. 3) suggest that Opus 10 No. 1

---

11 The idea of Webern 'constructing' Nature in this way is in keeping with Julian Johnson's notion about Webern transforming Nature into an abstraction (see Julian Johnson, 1999)

12 From an autobiographical perspective, the 'Ideal' may refer to Webern's state of mind before his mother's death. Webern's diary entries of 1906 support this interpretation: his doctoral dissertation had been submitted and approved; he had begun a love affair with the woman whom he was to marry (Wilhelmine); he was able to satisfy his passion for nature by spending days walking through meadows and forests. In general, he was content throughout the summer of that year.

13 Sibelius's recounting of Mahler's words (Kurt Blaukopf 1976: 250).

14 Such a programmatic reading is unlikely to be shared by Julian Johnson, who avoids discussing Webern's music in terms of specific scenes or landscapes (1999: 3).

may have been always intended as an opening piece. In later analyses, I will address the extent to which Opus 10 No. 1 may be regarded as the 'Original Form' of the entire set of Opus 10 pieces.

5.1.1 Intervallic Structures

Opus 10, No. 1 is a remarkably thorough and sophisticated marriage of organic development and symmetry. This section of the analysis focuses on pitch features; it sets the scene for the discussion of timbre that follows. Figure 5.9 outlines the piece's main sections.

The kernel of the piece may be found in the opening bars. The semitonal ascent-descent is an obvious important intervallic shape and the kernel's contiguous intervals are notated as semitone, diminished fourth, minor sixth, perfect fourth, and diminished fifth. Perhaps the most important non-contiguous intervals are the minor thirds outlined by the pitches C-Eb, B-D and, for different reasons, the pitches B-G#. The first two of these intervals have been noted here because their pitches bear relevance to the development of the kernel. Within the kernel itself, however, these intervals are latent.

The interval B-G# can be distinguished from the other non-contiguous minor thirds in a number of ways (see Figure 5.10). In contrast to the other intervals, a timbral link between the B and G# tones arises from the rapid amplitude fluctuations of the flute fluttertongue and the rapid successive attacks of the celeste trill (Huron's P9). The link is reinforced on the basis of timbral similarity and same sound source by the perceptual grouping of the intervening glockenspiel tones (P9); the perceptual grouping of the glockenspiel tones is itself reinforced by the registral leap from B4 to Eb6, because, at one level, this causes a perceptual division (P5).

The G#-A of the celeste trill marks both the end of the expository kernel and the beginning of the first development section (see Figure 5.9); this trill is obviously related to the opening semitonal ascent-descent figure.

The first development is, in Webern's words, 'fashioned from' all of the important intervals that are in the kernel except for the perfect fourth; even the registral direction of these intervals is preserved. The arrangement of the intervals introduces a new idea: expansion and contraction. The most significant expansion is perhaps that which occurs in the harp, violin, and viola lines of bars 3-6; here, the semitonal ascent-descent figure is modified so that it introduces a 'new' interval - the major second. The notation of the flute part as an augmented second, rather than as a(n enharmonically-equivalent) minor third, establishes a link between the flute's interval and the major second; this link is important because it facilitates a bridging of the major second expansion and the clarinet's opening major third. Notated minor thirds do, however, occur vertically in the harp, and violin and viola, the first two of these intervals consisting of the same pitches as the kernel's latent (i.e. bracketed) minor thirds. The flute's augmented second is also a notational variant of the kernel's minor third B-G#, and in keeping with this relationship, the clarinet's major third, augmented fifth, and augmented fourth are notational variants of the kernel's diminished fourth, minor sixth, and diminished fifth, respectively.

The notation in the score gives the first development section the visual impression of being quasi-symmetrical (see Figure 5.11). The bar in which it ends—bar 6—is itself the central bar of the piece and acts as the axis of a large-scale intervallic symmetry that will be discussed later.

In bar 6, the kernel's pitch class content is found in its entirety. If the Bbs and Dbs are excluded on the basis of their belonging exclusively to the first section, the clarinet's F is the only additional pitch. This idea is carried through to the next development section, where the pitch class content of the violin and cello in bars 7-8 is, except for the F#, also found in the first half of the first development section.

Other than the pitch-class relationship, the second development seems to be concerned primarily with two things. Firstly, the expanded version of the opening motif is presented in retrograde, retrograde-inversion and inversion, overlapping in a stretto-like fashion; it is perhaps no coincidence that the presentation of ideas in retrograde is introduced at the axis of symmetry of the whole piece. Secondly, compound intervals are introduced to extend the intervals of the kernel beyond the span of an octave, both vertically and linearly. The vertical presentation may be observed in bar 7: the simultaneous tones of trumpet and trombone produce a minor ninth, which is derived from the opening semitone interval; this minor ninth is then followed, via contrary motion, by its inversion—a major seventh. (I will return to this pattern later, as a timbral perspective may modify our perception of such pitch relationships.) The linear presentation of compound intervals is apparent in the octave displacement of cello and violin notes in bars 7-8.

During the overlap between the second development and the final section, linear octave displacement (G6-A4-G#4), simultaneity (the G is sustained throughout the A and G#) and retrograde features (the notes outline the expanded ascent-descent motif in retrograde) are combined.

The final section provides the necessary intervals and pitches to complete the symmetrical framework of the piece. In bar 10, the G#-D augmented fourth mirrors the D-G# diminished fifth of bars 2-3 (see Figure 5.12); the final pitch—F—is symmetrical to the opening B via both the celeste's G# trill and the clarinet's B-F in bar 6. Moreover, there is a sense of quasi-symmetry to the harp phrase, centred around Bb-Bb-A—a reiterated pitch and then semitone interval—which then develops into an inversion of the expanded ascent-descent motif (Bb-A-B). In light of the symmetry noted in both the first development section and the large-scale structure of the piece, the allusion to symmetry in bars 10-11 may contribute to a sense of reprise.

The symmetry and sense of reprise are also expressed by the rhythmic similarity between the notes in the final bar and the opening motif (B-C-B); whereas the second and third sonorities of the opening motif are separated by a triplet quaver rest, the second and third entries in the final bar are also separated by a short rest). In both cases the rest occurs on the half-bar, causing a 'hesitation'. Moreover, an anacrustic relationship between the first and second sonorities of the opening motif is reflected in the last bar, where a very slight increase in loudness, caused by an overlap of parts, gives an impression of such a relationship between the first two entries. Pitch reiteration in the final bar is prepared for by pitch reiterations in the harp (bars 9 and 10-11). I will discuss this issue of reiteration in greater detail later; it is, however, sufficient to point out now that the retrograde version of the expanded motif, which featured the first pitch reiteration in the harp (bar 9), effectively functions as a contracting version of the opening motif (B-C-B) and that the reiteration of a single pitch in bar 12 may be regarded as the ultimate contraction of this motif, achieving a sense of closure.

5.1.2 Timbral structure

The timbral structure of Opus 10, No. 1 parallels the intervallic structure in that aspects of the timbral structure are symmetrical and/or develop organically. For instance, at the junction of the kernel and first development section, the celeste trill develops the opening semitonal ascent-descent figure, not only by the pitches it uses, but also by combining timbral features. The opening figure's sonorities (B-C-B) are each initiated by an impulsively-excited tone (in this case, produced by harp and/or celeste) and these tones are doubled or sustained by a 'continuously-excited' tone (bowed-string or wind instruments). However, within the continuously-excited flute tone, the fluttertongue causes rapid amplitude fluctuations that give the impression of a rapid succession of attacks. By contrast, the celeste trill provides a rapid succession of actual attacks without being sustained by continuously-excited tones. Provided the oscillation is sufficiently rapid, the trill's tones may, on the other hand, be perceived as a single 'continuously-excited' sonority with rapid amplitude fluctuations; this aural illusion is made possible by the overlapping of decays and excitations that occurs even if the damping pedal is pressed. The timbral and pitch links of both rapid amplitude fluctuation or (rapid attack reiteration) and semitonal ascent-descent ideas frame the three-note timbrally-distinct glockenspiel figure (P9). Thus, the notions of timbral development and symmetry are suggested within the kernel itself.

Webern satisfies the 'variation' condition by also using timbre in a complementary fashion (P9 as a form delineator, rather than stream segregator). Notice that, in the kernel, the initial attack of each sonority is impulsive—an accented initial attack in bar 3 means that even the quasi-continuously-excited celeste trill is perceptually consistent with this notion. The tones of the first development's notationally variant intervals are, by contrast, continuously-excited.

Perhaps the most significant timbral development of the first development section occurs in the clarinet line. The notes of this line are rhythmically grouped into pairs and, as was mentioned earlier, these intervals correspond to the B-Eb, Eb-G and D-G# intervals of the kernel. Whereas in the kernel, timbral factors, such as brightness and amplitude fluctuation, cause divisions between B and Eb, and D and G#, in the clarinet line, the transitions between tones are smooth and timbrally more consistent. The quaver rest, which causes the only break in the clarinet line, strategically replaces the kernel's perfect fourth interval.

Moreover, this timbral complementarity contributes to the sense of intervallic development, because in order for the tones of the clarinet line to remain so timbrally consistent, the largest interval fits comfortably into the clarino range and the smaller intervals fit within this intervallic band, causing a wedge-like expansion and contraction of pitch (D11 (C3), D12). Here, the clarinet provides a special function; assigning these intervals to this part of the clarinet range maximises both the smoothness of transitions between tones and a sense of timbral consistency that would not have been possible if they were assigned to a different instrument.

In the second development, the muted cello begins with a major second interval—C-D. The presentation of these pitches in this way, perhaps surprisingly, modifies one's view of previous major seconds. Thus far, I have pointed to only one previous instance of a major second i.e. that which occurs in bars 5-6. Another such interval occurs, however, in the kernel, and the tones of that interval are timbrally linked: the C sonority consists of bell-like harp harmonic, celeste tone, and muted viola harmonic and, therefore, bears similarity to the 'bell-like' glockenspiel tones. The C is however more closely linked to the D than to the Eb or G, because although they have a similar bell-like quality and sustaining capacity as the C sonority, the Eb and G are registrally higher and dynamically (slightly) louder than the D and are, therefore, more dissimilar in terms of brightness (P9).

In retrospect, then, the major second that occurs in bars 5-6 is not a new interval, but is itself latent in the timbral organisation of the kernel. The C-D of bar 6 preserves this sense of timbral similarity by bringing together the pitch classes in a single sound source (the cello).

Even greater timbral similarity than the kernel's C and D occurs between the kernel's Eb and G as both are played on glockenspiel; in bar 6, this sense of timbral similarity is also preserved, but because the tones are played simultaneously, they are divided between sound sources (trumpet and trombone).

In bars 6-7, the timbral structure enables the listener to hear from different perspectives the pitch structure. Whereas the cello is separate, the brass coalesce, allowing attention to fall on vertical intervals. Parncutt data (see Figure 5.13) support this reading. If one accepts that the lack of onset synchrony (P7) with other instrument tones enables one to focus on the brass, it is valid to analyse the brass tones in isolation. The data show that the pitches of the intervals G3-F4, F3-Ab4, F#3-G4 and F#3-A4 have the highest salience values for their respective sonorities, confirming the perceptibility of the intervals.

The brass have the potential to be segregated, nevertheless. This is important whether the tones are to be perceived vertically (as intervals) or linearly. Huron's P1, P2, P4, P5 and P6 are sufficiently (dis)satisfied for the brass to be heard linearly, enabling the listener to focus on the pattern of retrograde (C-D-C#), retrograde-inversion (G-F-F#) and inversion (Ab-G-A) that is initiated by the cello. The pitch saliences of the brass facilitate this linear perception: the first pitches of the retrograde inversion (G) and inversion (Ab) are the most salient.

At the overlap between the end of the second development and the beginning of the final section, timbre once again elucidates the pitch structure: it provides quasi-symmetry with the opening bars, because it is as though the timbral ideas are condensed into the three sonorities of the retrograde-expanded motif. Like the kernel's first three sonorities, all of the sonorities in this motif have an 'impulsive' initial attack and 'continuous' steady state. The G sonority consists of glockenspiel and high violin tones, providing an obvious timbral link with the kernel's glockenspiel tones. Another obvious link occurs between the G# sonority and the kernel's C sonority—in both cases, a celeste tone is doubled by an artificial string harmonic. The harp harmonic of the kernel's C sonority, is, however, not preserved in the G# sonority of bar 10; instead, the latter sonority is followed by a whole phrase of harp harmonic tones.

However, the G# sonority also marks the beginning of the final section proper: the celeste and muted cello harmonic G# followed by the bell-like harp harmonic D are timbrally 'symmetrical' to the glockenspiel D and celeste G# trill at the end of the kernel; whilst the timbres in bar 10 are derived from the kernel's C sonority, they are perceptually fairly similar to the kernel's D and G# in terms of both their brightness and their initial impulsive attack. On the other hand, the timbral progression from the glockenspiel D to the harp harmonic D is an example of organicism. Specifically, the progression traces a slight, but significant, gradual decrease in psychoacoustical brightness. Thus, the link between the kernel's C and D is reinforced by the harp harmonic of the final section's D.

Another interesting timbral link occurs between the A sonority of the expanded retrograde motif and the second B sonority of the kernel. In bar 1, the amplitude fluctuations of the flute tone were caused by the reiterative 'attacks' of the flute fluttertongue, the continuous excitation of the instrument enabling a general dynamic increase within this same tone. In bar 9, the reiterative attacks are provided by the harp and a general dynamic crescendo (or, as psychoacousticians might say, a 'continuous amplitude increase') is provided by the muted trumpet tone; thus, the qualities of a single instrument tone are divided between two instruments. The timbral link is reinforced by the use of harp attacks, because a harp attack initiates the flute fluttertongue sonority in bar 1; moreover, the timbres of flute and trumpet tones are (according to Grey 1977) fairly similar in this register (especially in terms of brightness).[15]

The reiterative attacks of the harp in bar 9 also provide another very important function. Having established a relationship between this sonority and the flute sonority of bar 1, a connection can now be made with the flute fluttertongue figure of bars 8-9. With the exception of the G#-A celeste trill and the B-C-B of the kernel, this flute figure contains the only other instance of a semitonal ascent-descent in the piece. The harp pitch reiteration in the retrograde-expanded motif effectively removes the upper neighbour note and provides the link with the fluttertongue that I have described. Whereas this pitch reiteration seems to provide a timbral function, the pitch reiteration of the harp harmonics figure provides a 'melodic' function. By evolving into an inversion of the expanded motif in bar 11, the pitch reiteration of the harp figure facilitates the pitch reiteration in the final statement of the motif.

Timbral similarity reinforces, moreover, the link between the closing reiterated Fs and the original motif (B-C-B). The trumpet, celeste and flute timbres that doubled the harp in bars 0-1 are rearranged in bar 12. By passing from flute to trumpet and then to celeste, the tones of bar 12 seem to move smoothly within the rise time dimensions i.e. the rise time of the attacks becomes increasingly shorter;[16] and remain consistent within the brightness increases; these transitions are facilitated by the consistently quiet dynamic and overlapping flute and trumpet tones.

5.1.3 Timbre as delineator of pitch relationships

We have thus far observed ways that timbre and intervals interact to produce an organically-generated symmetrical structure. Beyond this structure, there are a number of

[15] The very quiet dynamic increases the likelihood of proximity, because the relative strengths of spectral components are likely to be more even or less variable than when the tones are played loudly.

[16] Studies by Luce and Clark (1965) and Grey (1977) confirm that flute attack transients are longer than trumpet tones. However, from a rise time perspective, the 'attack' dimension of Grey's model is unreliable because the correlate measures the presence of inharmonic transients in high frequencies before a tone's main harmonic portion. Tones that have few inharmonic transients and long rise times (such as the French Horn) rate low on this dimension.

important relationships between certain pitches and intervals, and these relationships are often facilitated, or reinforced by timbral factors.

Of particular interest are major and minor thirds (or their enharmonic equivalents), because these intervals are nearly always presented in pairs, and each presentation is distinctive (see Figure 5.14).

In the kernel, the diminished fourth is, enharmonically, a major third and the minor third emerges from timbral links. This first presentation of the major and minor thirds is linear, and a common tone—the B—links the intervals. The three sonorities have distinctive timbres, each played on different instruments: the effect here may be described as 'pointillistic'.

The next instance of a major and minor third pair occurs in bars 3-5. Each interval is assigned to a different instrument and is perceptually noticeable because it occurs at the beginning of an entry. Note that the flute's 'minor third' is distinguishable from the harp, violin, and viola material with which it coincides, as the flute's initial attack slightly anticipates the latter material; this not only helps to draw attention to the flute's 'minor third'—it also gives rise momentarily to a linear augmented triad.

All other instances of major and minor third pairs are found in the second development section. The first one is a linear presentation that has each interval played on a different sound source: minor third on trumpet, major third on flute. On this occasion, however, there is no overlap. The order of the intervals may be regarded as a retrograde presentation of the previous couplings, because the minor third precedes the major third. Moreover, the contour of the first four notes of the flute figure in bars 8-9 gives the impression of an 'inversion' of the trumpet figure.

The next minor-major third pair is unique in that it is primarily vertical, though it does preserve an aspect of linearity. The tones of each interval are divided between sound sources, the first interval occurring in bar 7 when the high violin entry joins the cello's first sustained tone, and the second occurring in bar 8 at the dynamic peak of the crescendo-diminuendo hairpins in both parts. Furthermore, this coupling is also a sort of retrograde-inversion of the coupling in bars 3-5; the pitch classes are identical—F-A and C#-Bb—but here they are presented in retrograde, and inverted so that compound major and minor sixths (or their enharmonic equivalents) result. In the context of the contrasting brass material, the timbral similarity of violin and cello tones facilitates the fusion of the tones for each interval (P9).

The last three instances of the interval pairs are all linear and played on single sound sources. One of these occurs in the cello line alone, this time presenting the intervals in the original order i.e. major third (C#-A) followed by minor third (A-C). A common tone links the intervals, though unlike in the kernel, where this sort of linkage also occurred, the common pitch (A) occurs mid-phrase. The first pitch (C#) is also a common tone as it links this major-minor third pair to the retrograde-expanded motif discussed earlier. Despite the interruption of the line by a displaced pitch (B) the tones of this major-minor third pair are more timbrally consistent than those previously discussed.

The penultimate interval pair occurs in bar 8 of the violin part. Like the previous interval pair, it consists of three notes, one of which is common to both intervals. This time, however, the common pitch is the third (and last) pitch; both the location of the common pitch and the order—minor third, diminished fourth (or 'major third')—suggest that the D-C#-F is a retrograde version of the kernel's interval pair. This is the most compact version of the intervals so far, but the octave-displaced first tone (D) causes slight timbral inconsistency.

The timbral organicism of the major and minor third pairs culminates in the final interval pair: the flute's G#-E-F is the most timbrally consistent and compact linear presentation possible—a three-note cell, devoid of intervening or displaced pitches. The first note (G#) is, once again, the common pitch, and the original order—major followed by minor—is also restored. The three-note cell is part of a figure that also seems to contain a reference to both the semitonal and expanded ascent-descent motives, and is dovetailed to those motives by the common interval E-F.

Although the linear fusion of semitonal and expanded motives is disguised by the octave-displaced D#, an interesting pitch relationship does arise from this displacement. The pitch relationship is, however, only made possible via a timbral link. This link occurs between the celeste and flute at the G# of bar 8—that is, the point at which the rapid amplitude fluctuations of trill and fluttertongue overlap. The registral prominence of the last note of the flute figure (D#) hints at a possible 'higher level' pitch relationship with the figure's first pitch (G#), and the return of the celeste on G# in bar 10 reinforces this link.

The perfect fifth relationships of G#-D#-G# and a compound perfect fourth relationship of D-G-D occur almost simultaneously. The timbral links between the tones of both patterns seem to develop organically. For the G#-D#-G#, the development is obvious: the celeste trill, flute fluttertongue combination of the first G# leads to flute fluttertongue alone for the D#, and then a return to a celeste tone, non-trilled and doubled by muted cello harmonic. For the D-G-D, the link between the violin tone for the D harmonic minor leads to a violin G that is doubled by glockenspiel, and then the bell-like harp harmonic for the returning D.

Despite originating from quite distinct timbres, the G#-D#-G# and D-G-D patterns seem to arrive at similar timbral goals. In contrast to the impulsively-excited celeste trill of the first G#, the D-G-D pattern begins with continuously-excited violin tones. Both patterns end with a bell-like tone: celeste tone in the case of the G#-D#-G#, and harp harmonic in the case of the D-G-D. Since celeste tones generally have less sustaining power than harp tones, the doubling of the G# tone in bar 10 by a continuously-excited muted cello harmonic helps to sustain the brightness of the celeste tone's onset.

The D-G-D pattern is perhaps a (long-awaited) development of the kernel's perfect fourth G-D, which was heard on glockenspiel; in addition to the use of the same pitches and the perfect fourth interval, the pattern's link to the kernel's perfect fourth is reinforced by the glockenspiel tone (G) of bar 9. Moreover, the G#-D#-G# perfect fifths may be regarded as an 'inversion' of the D-G-D pattern, transposed up a semitone. This transposition is significant, because the G# has especial importance in the piece.

As I have already pointed out, in reference to the B-F symmetry of the opening and closing bars, the G# of the celeste trill seems to function as the pitch centre of the piece. The G# is, however, also a member of a diminished seventh chord outlined in the piece's symmetrical structure; the tritones, which feature at structurally important points, combine to form this diminished seventh chord (see Figure 5.12).

5.1.4 Conclusion

The 'completeness' of Opus 10, No. 1 in terms of the variety and complexity of symmetry, pitch and timbral links, and so on, is in keeping with the notion of '*Urbild*' as the creation/world. It gives the impression that the piece requires no further development, and one might expect further developments of the kernel to be, if not impossible, at least unlikely. In this sense, the 'Original Form' aspect of the title '*Urbild*' is perhaps surprising, seeming to imply that the other pieces in Opus 10 are 'fashioned' from ideas presented in this piece. It seems likely that if Nos 2-5 are in any way related to the first piece, the kernel that generated the first piece may, ultimately, be regarded as the original source of those ideas. This study strongly suggests that an exploration of relationships between the Opus 10 pieces should focus not just on possible pitch and rhythmic connections, but also on timbral links, complementary relationships, parallels in the ways that material is generated, and so on. Such links cannot arise from simple reiteration of ideas presented in the first piece, as this would compromise the Webern-Mahlerian view of musical development that I outlined at the beginning of this analysis. The notion of variation must now extend beyond the microcosm that is Opus 10, No. 1 to encompass the entire Opus 10 set.

5.2 No. 2, '*Verwandlung*'

If we accept that the balance between organicism and quasi-symmetry of Opus 10 No. 1 may represent the ideal or 'creation' of the (Swedenborgian) world, the rapid transformations of musical material and abrupt mood changes in Opus 10 No. 2 might be perceived as an allusion to the upheavel that was caused when God sent the Flood, severing any direct communication between man and the heavens (see Figure 5.7, Scene 6). The abrupt mood changes may allude also to Scene 4 of *Tot*, which features an emotional outburst by the father; the father's doubts about not having been loving and understanding enough perhaps reflect Webern's own feelings about his relationship with and responsibilities to his mother. These notions of 'transformation' and 'change' are adequately conveyed by the Opus 10 No. 2 arrangement title '*Verwandlung*'.

Despite the extreme mood changes, organic musical development can be traced throughout the piece and may even contribute to the piece's teleology. In the following highly detailed, extensive analysis, I identify links between Opus 10 Nos. 1 and 2 and extrapolate the main organic threads of No. 2. Discussion of the music in terms of threads is an analytical principle that, as I will demonstrate, generates a range of schemata that facilitate the perceptual extraction of the piece's timbral links. Following this discussion, some issues relevant to timbral rhythm are addressed in an investigation into the piece's teleology from metrical and anacrustic perspectives.

Throughout the analysis, I refer to certain phenomena as anacrustic. In order to avoid confusion, my use of the term 'anacrusis' should be understood according to the following definition.

Anacrusis

An anacrusis is musical material that is perceived as anticipatory. The extent to which it is perceived as anticipatory depends upon context. For instance, whereas in tonal music the stability of the tonic provides a goal towards which the harmonic progressions strive, in music that has no overt tonal reference the sense of anticipation may rely solely upon the 'projective potential' of its rhythms (see Chapter 3, p. 68).

In order to be an anacrusis, the musical material must be perceived as less stable than material that follows. Cooper and Meyer (1960: 73) explain that the listener can determine this only in retrospect. If the metrical context immediately preceding the anacrustic material is sufficiently clear-cut, the anacrusis may be left unresolved (though the sensation might be stronger if it does resolve). The effect of an unresolved anacrusis is analogous to an unresolved dominant chord in the context of tonal harmony: the tension is carried into the ensuing silence. From the listener's perspective, the resolution of such an anacrusis or chord is entirely conceptual. The context preceding the anacrusis is likely to consist of moments that are sufficiently stable for the listener to appreciate the anacrusis's instability.

5.2.1 Derivations of the 'Original Form'

Before mapping out the organic threads, I will discuss a number of ideas that occur in the first section of the piece. This section of the piece deserves special attention, because many of its ideas may be perceived as originating from Opus 10 No. 1, and differences between the 'Opus 6' and Opus 10 versions have perceptual and structural significance.

The modified ascent-descent motif

The pitch classes of the first three dynamic peaks of No. 2 (G(4), F#(6), Ab(6)) outline a 'minor second' 'descent' followed by a 'major second' ascent, which is an inverted form of the modified ascent-descent idea that plays an important role in No. 1 (see Figure 5.15). This link is difficult to perceive aurally, because the first interval is distributed between two instruments (violin and Eb clarinet) and the second interval is displaced by two octaves (Eb clarinet). In the Opus 10 context, these intervals may be regarded as a development of the climactic, 'pointillistic' version of the motif, which occurs in bars 9-10 of No. 1.

In contrast to No. 1, the tones 'belong' to separate musical lines, which feature legato transitions from one tone to the next within single sound sources. The first two notes of the clarinet part may be perceived as separate from the violin part because the sound sources cause obvious timbral differentiation (P9), the tones are continuous (not re-articulated) (P2, D3) and the duration of the tones is sufficiently long for the tones to be perceived as belonging to the stream (P5, D12). However, the tessitura differences reduce the timbral consistency (P9); the resultant timbral differentiation has an effect on the perception of differentiation between clarinet and violin parts: within the brightness dimension, the violin F#5 mediates the Eb clarinet tones. Moreover, the violin F#5 is intermittent (P2, D3), bridging the registral gap between the Eb clarinet tones (P5, D11, D14, D15). Its onset has a global amplitude level that is approximately equivalent to each of the opening clarinet tones; the diminuendo reduces the global amplitude level to the extent that the violin C# is likely to be relegated into the background.[17]

In the 'Opus 6' version of Opus 10 No. 2, these tones are less likely to be perceived as a group because the phrasing and dynamic do not facilitate their isolation. The violin F#5 crescendos as part of a single hairpin for the whole phrase, which means that the tone lacks a global amplitude level equivalent to the Eb clarinet tones. The Eb clarinet line, which is assigned to oboe, has a single slur over the entire phrase, and has no semiquaver rest separating the second and third tones (see Figure 5.16). Whether or not Webern modified the dynamics and phrasing so that the first three pitches could be regarded as a development of the Opus 10 No. 1 motif, there is no doubt that the revision makes the connection more apparent.

Expansion

Despite the octave displacement, the minor-major second progression can be regarded as the root of a wedge-wise expansion—another idea that features in Opus 10 No. 1. The Eb clarinet's second pitch is overlapped by the trumpet's opening minor third interval; the Eb clarinet's re-entry then overlaps the trumpet interval with a major third; overlapping the

[17] The effect of dynamics is smooth transitions within dimensions; the listener is likely to link or perceptually group tones that move within dimensions in the same direction and to the same degree, especially if they have equivalent global amplitude levels—it is a microcosmic example of the timbral transposition or analogy (see Chapter 3, p. 69). It applies even if the exact combination of dimensions differs.

last tone of the Eb clarinet phrase, the oboe enters with a diminished fourth (sounding major third) followed by wider intervals—major sixth and diminished octave—only to close with a(n uninverted) modified ascent-descent motif (major-minor second).

In the 'Opus 6' version, the instrumentation of this passage is different (see Figure 5.16). The Eb clarinet line of bars 1-2 is assigned to oboe, the trumpet figure of bars 1-2 and the oboe line of bars 2-4 are played by clarinet, the Bb clarinet of bar 2 (and the trumpet triplet of bar 3) is played by trumpet. The effect of the re-orchestration, the dynamics in bar 1, the phrasing changes and the introduction of rests in the Eb clarinet and oboe lines help to isolate the intervals of the wedge-wise expansion.

The muted fluttertongue trumpet figure (x)

In the Opus 10 version, the trumpet entry of bars 1-2 marks one of the most obvious links with No. 1. This muted fluttertongue trumpet figure (*x*) is a transposition of the muted trumpet figure in bars 6-7 of No. 1 (see Figure 5.9). The relationship between this figure and the first four notes of the fluttertongue flute in bars 8-9 of No. 1 is now strengthened by the rapid amplitude fluctuations of the trumpet tones. One might even regard the transition from flute to trumpet in bar 12 of No. 1 as a step towards this development. Such links with No. 1 would have been considerably weaker if the 'Opus 6' orchestration had been preserved, because figure *x* was assigned to fluttertongue clarinet.

The inverted modified ascent-descent motif (y)

An inversion of No. 1's modified ascent-descent motif is outlined in the last three notes of figure *x* and another inversion of the modified ascent-descent (bar 2) overlaps the last note of this figure in bar 2 (*y*). In contrast to the fluttertongue effect of figure *x*, trills provide the rapid fluctuation for motif *y*. In the light of the relationship between fluttertongue and trill effects discussed in the analysis of No. 1, the figures may be regarded as timbrally linked.

The trumpet triplet figure (z)

The trumpet's triplet figure (*z*) in bar 3 reinforces the links with No. 1. This figure draws upon the kernel preserving the crotchet notation of the triplet and the pitch classes D and Eb; in both cases D is the lowest pitch, Eb the highest. In No. 2, the middle pitch B replaces the G; one could regard this B as being derived from the B that immediately precedes the triplet figure in No. 1. Figure *z* can be regarded as a development of No. 1 also because both dynamic and registral direction are reversed: the descending *diminuendo* becomes an ascending *crescendo*.

Instrumentation revisions

The instrumentation of motifs *x*, *y* and *z* affects the various links. In the 'Opus 6' version, *x* is played by clarinet and *y* and *z* on trumpet. Just as the figure *x* instrumentation has important consequences (discussed earlier), the division of *y* and *z* between clarinet and trumpet has two significant effects:

(i) It allows *y* to lie outside the wedge-wise expansion. The Bb clarinet tones are timbrally closer to the Eb clarinet tones; this timbral proximity reduces the Bb clarinet entry's salience, because the Eb clarinet is already sounding (P9).

(ii) The division of the line anticipates the melodic thread played by clarinet and trumpet in bars 9-14. Webern may have had this link in mind in 'Opus 6': clarinet and trumpet lines overlap (figures *x* and *y*), suggesting the idea of continuity. In the Opus 10 version, the absence of overlap (figures *y* and *z*) helps to link figures *y* and *z* to the Opus 10 No. 1 kernel and is more consistent with the absence of overlap in the later melodic stream.

A development of figure x

In bars 4-5, the minor-major third aspect of figure *x* is developed. Whereas the minor and major thirds are non-contiguous in figure *x*, they are contiguous in the violin and piccolo lines. In the Opus 10 version, the ideas are connected also timbrally because both are tremolando, causing rapid amplitude fluctuations. The violin and piccolo tones may be regarded as a development in that an actual reiteration of attacks is required to produce the effect.

These motifs are linked timbrally also in the 'Opus 6' version: figure *x* is played on clarinet; the motif in bars 4-5 is played on harmonium (non-tremolo). Although the tremulousness link is absent, the tones of the Bb clarinet resemble harmonium tones perhaps more closely than any other orchestral instrument tones; both clarinet and harmonium are single reed instruments, which suggests that they are likely to have similar rise times, spectral flux, and jitter (see Chapter 1).

Most authors agree that the point at which the piccolo, clarinet, celeste, solo violin and solo viola converge is the climax of the piece's first section. In the 'Opus 6' version, the instrumentation is different and the climax is conveyed by dynamic. The Eb clarinet line is played *mf* on viola (bars 4-5), the viola line is played *mf* on cello (bars 4-5), the clarinet line is played *f*, and the violin line is played *f* on (non-tremolo) harmonium. The lines do not converge in the same way as in Opus 10, because the cello line crescendos through bar 5, causing an increase in its salience.

In the Opus 10 version, the climax is achieved through a more vivid orchestration –an orchestration that highlights the development of figure *x*. This orchestration will be discussed later, in relation to the organic threads 'phrase climax' and 'impulsiveness' (see pp. 119-24).

5.2.2 Threads

The section definition thread

I will now outline one of the perceptually most salient threads in order to clarify the piece's basic structure. Exposition of this thread here will help the reader to place into a conceptual framework the observations that I will make later.

The 'section definition thread' (SD) is most strongly characterised by pseudo-continuously-excited tones. It begins in bars 5-6, where the timbrally salient triangle trill marks the end of the first section and the beginning of the second section. Robert Hanson (1976: 135) has suggested that this trill marks a division because it is the 'first percussion sound'. However, Hanson's analysis is not entirely accurate. The first percussion sound is the celeste tone on the downbeat of bar 5; this punctuates a point of climax in the first section (see later, pp. 119-20). The triangle trill is the first *non-pitched* percussion sound. Its section-defining capacity lies in its inharmonicity, which is far greater than for any other sonority up until bar 5. Its perceptual isolation is distinct from previous sonorities (which are part of streams that are created by successive sonorities within single sound sources), setting a precedent for the isolated sonorities that follow in the next section.

Hanson implies that the second section does not begin until the silence after the triangle trill is broken (bar 6). However, by interpreting the triangle trill as marking a 'beginning' rather than just an 'end', one may interpret as marking—and indeed motivating—new transformations of musical ideas and textures each instance of rapid trills and/or tremolos played on impulsively-excited metal instruments (bars 5-6, 9, 11 and 14). The celeste trill is an exception, because it is by far the least bright of the tremulous struck metal tones.

In the 'Opus 6' version of this piece, the triangle trill of bars 5-6 is marked *pp* with a hairpin, and the A4 of bar 5 (played on harmonium rather than violin, see later, pp. 132ff) is extended by a quaver into bar 6. These markings are consistent with the idea that this point defines both the end of the first section and the beginning of the second section, though Webern's revision for the Opus 10 version facilitates perception of this dual function arguably more effectively. In Opus 6, the hairpin of the triangle trill sonority and the *crescendo* of a cello tone (bar 5) convey a greater sense of forward motion than the *ppp diminuendo* of the Opus 10 version; this forward motion weakens the sense of section closure, but is certainly in keeping with the piece's anacrustic function (see later, pp. 132ff). In Opus 10, the *diminuendo* of the triangle trill, which is consistent with a global *diminuendo* in bar 5, does convey a sense of closure, and facilitates perception of a link with the glockenspiel trill diminuendo of bar 9, which marks the end of the next main section. The link is possible because the dynamics effect perceptually analogous variations in the pattern of both global amplitude levels and the spread of spectral components.[18]

The triangle trill may be linked perceptually to a celeste trill in bar 7 both in terms of inharmonicity (relative to the wind and string tones, which are far more harmonic) and pseudo-continuousness. In the Opus 10 version, this link is important because the pitch oscillation of the celeste trill provides a step towards the next section definition thread. In the 'Opus 6' version, the link between triangle trill and celeste trill is strengthened by analogous global amplitude variation (hairpins); the celeste trill, in turn, facilitates a link to the celeste tremolo and glockenspiel trill of bars 10-11 in that version. The effect is that the sections are not as clearly defined (or, to put it another way, are not quite the same) in the 'Opus 6' version as in the Opus 10 version. The triangle trill of the first section boundary is much easier to perceive as linked to the glockenspiel trill (Opus 10) than to the four-note semiquaver pitch reiteration of the harp ('Opus 6'), because of greater similarity in terms of rapidity and type of excitation and brightness. This four-note semiquaver pitch reiteration is linked to the end of the next section, because a four-note semiquaver pitch oscillation occurs in the harp in bar 10, immediately preceding the trilled glockenspiel of bar 11. Despite this link, the harp figure of bar 9 is perceptually less salient than the bright, inharmonic, struck metal trills/tremolos, which means that it is more likely to be perceived as marking a sub-section. In the Opus 10 version, the greater timbral similarity of the bright struck metal trills/tremolos of bars 5-6, 9, 11 and 14 facilitates perception of these events as 'equivalent'; the less bright celeste trill might be regarded as marking a subsection.

The 'phrase climax' thread

Earlier, I pointed out that the climax of the first section occurs in bars 4-5 and that the

[18] The perception of such patterns as timbral transposition/analogy (see Chapter 1, p. 69) is likely to be facilitated if transitions within dimensions are smooth, to a similar degree, and occur within at least one common dimension (e.g. brightness). For a discussion of what constitutes a 'common' dimension, see Chapter 1, pp. 4ff and 22-3.

Opus 10 version defines this climax more clearly than the Opus 6 version. In the Opus 10 version, the 'phrase climax' thread begins when the peak of the climactic phrase of bars 4-5 is punctuated by an accented long tone in the celeste, doubled by a muted viola *diminuendo* tone (bar 5, beat 1). The second step of the 'climax' thread occurs in bar 6, where the muted viola, now *sul ponticello*, plays a trilled *diminuendo-crescendo*; at the peak of the dynamic hairpin, the celeste plays an accented staccato tone. The next step of the climax thread (bar 7) combines the ideas of celeste and trill and retains a string component through the use of solo muted cello and solo muted double bass. Whereas the celeste and viola play in unison in bar 5, the development in bar 6 separates the string and struck metal components because, as the notation indicates, their attack points do not coincide. The development in bar 7 sees a return to the synchrony of the bar 5 climax, because the string and struck metal components do not differ in note duration and dynamic contour, having acquired the chordal function and dynamic contour from bar 6 (*crescendo-diminuendo*). The new sonority occurs at the textural peak of what might be regarded as a sub-section of the piece's second section. It seems appropriate that the climax of this sub-section, which is characterised by fragmentation (bar 7), is reached through a timbral event that generates its own microcosmic climax through fragmentation of an earlier sonority (bar 6).

The chord thread

In contrast to my definition of sections, Michael Russ (1988: 248) suggests that the violin phrase in bar 7 marks the end of a section consisting of 'tiny fragments', and that a third section is characterised by 'clarinet melody with chordal accompaniment' (248). Although these bars can certainly be perceptually divided in this way, such a hearing overlooks the development of chordal elements earlier in the piece. In fact, the climax thread is embedded within the 'chord' thread. The peak of the climactic phrase of bars 4-5 can be regarded as the source of the 'chord' thread, because the downbeat of bar 5 is the first instance of a real chord within the polyphonic textures that characterise the first section. Earlier tone simultaneities are not 'chordal' in the same sense. Even when the dynamic contours of lines seem fairly well matched (e.g. trumpet and Eb clarinet lines in bars 1-2), the lines are likely to be perceptually segregated rather than fused into a single event. Such streaming may be attributed mostly to differences between the rhythms of the individual lines.

In bar 5, the components of the chord are distributed over two octaves: Bb6 (piccolo and violin), B5 (clarinet) and C6 (celeste and viola). In bar 6, these pitch classes are compressed into a cluster and transposed; the Bb and B become the viola trill Eb4-Fb4 and the C becomes the celeste F. Whereas the viola and celeste of bar 5 are in unison (C), the tones form a dyad Eb-F (and Fb-F, depending on how you view the upper note of the trill) at the peak of the trill's hairpin in bar 6. At the peak of the second section, the dyad becomes a trichord, with the string minor second relationship developing into a vertical string sonority that recalls two of the pitch classes from the first chord (Bb4-B4). The third component is, of course, the celeste trill. This develops the minor second trill and major second relationships of the second chord into a major second trill E-F#.

After this point, the chord thread moves in different directions. By bar 8, the chord has shed the celeste trill, but gained violin and viola tones. This four-note string chord (Gb3, C4, Eb4, E4) also has a new dynamic contour—a *crescendo*. In bar 9, there is a chord for muted horn, muted trombone and harmonium (Bb2, Eb3, A3, E4). Although half the duration of previous chords (quaver instead of crotchet), this chord is a development of the string chord because it consists of four tones that blend timbrally most effectively. In all of the recorded performances that are currently available, this chord is barely audible, if at all. In fact, it seems to provide an (at least notional) joining function, growing out of the flute fluttertongue G towards the next chord, which is on the second beat of bar 9. Being part of, but separate from, the wind chord, the tremulousness of the fluttertongue may suggest a return to the tremulous components of the chords that occur before the string chord in bar 8.

Comparing versions

In the 'Opus 6' version, the flute of bars 8-9 is non-tremulous (a non-staccato quaver tied over to a non-tremulous crotchet), but the bar 8 chord includes a fluttertongue bassoon (C4). The other components of the bar 8 chord are scored for sul ponticello viola (E3, Eb4) and harmonium (Gb3). The chord on the second beat of bar 9 develops the tremulous idea; it features a single pitch four-note semiquaver figure in harp. In the Opus 10 version, this figure is relocated to the central bars of Opus 10 No. 3 and replaced with a glockenspiel trill. In the context of the 'Opus 6' version of No. 2, the harp pitch reiteration seems to be a development of the bassoon fluttertongue of bar 9 as well as the (unpitched) triangle trill of bars 5-6.

In bar 9 of the 'Opus 6' version, the artificial string harmonics of the second beat have hairpin dynamics, suggesting a link with the previous isolated sonorities. In Opus 10, the hairpin is replaced with a *diminuendo*, which is part of a larger hairpin that begins on the bar 8 chord. This is a development because the chords are not treated (or perceived) as entirely separate entities.

Like the 'Opus 6' version, the Opus 10 version of the chord on the second beat of bar 9 maintains the idea of tremulousness. It is the culmination of many of the events that occur in previous bars: the brightness of the glockenspiel trill recalls the brightness of the triangle trill of bars 5-6; the semitone trill is perhaps derived from the viola trill of bar 6; the combination of rapid pitch oscillations on struck metal combined with strings has a precedent in the chord of bar 7; the chordal upper strings are prepared for by their presence in the four-note string chord of bar 8; and the use of artificial harmonics was first heard in the climactic phrase of bars 4-5. In the light of these relationships, it seems fitting to consider this chord as marking the end of the second section; the relationships reinforce the divisions that I made according to the Section Definition Thread (see earlier, p. 118).

In bar 10 of the Opus 10 version, a different type of string sonority emerges—a five-note plucked harp chord. In terms of the chord thread, its excitation can be seen not only as an anticipation of the harp's impulsiveness in the *sf—p* chords of bars 10-11, but also as a preparation for the percussive col legno strings of that chord. The *sf—p* chords can be seen as a development of earlier chords because they have four pitch classes and preserve the combination of string and struck metal, though of course the perceptual effect is quite unique.

'Opus 6' differs considerably in these bars. There are no spread harp or *sf—p* chords; instead, the four-note semiquaver figure that occurred in bar 9 features in the harp upbeat to bar 11 (E3-Fb3 alternation), with a crotchet tremolo sul ponticello violin (G3), fluttertongue bassoon (B2) and fluttertongue Eb clarinet (B3). Other tones are tied over the bar line. A double bass (D4) tremolo natural harmonic crescendos through a crotchet upbeat into a quaver on the downbeat of the following bar. Similarly, a celeste tremolo tone (A4) crescendos through a quaver into a tremolo quaver on the downbeat and a timpani roll (F3) and cello (C#3) triplet quaver is tied over to a quaver.

The effect of the Opus 10 version is far more striking as the *sf*—p chords are far more impulsive than previous material (see later). Rebounding off the *sf—p* is a chord scored for muted horn, muted trombone and harmonium. This wind chord is the only other instance in the piece where instrumentation is identical to another chord. The timbral connection of the chords (bar 9/1 and bar 10) is far less explicit in the 'Opus 6' version. The first chord (bar 9 beat 1) features celeste (E4), fluttertongue muted trumpet (A3) and fluttertongue muted trombone (Eb3); and in the second chord (bar 10), the harmonium's triplet crotchets of bar 10 (C3 and B3) are played on violin and viola. In Opus 10, the bar 10 wind chord differs from the earlier chord in that the crescendo begins p rather than pp (just as the *sf—p* chords differ from each other only in terms of dynamic); the only other difference is the slightly longer note value. One could regard the triplet crotchet duration as being derived from the chord in bar 7.

In Opus 10, the functions of these chords are also similar. Both sonorities are preceded by a two-note figure that consists of a staccato semiquaver anacrusis followed by a note on the downbeat; the wind chords rebound off the downbeat, crescendoing towards (and in the case of the chord in bar 10, merging into) a sonority that features a trilled glockenspiel.

The brass and harmonium chords (bars 9 and 11) and timbral characteristics of other chordal events pave the way for chordal sonorities of bars 12-14. Whereas in bars 10-11 the *sf* and the *p* are assigned to separate chords, in bar 12, the oboe, Eb clarinet and trumpet play a three-note chord that contracts the *sf—p* to a single *sfp* attack. Moreover, the semiquaver anacrusis and downbeat that characterises the sonorities in bars 8-9 and 10-11 is heard on entry of the piccolo, clarinet and glockenspiel in bars 13-14. The combination of anacrusis and trill in woodwind and glockenspiel links, of course, with the ideas in bars 8-9 and 10-11.

The impulsiveness thread

Of all the threads, 'impulsiveness' is perhaps one of the most fascinating. It begins in bars 1-2, where a continuously-excited instrument (trumpet) emulates the production of a pseudo–continuously excited tone on an impulsively-excited instrument (fluttertongue). There is no re-excitation, only the impression of re-excitation—the production of air, which is the source of excitation, being constant. Although belonging to a different stream, the staccato Bb of the clarinet, which doubles the trumpet fluttertongue E, anticipates the doubling of tremolo violin with pseudo-impulsive piccolo in bars 4-5. This is a subtle development of the relationship between impulsiveness and tremulousness. Unlike the trumpet fluttertongue, the violin tremolo is produced through re-excitation of the string, each excitation being caused by moving the bow in a different direction. Moreover, the staccato piccolo tones accentuate the attack portions of the violin tones—the piccolo and violin tones are perceptually fused.

The impulsiveness-continuousness/continuousness-impulsiveness subthread

The impulsiveness thread divides into three sub-threads. One could perceive the first of these as moving further along the continuousness-impulsiveness continuum towards impulsiveness: the triangle trill of bars 5-6 develops the notion of re-excitation, because the listener recognizes that the re-excitations are produced on an impulsively-excited instrument. However, the tone is, paradoxically, less 'impulsive' than the violin and piccolo tones of bars 4-5, because the loudness contour from the initial attack to the end of the tone is considerably less steep. This sub-thread develops into the 'section definition' thread, which I discussed earlier.

Another movement towards a pseudo-continuously-excited tone occurs in the celeste part of bars 5-7. The long impulsive celeste tone of bar 5 is followed by a short celeste tone in bar 6. The rapid succession of short tones in the celeste trill of bar 7 is perceived as pseudo-continuously excited.

The anacrusis sub-thread

The second sub-thread sees a separation of the staccato and tremulous elements in the viola and celeste tones of bar 6. This separation not only has implications for the chord and climax threads, which were discussed earlier, but also for the development of the anacrusis thread: in bars 8-9, the staccato and tremolo tones are separated even further, as they are now presented in succession and in the same sound source. The tones are also linked to the violin and piccolo tones of bars 4-5 in that the tremolo, which is common to both, is reinforced by a familial relationship (rise time, spectral flux and jitter) between flute and piccolo. In terms of the movement towards impulsiveness, the staccato flute tone is a development of the separation of the tones in bar 6 and the pseudo-impulsiveness of piccolo-violin tones in bars 4-5. In terms of anacrusis, it is a development of the triangle trills notational anacrusis, which occurs across the bar-line in bars 5-6.

The anacrusis idea is taken up by impulsively-excited instruments in bar 9. The cymbal and triangle staccato triplet quaver has obvious timbral links with the triangle tone of bars 5-6 and the staccato celeste tone of bar 6. The climax of the anacrusis sub-thread occurs in bars 10-11, where the *sf—p* chords give rise to an accented anacrusis. The inclusion of celeste tones is certainly in keeping with the notion of climax.

The impulsiveness of the *sf* chord seems to be magnified by the staccato *p* chord that follows—a sensation that might be likened to an 'extraneous noise' 'specificity' in impulsive tone perception. This type of extraneous noise specificity is perhaps most closely associated with 'impulsive' keyboard instruments, such as the harpsichord; here it lends a character that is consistent with this passage, blurring the distinction between production and motif.

The wind anacrusis-tremulousness sub-thread

Both the separation and the anacrustic pattern of staccato and tremolo tones in bars 8-9 have important implications for the third sub-thread. The flute fluttertongue recalls the same type of tremulous excitation as the trumpet fluttertongue. This return is important for the development of the anacrustic wind trills that occur in bars 12-14. The developments that lead to these wind trills will be outlined in the discussion of the wind tremulousness sub-thread. However, one of the developments refers directly to the flute pseudo-impulsiveness of bar 8. In bars 13-14, a semiquaver anacrusis followed by trills occurs in piccolo, clarinet and glockenspiel; the higher register, and the doubling of the pseudo-impulsive wind tones with an actual impulsive tone results in a more 'impulsive' rendering of the anacrustic motif.

The tremulousness thread

This thread follows through the developments that lead to the final tremulous sonority. It begins in bars 1-2 (fluttertongue trumpet *x* and trilled clarinet *y*), which introduce pitch reiteration and pitch oscillation. (This is the starting point also for the wind-tremulousness subthread, which is discussed below.) The wind pitch reiteration develops into string pitch reiteration combined with impulsive wind attacks (piccolo). The thread divides—the progression to trilled string in bar 7 marks the first development of the semitone-tone motif subthread (see below). The tremulouness thread on the other hand develops from the impulsiveness of bars 4-5 into the triangle reiterations of bars 5-6. This develops (via the semitone-tone motif subthread) into a pitch oscillation in the celeste. As discussed in the section definition thread, this develops into the pitch oscillation of the glockenspiel. In bar 11, the tremulous sonority draws upon the pitch oscillation of the glockenspiel and the inharmonic pitch reiteration of the triangle. However, the inharmonicity is provided by tremulous cymbals, which are first heard as an impulsive cymbals and triangle anacrusis in bar 9 (see the anacrusis ub-thread). The dynamics suggest the cymbals inharmonicity (*pp cresc. p* in contrast to the glockenspiel's *p cresc. ff*) should not dominate the sonority. Finally, the climactic sonority brings together wind pitch oscillation (see the wind tremulousness subthread below) and glockenspiel pitch oscillation, which is joined by triangle pitch reiteration (drawn from bars 5-6 and 9).

In the most recent recordings by Claudio Abbado (1989) and Boulez (1995), the glockenspiel trills in bars 9, 11 and (possibly) 14 seem to be executed as tremolando on the notated pitch, rather than oscillating with the note above. Günter Wand's percussionist (1991) seems to tremolo in bar 9, but not in bars 11 or 14. The ♭ marking above the trill in bar 14 suggests that the glockenspiel trills should be played as pitch oscillations rather than pitch reiterations. On the other hand, the aural ambiguity of these trills (at least in the above recorded performances) indicates a fuzzy timbral boundary between pitch oscillations and reiterations. In glockenspiel tones, pseudo-continuousness results in an increase in inharmonicity; this is likely to be caused by the successiveness of inharmonicity during the initial attack of each impulse.

The wind tremulousness sub-thread

As mentioned in the tremulousness thread, this begins in bars 1-2, where a fluttertongue trumpet motif overlaps with (a staccato tone of) a trilled clarinet motif. Whereas the trumpet's tremulouness is developed in the wind-anacrusis tremulousness subthread, the clarinet's pitch oscillations link to the Eb and Bb clarinets of the final bars.

In 'Opus 6' the step after the first tremolo (on clarinet) is a fluttertongue bassoon C4 (bar 8). In contrast to Opus 10, this tone was not part of a motif (flute)—it was part of an isolated chord. The next step after this is in a chord on the upbeat to bar 11 (see section definition thread), where the bassoon tremolo is combined with string tremolo (violin and double bass), struck metal tremolo and plucked harp pitch reiteration. In effect this anticipates the different rates and types of pitch reiteration that characterises the following piece ('Opus 6' version of Opus 10 No. 3): perhaps Webern's reasons for reorchestrating this passage for Opus 10 were because multi-tremulousness had been aired too soon.

In the 'Opus 6' version, the B4-C#5 trill in bars 12-14 was played on bassoon rather than oboe. Webern may have felt that the bassoon link between this trill and preceding tremolos was insufficiently organic,[19] leading him to make the tremolo-trill link through motivic and articulative connections. In the Opus 10 version, the bar 9 chord is played entirely on non-tremolo strings. The fluttertongue idea is transferred to flute on the downbeat. The new articulation is a step towards the *sfp* trills of bar 12 and a more overt reference to the motif in piccolo and clarinet parts of bars 13-14. (The accented tremolo corresponds to a sudden dip in amplitude after the initial peak; the *sfp* trill exaggerates the peak.) During the climactic trilled tremolos of the final bars, the horn features the trilled minor-major second motif (*y*); in contrast to the clarinet rendering in the opening bars, all three notes are trilled and are embedded within a larger phrase.

The semitone-tone motif sub-thread

A subthread of the tremulousness thread involves the semitone-tone motif, which played such an important role in Opus 10 No. 1. The main pattern is a descending minor second followed by an ascending major second. It begins as motif *y* of bar 2, and is developed in the fragmentary sub-section in three ways. A very compact (linear-vertical) version of the motif occurs in bar 6: taking the pitch oscillation of motif *y*, a viola trill provides a minor second, which then forms a major second with the celeste tone with the 'main' (notated) trill note at the peak of the hairpin. This staccato celeste tone marks the starting point for the next (compact linear) version, forming a minor second with the 'main' note of the trill in bar 7; the development is the separation of the trill from the punctuating tone. The trill of bar 7 is part of a chord with strings (muted solo cello and double bass). The next development emerges from this sonority, unfolding the motif into a (fully linear) D-Db-C

[19] He removed the bassoon from the orchestra for the Opus 10 version.

(violin). This unfolding is not presented as a continuous descent, however. Octave displacement in the motif (D4-Db5-C5) gives rise to a major seventh—a contour that balances the minor ninth of the trombone which preceded and overlapped with the string-celeste chord. The chord provides the axis to this quasi-symmetry, which may be read as an allusion to the quasi-symmetry of Opus 10 No. 1.

Following these developments, the motif is not heard until the final bars, where it returns to its original form (in this piece), i.e. a minor-major second descent-ascent; as was noted in the wind-tremulousness subthread, each tone is trilled at the piece's tremulous climax (horn, bars 13-14).

Note how, throughout this subthread, the motif is characterised by different instrument families: it begins on single reed, followed by string and struck metal (which develops from string-metal to metal to string), and then finally lip reed (brass).

5.2.3 Metre and Anacrusis

The tracing of threads is clearly a useful means of generating schemata that facilitate perception of the organicism of Opus 10 No. 2. However, other perceptual phenomena, such as timbral rhythm, offer alternative schemata and insight into why the situating of the piece before Opus 10 No. 3 is consistent in the various versions (including the Orchestra Pieces ink copy; see earlier, pp. 95-6).

Projected timbral metre

Russ's metrical reading of Opus 10 No. 2 (1988) offers a useful initial point of departure. He has illustrated (258ff.) ways in which two implied metrical systems operate simultaneously: one arises from the notation (3/4) and another is 'contextually established' (2/4). In fact, what Russ demonstrates is that a metre of 5/4 is projected, not 3/4 (see Figure 5.17). The 5/4 groupings are subdivided as sets of either two-plus-three or three-plus-two. Such subdivisions explain partly why the first 5/4, which extends from the Eb clarinet G4 to Gb4 (bars 1-2), is slightly unsettling; whereas this 5/4 is a three-plus-two grouping, the two succeeding 5/4s are two-plus-three. The third 5/4, which is the textural climax of the first section, is the most stable because the second 5/4 has set a context and the subdivisions of the third 5/4 coincide with the 2/4 groupings.

Although Russ claims to employ William Benjamin's concept of 'accent of image shift' (1984: 379), he does not always take into account the timbral stresses that Benjamin's concept implies. The opening bars are a case in point. Russ suggests that the Eb clarinet creates a 'hemiola-type syncopation' against the violin's '2/4', but the note against which the Eb clarinet stream 'syncopates' is relatively weak; it begins at the tail end of a *diminuendo* and crescendos through to the next bar of '2/4'. The difficulty of perceiving these non-coincident tones as a true syncopation is further confounded by the lack of a 2/4 context.[20] On the other hand, whilst the second downbeat of the violin (beat 3, bar 1) seems to be confirmed by the initial attack point of the trumpet entry, Russ does not take into account the trumpet's *crescendo-diminuendo*. This hairpin suggests that the first two notes are themselves an anacrusis to beat 1 of bar 2.

If the notation in bar 1 projects little more than a conceptual 'hemiola' between Eb clarinet and violin streams, the question of how listeners perceive the Eb clarinet stream remains. Bar 1 could be heard as a 6/8 bar or, perhaps more appropriately, a pair of 3/8 bars: the hairpin dynamics of the first two tones do not suggest a strong-weak or weak-strong relationship. However, the second tone (Ab6) is likely to be perceived as stressed because it is the brightest tone in this context, and difficulty of producing the tone, which is high in the instrument's tessitura, may cause some performers to accentuate the tone. If such an accentuation occurs, it is likely to reinforce the perceptual effect of a strong downbeat, the first tone (whether or not a '3/8' bar) functioning as an anacrusis.

---

20 The 2/4 of Opus 10 No. 1 may offer a possible context however. As Russ points out earlier in his study (248-249), the pieces have a 1:2 tempo ratio: ♩ = 50 (Opus 10 No. 1) to ♩ = 100 (Opus 10 No. 2).

The accented anacrusis

Accented anacruses have a strong-'weak' relationship with the downbeat, though they are usually perceived and achieve their greatest impact in the context of a uniform metre. A somewhat problematic example of an accented anacrusis occurs at the end of bar 5. The triangle entry acts as an accented anacrusis, because it anticipates a downbeat with a bright, inharmonic, impulsive, but quasi-continuously-excited timbre. The crotchet downbeat that follows is less salient; it is marked with a *diminuendo*, which indicates a far less dramatic shift within timbral dimensions (Timbral Rhythm Guideline iii) than between the fifth and sixth quavers of bar 5. Although the quaver at the end of bar 5 may at first be perceived as an anticipation of the crotchet downbeat, the downbeat of bar 6 itself is imperceptible. The notation of the trill implies a tie across the bar-line. Although the trill could be re-articulated by reducing the dynamic to *pppp* before playing the *ppp* downbeat, the re-articulation might be difficult to perceive. More importantly, the appropriateness of a re-articulation is arguable given that Webern changed the dynamics from *crescendo-diminuendo* ('Opus 6') to just *diminuendo* (Opus 10). The change suggests that Webern did not want an emphasis on the downbeat. Moreover, if he had wanted a re-articulation, he could have clarified this in the notation by placing another 'tr' above the crotchet.

Whereas Russ indicates that the triangle trill begins off the downbeat of an implied '2/4', the perceptual effect is of a downbeat that overlaps with the end of the 5/4. In terms of note values, the trill and the following rest are two crotchets and a quaver. However, the *ritenuto* causes an elongation of the trill, which could conceivably cause the perceived sum of the trill and rest to approximate to a 3/4 bar in the new tempo. The duration of the rest should not, however, be longer than a crotchet in the new tempo; if it is any longer, it may be heard as a section-defining pause, and the sense of teleology may be lost. Whilst maintaining that the triangle trill attack point may be perceived as a downbeat in retrospect, the anacrustic sensation within the 5/4 context still applies. Thus, the trill may be perceived as anacrustic within two different metrical systems. The '3/4' ultimately predominates, and the viola trill that follows functions on the one hand as the long awaited resolution of the '3/4' anacrusis; on the other, the staccato celeste quaver at the peak of the viola hairpin projects into the next bar.

The staccato celeste quaver functions as a 'counter-anacrusis' i.e. a sonority that interrupts—and perhaps diverts the listener's attention from—a resolution. Counter-anacrustic ideas do not necessarily disrupt the piece's overall teleology, even if they might disrupt the teleology of an individual phrase. On the contrary, such interruptions seem to project the listener's attention into the next phrase, functioning as (part of) an anacrusis to that phrase.

The progressive anacrusis

Cooper and Meyer (1960) describe such a phenomenon as the 'progressive anacrusis'. In Opus 10 No. 2, the progressive anacrusis is potentially weakest at bars 5-6 and bars 7-8, because the rests can be perceived as divisions if they are improperly performed. In Boulez's latest recording (2000) the anacrustic effect is lost in both of these places, because at bars 5-6 the triangle entry is quieter than *ppp* (it is barely audible) and the *zögernd* ('hesitation') of bar 7 does not feel as though it is leading into the next bar; the violin motif is drawn out too far and the crotchet rest at the return to tempo is slightly too long for bars 7 and 8 to be perceptually linked. It is obvious from this recording that Boulez conceives No. 2 in distinct sections.[21] Abbado's recording (1993), on the other hand, conveys marvellously the anacrustic sense throughout the entire piece (though the triangle trill and rest in bars 5-6 tend to rush).

Hanson (132) has suggested that bars 9-14 act as an extended 'upbeat' to No. 3. The sense of forward motion does indeed intensify from bar 9. A sense of direction towards bar 12 is caused by a number of factors. Anacruses to bars 10, 11, and 12 each increase in number of notes (one, three, and five, respectively) and rapidity (an overall *accelerando*[22] combined with an increase in note values from the quavers of the first two anacruses to the quintuplet semiquavers of the third). Each of the anacruses ascends towards the

[21] This does not invalidate Boulez's performance, which works on its own terms, according to Boulez's aesthetic outlook.

[22] Hanson observes the *accelerando* (1976: 136).

downbeat of the following bar, their ranges increasing from a major seventh (G#4-A5) to an augmented ninth (Db4-E5) to a perfect twelfth (F4-C6). There is also the general dynamic increase (from *pp-ff*), which was mentioned earlier in the study.

The counter-anacrustic *sfp*s contribute to the progressive anacrusis effect. The *sf—p* is one of the most striking timbral events in the piece; its *col legno* strings, celeste, and harp are set against the clarinet line. The timbre of the *sf—p* chords is unanticipated and the effect unexpected, because the weight of the *sf* just precedes the downbeat of bar 11 (which is the arrival point of the clarinet's three-note anacrusis).

In a sense the *sf—p* of bars 10-11, prepares the listener for the *sfp* in bar 12. Even though the downbeat of bar 12 is clearly the arrival point of the quintuplet anacrusis, the trumpet *sfp*, reinforced by *sfp* entries in oboe and Eb clarinet, acts as a second 'downbeat', but is stronger than the first. The effect is that, in retrospect, the actual downbeat of bar 12 acts as an 'anacrusis' to the second beat.

In marking the final surge towards bar 12, the *sf—p* may be regarded as initiating a switch in timbre and texture; a single melodic line in clarinet and isolated chords changes to energetic counterpoint between trumpet and horn with bright tremulous timbres in the 'background'.

Masking

On the other hand, the continuity and teleology of the clarinet line are facilitated partly by the *crescendi* of horn, trombone and harmonium, and to a greater extent by the trilled glockenspiel and rolled cymbal, which carry the general *crescendo* through to the trumpet-horn duet and final textural accumulation.[23]

---

[23] The anacrustic quality is even stronger in the final bars, because the trumpet and horn duet provides a sense of timbral consistency that helps the material in these bars to be perceived as a single entity, making it easier to perceive them as an extended anacrusis. Pre-conditioning also plays a role: even the fanfare-like character of the trumpet-horn duet suggests something anticipatory.

The function of the trill and cymbal roll (bar 11) is one of masking as well as of section defining (see the section definition thread). In bars 9-12, the clarinet's anacruses *crescendo*, each ascending as though leading directly to the trumpet's anacrusis, which also ascends. In contrast to the motives in bars 2-3, this single stream links two distinct sections (9-11 and 11-14) that may be defined not simply by the timbral characteristics of clarinet or trumpet tones, but also by the distinctiveness of the other instrument timbres and orchestral textures.

The trumpet may succeed the clarinet not only to shift to a different timbral and textural domain. The instrumentation change may have been partly to bring the stream further into the foreground. The perceptual prominence, caused by the trumpet's brightness and the registral height of the first note of its anacrusis, enables its tones to be heard through the glockenspiel trill and cymbal roll. Had Webern chosen to leave out the glockenspiel trill and cymbal roll at this point,[24] the instrument change might not have been necessary for stream continuity. It may, in fact, have been less desirable, because the absence of the tremulous masking effect could cause the listener to focus too much attention on timbral dissimilarities e.g. qualitative effects of jitter differences and the clarinet's 'hollowness' specificity.[25]

Pitch relations

Another factor that may contribute to the anacrustic effect is a pitch pattern outlined by prominent high notes. Figure 5.18 outlines the pitches that occur on the (notated) downbeats of bars 10-12 and the first note of the trumpet anacrusis (bar 11).

These pitches may be regarded as the most perceptually-salient notes of the line for a number of reasons. Each is likely to have a higher salience value than the pitches that immediately precede them because the tones of this pitch pattern are both brighter and

[24] There is no cymbal roll in the 'Opus 6' version.

[25] As pointed out in Chapter 1 (p. 14), data from the SHARC Timbre Database show trumpet and clarinet tones in similar centroid regions.

registrally higher.[26] In the case of A5, E5 and C6, the notes, which are longer than the individual notes of the anacruses, provide the ear with more time to process the acoustical information; these notes would probably also be given a little extra weight, as suggested by the crescendi and downbeats. The salience of G5, on the other hand, varies according to the speed of the quintuplet: if time is taken over the quintuplet, this allows more room for the *crescendo*, which could cause the A5 immediately preceding the downbeat to be perceptually more prominent than the G5 (e.g. as in Boulez 2000); if the quintuplet is taken quickly (as the accelerando indicates that perhaps it should), the first of the anacrusis notes is probably the most prominent (e.g. as in Abbado 1993).

The pitches of Figure 5.18 seem to allude to two chords. Whereas the overall pattern arpeggiates the elements of an A minor chord with added minor seventh, a sub-grouping of the E-G-C ascent is facilitated by the descent from A5 to E5. The possibility that the E-G-C pattern may allude to C major (in first inversion) seems to be reinforced by the sub-grouping G5-C6; this further sub-grouping may be attributed to timbral proximity (both these pitches being played on trumpet), and anacrusis-downbeat relationships. If the above pitch patterns do contribute to the anacrustic effect of bars 9-12, the sense of anticipation is maximised by the arrangement of the broken 'chords' into a perfect fifth and perfect fourth. In particular, the G-C perfect fourth may not be part of a latent tonal scheme, but its strong directional thrust across the bar line is perceptually analogous to a local V-I progression in tonal music.

Many factors—pitch, masking, continuous global amplitude increase, textural accumulation and so on—contribute to Opus 10 No. 2 functioning as an accented, extended anacrusis to No. 3. However, Webern's manipulation of anacrustic features and overlaps between projected timbral metres in No. 2 are perhaps the principal means by which No. 3 is anticipated.

[26] See earlier discussion on the relationship between brightness and register.

Conclusion

Many listeners may share Berry's discomfort with Cone's notion that most compositions function as a large extended upbeat followed by its downbeat (Berry 1971; Cone 1968); such a 'high level' of perception can blur foreground details. But perhaps Opus 10 No. 2 offers a counter-argument; in order for the piece to be perceived as an extended anacrusis, it relies on schemata that require close attention to foreground elements, particularly in bars 1-9.

Of all its musical developments, perhaps the forging of links between tremolo and trill is the most fascinating. The relationship between these ideas was first aired in Opus 10 No. 1, and by the end of No. 2, the notion of tremulousness is clearly and vividly brought to the listener's attention; the transformation that occurs—from muted trumpet fluttertongue to vertically-combined, crescendoing trilled chords in high wind, high brass, glockenspiel and triangle—produces a previously unheard and aurally spectacular effect.

5.3 No. 3, '*Rückkehr*'

Opus 10 No. 3 is the antithesis of No. 2. It has the most clearly defined sections of all of the pieces in the Opus 10 set—a characteristic that is attributable to a consensus of structure-delineation amongst many parameters (timbre, pitch, rhythm, tempo etc.). The outer sections of the piece are chordal 'blocks' of texture. Compared with Webern's other works of this period, they are unusually 'stable' passages of music. Their stability is the goal towards which the progressive anacrusis Opus 10 No. 2 strives.[27]

The opening chordal 'block' is constructed from superimposed ostinati—a development of the cumulative superimposition of different tremulous sonorities that occurs in the final

[27] The anacrustic relationship between these pieces might suggest that they should run successively without separation. However, Webern does not supply an 'attacca' marking at the end of No. 2, and No. 3 'begins' with a notated crotchet rest (dotted minim rest in the 'Opus 6' version). The pause between movements, which may be longer than a rest, may be necessary in order to avoid the reverberation of the striking final chord intruding on the opening of No. 3, and may increase the dramatic effect. Whatever the length of the rest, the performers must be careful to maintain the tension throughout; putting down instruments between pieces will release the tension and greatly weaken the anacrustic effect.

bars of No. 2 (see Figures 5.15 and 5.19). The reprise of this material conveys a sense of 'Return' that is in keeping with the arrangement title ('*Rückkehr*'). It is a structural 'Return' that is akin to Schoenberg's structural return (canonic retrogression) in '*Farben*', which I have suggested reflects Mathilde's actual return to Schoenberg (see pp. 76-7).[28] Unlike Berg's '*Farben*' allusions, this structural parallel is difficult to read as a direct allusion to or comment on events in Schoenberg's private life.

Nevertheless, Opus 10 No. 3 seems to express autobiographical and narrative ideas that are similar to those embodied in '*Farben*': it is associated with notions of life, death, time, and the request for the 'return' of a lost loved one. A letter that Webern wrote in 1912 may clarify this extra-musical meaning:

> I would like to tell you that the grief for my mother grows within me more and more. Almost all my compositions have originated in her memory. It is always the same thing that I want to express. I bring it to her as a sacrificial offering. (Webern to Schoenberg, 17 July 1912; trans. Moldenhauer (1978: 83).)

The date that Opus 10 No. 3 was composed (the day after the anniversary of Webern's mother's death, see p. 96) adds credibility to the idea that Opus 10 No. 3 was intended as a 'sacrificial offering'. The piece's 'ostinato machine' (bars 0-3 and 7-11) functions like the inner workings of a clock: a machine that, like Schoenberg's pulsating fifth canonic voice and Berg's treadmill, may represent life. On the other hand, the ominous snare drum rolls, which bring the machine to a standstill, may be a reference to death. Their association with death may be traced to the snare drum rolls that precede the climactic section of Webern's *Six Pieces for Large Orchestra*, (published) Opus 6, No. 4 (bars 28-34)—a piece that bore the tempo indication '*Langsam, marcia funebre*' in an early version.[29]

---

28 As noted earlier, Webern played an important role in initiating Mathilde's return to Schoenberg.

29 The Moldenhauers (1978: 83) have suggested that this piece 'was conceived as a memorial to his mother'.

These ideas of time, life, and death are linked to the concept of 'Return' in the song *'O sanftes Glühn'*:[30]

> Oh gentle mountain radiance,
> Now I see Her again.
> Oh God, so tender and beautiful,
> Mother of Grace, in heaven
> Come down, return.
> You greet and bless - -
> The breath of evening takes the light away—
> I see your beloved face no more.
> (Text by Webern; trans. Peter Westergaard, 1968.)

The text suggests that Webern is, moreover, calling out for communication with a divine being.[31] In both '*O sanftes Glühn*' and Opus 10 No. 3, Webern seems to be like the father in *Tot*, yearning for a return to the 'exalted state'. If we accept that Opus 10 No. 1 may represent the 'ideal' exalted state and the Creation before God sent the Flood, the timbral links between Nos. 1 and 3 may be perceived as a yearning for a return to the ideal. The most characteristic sounds of Opus 10 No. 3 are the bell-like timbres, such as harp harmonics and celeste tones, which link to the bright timbres of Opus 10 No. 1; in my analysis of Opus 10 No. 1, I suggested that such timbres might allude to the divine (see p. 99).

Further reinforcing the link with *Tot*, the outer sections of Opus 10 No. 3 are, like the third scene of the play, 'pervaded by the distant sound of cowbells' (see Figure 5.7).[32] This link with the scene is even more apparent in the 'Opus 6' version of the piece: the tremulous cowbells, low orchestral bells and cymbals (the cymbals were omitted in the

---

30 The song is also linked musically with Opus 10 No. 3. It features a reference to the triplet rhythm of the superimposed layers that characterise the final section of No. 3.

31 The reference to the Mother of Grace may apply not only to the Virgin Mary, but also to Webern's mother, who was a devout catholic.

32 Cowbells depict the Alps. This is, like the honky tonk piano in *Wozzeck*, an example of a timbre that carries strong cultural associations.

Opus 10 version) are marked '*aus der Fern*e' (in the distance) (see Figure 5.20). The sonorities set the scene for Webern's appeal to the 'Mother of Grace' in '*O sanftes Glühn*', which follows in the 'Opus 6' version (see Figure 5.21).

5.3.1 The ostinato machine

The Opus 10 No. 3 ostinati develop from the tremulous sonorities of Opus 10 No. 2; however, they contrast with the preceding sonorities, because all of the tones are impulsively excited and the timbral change rates vary amongst the streams. The texture consists of 'non-pitched' tremolos, pitched tremolos and 'slow' regular pitch reiterations (quavers and crotchets) are combined. The different rates of change highlight the fact that there is a (fuzzy) critical point at which the rapidity of reiterations becomes a timbral, rather than a rhythmic, phenomenon. In the reprise, the texture is more complex. In addition to imperceptible attacks of sustained continuously-excited pitched tones (cello artificial harmonic), pseudo-continuously excited 'non-pitched' tones (tremolo bells and cowbells), a pseudo-continuously excited pitched tone in which individual attacks are perceptible (mandolin tremolo), 'slow' pitch reiterations (harmonium triplets and harp crotchets), and 'slow' pitch oscillations (celeste D#-E quavers).[33]

Salience

In most performances, the pitches of the opening cowbell and low orchestral bell tones are indiscernible. This is due to beating amongst frequencies within the same critical band, particularly in the case of low frequencies, because the critical bands are wide. The beating amongst spectral components of many inharmonic sound sources (the bells) causes an indeterminacy of pitch that facilitates the parsing of the sound sources that have (generally) harmonic spectra. In other words, the listener may be able to focus on the pitched aspects of the sonorities, relegating into the background the non-pitched elements.

However, in bars 1-3 of the 'Opus 6' version, tremolo cymbals (marked trill) are combined with the low bells and cowbells. To a certain extent the removal of the cymbal

[33] These are reiterated D#s in the 'Opus 6' version.

roll for Opus 10 No. 3 is perhaps related to the effect of the tone's density of inharmonic components and wild spectral flux (James Beauchamp 2000). Without the cymbal, the bells are far less densely inharmonic; they are likely to be perceived as a diffuse pitch band rather than an unpitched sonority. The greater density of the rolled cymbal tones' inharmonic content would perhaps detract from or mask this pitch band, and, combined with the brightness of the sonority, would certainly be more likely to detract from and partially mask the tones that have (principally) harmonic spectra.

For the same reason, in bars 4-7 of the 'Opus 6' version, the doubling of the bells with the bright inharmonicity of triangle and cymbals would have perhaps brought these sonorities too far into the foreground. Webern's marking of '*aus der Ferne*' (from the distance) for the bells certainly suggests that these sonorities should not be too prominent.

In the opening sonorities of the Opus 10 version, the mandolin, guitar, and harp tones may be most easily distinguished from the bell tones in terms of their excitation. Although all of the instruments in the sonority are impulsively-excited, these three alone are plucked or strummed; they differ from the bells in terms of inharmonicity (plucked/strummed tones are only slightly inharmonic), spectral flux (see Figure 1.5b), and timbral weight fluctuation (greater fluctuation in bells, see Chapter 2, p. 43).

On the one hand, the listener's ability to identify these means of excitation facilitates parsing. On the other, the instruments that may be most differentiated from the bells (i.e. guitar and mandolin, because they decay more rapidly) play tremulously, bringing them timbrally closer to the tremulous bells than would otherwise be the case; normally the rapidity of attack and decay would be strong distinguishing factors. The effect here is that the tremulousness contributes to textural homogeneity, but the rapidity of decay enables the guitar and mandolin reiterative attacks to be perceived more easily than the bells' reiterative attacks. The rather more 'bell-like' celeste and harp tones are non-tremulous; this helps to distinguish them from the tremulous bell, guitar and mandolin tones, their different rates of onset (celeste in crotchets, harp in quavers) contributing to the effect of multi-layered textures. In bars 1-2, the smooth global amplitude variations of the pitched instruments (*crescendo* and *diminuendo*) increase the likelihood that the bells are perceived as less salient, 'background' sonorities.

According to Parncutt pitch salience data, the most salient pitches in the opening sonorities are usually played by the guitar (E and A) (see Figure 5.22). However, the data do not take into account the issues discussed above. There is far greater global timbral fluctuation in the celeste and harp streams than in the pseudo-continousness of guitar tones: the impulsive celeste and harp tones change to such an extent that each onset may be perceived as a 'new' timbral event. Moreover, the celeste and harp (and to a certain extent the mandolin) tones are likely to be much more salient than the Parncutt data suggest, because of the brightness of the tones in mid-high registers.

These sonorities and events are likely to become relegated to the middleground in bars 1-2. The listener's attention is diverted by the solo violin tones; other than being marked a dynamic level above the 'shimmering' texture, various timbral factors ensure that the melody stands out in these bars:

(i) The tones are produced on the only truly continuously-excited instrument.

(ii) These tones alone would probably be subject to slight periodic variations in frequency (vibrato).[34]

(iii) The different pitches of these tones form a linear trajectory which distinguishes them from the 'shimmering texture'. Although the 'shimmering' texture is 'layered', it consists of reiterated vertical aggregates that are punctuated by celeste tones on every crotchet.

5.3.2 Stream contours

Webern often writes melodic lines that consist of angular pitch contours that are caused by registral displacement. Opus 10 No. 3 is not unusual in this respect. However, Allen Forte claims that

[34] String vibrato causes also periodic variations in amplitude (Goad 1994).

> ... the simple melodic profiles formed by the solo instruments' lines are certainly intended to convey visual images of Alpine profiles (1998: 213).

Such references to Webern's love of Nature and assertions about Webern's intentions might seem gratuitous, because they lack sufficient explanation; however, Forte's claim is not entirely without value. In the outer sections, which are played in a slow tempo, the fairly long durations of the melodic tones, provide the listener with unusually adequate time to absorb timbral nuances. It is possible to perceive such nuances in terms of Forte's suggested Alpine scene. For instance, in bars 1-2, the violin's melodic line is played on the G string. The very high position of the F5 links the strength and spread of upper spectral components, conveying a sense of tenseness that seems to magnify the distance between F5 and B3. The release of tension would be less effective if the F5 were played on one of the upper strings, because the strength and spread of spectral components would be more comparable with the lower tone. One could suggest—tentatively—that this sense of release, which is caused by the shift towards a wider, more even spread of spectral components in the lower tone, conveys the impression of 'depth' during the B3. Moreover, the shifts within timbral dimensions are much smoother than if the melody were played on more than one string; an implied portamento, which arises from the shift, is typical of German performance practice of the time (Philip: 1992). In the light of Webern's frequent references to his love of Nature, the setting of Tot, and the '*O sanftes Glühn*' text, the listener's absorption of such timbral nuances might be considered analogous to an onlooker's contemplation of an uneven landscape.

The relative tension and relaxation, which high and low positions on a violin string convey, can also be heard in wind and brass according to the differences in the physical exertion required to blow through short and long pipes. In spectral terms, the shorter pipes (like the shorter strings) limit the strength and spread of spectral components.[35] These differences affect our perception of the horn melody Eb5-Ab4-D4, which begins high in the instrument's tessitura and falls into a more comfortable range. It would seem then that if the melodic profiles of Opus 10 No. 3 do really convey alpine profiles, it is not through the distribution of pitches in the notation, but through the listener's perception of shifts within timbral dimensions.

Streaming

The angularities of the melodic lines enable pitches occupying similar registral positions to be associated perceptually. In some cases the links may lead to the perception of multiple voices, such as in the muted trombone melody of bars 8-9 (DR11 (C3), but single stream perception is possible because DR12 is satisfied). In these bars, the progressions C4-Bb3 and Gb5(F#5 in 'Opus 6')-A6 are quite clear because of the melody's wedge-wise expansion.

The angularities of the violin melody are perhaps more structurally significant. Although a smooth shift within timbre dimensions (caused by portamento) facilitates a perceptual link between F5 and B3, the registral isolation of F5 clarifies perception of the ascending sub-phrase B3-F#4-C5. This may be attributed to the extended duration of the B3 (in this context), timbral proximity, which is greater between B3 and F#4 than between F5 and B3, and the smooth reduction in global amplitude level (*diminuendo*) of B3-F#4-C5.[36] This perfect-diminished fifth progression is important, because it is presented as a *diminuendo*
descent in the horn (Eb5-Ab4-D4, bars 3-4). The timbral analogy in terms of global amplitude facilitates perception of this pitch link. However, in terms of the brightness dimension, they shift in opposite directions (violin increases, horn decreases).

---

35 In limiting the upper spectral components, the spectral centroid is likely to be much nearer the fundamental.

36 The *pp* marking is simply an indication that the dynamic reached on F#4 should be the same as the dynamic before the *crescendo* (*pp*).

Dialogue

Forte uses the term *Klangfarben* to describe the exchange from guitar and plucked cello to bowed viola.[37] The perceptual effect of these short phrases is, in Paul Griffiths's terms, a 'musical dialogue' (2000: 42). This dialogue is quasi-symmetrical, the end of the bar line functioning as the axis. The Eb3-E4 minor ninth of the guitar and cello line is inverted in the following interval which is played on viola (E5-F4 major seventh). The slurs pair each of the viola's intervals E5-F4 and Eb5-B4; the distinction between the intervals is even clearer in the 'Opus 6' version because the Eb5-B4 is marked *f diminuendo*. The Eb5-B4 of the viola line inverts the pitch classes of the vertical interval Eb4-B4 (guitar/cello and harp) so that the augmented fifth becomes a diminished fourth. This link is clearest in the 'Opus 6' version because the guitar line, which is not doubled by pizzicato cello, features the interval Eb4-B4 as its second sonority.

The sense of dialogue and the quasi-symmetry supports the links with *Tot* and Opus 10 No. 1. The modification of dynamics for the Opus 10 version of bar 6 of No. 3 supports this link, because the replacing of *f* with *ppp* diminuendo (Eb5-B4) helps to convey the sense of quasi-symmetry more effectively.

5.3.3 The four-note reiterated pitch motif

In the context of Opus 10, the semiquaver repeated pitch idea of No. 3 seems to be derived from the first two notes of the clarinet melody. This was not apparent in the 'Opus 6' version, because the mandolin (Bb) was played on fluttertongue flute (crotchet). A fluttertongue tone suggests the idea of tone reiteration, but it is not the most effective way of bridging the perceptual gap between the ostinati of the outer sections and the opening of the clarinet melody. Its ineffectiveness may be attributed partly to the absence of winds in the ostinati (the harmonium of the 'Opus 6' version is marked '*Percussione ohne Wind*') and partly to the rapidity of its note 'reiterations' being not as close as the plucked

[37] Incidentally, Forte states that the guitar line of the 'Opus 6' version is replaced by cello in the Opus 10 version. A reader who has the score to hand will notice that, in fact, the cello doubles rather than replaces this line.

harp and mandolin semiquavers to the clarinet's tongued staccato semiquavers .

The harp's role in the motif seems to act as a bridge also between the outer two sections of the piece. In the opening section, the mandolin D5 and harp C#6/Db6 form a major seventh; the motif of bar 5 forms another major seventh—this time the harp plays the lower pitch (B3) and the mandolin the upper (Bb4). In the final section, the major seventh can be heard in the high bell-like harp harmonic E5 and celeste D#6. Whereas the harp plays quavers and the celeste plays crotchets in the first section, these note values are now switched so that the celeste plays quavers and the harp plays crotchets.

As we discovered in the analysis of Opus 10 No. 2, the motif has various links outside its immediate context. In the 'Opus 6 version', the four-note semiquaver motif is played on harp in No. 2. In the light of the motif's occurrence in the upbeat to bar 11 of this version, the *sf—p* impulsive staccato chords of the Opus 10 version (bars 10-11) can be seen as related to the motif and, in turn, to the impulsive ostinati of the outer sections.

The motif can be found also in Orchestra Piece 1. In the final four bars, there is an anacrusis of four repeated Bb2s on harp marked *pp crescendo*. Although the note values are different from the Opus 10 No. 3 motif, the 2/2 time signature of Orchestra Piece 1 suggests that the durations of quavers are similar to those of semiquavers in the 3/4 time signature of Opus 10 No. 3.

However, the origins of the motif date from much earlier. In the early ink sketches of Opus 10 No. 4 (bars 4-6), there is a semiquaver repetition of A4 on mandolin that consists of a four-note anacrusis and one note on the downbeat (marked pp without *crescendo*). This clearly demonstrates that Webern had in mind the anacrustic idea as early as 1911. And if it dates from 1911, it may also link with ideas in Opus 10 No. 1, particularly the reiterated pitches played by harp in bar 10 and flute, trumpet and celeste in the coda. The instrumentation of the motif in the No. 4 sketch (mandolin) is interesting given that the motif is played on harp in Orchestra Piece 1 and the 'Opus 6' version of No. 2. There may be more to the story of this motif than we can as yet trace, but it is at least interesting that Webern draws together these instrumentations and presents them simultaneously in Opus 10 No. 3.

5.4 No. 4, '*Erinnerung*'

Opus 10 No. 4 bears the arrangement title '*Erinnerung*', which may be translated as 'Remembrance', 'Memory' or 'Reminiscence'. The extent to which the piece was intended to convey the notion of 'Reminiscence' when it was first composed (1911) is moot—extant evidence is insubstantial. However, the death of Webern's nephew and the themes of grief and 'remembrance' in *Tot* (see Figure 5.7) suggest that pieces that were composed in 1913 after Opus 10 Nos. 2 and 3 might have been written specifically with a 'Reminiscence' function in mind. In this study of Opus 10 No. 4, I will address aspects of the 1913 pieces that may be linked to the notion of 'Reminiscence', and will analyse Opus 10 No. 4 from various perspectives, including form, sketches and early versions, and intervallic symmetry.

5.4.1 'Reminiscence' in the 1913 groupings

In Section 5.0.2 (p. 96), I pointed out that the fragmentation of Opus 10 No. 3 layers, which occurs in Opus 10 No. 4 (see Figure 5.6c, bars 3-6), was perhaps originally a function of Orchestra Piece 1 in the Orchestra Pieces (ink copy) grouping. This allusion to a preceding piece is an example of how the notion of 'Reminiscence' may be conveyed. However, it is different from an extended restatement or extended reworking of material. The perceptibility of material as an 'allusion' or 'reminiscence' seems to depend on duration, though the critical point at which listeners cease to regard material as an allusion/reminiscence is likely to be fuzzy. This issue, which is beyond the scope of the present analysis, might be usefully clarified through experimental work.

In addition to the 'reminiscence' that occurs in Orchestra Piece 1, traces of 'reminiscences' lie in the orchestral song '*O sanftes Glühn*' and other Orchestra Pieces. In my discussion of these pieces, I refer to the 'Opus 6' versions of Opus 10 Nos. 2 and 3, because they are more likely to resemble the suggested pieces 'I' and

'II' of the Orchestra Pieces ink copy (see Figure 5.4c) than the current published score.

Early version of O sanftes

The earliest extant sketch of Opus 10 No. 4 shows different versions of the piece's infamously enigmatic final quintuplet gesture (violin). Webern's apparent struggle with the details of this final gesture is perhaps indicative of the gesture's importance in the composition (see Figure 5.23a).

A similar quintuplet rhythm appears in the early sketches of '*O sanftes Glühn*' (see Figure 5.23b). A copy based on these sketches might have been the proposed original 'V' of the Orchestra Pieces ink copy (see Figure 5.4c). The '*O sanftes Glühn*' quintuplet figure has the potential to be perceived as 'reminiscent', because it is assigned to the *celeste*, which facilitates a perceptual link with the celeste and bell timbres of Opus 10 No. 3. Moreover, in alluding to Webern's mother through references to the appearance and disappearance of the Mother of Grace vision (see Section 5.3), the song text conveys a sense of the ephemeral nature of a reminiscence.

Orchestra Piece 4

As the Orchestra Pieces set progressed, Webern might have felt that the '*O sanftes Glühn*' text and the celeste quintuplet were insufficient to convey the idea of 'reminiscence'; the replacement piece—Orchestra Piece 4—conveys the notion through a reference to layered ostinati in bar 9 (see Figure 5.24). In contrast to the fragmentation that occurs in Orchestra Piece 1, this allusion is a 'block' *fragment* of ostinati: a fluttertongue flute is set against solo cello semiquavers, and celeste and harp harmonic triplet quavers.

Unfortunately, Orchestra Piece 4 is incomplete, which means that we do not know whether or not the final bars of the score featured a quintuplet. If they did not feature a quintuplet, the piece's block ostinati fragment would have bridged a gap between the fragmentation of ostinati in Orchestra Piece 1 and a substantial block of tremulous sonorities, which occurs in Orchestra Piece 2.

Orchestra Piece 2

The Orchestra Piece 2 block of tremulous sonorities (bars 12-14) has a duration that approaches the durations of the extended blocks of tremulous sonorities that occur in Opus 10 Nos 2 and 3. The increase in the durations of these reminiscences is perhaps analogous to the process of remembering; this process results in distortion, the 'misreading' of earlier material being analogous to mis-remembering. In Orchestra Piece 2, the timbral characteristics of the earlier extended blocks are 'misread' as a combination of tremulous continuously-excited tones (the final bars of Opus 10 No. 2) and pseudo-continuously-excited impulsive tones (Opus 10 No. 3).[38]

Orchestra Piece 2 and 'O sanftes Glühn' (early version)

Before the insertion of Orchestra Piece 4, the early version of '*O sanftes Glühn*' might have been the source of material that was to be developed in Orchestra Piece 2. In bar 7 of Orchestra Piece 2, a bass clarinet quintuplet is overlapped with a tremolo bell and trilled contrabassoon tone; this combination of ideas would have drawn together the '*O sanftes Glühn*' quintuplet idea and the trilled wind tones and pseudo-continuously-excited triangle tone of Opus 10 No. 2 (final bar).

However, the withdrawal of '*O sanftes Glühn*' would have left the quintuplet of Orchestra Piece 2 without an organic link. This is perhaps one of the reasons why Webern wrote the Orchestra Piece 5 short score,[39] which has a link to Orchestra Piece 2 that is stronger than the link between '*O sanftes Glühn*' and Orchestra Piece 2.

Orchestra Piece 5

Orchestra Piece 5 features a quintuplet (violin) that is doubled by a crescendoing triangle tone. In order to *crescendo*, the triangle tone must play tremolo (like the violin). This inharmonicity and pseudo-continuousness towards the end of the quintuplet facilitates a perceptual link to the Orchestra Piece 2 tremolo bell tone.

The sonority facilitates an even stronger timbral link with Opus 10 Nos. 2 and 3, which feature triangle trills. In Opus 10 No. 2, the triangle trill of the final bar is non-

[38] In bar 20, a reference to the harp four-note repeated pitch motif reinforces the link with Opus 10 No. 2.

crescendo but perceptually salient; in Opus 10 No. 3, triangle trills double tremulous bells in bars 3-6 (see Figure 5.20). In bars 19-21 of Orchestra Piece 5, the tremolo bell and tremolo timpani of the sustained chord allude even more explicitly to Opus 10 No. 3; as an 'ostinato', this reference is, nevertheless, more subtle than the superimposed rhythms of Orchestra Piece 4.

The Opus 10 No. 4 quintuplet bears far greater similarity to the Orchestra Piece 5 quintuplet than to the '*O sanftes Glühn*' and Orchestra Piece 2 quintuplets: the quintuplet has a tie on the first note, is scored for violin, and is at the end of the piece. In this sense, the Orchestra Piece 5 quintuplet signals a move towards Webern's final grouping criteria.

Regroupings

As I suggested earlier (see p. 94), Orchestra Piece 5 was probably the last piece to be written and, very soon after writing it, Webern abandoned most of the pieces in favour of the 'Opus 6' grouping. The 'Opus 6' version of '*O sanftes Glühn*' is quite different from the early sketches. It omits the quintuplet figure, and refers to both Opus 10 Nos. 2 and 3: the muted trumpet and celeste trills link to the muted fluttertongue trumpet and trills of Opus 10 No. 2; and the tremolo/ layered timbral effects of bars 24-28 link to the ostinati of Opus 10 No. 3. These features appear to have been worked into the version specifically for the 'Opus 6' grouping, providing a concise way of expressing the 'reminiscences' to tremulousness and ostinati that were previously distributed throughout Orchestra Pieces 1, 4, 2, and 5.

In turning to Opus 10 No. 4 for his final selection, Webern was perhaps able to achieve more in six bars than he could in any of the other pieces. The fragmentation of layered ostinati facilitate perception of the piece as a direct reference to Opus 10 No. 3 and the trombone motif is a direct reference to the fragmented subsection of Opus 10 No. 2. In view of the above analysis, perhaps the most intriguing feature of Opus 10 No. 4 is the quintuplet final gesture. In the context of this briefest of pieces, the gesture conveys more effectively than the Orchestra Pieces and '*O sanftes Glühn*'

---

[39] Note that the intended positioning of Orchestra Piece 5 within the Orchestra Pieces scheme is unclear.

the notion of 'Reminiscence'. Its dissipation into silence at the tail end of fragmented textures alludes to a fleeting, fragmented memory.

5.4.2 Form

Having proposed a rationale for Opus 10 No. 4's inclusion in the Opus 10 grouping, I will now discuss the piece itself in more detail.

Forte's (1998: 220) divisions of Opus 10 No. 4 are typical of most authors. He outlines a tripartite design: the end of the mandolin line in bar 1 marks the end of the first section; the second section begins with the viola entry and ends with the trombone two-note figure; the third section begins with the harp entry of bar 5 and continues until the end. Forte suggests that the re-entry of the mandolin marks the beginning of a subsection. However, the ostinato-like nature of the mandolin line suggests that it is more appropriately grouped with the rest of the ostinati; the violin figure, on the other hand, may function as a subsection, if not an overlapping coda-like fourth section.

Unlike Forte, I regard the third section as beginning with the snare drum. Forte omits this figure presumably because it is non-pitched, and it does not fit into his octatonic design. In a sense, the second and third sections fuse into a single section, not only because of the overlapping snare drum figure, but also because the single-note repetition of the clarinet line links it to the layers of the third section. Like the rest of the third section layers, the clarinet line is rhythmically unique (though see below, p. 151).

Developments

In addition to the links with Opus 10 Nos 2 and 3, which were discussed earlier, Opus 10 No. 4 may be regarded as developing ideas that were first aired in Opus 10 No. 1. For instance, the *Klangfarbenmelodie*-like interacting layers of bars 4-6 may be linked to the pointillistic opening and ending of No. 1; the harp harmonics facilitate a timbral link with bars 10-11 of No. 1, and the sustained trill may link to the celeste trill of bars 3-8 of No. 1. Other links can also be made: in both No. 1 and No. 4 muted trumpet and muted trombone are major contributors of melodic figuration and are coupled with clarinet and muted string sonorities. These links are perhaps not surprising if we accept that Opus 10 No. 1, like Opus 10 No. 4, was included in the 'VII *Kammerstücke*' set of 1911.

Opus 10 No. 4 develops also its own material. The second and third sections and the 'coda' develop the rhythm and contour of the opening mandolin melody. In the second section, the number of pitches combined in the trumpet and trombone figures is the same as that of the mandolin melody. The basic contour of the melody is the same, but all intervals except the ascending major seventh are stretched. The durations of the second, fifth and sixth notes are lengthened and the division between instruments results in a fragmentation of the melody; the preservation of the triplet in the central portion contributes to the sensation that these melodic fragments are related to the mandolin melody.

The idea of fragmentation is taken even further in the third section, because the 'ostinati' interact. This does not, however, affect the link with the opening melody. At the height of the textural accumulation, the mandolin plays an 'ostinato' that is, notationally, a retrograde rhythm of the mandolin melody with an added triplet quaver (the second triplet of the retrograde equates to the final note of the melody). In performance, the *ritenuto* of bar 5 causes the opposite effect. It causes the tempo to slow down to the extent that the durations of the first two triplets may equate to 'in tempo' quavers. The following three triplets are slower and the final two notes are quavers, which are back in tempo. The perceptual effect is that the mandolin ostinato is a rhythmic diminution of the clarinet ostinato of bars 2-3, but with an added note at the peak of the ritenuto. In both ostinati the perceived stretching of tempo occurs at the dynamic peak. These rhythmic links are only possible in the later versions, as the early ink sketches do not contain tempo markings.

In the context of Opus 10, the clarinet ostinato of bars 2-3, which is two sets of three crotchets, may be perceived as an augmented version of the harmonium triplet quavers of No. 3. The timbre of the clarinet here may be perceptually linked to the harmonium; as I pointed out in relation to Opus 10 No. 2 (see p. 117), these single reed wind instruments are linked in terms of rise time, spectral flux and jitter; the likelihood of their perceptual proximity in timbre space is further increased by the common low global amplitudes (both are marked *ppp*). Conceptually, this ostinato link may be reinforced by the link between the clarinet ostinato and the mandolin ostinato's notated triplets, because of the notational link with the (perceived) triplet rhythm of the opening mandolin melody.

The violin's quintuplet is a further development of the opening mandolin melody: the three central notes are, like the triplet of the mandolin melody, perceived as faster than the outer notes. The final note is displaced by an octave; the resulting registral isolation facilitates the 'triplet' sensation by causing the three central notes to be perceptually grouped.

5.4.3 Early versions

In order to clarify other aspects of the form Opus 10 No. 4, I will draw upon aspects of sketches and other early versions.

The Ink Sketches

The earliest versions of Opus 10 No. 4 (the incomplete ink sketches) differ from the later versions in a number of ways.[40] The sketch of bars 0-3 does not feature hairpin dynamics in the viola, clarinet and trombone lines and tempo markings in bars 2-3. Perhaps more significantly, bars 0-1 feature a slur over the mandolin phrase; in the later versions this slur is omitted. The omission allows the phrase to be played and heard as a set of three intervals: ascending whole tone anacrusis, ascending major seventh, descending diminished octave (major seventh). The relationships between tones player may be highlighted through manipulation of the global amplitude level; the perceptibility of the intervals is likely to depend principally upon the player's capacity to maintain or reduce the amplitude level of the initial excitation during the decay portion.

In bar 2 of the sketch, the trumpet melody is slurred across the entire phrase, but in Opus 10, the slurring groups the notes into two intervals: B4-F5 and Eb4-D5. The

---

[40] These are housed at the Paul Sacher Stiftung and are currently filed in two separate folders: SAW30 (bars 0-3) and SAW 31 (bars 5-6). The sketch of bars 0-3 was originally grouped by the Moldenhauers as one of the 'Eight Orchestra Fragments' (see p.94, fn. 4), but is now grouped with a sketch of '*O sanftes Glühn*'. The sketch that refers to bars 5-6 was, according to the Moldenhauers' pencil notes, originally 'catalogued incorrectly under Four Posth Orch. Pieces [i.e. the first four of the posthumously-published *Orchestra Pieces* (1913)]'. According to Felix Meyer (private communication), this annotation is probably Rosaleen's since Hans was blind or going blind at the time.

new slurring facilitates isolation of the ascending major seventh interval and, combined with the trombone's slurred interval that follows (bars 3-4), this interval links to the intervals of the mandolin phrase. The trombone G#4-G3 is a descending augmented octave (minor ninth), which suggests a possible inversional relationship with the mandolin's diminished octave, but with the registral direction preserved. However, in the ink sketch, there is no bar 4, and hence no G3, slur or augmented octave interval. The absence of this bar, the incompletion of bar 3, and the differences/absence of slurring perhaps suggest that the relationships between the mandolin, trumpet and trombone figures became apparent to Webern only during the later stages of composition.

The second ink fragment consists of three incomplete bars in neat ink with various modifications and deletions. The page also features many rough sketches, particularly of the final quintuplet gesture.

The first two bars correspond to bar 5 of the later versions. In the first bar, the harp does not have a hairpin, and its last two notes, which are tied, are not indicated as harmonics; the celeste tones are notated as semiquavers rather than quavers. The clarinet's trill C-Db is played on horn and the mandolin's reiterated Bs are a single sustained B played on trumpet.

The second bar marks a change in time signature from 3/4 to 2/4. It features a sustained clarinet tone (Bb3) and, significantly, the mandolin anacrusis motif that I noted in my analyses of the other pieces (A4); the violin quintuplet figure begins as a semiquaver anacrusis and is marked both muted and sul ponticello. There are a number of pencil markings in this bar, including a figure that resembles the quintuplet gesture written on the horn stave and a figure that is related to the ostinato material on the stave below (notated pitches Bb4 and D4).

From a 'reminiscence' perspective the most important feature of these early ink sketches relates to the mandolin ostinato. The idea features here as a four-note semiquaver anacrusis with a semiquaver on the following downbeat, confirming the validity of a link between the mandolin ostinato of the later version and the pitch reiteration of the four-note semiquaver anacrusis that occurs in the central portion of

Opus 10 No. 3. In the Opus 10 context, the mandolin ostinato is a rhythmic and timbral 'reminiscence' of Opus 10 No. 3; however, as with the reminiscences in the Orchestra Pieces, the memory is distorted, and the motif is 'misread' / 'mis-remembered' as an ostinato.

The 'VII Kammerstücke' version

Meyer and Shreffler's study of the 'VII *Kammerstücke*' version of Opus 10 No. 4 (1993) features a discussion of the instrumentation. The most significant difference between the 'VII *Kammerstücke*' version and Opus 10 No. 4 is that the trill in bar 5 of the former is played on muted horn rather than clarinet. Meyer and Shreffler (360) suggest that the use of the horn helps provide maximum variety because each of the instruments features only once, and that Webern's later decision to use the clarinet twice helps to convey a sense of 'colouristic balance' by reducing the 'dominance' of the brass instruments.

Meyer and Shreffler suggest that the piece is 'more obviously "sectionalized" ' because of this instrument change. However, the extent to which the change facilitates the distinction between sections is debatable. Meyer and Shreffler define the sections in terms of timbrally distinct melodic gestures: 'plucked string instrument' (bars 0-1), 'brass [trumpet and trombone]' (bars 2-4) and 'bowed string instrument' (bars 5-6). Although the use of horn in bar 5 would carry the brass idea of the second section into the third, one could argue that the use of clarinet makes the distinction between the sections even less clear-cut. (This reinforces the point that I made earlier about the 'ostinato' character of the clarinet line linking it to the third section; see p. 151.) Not only does the instrument feature in both sections, but the use of a single sound source helps also to bring the ideas of note reiteration and pitch oscillation into the same perceptual thread (Huron's P9). The relationship between pitch reiteration and pitch oscillation recalls the complex tremolo-trill relationships of Opus 10 No. 2, and also the more clear-cut progression from reiteration to oscillation that Webern makes in the final version of Opus 10 No. 3. In the 'Opus 6' version of No. 3, none of the ostinati feature pitch oscillations (all of the percussion trills function as tremolos). In Opus 10, Webern changed the repeated D#s of the celeste into an oscillation between D# and E; his choice of interval may have been influenced by the minor second oscillation of the Opus 10 No. 4 trill.

Despite the aforementioned links, the new instrumentation does support Meyer and Shreffler's proposed three-section format. The revision in bar 5 of Opus 10 No. 4 may facilitate the perceptual grouping of the layered ostinati of bars 4-6 and the violin melody of bars 5-6. Clarinet and string tones are perceptually linked in Opus 10 No. 1 (bars 3-6), Opus 10 No. 2 (bars 1-2) and Opus 10 No. 3 (bars 5-6), because they occur simultaneously. In bars 1-2 of No. 2, the clarinet and violin become closely associated because Eb clarinet and violin tones make up the opening 'pointillistic' motif (discussed in the Opus 10 No. 2 analysis). This links with No. 4 because the contour of the violin figure of bars 1-2 of No. 2 is similar to that of bars 5-6 of No. 4. Both figures consist of five pitches, the first four outlining a descent and the last pitch providing an ascent; in each case there is a 'rhythmic' acceleration and diminuendo towards the final tone. Unlike the 'Opus 6' version of No. 2, which featured trumpet trills in bar 2, Webern's use of Bb clarinet trills reinforces the link with bar 5 of No. 4.

The change from horn to clarinet facilitates also another link with Opus 10 No. 2. In the Opus 10 context, the violin quintuplet may be regarded as a reference to bars 11-12 of No. 2. The violin figure has the same registral contour as the muted trumpet, rhythmically augmented and in retrograde. Moreover, whereas the clarinet trill overlaps with the quintuplet figure, in No. 2 the quintuplet figure precedes the trills. The second section also has a precedent. Apart from the obvious link between the two-note trombone figures of Opus 10 No. 2 (bar 7) and No. 4 (bars 3-4) bars 1-4 link to the final section of Opus 10 No. 3. The angular brass figures, sustained viola artificial harmonic and clarinet note repetition recall the trombone melody, sustained cello artificial harmonic and ostinati of Opus 10 No. 3. The trombone links are reinforced by the omission of the glissando that features in the 'VII *Kammerstücke*' version of No. 4. The link between the clarinet note repetition of No. 4 and the ostinati of No. 3 is reinforced by the timbral similarity between clarinet and harmonium. This link cannot be made with the Opus 6 version of No. 3, because Webern specifies '*Percussion ohne Wind*' (literally 'percussion without wind'). Rather than simply key clicking, the harmonium tones in Opus 10 are excited also by air production through a single reed.

5.4.4 Intervallic symmetries

In most studies, the criteria for defining the sections of Opus 10 No. 4 are generally dictated by non-pitch content, even though their discussions focus on pitch content.[41] The boundaries of those sections do seem to coincide with significant points in the pitch structure, nevertheless. These will become apparent in this final discussion of No.4, which focuses on pitch symmetries. Unlike Peter Johnson's study (1978b), which highlights symmetrical properties of pc sets (including interval classes within pc sets) in No. 4, the symmetrical formations described in the following analysis arise from the presentation of successive intervals.

The opening nine notes on mandolin and harp combined with the first three notes of the second section (each of which belongs to a new instrument entry) cover all twelve notes of the chromatic scale. This non-intervallic and non-symmetrical pitch feature makes clear from the outset the significance of 'succession' within the pitch structure.

If we consider the second section to begin with the viola Bb5 and to end with the trombone G3, a symmetrical pattern emerges from the viola, clarinet and trombone pitches (see Figure 5.25). These tones may be perceptually grouped for a number of reasons. The viola and clarinet entries are grouped, partly because of the silence that immediately precedes them. The trombone pitches are grouped because they are played on the same sound source and functions as a motif. The overlapping of the sustained tones Bb, A and G# facilitates the grouping of these pitches into a symmetrical pattern. The Bb5, which opens the section sounds for a crotchet duration before the clarinet enters on A4; at the close of the section, this is balanced by a crotchet trombone G. The trumpet figure operates outside this symmetrical pattern, because it has a more melodic function.

The rhythmic symmetry of the viola-clarinet and trombone lines is complemented by the pitch symmetry of their minor ninth intervals. There is a sense of development within this symmetrical structure, because of the progression from separate sound sources (Bb-A4) to single sound source (G#4-G3). This development is in keeping with the organicism that plays such a distinctive role in the symmetrical structures of

[41] Forte (1998: 220-25) is a possible exception, though his divisions do still coincide with divisions made according to non-pitch content.

Opus 10 No. 1. The use of the minor second A4-G#4 as the pivot of the symmetrical pattern and the positioning of this symmetrical pattern within the central portion of No. 4 reinforces the link with No. 1, because the celeste trill G#4-A4, which can be heard throughout the central sections of No. 1, provides the pivot to No. 1's large-scale symmetrical structure.

The G# of the trombone functions as an axis in another (quasi-)symmetrical structure. In Figure 5.26a, the pitches either side of the pivot occur at section overlaps: Bb-A, which belong to the second section, are also included in the opening twelve-note collection of successive pitches; G-F# are the last and first pitches of the second and third sections, respectively. The symmetry is distorted only by the octave displacement of pitches.

Octave displacements aside, this seems to constitute the kernel of a somewhat larger structure (see Figure 5.26b). This structure implies that G#—the point of reflection—stands as the pitch centre of Opus 10 No. 4. Its validity depends on whether one accepts the C4-Db4 clarinet trill and the E4-F4 celeste chord as a single interval; the pitches form two major thirds (C4-E4; Db4-F4), but the simultaneity suggests that they may be taken as a single event.

The structure is almost in place even in the early ink sketches: the harp F# (bar 5) fails to make the link with the G# pivot because the trombone G (and the rest of bar 4) is missing. In the Opus 10 version, the pitches of the harp chord, muted trumpet, and muted violin and the non-pitched tones of the snare drum operate outside this structure. The exclusion of the first pitch of the opening mandolin figure may be justified by the exclusion of notes at the opposite end of the structure.

The exclusion of the final notes perhaps supports the notion that the violin quintuplet functions as a separate coda-like section. The figure's links with previous material certainly offer further supporting evidence. For instance, the quintuplet draws upon the pivotal role of the trombone's G#: both figures begin with a sustained tone in the instrument's highest register, the violin's Ab being enharmonically equivalent to the trombone's G#. The figures have also a strong gestural relationship. The notated rhythms of the G# and Ab tones begin with an off-beat crotchet triplet and end with a tie over the bar line; each tone begins very quietly, *crescendo*s towards the bar line and is followed by a large descending interval. The 'surprising' effect of the violin's quintuplet notes can perhaps be attributed to this gestural similarity, because the listener may expect the phrase to end in the same way as the trombone figure, i.e. after the second note.

The pitches of the violin phrase are also part of a quasi-symmetrical structure which features the first five pitches of the second section (see Figure 5.27). The violin's pitches Bb5-E5-D5-Eb6 are, in retrograde, a perfect fifth above the viola, clarinet and trumpet Bb5-A4-B4-F5; the violin's high Ab6 is two octaves and a perfect fifth higher than the trumpet Eb. These relationships perhaps provide a rationale for the intervallic extensions that characterise the trumpet's development of the opening melody. Perhaps coincidental, but interesting nonetheless, is the point of axis for the outermost pitches of this structure (viola Bb5 and the violin Eb6)—G5-F#5. At the midpoint between these groups of pitches, the cusp of the second and third sections features these same pitch classes at octave displacements (trombone G3, harp F#5).

Conclusion

The symmetries described in the above analyses enable us to attribute all of Webern's pitches to a specific function. Their similarities with the symmetrical structures and organicism of Opus 10 No. 1 support the notion that these pieces were considered as related within the 'VII *Kammerstücke*' grouping. However, the final Opus 10 grouping might have provided the piece with a context in which to express or allude to a wider range of musical and extra-musical issues than was possible in the 'VII *Kammerstücke*'.

Bearing in mind the piece's links with Opus 10 Nos. 1 and 2, the piece may allude to more than just the life (ostinati) and death (snare drum) of a loved one. Whilst these sentiments pervade *Tot*, the developments might be perceived as an allusion also to the Husband's recitation from the Ancient Book (Scene 6). The Book holds a memory of how mankind's communication with the angels before the Flood (kernel and quasi-symmetry Opus 10 No. 1) was severed by the changes that the Flood set in motion (fragmented section of Opus 10 No. 2). This certainly provides an extra-musical dimension to the trombone tones' pivotal role in the piece's organic intervallic structures.

5.5 No. 5, '*Seele*'

The final movement's title—'*Seele*' (meaning 'Soul')—is obviously influenced by Webern's religiosity. Up until bar 18, the piece is quite rapid and unpredictable, its extremes of dynamics and chords with sharp attacks sound almost 'violent' (see Figure 5.28). If we have taken aspects of Opus 10 No. 2 to reflect the suddenness and emotional turmoil of death, and the ostinato machine of Opus 10 No. 3 to represent life, it is not surprising to find that these aspects of the pieces are combined in Opus 10 No. 5. The passage up to bar 18 may represent a struggle against death; and if my interpretation of the snare drum rolls of Opus 10 No. 3 is valid, we should perhaps hear the final death blows in the two biting strokes of the snare drum. Bars 16 and 17 are, significantly, the only instances where the snare drum features in the piece.

From bar 18 onwards, the piece consists of fragmented sounds that can be linked in various ways to Opus 10 Nos. 1, 3 and 4. For instance, the combination of celeste, harp, and string harmonic in bars 18-20 link with the first bar of No. 1. In placing these tones immediately after the final 'death blows', Webern might be suggesting that the afterlife brings some sort of return to the 'Ideal' or 'Original' state.

The final scenes of *Tot* support such an interpretation. Scene 5 is set on 'All Soul's Day', and the end of Scene 6 (see Figure 5.7) sees a fulfilling of the father's yearning for the pre-Flood exalted state: it closes with him seeing God.

Building upon this extra-musical interpretation, I will now provide a more detailed analysis of Opus 10 No. 5. As with analyses of the other movements, the following reading is informed by early versions of the pieces; some of Webern's revisions since 'Opus 6' provide strong supporting evidence for my earlier claims that the pieces should not be considered as discrete entities.

5.5.1 The Opus 10 Context

In contrast to a literal translation of 'Seele' ('Soul'), a non-literal translation of the term as 'essence' facilitates understanding in purely musical terms the links between No. 5 and the other pieces.

However, if No. 5 may be said to capture the 'essence' of the other pieces in the set, the notion that No. 4 is a 'recollection' of earlier ideas presents a problem. No. 5 cannot easily make references to the other pieces without appearing to duplicate what No. 4 achieves. If it is to avoid duplication, references to the other pieces should be distinct from how they appear or are perceived in No. 4 and references to No. 4 should be characteristic features of that piece, rather than one of its 'recollections'.

It comes as no surprise then that there is very little evidence of references to the 'recollections' that No. 4 expresses. (The trombone figure is the exception, and the reason for this will be discussed in due course.) A feature that does link the pieces reflects the concision of No. 4's pitch content. In bars 1-3 of No. 5, all twelve notes of the chromatic scale are stated without repetition (glockenspiel melody and the first notes of both muted trumpet and muted string entries); a direct link is thus formed with the fourth piece's opening pitch exposition. But No. 5 goes a step further. Another revolution of the chromatic scale occurs in bars 3-4; there are no repetitions, but the revolution overlaps with the previous revolution because it includes the last note of the glockenspiel melody (C). These revolutions suggest that the entire introductory passage outlines a quasi-symmetrical formation, with the glockenspiel C functioning as the axis. As occurred in bars 3-6 of Opus 10 No. 1, string chords lie at the axial point, but in this case, the string chords are not the axis—their 'attack' points lie equidistant (i.e. a crotchet) either side of it. As with the clarinet melody of Opus 10 No. 1, solo melodic material is exposed on both sides of the axis (glockenspiel, bar 1 and oboe, bar 4).

There are a number of ways in which No. 5 provides balance and symmetry within Opus 10 as a whole. For instance, the opening glockenspiel figure may be perceived as recalling the sonority of the Opus 10 No. 1 kernel. In both No. 1 and No. 5, the glockenspiel tones have a melodic function. In the absence of this link, the consecutive glockenspiel tones of No. 5 can seem slightly out of place—the bells and bell-like sonorities of No. 3 do not quite set the precedent for such brightness, and the pseudo-continuously-excited glockenspiel tones of No. 2 were non-melodic. The link between the melodic glockenspiel tones may have contributed to Webern's decision to open the Opus 10 set with No. 1.

On a higher level, No. 5 acts as an extensive parallel to No. 1. Just as No. 1 can be described in terms of introduction / exposition, development(s), recapitulation / restatement and coda, No. 5 conforms to what Forte has suggested (1998: 225) is a sonata-like design. In contrast to the overlapping of sections in No. 1, the presence of rests and fermatas helps the listener to perceive the sections as perceptually distinct. However, Forte sees the piece's 'Development' and 'Reprise' sections as overlapping in bar 17. In proposing this overlap, he overlooks the *accelerando* through bars 16-17 and the fermata after the rest at the end of bar 17; his criteria for structural definition seem to be guided only by his octatonic design.

Forte's divisions do not include a Coda. However, the silent 2/4 bar (bar 30) and the fermata on the sustained A of bar 31 and the return to tempo in bar 32 contribute to a clear perceptual division. These bars seem to have also a 'coda-like' function; the *ritenuto* and *diminuendo* of previous bars allow the sonorities to peter out into the silence of bar 30. The return to tempo in bar 32 has the perceptual effect of making these bars seem like a quirky or witty comment on previous material. The coda of No. 1 provides a similar function.

Taking into account the above differences, Figure 5.29 outlines an adapted version of Forte's divisions. The reader should note that the terms used to describe the sections are problematic. In particular, the relationship between the 'Exposition' and 'Development' sections is not at all clear. Forte (1998: 225-32) defines bars 10-17 as a 'development' of previous material, but does not explain the nature of the developments that occur. In fact what does occur in this section is not just a development of material from No. 5, but of material from other pieces in the Opus 10 set.

5.5.2 The Developments

In bars 13-14, there are superimposed layers of tones that differ in their type of excitation; this texture is clearly a reference to the superimposed ostinati of Opus 10 No. 3. The differences in excitation result in a fairly even spread along the impulsiveness-continuousness continuum. The guitar tone is the most impulsive, the tone of each single excitation decaying fairly rapidly. The tremolo mandolin is pseudo-continuous, but the individual excitations of the tremolo are not difficult to isolate. The distinction between impulsiveness and continuousness becomes less clear where the celeste trills and the tremolo solo cello harmonics are concerned. Individual re-excitations of the string tremolo may be isolated, but far less clearly than if it were an impulsively-excited tremolo; the use of pedal can blur the tones of the celeste trill, so that individual excitations do prove difficult to isolate. With the exception of the untrilled, untremulous sustained Eb clarinet melody, the *sul ponticello* viola trill is the most continuous element in these bars.

Whereas the mandolin trill and guitar tones refer directly to Opus 10 No. 3, the cello's tremolo artificial harmonics are derived from No. 2. In the same way, the celeste trill can be regarded as a derivation of No. 2 (bar 7) and, in the context of Opus 10, also of No. 1 (bars 3-8); as a bell-like sonority within a layered context, it may be perceived even as a derivation of No. 3.

The high Eb clarinet melody of these bars reinforces the link with No. 2 (bars 1-2). As a four-note melodic idea, it provides a link also with the similarly angular four-note violin and muted trombone melodies of bars 1-2 and 8-9 of No. 3. In No. 5, Webern's dynamics highlight each of the intervals—descending minor ninth, ascending perfect fourth and descending major seventh—even more than in the 'Opus 6' version. (The dynamics of the 'Opus 6' version have the effect of a continuous crescendo, but each interval is marked clearly as a stage within that crescendo: the first interval is marked *p*, the second is marked *f*, and the third occurs at the end of the crescendo. See Figure 5.30) These intervals may be a development of the ascending minor ninth of the violin melody (bars 1-2 of No. 3) and descending perfect fifth and ascending major seventh of the trombone melody, because the registral direction is reversed and the 'perfect' interval is inverted.

In the light of these relationships, the roles of the two-note trombone figures of bar 7 of No. 2 and bars 3-4 of No. 4 become much clearer. The trombone figure of No. 4 is distinct from that of No. 2 in that the hairpin dynamics emphasize the interval by peaking at the attack point of the second tone. This function of the dynamics occurs twice in the violin melody of the 'Opus 6' version of No. 3, but Webern replaces these *crescendo-diminuendo* hairpins with a single *crescendo-diminuendo* in the Opus 10 version (the gradation of the *diminuendo* does, nevertheless, feature two hairpins). This alteration of the dynamics in No. 3 enables the trombone figure of No. 4 to be regarded as a step in the development towards the Eb clarinet melody of No. 5. The Eb clarinet melody may thus be perceived as a synthesis of the muted trombone figures of Nos 2 and 3.

In the 'Opus 6' version of No. 5, the 'ostinati' are more fragmented than in the Opus 10 version and the instrumentation differs in a number of ways. There are no tremolo mandolin, cello artificial harmonic or guitar tones; the pitches D4-B4 are an oscillating tremolo on *sul ponticello* viola and Db4-C5 and C4-C#5 are oscillating tremolos on harmonium. In the 'Opus 6' version, the trill Ab3-Bbb3 is assigned to Bb clarinet, G3-A3 to violin and G4-A4 to trumpet. The use of the trumpet facilitates a link with No. 2, because the trilled motif in bar 2 of the 'Opus 6' version is played on trumpet. The absence of this link in the Opus 10 version perhaps suggests that Webern modified his view of the relationships between Nos 2, 3 and 5 to account for the new context that arose from having Nos 1 and 4 in the set.

This change of perspective would certainly account for Webern's re-orchestration of other trills in bars 13-15 and 28. If Webern employed a Bb clarinet trill in Opus 10 No. 4 for the reason outlined in the analysis of that piece (see p. 155), it is possible that he changed the instrumentation of the trills from clarinet to viola and cello to avoid direct links with No. 4. In effect, Webern avoids connotations of fragmentation in the Opus 10 version of No. 5, not only because the 'ostinati' are not fragmented, but also because the 'ostinati' do not feature a clarinet trill. It would seem that Webern had intended the 'Opus 6' version of No. 5 to fragment the ostinati of No. 3, but because of the insertion of No. 4 in the Opus 10 version, such fragmentation is no longer necessary.

If the 'ostinati' of No. 5 had featured a clarinet trill, they could have been perceived as re-assembling No. 4's fragmented ostinati. One could argue that it is still possible to perceive the No. 5 'ostinati' in this way because they consist of impulsive guitar, mandolin and celeste tones. However, the pseudo-continuousness of these tones (the guitar tone is doubled by tremolo cello) facilitates a direct link between No. 5 and the No. 3 ostinati. (The directness of the link may cause the listener to bypass the fragmentation that occurs in No. 4.) An extra-musical reading further supports perception of this direct link: the connotations of the ostinati and the Eb clarinet melody may be read as Nature (the 'Alpine landscape' of No. 3) being thrown into turmoil (the 'Change' of No. 2) during the Flood.

As the instrumentation of the No. 5 'ostinati' now stands, perceptual links may be made with the *sul ponticello* viola and celeste trills of No. 2. These trills feature in the most fragmented section of No. 2. In retrospect, the trills in bars 6-7 of No. 2 may be perceived as the source of the trill and tremolo 'ostinati' of No. 5. The ostinati of Opus 10 No. 3 may be seen as a step towards this development because they combine pitch oscillation and pitch reiteration. The 'Opus 6' version of No. 3 does not facilitate perception of this organic thread, because, as was noted in the analysis of No. 3, the ostinati do not feature pitch oscillation.

Links with Opus 10 No. 1

The changes to the instrumentation in bars 13-15 may have been motivated also by the incorporation of Opus 10 No. 1 into the set of pieces. The assignation of the G4-A4 trill to celeste facilitates perceptual links with the continuous trill of Opus 10 No. 1. The perceptibility of this link owes much to the duration of the trilled celeste sonority; it would have been more difficult to perceive if there was only one short trill (as in 'Opus 6'), but the G4-A4 and Ab4-Bbb4 trills are consecutive.

In bar 7, the staccato pitch oscillation in celeste (D4-E4) is measured, but begins on the cusp of tremolando and slows down. It is combined with a slurred tremolo dyad (Eb3-Gb3) in sul ponticello cello. This superimposition of 'ostinati' refers to the ostinati of No. 3. The celeste oscillation is a developmental step towards the pseudo-continuously excited celeste trill that features in bars 13-15. In the Opus 10 version, the cello sul ponticello slurred tremolo of bar 7 is developed into a more intense sonority in bars 13-15—the tremolo artificial harmonics and tremolo mandolin have greater capacity for intensity than the 'Opus 6' slurred tremolo, because of the reiterative attacks. The 'ostinati' of bars 13-15 have greater capacity for blend than those of bar 7; the celeste's impulsiveness is clearly distinct from the cello's continuousness, but because the ostinati of 13-15 span the impulsiveness-continuousness spectrum.

Many links with other aspects of the Opus 10 pieces can be found in the Reprise section. For instance, in both 'Opus 6' and Opus 10, bars 27-28 of No. 5 feature a descending minor ninth in violin. This idea is a new instrumentation of the two-note trombone motifs of Nos. 2 and 4; as such, it is linked with the violin and melody lines of No. 3 and the Eb clarinet melody of No. 5. The first tone, which is an artificial harmonic, gives rise to a link that only occurs in the Opus 10 version. In bars 18-19 of the 'Opus 6' version, the harp plays a descending minor ninth followed by a minor sixth (B6-Bb5-D5); in the Opus 10 version, this is doubled by celeste tones and artificial string harmonics in violin, viola and cello. As was noted in the opening to this Section, this new instrumentation recalls the opening of Opus 10 No. 1. Webern's reorchestration effectively causes a reference to the 'Ideal' and 'Original Form' that provides the step towards the final statement of the two-note figure.

The links with Opus 10 No. 1 do not stop there; bars 22-24 of No. 5 and bars 3-6 of No. 1 may be linked. Bars 22-24 may be regarded as a reference to the quasi-symmetrical formations of No. 1, where a linear clarinet melody lies across an axis of flute and strings. This link is perhaps even clearer in the 'Opus 6' version, because the sustained C5-B4 dyad is played by flute rather than oboe. If the 'Opus 6' orchestration had been preserved, it would have neatly developed the two-note flute idea—instead of a 'vertical' role (i.e. an axis), the flute would play a linear one. The '*Ruhig*' (quiet/calm) indication that features in bar 21 of the 'Opus 6' version reinforces this link. With the exception of Opus 10 No. 1 (which of course was not part of the 'Opus 6' set), No. 3 is the only piece that has a '*ruhig*' indication.[42] The

[42] In the 'Opus 6' version, the piece was marked '*Sehr ruhig*' (very quiet/calm); this was later changed to '*Sehr langsam und äußerst ruhig*' (very slow and extremely quiet/calm).

link to No. 3 is fitting because the Alpine regions were closely associated with Webern's notion of the 'Ideal'.

The change in the instrumentation of bars 22-24 of No. 5 (Opus 10 version) may have been for reasons of internal balance. The only other instance of oboe playing in No. 5 occurs at the end of the introduction; in the 'Opus 6' version, the (axis) chords that lead up to the oboe have a *crescendo-diminuendo* hairpin, which suggests a link with the string axis chord of bar 23. The chords in bars 1-2 of this version are played on harmonium rather than strings, facilitating a link with the harmonium and string natural harmonic chord of bar 4 of No. 3, which also functions as an axis. The timbral association of string chords and harmonium chords in Opus 10 is greatly facilitated by the ambiguous attack points that the instruments can produce.

The C5-B4 dyad of bars 22-24 seems to refer to the 'sigh-like' motifs of bars 3-4 (oboe), 5 (violin and piccolo; clarinet), and 7 (trombone; violin) of No. 2. The link between bars 3-4 of No. 2 and 22-24 of No. 5 is perhaps less obvious in 'Opus 6' than in Opus 10 because the instrumentation of the 'sighs' differs (clarinet and flute, respectively). In the Opus 10 version, the common use of an instrument that has relatively little material to play in the entire set of pieces (oboe) facilitates perception of the link.

In view of the various developments of the minor second interval throughout Opus 10 (e.g. wedge-wise expansion, linear octave displacements giving rise to major sevenths, diminished octaves, augmented octaves and minor ninths), it is appropriate that the interval should return to its 'original form' in the final section of Opus 10 No. 5, especially if the extra-musical reading (a return to the 'ideal'/'original state') described earlier is valid.

It is significant that this rendition of the minor second is presented in a way that captures the listener's attention; the interval is assigned to an instrument otherwise little used in these pieces, which has a distinctive sound (its 'nasality' often being attributed to formants), and is drawn out expressively and framed by silence. This vivid treatment serves to draw attention also to the variants of the minor second interval that occur in the final bars of the piece.

In bar 26, the staccato clarinet plays Eb5-E5. In the 'Opus 6' version, the pitches are notated D#5-E5 and are played by harmonium marked '*Percussion ohne wind*'. This suggests a direct link with the harmonium (marked '*Percussione ohne wind*' in the 'Opus 6' version) and celeste and harp ostinati of No. 3. The combination of plucked string, struck metal (celeste) and staccato single reed wind tones recalls the timbral combinations of the No. 3 ostinati. In the Opus 10 version, the link is perhaps facilitated by the celeste ostinato in No. 3 being changed from reiterated D#5s to the pitch alternation D#5-E5. Moreover, the pitch classes of the first chord (excluding the acciacatura Bb), F-D#/Eb-D are derived from these ostinati (harmonium F, celeste D#, cello harmonic D). In view of the material that follows, the A and Ab of the next chord are significant pitch classes; they may even be regarded as derived from the celeste pedal in Opus 10 No. 1 (G#-A).

The chords in bar 26 are of course linked to the opening of No. 5. The celeste perfect fourth (D5-A4) recalls the glockenspiel's bell-like perfect fourth of bar 1. The chord in bar 27 has a direct timbral link with the guitar, celeste and harp chords that feature at the beginning of the development section (bars 11 and 12). These chords are a development of the guitar and harp chords of bars 5 and 6, which themselves recall the guitar and harp chord that lies at the axial point of No. 3.

Links to Opus 10 Nos. 2 and 4

A variant of the minor second dyad features in bars 27-28. As was noted earlier, the violin's descending augmented octave E6-Eb5 (minor ninth) of bars 27-8 refers to the trombone's descending minor ninth in No. 2 (bar 7) and descending augmented octave in No. 4 (bars 3-4). (It is perhaps linked also via an inversion of this interval (ascending major seventh) that features in the trombone melody of No. 3 to the angular four-note violin melody in No. 3.) Overlapping with the Eb5 is a G#-A trill in cello and a trumpet D. The pitch classes in these bars can be seen as a direct development (with some enharmonic equivalents) of the chords in bar 26 of No. 5.

These bars refer to the transitional, fragmented passage of No. 2; they share a minor ninth descent, string trill, tremulous untuned percussion and mid-range brass (low trumpet D4, which is registrally similar to the trombone figure Ab4-G3). One could pursue the extra-musical interpretation even here. In view of the documentary evidence, this section of No. 5 might be regarded as transitional in that the 'soul' is transcending into heaven.

The coda functions in a way that is similar to No. 4. The sustained long note sounds as though it will descend in a manner similar to the trombone and violin two-note figures. However, it is followed by a staccato chord, which has the major seventh interval E3-D#4 embedded within it. In the Opus 10 version, this is played on harp, but the 'Opus 6' version once again betrays a connection, because these pitches are played on harmonium.[43]

The final death blows: an accented anacrusis

In this final main section of the analysis, I will discuss the revisions that were made to the piece's climax, which features the final 'death' blows.

The four-note semiquaver motif, which occurs in bar 9 (violin) and immediately before the final 'death' blows (bar 15, violin and viola), is a motif that, as I have noted in other analyses, seems to have preoccupied Webern throughout the compositional project. These motifs are linked timbrally with the motif in the central portion of No. 3 (bar 5); they are excited by plucked string. The faster tempo of No. 5 helps the renditions of the motif to bridge the gap between the clearly distinguishable impulses of the motif in bar 5 of No. 3 and the tremulous ostinati of that piece's outer sections. The renditions of the motif are also treated more explicitly as fragments of superimposed ostinati; different modes of excitation are combined. In bar 9, the violin plucked string four-note motif is set against tremolo plucked string (mandolin), tremolo struck metal (celeste) and an initial excitation of more sonorous plucked string (harp), struck metal (glockenspiel) and struck wood (xylophone). In bar 15, the plucked string motif is presented a major seventh apart in violin and viola; it is set against celeste trill (struck metal) and trumpet fluttertongue (wind). It would seem significant that this most explicit reference to the central portion of Opus 10 No. 3 comes before the final 'death blows' of bars 16 and 17.

---

[43] The enharmonic spelling of the 'Opus 6' version (E3-Eb) suggests that Webern may have regarded this as a development. In the 'Opus 6' version the progression in the harmonium part is from D# (No. 3) to D#-E (No. 5) to E-Eb.

Webern's orchestration of this climactic point underwent a number of revisions. In the 'Opus 6' version of bar 16, the Ab6 is played on tremolo violin artificial harmonic *ff* crescendo. The use of piccolo in the Opus 10 version ensures a brighter, much more piercing sonority. The revision may have been partly motivated by the use of artificial harmonics in bars 18-19 of the Opus 10 version; the avoidance of artificial harmonics in bar 16 ensures greater contrast between the 'Flood' and return to 'Ideal' sections.

In bar 16 of the 'Opus 6' version, the piccolo minim is doubled by tremolo cymbals, the sustained inharmonicity of the cymbals reduces the impulsive impact of the staccato off-beat chord; the chord may be slightly masked because it occurs at the peak of the cymbal roll. In the context of the extra-musical reading of Opus 10, the cymbal roll may have been superfluous; sufficient inharmonicity is provided only by the snare drum strikes—and these play a significant role within the extra-musical interpretation. If the extra-musical connotations of the snare drum tones did affect Webern's treatment of these bars, it is not surprising that he increased the dramatic effect by marking to a higher dynamic level the snare drum and glockenspiel tones (*f to ff* for snare drum and *f to fff* for glockenspiel). Other dynamic changes in these bars include the *pizzicato* cellos, which are changed from *f* to *sf*. This dynamic marking seems, however, to convey also the nature of the attack—the strings should be excited near the bridge rather than over the fingerboard (which would have a more sonorous effect). The idea that the attack quality is the focus here is supported by the addition of staccato markings, which are normally unnecessary for pizzicato tones; these tones should be short and 'sharp' in both senses of the term (emphasising upper harmonics and providing a rapid attack followed by very rapid decay). Greater dynamic weight is achieved in the Opus 10 version of these bars because the harp doubles the cello and double bass pizzicato chords. The harp tones would make up for any lost sonority caused by exciting the cello and double bass *pizzicati* near the bridge.

Also adding greater weight, increasing brightness and impulsiveness is the addition of xylophone and glockenspiel tones on the final 'death' chords. In 'Opus 6' these chords feature cello and viola artificial harmonics and harmonium tones, which do not lend themselves so easily to impulsiveness.

Similar revisions were made earlier in the piece. The dotted motif of bars 8-9, which seems to be a development of the opening glockenspiel and oboe figures, is played on piccolo in the 'Opus 6' version. In Opus 10, the tones are impulsively excited—a combination of plucked string (harp), struck metal (glockenspiel) and struck wood (xylophone). The use of glockenspiel here facilitates perceptual linking of the motif with the opening.

Although notated on a downbeat, the four-note semiquaver motif of bar 9 functions as an anacrusis to the harmonium chord. The use of struck wood (xylophone) associates this passage and bars 15-17 with the col legno *sf—p* of No. 2. This link is most easily made in the light of the 'Opus 6' version of No. 2, which features the four-note semiquaver anacrusis at the *sf—p* point. The final 'death' chords of No. 5 (bars 16-17) bring forcefully to the listener's attention the idea of the accented anacrusis.

Is it perhaps too far-fetched to suggest that the idea of anacrusis is of crucial importance within the extra-musical interpretation? The relationship between the accented anacrusis and its resolution might be read as a conceptual analogy of the necessity for dramatic 'Change' to precede resolution: the Flood must precede man's salvation, and life and death must precede the soul's transcendence into heaven.

5.5.3 Postscript

Webern's music is so often regarded as the antithesis of Berg's music. His aphoristic works are often regarded as radical because they appear abstract and fragmentary; his musical ideas are rarely regarded as allusions to autobiographical or other extra-musical events. My narrative reading suggests that Webern's music is, on the contrary, perhaps just as symbolically meaningful as Berg's music.

The pitches in Webern's Opus 10 Nos. 1 and 5 suggest that Berg's life-long obsession with Fate (represented musically as B-F) and Webern's extra-musical allusions might even be related. As was noted in Section 5.1, in Opus 10 No. 1, B-F lies at the axial point of the first development and spans the piece's large-scale symmetrical structure (B is the first pitch and F is the last pitch). This suggests that Webern might have believed that Fate was an inherent and essential part of '*Urbild*' (Creation). The pitches in Opus 10 No. 5 further support this idea, suggesting that the '*Seele*' is fated to return to the Ideal state. The Introduction opens with B (bar 1) and closes with F (bar 5); the point at which we return to the 'Ideal' state is a B (bar 18); the highly salient final version of the minor-second interval (now in its 'Original Form') resolves to a B (bar 22-24); the final pitch is an F that is, furthermore, timbrally linked to the end of Opus 10 No. 1—it is played on celeste.[44]

5.6 Conclusion

In this extensive study of Opus 10, I have shown how timbral perspectives may be drawn into a broad musicological framework. Drawing upon sketch materials and early versions of the pieces, I have speculated about Webern's grouping criteria in order to elucidate aspects of Opus 10's overall structure. These speculations were supported by references to contemporary documents (events in Webern's life, letters, the titles of the Opus 10 arrangement, and the stage-play *Tot*), which raised issues of extra-musical allusion and narrative approaches to musical structure.

I have demonstrated how a secret programme, which is influenced by Swedenborgian philosophy, reveals Webern's preoccupation with the metaphysical and the sublime, and his concern to balance various notional extremes, such as change and stability, life and death, and death and transcendence. My timbre and pitch analyses of the individual pieces took into account such ideas. In Opus 10 No. 1, the music's timbral and intervallic quasi-symmetries and organicism reflect the quasi-symmetries and organicism that are fundamental to Nature and Creation. In No. 2, interwoven timbral organic threads convey the notion of Transformation, whilst dramatic Change is conveyed through timbrally salient anacrustic events that project the music towards No. 3. In No. 3, timbral allusion and a structural reprise convey the concept of Return; the ideas of life and death are conveyed by an ostinato machine and snare drum sonorities, respectively. In No. 4, brevity, textural fragmentation and timbral and motivic allusion convey the notion of Reminiscence. And in No. 5, allusions convey the essence of the other pieces and the Soul's return to the Ideal state.

---

[44] The link between the B-F of the Introduction and the B-F of the Reprise is, of course, a natural consequence of the 'sonata'-like design.

Study of the early versions informed my reading. I have shown that Webern's revisions of dynamics, slurring, and instrumentation facilitate perception of relationships within and between pieces. In particular, hairpin dynamics seem to have a greater structural purpose in Opus 10 than in the earlier versions. Such parallels between the versions should, however, be considered with caution. Webern's grouping criteria must have changed for each re-grouping. In the context of a largish group of pieces, like the Orchestra Piece set, a degree of repetitiousness is perhaps desirable, because the structure accommodates gradual development. In the modest five-piece work that is Opus 10, there is perhaps less room for repetitiousness. Webern's insertion of Opus 10 No. 4 into the set of pieces is indicative of this concern for utmost concision.

Webern's criteria for the Opus 10 grouping seem to be based also on the concepts of organicism and symmetry that permeate Opus 10 No. 1. Many of No.1's ideas may be traced throughout the other pieces. Moreover, No. 1's symmetrical formations act as microcosms to the large-scale symmetry of Opus 10.

No. 3 functions as the pivot to this large-scale quasi-symmetrical structure. Either side of No. 3, a short piece which has a low global amplitude threshold (the loudest indication being a *p crescendo-diminuendo*) is coupled with a piece that is more extensive, has a far wider global amplitude range, and features dramatic, highly perceptually-salient events. No. 3 provides the pivot also for a large-scale symmetry between the outermost pieces; this symmetry is based on timbral and pitch links.

Analysis of the Opus 10 pieces has been greatly enriched by focusing on timbral matters. Application of Huron's voice-leading Principles and Parncutt's pitch salience algorithm elucidated some useful points, and the discussion of timbre in terms of dimensions highlighted many structurally significant links. In the Opus 10 pieces, the timbral dimensions that most often facilitate perception of structure include impulsiveness-continuousness, brightness and inharmonicity, and dimensions, such as rise time, spectral flux and jitter, that help to define instrument families.

Structural perception was facilitated also by holistic, direct perception of timbres, particularly timbres that have extramusical connotations, such as the pseudo-continuously-excited bells and cowbells (the Alps) in Opus 10 No. 3. The extra-musical connotations of other sonorities, such as the simultaneous ostinati (time and the 'treadmill'), the snare drum (death), and quiet 'bell'-like tones, such as harp harmonics, celeste, etc. (the divine), might have been perceived directly within Second Viennese School culture.

Conclusion

Timbre: the analyses

In this thesis, I have demonstrated that greater sensitivity to timbral issues can offer analysts new insights into the music of the Second Viennese School. In each of the works studied—Schoenberg's '*Farben*', Berg's *Wozzeck,* and Webern's Opus 10—timbre is a significant structural determinant. It highlights and enriches structures through extra-musical allusion. In particular, it helps to communicate concepts of Time, Change and Return. Time is conveyed through regular rates of timbral change; Change is depicted by vivid, often organic timbral developments; and Return is conveyed by timbral retrogression or timbrally-modified restatement.

In order to facilitate discussion of timbre-related issues, the analyses drew on a basic conceptual model that represents timbral differences as relative distances within a dimensional space. Even when links may be made according to instrument family, it was often useful to attribute the connection to specific dimensions, because not all instrument families are clearly defined, and usually the instrument type functions as just a vehicle for the dimensions.

In the analyses, rise time, spectral flux and jitter dimensions were shown to be useful indicators of instrument family; other useful dimensions include brightness and inharmonicity, global amplitude, and specificities (e.g. hollowness). Sometimes, dimensions proved most useful when grouped onto the same continuum (e.g. impulsiveness and continuousness in '*Farben*' and Opus 10 No. 2); at other times they were more useful when treated separately.

Some of the most interesting perceptual phenomena in the analyses included shifts within timbral dimensions. It is perhaps unsurprising that many of the timbral developments involved graded shifts; however, timbral complementarity played a role, particularly in Webern's music, which so often sought to maintain the equilibrium between organicism and contrast.

Other interesting timbral phenomena included timbral-temporal patterns and timbral transposition/analogy. The analytical strategies involved taking into account the listener's attentional focus, rates of timbral change, templates, threads, and networks, and offered a range of schemata that listeners might wish to employ. In order to gain an understanding of the significance of the phenomena and the appropriateness of the strategies, broadening the context to encompass works outside a specific composer's oeuvre was shown to be desirable, and sometimes necessary.

In combination with other issues, timbre has helped us to uncover possible secret programmes. The link between timbre and secret programmes has often necessitated pursuance of roads of inquiry that are not strictly timbral, such as study of sketches and early versions, and investigations into issues of influence, allusion, and autobiography. One work in particular—Schoenberg's '*Farben*'—provided Berg and Webern with a useful point of departure for the creation of new timbral effects. These effects were far from superficial, often being closely associated with extra-musical issues. In contrast to Schoenberg, Berg and Webern made use of timbres that may be perceived directly, because they appeal to listeners' cultural experiences.

My analyses embraced also a number of non-timbral issues; in particular, I drew attention to pitch/intervallic relationships. This proved essential not only for clarifying aspects of musical structure, but for showing how timbre works within a large scheme, both on its own terms and as a pitch perception facilitator.

In the analyses, timbre played a role often in gestural or motivic links. When motives or sonorities were linked, the sources were often instruments of the same type or instruments of the same family. However, some of the most interesting links arose from the imitation of an instrument by an instrument that is normally considered from a different family. It was shown that these allusions might be achieved through manipulation of chimeric percepts, which combine sounds from different sources.

The Listener

The schemata suggested in this study should not be regarded as prescribing what should and should not occur in a performance. Nevertheless, the issues that I have discussed do raise questions about aesthetic criteria for judging performances. As a general principle, qualitative judgements might be based on the extent to which a performance enables one to adopt a variety of schemata. For instance, in '*Farben*', a lack of attention to detail can result in a loss in the ability to hear out different rates of instrument change and can make streaming difficult. Whereas such clarity might be deemed necessary, a certain degree of ambiguity can enrich the performance, as in the continuity or segregation of the opening chords. The same principle applies to Opus 10 No. 2, where the section divisions may be clearly defined without losing the sense of teleology.

However, whether or not a performance is multileveled, its success will ultimately depend on whether or not the listener adapts her/his schemata to suit the performance. The perceptibility of the phenomena—and ultimately the qualitative judgements about a composition or a performance depend upon the listener's capacity for imagination. This imagination develops of course with education. For instance, A. Lynne Beal demonstrated that, when presented with a series of complex tones (e.g. tones played on different instruments), non-musicians, in contrast to musicians, tend not to perceive relationships amongst pitches—they perceive each pitch individually, (1985: 411).[1] This finding may go some way to explaining why non-musicians (and some musicians!) often regard *Klangfarbenmelodie* and the fragmented lines of Webern's music as incoherent—the listeners may expect to hear pitch relationships, but they have not been taught to focus on such relationships within a Webernian context.[2]

This demonstrates also the effect of cultural conditioning on musicians; it suggests that we could usefully 'unlearn' some of the schemata that we adopt habitually.

Analytical Methodology: Future Developments

This thesis has demonstrated that a general musicologist or music analyst can take practical steps to addressing issues of musical timbre, without tying themselves to a complex method, or a method that requires advanced equipment and is reliant on

---

1 Her study sought to investigate the suggestion put forward by John Sloboda (1976: 14) that 'musicians code relations between notes rather than the notes themselves'.

2 I mean 'taught' in a loose sense i.e. through tuition and/or familiarity with the repertoire.

recordings.[3] Throughout the thesis I have advocated an approach which makes use of an eclectic toolset. I have suggested that, if we are to make the most of the methods we employ, we need to recognise their capacities and limitations. I have demonstrated how data from Parncutt's pitch salience algorithm, Huron's voice-leading Principles, and timbral rhythm guidelines provide a sound basis for a theory of timbre for music analysis. These models were, like the basic conceptual model of timbre, treated as templates, as points of departure for interpretation.

However, these models may be improved in a number of ways. One of the problems that arose from the Parncutt algorithm involved the analysis of tones that are inharmonic, especially if the tones varied in their inharmonicity (Opus 10 No. 3). This is because the exact details of the spectral content of the inharmonic instrument tones is as yet unknown; more detailed experimental work into inharmonic instrument tones may help to resolve this problem.

The timbral rhythm Guidelines could be developed further. An area that requires development is the representational/notational system for electroacoustic music. The principle of using blocks and numerical time units to denote segment durations offers a workable starting point, but the issues that require resolution are likely to arise from engagement with a range of specific pieces. Such work was beyond the scope of this thesis; the intention here was principally to introduce the Guidelines as one of many possible schematic approaches to timbral perception that may offer insight into a wide range of musics.

Although supported by existing experimental work (e.g. Deliège 1987), the timbral rhythm Guidelines could benefit also from experiments into listener's perceptions of timbral change rate and timbral event salience within specific pieces. In this thesis, the approach has been intuitive, but it is valid because my findings are based on perceptual reality (informed by existing psychoacoustical work on timbral differentiation, e.g. McAdams et al 1995, and my own listenings).

---

3 The Parncutt pitch salience program is a simple program that can be used on Macintosh computers or PCs.

Taking the principle that instrument families exist simply because of proximity within various dimensions, one could begin to develop a more systematic theory of timbre by families according to dimensions, such as 'jitter', 'flux', 'centroid' etc. The results from experiments that are currently available are too impoverished for such a system to be created. As we learn more about what differentiates timbres, and as we learn more about the nature of the correlation between quantitative and qualitative evaluations, we can begin to put together a system and to approach orchestration in new ways. These strategies are important because, as the relationship between acoustic and electroacoustic music becomes fuzzier and as non-Western instruments join the palette, the potential for new sounds is ever increasing.

Bibliography

Adler, S. (1989). *The Study of Orchestration*, 2nd edition. New York: Norton.

Adlington, R. (1997). Review of David Epstein, *Shaping Time*. *Music Analysis*, 16(1), 155-71.

Aiello, R.; Sloboda, J. A. (eds.) (1994). *Musical Perceptions*. Oxford: Oxford University Press.

American Standards Association (1960). 'Timbre' in *Acoustical Terminology, S1.1-1960* (American Standards Association, Inc., New York). Also in ASA (ANSI) (1973).

Ashby, A. (1998). Singing the aphoristic text: Berg's *Altenberg-Lieder*. In Siglind Bruhn (ed.), *Encrypted Messages in Alban Berg's Music*. New York: Garland, 191-228.

Bailey, K. (1997). Berg's aphoristic pieces. In A. Pople, *The Cambridge Companion to Berg*. Cambridge: Cambridge University Press, 83-110.

Bailey, W. B. (1984). *Programmatic Elements in the Works of Schoenberg*. Ann Arbor: UMI Research Press.

Baliello, S.; Poli G. de; Nobili, R. (1998). The colour of music: spectral characterisation of musical sounds filtered by a cochlear model. *Journal of New Music Research*, *27*(4), 325-58.

Balzano G. J. (1986). What are musical pitch and timbre? *Music Perception*, *3*(3), 297-314.

Barrière, J-B. (1989). Computer music as cognitive approach: simulation, timbre and formal processes. *Contemporary Music Review*, *4*, 117-30.

Beal, A. L. (1985). The skill of recognizing musical structure. *Memory and Cognition*, *13*, 405-412.

Beauchamp, J. (First accessed 2000). *User Reports*. Experimental Music Studios, School of Music, University of Illinois at Urbana-Champaign. Http://ems.music.uiuc.edu/news/spring96/reports.html .

Benjamin, W. E. (1984). Theory of musical meter. *Music Perception*, *1*(4), 355-413.

Berglund, B.; Lindvall, T. (eds.) (1995). *Community Noise*. Stockholm: World Health Organisation. Http://www.nonoise.org/library/whonoise/whonoise.htm#3.3 .

Berg, A. (1929). A lecture on Wozzeck. In Douglas Jarman (1989), *Alban Berg: Wozzeck*. Cambridge: Cambridge University Press, 154-70.

Berry, W. (1971). Review of Edward T. Cone's *Musical Form and Musical Performance*. *Perspectives of New Music*, *9*(2)-*10*(1), 271-290.

Berry, W. (1976). *Structural Functions in Music*. New Jersey: Prentice-Hall.

Berry, W. (1985). Metric and rhythmic articulation in music. *Music Theory Spectrum 7*, 7-33.

Bismarck, G. von (1974a). Sharpness as an attribute of the timbre of steady sounds. *Acustica*, *30*, 159-72.

Bismarck, G. von (1974b). Timbre of steady sounds: a factorial investigation of its verbal attributes. *Acustica*, *30*, 147-158.

Blaukopf, K. (1976). *Mahler: A Documentary Study*. London: Thames and Hudson.

Bloom, H. (1973). *The Anxiety of Influence: A Theory of Poetry*. London: Oxford University Press.

Bloom, H. (1975). *A Map of Misreading*. Oxford: Oxford University Press.

Bloom, H. (1988). *Poetics of Influence*. New Haven: Schwab.

Bloothooft, G.; Plomp, R. (1986). The sound level of the singer's formant in professional singing. *Journal of the Acoustical Society of America*, *79*(6), 2028-33.

Boulez, P. (1987). Timbre and composition—timbre and language. *Contemporary Music Review*, *2*(1), 161-72.

Bowen, J. (1999a). Finding the music in musicology: performance history and musical works. In N. Cook and M. Everist (eds.), *Rethinking Music*. Oxford: Oxford University Press, 726-760.

Bowen, J. (1999b). Performers interpreting history: finding 'Una voce poco fa' Conference paper presented at the Third Triennial British Musicological Societies' Conference (15-18 July 1999), University of Surrey.

Brand, J.; Hailey, C.; Harris, D. (1987). *The Berg-Schoenberg Correspondence: Selected Letters*. New York: Norton.

Bregman, A. S. (1990). *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, Mass: MIT Press.

Britannica.com. Inc. (First accessed 1999). Weber's Law. *Encyclopaedia Britannica 1999-2000*. Http://www.britannica.com/eb/article?eu=78412

Broeckx, J. L. (1997). Beyond metaphor: musical figures or 'Gestalte' as expressive icons. *Journal of New Music Research, 26*(3), 266-76.

Brown, G. J.; Cooke, M. (1994). Perceptual grouping of musical sounds: a computational model. *Journal of New Music Research, 23*(2), 107-32.

Brown, G.J. (First accessed 1997). *NIPS-96: Workshop on Connectionist Modelling of Auditory Scene Analysis.* Http://www.dcs.shef.ac.uk/~guy/NIPS/index.html

Bruhn, S. (ed.) (1998). *Encrypted Messages in Alban Berg's Music.* New York: Garland.

Burkhart, C. (1973). Schoenberg's *Farben*: an analysis of Op. 16, No. 3. *Perspectives of New Music, 12*(1). 141-72.

Burns, E. M.; Ward, W.P. (1978). Categorical perception—phenomenon or epiphenomenon? Evidence from experiments in the perception of melodic musical intervals. *Journal of the Acoustical Society of America, 63*(2), 456-68.

Campbell, M.; Greated, C. (1987). *The Musician's Guide to Acoustics.* London: Dent.

Clark Jr., M.; Luce, D.; Abrams, R.; Schlosberg, H.; Rome, J. (1963). Preliminary experiments on the aural significance of parts of tones of orchestral instruments and on choral tones. *Journal of the Audio Engineering Society, 11*(1), 45-54.

Clarke E. (1987). Categorical rhythm perception: an ecological perspective. In A. Gabrielsson (ed): *Action and Perception in Rhythm and Music.* Stockholm: Swedish Academy of Music, 19-33.

Clarke E. (1995). Expression in performance: generativity, perception and semiosis. In J. Rink (ed.): *The Practice of Performance: Studies in Musical Interpretation.* Cambridge: Cambridge University Press, 21-54.

Clarke, E. (1989). Mind the gap: formal structures and psychological processes in music. *Contemporary Music Review*, 3, 1-15.

Clarke, E. (1997a). From perception to critique: direct realism and musical meaning. *Proceedings of the Third Triennial ESCOM Conference*, Uppsala, Sweden, 589-593.

Clarke, E. (1997b). Perception and critique: ecological acoustics, critical theory and music. *Proceedings of the International Computer Music Conference*, Thessaloniki, Greece, 19-22.

Clarke, E.; Dibben, N. (1997). An ecological approach to similarity and categorisation in music. *Proceedings of SimCat 1997: An Interdisciplinary Workshop on*

Similarity and Categorisation. Dept. of Artificial Intelligence, Edinburgh University, 37-41.

Cleveland, W. (1993). *Visualizing Data*. Summit, NJ: Hobart Press.

Cogan, R. (1984). *New Images of Musical Sound*. Cambridge Mass.: Harvard University Press.

Cone, E. T. (1968). *Musical Form and Musical Performance*. New York: Norton.

Cone, E. T. (1985). *Musical Form and Musical Performance* Reconsidered. *Music Theory Spectrum*, *7*, 149-158.

Cook, N. (1990). *Music, Imagination, and Culture*. Oxford: Clarendon Press.

Cook, N. (1994). A theorist's perspective on perception. In Rita Aiello and John A. Sloboda (eds.), *Musical Perceptions*. Oxford: Oxford University Press, 64-96.

Cook, N. (1995). The conductor and the theorist: Furtwängler, Schenker, and the first movement of Beethoven's Ninth Symphony. In John Rink (ed.), *The Practice of Performance: Studies in Musical Interpretation*. Cambridge: Cambridge University Press, 105-125.

Cook, N. (1998). *Music: A Very Short Introduction*. Oxford: Oxford University Press.

Cook, N. (1999). *Analysing Performance and Performing Analysis*. In N. Cook and M. Everist (eds.), *Rethinking Music*. Oxford: Oxford University Press, 239-61.

Cook, N. (1999). Words about music, or analysis versus performance. In P. Dejans (ed.) *Theory into Practice: Composition, Performance and the Listening Experience*. Leuven: Leuven University Press.

Cooper, G. W., Meyer, L. B. (1960). *The Rhythmic Structure of Music*. University of Chicago Press, Chicago, Illinois.

Crawford, J. C. (1984). Schoenberg's artistic development to 1911. In J. Hahl-Kach (ed.) J. C. Crawford (trans.), *Arnold Schoenberg—Wassily Kandinsky: Letters, Pictures and Documents*. London: Faber and Faber.

Crowder, R.G. (1989). Imagery for musical timbre. *Journal of Experimental Psychology*, *15*, 472-78.

Dannenberg, R. B.; Derenyi, I. (1998). Combining instrument and performance models for high-quality music synthesis. *Journal of New Music Research*, *27*(3), 211-38.

Deliège, I. (1987). Grouping conditions in listening to music: An approach to Lerdahl and Jackendoff's Grouping Preference Rules. *Music Perception*, *4*(4), 325-60.

Derenyi, I; Dannenberg, R. B. (1998). Synthesizing trumpet performances. In *Proceedings of the International Computer Music Conference.* San Francisco: International Computer Music Association, 490-496. Accessed from http://www.cs.cmu.edu/~rbd/papers/csis98/csis98.htm .

Devoto, M. (1998). The death leitmotif in *Wozzeck* and *Lulu*. In Siglind Bruhn (ed.), *Encrypted Messages in Alban Berg's Music*. New York: Garland, 243-8.

Donnadieu, S.; McAdams, S.; Winsberg, S. (1994). Caractérisation du timbre des sons complexes. I: analyse multidimensionelle. *Journal de Physique*, *4*(C5), 593-6.

Dubnov, S.; Tishby, N.; Cohen, D. (1995). Hearing beyond the spectrum. *Journal of New Music Research*, *24*(4), 342-68.

Dubnov, S.; Tishby, N.; Cohen, D. (1997). Polyspectra as measures of sound texture and timbre. *Journal of New Music Research*, *26*(4) 277-314.

Dunsby, J. (1995). *Performing Music: Shared Concerns.* Oxford: Clarendon Press.

Ellis, D. (First accessed 2000). *Perceptual modeling and auditory cue synthesis from the Machine Listening Group at the MIT Media Lab.* International Computer Science Institute: Berkeley, CA. Http://sound.media.mit.edu/

Ellis, D., *Auditory Home Page*. Http://sound.media.mit.edu/~dpwe/AUDITORY/ .

Fletcher, N. H. (1994). Nonlinear dynamics and chaos in musical instruments. *Complexity International*, *1*, Http:www.csu.edu.au/ci/vol1/Neville.Fletcher/paper.html .

Ferneyhough, B. (1972). Concerning the functional role of timbre in the early works of Anton Webern: a study of some aspects of the Five Orchestral Pieces, Op. posth. (1913). In James Boris and Richard Toop (1995), *Brian Ferneyhough—Collected Writings*. Amsterdam: Harwood Academic Publishers, 166-82.

Forte, A. (1998). *The Atonal Music of Anton Webern*. New Haven: Yale University Press.

Förtig, P. (1969). Analyse des Opus 16 Nr. 3. *Melos*, *36*(5), 206-12.

Fox, J.; Long J. S. (eds.) (1990). *Modern Methods of Data Analysis*. Beverly Hills: Sage.

Goad, P. J. (1994). Timbral sharpness and modulations in frequency and amplitude: implications for the fusion of musical sounds. PhD Thesis: University of Washington.

Goodman, E. (1997). Report: TAGS Day, Royal Holloway, 22 May 1997. *Newsletter of the Society for Music Analysis, 11*, 7-8.

Gordon, J. W. (1984). Perception of attack transients in musical tones (timing, rhythm). PhD Thesis: Stanford University. Issued through the Department of Music, Center for Computer Research in Music and Acoustics, Report No. STAN-M-17.

Gregory, A. H. (1990). Listening to polyphonic music. *Psychology of Music, 18*, 163-70.

Gregory, A. H. (1994). Timbre and auditory streaming. *Music Perception, 12*, 161-74.

Grey, J. M. (1977). Multidimensional scaling of musical timbres. *Journal of the Acoustical Society of America, 61*, 1270-77.

Grey, J. M.; Gordon, J.W. (1978). Perceptual effects of spectral modifications on musical timbres. *Journal of the Acoustical Society of America, 63*, 1493-500.

Guigue, D. (1997). Sonic object: a model for twentieth-century music analysis. *Journal of New Music Research, 26*(2), 346-75.

Hagerman, B.; Sundberg, J. (1980). Fundamental frequency adjustment in barbershop singing. *Speech Transmission Laboratory Quarterly Progress and Status Report, 1*, 28-42.

Hajda, J. M., Kendall, R. A., Carterette, E. C., Harshberger, M. L. (1997). Methodological issues in timbre research. In I. Deliege and J. Sloboda (eds.), *Perception and Cognition of Music*. Hove: Psychology, 253-306.

Handel, S. (1995). Timbre perception and auditory object identification. In B. C. J. Moore (ed.), *Handbook of Perception and Cognition* (2nd ed.) (*Hearing*, pp. 425-61). San Diego: Academic Press.

Hanson, R. (1976). Anton Webern's atonal style. PhD Thesis: University of Southampton.

Harrison, L. (1988). Music analysis and musical perception: studies in the psychology of musical structure. PhD Thesis: University of Lancaster.

Hasty, C. F. (1997). *Metre as Rhythm*. Oxford: Oxford University Press.

Helmholtz, H. von (1877/1954). *On the Sensations of Tone*. New York: Dover.

Hirschorn, Martin (ed.) (1989). Acoustical engineering data: nominal one third octave band frequencies and ranges. *IAC Noise Control Reference Handbook*. Industrial Acoustics Company. Http://www.industrialacoustics.com/ACOUTAB1.htm .

Houtsma, A. J. M. (1997). Pitch and timbre: definition, meaning and use. *Journal of New Music Research*, *26*(2), 104-15.

Howell, T. (1998). Sibelius' Tapiola: Issues of Tonality and Timescale. *Sibelius Forum: Proceedings of the Second International Sibelius Conference*. Helsinki: Sibelius Academy Publications, 237-48.

Howell, T. (1999). Sibelius *Tapiola*: The Full Monty. Conference paper presented at the Third Triennial British Musicological Societies' Conference (15-18 July 1999), University of Surrey.

Howell, T. (2000). Sibelius the Progressive. In Timothy L. Jackson and Veijo Murtomaki (eds.), *Sibelius Studies*. Cambridge: Cambridge University Press, 35-57.

Huber, P. J. (1987). Experiences with three-dimensional scatterplots. *Journal of the American Statistical Association*, *82*(398), 448-53.

Hudson, R. (1994). *Stolen Time: The History of Tempo Rubato*. Oxford: Clarendon.

Huron, D. (under review, 2000). Tone and voice: a derivation of the rules of voice-leading from perceptual principles. *Music Perception*. Http://www.musiccog.ohio-state.edu/Huron/Publications/huron.voice.leading.html .

Huron, D. (1989). Voice denumerability in polyphonic music of homogeneous timbres. *Music Perception*, *6*(4), 361-382.

Iverson, P. (1992). Auditory stream segregation by musical timbre. Paper presented at the 123rd meeting of the Acoustical Society of America. *91*(2), 2333.

Iverson, P. E. (1993a). Auditory stream segregation by musical timbre. PhD Thesis: Cornell University.

Iverson, P. E.; Krumhansl, C. L. (1993b). Isolating the dynamic attributes of musical timbre. *Journal of the Acoustical Society of America*, *94*, 2595-603.

Iyer, V. S. (1998). Microstructures of feel, macrostructures of sound: embodied cognition in West African and African-American musics. PhD Thesis :University of California, Berkeley.

Jarman, D. (1989). *Alban Berg: Wozzeck.* Cambridge: Cambridge University Press.

Jarman, D. (1997). Secret programmes. In A. Pople, *The Cambridge Companion to Berg.* Cambridge: Cambridge University Press, 167-179.

Johnson, J. (1999). *Webern and the Transformation of Nature.* Cambridge: Cambridge University Press.

Johnson, P. (1978a). Studies in atonality: non-thematic structural processes in the early atonal music of Schoenberg and Webern. PhD thesis: University of Oxford.

Johnson, P. (1978b). Symmetrical sets in Webern's Op. 10, No. 4. *Perspectives of New Music, 17*(1), 219-29.

Johnson, P. (1999). Performance and the listening experience: Bach's *Erbarme Dich.* In P. Dejans (ed.) *Theory into Practice: Composition, Performance and the Listening Experience.* Leuven: Leuven University Press 1999.

Johnson, R. (1997). *Sforzando 1.1 (Sforzando Pro).* Program available from http://www-personal.usyd.edu.au/~rjohnson/sforzando/index.html

Kay, P.; McDaniel, C. K. (1978). The linguistic significance of the meanings of basic color terms. *Language*, Vol. 54, pp. 610-46.

Kendall, R. A. (1986). The role of acoustic signal partitions in listener categorization of musical phrases, *Music Perception, 4*(2), 185-214.

Kendall, R. A., Carterette, E. C. (1991). Perceptual scaling of simultaneous wind instrument timbres. *Music Perception, 8*, 369-404.

Kendall, R. A., Carterette, E. C. (1993a). Verbal attributes of simultaneous wind instrument timbres: I. von Bismarck's adjectives. *Music Perception, 10*(4), 445-68.

Kendall, R. A., Carterette, E. C. (1993b). Verbal attributes of simultaneous wind instrument timbres: II. Adjectives induced from Piston's *Orchestration. Music Perception, 10*(4), 469-502.

Korsyn, K. (1991). Towards a new poetics of musical influence. *Music Analysis, 10,* 3-72.

Körte (1915). Kinomatoscopishe Untersuchungen. *Zeitschrift für Psychologie der Sinnesorgane,* 72, 193-296.

Krimphoff, J.; McAdams, S.; Winsberg, S. (1994). Caractérisation du timbre des sons complexes. II: Analyses acoustiques et qualifaction psychphysique. *Journal de Physique*, *4*(C5), 625-8.

Krumhansl, C.L. (1989). Why is musical timbre so hard to understand? In S. Nielzén and O. Olsson (eds.), *Structure and Perception in Electroacoustic Music*. Amsterdam: Elsevier, 43-53.

Leman, M. (1999). Relevance of neuromusicology for music research. *Journal of New Music Research*, *28*(3), 186-99.

Lerdahl, F. (1988). Cognitive constraints on compositional systems. In J. Sloboda (ed.) *Generative Processes in Music: The Psychology of Performance, Improvisation and Composition*. Oxford: Oxford University Press, 231-59.

Lerdahl, F., (1987). Timbral hierarchies. *Contemporary Music Review*, *2*, 135-60.

Lerdahl, F., Jackendoff, R. (1983). *A Generative Theory of Tonal Music*. Cambridge: MIT Press.

Lessem, A. P. (1979). *Music and Text in the Works of Arnold Schoenberg: The Critical Years, 1908-*. (Studies in Musicology, No. 8) London: UMI Research Press.

Lowe, B. (1997, unpublished). 'One movement or two?': structural multiplicity in the recorded legacy of Sibelius' *Fifth Symphony*, first movement. Paper presented at TAGS Day for Music Postgraduates (22 May 1997), Royal Holloway, University of London, and Cambridge University Music Analysis Conference (CUMAC) 1997.

Luce, D.; Clark, M. (1965). Duration of attack transients of non-percussive orchestral instruments. *Journal of the Audio Engineering Society*, *13*(3), 194-9.

MacDonald, M. (1976). *The Master Musicians: Schoenberg*. London: Dent.

Maegaard, J. (1972). *Studien zur Entwicklung des dodekaphonen Satzes bei Arnold Schönberg*. Copenhagen: Wilhelm Hansen.

Malloch, S. (1997). Timbre and technology: an analytical partnership. The development of an analytical technique and its application to music by Lutoslawski and Ligeti. PhD Thesis: University of Edinburgh.

Marshall, C. (1982). Towards a comparative aesthetics in music. In R. Falck and T. Rice (eds.), *Cross Cultural Perspectives in Music*, Toronto, 162-73.

Martin, S. (1996). Analysing musical recordings: an empirical approach. PhD Thesis: University of Southampton.

McAdams, S. (1984). Spectral fusion, spectral parsing and the formation of auditory images. PhD Thesis: Stanford University. Issued through the Department of Music, Center for Computer Research in Music and Acoustics, Report No. STAN-M-22.

McAdams, S. (1989). Psychological constraints on form-bearing dimensions in music. *Contemporary Music Review. 4*, 181-98.

McAdams, S. (1993). Recognition of auditory sound sources and events. In *Thinking in Sound: The Cognitive Psychology of Human Audition*. Oxford: Oxford University Press.

McAdams, S. and Pressnitzer, D. (1996). Psychoacoustic factors contributing to musical tension in Western non-tonal music. *International Journal of Psychology*, *31*(3), 148.

McAdams, S.; Bigand, E. (eds) (1993). *Thinking in Sound: The Cognitive Psychology of Human Audition*. Oxford: Oxford University Press.

McAdams, S.; Cunibile, J.C. (1992). Perception of timbral analogies. *Philosophical Transactions of the Royal Society, London, Series B: Biological Sciences, 336*, 383-9.

McAdams, S.; Winsberg, S.; Donnadieu, S.; De Soete, G.; Krimphoff, J. (1995). Perceptual scaling of synthesized musical timbres: common dimensions, specificities, and latent subject classes. *Psychological Research*, *58*, 177-92.

Melka, A. (1994). Methodological approaches to the investigation of musical timbre. *Journal de Physique*, *4*(C5), 569-76.

Mencl, W. E. (1994). The effects of spectral and harmonic envelopes on similarity and pitch judgement. PhD Thesis: Dartmouth College.

Meyer, F.; Shreffler, A. (1993). Webern's revisions: some analytical implications. *Music Analysis*, *12*(3), 355-79.

Misdariis, N.; Smith, B. K.; Pressnitzer, D.; Susini, P.; McAdams, S. (1998). Validation of a multidimensional distance model for perceptual dissimilarities among musical timbres. *16th International Congress on Acoustics and 135th Meeting Acoustical Society of America, Seattle, Washington, 20-26 June 1998*. Http://mediatheque.ircam.fr/articles/textes/Misdariis98a/ .

Moldenhauer, H.; Moldenhauer, R. (1978). *Anton von Webern: A Chronicle of his Life and Work.* London: Gollancz.

Nandini, I.; Aarden, B.; Hoglund, E.; Huron, D. (1999). Effect of intensity on sensory dissonance. *Journal of the Acoustical Society of America, 106*(4) 2208-09.

Nielzén, S.; Olsson O. (eds.) (1989). *Structure and Perception of Electroacoustic Sound and Music.* Amsterdam: Elsevier.

Nosulenko, V. N.; Samoylenko E. S.; McAdams, S. (1994). L'analyse de descriptions verbales dans l'étude des comparaisons de timbres musicaux, *Journal de Physique*, *4*(C5), 637-40.

Osmond-Smith, D. (1989). Between music and language: a view from the bridge. *Contemporary Music Review*, *4*, 89-95.

Page, T. (ed.) (1987). *The Glenn Gould Reader.* London: Vintage.

Parks, R. S. (1999). A Viennese arrangement of Debussy's '*Prélude à L'Après-Midi d'un Faune*': orchestration and musical structure. *Music and Letters*, 53(1), 50-73.

Parncutt, R. (1987). The perception of pulse in musical rhythm. In A. Gabrielsson (ed.), *Action and Perception in Rhythm and Music.* Stockholm: Royal Swedish Academy of Music, 127-38.

Parncutt, R. (1989). *Harmony : A Psychoacoustical Approach.* (Springer series in information sciences, No. 19) Berlin; New York: Springer-Verlag.

Parncutt, R. (1992). *Pitch Model in CX-complex.* Based on R. Parncutt (1989).

Parncutt, R. (1993). Pitch properties of chords of octave-spaced tones. *Contemporary Music Review, 9*, 35-50.

Parncutt, R.; Strasburger, H. (1994). Applying psychoacoustics in composition: 'harmonic' progressions of 'non-harmonic' sonorities. *Perspectives of New Music, 32*(2), 88-129.

Penel, A.; Drake, C. (1998). Sources of timing variations in music performance: a psychological segmentation model. *Psychological Research, 61*(1), 12-32.

Perle, G. (1967). Three views of *Wozzeck. Saturday Review*, 2 December, 54-55.

Perle, G. (1980). *The Operas of Alban Berg. Volume I: Wozzeck.* Berkeley: University of California Press.

Philip, R. (1992). *Early Recordings and Musical Style*. Cambridge: Cambridge University Press.

Plomp, R. (1976). *Aspects of Tone Sensation: A Psychophysical Study*. London: Academic Press.

Plomp, R. and H. Steeneken (1969). Effect of phase on the timbre of complex tones. *Journal of the Acoustical Society of America, 46*, 409-21.

Plomp, R.; Smoorenburg, G. F. (eds.) (1970). *Frequency Analysis and Periodicity Detection in Hearing*. Leiden: A.W. Sijthoff.

Poli, G. de; Prandoni, P. (1997a). Sonological models for timbre characterization. *Journal of New Music Research, 26*(2), 170-97.

Poli, G. de; Pandroni, P. (1997b). Sonological models for timbre characterization [abstract]. *Journal of New Music Research Electronic Appendix*. Http://www.swets.nl/jnmr/vol26_2.html#depoli26.2 .

Pople, A. (1997). *The Cambridge Companion to Berg*. Cambridge: Cambridge University Press.

Popovic, L. (1996). Liszt's harmonic polymorphism: tonal and non-tonal aspects in *Héroide Funèbre*. *Music Analysis, 15*(1), 41-55.

Porter, C. E. (1989). Interval cycles and symmetrical formations as generators of melody, harmony and form in Alban Berg's string quartet, opus 3. PhD Thesis: City University (New York).

Pressnitzer, D.; McAdams, S. (1997). Influence de la phase sur la perception de rugosité de sons complexes. *Actes du 4e Congrès Français d'Acoustique*, Marseille, *1*, 535-538.

Pressnitzer, D.; McAdams, S. (1998). Acoustics, psychoacoustics and spectral music. *Contemporary Music Review* and IRCAM—Centre Georges-Pompidou 1996-2001. Http://varese.ircam.fr/articles/saisie/recherche/cgi-bin/MkEntete.cgi?Pressnitzer98b .

Pressnitzer, D.; McAdams, S.; Winsberg, S.; Fineberg, J. (1996). Roughness and tension of orchestral timbres. *Proceedings of the 4th International Conference on Music Perception and Cognition*. McGill University, Montréal, Canada, 85-90.

Puffett, D. (1996). *Debussy's Ostinato Machine*. (Papers in Musicology, No. 4) Nottingham: Nottingham University.

Puffett, D. (1997). Berg, Mahler and the *Three Orchestral Pieces*, Op. 6. In A. Pople, *The Cambridge Companion to Berg*. Cambridge: Cambridge University Press, 111-44.

Rapoport, E. (1996). Emotional expression code in opera and lied singing. *Journal of New Music Research*, *25*(2), 109-49.

Reich, W. (1968). *Schoenberg: A Critical Biography* (trans. Leo Black, 1971). London: Longman.

Repp, B. H. (1998). Obligatory 'expectations' of expressive timing induced by perception of musical structure. *Psychological Research*, *61*(1), 33-43.

Repp, B. H. (2000). Compensation for subliminal timing perturbations in perceptual-motor synchronization. *Psychological Research*, *63*(2), 106-28.

Rieman, E. (1998). Tonality and unreality in Berg's *Wozzeck*. In Siglind Bruhn (ed.), *Encrypted Messages in Alban Berg's Music*. New York: Garland, 229-242.

Rink (ed.), (1995a). *The Practice of Performance: Studies in Musical Interpretation*, Cambridge: Cambridge University Press.

Rink, J. (1995b). Playing in time: rhythm, metre and tempo in Brahms's *Fantasien* Op. 116. In John Rink (ed.), *The Practice of Performance: Studies in Musical Interpretation*. Cambridge: Cambridge University Press, 254-82.

Rink, J. (1998, unpublished). Round table discussion: analysis in action [with Jonathan Dunsby, Eric Clarke and Dai Griffiths]. Paper presented at 'Analysis and the Performative', Society for Music Analysis and Critical Musicology Joint Study Day (18 October 1998), University of Southampton.

Rink, J. (1999). Translating musical meaning: the nineteenth-century performer as narrator. In Nicholas Cook and Mark Everist (eds.) *Rethinking Music: Issues of Historiography*. Oxford: Oxford University Press, 217-238.

Roberts, B.; Bailey, P. J. (1993). Spectral pattern and the perceptual fusion of harmonics. I. The role of temporal factors. *Journal of the Acoustical Society of America*, *94*(6), 3153-64.

Roberts, B.; Bregman, A. S. (1991). Effects of the pattern of spectral spacing on the perceptual fusion of harmonics. *Journal of the Acoustical Society of America, 90*(6), 3050-60.

Robinson, K. L. (1993). Studies in timbre and pitch. PhD Thesis: University of Cambridge.

Robinson, K.; Patterson, R.D. (1995). The Duration Required to Identify the Instrument, the Octave, or the Pitch Chroma of a Musical Note. *Music Perception, 13*(1), 1-15.

Rogers, W. F. (First accessed 2000). The instruments of musical sound. In *Review Notes—The Physics of Music PH007.* Http://physics.westmont.edu/classes/p007/review/ch11/ .

Russ, M. (1988). Temporal and pitch structure in Webern's Orchestral Piece Op.10, No. 2. *Music Analysis, 7*(3), 247-79.

Saariaho, K. (1987). Timbre and harmony: interpolations of timbral structures. *Contemporary Music Review, 2*(1), 93-134.

Saldanha, E. L.; Corso; J. F. (1964). Timbre cues and the identification of musical instruments. *Journal of the Acoustical Society of America, 36*, 2021-26 (or *46*, 409-21).

Sandell, G. J. (1990). Reviews of Wayne Slawson's *Sound Color* and Robert Cogan's *New Images of Musical Sound. Music Theory Spectrum, 12*(2), 255-61.

Sandell, G. J. (1995). Roles for spectral centroid and other factors in determining 'blended' instrument pairings in orchestration. *Music Perception, 13*(2), 209-46.

Sandell, G. J. (First accessed 1997). *SHARC Timbre Database.* Http://www.parmly.luc.edu/sharc/ .

Sandell, G. J.; Martens, W. (1995). Perceptual evaluation of principal component-based synthesis of musical timbres. *Journal of the Audio Engineering Society, 43*(12), 1013-28.

Schoenberg, A. (1911/1978). *Harmonielehre.* [*Theory of Harmony.* R. E. Carter, trans. London: Faber] Vienna: Universal Edition.

Schoenberg, A. (1975). *Style and Idea.* [Leonard Stein, ed.] London: Faber.

Schramm, B. L. (1993). Timbre and texture as structural determinants in George Crumb's *Star Child.* PhD Thesis: University of Rochester.

Shreffler, A. C. (1994). *Webern and the Lyric Impulse*. Oxford: Oxford University Press.

Semjen A.; Schulze, H-H; Vorberg, D. (2000). Timing precision in continuation and synchronization tapping. *Psychological Research 63*(2), 137-47.

Sincich, T. (1993). *Statistics by Example*, 3rd edition. London: Collier Macmillan.

Slawson, W. D. (1985). *Sound Color*. Berkeley: University of California.

Sloboda, J. A. (1976). Visual perception of musical notation: registering pitch symbols in memory. *Quarterly Journal of Experimental Psychology*, *28*, 14.

Sloboda, J. A.; Edworthy J. (1981). Attending to two melodies at once: The effect of key relatedness. *Psychology of Music, 9*(1), 39-43.

Smith, J. A. (1986). *Schoenberg and His Circle: A Viennese Portrait*. New York: Schirmer.

Straus, J. (1990). *Remaking the Past: Musical Modernism and the Influence of the Tonal Tradition*. Cambridge, MA: Harvard University Press.

Street, A. (1989). Superior myths, dogmatic allegories: the resistance to musical unity. *Music Analysis*, *8*(1-2), 77-123.

Street, A. (1994). The obbligato recitative: narrative and Schoenberg's *Five Orchestral Pieces*, Op. 16. In A. Pople (ed.), *Theory, Analysis and Meaning in Music*. Cambridge: Cambridge University Press, 164-183.

Tanner, M. P. (1999). The Liszt Sonata in B Minor: an analytical study of recorded performances. PhD Thesis: Birmingham Conservatoire.

Terhardt, E. (1974). On the perception of periodic sound fluctuation (roughness). *Acustica*, *30*, 201-12.

Terhardt, E. (1979). Calculating virtual pitch. *Hearing Research*, *1*, 155-82.

Terhardt, E. (1991). Letter to Richard Parncutt (19 July). *Fachgebiet Akustische Kummunikation am Lernrstuhl für Elektroakustik der Technischen Universität München* (Munich, Germany).

Terhardt, E. (First accessed: 2000). *Auditory roughness*. Http://www.mmk.ei.tum.de/persons/ter/top/roughness.html .

Toiviainen, P.; Kaipainen, M.; and Louhivuori, J. (1995). Musical timbre: similarity ratings correlate with computational feature space distances. *Journal of New Music Research*, *24*, 282-98.

Truax, B. (ed.) (1999). *Handbook for Acoustic Ecology*, 2nd edition. [Originally published by the World Soundscape Project, Simon Fraser University, and ARC Publications, 1978.] Http://www.sfu.ca/sonic-studio/index.html .

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, MA: Addison-Wesley.

Vaughan, V. S. (1998). Music analysis and performance interactions within the undergraduate curriculum. PhD Thesis: University of Southampton.

Wapnick, J. (First accessed: 1997). *McGill University Master Samples* Http://www.music.mcgill.ca/resources/mums/html/mSampIdeas.html .

Wellesz, E. (1925). *Arnold Schönberg*. [W. H. Kerridge, trans. Greenwood: Westport, 1970] London: Dent.

Wessel, D. L. (1979). Timbre space as a musical control structure. *Computer Music Journal*, *3*(2), 45-52.

Westergaard, P. (1968). Preface to Anton von Webern, *Three Orchestral Songs 1913/14 for voice and orchestra*. New York: Carl Fischer.

Whittall, A. (1997). Berg and the twentieth century. In A. Pople, *The Cambridge Companion to Berg*. Cambridge: Cambridge University Press, 247-58.

Windsor, W. L. (1995). A perceptual approach to the description and analysis of acousmatic music. PhD Thesis: City University (London).

Woodward, G. (1986). Non-pitch aspects as structural determinants in the atonal works of Anton Webern. DMA Thesis: Cornell University.

Worral, D. (First accessed 1997). *Physics and Psychophysics of Music (ACAT 1003)*. Http://online.anu.edu.au/ITA/ACAT/drw/PPofM/INDEX.html .

Wright, J. K.; Bregman, A. S. (1987). Auditory stream segregation and the control of dissonance in polyphonic music. *Contemporary Music Review*, *2*(1), 63-92.

Zwicker, E.; Flottorp G.; Stevens, S. S. (1957). Critical bandwidth in loudness summation. *Journal of the Acoustical Society of America*, *29*, 548-57.

Discography

Abbado, C. (1971). *Berg:* _3 Orchesterstücke_*;* _Altenberg-Lieder_*;* _Lulu-Suite_. London Symphony Orchestra (Claudio Abbado). Hamburg: Polydor International (Deutsche Grammophon), 437 005-2.

Abbado, C. (1993). *Sechs Stücke für Orchester*, op. 6 (1909); *Fünf Stücke für Orchester*, op. 10. In *Schoenberg:* _Ein überlebender aus Warschau_. *Webern:* _Orchesterwerke_. Wiener Philharmoniker (Claudio Abbado). Hamburg: Deutsche Grammophon, 431 774-2.

Barenboim, D. (1995). *Schönberg:* _Verklärte Nacht_*; Piano and Orchestral Pieces.* Chicago Symphony Orchestra (Daniel Barenboim). Hamburg: Teldec Classics International, 4509-98256-2.

Berglund, P.; Rattle, S. (1997). Sibelius: Symphony No. 5. In *Sibelius* _Finlandia_. Helsinki Philharmonic Orchestra (Paavo Berglund); Philharmonia Orchestra (Simon Rattle). London: EMI Records, HMV 5 72158 2.

Boulez, P. (1991). *Anton Webern: Complete Works, Opp.1-31.* Juillard String Quartet; London Symphony Orchestra (Pierre Boulez). London: Sony Classical, SM3K 45 845.

Boulez, P. (1995). Schoenberg: *Die glückiche Hand.* In *Arnold Schoenberg: The Expressionist Years.* BBC Singers, BBC Symphony Orchestra (Pierre Boulez) London: Sony Classical, SMK 62 020.

Boulez, P. (2000). *Complete Webern.* Ensemble Intercontemporain; Berlin Philharmoniker (Pierre Boulez). Hamburg: Deutsche Grammophon, 457 637-2.

Chailly, R. (1994). Schoenberg: *Five Pieces for Orchestra*, Op. 16, Nos. 1, 3 and 4 (1949 version). In *21st Century Classics.* Royal Concertgebouw Orchestra (Riccardo Chailly). London: Decca, 443 752-2.

Craft, R. (1995). Schoenberg: *Five Pieces for Orchestra*, Op. 16. In *Arnold Schoenberg:* _A Survivor from Warsaw_. London Symphony Orchestra (Robert Craft). Port Washington, NY: Koch International Classics, 3-7263-2 H1.

Dohnányi, C. von (1995). Webern: *Five Orchestra Pieces*, Op. 10. In *Webern:* _Passacaglia_*; Symphony; Variations.* The Cleveland Orchestra (Christoph von Dohnányi). London: Decca, 444 593-2.

Gibson, A. (1960). *Sibelius: Symphony No. 5 /* _Karelia Suite_. London Symphony Orchestra (Alexander Gibson). London: RCA Victor LSC 2405.

Griffiths, P. (2000). The complete works of Webern. In Pierre Boulez, *Complete Webern* [notes, pp. 33-53]. Ensemble Intercontemporain; Berlin Philharmoniker (Pierre Boulez). Hamburg: Deutsche Grammophon, 457 637-2.

Metzmacher, I. (1999). *Berg:* _Wozzeck_. Chor der Hamburgischen Staatsoper, Philharmonisches Staatsorchester Hamburg (Ingo Metzmacher). Köln: EMI Electrola, 7243 5 56865 2 7.

Rattle, S. (1989). *Schoenberg,* _5 Orchesterstücke_, *Op. 16; Webern,* _6 Orchesterstücke_, *Op. 6, Berg,* _Lulu-Suite_. City of Birmingham Symphony Orchestra (Simon Rattle). Hayes: EMI Records, CDC 7-49857-2.

Schoenberg, A.; Stevens, H. (1995). Schoenberg as a painter. An interview with Halsey Stevens in *Arnold Schoenberg: The Expressionist Years*. BBC Singers, BBC Symphony Orchestra (Pierre Boulez) London: Sony Classical, SMK 62 020.

Wand, G. (1991). Webern: *Five Orchestra Pieces,* Op. 10. In Stravinsky, Fortner, Webern, Martin. NDR-Sinfonieorchester (Günter Wand). Hamburg: BMG Music (RCA), RD60827.

Wintle, C. (1993). Webern: Orchestral Works. Schoenberg: *A Survivor from Warsaw*. In Claudio Abbado, *Schoenberg:* _Ein überlebender aus Warschau_. *Webern:* _Orchesterwerke_ [notes, pp.3-5]. Wiener Philharmoniker (Claudio Abbado). Hamburg: Deutsche Grammophon, 431 774-2.

Zender, H. (1997). Schoenberg's *Five Pieces for Orchestra*, Op. 16. *Schönberg; Messiaen*. Rundfunk-Sinfonieorchester Saarbrücken (Hans Zender). Saarländischer Rundfunk: CPO, 999 481-2.