Structuring Processes in Electroacoustic Composition

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All figures referenced in the text are bound in volume II.

Composition Folio Contents

(i) All compositions are recorded on CD I and CD II.
(ii) 'Receive' is recorded on the video cassette.
(iii) Recordings of the three live works are each accompanied by a performance score.

- Puzzle Wood: 1994, duration 13'20.
  Acousmatic composition.
  Recorded on CD I: 'Rocks and Wraiths', track 2.
  Performance requirements: sound diffusion system; home listening.

- Earth Haze: 1995, duration 13'54.
  Acousmatic composition.
  Recorded on CD I: 'Rocks and Wraiths', track 1.
  Performance requirements: sound diffusion system; home listening.

- Earth Haze: 1995, duration 15'27 (old version).
  Acousmatic composition.
  Recorded on CD III, track 98
  For reference only.

- Imago: 1995, duration 14'30.
  For bass clarinet, b flat clarinet and acousmatic sound.
  Recorded on CD I: 'Rocks and Wraiths', track 3.
  Performance score: 'Imago'.

  Performance requirements: Power Macintosh Computer with high quality analogue outputs, MAX software, MIDI pedal, microphones for instrument amplification, signal processing effects unit, (sound diffusion system preferable).

  Recording performed by Ben Harlan: clarinets; Hanna Marshal: cello. Engineered by Natasha Barrett, City University recording studios, 1996.

- Receive: 1995, duration 9'00.
  Music and film collaboration.
  Recorded on VHS video.

Performance requirements: sound diffusion system and large projection screen. Sound played from DAT, visuals played from high band U-matic tape (or SVHS). Visuals created by Michael Cleary.

Commissioned by Sonic Arts Network.

- Racing Unseen: 1996, total duration 20'20.
  Acousmatic composition
  In two movements: Racing Wide
  Racing Inside
  Recorded on CD II: 'Rocks and Wraiths', tracks 7 and 8.
  Performance requirements: sound diffusion system; home listening.

- Racing Through: 1996, duration 3'00.
  Acousmatic composition.
  Electroclip version of 'Racing Unseen', recorded on CD III, track 99
  Performance requirements: sound diffusion system; home listening.

  Commissioned by *DIFFUSION* i MéDIA

- Surf: 1997, duration 9'50.
  For two classical guitars and acousmatic sound.
  Recorded on CD II, track 2.
  Performance score: 'Surf'.

  Performance requirements: Power Macintosh Computer with high quality analogue outputs, MAX software, MIDI pedal, microphones for instrument amplification, signal processing effects unit, (sound diffusion system preferable).

  Recording performed by Natasha Barrett (both guitar parts). Engineered by Natasha Barrett, City University recording studios, 1997.

- Little Animals: 1997, duration 12'40.
  Acousmatic composition.
  Recorded on CD II, track 1.
  Performance requirements: sound diffusion system; home listening.

• Buoyant Charm: 1997, total duration 25'30.

In four movements: Charms and Darkness
Escaping Rapids
Lost and Let Go
Afloat and Buoyant

For mixed ensemble and acousmatic sound.
Recorded on CD II, tracks 3-6.
Performance score: 'Buoyant Charm'.

Performance requirements: Power Macintosh Computer with high quality analogue outputs, MAX software, MIDI pedal, microphones for instrument amplification, signal processing effects unit, (sound diffusion system preferable).

Recording performed by Steve Nobel: percussion; Phil Durrant: violin; Alexander Frauenheim: double bass; Ben Harlan: clarinets; Chris Burns: piano; Jim Denly: saxophones and bass flute. Engineered by Natasha Barrett, City University recording studios, 1997.

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Declaration

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Abstract

This thesis accompanies the folio of electroacoustic compositions, describing the reasons behind, and methods of realising, the compositions. Each approach is designed to create a musical structure that relates sound materials throughout the work in a meaningful way, with the final aim of presenting a memorable experience, enticing further listening. These relationships are explained by analysing the musical structure and by presenting sound examples on local and global scales.

The methods by which we may perceive and remember sound information are important to the compositional processes. Detailed relationships achieved by using computer sound-transformation and mixing techniques are shown to provide scope for listeners to explore and react personally to the music, investigating the structure with different listening strategies.

The significance of pitch in acousmatic music is shown to have an underlying and unifying structural role. Methods of unifying structure and capturing the listeners' attention over longer durations are investigated by considering sound-behaviour throughout the composition, and the listeners' perception of time in relation to different sound materials. The discussions suggest coherence not evident on a local scale.

Composition of the work involving mixed media attempt to integrate the different parts such that the listener's attention focuses on the totality. Consideration of the differences between acousmatic, visual, and live aspects, affect the structural co-ordination between different media and the complete structure itself.

Introduction

During the compositional process I find that the relationships between musical materials, within and outside the real duration of the work, are fundamental to the continual inspiration. Discovering and organising these relationships embody most of my compositional methods, such as those used to select, create and develop initial source materials, or express an imagined idea in terms of sound. Fascinated by exploring 'sound' in electroacoustic music, it was subsequently necessary to explore structuring processes other than those initially learnt through instrumental composition. This thesis provides a commentary on those ideas, and in many instances, sound and visual examples illustrate the discussion.

Each chapter outlines aspects of the structuring methods investigated through the compositional process. These are not necessarily exclusive to any single composition and the analysis process uncovers many ideas, each of which may be relevant to different chapters. This is particularly true since the nine compositions were realised over a relatively short period of less than three years.

Chapter 1 begins by outlining subjective and objective approaches to the discussion, and proceeds to consider aspects of perception, cognition and memory that were compositionally important. Although initial examples are taken from 'Puzzle Wood', this chapter is focused on a study of 'Earth Haze', illustrating the multiplicity of composed structure, and how I have attempted to guide listeners, or enhance their capacity for interpretation.

Ideas surrounding the importance of pitch in acousmatic composition emerge through the analysis presented in Chapter 1. Chapter 2 is concerned with the role of pitch - its conscious structural application, and subconscious perception by the listener; ideas on perception and memory established in Chapter 1 aid the discussion.

Chapter 3 is concerned with methods to unify the structure and maintain the listener's attention over longer durations. Structural ideas related to the complete work are investigated with reference to 'Racing Unseen' (full and electroclip version) and 'Little Animals'. The consideration of time-flow and consistencies in sound behaviour provide a significant departure from the previous chapters.

In Chapter 4, a discussion of the mixed works 'Imago', 'Surf', 'Buoyant Charm', and 'Receive', illustrates the reasons for, and methods by which, I attempt to integrate the different media. Through the compositional process, I suggest how each aspect of the mixed work may alter the structural organisation of the entire composition.

Chapter 1. Context, Paradox and Structure

1.1 Introduction

Acousmatic composers often use aural compositional methods, where sound material is evaluated through the listening experience. This immediate 'feedback' of information can be beneficial to the development of musical material and the composer's short-term intentions. However, it often leads to a decrease in coherent structural development over longer time-spans, due to varying aural attention spans and the inadequacy of memory to evaluate musical development throughout a work of any length.

Traditionally, instrumental music is structured in non-real-time through a system of notation. Notation is insufficient to accommodate the elements important to acousmatic material, and some alternative method of organisation is required. These initial observations evoked many questions concerning the structure of acousmatic music, the subject of which preoccupies most of this chapter, and is returned to throughout the thesis.

1.1.1 Personal and universal statements surrounding the discussion of the music

Discussing a concept that one hopes will be universally perceived amongst listeners, at least in part, can be problematic due to the subjectivity embedded in personal ideas. In developing a valid method of discussion, I found it useful to draw on Kant's ideas concerning 'judgement'. If judgement is based on the cognition of the material facts, it is objective in nature, and one may assume similar judgements to be made by other people. However, judgement can also involve private feeling, where a subjective perception of the 'object', or material facts, results in a subjective judgement[1]. This highlights my own experience that a 'judgement' will always involve both objective

[1] These ideas are developed extensively in Kant (1951:38).

and subjective interpretations of the material facts, where objective assumptions are common to many, and subjectivity is unique to each individual. Furthermore, the act of reflecting subjectively on an object may change our perception of it[2], such that subsequent reflections draw on alternative discussion criteria.

Throughout the thesis, I have attempted to clarify the presentation of ideas by separating objective judgement from personal aesthetic[3] experience. This separation can appear problematic, a matter which Kant clarifies by pointing to the exclusiveness of objective and subjective judgement, and the paradox of an aesthetic judgement:

> "A universality which does not rest on concepts of objects is not logical but aesthetical - i.e. it involves no *objective* quantity of the judgement, but only that which is *subjective*." (Kant, 1790: 49)

Further:

> "Intuitions can indeed be sensuous, but judgements definitely belong purely to the understanding, and to judge aesthetically or sensuously, supposing this to be knowledge of an object, is therefore a contradiction.... objective judgement in contrast, is always brought about through the understanding alone and thus cannot be called aesthetic." (Kant, 1790 in Crawford, 1974: 33)

In applying this idea to music, we can regard the listening experience as the integration of two main reactions: (i) a judgmental reaction based on a reasoned evaluation of the sound material, and (ii) an often inexplicable emotional reaction where one cannot be convinced into feeling a certain emotion through any reasoned judgement. However, although a 'feeling' cannot be explained, its grounds can often be described using factual information, which subsequently involves a reasoned judgement. By exploring these 'grounds', one can establish a compositional methodology.

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[2] This idea is discussed extensively in Popper (1968).

[3] The term 'aesthetic' has served numerous meanings throughout the history of philosophy. Bowie (1990) provides a comprehensive summary. In the current context its definition, although narrow, is that of a personal, subjective 'feeling' response to the source stimulation.

1.1.2 The composer's and listener's exploration of material

The process of compositional evaluation or exploration takes place over two time-scales: (i) throughout the course of the piece, during which time a continual flow of sound information interacts with memory, and (ii) in the shorter or longer time span after the piece has finished, where the music is remembered either in relation to itself, to private memories, or to the present environment and situation. There are three considerations in such an evaluation:

(i) The role of the composer as listener, established when manipulating sound aurally, presents confusion between the 'poietic' and the 'esthesic'. These are terms coined by Nattiez (1990) in his 'semiological tripartition', a theory which suggests a way of describing the link between the symbolic form and its interpretants. At the centre of the model exists what he calls the 'neutral' level, which is the work itself independent from any creation or interpretation processes. On one side exists the 'poietic', which consists of all the factors contributing to the creation of the work, such as the link amongst the composer's intentions and his creative procedures. On the other side exists the esthesic, consisting of all the factors determining the perception of the work, such as how an aspect of sound is captured by a listener's perceptive strategies. In the model, poietic intentions and esthesic perceptions are mutually exclusive, but related through a common dependence on the neutral level. However, from an acousmatic composer's point of view, Nattiez's distinction breaks down because during the act of composition, as well as through subsequent discussion of the final work, the composer's decisions are also made from a listener's perspective, therefore combining poietic and esthesic stances in the same judgement. This method of discussion applies to all the compositions in the folio.

(ii) The capacity to perceive a musical structure will vary for each listener due to different degrees of familiarity with the work or style, the difference between listener's long- and short-term memory, and ability to focus on the musical material (Clarke, 1987). This is of particular concern to the discussion on structural variability, presented in section 1.6 and in Chapter 2.

(iii) Composing in the acousmatic context involves an intensive listening method, where material is reviewed constantly, and subtle changes are made on the micro-scale. Subsequently the composer considers acoustic attributes that most listeners will rarely hear. Therefore, when forming objective grounds to explain a musical structure, one may draw disproportionate attention to attributes only grasped after several listenings, or which may not be grasped at all.

In the light of these considerations, this chapter discusses ideas concerning the perception of sound, combined with judgmental and emotional reactions gained from experimenting aurally in the composition studio. These ideas are used to explore the role of context, paradox, allusion and aural expectation within the compositional structure.

1.2 Memory

> "Without thought and memory there could be no musical experience. Because they are the foundation for expectation, an understanding of the way in which thought and memory operate throws light both upon the mechanism of expectation itself, and upon the relation of prior experience to expectation." (Meyer, 1956:87)

1.2.1 The storing of information in memory

Some of the methods we use in remembering information are important to consider when investigating how we may perceive and compose a musical structure. Psychologists are constantly reviewing the different theories concerning perception, cognition and memory. The following ideas are those which have most relation to a compositional method, and which I have extended to be compositionally applicable.

When listening to sound we perceive the acoustic information in the first instance, and subsequently form meaning when attempting to understand this information. Through the duration of the piece, the incoming sound information adds to the listener's understanding of the music. Information is organised hierarchically into 'levels of understanding', where the acoustic information constitutes the lowest level. Higher levels embody the relationships between lower level events, which are more abstract and have no immediate material reality. New or developing levels will constantly refer to those levels of understanding already established (Clarke, 1987: 212). Furthermore, Childs (1992: 59-78) suggests we compare events across time with other events in our memories, and once we have recognised a connection, are unable to stop uncovering the relationships. Particularly with acousmatic music, the listener's perception of new sound detail will lead to the recall of real experience, relying on memories external to the current musical material. In other words, the understanding of a musical hierarchy extends beyond the parent acoustic information.

The understanding on one level, may change as a result of the association with new information and, from this point of view, memory is dynamic (Dowling and Harwood, 1986). When incoming sound information upholds the existing relationships, there is no change, only reinforcement, in the levels of understanding. In this respect, memory relationships are stable.

The concepts of stability and change in levels of understanding are important when attempting to establish control over stability and change within the perceived musical form. If the composer presents material consistent to the existing memory relationships, structural levels of understanding will not change, and the musical structure will appear stable. With disparate or ambiguous information, either a new level of understanding will be created, or an existing one will change, which results in instability. With sufficient complexity in the sound information, each time the music is heard, the ambiguity may be resolved differently, which results in varying perceptions of form.[4]

When mentally processing sound information, it is sometimes assumed we 'chunk' the information into discrete units (Howell, Cross and West 1985). However, it is often impossible to define separate sound events or categories, particularly in acousmatic music, where continuous streams of transforming sound cannot be segmented through methods such as identifying phrase or repetition. In this respect, instead of segmenting material into different duration 'chunks', it may be more likely that the categorisation mechanism involves the *association* of sound attributes, irrespective of any clear segmentation procedure determined by duration. The idea of a 'perceptual present' (Kramer, 1988:371, and Yako 1997:47) can be developed in conjunction with this idea of attribute association. The 'perceptual present' is a point in time, but in practical terms has a certain time span that varies depending on context. Around the 'perceptual present' exists a metaphorical horizon, where the extremities fade into the past and future. Although both Kramer and Yako fail to explain duration characteristics of the 'present', it can be postulated that the proximity and clarity of the perceived information between the 'point' and the 'horizon' may change each time the work is heard. Furthermore, through the duration of the music, the central point of the 'perceptual present' changes in real time while the proximity and clarity of the

[4] The main problem with this method of creating stability and change is that the composer is presented with intangibles, such as the individuality of each listener - their experiences, musical knowledge, and desire to *listen* to the music. Despite these problems, there will exist some perceptual structural coherence due to a collective understanding of nature and society.

metaphorical horizon changes with the accumulation of new information. The relationship between 'point' and 'horizon' may exist not only as a temporal parameter, but also in terms of the strength of memory associations between acoustic, musical and extra-musical sound attributes. Therefore, with respect to the idea of the 'unit' of information, a discussion avoiding an inappropriate 'time-chunking' of continuous material can be based on the idea of a 'present', consisting of a short unit surrounded by a fading horizon. In other words, the combination of association mechanisms and the idea of a 'perceptual present' present alternatives to segmentation theory in the perception of a continuous stream of transforming sound.

1.2.2 Enhancing memory

Relatively few items of information are stored in short-term memory, which is thought to have a capacity limited to approximately seven items, each held for approximately 30 seconds. Conversely, long-term memory may be limitless (Dowling and Harwood, 1994:136). Concerning sound, the memory for new material may be enhanced in two ways. (i) New sound material may be associated with one sound or a collection of sounds contained in long-term memory. The connection with established levels of understanding would place the information within a context in such a way that it can be remembered. (ii) A number of new sounds may contain common attributes that allow them to be grouped, and therefore held as one item of information. The composite group may also form a strong link with long-term memory, whereas for an individual sound, the connection may be too weak to be significant. For example, if presented with a 'café-sound' environment, we may form a reduced representation of the many different complex sounds associated with 'café', and group them as one item of information by drawing on the content of long-term memory and our knowledge of the real world. Likewise, a composer or listener drawing upon any one of the 'café components' may subsequently retrieve the whole 'café-group' from long-term memory or, if the association is weak, fail to make any such connection. This is particularly significant for a compositional method that incorporates soundscapes (either an environmental recording or a sound collage - both of which are used in the folio of compositions), and then selects isolated components for further development.

It may be possible to use this method of association to manipulate background and foreground sound material within the musical work. A single sound may suggest a certain sound-collection or sound-environment. This single sound may remain in the foreground of our *perception,* and the implied sound-environment in the background of our *imagination.* A subsequent *real* acoustic reproduction of the previously only *implied* sound-environment could result in its movement from background imagination to foreground perception. Although the imagined sound material is directly related to the listener's prior knowledge, a common experience of nature and culture results in each individual drawing and grouping information in a similar way. Sound example 1.1 attempts to illustrate this concept of foreground and background imaginations and acoustic realities. Sound example 1.1a (track 1) is an extract from the very end of 'Puzzle Wood'; a sound-world consisting of a sustained pitch layer featuring a 7th interval, two semi-tone intervals a perfect 4th apart, levelling to a main pitch centre during the last 30 seconds of the example, a gentle 'metallic clinking' textural layer and a faint 'walking-bass' pattern oscillating between perfect 4th and perfect 5th intervals. This sound-world occupies our perception throughout the final minute of the composition. Sound examples 1.1b–1.1d (tracks 2-4) are extracts from earlier locations, presenting sound materials that imply different aspects of this end sound-world. In 1.1b the material, although initially featuring a variety of pitch information, levels to an oscillating semi-tone layer, and a single pitch centre, towards the end of the example. This is similar to example 1.1a, but in a higher transposition. Also heard in example 1.1b, most prominent half way through, is a more foreground variation on the gentle 'metallic clinking' textural layer. Example 1.1c is a fleeting extract, consisting of the same style of texture, and exact pitch centre, as is revealed towards the end of sound example 1.1a. Numerous fleeting references to the end sound-world can be found throughout the work, and it is likely that their brief duration creates a subconscious link. Example 1.1d presents a layered sound-world. The foreground consists of a broken, high-pitch layer, and the background consists of a reverberant, metallic texture and other attack articulations. Although with the characteristics of a minor pitch mode, this rear sound texture alludes to the 'metallic clinking' layer. The total information gained from these fragments is similar to that heard in sound example 1.1a. However, unlike the first extract, the materials in examples 1.1b-d are not heard simultaneously, and therefore the implied sound scape can only be imagined, and not fully perceived until the end of the work. Example 1.1e (track 5) presents the original sound recording, which, when subjected to numerous transformation techniques, provided acoustic and inspirational material for the above development procedure.

This capacity for reduced representation, group recall, and the manipulation of perception and imagination, when combined with acoustic clarity[5], allows the composer to use an increasingly complex and dense sound-world.

1.2.3 Weighting

'Weighting' is the extent to which one of many properties of a sound is perceived as the main property. Two important methods of weighting are distraction and repetition. With the former, the listener's attention can be distracted by submerging or masking the focal characteristic in an increased density of sound information, or by introducing a new sound attribute which will attract attention. Example 1.2a (track 6) takes an extract from the opening of the second movement of 'Racing Unseen'. Repeating 'wave' sounds are clearly audible, but the addition of sound fragments gradually obscures the original sound. Example 1.2b (track 7) takes an extract from 1'40 into the development, where the ear has been re-directed away from the 'wave' motion towards the progress of the added sound fragments.

Repetition has the opposite effect to distraction, often serving to enhance memory for the event due to time prolongation. This is demonstrated in examples 1.3a and 1.3b (tracks 8 and 9) taken from 'Racing Unseen', movement one. Example 1.3a presents a short group of attacking metal sounds, which are in fact, hammer blows. The most prominent attack occurs after three seconds, while the other articulations are

[5] 'Acoustic clarity' is achieved by avoiding unwanted masking effects, and by presenting a sufficient sounding duration such that aspects intended by the composer can be perceived by a listener.

variations on this material. Example 1.3b shows how the main attack in example 1.3a is repeated over an extended period through various transpositions (occurring in the form heard in example 1.3b approximately 26 seconds into the example). The repetition results in enhancing the listener's memory for the sound. Experiments investigating this attribute of memory enhancement in instrumental music suggest that it is a feature of exact repetition. A certain amount of varied repetition has the opposite effect of blurring the recognition of events, and therefore serving to destroy the prolongation (Pressing, 1985: 110). In the above example, there is a large degree of varied repetition through transposition and speed changes, but nevertheless recognition and prolongation of the feature occurs. Therefore, unlike in instrumental music, in acousmatic music the effect of varied repetition to blur the recognition of events may be dependent on other factors apart from transformation, such as allusion and context, and whether the basic identity changes significantly. In sound example 1.3b, the material maintains its metallic, percussive characteristics, and although it may suggest different allusive associations for each listener, in the musical context, is nevertheless striking in character.

The weighting of an object will effect the listener's perception of change. If our focus of attention shifts away from the changing attribute of a sound, the transformation goes unnoticed. Similarly, if the prime focus is on transforming material, the perception of change will be enhanced. The ability to disguise or enhance change is useful to the composer when manipulating the listener's expectations where, for example, an awkward transformation process might appear to be perceptually seamless due to weighting the focus away from the changing property. In effect, this disguises the change and surprises the listener who was unaware that the change had occurred. Similarly, one can emphasise change by weighting the focus in favour of the changing property such that the listener is consciously aware of the transformation process.

Weighting can also involve a specific sound or characteristic in the context of the whole work. Over an extended duration, a sound weighted by either of the above two methods may lose its emphasis if it does not maintain links to the macro-structure. Likewise, a sound can acquire weight from its structural role, without being emphasised by either distraction or repetition. Therefore long-term and short-term weighting may differ, and change throughout the listening process. A simple example can be drawn from 'Earth Haze', where the significance of different sound-types changes during the course of the work. To clarify this feature, figure 1.4 illustrates graphically the complete work and its main source materials. Section 1.6 presents a detailed discussion of this analysis. Nevertheless, from a brief observation of the different sound-types and respective locations in the work, (indicated by different colours in the top section of the graph), it is clear that the significance of each varies depending on the time-scale under consideration. For example, during the opening four minutes, the red colour (representing the 'crash / crunch' sound-type) has a minor role, while in the context of the whole work it is fundamental to the combined sound-world.

The effect of weighting is further dependent on two considerations: the focused acoustic property such as a specific frequency range, and the strength of any subsequent extra-musical association. In other words, the effect combines acoustic perception and allusive imagination - considerations particularly applicable to acousmatic music, where allusion is an important compositional component. For example, the acoustic features of a spatially located background sound include treble roll-off, low amplitude, acoustic masking, and in some environments, reverberation. If the associated sound allusion is also normally perceived as background within the given context or sound scape, our perception of its background role will not be disturbed. Acoustic weighting of foreground attributes within this sound, such as an increase in amplitude, may have little effect on our perception of the sound's background role, even if it is the loudest component in the sound scape. Altering further acoustic spatial clues, such as frequency and reverberation mix, may create an ambiguity between perceived-*acoustic* and imagined-*connotative* spatial locations. If the manipulation of spatial features places the sound 'convincingly' in the acoustic foreground, then its background connotations may become irrelevant.

Weighting effects are important when considering our perception of change, and are dependent on acoustic and allusive relationships throughout the structure of the work.

1.3 Allusion

The general definition of allusion is that of conveying an indirect reference with the suggestion of further association. The allusive potential of a sound is its capacity to infer beyond the intrinsic acoustic content. Allusion may be personally unique, but also contains characteristics shared amongst many listeners. Meyer's discussion of 'image processes' proves useful in highlighting this distinction. He describes 'image processes' as the *personal* stirrers of memory and imagination, and the image processes of the whole *community* are referred to as 'connotations'. He suggests that connotations and image processes can be different. For example, "the particular experience of an individual may cause a 'happy' tune to be associated with images of a sad occasion," (Meyer, 1956: 257).

It is rare for an acousmatic composition not to draw on allusion of some kind, and assumptions that other listeners will share a similar image are often the bases for important compositional considerations. Throughout the folio of compositions, the validity of these assumptions is in part effected by sound transformation and mixing techniques: in general upheld when an unprocessed sound retains clarity within the mix. However, to say that 'shared' allusion is more appropriate to 'untreated' sound-sources would be an over-simplification of the image forming process. Because the tools available to the composer increasingly provide the means to transform a recognisable source-sound into a remote version, it is useful to investigate the perceptual effect of the transformation process. Although not necessarily allied with transformation of a source, Smalley's use of the term 'gestural surrogacy' (Smalley, 1992) describes sources and causes of sound-making as becoming detached from known, physical gestures. To summarise, there exists different levels of surrogacy from the original 'primal gesture', which is the human experience of physical gesture, on which sounding gesture is based. First-order surrogacy, "projects the primal level into sound, and is concerned with the sonic object used in work and play prior to any 'instrumentation' or incorporation into a musical activity" (Smalley, 1992: 514). At the extreme, remote surrogacy considers the source and cause as unknown. In other words, there exists a continuum of source and cause recognition, which moves from the unambiguous, where the vast majority of listeners identify the source and cause, to sound of no apparent real-world linkage, allowing for no such agreement.

Allusion can maintain a connection to the original sound-source, or form unconstrained from the immediate perception, at any level of perceived surrogacy. This behaviour suggests two levels of allusive potential, which I have called 'primary' and 'secondary' allusions. Primary allusion occurs when a sound directly stimulates an allusion. Secondary allusion consists of all the subsequent associations with primary allusion, gradually becoming more remote from the original sound. In other words, the initial primary allusion sets off a chain of memory relationships personal to each individual. Like a word association game, the further one travels down the chain of relationships, the more distant the present idea is from the initial idea, and the more variable is the interpretation. This may result in a strongly recognisable sound becoming more abstract, or an abstract instrumental source stimulating extra-musical associations.

Throughout the compositional process I increasingly felt that source recognition alone is not a sufficient base for collective allusion, and as Christiane ten Hoopen points out (Chion, 1994: 128), it is the "*sounding flow* itself" which is important. The sounding flow is fundamental to primal gesture, and while sounding analogies and gestural surrogates may become more ambiguous, the link to primal gesture through motion, energy, timbral and spatial distribution may strengthen. The 'sounding flow' link is more general than the identification of a specific sound-source, and therefore more listeners are likely to comprehend the former. Through the combined characteristics of source recognition and energy trajectory, all types of acousmatic sound may contain the potential for collective allusion. In 'Puzzle Wood' there is a persistent flow characteristic (although this was not recognised during the composition of the work). Each gesture, particularly during the first four minutes, is characterised by an aggressive, surging wave shape, of varying length and direction. The implications embedded in this gesture are inexplicit, and listeners are likely to gain different experiences. However, the experienced strength of this 'sounding flow' has greater significance in the image forming process than any of the other recognisable (real or imagined) sound sources.

The strength of allusion can affect the perception of everyday sounds outside the time-duration of the work. An amusing conversation with the performers involved in 'Imago' brought to light the effect the piece had on their perception of everyday sounds. For example, a teaspoon rattling in a teacup stimulated an instant reflex to pick up their instruments and begin playing at the appropriate cue, even though the tape part for 'Imago' does not actually contain this real sound-source. In other words, the perception of sound 'outside' the work effects future listening, such that there is a two-way transfer of meaning between musical and real-world associations.

Titles and programme notes are important to all the compositions, and their degree of explicitness is related to the capacity for allusion within the composed sound-world. For example, the programme notes accompanying 'Racing Unseen' are brief, and vaguely evocative, while the musical material contains explicit aspects of 'racing' sound-worlds. Conversely, the acoustic content of 'Little Animals' initially appears to have little in common with the title, and subsequently the programme notes contain more descriptive detail. Programme notes to all works can be found in Appendix 1.

1.4 Paradox - The Eye and The Ear

A paradox exists where a statement or result holds true under conditions of contradictory information (the information consisting of either received opinion or logical fact) - it is *a self-contradiction*. The strength of a paradox depends on personal belief: paradox based on scientific logic holds true against all argument, while paradox based on philosophical belief can be undermined. For example, the theory explaining 'irrational numbers' presents an indisputable scientific paradoxes. An irrational number, such as the square route of '2', cannot be expressed by an ordinary fraction (in other words as the ratio of two integers). However, Pythagoras' theorem - concerning the relationship between the sides of a right-angled triangle - proves that all real numbers have a finite square route and are therefore located at a point on a straight line. In the case of the above example, the square route of '2' is represented by both an interminate decimal and, as proved by Pythagoras, can be represented as a finite point on a straight line. Acoustically, the Shepard tone presents a paradox where we perceive an ascending or descending pitch to a note which it is fact static, (demonstrated in 1963 by Roger Shepard with discrete pitch-steps, and in 1968 by Jean-Claude Risset for continuous gliding tones). This effect occurs because the way in which we evaluate pitch is biased towards spectral distribution, and although the pitch of the note remains constant, the moving spectral components give the illusion of gliding tones. Kenneth Knowlton, who in 1970 generated 'beats' which appeared to speed up and slow down endlessly, explored the idea of a rhythmic paradox. He achieved this by using waveforms comprising periodic pulses with different periods and amplitudes in octave relations. Jean-Claude Risset (Risset, 1997: 7-10) has attempted to extend this principal into live instrumental performance, with his work 'Contra Nature' for solo percussion and computer-generated tape (1996). Although the paradox is clear when using solo computer-generated tones, in the live performance, amplitude and timing inaccuracies, combined with differences in sound qualities of each instrument and the relative balance of the live and tape parts, serve to obscure or destroy the effect which is likely to have more potential in an acousmatic work.

A paradox in sound can involve more than the acoustic examples outlined above. One of the more common musical examples of a paradox is found in works by Bach, where a canonic or fugal theme is played backwards in counterpoint to another theme, while both parts move forward in time[6].

In all examples of sound paradox, logic and perception are key factors: the listener must *perceive* both the ascending pitch movement, or the reversed theme, while acknowledging the *logical* opposites of stasis and forward motion respectively. Paradox may also involve opinions and judgements, where personal belief (established through the course of the music, or based on everyday knowledge of sound behaviour) is the basis for one side of the contradiction. Under these circumstances, examples are less clear, and although paradoxes involving spectral motion are found in the folio of works, the application is subtler than that of the Shepard tone. Likewise, similar analogies to the thematic material from the Bach example can also be found.

Before describing my own application of musical and acoustic paradoxes and their structural role, it is necessary to outline the inspiration gained from visual art examples. Here, the role of opinion and perception in the formation of paradox is clearer than in music, and can be used to further a discussion in relation to the electroacoustic works. The visual work of Mauritius Cornelis Escher serves as a useful illustration. In Escher's work visual paradox, semantic illusions and what have been termed as 'tangled hierarchies' play with one's visual senses. 'Tangled Hierarchy' is a term used to explain a movement upwards or downwards through some hierarchical system, resulting in an unexpected return to the starting point (Hofstadter 1979:10). In visual art this is often in the form of a 'spatial illusion', where the misinterpretation of factual data has resulted in a deceptive appearance. For example, if the viewer is presented with a graphical representation of a familiar three-dimensional object, because the object is drawn on a two-dimensional surface, changes to the graphical representation can be made which result in an impossible representation of the real three dimensions. Nevertheless, the features are so strong we want to believe the representation, and the viewer, in trying to resolve this contrary information, generates

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[6] A detailed description of this process and other forms of structural paradox are described in Hofstadter (1979).

paradox. One of the key words in the above text is 'familiar'. For a contradiction to occur, part of the information must already be established as the norm. Figure 1.1 is a copy of Escher's 'Waterfall'. In this illustration, our knowledge of gravity suggests that the water should not be able to flow upwards and form the cycle of water-flow and waterfall (Escher, 1989: plate 76). In acousmatic music, a similar tangled hierarchy can be created by drawing on the listener's knowledge of sounds in the world compared to the sound behaviour in the music (in other words drawing on allusion), and by playing on norms set up during the real-time course of the work. The latter instance is similar to the Bach example, where paradox is generated internally within the music. Both cases generate listener expectations against which further information can conflict. In other words, paradox can draw on both musical and allusive spectromorphological activities.

Two problems exists when attempting to engineer the situation in an acousmatic work:

(i) When forming images, the ear is more abstract than the eye. A real-world sound could have many possible sources and much reflection and evaluation is necessary to clarify one's perceptions of the sound material. Conversely, real-world visual images present clear information such as line, texture and object, even if the subject of the image cannot be grasped instantly. This difference between the perception of information via the eye and the ear is summarised appropriately by Xenakis:

> "The eye is quicker and more immediate, agile and accurate than the ear, which is less agile and demands reflective thinking. Therefore the ear is more abstract, and its creations are thus also". (Xenakis, 1955:21)

Paradox relies on concrete information. One is never completely certain about the qualities of a fleeting sound. Consequently, listeners may attempt to resolve an ambiguity rather than perceiving a conflict between two pieces of information they believe to be true.

(ii) Unlike paradox based solely on logic (i.e. the case of irrational numbers), Escher's visual art examples are ultimately resolved if the viewer makes the distinction between the two-dimensional representation and the three-dimensional reality. Likewise, musical paradox involving allusion (in other words illusion involving allusion), ceases to exist when the listener is unable to 'accept' the acousmatic listening-mode, and only perceives the acoustic content of the source material. However, paradox generated *within* the music may present a contradiction unresolved by re-evaluating implication and reality, such as the case of the Bach example described above. Sound example 1.4 (track 10) demonstrates an internally created paradox in an extract from 'Racing Unseen'. The opening of the extract contains the sound of distant church bells. Throughout the extract the 'large' bell-sound transforms into 'small' resonant metallic materials, while the pitch and phraseology of the initial sound is maintained (although pitch mode moves from major to minor). In effect, the listener maintains a strong sense of the original aural-image, while perceiving an acoustic source containing contrary characteristics. The sense of paradox is dependent on the listener perceiving the transformation in allusive as well as acoustic terms, while maintaining a memory for the initial material. Conversely, in a visual paradox, the 'memory' aspect is less important because the time domain has no role. Pictorial information is static, and although the complete image may not be held in sight at any one moment, (the eye scanning over the image, gaining different concentrations of information from central and peripheral vision), the viewer is able to take repeated glances at information which does not change. This concept of time is the fundamental difference between sound and a static visual image.

Paradoxical conflicts and the search for resolution can be achieved by stimulating the listener's imagination through time[7]. Therefore, paradox formulated through time calls for an attention span and involves a *structural evolution.* A pre-requisite for the perception of musical structure is a memory of the past and an anticipation of the future. During the first listening, the ear may continually search for a resolution in the paradox within the evolving material, which subsequently enhances the attention span. After repeated listening, memory for material will change in relation to further discoveries within the music. In other words, sound changes its

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[7] However, a listener may not necessarily interpret a 'conflict' or seek a 'resolution', and instead form some source-bonding relationship between the different materials.

function in relation to listeners' constructive processes through time, and subsequently listeners may perceive and resolve paradox differently each time they hear the work. The composer can further stimulate the perception of paradox through the choice and transformation of intrinsic acoustic and allusive sound contents.

1.5 Context and Paradox: Considerations for the Composer

1.5.1 Guided and constructive listening processes.

> "Unity is a product of my perception due to free-play. Only people with imagination can hear musical unity since only they can carry out this indeterminate synthesis." (Kant in Crawford 1974: 56).

The listening process can be two-fold: on one hand the listener is guided by the acoustic content of the sound material - its spectral characteristics, shape, gesture and direction, and on the other hand, especially in acousmatic music, the listener is constantly interpreting the sound meanings, which, when concerned with secondary allusion, are constructed externally to the intrinsic content of the work.

In electroacoustic music, the listener could be presented with *anything*. Idealistically there are no constraints, although in reality both the composer's decisions, and a listener's pre-conceptions will inevitably be coloured by personal expectations, cultural contexts, performance contexts, personal ideologies, and available compositional tools. However, during the course of listening, the composer guides expectations (for better or worse, weakly or strongly)[8], and the listener is required to deduce a set of rules so that the developing structure can be re-evaluated in the light of ensuing developments.

1.5.2 Relating material through time

The composer will endeavour to relate materials diachronically and synchronically in a meaningful way. The former relates materials over time. It involves linear elaboration and is concerned with degrees of change and transformation. The latter relates

[8] An interesting analogy can be drawn from the expression "the engineer of human souls" - coined by Stalin to define the job of a writer. Just as an engineer constructs a machine, so must the writer construct the mind of a new man (Skvorecky, 1977).

materials at a single moment. It involves vertical elaboration, and is concerned with the identification and relationship of simultaneous or coinciding sound-flows. Although listeners may not perceive such thorough relationships, they will relate sound materials by detecting similarity and difference, which often change after repeated and closer listening. As the ear gradually acquires sensitivity to variation, the *perceived* acoustic information may change, and subsequently influence both the perceived musical and extra-musical form.

The listener's deductions can follow one of two paths. One approach imposes an interpretation onto the various relationships, or as Nattiez explains:

> "A given object assumes significance for an individual apprehending it when he places that object in relationship to other sectors of his life as actually experienced, that is to say the totality of other objects belonging to his experience of the world". (Nattiez 1990: 9)

A second approach, (less open to listener individuality), rests on the psychoacoustic perception of sound. If certain information is missing, our perception may 'invent' the missing data, based on psychological phenomena of continuity and gestalt grouping mechanisms. For example, when presented in a close time-frequency relationship, the acoustic characteristics of different sound materials will relate differently than when presented in isolation. (This effect is called 'streaming', and occurs where the auditory system obtains one or many sequences of events are from a single source.[9])

1.5.3 Frames of reference (and the importance of context)

A 'prototype' is a conceptual model created by the individual's experience of the world. With reference to Plato's example of a chair: some chairs are more chair-like than other chairs, but all chairs conform to the prototypical chair[10]. With respect to acousmatic music, when the relationships between two different sounds remain

[9] McAdams & Bregman (1979) detail further the idea of auditory streaming.
[10] The 'chair-like' analogy is described in Lerdahl (1987: 144), who outlines a discussion on timbral prototypes.

unchanged even after the addition of new sound material, over a period of time, model relationships begin to emerge. In other words, further evidence gained from the addition of new sound material confirms the original relationships as the norm (similar to the method described in section 1.2.1, by which information is established in long-term memory). The prototypical *relationships* amongst different sounds - as opposed to the prototypical sound itself - I define as the *frame of reference*.

In the case of a complex sound possessing a number of attributes each of which could be salient, such as volume, pitch-noise content, texture and energy motion, either the complete sound will be attracted to the model with which it has most in common, or each component may be attracted to a different model. With the latter, different frames of reference may associate with the complex sound, and if conflicting, evoke a paradox. Similarly, a persistent change in context may result in the changing salience of each attribute, such that within the developing structure of the work, the musical 'role' of the complex sound, or any one of its components, may also become paradoxical. The practical methods and consequences of superimposing frames of reference are considered in section 1.5.5.

Finally, our perceptual sensitivity to the change of a specific sound parameter is a compositional consideration. For example, our sensitivity to fine changes in pitch and duration are good, while the relative judgement of spatial depth and texture is less good (McAdams 1989: 182, provides a detailed discussion). Therefore, acoustic features from which we perceive a strong sense of change, may distract from those from which we perceive a weak sense of change, and form stronger links to their respective frames of reference.

1.5.4 Different 'frames of reference' considered

The following is not an exhaustive list, but serves to describe some of the ideas explored in my compositional method.

Macro- and micro-frames of reference and the effect on texture and object relationships

The concept of the 'sound-object' has received many definitions. Schaeffer's sound-object considers the attributes of the sound ignoring the 'message' it may carry, and in other words, ignoring any connection to its source production or subsequent allusion[11]. Nattiez (1990:92) suggests that this level of description is 'neutral' (with respect to the semiological tripartition discussed above). This is because not every identifiable trait is necessarily relevant to the poietic or esthesic, some traits heard without intention and others intended, but not heard. Nattiez further suggests that sound-objects have an esthesic function not foreseen in Schaeffer's interpretation. Instead of being grasped "so to speak in the blink of an ear" (Nattiez 1990:100), sound 'unscrolls itself', manifests itself with time, and is a living process. In other words, the sound becomes esthesic.

When listening and composing I find that the sound-object requires a contextually relevant acoustic definition to clarify the esthesic function. It needs to contain sufficient acoustic features to distinguish it from surrounding material, such that it is a clear component in the musical flow. This definition of a sound-object is central to its distinction from a sound texture, which features the massing of many characteristics in a static or directed trajectory. For example, the definition of a sound-object postulated by Barry Truax: "a sound entity that exhibits an internal consistency in its acoustic behaviour" (Truax, 1987: 38), could easily characterise an object or a texture.

Escher illustrates graphically the problem of defining texture and object characteristics in his periodic drawings. Similar or irregular shaped figures are contiguous to one another, and when viewed in isolation, each can be regarded as a complete object, while when viewed in context we see a graphical series of repetitions. Figure 1.2 is a copy of 'Circle limit IV, (Heaven and Hell)', (Escher 1989: 25). In this illustration, white angels and black devils are arranged about, and radiate from, the centre. The angels and devils alternate on black and white backgrounds, and "In this

[11] Smalley (1992:516) discusses this aspect of Schaeffer's 'listening mode', and places it in context with other possible modes of listening.

way, heaven and hell change places" (Escher 1989: 10). He outlines two main rules upon which this work relies: (i) without recognisability there is no meaning, and (ii) without shade contrast there is no visibility. The significance of the border between two adjacent shapes is key to understanding the nature of a paradox between two sounds:

> "...on either side of it, simultaneously, a recognisability takes shape. But the human eye and mind cannot be busy with two things at the same moment, and so there must be a quick and continuous jumping from one side to the other." (MacGillary 1976: 6)

In the context of a musical work, macro- and micro-listening methods may be fundamental to the crossover between sound classified as object or texture. Although the listener may recognise object *and* texture simultaneously, it is difficult for the ear to focus on both at the same time - similar to Escher's description concerning line boundaries between two shapes. For example, when viewed on a macro-level, one may perceive sound material as a texture, while on the micro-level, as an object, or collection of objects. The distinction between macro- and micro-listening will likewise depend on the material in question, and whether the *relationships between different sound-objects* exist on macro- or micro-levels. For example, if a 'sound' is revealed slowly or contains characteristics defined by many variations, and the macro-duration is also defined over a long duration, the sound may be perceived as an object, depending on the definition of 'long'. Sound example 1.5a (track 11) takes a 45-second extract from 'Puzzle Wood'. This extract presents many sound-types and I am here concern with the characteristics of the noise-surge, implying a forceful, breath exhalation. Over the 45-second period, the ear has time to distinguish the characteristics of this sound, and define it as a sound-object. If however the listening duration is over a short period (such as on the micro-level, at five-second intervals), the same sound may be perceived as a texture due to the 'defining' sounding-duration not being heard. Sound examples 1.5b, 1.5c and 1.5d (track 12) present this scenario, taking short extracts from example 1.5a. Similarly, for a single sound lasting only a fraction of a second, when massed over any duration will most likely be perceived as a texture.

To summarise, perception of object and texture depends on the duration frame of reference (or macro- micro-listening stance), combined with the sonic clarity of adjacent materials. Finally, reference to other sound allusions may strengthen the defining characteristics of the object - a concept allied to the earlier discussion on memory in section 1.2.

<u>'Real' and 'synthetic' sounds, and their relationships in familiar and unfamiliar spatial environments</u>

The perception of realism is a combination of sound and spatial qualities. The following considers each in turn, and how when combined, they produce varying states within the 'sound-world realism' frame of reference.

(i) Describing sound as real or synthetic may appear contradictory as all sound is 'real', and any computer manipulation may disrupt both the natural acoustic resonance and any association with real-world physical behaviour. I use these terms to separate sound qualities that *suggest* a 'real' acoustic source, from those qualities contextually lacking real or imagined acoustic reality. A real acoustic source is one which appears to be produced by a resonating body or volume of air. Such sound is characterised by attention to small details, irregularities, instability and change in spectral evolution. A synthetic sound (often sounding as if created by computer synthesis) perceptually appears to lacks these characteristics. The transition from real to synthetic acoustic qualities is a continuous and relative scale. Often the perceived strength of each is dependent on the musical context. Sound examples 1.6a-f (tracks 13 and 14) present a series of sound transformations illustrating the transition from real to synthetic (examples 1.6g-h are referred to later). Example 1.6a is a source recording of a pine tree branch being 'rocked' up and down. Examples 1.6b-f are transformations of the same sound which gradually reduce the real acoustic characteristics, such that example 1.6f takes on distinct synthetic qualities.

This distinction is independent of gestural behaviour in that a synthetic sound may take on the gestural attributes of real physical behaviour, yet will remain 'synthetic' in its spectral attributes. Likewise, real sound may display gestural behaviour impossible in a real-world scenario.

(ii) The second important component in the perception of realism is the 'space' in which the sound exists. A sound exists in both the 'virtual' space (in other words space composed though use of reverberation effects or delays, stereo imagery, equalisation and location), and in the 'listening space' (the space in which the speakers are replaying the sound). Although it is often appropriate to consider the latter while composing, for example when designing the work for concert or home listening, it is the former concept of space that I am concerned with in this instance. Throughout a composition, there may exist varying spatial implications ranging from familiar to unfamiliar. The simulation of a real-world space may result in it being familiar, due to a connection external to the music. A 'non-real-world' space may also be familiar through its association with an earlier musical occurrence, in other words through a connection internal to the music. When the listener fails to identify any external or internal association, the space is considered as 'unfamiliar'. There will exist a continuum between familiar and unfamiliar acoustic spaces due to spatial simulations only approximating to the ideal model, and due to the ear being unsure whether a spatial treatment has been applied earlier in the work.

The relationships between sound reality and spatial familiarity are interesting because they contribute to a formula defining the perception of realism throughout the whole composition. Figure 1.3 illustrates this interplay between real and synthetic sound qualities, and their activity in familiar and unfamiliar spatial environments. Maximum realism is achieved when a 'real' sound is set in a recognisable space. The definition of minimum realism is found through achieving a maximum conflict of information. Trevor Wishart's discussions on the disposition of objects in space (Wishart 1985: 70-79) suggest a method of achieving this maximum conflict. He describes in detail the disposition and substitution of clearly recognisable sounds in an acoustic space, resulting in a 'surreal landscape'. The addition of 'surrealism[12]' to the model outlines the state of minimum realism, achieved through the surreal juxtaposition of sounds in a recognisable space creating a maximum conflict of information. Real and synthetic sounds set in unfamiliar spaces are located in the centre of the model. When a synthetic sound is set in an unrecognisable space the ear recognises neither aspect, and with little conflict of information the set of relationships are plausible, if not necessarily allusive of the real world. If the musical context results in the space gaining familiarity, the sound-space combination decreases in perceived realism as the ear attempts to place the synthetic sound in the familiar space. When a real sound is set in an unrecognisable space, the ear may attempt to resolve the surreal juxtaposition. If the musical context results in the space gaining familiarity, the ear accepts the sound-space combination, which subsequently increases in perceived realism.

To summarise, the degree of realism throughout the whole composition may be defined by the following: the extremes consist of real sounds in familiar spaces, and surreal sound relationships in familiar spaces; the continuity consists of relative combinations of real and synthetic sounds in unfamiliar spaces[13]. The model changes as spatial parameters become more familiar through repeated occurrence, an aspect indicated in figure 1.3. It is impossible to present a short sound example due to the perception of reality and familiarity changing in the context of the complete work. From this perspective, 'Little Animals' attempts to maintain a sense of total realism by considering these aspects of acoustic realism and spatial recognition throughout the structure. Chapter 3, section 3.3.1 provides detail of this compositional process.

<u>The relationship between intrinsic and extra-musical sound attributes</u>

Sound material can often be appreciated purely for intrinsic acoustic characteristics, with no suggestion of extra-musical content. These same acoustic characteristics may also be common to sound material rich with allusive potential. Although the

[12] Surrealism aims to escape the control of reason or preconception.

[13] This conclusion is coherent with McAdams ideas on source detection (1987: 41-42), which suggest that in order for a source to be perceived, it must have a common spatial origin, coherent amplitude behaviour and a regular system of resonant structures.

relationship between these two types of material exists on the intrinsic acoustic level, when presented together, the material containing strong allusive potential may subsequently influence sound material lacking in connotation. Allusions can therefore 'signpost' musical options in the perception of structure, influencing our perception of sound remote from explicit connotation. This relationship can be particularly affective when a sound undergoes a perceived acoustic transformation (continuous or fragmented over time), from contextually recognisable to unrecognisable or vice-versa. Throughout 'Little Animals' sound material relates in this manner. Sound rich in connotation opens the work, and then throughout the last six minutes progressively fragments into pitch-textures. The material in the second half of the work takes on the allusive connotations implied by similar intrinsic characteristics in the opening, and the recurrence of certain distinctive sound gestures signposts areas of structural co-ordination. These compositional techniques are described in sections 3.3.1 and 3.3.2, which detail the increase in the density of musical relationships throughout the work, illustrated with sound examples and a graphic score.

The relationship between a sound allusion and its real-world counterpart

An acousmatic sound may contain enough distinguishable features for it to be perceived as approximating to a real-world sound - in other words associating with a prototype. The strength of this relationship depends on the way in which other sounds approximate to the same prototype. The stronger representations will overshadow the weaker, and as new representations unfold, the hierarchy of proximity to the prototype will change.

Similarly, by reducing the strength of extra-musical relationships, perceptual emphasis can be directed towards the musical. In sound example 1.7, this is achieved by manipulating intrinsic pitch qualities. In Examples 1.7a and 1.7b (track 17), water droplets are heard falling into a metal bowl. In examples 1.7c and 1.7d (track 17), the sources are time-stretched and filtered to emphasise the pitch qualities. 1.7a and 1.7b approximate to the 'water-droplet' prototype, while 1.7c is lower in the hierarchy of association. Example 1.7d is located between 1.7b and 1.7c in the hierarchy because although it contains pitch and gestural attributes not found in the prototype, it maintains the 'droppy' characteristic. Further sound manipulations were applied to remove the phase vocoder artefacts[14], and the material was then used in 'Earth Haze', example 1.7e (track 18).

In the context of 'Earth Haze', the material in extract 1.7e approximates to the 'water-droplet' prototype. However, unlike examples 1.7a-d which present comparisons to the original source, in 'Earth Haze' there is no such comparison, and the degree of approximation to the prototype, if occurring at all, is a product of the listener's imagination.

1.5.5 Superimposing frames of reference

Earlier I discussed the possible relationships between a single 'complex' sound (containing many different types of musically relevant material), and different frames of reference. Either the complex sound will be attracted to the model with which it has most in common, or each component of the sound may be attracted to a different model. In the latter instance, three scenarios may follow: (i) frames of reference may either become 'superimposed' through their relationship to the single parent sound; (ii) if the information pertaining to each frame of reference is contradictory, paradox is evoked; (iii) if our perception attempts to resolve the contradiction, it may eliminate, or label as 'untrue' one of the frames of reference.

For example, the illusion of a sound moving through a large space is dependent on two main acoustic effects: the spatial-location of the source, and the balance of source and reverberated sound in the total mix. To achieve a complete illusion of spatial movement, spatial-location and 'reverberation mix' need to relate in a specific way. These two factors of spatial movement can be regarded as two different frames of reference. If a sound moves away from the listener, the perceived amplitude and high-frequency content will decrease. At the same time, the perceived stereo width will narrow (but paradoxically be in a wider space) and assuming sufficient energy is propagated by the sound, the balance of reverberation in the total mix may increase.

[14] For a description of phase vocoder artefacts refer to Appendix 2.

When both factors of spatial movement relate in this way, motion of the single sound unambiguously belongs to both frames of reference. However, if the relationship changes, for example the amplitude and frequency content remain constant, but the reverberation continues to increase, the illusion of spatial movement is incomplete. To make sense of the contradictory information we may decide that the 'reverberation mix' frame of reference is irrelevant, and instead place emphasis on the changing parameter - in other words the 'ambience' frame of reference.

The above describes the perceptual resolution of ambiguity. The composer can intervene in this process by extracting the sound attributes causing the ambiguity, and transform the material into two independent sounds. In this instance, the ambiguity can be resolved during the course of the music. From the above example, I would extract the upper frequency components, maintaining their loud volume, and place the separated sound material at a stereo position or time placement different to that occupied by what is left of the original sound material. The result leaves the high frequency material in the foreground, while the rest of the sound adheres to the illusion of a changing spatial location. Through this method, it may be possible to superimpose conflicting relationships, without the need for resolution, through common association with a parent sound. A common memory may sustain the relationship even after a remote computer transformation of the original source. As a final musical requirement, it may be necessary to combine the extracted material with a new sound, (containing similar characteristics), thus sustaining suitable acoustic detail and sound quality, which may also serve as a method to subtly expand the repertoire of source materials. This relationship occurs frequently in 'Puzzle Wood'. Sound example 1.8 (track 19) presents an extract 1'15 in duration. The opening of the example consists of a sound-world which, within the context of the whole work, results in it being perceived as a single complex sound and associating with numerous frames of reference. After 30 seconds into the extract, the sound-world has clearly separated into foreground high frequency material, and background reverberant material, gradually clarifying sound attributes which may cause a perceptual ambiguity. This method of resolving perceptual ambiguity was important through the compositional process, but in 'Puzzle Wood', it was applied to subtle effect, as example 1.8 illustrates.

1.6 The Potential of Structure in an Electroacoustic Work

'Earth Haze' is an acousmatic composition, 15'25 in duration, completed in February 1996. The work was composed mainly with aural methods. Interested in identifying these methods more accurately, I made a thorough analysis of the whole work. The information gained presented a number of ideas, which I have divided into three categories: (a) the variability in structure; (b) the importance of pitch in the perception of structure, combined with (c) the role of distraction tactics in the compositional process. Part (a) is presented in the following, and parts (b) and (c) are presented later in Chapter 2.

During September 1996, I revised the composition, and its length reduced form 15'25 to 13'55. Changes were based on the evaluation of aural and analytical information, and on conclusions reached through the rest of this chapter and Chapter 2. Because some of the following arguments are based on musical flaws now amended, it has become relevant to maintain musical reference to the initial version.

1.6.1 Notation issues

It would be difficult to present an analysis of an acousmatic work without a visual representation of some kind. Analysis using solely aural methods lacks accurate acoustic and time references and relies on the listener's ability to remember a vast amount of information in one instance. There are a few choices for visually representing sound, including three-dimensional spectral diagrams, sonogram displays, and graphic scores drawn for performance, diffusion, or analysis. The first two choices contain vast amounts of visually complex information concerning the frequency content of sound material, much of which is irrelevant to musical analysis, and lacking information about sound relationships and extra-musical potentials. The other choices lack an established repertoire of notation symbols, yet nevertheless, for the purpose of the analysis I have designed a graphic score representing the complete composition.

With the need to maintain a clear and simple visual representation, the notation uses a number of generalisations, outlined in the following section.

The composer often has 'inside knowledge' that a listener will rarely gain. With this in mind I analysed the work nearly half a year after the composition was complete, attempting to transcribe the information from the point of view of an informed listener. Although basing an analysis on the subjective interpretation of acoustic information may be problematic, there is sufficient consistency in the results to validate the conclusions.

1.6.2 The analysis diagrams

The main analysis diagram (figure 1.4) is divided into three sections: an upper section plotting audible sound materials, a middle section indicating macro-demarcations for time-units of material, and a lower section in which I have extracted significant pitch material.

Plot of audible sound materials

A coloured graph indicates identifiable sound material. It serves as a reference system for time placements, and how different sound-types may relate. It is not meant to illustrate the complete composition in a graphic score format. Each colour corresponds to a sound source described in the sound example list on pages 43-45, and each sound type has been given a word label to simplify the descriptive analysis. Throughout the work, the original source sounds are rarely heard, but characteristics such as the timbre and 'energy flows' are maintained through most of the computer transformations. The horizontal axis represents time, and is divided into five-second units by the vertical lines. The vertical axis represents the position of the sound in the listener's field of aural focus. Foreground, mid-ground and background levels of focus have been indicated. It is important to understand that the vertical axis does not plot spatial placement.

Macro-scale time-unit demarcations

Although the continuous nature of the material does not lend itself to time segmentation, macro-groupings can be based on points of climax, surface changes, and other articulations that may serve as significant points in the structure.

Significant pitch material

Pitch material, extracted aurally from the work, is aligned with the above two graphs. The extracted pitch information is considered in Chapter 2.

The information gained from figure 1.4 is condensed into a more manageable form in figure 1.5. In this figure, possible ways of perceiving the material, in other words 'listening strategies', have been aligned vertically. For practical reasons the vertical axis plots time, and by comparing the information in adjacent columns, one can compare how the form changes with respect to alternative listening strategies. Curved brackets group areas of similar material, and although, as mentioned above, the segmentation of continuous sound information is difficult and often impractical, break-points have been located at changes in the aural foreground, although no change may have occurred in any of the mid- or background levels. In other words, by drawing information from the immediately most important *layer* of sound material, a continuous stream of information can be segmented. When the significant layer of sound material involves a continuous transformation over a number of seconds, the segmentation point is unfortunately approximate, and contextually disputable. Figure 1.51 contains information directly relevant in this chapter, and to which all references will be made.

Figure 1.6 illustrates one possible way in which common association may relate all materials. This illustration is intended to represent my subjective interpretation as a listener, and not as the composer of the work.

'Earth Haze' - Sound example list: word-labels

Refer to audio examples 1.91-1.911 (tracks 20-30), and figure 1.4 for colour codes.

The following text consists of:

(i) Sound-type word labels.

(ii) A brief description of the sound-source and the recording environment.

The corresponding sound examples contain the original source recordings and one example of each of the many subsequent transformations, illustrating how the word labels are applicable to both types of material.

'Rocks'.

The original sound takes three forms: resonant and dry studio recordings, and a scraping rock-moss environmental recording. Sound example 1.91a is an original source, sound example 1.91b is a transformation (track 20).

(Studio and environmental recording)

'Ice'.

This is a recording of 'creaking' ice, and as the acoustic attributes are similar to 'rocks', has been coded with the same colour. Sound example 1.92a is an original source, sound example 1.92b, is a transformation (track 21).

(Studio)

'Wood'.

The original sound takes two forms: resonate clave attacks and scrapes, and a dry tree branch being shaken in a forest. Sound example 1.93a is an original studio recording; sound example 1.93b is the environmental recording. 1.93c is a transformation of the studio recording, and 1.93d (track 22) a 'branch-wood' transformation mix.

(Studio and environmental recording)

'Busker'.

An extract from the recording of a busker playing folk tunes in a busy pedestrian area. Example 1.94a is the original recording, 1.94b is a transformation using granulation techniques to extend the sound over 43 seconds (track 23).

(Environmental)

'Dustcart Crash and Hooter'.

This is the recording of a dustcart being filled with glass, the subsequent engine sound as the contents are compressed, followed by the pressure-release hiss of the piston, and the reversing siren. Sound example 1.95a presents the original recording, and example 1.95b, a transformation concentrating on the 'hooter' part of the source (track 24).

(Environmental)

'Dog Snuffle', 'Door Creaks' and 'Footsteps'.

Although all these sounds were recorded out of the studio with portable recording equipment, the recordings contain an indistinguishable level of background extraneous noise, and so have been categorised as studio recordings. Sound example 1.96a presents the 'dog snuffle', 1.96b the 'door creak', and 1.96c the 'footsteps' recorded in a forest (track 25). There are no transformations of these sounds, only re-mixes.

(Studio)

'Speech'.

This term accounts for the recording of a distant voice in the above mentioned forest, as well as a close-microphone studio recording. Sound example 1.97 presents the source recording made in a forest (track 26). There are no transformations of these sounds, only re-mixes.

(Studio and environmental recording)

'Water'.

Dribbles of water into a metal resonant container.

Example 1.98a is an original source, example 1.98b, a transformation (track 27).

(Studio)

'Crunch'.

Crunching ice-cream cone with mixed slurping / coughing vocal sounds, recorded in an enclosed moving vehicle. Sound example 1.99 is the original source (track 28). There are no transformations of this sound, only re-mixes.
(Environmental)

'Breath synth.'
This represents all heavily transformed or original sound material suggesting the forceful exhalation of air or human breath. Sound example 1.910a and 1.910b present two examples of this sound-type (track 29).
(Studio recordings and extreme transformations)

'Synthetic'.
This term represents all non-attributable sound material, ranging from analogue feedback to extreme phase-vocoder transformations. It includes material that has lost all sonic association with the above sources. Sound example 1.911 presents an example of this sound-type (track 30).
(Extreme transformations)

1.6.3 Deductions from the analysis

Focus-dependent Structural variability

The listening strategies considered in figure 1.51 are:

(i) Sound grouping based on macro-details, without considering pitch.
(ii) Sound grouping based on micro-details, without considering pitch.
(iii) Macro-scale time demarcations derived from surface articulations (as opposed to sound continuities), suggesting structural divisions.

Material is grouped differently in each column. This suggests that structural divisions within the work vary in placement and duration depending on the attributes regarded as most important at any given moment. In between the extremes of macro-scale and micro-scale listening, exists a continuous range of listening strategies:

(i) Sound grouping based on macro-details, without considering pitch

The macro time-scale takes section timings from generalisations over the longer duration. Although the definition of 'long' is relative[15], in 'Earth Haze' it is considered in the context of the 15-minute work, and on the whole consists of a summary of the type of material most likely to be heard by a first-time listener, approximating over a duration of between three to 15 minutes. This includes longer duration surface features, changes in sound continuities and general source-type identification, combined with large-scale change in relative volume, density and gestalt similarities in micro-level activity.

In figure 1.51, column 2 indicates that there are four main structural units, each approximately four minutes long. The first unit (0'00-4'00) consists of 'rock' material recorded in the studio combined with dense 'synthetic' gestures, which rise to a 'busk'-noise climax and tail off to a quiet end. The second (4'00-8'30) consists of sparse and spectrally thin material, moves through a section of rhythmic propulsion, rises into a 'busk' climax, and falls away into 'rock' and 'wood' repetitive textures. The third (8'30-12'18) section consists of a slow rise of 'synthetic' material leading into 'crash-crunch' sound-types, which fall away into a detailed series of iterations. The final section (12'18-15'27) consists of 'synthetic' fore- and background perceptual focuses, which move into dense 'busk' material, relaxing into a quiet close.

(ii) Sound grouping based on micro-details, without considering pitch

After a few listenings, smaller details may begin to have importance to the listener and reveal more detail at the micro-level. The micro-scale consists of point-to-point sound movements perceived in two ways. The first consists of the detailed structure *within* the macro defined group, and is illustrated in figure 1.51 by the internal brackets in column 2 - in other words, the subgroups inside the macro-definition, which consist of

[15] Discussed in section 1.5.4

mainly homogeneous acoustic material. The second method considers small surface changes, and therefore uses new sound descriptions to segment the material. These new classifications are outlined in column 1. The grouping in column 1 is different from the micro-grouping in column 2.

The detail in column 2 displays many possible options in micro-grouping. I have identified up to three different levels of internal grouping, (three layers of brackets) which have mutually inclusive relationships, and are amongst a few of the possible options. From 0'00 to 4'00, this grouping is unambiguous: one level consists of two large units, while a more detailed level consists of one large unit and two smaller units. From 4'00 to 8'30, the grouping is subject to variation in many ways, consisting of different combinations of bracketed information. There is a similar ambiguity in the third section, while in the fourth, no subdivision other than the macro-group is possible due to the dense weave of sound information.

(iii) Surface articulations

Column 3 follows the same structural divisions as column 2, indicating that surface articulations coincide with changes in the macro-grouping of materials. (Sound examples can be gained by referring to the programme time-code on the CD of 'Earth Haze', early version).

From this evidence, a number of influences on the perception of structure can be deduced:

(i) Micro-structures become evident through the detail acquired by repeated listening. Therefore, as the listener becomes more familiar with the material, the perceived structure will change.

(ii) When a micro-group exists as a subgroup of a macro-group, a change in one will effect a change in the other.

(iii) As macro- and micro-details become more evident, the numbers of perceived structural possibilities expand. This is not to say that the listener will necessarily perceive simultaneous multiple structures, but is instead offered a choice of different structural paths throughout the work.

(iv) The difference in perceived structure may be due to the time-scale over which the material is evaluated. This is because while macro- and micro-scales yield different structures, the material itself determines their duration definitions. Section 1.5.3 explained how the duration definitions of macro and micro are in part related to the sound material, where material which exhibits a fast rate of change will have a shorter macro-duration than material which presents slowly changing and developing sound gestures. Therefore, the perception of structure is influenced by the rate of change in material content, which in turn changes the relative duration of macro and micro, and subsequently confuses the ear over the evaluative time-scale. For example, if one evaluates the opening material between 0'00 to 1'38, the ear groups material through macro-scale characteristics, whilst if the evaluation takes place between 0'00 to 2'10 - although this section is longer - micro-scale characteristics may prove more attractive.

Although the above suggests listeners may perceive structure differently on each occasion, it is possible that they will simply 'rehearse' the same listening strategy, and gradually become *less* open to new options in the structure. In this case, the work may be perceived differently between listeners, but remain constant for each individual.

The extra-musical relationship between materials

Relationships between the allusive attributes of different sound materials have an effect on the perception of structure. However, this effect is difficult to discuss due to the subjectivity involved when forming allusion. Nevertheless, where no link is found between the acoustic qualities of sound materials, an extra-musical link may be discovered, and consequently, seemingly disparate material will associate through a mutual allusion. Examples of this relationship and the subsequent perception of musical structure are suggested in figure 1.6. The large text represents main sound-association groups, and the smaller text indicates subgroups. Three observations can be made:

(i) The three main groups: 'human / industrial', 'synthetic' and 'environmental', are all directly related. In the original list of materials on pages 43-45, I specified whether the source recording was a studio recording or an environmental recording. This is significant because environmental sounds more readily maintain their original source-bonding attributes, and are closer to primary than secondary allusion[16]. Subsequently, the 'environmental' main-group may form the strongest bond between materials.

(ii) All subgroups are indirectly related through their association with a main group.

(iii) Although the allusive associations implied in figure 1.6 may be subjective, those illustrated are extensive enough to assume that a listener will form some web of extra-musical connections, and in so doing provide the link between acoustically disparate sound material.

The Edited version of Earth Haze

The location and duration of edit points are marked along the top of figure 1.4. There are two types of edit: durations between one to four seconds, and durations between six to 19 seconds. The shorter edits normally serve to tidy the timing articulation of specific features, and involve the overlapping as opposed to deleting of material. With the longer edits, it is difficult to overlap the surplus material, which is therefore deleted. Three observations can be made about the location and duration of these edits.

(i) They occur in areas approaching or consisting of material with significant extra-musical potential, or reduce the length of sustained pitch planes (normally consisting of synthetic material).

(ii) The material (long and short edits) edited from each of the first two main sections (0'00-4'00 and 4'00–8'30) is approximately equal, totalling 35 and 33.5 seconds respectively.

(iii) Although not evident from figure 1.4, by listening to the final version of 'Earth Haze' it is clear that no edit deletes material with significant extra-musical potential.

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[16] For definitions of primary and secondary allusion, the reader can refer to section 1.3.

From these observations, three conclusions can be reached:

(i) The total edits shift the central point of the work from the ambiguous 'crash-crunch' material at 7'45 to the extended, rear-focus, synthetic plane at 8'40. This material marks a point of rest compared to the previous central point, which consisted of goal-directed repetitive movement.

(ii) The edits serve to re-weight the material in favour of extra-musical ideas. For example, at 2'02, a 14-second duration is edited out of the synthetic pitch plane, resulting in the faster approach of the 'busk' material at 2'30. In the unedited version, this extended plane created a static musical flow too early in the work. At 3'16, the 11-second edit results in a faster move from the 'busk' material to the footsteps which terminate the first section, again preventing a hiatus in the musical flow. The 19-second edit at 7'35 also serves to eliminate the delay in the musical flow and emphasise the new central resting point at 8'40.

(iii) In the old version, the overall flow of the material moves vaguely from extra-musical to musical or from real to synthetic, identified by the distribution of colour in figure 1.4. In the edited version, this trend is enhanced by compacting ideas in the first two sections, which results in a comparatively extended development of ideas in the material after 8'30 (reference to non-edited timings). This is clear in figure 1.4, where, after the edits, the visual analysis of the first eight minutes would consist of higher density, changing colour information than the rest of the work.

1.7 Summary

Many ideas concerning musical structure in both theoretical and real terms have been presented in this chapter. Subjective judgement, experimental evidence and real musical examples provide foundation for the discussion.

It is necessary to highlight a number of features that are relevant considerations throughout the following chapters:

(i) The psychological association mechanisms used when remembering information are considered in the compositional process, and implemented in the music. They serve to establish and destroy hierarchies of information in both the sound material and in the listener's memory. In addition to normal thematic or spectromorphological development, the associative mechanism itself can be used as a structuring method.

(ii) Memory capacity may be enhanced when sound material or arrangement approximates to a musically internal or external model. It is not necessary for this association to be exact, and allows for 'artistic licence' on the part of the composer. It may also allow the composer to use an increasingly dense and complex sound-world which remains accessible to the listener.

(iii) The analysis pinpoints ideas on structure with musical examples. Although the use of word-names to describe materials and the segmentation procedures may appear coarse and sometimes restricting, they serve as a possible way to present the grounds for discussion.

Chapter 2. Acousmatic Pitch - a Neglected Fundamental

2.1 Introduction

The importance of the pitch content in acousmatic sound became evident when attempting to find common ground between acoustic and acousmatic materials in the mixed works. One investigation centred on describing the different materials with the same language. Redefining musical materials as sound-shapes and exploring them with spectromorphological terms, such as texture, direction and gesture was found the most appropriate. 'Note-noise' and 'tessitura' were the terms applied most frequently to both acoustic and acousmatic materials, and called for a more detailed investigation of these sound attributes within the compositional process. The results of this investigation in relation to the mixed works are discussed in Chapter 4. This chapter investigates the role of pitch in the acousmatic works, initially presenting some fundamental ideas related to the concepts of note and noise difference and variation in tessitura, and then considers the importance of pitch in the perception of structure and the compositional process, with examples from the analysis of 'Earth Haze'.

Outline of the analysis and the concept of pitch

A complete discussion of the role of pitch within an acousmatic work is inseparable from a discussion of the sound as a whole. However, for the purpose of the analysis there are two categories: (i) sound material transformations, (ii) pitch information and development. The former was presented in section 1.6.

To gain complete insight into the structure of 'Earth Haze', an overview is necessary. It is impractical to present sound examples throughout the whole of the work, so in addition to the main graphical figures, there are sound extracts highlighting the more important observations.

Pitch and timbre are closely allied, and a discussion of audible pitch will always include comparisons with surrounding sound material. The pitch analysis of 'Earth Haze' does not claim solely to identify pitch information in its absolute form.

Section 2.2.2 outlines methods by which pitch qualities can be exposed by comparison, and these methods are also used to identify relative pitch intervals in the analysis. I have attempted to maintain consistency by ignoring relative pitch or tessitura interval between sound materials that show no audible pitch-centre when heard in isolation. Finally, it should also be considered that the ability to hear pitch varies with different rooms and speakers due to internal resonance, frequency reinforcements and cancellations.

Pitch attributes can be perceived in a number of ways:

(i) All sound materials apart from white noise contain ranges of prominent frequency components that serve to 'colour' the sound. The strength of this coloration is relative, and therefore the distinction as to what could be labelled a 'pitched sound' is only found when different sounds, or a transposition of the same sound, are compared.

(ii) Clear pitch is perceived when several frequency components are related by ratio in the harmonic series (where each component has a value of the harmonic number times the fundamental), or where there is a singularly strong sine tone. However, many sounds contain an inharmonic frequency structure, (where each successive harmonic is different in frequency with respect to the value of harmonic number times the fundamental, (Berg: 1982)), and identifying the absolute pitch (by identifying the fundamental frequency and harmonic ratio relationship) may be an ambiguous task. This is also true for sound containing several strong frequency ranges.

Consequently, discrete pitch transcriptions in the analysis of 'Earth Haze' may be open to dispute. However, it is likely that listeners will maintain consistency when hearing pitch relationships. For example, when many inharmonic frequency components are of equal strength, a listener will hear either the theoretical fundamental frequency, or the second partial, or the third etc., as being the perceived pitch fundamental. It is likely that a listener will perceive the same partial number in each sound, due to the ear tending to follow lines of good continuity[17]. Therefore, many listeners will perceive the same intervallic relationships, although different discrete pitches. The maintenance of intervallic relationships is also true for pitch material involving microtonal modulation.

In figure 1.4, extracted pitch material is aligned with the time proportionate analysis. Short pitch groups (gr.), and sustained pitch planes (pl.) are identified on the first two staves. Pitch groups consist of contour fragments - memorable, but only lasting a few seconds - while pitch planes consist of sustained, single pitch or chordal material, which lacks internal contour and lasts any length of time. The movement between pitch planes may form a macro-scale pitch-contour. Intervallic relationships and significant pitch-contours are grouped on the lower staves. Figure 1.5 extracts the information from figure 1.4 to suggest alternative listening strategies in the perception of form, and unlike Chapter 1, this chapter considers the strategies in relation to pitch.

[17] Swapping between different partials of consecutive notes would interrupt a smooth pitch contour by interval displacements.

2.2 Pitch and Distraction Tactics

Distraction tactics involve the refocusing of attention between different sound attributes, and can be applied to all aspects of a sound. In the discussion of acousmatic music, where the traditional significance of musical elements[18] is turned on its head, it may seem unusual to discuss the principal in relation to pitch. However, because our sensitivity to change and our ability to recognise, remember and deduce difference is stronger with pitch than many other sound attributes (McAdams, 1989: 182), distraction tactics involving the shift of focus away from pitch attributes may have a profound effect on our musical perception. Further, there is experimental evidence to suggest that a change in timbre may disguise the recurrence of a melody, and in general, people find it difficult to attend to pitch information when there is a simultaneous change in timbre (Radvansky, Flemming and Simmons, 1995:127). In other words, a change in timbre - which is a main concern in acousmatic composition - may disguise or distract from the conscious recognition of interval or contour.

2.2.1 Establishing a distraction method - Ligeti's 'Continuum'

Pitch is an inescapable aspect of traditional instrumental articulation. Valuable insight into a distraction method can be gained from examples of instrumental music where pitch and harmony are important aspects of the composition. Liget's 'Continuum' is one such example. Musical discussions about this work[19] focus on the importance of pitch and harmony as being central to the definition of 'pitch-space'. For example, a pitch interval may be gradually filled into a cluster, and then notes are dropped, thinning the texture to a new interval pair or chord. However, these discussions provide little reference to the importance of instrumentation, and the effect it has on our perception. This four-minute work written for harpsichord consists of fast

[18] A traditional consideration of musical elements would begin with pitch and rhythm, working progressively through metre, phrase and tessitura and gradually more refined timbral components.
[19] Clendinning (1993: 192-234), Hicks (1993: 172-191), Ligeti (1965), Ligeti (1983), Ligeti (1993: 164-171).

repeating note patterns. The notes' repetitions give the perceptual illusion (in other words a psycho-acoustic effect), of a secondary pulsating rhythm, and this distracts from the harmonic flow of the material, such that the rhythmic effects are in the foreground, while the harmonic motion is in the background of our perceptual focus. The work 'Coulée' of the same period uses identical notation and is scored for organ. In this work the psycho-acoustic effect is also present, yet is insufficient to distract from the harmonic motion of the material. The difference between 'Continuum' and 'Coulée' lies in the instrumentation: the percussive action of the harpsichord's mechanism further enhances the articulated flow of sound, creating a percussive surface activity which distracts conscious perception from the work's simple pitch material. An electroacoustic concert provided my best experience of this work[20]: the amplified harpsichord, projected over loudspeakers, served to emphasise even further the hard attack of each articulation.

2.2.2 Distraction tactics in acousmatic music

Distraction tactics can serve to integrate pitch subtly into the acousmatic compositional process. An acousmatic sound can be described in three main ways:

(i) In its extra-musical potential through direct association with the contents of our memory and imagination.

(ii) In its musical-acoustic content, where the ear is drawn to specific acoustic characteristics and explores the subsequent musical development.

(iii) In 'traditional' musical parameters, where pitch, rhythm and other duration relationships are important, heard in the way a listener might perceive instrumental music. Since this description is based on the listener's current musical knowledge, it could be termed 'musically connotative'.

In general, all sound has the potential to contain varying degrees of pitch and rhythm. Often the content is clearly audible but ignored due to one's attention focusing on other sound attributes. Extraction and development by the composer can emphasise

[20] Performed by Jane Chapman, 1st March 1994, New Hall, City University, London.

the presence of pitch that the average listener[21] may not have heard initially. I use a two-fold process of encouraging the ear to perceive the pitch or noise of a timbre: by controlling the context (musical and extra-musical), and by spectral manipulation.

Pitch context – musical

Pitch content becomes perceptually evident when the composer applies methods of 'sequencing' or 'contouring'. When articulating a single 'note', the sound may appear to contain little in the way of pitch. When articulating a series of different notes in succession, one compares discrete articulations and detects differences in pitch or tessitura. Consequently, pitch becomes a more significant component of a sound initially thought of as non-pitched, and the re-weighting of perceived attributes towards pitch may reduce the significance of other characteristics. In 'Earth Haze', water droplets have been sequenced in this manner to expose a pitch contour. Sound example 2.1a (track 31) contains the original material in which pitch attributes have already been enhanced by filtering techniques. In sound example 2.1b (track 32), I have assembled material from a one-minute extract to demonstrate the contouring effect. In this example, the water material is mixed with other sound gestures serving to enhance the contour direction, even though the degree of pitch content is comparably less than that in example 2.1a.

Another method of drawing attention to the pitch content of a noise-based sound, (used in both acousmatic and mixed works), involves the comparison of sound-masses or sound-objects[22]. The pitch content of one sound will become more prominent when embedded in a sound mass containing less pitch. The opening of 'Little Animals' presents a clear example of this method. Sound example 2.2a (track 33) presents the original extract, which opens with noise-based 'tearing surges'. Two new sounds are introduced 22 seconds into the extract. These sounds can be heard in examples 2.2b and 2.2c (tracks 34 and 35), and when heard separately, the pitch content is of low importance compared to other aspects of timbre. When heard in the

[21] The 'average' listener is one not normally manipulating sound in an acousmatic context.

[22] Section 2.5.4 provides a detailed definition of the 'sound-object'.

noise-based setting of example 2.2a, pitch attributes distinguish the material while masking effects disguise other timbral features.

Pitch context - extra-musical

Pitch behaviour is often the focal point of many extra-musical sounds and is vital for certain allusive associations, such as the Doppler effect of a car travelling past, or the squeak of a rusty gate hinge. In instances where the transformation process has destroyed most extra-musical characteristics, consistency in pitch behaviour between source- and transformed sound may allow memory to prolong the extra-musical bond, which in reality no longer exists. For example, 'hooter' sounds (from the 'dustcart and hooter' source in the sound example list, and used in original form at 10'10 in the composition) are embedded into the musical flow towards the end of 'Earth Haze', and despite sound transformation destroying the source-bond, are associated in memory to the original source because the pitch behaviour is maintained. Sound examples 2.3a and 2.3b (track 36) illustrate different transformation procedures applied to the 'hooter' sound. Example 2.3a applies transposition techniques, and example 2.3b applies granulation[23] methods. Sound example 2.3c (track 36) contains an extract from 'Earth Haze' illustrating how this material forms part of the composition – a low volume component in a mix of semi-synthetic material, placed at regular time locations.

Pitch may strengthen extra-musical relationships between sound materials, drawing the ear to associations that initially may be overlooked. In the above example, the 'hooter' transformations associate with the rest of the sound-world through harmonic, intervallic relationships. In a less explicit way, François Bayle's 'L'Aventure Du Cri' (Bayle, 1972) uses common pitch as one method of cohering the timbral sound palette. The work consists of 15 sections, and to appreciate the consistency in Bayle's style it is necessary to refer to the complete recording.

Finally, the re-contextualisation of pitch material may be achieved through sampling existing musical works, and integrating the sample in the acousmatic sound-

[23] 'Granulation' techniques involve the segmentation of the sound into tiny 'grains' that are repeated and / or transposed and mixed together forming an approximation to the original sound.

world. Memories of the recognised sampled music are then associated with the new acousmatic work. Although not used not used in the folio of compositions, this device is found particularly in the work of Christian Calon (e.g. 'La disparition' (Calon 1988)).

Spectral manipulation

Strengthening or eliminating selected frequency ranges in a sound can change the pitch-noise content. Often spectral manipulation involves analysis-synthesis techniques where the frequency content of the sound is analysed to reveal the strength and morphology of each component. There are two advantages to this method of pitch enhancement. (i) Often a computer display of the spectrum provides a visual reference for the ear. This is sometimes beneficial over aural methods as it overcomes the variability of the ear in identifying the desired frequency components. (ii) The computer programme selects the specific frequencies to be transformed, based on user data input. This also overcomes the inaccuracy of the ear in identifying the desired information. In both instances, the non-linear response of our auditory system must be taken into account because the loudest frequency component in decibels displayed by the computer may not be the loudest perceived frequency.

Extracting and enhancing certain frequency ranges at the expense of non-pitched detail reduces the acoustic information available for extra-musical interpretation. This may subsequently eliminate the pitch distraction if the effect relies on non-pitched information. In other words, the process begins with the complex sound and then reduces its detail, effecting a reduction in source-bonding, or extra-musical potential, and an increase in the significance of the pitch content. In sound example 1.6a (track 13, referred to in Chapter 1), one hears the original source-sound of a pine tree branch being 'rocked' up and down. Example 1.6b selects the 200 strongest frequency components per record size of 2048 samples, sampled at 44.1KHz, followed by examples 1.6c, 1.6d, 1.6e and 1.6f (tracks 13-14) which progressively eliminate the weaker frequency components by selecting the 100, 50, 25 and 10 strongest frequency components respectively[24]. This process can over-emphasise areas of the spectrum, which may be undesirable, and the next composition stage, presented in sound example 1.6g (track 15), involved the application of EQ and spectral transposition to enhance the treble end of the frequency range. This material is used as part of a sound texture in 'Earth Haze', presented in example 1.6h (track 16).

In the acousmatic works, this method of pitch enhancement is often used to investigate the potential crossover from musical to extra-musical frames of reference discussed below.

[24] Appendix 2 outlines the process of spectral manipulation using phase-vocoder techniques and Fast Fourier Transform.

2.3 Pitch In the Compositional Process

2.3.1 Chance and intent

Extra-musical interpretation is different for each listener, even though common trends may be involved[25]. Conversely, when detecting the pitch characteristics of a sound, listeners may show greater agreement. Although judgement of pitch content depends on the salience of the feature, and of discrete pitch on perceptual interpretation - such as whether the audible pitch is theoretically the fundamental or a higher harmonic, a process described in section 2.1 - in general, conclusions are less dependent on imagination. Therefore, from a given collection of sound materials, a particular pitch-contour will be more commonly identified than a particular extra-musical scenario. Sound example 2.4 (track 37) takes a short section from 'Earth Haze' (4'20-4'53 old version). Although the extract is composed using numerous mixing and transformation methods, there are clearly a number of unrelated sound materials: spoken text, crashes, bass-surges, wood and stone source-sounds. Amongst many listeners, the attributes most consistently identified from this collection of sound materials will be the pitch material extracted in figure 1.4 (although gestural flow is also strongly identified), while on the other hand, possible extra-musical scenarios are numerous. In other words, from a hypothetically random selection of material, there is a higher probability that consistent 'grouping' and association will be made through musical attributes, and not through plausible extra-musical inferences.

For the composer, this implies a compositional method. If I choose to control non-musical aspects of the selected sound material, it is likely that the unfolding pitch content and timbral range of each sound will group through rules of good continuity to form pitch contour or even harmonic movement, and furthermore, is likely to be perceived similarly amongst listeners. If I choose to control the intervallic or harmonic relationship between the sound materials, it is less likely that listeners will perceive the

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[25] Trends are formed through social interaction and experience of common sound environments.

same extra-musical relationships, if they perceive any meaning at all. In the former method, the subsequent discovery of chance musical formations can be consciously developed later on in the compositional process (not necessarily later on in the musical chronology), and likewise take on meaning in relation to the rest of the structure. The listener gains the impression that extra-musical and musical relationships were both intentionally composed throughout the work.

During the composition of 'Earth Haze', consistent pitch formations were discovered after approximately half the material had been developed. This is reflected in the pitch analysis, where during the later sections there is greater consistency in the pitch relationships suggested early on in the work, displayed mainly by the extension of pitch-groups into pitch planes. This example presents a chronological chance-intent pitch development. 'Little Animals', (written nine months later), contains more pitched material than 'Earth Haze', and is developed by a more thorough application of this method.

2.3.2 'Frame of Reference' and its implications for a distraction method

Structural variability

If the relationship characteristics between two sounds are sustained after the addition of new material, over a period of time, this relationship is regarded as a model relationship. In other words, further evidence gained from the addition of new material confirms this relationship as a norm. This relationship is the frame of reference. It describes the contextual way in which we perceive the connection between sound material.

In Chapter 1 I discussed the problem of unambiguously segmenting continuous acousmatic sound material, which is evident aurally from the music and visually from the analysis of 'Earth Haze'. Nevertheless, from the analysis it is apparent that throughout the work, at any given point, the main structural divisions vary in placement and duration depending on the frame of reference. In figure 1.5, columns 5 (grouping based on macro-scale structures in pitch and tessitura) and 6 (sound grouping based on macro-details without considering pitch) draw attention to the attributes most likely heard by a first time listener - longer-duration surface features, main articulations, gestures and energy trajectories. Columns 3 (grouping based on micro-scale structures in pitch and tessitura) and 4 (sound grouping based on micro-details without considering pitch) form a summary of the smaller details in pitched and non-pitched attributes which may be perceived after repeated and closer listening. The locations of brackets grouping information are different in each column. This suggests that the macro- and micro-grouping of pitched and non-pitched aspects of the same sound material, creates simultaneous layers of musical structuring to which the ear is drawn depending on the perceptual focus, which is in turn influenced by both the strength of the distraction (the gravity of pitched and non-pitched information over long and short time-spans) and the frame of reference, (the extent by which a model relationship between pitched and non-pitched information has been formed up to that point it the music). These influences on the perceptual focus are discussed in detail below.

In 'Earth Haze', the arrangement of perceptual focuses is designed to combine a method of guiding the ear through the structure, with a method of allowing freedom of choice. When attempting to guide the ear, only one layer of activity is presented, and hopefully only the one listening strategy; while when attempting to present a choice, many layers of activity coincide, presenting many simultaneous listening strategies. For example, if the ear is drawn to macro-groupings of pitch ranges and tessitura (column 5), during the first four minutes, there are at least three possible grouping methods (shown by three layers of brackets). If on the other hand, the ear is drawn to micro-groupings of pitch and tessitura (column 3), I have been able to suggest only one logical grouping method.

The perceptual focus

The perceptual focus at any point in the music is partly dependent on the listener's concentration. Assuming the listener is concentrating on the work, the frame of reference can influence the level of focus. When a sound is heard in isolation, either out of context (in the development process where the composer is also the listener), or in the context of the composition, the listener may be distracted from one characteristic (characteristic-'a') by a stronger characteristic (characteristic-'b'). By placing this sound in a characteristic-'a' frame of reference, the grouping of similar attributes will reinforce the role of 'a' and it will distract our attention from the singularly stronger character-'b'. Sound examples 2.5a and 2.5b (tracks 38 and 39) are extracts from 'Little Animals'. Both sound examples feature the same sound-source - a 'crying' sound, created from a transformed bicycle pump noise[26]. In the first extract, the extra-musical qualities of this sound are prominent above the rest of the material, with which it shares little in common. In the second extract the same sound is time-stretched and mixed with material of similar pitch and gestural characteristics. Subsequently the ear is attracted to pitch, gesture and phrase, more so than in the first example, and these aspects have even greater weight when the extract is listened to in the context of the work. Although in the second example time stretching alters, and exposes, certain aspects of the source, the existing frames of reference also influence the perception of these properties. By controlling the dominating frame of reference, the composer can control the degree and nature of the distraction. For example, if the frame of reference is weighted towards musical relationships in the material then the listener's perception may be distracted from the 'extra'-musical potential.

2.3.3 The application of pitch as an important structuring method

The acousmatic works in the folio contain underlying, prolonged pitch structures, which occurred initially by accident and then through design.

Unifying different materials through pitch prolongation

The previous section describes how over a period of time, contrast (forming pitch-contour) or consistency (reinforcing the frame of reference) strengthens the perception of pitch. However, unless the pitch information is already prominent, it is unlikely to

[26] Chapter 3, section 3.6.1 provides more information about this sound-type in the context of 'Little Animals'.

hold the foreground of our perception unless one applies re-weighting methods, such as spectral alteration and intervallic comparison. Nevertheless, an underlying musical prolongation (consisting of sustained, repeated, broken and resumed material), may serve to unify constantly changing and possibly disparate extra-musical aspects of different sound materials, and over a longer duration such consistency may be sufficient to re-weight the frame of reference towards the musical relationships. The extract from 4'30-6'30 in 'Earth Haze' (the reader needs to refer to the original version of 'Earth Haze' for a sound example) illustrates this idea, and the corresponding graphical material in figure 1.4 provides a visual accompaniment. This section contains a large amount of extra-musical material, seen and heard respectively in each type of example. The underlying pitch plane is constant throughout, initially focusing on a G#/G/F#, briefly deviating to G#, and then resuming the G focus. At 5'50 there is a movement to G#/E oscillating plane, again focusing mainly on G#. This pitch prolongation assists the ear in unifying the various extra-musical materials.

Pitch prolongation may also serve to relate material out of the real-time flow of the music. When a perceptually evident transformation enhances the pitch content of a sound, the listener remembers the sound's extra-musical past. Subsequently, common pitch attributes amongst transformed materials will link two previously unrelated parent sounds.

The prolonged material and structural significance

The underlay of 'prolonged' structural features include rhythmic qualities, gestural, textural, tessitura and allusive inferences, as well as pitch. They exist at the macro-level, and are perceived overall subconsciously - conscious perception being distracted by the surface attributes of the music. Which type of prolonged material is structurally most significant? This question arose when working on the final mixes of 'Earth Haze' and 'Racing Unseen'. In figure 1.4 and 1.5, of particular interest is the section from 7'24 to 9'00 (sound example 2.6a, track 40). At 8'20 two adjacent sections overlap by ten seconds (sound example 2.6b track 41), and figure 1.4 shows a clear move between two different types of material ('crash' / 'busk' fragmented texture in the foreground, overlaying a smooth 'synthetic' plane in the background). Despite this sharp contrast in material, one perceives the join as effortless. This is because throughout the two-minute surrounding section (from 7'24 to 9'30) there exists an underlying prolongation, consisting of layered pitch-planes in the low-mid register. Figure 1.5, column 6 (sound grouping based on macro-details without considering pitch) indicates a change in group at 8'30 where this transition occurs, while column 5 (grouping based on macro-scale structures in pitch and tessitura) indicates a larger overlap (from 7'24 to 9'30), which centres that of column 6. In other words, pitch prolongation provides consistency amongst different types of material, and in this example, its use has avoided a potentially awkward foreground transition.

The above example by no means proves that the prolonged structural layer has greater significance when consisting of relative-pitch information. Simple extra-musical associations (such as 'wateriness' or 'vocal-like') are as easy to remember as simple pitch movements. The reason that underlying relative-pitch movements appear more common may be because they are easier to analyse and identify, which does not necessarily mean they have greater influence in our perception of structure. Further, for the acousmatic composer, pitch considerations are often of less importance than complex extra-musical relationships, where the resulting material consists of simple movements between note and noise. In 'Earth Haze', pitch is mainly confined to sustained planes (smooth or oscillating) and two- or three-note groups, which results in intervallic relationships having prominence over relative-pitch contour. This is evident from the extracted pitch material in figure 1.4.

Structural Clarification

Earlier I suggested that by composing many layers of coinciding musical activity, the listener could freely explore a number of possible structural options. In figure 1.5, different bracketed groups of material present some of these possibilities. However, this choice may also cause a perceptual confusion negatively effecting the musical experience. This section looks at how pitch may serve to resolve such conflicts.

In figure 1.5, from 0'00 to 4'00 the brackets grouping similar macro-pitch and non-pitch information coincide (columns 5 and 6). This results in an unambiguous structuring of the material: whether attention shifts between extra-musical or musical parameters, overall, the listener perceives the same structure. In contrast, the structural options in the section from 4'00 to 8'00 are more conflicting, and are dependent on listening strategy. During this section, the pitch material consists mainly of sustained, overlapping planes, which lack the articulating qualities of pitch groups (shown in column 1 and by reference to figure 1.4). There is also little coincidence in pitch and non-pitched structural grouping, and both factors contribute to the ambiguous structuring of this section. In other words, pitch attributes reduce the structural ambiguity in the first section, and contribute to the ambiguity in the second section.

Defining the structure with pitch

Further analysis of the pitch material suggests that in addition to clarifying, it may *define* the structure in a number of ways:

(i) Pitch-groups and pitch-planes

In the pitch analysis there are two categories of material - the extended pitch-plane, resting mainly in the background of our perception as a prolonged layer, and the short pitch-group, situated mainly in the foreground. From both figure 1.4, and 1.5 column 1, it is clear that there is general movement from pitch-group to pitch-plane throughout the composition. (1) Pitch-groups occupy the first few minutes, followed by pitch-planes and pitch-groups forming two independent layers of activity. (2) Gradually the distinction between pitch-group and pitch-plane disappears due to planes consisting of sustained, oscillating groups. (3) The rate of change in pitch-plane increases through to 12'20, and further confuses the distinction between plane and group.

(ii) The density of interval occurrence

In figure 1.4 and figure 1.5 column 2, areas of high interval-density can be located. These areas coincide with or immediately precede significant articulations in the sound material. For example:

0'00-1'00 (absolute time on the recording, referred to hereon as 'abs') = the opening statements.

2'37-2'57 abs = development of the first noisy 'busk' material.

5'48-6'02 abs = change in material direction from static to rhythmically propelled. Areas lacking intervallic movement are, in general, mid-way between the boundaries of structural groups. It can be concluded that the density of interval occurrence signals change or consistency in the material. This appears very similar to instrumental music, where a modulation often articulates a structurally significant moment.

<u>(iii) Pitch-sound hierarchy</u>

The definition of 'synthetic' used in section 1.5.4 results in this type of material being more susceptible to our perception of pitch, due to it being less likely that the ear is distracted by strong extra-musical inferences. In figure 1.4 there is a correlation between the pitch interval and the placement of synthetic material (the grey colour) in our perceptual field. When this sound material is in foreground focus, the pitch material consists mainly of minor 2nds. Minor 3rds and major 2nds occupy mainly the mid-ground, major 3rds occupy mainly the mid-background, and augmented 4ths and perfect 4ths / 5ths are located mainly in the background of our perceptual field. Although the reader will identify exceptions to this rule, there exists a consistency throughout the work. For example:

1'32 abs	= foreground	Minor 2nd interval
14'32 abs	= foreground	Major / Minor 2nd
12'02 abs	= foreground	Minor 3rd interval
0'32 abs	= mid-foreground	Minor 3rd interval
0'22 abs	= mid-foreground	Major 2nd
15'03 abs	= mid-foreground	Major / Minor 2nd
15'22 abs	= mid-foreground	Minor 3rd
0'12 abs	= mid-background	Major 3rd interval
1'05 abs	= background	Perfect and augmented 4th interval
2'47 abs	= background	Augmented 4ths, perfect 5ths interval

13'12 abs = background Major 3rd

In general, the mid-foreground sounds in a minor mode (consisting of minor 2nd, major 2nd, minor 3rd), and the mid-background in a major mode (consisting of major 3rd, perfect 4th and 5th, augmented 4th).

Summary

Distraction tactics disguise the presence of specific acoustic attributes - in this case pitch - such that the significance lies with our subconscious perception and the 'feeling' of musical structure and direction. The method may have greatest potential in acousmatic work employing sound material with a high extra-musical content.

In 'Earth Haze', subconscious pitch perception has two main uses:

(i) As a structural 'clarifier', where pitch prolongs and unifies other musical or extra-musical ideas.

(ii) As structural 'definer', where pitch is associated with synthetic sounding material, establishing a pitch hierarchy in relation to the perceptual focus. The movement between pitch groups and pitch planes forms a chronology, and the density of intervallic motion points the ear to significant musical directions.

2.3.4 'Earth Haze' and pitch - chance more than intent?

The analysis was realised six months after 'Earth Haze' had been completed, and only then were many of the clear trends in pitch relationships observed. During the compositional process, sound development and allusion were of prime importance, and although the 'chance followed by intent' method described in section 2.3.1 was applied to some degree, it is questionable whether the emerging pitch and tessitura ranges were an 'accidental' side effect. The results may be a combination of two factors: the subconscious selection of pitch material and the computer-transformation processes. Take the example of the 'busk' source-sound. The pitch material contained in the original recording was developed in many ways:

- Filtering to remove the background noise of the environmental recording - resulting in a clearer version of the original melody.
- Time stretching - turns the contour of the melody into a sustained pitch plane.
- Granular synthesis - turns the contour of the melody into a slow moving harmonic mass, or fragments the melody into separate 'grains' which obscure the pitch.
- Segmentation - results in interval pairs and short extracts, further developed by repetition.
- Transposition – pitch-shifting down emphasises the 'plane-pitch' aspect; pitch-shifting up emphasises the 'group-pitch', while vari-speed pitch-shifting changes the shape of the original contour.
- Harmonic distortion - increases the noise and reduces pitch clarity.
- Spectral stretching and shifting - in this instance used to shift sections of the spectrum so that other simultaneously sounding materials are not acoustically masked.

Some of the sound transformation techniques have side effects that enhance or obscure the original pitch content similarly amongst different sound-types. If the same processes are used to transform a number of different sound materials, the transformation artefacts, (such as the strengthening of specific frequency bands), may be used subconsciously as a method of sound association.

Chapter 3. Structure and the Complete Work

3.1 Introduction

The previous chapters were partly concerned with methods of developing and organising sound material into a musical structure, how one can account for the way in which we may perceive and remember a sound, and how paradox, ambiguity, context and pitch manipulations may be significant contributors to the structuring process. When composing 'Racing Unseen', such structuring methods were particularly important in maintaining coherence throughout its length of 20'20. During the compositional process, it was necessary to re-assess the relationship of sound materials, and due to the length of the work, I became increasingly aware of my varying perception of time-flow.

The composition of 'Little Animals' followed 'Racing Unseen'. The structuring process focused on sound relationships that revealed themselves gradually and remained non-developmental throughout the whole work, in other words, focusing on relationships which do not change in meaning through transformation, contextual change, or influence by other associations. The compositional process began by selecting sound materials that were acoustically and extra-musically unrelated, and then I attempted to unify these materials.

This chapter begins by looking at a framework facilitating 'Racing Unseen's' lengthy duration, followed by a consideration of the 'holistic' structural ideas tackled in both 'Racing Unseen' and 'Little Animals'. Then follows a closer look at experienced and real-time flows throughout the complete structure, drawing on examples from both works. The chapter concludes by reconsidering the essence of the source-sound and its place in the spatial composition.

3.2 Considering Extreme Duration

As a composer, I find it difficult to maintain musical coherence in any work approaching 15 minutes in duration. As a listener I find this to be particularly true with acousmatic music where, as length increases, remembering past events can be difficult - particularly on first-time listening - due to the potentially unlimited sound-world. Chapter 1 describes how this ability to remember significant past events depends on the type of material, and the way in which it is treated in the compositional process; for example, techniques designed to group similar materials will reduce the quantity of information the listener needs to remember. At the opposite extreme, if the sound-world is restricted, events will be easier to remember, but the lack of variety may result in lack of interest.

3.2.1 Structural ideas encountered while composing 'Racing Unseen'

Sound boundaries

The sound-world of an acoustic work may be partly unified by the overall instrumental timbre, where each specific instrument provides a framework of limitations within which the composer works. With acousmatic music, in the attempt to achieve a unified sound-world fundamental to the compositional idea, the composer is required to construct sonic boundaries from the potentially unlimited sound-palette. However, the experimental nature of acousmatic composition results in the ongoing adjustment of initial boundaries, due to the development of material which fails to satisfy the musical or extra-musical requirements. For example, while composing 'Earth Haze' (more so than the other works), the sound palette was continually re-defined through the addition of new materials and, with each addition further development is suggested. Consequently, the work grew longer than I had initially anticipated - and only in retrospect was it edited from 15'25 to 13'54. The nature of these edits are described in section 1.6.3, and result in the later version maintaining the essence of the original, while superfluous development is eliminated.

Information and memory

The human potential to reproduce vocally pitch and rhythm (even if the listener may not be able to reproduce vocally the material in practice), indicates that these attributes can be mentally rehearsed and 'internalised' by the listener, thereby rendering the material more memorable. Unlike pitch material, spectral transformations can rarely be reproduced vocally (although Trevor Wishart's live vocal improvisation, 'Vocalise' does achieve dynamic sound transformation with the use of his voice and a microphone), and may initially imply that acousmatic music is difficult to 'remember'. However, a listener's internalisation of spectral development may involve a method other than rehearsal in the manner of vocal reproduction. Often when listening to acousmatic music I place sounds and gestures in a *metaphorical* spatial relationship to each other. This is different from the allusion or illusion of spatial relationships projected by the listener to form the sound-world(s) of the composition. In addition, gestural characteristics, spectral densities and sound trajectories can feel 'internalised' through their physical behaviour. Internalised spatial relationships and physical behaviours constitute two methods of 'rehearsing' the musical role of different materials.

On first listening, an acousmatic sound may contain information challenging to remember. Conversely, *over a period of time*, I find that memory partially forgets some of the information, and only remembers the associated 'model' features - such as noisiness, gestural shape, main allusion, or in the Plato example in Chapter 1, the 'chairness' of the chair. In other words, over a period of time, the grouping and association mechanisms (outlined in Chapter 1) suggest that the quantity of information and complexity of the relationships necessary to remember the original sound are reduced. This may subsequently facilitate memory of a lengthier or more detailed structure.

Sound transformation and acoustic frequency limitations

For a sound dimension to support structure it needs to be capable of the following: (i) sufficient perceptually different configurations for potential development, and (ii) scope to allow our perception to encode change, while another dimension is also changing. Our judgement about pitch and duration differences are good, allowing a rich set of configurations, while relative judgement of spatial location and texture are poor, as mentioned in Chapter 1 (McAdams, 1989:182). However, in acousmatic music, the computer manipulation of sound increases the number of distinguishable configurations accessible for development. Therefore, sound aspects such as spatial location, or spectral motion, which in acoustic music lack sufficient form-bearing criteria, may provide a framework for the musical structure. For example, frequency bands can be isolated and emphasised in all registers, such that the spectral movement is clearly distinguishable, and may be used to support structural development.

3.3 Holistic Concepts

In all music there are characteristics, some governing, some remaining constant throughout, the entire work. These characteristics, by definition lack, a goal-directed development where their musical role does not change in relation to past, or in anticipation of future events, even though their nature may be revealed gradually[27].

'Little Animals' departs from the previous work in a number of ways. One significant change involved considering *at the outset* (before any significant mixing had taken place) the relations between sound organisation methods, and the expression of extra-musical ideas. The following considers this compositional approach as 'holistic'. Examples of holistic concepts are drawn from 'Little Animals', and illuminate personal influences behind the nature of the sound organisation.

3.3.1 Juxtaposition and the real world

The way in which real environments are experienced every day, (a combination of sound and visual information), was important to the musical organisation of 'Little Animals'. Early memories of my parents' home (the Forest of Dean in Gloucestershire) consist of a detailed juxtaposition of natural and human-made, sound and visual environments[28]. The combination of both source-types provides insight into the composed relationships within the work.

In a coniferous forest environment, the combined acoustic and visual relationships have a particular characteristic. The trees and foliage are dense, and the acoustic feels 'close', but lacks the reflective characteristics of an enclosed space. The visual information conflicts with the acoustic because the sight-line leads into the

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27 An analogy can be made with Xenakis' idea of 'outside-time' (Xenakis, 1971: 170), which is an aggregate of sonic characteristics such as pitch, intensity and duration that exist independently of the temporal elements. (Temporal elements are sonic events creating durations on the time axis). This is different from 'inside-time', which consists of the 'functional relationships' between the temporal elements and the structural direction of the musical material.

28 Although ten years later, the real juxtaposition itself is less significant, and instead, it is the *memory* and its associated feelings which are most important.

distance through the network of tree-trunks. The content of the acoustic environment consists of close, delicate sounds such as branches moving in the breeze, pine needles dropping to the ground and moisture seeping through the foliage; while in the distance there may be the sound of birds and wind. In a clearing, (normally on the side of a hill where the trees have thinned, or where a forest trail has been cut), one will see distant roads, firebreaks or telegraph-pole cuttings. Combined in the whole experience is a distinctive pine forest smell.

The deciduous forest environment consists of oak and beech trees, which grow less densely, and allow sunlight through the canopy. The acoustic feels more 'spacious' and assimilates the visual scene. The sound-world is rich with a lively animal habitat, and it is likely one will hear the sound of other people walking past, a dog barking, horses hooves, or a distant tree-cutter.

Both descriptions present unusual sound and visual juxtapositions, where real-life acousmatic and visual spatial perceptions conflict or cross-reference each other. The acoustic dimension conflicts with the visual sight line because the trees mask the visual sound-source, while the acoustic 'tree-filter' only partially masks the sound. Acousmatically, close, mid and distant sound-sources are clearly defined, while there is the juxtaposition of natural and man-made sound and vision, either directly, or through the cross-reference of one to the other (where the man-made visual scene, such as the telegraph-pole cutting, implies the existence of a man-made sound-world, even if not heard at that moment).

The first prominent use of juxtaposition occurs in 'Racing Unseen'. The relationships between sounds placed within a landscape gradually change[29], followed by the juxtaposition of fore-, mid- and background landscapes, between which sound-sources allude metaphorically. For example, many different bell sounds, ranging from the huge 'church' bell to the intimate 'chime' occur in different guises throughout the work, most prominently from 5'34-7'48 in movement one. 'Little Animals' takes the idea of juxtaposition a stage further. The above descriptions of visual and sound environments strongly influence the composition but, because of their holistic

[29] An approach described by Wishart (1985: 79) as the disposition of sound-objects in a space.

embodiment within the music, they are difficult to illustrate with sound examples. However, the following attempts to illuminate some generalisations:

(i) Mixing sounds of clear source and allusive implication, with non-recognisable sounds implies visual and acoustic juxtaposition. For example, during the opening minute, a sound texture recognisable as a 'strong gale' or 'storm' is mixed with tiny iterative material (sound example 3.1, track 42). Because the former is recognisable, it influences how we hear the latter in that we attempt to form a real-world link. It would be difficult to imagine a *real* sound-source link with the iterative material that is also coherent with the 'strong gale' allusion. Therefore, the link is more likely to take the form of a visual analogy: possibly the detailed internal life of the forest. Similarly, chordal material which suggests a 'pipe organ' and used between 1'00-2'00 in 'Little Animals', although less recognisable than the 'strong gale', is juxtaposed with an unrecognisable source (a bicycle-pump recording), which has been transformed using filtering techniques such that it takes on some of the resonant properties of the organ-sound. Sound example 3.2a (track 43) presents the extract from 'Little Animals'. Example 3.2b (track 44) contains three variations of the organ sounds. Example 3.2c (track 45) presents the original 'bicycle pump' recording, followed by the filtered version, which is woven into the texture in example 3.2a, (most prominent during the first 30 seconds). In this example, the imagined sound-source link is a sounding analogy.

(ii) Gradually some of the recognisable sounds fragment, (prominent from four minutes onwards) and lose their original source association. However, they also maintain some of the original expressive characteristics, either in their actual acoustic content or by association with an earlier original sound occurrence. Sound example 3.3a (track 46) is a 24-second extract from 2'32 containing the pre-fragmented material. Sound example 3.3b (track 47) is a 20-second extract from 4'44 in which the expressive characteristics from the former are re-mixed, and the density and gestural energy of the sound materials are reduced. Sound example 3.3c (track 48) is a 38-second extract from 8'00 in the work, where fragmented, telescoped and elongated gestures are further re-mixed, disguising many of the original imagined source associations, while maintaining the expressive characteristics heard in example 3.3a. The graphic score (figure 3.1), provides a visual reference. The material at 2'32 is clear in its gesture, while at 4'44 the visual reference shows less clarity in line and greater emphasis on texture. At 8'00, the material has clearly taken a linear flow. In general, the material between 4'30 and 6'00 consists of a fragmented and more densely mixed version of the material presented between 1'00–4'00.

(iii) Gradually, the later sound developments condense into abstract pitch and rhythmic material, which are mixed with the bare, expressive essence of the earlier sounds. This process begins to gain clarity at ~8'00, (sound example 3.3c above). Sound example 3.4 (track 49) contains a 1'23 extract from later in the work at 10'40, illustrating the final stages of this development. Figure 3.1 provides a visual reference, where from 7'55 to the end, the material is predominantly textural.

3.3.2 Internal and external flow characteristics

The 'rate of flow' is determined by a combination of pulse, phrase and metre. When composing, I often observe 'rates of flow' in the material common to previous work. This may be due to my own feeling of a 'natural' pulse, and it is reasonable to assume that every listener feels a rate of flow when not influenced by a regularly segmented or accented musical articulation.

I have used the term 'internal flow' to mean a rate of flow which is determined by the immediate intrinsic characteristics of the material. 'External flow' occurs where the material lacks immediate intrinsic flow articulation, and instead, listeners impose flow characteristics onto the material by combining their own 'natural' sense of timing with features derived from a memory of the wider musical context. Often the imposition of external flow characteristics occurs subconsciously as part of the listening process, as the ear looses conscious awareness over lengthier sections of material.

In ‘Little Animals’, internal and external flow characteristics unfold and influence each other throughout the work, and are designed to flow together seamlessly. Figure 3.1 draws attention to these areas of organisation. The reader needs to refer to the complete composition for sound examples due to rates of flow being dependent on long- and short-term contexts. Establishing the internal rate of flow draws on a number of sound attributes:

(i) Wide, regularly spaced articulations outline phrase lengths.
(ii) Close articulations outline tempo and pulse.
(iii) Periodically accented gestures suggest metre.

These characteristics appear no different to those outlining the rate of flow in traditional music. However, their embodiment within the acousmatic sound-world means they are often disguised due to the ear being drawn towards extra-musical characteristics, or due to composition techniques that blur the start or climatic point of the articulation.

The opening minute is free flowing, and the listener will feel the continuous propulsion of material towards the attack at 1’07. From 1’07 to 2’30 the material consists of loosely structured phrases, formed by a combination of the bass ‘organ / choral’ pitch material and the various attack articulations. For example, the attack at 1’07 begins the first phrase, the bass chordal pitch rise (D-E-F-G-A) begins the second phrase, the bass chordal descent (Bflat–A-F-G-F) outlines the third, and the loud attack at 1’40 begins the fourth. The regularity of events in between these articulations may result in listeners feeling a dictated musical flow (63 / 31 bpm) depending on whether they listen to the complete musical context, in other words the section from 1’07–2’30, or whether they are listening to shorter time-intervals.

From 2’30 to 4’15 the articulations, although frequent, are too irregular to establish phrase or pulse. Between 4’15 and 6’00, there are many small ‘pockets’ of material containing their own pulse, and in some cases, rhythmic implication. The numerous changes in pulse prevent the listener from establishing a regular tempo, and there remains the ambiguous implication of phrase due to the irregular duration of each rhythmic pocket. However, there is stability in phrase and tempo over the short term (between two and six seconds of each rhythmic pocket) which, combined with the seamless mix of sound materials, leads the ear to search for a long-term stability.

From 6'30, the fragmentation of material (described above) disguises many of the previous explicit extra-musical implications, and subsequently the ear is drawn towards the intrinsic sound qualities. The music contains various tempi that are constant over a sufficient duration so that they will be perceived as being unambiguously derived from micro-level activity (on figure 3.1, tempi of 61, 98, 55 and 68 bpm have been identified). A combination of regular tempo, amplitude and duration amongst most textural components draws the ear to search for a metre that does not exist. In addition, the slow-moving macro-level activity results in an ambiguous phrase structure. Consequently, surface characteristics in the music dictate tempo, while the listener 'externally' imposes phrase lengths and metre through comparison with a larger musical context.

From 9'30, the material maintains the previous level of detail, but contains ambiguous tempo characteristics, fluctuating between 52 and 59 bpm. However, there is a strong sense that a tempo exists, although fluctuating, due to the gradual exposure of clear and regular pitch material. In this section, a listener may perceive the flow characteristics in a number of ways. If listened to over the short duration, the general consistency in style results in an 'averaging' of internal tempo. Phrase and metre on the other hand, are imposed externally, deduced from a memory of the wider musical context and the listener's natural sense of time-flow. If listened to over a long duration, tempo, metre and phrase will derive from the association of intrinsic sound content, and therefore from characteristics internal to the music.

3.3.3 Articulation and physical activity of events

In 'Racing Unseen', two behaviours characterise the sound material, and were important when selecting the technical methods of sound development. The first derives from the experience of 'travel' and long journeys by public and private transport. When one is the passenger, the world tends to rush by in a dream-like state, and even when conscious of the passing scene, memories of individual events and places tend to blur, sometimes with goal-directed thoughts of the destination. 'Racing Unseen' opens with the sound of a jet plane: its forceful, noise-based spectrum transforms over a period of time using granular synthesis techniques, and is mixed with voice-based granulated textures. This method of sound development creates a sound-world which is aggressive and fast moving, with a dense, constantly changing textured surface that evokes a feeling of high speed. Behind this sound 'screen' can be heard distant, metallic sounds: the sound of church bells transform into a metallic noise-based percussive repetition, maintaining the aggressive and fast-moving nature of the granulated material. The mixing of fast-moving and detailed layers, with distant 'ghost' images implying sound allusions, occurs consistently throughout the work.

The second characteristic concerns the physical material of the sound sources, and the manner in which these objects are resonated or set in motion. Many sounds appear to emanate from heavy and bulky objects such that the sound-motion suggests some large kinetic force. One of the main recording sessions involved a large, metal 'oil-drum' dustbin, filled with swarf, rolling on the floor. Mixed with these sources are many sounds that indirectly imply a human presence - such as noise-based vocal sighs or extended vocal cries. However, there is no direct allusion to the life force behind the heavy objects, and in other words, the force is unseen. The anonymous nature of the 'unseen force' further confirms its holistic role: influencing many sound-types, yet not changing their inherent characteristics.

Combined, these two sound-behaviour characteristics unfold throughout the work, and imply that the 'unseen force' is the vehicle by which the passenger travels.

3.3.4 Holistic concepts and the cross-over with development

The above sections demonstrate how holistic concepts unfold through sound transformation. Sound transformation also contributes to the development of musical meaning dependent on a sound-time chronology. Therefore, a single sound may ambiguously contain attributes of both holistic and developmental ideas. For example, the above idea of 'travel' in 'Racing Unseen' is also coupled with the chronological development of the opening 'plane' sound and its spectral characteristics, (which later features as an example in the perception of time-flow).

Perception can also confuse developmental and holistic concepts by detaching from the chronological flow of events and evaluating the musical material in a non-linear manner. Ferneyhough describes this as being particular to repeated listening:

> "When we listen intensively to a piece of music there are moments when our consciousness detaches itself from the immediate flow of events and comes to stand apart, measuring, scanning, aware of itself operating in a speculative time-space of dimensions different from those appropriate to the musical discourse in and of itself." (Ferneyhough, 1995: 43.)

I find this experience more likely when the material contains a high density of sound events and a rapidly changing surface texture, or where there are a number of simultaneous lines of development. This may be due to perception being overloaded with sound information, and in the subconscious attempt to find meaning, the ear evaluates the information in retrospect, even though new material continues to be heard. It is impossible to provide a short example because this effect occurs over a length of time. From all the works in the folio, 'Little Animals' is more susceptible to this listening characteristic, particularly from nine minutes onwards. Although the material does not contain a complex, high density of sound events, the surface micro-scale texture changes rapidly, while the macro-scale transforms more slowly than in the previous minutes.

The programme notes for 'Little Animals' and 'Racing Unseen' (Appendix 1) attempt to suggest some of the above ideas to a listener.

3.4 Perception of Time-flow

Time flows along a straight line, in one direction, and in one dimension. We measure the passing of time through cycles and periods, such as the earth's rotation, and pendulum swings. These measurements are not absolute, and the proof that time passes is circular - a process which relies on the comparison of one cycle with the next. This has particular importance when looking at the placement of materials, proportions and repetition in 'Racing Unseen'.

Although there is only one 'real' time, there are a number of different *perceived* time flows. The perception of time *duration* depends on the content of real time, and the perception of the time *direction* (forward, backward or static) is dependent on the relationship of events in the work. Composers have attempted to harness this aspect of perception, most notably Stockhausen and his use of 'moment form'[30].

Discussing the difference between composed and experienced time in the acousmatic works is problematic. Arguments which attempt to draw on the relationship of sound events positioned in the real-time flow of the music, although founded on concrete evidence, avoid the subjective evaluation of the listening experience. When looking at the perception of time-flow, I attempt to combine both viewpoints.

Psychology investigates the perception of time, and experimental evidence suggests that listeners' experiences of time change in relation to varying stimuli (Block, 1990). The following discussion takes care not to rely on the significance of the results. Although sometimes useful in suggesting paths of discussion, they rarely investigate the complexity of music, and often fail to consider everyday listening factors such as repeated listening, forgetfulness, lapses of attention throughout the listening process, and factors dependent on the listening situation, type of music, and

[30] Moment form consists of a number of sections of material, which lack clear beginning or end, as if they were a snap shot of a larger picture. The sections can be arranged in any order because, although the moments are related, they are not connected by time-directed development. Stockhausen applied this idea to some of his music, for example 'Momente' and 'Mixtur' (Maconie, 1990).

musical competence of the listener.[31] There is, however, one idea relevant throughout the following discussion, and that concerns the relationship of an experience-time interval and its information content:

> "...the experience of duration of an interval is a construction formed from its storage size (in memory). This leads to a working hypothesis that anything which might alter the size of storage of the information in a given interval will also affect the experience of duration of that interval. As storage size increases, duration experience lengthens." (Ornstein, 1969: 42.)

Graphs and analysis information

Examples concerning the following discussion draw from figures 3.2 and 3.3. Figure 3.2 presents a graphical analysis, representing levels of perceptual focus and time relationships in 'Racing Unseen'. It displays the location of different materials, and attempts to indicate the main and secondary focuses, particularly where overlapping material prevents the identification of clear divisions. In the previous chapters I discussed how acousmatic music, which, prone to continuous development, does not allow the clear segmentation of different sections. This is problematic when discussing the relationships of material - how can the listener identify proportions if beginnings and ends of sections cannot be unambiguously defined? In figure 3.2, the identified sections embody clear breaks in the material or a definite change in style. When less clear, a new segment is regarded as beginning where a new sound attracts the ear. For example at 1'59 in movement one, a change in pitch from a major to minor mode articulates a change in the sustained layers. This method of segmentation is inappropriate for some material, and instead an approach which identifies the *location* of prominent features, may be more accurate. Such instances occur where material moves rapidly to the foreground aural focus, for example at 0'06, 0'35 and 1'15 in movement one.

[31] A comprehensive summary of the musically relevant psychological experiments which test memory for perceived proportions and subjective time can be found in 'The Time of Music' (Kramer 1988).

Figure 3.3 suggests how the association of materials between the two movements leads to a difference between real- and experienced-time, although the identified material characteristics show only one possible interpretation.

3.4.1 Relationship of events and the influence on experienced time

Musical Development

A sound characteristic determined in accordance with an earlier event results in constantly changing listener expectations. In this procedure, sometimes called linear development (composed or imposed by the listener), time moves in a foreword, goal-directed manner. Kramer (1988: 22) makes a useful comparison to Markov Chains: based on a set of probability equations, the higher the order in the chain, the more probable an expected event will occur and therefore the greater the linearity. For probability to exist, the listener requires some initial relevant knowledge on which to base predication. The 'language' and sonic boundaries of acousmatic music are less predictable and less defined than instrumental music. Therefore until the listener 'learns' the composer's typical compositional 'rules', or builds prediction based on repeated listening (such as probability generated through the use of tempo and phrasing, or the focusing of a spectral gesture), goal-directed development can be hard to grasp.

Establishing realistic listener expectations may be problematic for acousmatic composers because they are often submerged in, and pay attention to, the more unusual aspects of everyday sound-worlds. In remembering my first introduction to acousmatic music and observing composers' working methods, it appears likely that in addition to the composer's own skill, the solution to this problem is a combination of trust, intent and open-mindedness on the part of both listener *and* composer[32]. If the composer is open-minded to the 'potential' of sound, initial materials which appear illogically arranged, can be logically developed, and subsequently present an opportunity for the

[32] I do not necessarily agree with Boulez's argument that listeners need re-educating, (Boulez, 1990) but instead, that they are required to listen with an 'open mind'.

listener to establish rules throughout the music. Further, acousmatic music may entice a different attention span to instrumental music because before expectations can be manipulated, it is necessary to establish rules on which to base the expectations. Although establishing rules is not necessarily a lengthy process, in acousmatic music this facet of perception may either prolong attention spans through enhancing interest, or reduce attention spans through demanding too much from the listener. In instrumental music, expectations are already partly in place due to familiarity.

The *relationships* between events are vital to the musical development. Unfortunately, it is easy for the composer to concentrate disproportionately on the transformation or development of the *single* sound, and lose the coherence of event relationships throughout the work.

Development of the two movements

The two movements show many similarities in duration and types of material. The similarities result from the sound composition stage. Searching for the 'right' sound produces 'debris' of material, some of which deviate from the original idea and need to be put aside. However, in this instance, the by-products from working on the main material in movement one, retained interesting associations to the original ideas, and were re-worked in the second movement. Although movements one and two sound very different, the similarities may be sufficient to establish listener expectation and prediction. This results in the work being easier to remember, due to the listener having already heard aspects from the second movement in the first (but mixed in a different way), and by developing prediction based on earlier gestural interplay. Some of the main similarities include the following:

(i) Both movements are nearly the same length, and divide into three main sections. Figure 3.2 graphically identifies these durations. In movement one: 0'00-3'30, 3'30-7'34, 7'34-10'00; and in movement two: 0'00-3'12, 3'12-7'40, 7'40–10'20.

(ii) In both movements, a continuous flow of material defines the first section, each of which develop sustained layers and repetitive cycles.

(iii) Environmental sound recordings open each movement. Movement one opens with the sound of a jet plane, movement two opens with the sound of waves.

(iv) Both movements end with similar sound treatments. In movement one, tiny 'chimes' (7'30) grow through gentle 'sways' and accumulate into the thick, distorted, resonant texture. In movement two, tiny pitched sounds containing a vocal implication (7'40) grow through gentle 'sways' and accumulate into a thick, detailed and loud texture.

(v) There is a consistent relationship between smaller time units, illustrated in Figure 3.2. The first main section in each movement (0'00-3'30 in movement one and 0'00-3'12 in movement two) can be divided into three smaller sub-sections (sub-sections 1.1, 1.2 and 1.3). In movement one, sub-section 1.1 is 1'32 in duration and consists of a dense, detailed, noise-based sound-world. Sub-section 1.2 is 0'42 in duration and consists of a spectrally rich sustained layer and sub-section 1.3 is 1'16 in duration and consists of streams of attacks combined with 'granulated-surge' gestures. In movement two, sub-section 1.1 is 1'40 in duration and consists of wave material increasing in density through the addition of many sound fragments. Sub-section 1.2 is 0'46 in duration and consists of 'metal' sways moving into a deep texture. In sub-section 1.3, a consistency of material leads the ear forward past the natural resting point at 3'12, to location 3'33 in the work, where a quiet, distorted sound attracts the ear, i.e. a duration of 1'07.

(vi) The central main section in each movement contains five sub-sections, with an exact synchronisation of material at 4'52. The end location point for each subsection has been marked on figure 3.2, (sub-sections 2.1–2.5).

(vii) Extra-musical ideas link the two movements. Movement one is titled 'Racing Wide' and movement two, 'Racing Inside'. Without wanting to discuss these ideas in great length, the two movements are extra-musically opposite. The first movement mainly contains noisy, fast moving and expansive sound material, while the second movement, overall, presents a more intimate sound-world.

3.4.2 Repetition

There are many types of repetition: long, short, metric, exact and non-exact. Some are more common in the acousmatic works than others, and each has a different effect on the perception of time. Overall, periodicity provides scope for comparison, and facilitates the measurement of time. This is true for extact and non-exact repetition. The effect of repetition on experienced time is paradoxical, and changes depending on the individual listener and the real-time duration involved. Chapter 1 suggests that information is easier to process in memory when it can be 'chunked' into units. Repetitive material is susceptible to chunking, and if one moment 'back-tracks' to another so that the single moment is sustained, experienced time may be short, (Pressing, 1985: 110-115). On the other hand, (excessive) repetition may evoke boredom, and the duration will be a lengthier experience.

The opening of Racing Unseen movement two (0'00-1'30) contains cycles of repetition based on the 'wave' pattern, while in movement one, the same duration contains less repetition. When each 1'30-duration is played out of context of the respective movement, the movement two extract feels shorter than the movement one extract. This may be because the wave cycles, although of varying duration (main cycle durations in seconds are 6, 12.5, 8.5, 11, 10, 19, 10, 13, 10, the spacing indicated on figure 3.2), contain similar material such that each is perceived as the same repeated 'chunk'. The opening of movement one is divided into larger time units (main durations in seconds are 23, 25, 15, 29 the spacing indicated on figure 3.2), each containing a variety of sound information. Consequently, a listener may experience the complete 1'30 section in movement one as being longer than that in movement two. However, in the *context* of the complete movement, there exists a different scenario. In movement one, the continuous development of material towards a goal may in fact 'lead the ear forward' and *reduce* experienced time. For example, by identifying points of climax at 0'06, 0'35 and 1'15, the proportional change in duration leads the ear beyond the change in material at 1'30 and 1'54 to the location at 2'14. This is indicated in figure 3.2.

In 'Racing Unseen', a third function of repetition is to influence the perception of non-repetitive material. This happens simultaneously and chronologically. In movement one from 2'14-3'30, short, non-exact repetitive cycles overlay a constantly changing mass. When each type of material (repeated and changing) is heard in isolation, time is experienced differently. When the two types of material are heard together, the experience of time is roughly the same as that gained when listening to the solo repeated material. In other words, the repetitive layer influences the perception of the non-repetitive layer. Sound example 3.5 (track 50) illustrates this comparison: example 1.3b (heard earlier) contains 1'00 of the mixed extract, while sound example 3.5 contains 1'00 of the solo-sustained material. Furthermore, the repetitive nature of this section influences how we perceive the previous material, where the section from 1'32-2'14 is heard as being longer than that from 2'14-3'14. The effects of repetition in the above three scenarios are therefore dependent on the contextual time span under consideration.

A hierarchy of repetitive cycles

Repetition can also extend over long time cycles, and may be significant in maintaining a sense of coherent structure in long works, (Pressing, 1985: 110-115). To evoke the feeling of repetition, it is unnecessary for each cycle to contain identical material, and instead, some unifying feature may be sufficient. After the duration of one cycle has been established, it is likely that the ear will *impose* this attribute on following material, which, if played alone, may have lacked any sense of cycle repetition[33]. This is evident in the following examples taken from figure 3.2, where a simple articulation or climax can 'mark' a cycle within a continuity of material.

With different lengths of repetitive cycle, a hierarchy is established in which long cycles are less evident than shorter ones. As the music unfolds, mixing techniques obscure repetition, and fragment one cycle into a number of shorter parts, resulting in an adjustment to the order of the hierarchy. In some areas, there is a thick accumulation of layers, in others there is only a single repeating sound. Some of the

[33] A similar comparison can be made with the imposition of tempo, phrase and metre discussed earlier concerning 'Little Animals', in section 3.3.2.

cycles are indicated in figure 3.2. The time-location of multiple layers and the position of a layer in the hierarchy are factors which structure the work. Layers of cycles are built-up in the style of figure 3.4. The lowest level of the hierarchy was identified when considering the development of the two movements: each having three sections, characterised by the type and activity of material. This level is established only after one of the movements has been heard in full (indicated in figure 3.4 as occurring after ten minutes), due to the listener building and adjusting the hierarchy in a chronological fashion. For example, the first cycle is established during the opening material (after one minute in figure 3.4), and is characterised by a high noise component, implications of speed, a changing dynamic, pitch and spectral contour, the duration of which lasts approximately 30 seconds. The development of this sound sustains the original acoustic and implicative characteristics, and although vaguely defined, maintains the 30-second cycle identified in figure 3.2 movement one: 0'06-0'35, 0'35-1'03, 1'03-1'32, 1'32-1'59, 1'59-2'26. This cycle, although containing different sound material, is repeated with varying degrees of clarity throughout the movement (beginnings and ends obscured by the mixing process), for example also occurring between 3'30-4'00, 4'00-433, 4'52-5'23.

The next repetitive cycle emerges between 1'03 and 1'32 and consists of approximately one-second repetitions. In this manner, layers are added to the hierarchy throughout the work.

3.4.3 Density, diversity and rate of change

There is conflicting opinion over the effect of sound-event density on the experience of time. Some evidence suggests that high density, non-recursive sound information results in a shorter experience of time because there is not enough time in which to take in all the information (Ferneyhough, 1995), while the evidence presented above suggests that the same limitations of memory result in a longer perception of time. The former is more likely over the short duration - before the ear tires from the density of information. Such opposite opinion amongst listeners suggests such that it is inappropriate to discuss sound-event density in relation to short or long experienced time. It may be more applicable to focus on relative duration experiences, rates of change, momentum and time flows, formed through our perception of the *relationships* between densities of information.

The perception of increasing event density is paradoxical. From the single event, a gradual massing of many sounds will increase the density of the material, until maximum saturation results in the perception of a coherent texture (although at the micro-level the material may be constantly changing). The time it takes to move between extremes defines the rate of change or 'dynamic motion' of the material. In 'Racing Unseen' there are many examples of the changing relationship between sound event densities. The following provides two structurally significant examples:

(i) The bell-type sound occurs throughout the work in various guises. Its development is most prominent through 5'34 to 7'48 in movement one. To begin, the sound of distant church bells are heard, over which 'mass' high-pitched chime sounds, followed by a short surge at 5'56. This introduces a passage of high-density material, which gradually thins, decelerates and 'smoothes' with granulation and 'blurring' effects. At 7'23, the passage condenses to the single chime sound. The rate of change is very slow, and is intended to give the impression that a lengthy duration and a large 'metaphorical' space have been covered. The area of focus between 7'23-7'48 gives the misleading impression of a structurally central point.

(ii) In movement two, a dynamic change in the density of events occurs between 2'47-3'12, where a sudden rise out of the gentle texture builds into rich 'attack-sways', ending at 3'12. This passage begins and ends suddenly, and contrasts with the extended drone that follows. The change in direction is designed to guide the ear to a new section in the movement, outlined in figure 3.2. The reader can also refer to 2'35-3'35 abs.

3.4.4 Proportions

If the measurement of time-flow relies on the comparison of one time-cycle with the next, proportional relationships are an important consideration for the composer.

In 'Racing Unseen', the location of proportionally related materials was important to the structuring process. Real-time proportions were often used to organise material where two sections and their time ratio served as a starting point for the proportional relationship of further sections. These proportions are now irrelevant due to edits performed after evaluating aurally the complete context of the work. Furthermore, the general significance of real-time proportions is questionable because the experienced duration will vary depending on the material. In discussing the role of proportions in acousmatic music, there are two important questions:

(i) Are identical proportions experienced differently? Acousmatic music lacks a notation system allowing the composer to measure proportions in beats and bars, and varying tempo and event density result in each real-time interval containing a different information content. Evidence suggests that our judgement of different real-time duration (over long and short intervals), which contain the same complexity of material is accurate, while other real-time proportional relationships feel too long or too short. In other words, perceived duration is related to the information content of the elapsed interval (Ornstein, 1969). Clarke (1987: 232) also suggests that when listeners are strongly focused on developing musical structures, their judgements of proportion are based primarily on structural information rather than on duration. Clarke further suggests that if composers are concerned about a listener's perception of proportion, they must pay careful attention to the structural complexity of each section rather than just the real-time duration.

In 'Racing Unseen' I was particularly aware of this problem, and adjusted real-time duration by comparing the articulation speed of material in each section. For example, movement one section 1 is longer than movement two section 1 because the former contains a high density of changing information, while in the latter, sound relationships are presented in a clearer manner.

(ii) How can the listener identify proportions if beginnings and ends of sections cannot be defined? The problem of segmentation was discussed earlier concerning figures 1.4, 1.5 and 3.2.

Aurally, the comparison of past and present materials will change our experience of duration. In other words, "...our experience of time in retrospect may not agree with our experience of time in passing", (Block and Reed, 1978: 657). The difference between time experienced in passing and time experienced in retrospect is important in 'Racing Unseen', the conscious perception of which may depend on listener familiarity. The real-time placement of material and respective time proportions can be seen in figure 3.2, and were discussed when comparing the development of the two movements. Figure 3.3 suggests experienced duration relationships between the two movements. In this diagram, the information from figure 3.2 is represented in a simplified manner. Brief generalisations describing the most memorable materials, flow characteristics, and respective associations between the two movements during 'time experienced in passing' are compared horizontally. A real-time scale has also been incorporated, allowing the reader to cross reference figure 3.2 and related extracts from the music. When comparing the two movements, there are clear differences concerning the intrinsic content of the sound. However, figure 3.3 suggests that there are also similarities in flow-characteristics and sound relationships, particularly the number and duration of material sections. When comparing 'time experienced in passing', I have suggested that perceptual comparisons between the materials in each movement will result in a distorted experience of duration. Figure 3.3 shows that in each movement, from 0~3'30, the listener perceives similar characteristics: each opening with environmental sound material, divided into three sections and featuring continuous flows of repetitive cycles. From 3'12–7'40 in movement two, the listener associates material with 3'30-10'10 in movement one. This is because the material located between 6'27-7'00 in movement two, shows strong similarity to the material located at the end of movement one: a thick, distorted, resonant texture, the arrival of which is prepared by very quiet material featuring tiny gestural characteristics. From 7'00-7'40 in movement two, the material subsides to a quiet, static plane, suggesting the end of the movement. Furthermore, the material located between 3'12–6'40 in movement two, and 3'30-9'40 in movement one, shows only vague association. Through comparison of material between the two movements, the ear is misled into perceiving that 7'40 in movement two is in fact the end of the movement. Up to this point, the misleading impression that the 6'40-duration in movement one (3'30-10'10) is equal to the 4'28-duration in movement two (3'12–7'40), results in time being experienced as a shorter duration. However, experienced time is again redirected when a second, and more convincing parallel to the end of movement one is heard, occurring from 7'40-10'10 in movement two. Because the ear was previously misled, *in retrospect* the movement may now feel longer. This result may be because the passing of time and memory blur the distinction between different duration experiences, and the location of the sound is remembered as relative. The more striking the sound-object or texture, the more memorable is its relative location, such as the material located at the end of movement one.

<u>Proportional alteration - 'Racing Through', the electroclip version of 'Racing Unseen'</u>

The electroclip version of 'Racing Unseen' (track 99, CD III) is a three-minute work that attempts to capture the essence of the 20-minute version. Initially the re-mixed work identified and re-scaled the main proportional segments. This idea became impractical because proportional reduction destroys the timing and counterpoint of internal detail. In the longer version, the materials are designed to unfold over a length spanning several minutes, using a development process that gradually extends and emphasises sound characteristics.

One solution involved selecting the main material from the longer work and simplifying the development process both 'in' and 'through' time, maintaining the essence of the sound interaction without the need for an extended development. While it was easy to select the most important material within the real-time context, out of real time, the task was less easy. This is because materials composed over the extended duration not only constitute the structural hierarchy of the work, but also acquire their actual musical meaning through the method of gestural interaction. When worked on a smaller scale, the same materials lose this meaning. The final selection of materials used in the electroclip version were those found most memorable after a single and continuous audition of the full version. These materials were then re-mixed, with no relation to the original sections and only an approximation to the original sound chronology.

The process described above suggests that in 'Racing Unseen', prominent material characteristics have a stronger role in the work than proportional representation.

3.4.5 Sound-source re-contextualisation

A sound-source in its normal context has a specific time frame, which is formed by the interaction of all the events in that sound-world. Sound-sources in acousmatic music are mainly recorded in outdoor sound environments and in the recording studio. The prediction of behavioural properties amongst sounds in outdoor environments are formed through identifying one sound in relation to other events, and through knowledge of natural physical laws. For example, we know the sound of the sea will continue indefinitely, and the speed or intensity of the waves will depend on the weather conditions, the coastline and the listener's distance from the source[34]. Sound recorded in the studio usually lacks an interaction with other events. Its 'time frame' depends solely on the physical property of the object and the manner in which it is stimulated, such as resonating for a specific duration in response to an attack. We therefore build expectations from identifying the object and drawing on our knowledge of its sound environment.

These 'natural' time-flows can be disrupted during the compositional process. For example, the resonating metal attack may sustain indefinitely, or the sea may slow down to a halt. The listeners' expected sound time-flow could therefore conflict with the real sounding development, and result in a conflicting perception of time. Disrupting an expected time-flow can lead the ear to musical change, while avoiding

[34] Characteristic sound time-flows derived from nature have been used for centuries, such as the aeolian harp (May, 1992: 79-89).

any disruption will maintain a feeling of flow and consistency in the material direction. For example, at the beginning of 'Little Animals', the aggressive noise sounds (heard as a 'gale' or 'storm') die down to a gentle, distant 'stirring', over approximately 30 seconds, (illustrated in figure 3.1, and sound example 3.1, track 42). The effect gives way naturally to the underlying material, which continues the duration characteristics of the wind - tiny fragments of sound forming a continuous texture, lasting also for approximately 30 seconds. If the sound material had stopped abruptly, the natural time-flow would have been disturbed, and the following sound material would have appeared out of place.

3.5 Freedom and Prescription: Complexity and Process

Music can both provide the listener with the scope for free interpretation and prescribe a path through the structure. Prescription is achieved by satisfying listener expectations and therefore reducing (although not eliminating) the significance of anticipation and judgement. In addition to natural sounding time-flows discussed above, this characteristic is found to result from a 'musical process':

> '...a musical activity... whose complete identity is revealed only by accretion and degradation, whereby middle- and short-term memory are invoked to different degrees. Processes are interesting precisely because of the immensely rich interplay between memory and predictive imagination they involve, but also because they extend the concept of the 'object' into more explicitly temporal domains. Process might even be said to be the shadow of objects in time'. (Ferneyhough, 1995: 435).

Opposed to a 'musical process', characteristics of complexity offer a rich choice of event relationships, and therefore provide scope for an involved listener imagination. Overall, this is achieved by avoiding a strict hierarchy of musical elements; here one element is not composed to 'consume' a specific collection, therefore treating all sound elements as having equal priority in the musical organisation.[35] Thus, in Ferneyhough's case the composer "tries not to prescribe a prioritised path through the structure", (Ferneyhough, 1994: 115). What is important, "...is not the amount of information presented, but the contextual relationships, and the quality of mental structures derived from surfaces by the listener", (Boros, 1994: 90). In other words, the composer presents the hierarchical potential, and the listener realises a particular manifestation.

The distinctions outlined above suggest that for the listener structural choice, and for the composer hierarchical organisations, are incompatible. There is however

[35] This idea of a musical element is raised in connection to instrumental music, where the smallest element is the single note. However, there is a limit to the scale on which such equality can occur, and changing the scale, such as by defining a musical element as a motive consisting of many notes, automatically involves a hierarchical organisation. Furthermore, the application of equality in the organisation of musical elements may result in an overall sense of 'greyness', particularly if the equality is applied on an increasingly micro-scale (Alexander, 1995: 64-82; Toop, 1995: 86-88).

one flaw in this hypothesis, which is particularly relevant to acousmatic music involving sound allusion. The association of sound with the real world means that there will exist some hierarchies common to both free perception and composed prescription, whether the identification of a natural hierarchy - such as the spatial placement of sounds through reverberation, filtering and stereo width - or its subsequent surreal disruption (e.g. as described by Wishart 1985:79). At the same time, the allusive potential of sound material and the free play of the imagination create a level of complexity external to the intrinsic sound content (which is central to Ferneryhough's discussion). Truax (1994b: 179), confirms this idea by suggesting that the degree of contextual relationships, and therefore possible structural choices for the composer as well as the listener, are increased and enhanced in electroacoustic music by the inclusion of this 'outer complexity'. In other words, allusion involves the hierarchical organisation *and* the free interpretation of event relationships.

3.6 Reconsidering the Essence of the Source-sound

3.6.1 Getting away from stereotypes

Acousmatic composers tend to begin composition by exploring certain source-sounds. These source-sounds are derived from substances with resonant acoustic properties: glass, clay, plastic, wood and metal objects, supplying a varied and rich source of frequency characteristics. The composer then explores the intrinsic and extrinsic properties of these materials, and their development through the composition. Use of these sound materials produced certain stereotypes in my music, where even extreme transformation processes maintained some identifiable timbral characteristics of the original source. Often, to the collection of source-sounds were added environmental sound recordings, varying the acousmatic sound-world.

The composition of 'Little Animals' approached the problem from a different angle. Instead of beginning with abstract sound material and searching for allusive connections through the development process, I began by recording source material already containing an allusive potential (through mimetic approximation), which could be emphasised by straightforward editing techniques (such as cutting, pasting and mixing). After establishing these allusions in the composition, fragmentation techniques obscured the allusive aspect, revealing musical qualities. Some of these initial source materials and their early transformations are presented in sound examples 3.6a-c (tracks 51-53):

3.6a = bicycle pump squeaking sound (made by restricting the flow of air from the end of the pump) followed by a transformation.
3.6b = frying tomatoes followed by a transformation involving transposition and filtering.
3.6c = tearing industrial cellophane followed by a transformation incorporating the 'bicycle pump squeak'.

The next transformation stage mainly involved filtering, spectral stretching and fragmentation techniques. The fragmentation aspect is the most important as it serves to concentrate the ear on the relationship *between* fragments, as opposed to the allusive content and the physical resonant properties of the original sound. This method allowed the investigation of musical potentials without overt concern for the sounds' acoustic properties. The temporal aspect of this relationship was considered in section 3.3.2.

'Little Animals' differs from the previous works mainly due to this composition technique. However, with respect to the final compositional chronology, which is based on the development of extra-musical and musical material internal to the work, it contains no apparent distinction from the structuring methods applied in previous compositions.

3.6.2 Characterisation

The way in which material is 'characterised' can change the musical 'feel' for the entire work. Two types of materials are central to this observation: material with vague or ambiguous potential and material characterised by strong musical or extra-musical features. It can be assumed that the characteristics of the latter influence our perception of the former. However, the significance of this effect may not be appreciated until illustrated with a musical example.

'Surf' contains similar acousmatic sound materials to 'Little Animals', yet both compositions have distinctly different characters. The common material consists of fragmentary and iterative textural fields, vacant of clear gesture or extra-musical implication. When played alone the material appears only to reveal subtle variations in timbre and flow. Example 3.7a (track 54) contains two extracts from the pre-mixed sound material. In 'Surf', this material, which is located between bars 80–163 (2'55 in duration) and bars 251–267 (0'55 in duration), is characterised by the live part. Sound example 3.7b (track 55) presents a short extract (bars 108-124). Instrumental motives combine with the acousmatic material resulting in a two-fold identity: in real-time using motivic development, and in non-real-time through the relationship with previous musical ideas. This latter aspect is discussed in Chapter 4 section 4.5.2, with visual and sound examples (figure 4.2, sound examples 4.11a-e, tracks 80-84), illustrating both synchronic and diachronic types of identity. In 'Little Animals' the same acousmatic material is located between 8'00-12'40, and can be referred visually in figure 3.1. In this instance, the extra-musical implications embedded in the opening three minutes give character to the work. Sound example 3.7c (track 56) presents a compilation of some of the influential materials from the opening of 'Little Animals', and sound example 3.7d (track 57) presents an extract from 8'00, illustrating how these influences are manifested. Sections 3.3.1 and 3.3.2 described how through fragmentation and transformation, allusive attributes are obscured to reveal musical relationships. Despite the lack of 'real time' allusive qualities, the listener remembers the allusive sound-source link[36]. Sound examples 3.6a–c (tracks 51-53), present some of the transformation procedures, and sound examples 3.3a-c (tracks 46-48) present methods of re-mixing material in the final composition. (Both sets of examples were heard earlier.)

There are many other differences between 'Surf' and 'Little Animals' (instrumentation, duration and the character of other material), which also serve to give each work its own identity. However, due to approximately one third of each work consisting of similar acousmatic materials, the effect of sound characterisation is an important consideration.

3.6.3 'Space' from a composer's perspective

There are four components to a composer's spatial sound palette:

(i) 'Real' space in an acousmatic work is in fact the *illusion* of space through the application of signal processing effects, or through the recording of a source-sound in a space other than an acoustically dead recording studio. The concept of the 'listener's space' was discussed in section 1.5.4.

[36] This process of association is discussed in section 1.3 and 1.5.4.

(ii) 'Timbral' or 'spectral' space is the implication of width and depth through the relationship of frequency components.
(iii) 'Pitch' space is a refinement of timbral space, concentrating directly on the relationships of pitch, as opposed to the general frequency distribution.
(iv) 'Time-space' is the space implied through the time it takes for an action-response connection in the sound allusion.

The definition of real space appears to be very different from timbral and pitch space. However, a closer look at the application of spatial illusion through signal processing effects indicates that there exists a continuum between the two. The illusion of space mainly consists of the reverberation time (the time it takes for the reverberation to subside by 60 dB), the delay time (the time between the source and the onset of reverberation), and the strength of the early reflection (a sound reflection heard before the reverberation begins). Although there are other factors concerning the frequency colour and density of the reverberation, those listed are of main concern. A signal-processing device will usually allow the user to control the reverberation parameters. Convolution and resonant filtering techniques serve to emulate the sustain characteristic of the reverberation, whilst also allowing the user to transform the reverberant characteristics into a new sound without reverberation. When resonant filters are used to process a sound, the frequencies within the source oscillate respective filter-bands. Normally the composer can specify the characteristics of the filters, such as their bandwidth and 'Q' factors (the extent to which the filter is focused on a specific frequency, determining its ringing time). The filter output consists of frequency and envelope relationships found in the original sound, while the ringing-time determines duration characteristics. This results in a version of the source-sound in which frequencies are emphasised or removed, and sustain characteristics enhanced at the expense of detail in the amplitude envelope. The source-sound takes on characteristics of reverberation with a high pitch-colouration. Sound example 3.8a (track 58) presents a sound to which reverberation has been applied. Sound example 3.8b (track 59) presents the same sound processed with resonant filters. Sound example 3.8c (track 60) adapts the filter techniques used in example 3.8b such that there is a different implication of space, gained from 'internal' resonance and not reverberating space, due to the highly resonant 'Q' factor in the middle pitch bands. This method of transformation also provides a link between real and timbral space, where space is *implied* through spectral characteristics. For example, a single sound containing very high and low frequencies, while lacking in the middle register, occupies a wide frequency space[37]. Sound example 3.8d (track 61) presents the same filter procedure used in 3.8c, but changes the relative 'Q' factors to reinforce spectrally wide frequency components.

Musically, convolution has a similar effect to resonant filters. A technical description is too detailed for the current discussion. To summarise, the effect takes the amplitude and phase characteristics of the frequency components in one sound (an impulse) and imposes them onto the spectrum of a second sound. This has many musical implications, such as achieving musical and extra-musical association between two different sound-types. In the current discussion, convolution is significant in its ability to transform a reverberated sound into a new sound with sustain-characteristics, and in other words colouring the reverberation with the spectral detail of the impulse.

A second aspect of timbral space involves the implication of space through granulation techniques. Granulation creates a mass of many small 'grains' of sound, and implies space in two ways. (i) The source sound is extended in a quasi-delay fashion, implying the sustain characteristics of reverberation. Sound example 3.9 (track 62) presents a granulated 'bell' sound, mixed as part of the sound texture in 'Racing Unseen' between 6'10-7'23. (ii) The massing of many small particles into a dense texture implies a large 'spatial occupation', and in turn a large real space. Sound example 3.10a (track 63) presents the original source sound of a coin rolling on a metal sheet, and example 3.10b (track 63) presents the granulated version, which is mixed in 'Puzzle Wood' between 3'10–4'00.

The above describes three ways of linking real and timbral space. All the computer applications described above are time-variable, which effects a continual sound transformation, in turn evoking a sense of paradox between a sound-source

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[37] Smalley (1986) details the 'occupancy of spectral space'.

heard in a real space, and a sustained sound implying space through its spectral density or pitch content.

The fourth component of the spatial sound palette involves the implication of space through cause-effect delay times. Expectations concerning the behaviour of physical objects in the real world, result in stimulation and response relationships being experienced in the composition. The effect can range from musical implications, such as enlarging time-cycles or the delay-time between an upward sweeping gesture and its descending counterpart, to extra-musical implications, such as the delay-time between a ball being hit and it bouncing off a distant wall. In the current discussion the former is of most interest, while with the latter, extra-musical implications are associated directly with the concept of 'real' space discussed above. Many examples of varying structural significance can be found throughout the composition folio. Enlarging time-space implications important to the complete structure are presented in Chapter 4 section 4.5.1, concerning the material development in 'Imago'. Other instances are often combined with 'real' spatial settings, making it difficult to demonstrate the time-space relationship with practical examples. For example, in 'Racing Unseen, from 2'14-4'45, there is a clear change in cycle length between the 'repeating attack' material from 2'14–3'30 and the 'quiet metal / voice' surges from 3'30–4'45. The time-space 'energy' implications reduce in size, but the significance is partly disguised by changes in reverberation and amplitude (in other words, changes in 'real' space).

3.7 Summary

Throughout this chapter, many ideas suggest relationships which are not immediately apparent:

(i) Materials drawing on the juxtaposition of sound and visual stimulus in the real world (section 3.3.1) embody inherent sound boundaries, which are valuable for achieving structural coherence in a work of long duration (section 3.2). Drawing inspiration from real-world sources also involves the manipulation of natural physical laws, important to the perception of time-flow (section 3.4.5).

(ii) The idea of repetition outlined with respect to the perception of time-flow (section 3.4.2) is also central to the discussion relating to information and memory (section 3.2), where repetition reduces the quantity of different information a listener is required to remember. Repetition also pertains to the concept of internal and external flow characteristics (section 3.3.2), and is a central factor in articulating the difference between freedom and prescription in the perception of structure (section 3.5).

(iii) In the perception of time flow (section 3.4.1), the relationship of events can exist internally and externally to the music, and have internal and external flow characteristics (section 3.3.2).

(iv) The four definitions of 'space' (section 3.6.3) serve to enlarge the number of possible perceptually different configurations, such that space can be used as a forefront structuring method (section 3.2).

Chapter 4. Acousmatic to Mixed Electroacoustic Works

When investigating the 'live' element of a mixed work, one is dealing with more than instrumental performance. The term 'live' encompasses all work in which sound is performed within a space.

The folio of compositions contains three works for instruments combined with electroacoustic sound, and one film work, each tackling the problem of integration. Composition of the earliest work 'Imago', involved a method of simultaneously creating acousmatic and instrumental ideas, designed to achieve musical coherence through the method by which the materials are developed, and the means whereby those materials are unified into a structure. The results were unsatisfactory, and the method required greater consideration of the live performance element, which throws forth a number of musical considerations involving performer interpretation, conflicts between visual and sound information, and the integration of different musical languages. The following discussion concentrates on the combination of instrumental and acousmatic forces, highlighting problematic differences, and then presenting methods by which these differences have been considered in the three live works. The discussion of 'Receive' highlights relationships between sound and the visual image important to the musical structure. Often, methods which consider the numerous differences affect the musical structure of the work itself, and these consequences are presented later in the chapter.

In most instances, the reader will need to refer to the instrumental score as well as a sound example. Sound examples taken from the scores are referenced in two ways: bar numbers are indicated in the text, and absolute times from the recordings are indicated in Appendix 3. This is because the recording may not be accurate in relation to the timings in the score.

4.1 The Performance Aspect

4.1.1 The variability of performer interpretation

A work open to interpretation embodies the excitement of the 'unknown'. Different performers and different performances result in different musical interpretations. The diversity of the variation depends on the number and the nature of the live elements.

Live work using one instrumental performer, sound diffusion and live signal processing, contains three independent interpretation strategies, each of which has different degrees of variability, while a work written for many instrumental performers is not necessarily open to wider interpretation possibilities than the solo work. In 'Buoyant Charm' - for mixed ensemble and electroacoustic sound, I found the interpretation invariant, despite the different styles of score notation and the number of performers involved. Sections comprising graphical or improvisatory notations were performed as consistently as sections involving traditional notation. This result occurs because many performers need to maintain the sense of ensemble during passages of improvisation where a soloist may exercise more freedom.

Compared to mixed instrumental electroacoustic work, the performance of acousmatic music over a sound-diffusion system has few interpretation possibilities. This difference is due to the fixed nature of tape music, where varying performance results from a combination of the performance space, the speaker placement and the sound diffuser's spatial placement of sound.

4.1.2 Methods to achieve greater flexibility in performance and interpretation

Combining live performance and acousmatic material can be problematic. In an attempt to achieve integration, both parts need to contain equal restraint and freedom in musical shape. This is similar to when a quartet of live performers interprets a score: members of the ensemble respond to each other's performance of phrasing, dynamics, rubato and so forth, during the real-time course of the music. Acousmatic material is, however, fixed in its musical parameters, and can inhibit the performer's natural expressive phrasing, where fixed timing imposes the biggest restriction. Therefore the acousmatic element in mixed works calls for a malleable performance method, and this is particularly true if the performer is required to synchronise accurately, as opposed to achieving a general textural co-ordination.

In all the live works, flexibility in the acousmatic material is approached by a method of segmenting the conventional tape part into separate chunks of material. The chunks are designed to allow a proportion of overlap, like flexible joints, and the performers 'trigger' the sound material with a degree of timing freedom. In this way, the pre-prepared material is controlled by the composer, while the 'joints', which occur at points of low structural importance or where rubato would normally be inhibited by an inflexible tape part, allow the performers to achieve significant timing freedom effective on a global structural level. Where the material requires only general synchronisation, the performers can achieve further freedom, knowing that the next 'duration' of material will begin when they decide.

This method of arranging the acousmatic material also simplifies the learning process for the performer. The vague anticipation of events, indecision over the timing of quiet 'tape' entries, and ambiguities over the high point of a climatic surge, are on the whole eliminated by the performers' more accurate judgement over the current location in the score. Even if the performers cannot hear the beginning of a section of acousmatic material, their entry is correct because they are responsible for triggering each segment. For learning purposes, it is necessary to provide the performers with a substitute for the computer part. Along with the score, they are provided with a tape copy of the separate, triggered sound chunks, as well as a continuous example realisation of the whole work.

The technical set-up used for this performance method can be found in the score for 'Imago' ('Imago' figure 1). The system uses a Power Macintosh running the MAX software to interpret the MIDI data. Although not implemented in this system, it is also possible for the performer to control the amplitude of the triggered sound. However, this may be problematic because the performer is situated in a poor listening position, and unless the acoustic instruments were capable of touch sensitive MIDI control, the performer would find it difficult to gauge the relative amplitude between instrument and triggered sound. Furthermore, with the correct facilities, live DSP processing could convert instantaneous acoustic information into MIDI information and subsequently control the acousmatic material. However, due to the variety of performance spaces, performers and diffusion facilities, satisfactory results would require another performer to control the overall balance of sound within the space. In a concert situation, the diffuser or sound mixer is also a performer, interpreting the acoustic balance of the mix - often situated in the ideal listening position[38], can achieve a well defined sound-balance in response to the instrumental performers' interpretation.

In 'Buoyant Charm', there were problems with the triggering mechanism. It was impractical to give each performer a MIDI pedal due to confusion during the live event over who should trigger the sound. Instead, either a conductor or performer chosen from the ensemble takes sole responsibility for triggering the sound material. The improvisatory sections of 'Buoyant Charm', and the potential to take advantage of multiple triggering devices, suggest a further development of the triggering performance method. The acousmatic part could be divided into 'pools' of similar material, such as passive or dynamic gestures, 'themes' and 'developments' and so forth. Each performer, who is also an improviser, uses a MIDI sensor (MIDI pedal or Peizo electric sensor attached to the instrument) to trigger sound located in an allocated pool of material (where MIDI messages are routed to the correct location via MAX). All control over triggering is given to the performer, who is not necessarily presented with a score. The performers exercise control over the entire structure, determining the selection, performance and interaction of live and acousmatic material. Although the development of this work is outside the scope of this thesis, its brief description highlights the potential of a comparatively simple performance method.

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[38] A displacement of 30 degrees is the maximum angle over which a sound will continue to appear to be produced by the visual source (Jackson, 1953 cited in Howard, 1978: 284). This has a significant implication to the diffusion of the amplified live instrument.

4.2 The 'Visual-Listening' Experience

4.2.1 Visual information and the total perceived expression

In Chapter 3, I suggested that the visual articulation of events could enhance the listener's understanding of the music; synchronically appealing to sight and hearing with sound and physicality together articulating the perceived expression. Subsequently, a certain gesture may contain information that sheds light on the work, and a visual articulation may assist the listener in finding this musical 'key'. However, sometimes the visual element can be detrimental to the musical experience. The term, 'acousmatic', which implies that the meaning in the 'message' may be more fully attended when the visual is denied, supports this idea. Further, Dhomont (Contact 1995: 49) suggests that it is not the message which is acousmatic but the listening conditions. The musical effect of acousmatic listening conditions can be found to be most noticeable after 'visually' listening to an instrumental work, and then listening to a recording of the same work. Appreciation of *performance* qualities reside in memory, where although the listener may imagine the live performance, its presence is less significant, resulting in one's perception being directed more towards the *musical* qualities. In other words, the musical experience may be clearer when listening in the acousmatic context, particularly if the visual presence and spectacle of the skilled virtuoso would normally distract from the music. One explanation for this experience is the likelihood that our visual perception, which is on the whole immediately stronger than the ear, predominates during passages of intense musical information[39], the ear attending only to the surface articulation of the music.

Performance is an act of presentation, and is therefore an act of social interaction between two or more people. The listener is active in 'receiving' the visual physicality of the event, 'feeling' the performance gesture and using the visual information to help understand the articulation of the music. However, the listener can

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[39] A concept discussed in section 1.4.

also take the role of a 'passive viewer', in which the music is 'heard' but not 'listened' to, and where the visual performance is the consciously perceived element. *Musical* appreciation on the other hand can be shared collectively amongst members of the same community, but is also a solo occupation involving aspects of personal awareness and of the emotional self. In other words, when attempting to understand or appreciate musical qualities, the listener is an 'active participant', but by taking a passive role, will cease to 'receive' the music.

4.2.2 'Receive' - a collaborative film work

'Receive' is a nine-minute, collaborative film work, involving acousmatic tape and film. The tape part is designed for a sound diffusion system, and the film for projection on a large screen. The aim was to create a work in which neither medium could be regarded as a separate entity or predominantly hold the attention of the audience[40]. The following discussion serves to illustrate a positive example of the 'visual-listening' experience, highlighting relationships between sound and the visual image important to the musical structure.

Throughout the previous chapters, the potential strength of visual information has been emphasised. In attempting to balance the visual and sound information received by the audience, the ideas, described in section 1.4, concerning how the eye is more accurate when forming images than the ear, are significant. Three methods are used to reduce the explicitness of the visual information. Examples occur chronologically through the video copy of 'Receive':

(i) The film mixing technique uses very short visual segments inter-cut with long sections of black. A large quantity of visual information is presented in a short duration, such that the image cannot be comprehended in real time. This style begins

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[40] When viewing the video version, the balance between sound and vision remains approximately the same: the visual presence reduced from the large-screen projection to the small television screen; the sound presence reduced from mutli-speaker diffusion to television or home hi-fi loud-speakers.

from the opening, and dominates most of the work. The sound material on the other hand is continuous, and during the 'black' sections, perception can concentrate on listening. This method results in an interpretation of visual information *out* of 'real time', during which it acquires meaning through an interaction with the continuous sound material. Instances where sound and image coincide serve to articulate points in the total structure.

The duration of coincidence influences the perception structure, and ideas about varying perceptions of form can be drawn from section 1.6.3. When both visual and sound images change rapidly, the structure may be perceived in a number of ways. For example, from 0'00 to 1'55, the viewer is presented with brief glimpses of many different head studies, ranging from an old, angry-looking woman to images which suggest only the form or outline of a face or head. During this extract, the sound material presents many different vocal sources, transformed and mixed to obscure their explicit identity. This material is ambiguous and can be perceived in numerous ways with no explicit meaning. In contrast, a relatively long combined visual and sound image will have a stabilising effect. For example, from 5'54–7'17, the viewer is presented with the constant, (although fluctuating) image of a close-up portrait. The sound displays a similar consistency in its slow, wandering melodic line, which crosses recognisable singing qualities with more abstract pitch material.

(ii) The filming technique also applies a method that captures each frame with a different exposure, using varying long and short shutter speeds. The result emphasises normally imperceptible repeated physical movement, serving to portray the personality behind an image. For example, from 5'54-7'17 the image consists of a close-up portrait in which light reflects off the damp areas of the face, such as lips, teeth and eyes. When the head moves only the slightest amount, the long shutter speed causes the 'highlights' to smear visually, and the viewer follows every tiny movement of the head. The attention to unusual detail in the visual image also draws the ear closer to the sound material which, as described above, consists of semi-vocal singing qualities.

(iii) Harnessing the evocative potential of sound may also have a significant effect on our visual perception. The differences between our senses suggest evidence supporting this assumption. For example, the distinctive smell of a familiar home is often more evocative than the visual image; the sound and physical feeling of a clap of thunder is often more stirring than the lightning flash. In 'Receive', I controlled levels of evocative aural-visual information in two ways: a single sound is used in complete form, or 'split' into selected acoustic components, which are then processed to reveal obscured qualities. For example, sound and image at exactly 5'55 resembles lip 'smacking'. During the surrounding material, from 5'50–6'18, the visual maintains clear variations on the close-up 'lip' image, while the sound material is dissected into different characteristics, such as tearing, slurping, eating and other noise qualities, which remain, on the whole, ambiguous. The visual image serves to clarify the sound image for each listener. In this manner, through varying degrees of explicitness the sound material displays a freely developed, complex world, and the visual image provides the 'tip of the iceberg'. A more ambiguous example occurs at 3'20. The brief visual image implies a human head, attempting to shake itself free of bandages, while in the same dynamic articulation as the visual image, the sound material contains a vocal quality which attempts to break through disguising detail.

The above examples illustrate how, in 'Receive', sound and visual information interact to articulate the structure.

4.2.3 The recorded format

Earlier I discussed how visual *performance expression* could distract from abstract *musical qualities*, inhibiting appreciation of the music. In the recorded form, although the listener will hear and identify instrumental sounds, it is likely that the mode of listening will verge on the acousmatic. In other words, unless an instrument is used for its symbolic identity, instrumental sounds are heard more for their intrinsic content, than for their sound-source link. Further, with experienced acousmatic listening, the performer as a known source of sound may no longer exist in the mind of the listener, although the 'act' of performance may still be relevant. Alternatively, the whole concept of the live performer may even cease to be part of the listening experience.

Recording and mixing a live work present a problem in deciding whether the instruments should blend with the acousmatic part and lose their 'performance identity', or whether their presence should be emphasised in an attempt to maintain the visual sound-source link. In the live performance, both 'tape' part and performer are sounding in the same space, and the natural acoustic blends the two sound-sources even before the application of live effects processing. On a recording, a balanced use of effects will place the instruments and tape in the same space, yet the lack of visual information may result in the illusion that the performer is moving. In the recorded version of 'Imago', spatialisation effects are used sparingly, and instead the amplitude of both live and acousmatic materials is balanced such that the work can be heard from an acousmatic standpoint. In the live performance, instrumental identity is unambiguous and allows for a greater use of live effects processing, which serves to aid the coherence of the two sound-worlds.

A recording often presents one of the best examples of the performance mix, and highlights the fragility of the live event. The current recording of 'Surf' is the second version, where the most significant change involved a re-balance of levels. In the original mix, the guitar parts took a predominantly background role, and important material was often swamped by large acousmatic gestures. The performance was re-recorded emphasising significant live gestures, and de-emphasising minute detail into a decorative role. The re-balance brought the guitar material forward in the mix, unless the intention was for this material to remain in the background. The live performance of 'Surf' is a fragile situation: success depends on the diffused balance between live and acousmatic material, and on the performer adhering to the dynamic markings and phrasing indicated in the score. The main reason for this stems from the difference between the intimate nature of the guitar and the forceful size of the acousmatic gestures, the nature of which are discussed further in section 4.3

4.2.4 The visual sound-source link and spatialisation

In all culture, sound production is commonly accepted as the result of, or as the response to some physical action, where visual information allows the listener to identify the source. When depriving the listener of visual clues, the sound may take on an imagined source, or conversely suggest no source.

The full appreciation of mixed works may require a listening 'skill' in addition to the conventional ability to comprehend pitch, rhythm, timbre and duration interaction. This new skill involves the ability to reconcile, but not necessarily perceive as one, acousmatic and instrumental methods of sound production. In other words, reconciling material *seen* articulated, and material for which the listener is given no visual clue. However, by assuming the listener has this skill, it does not mean that the composer can ignore such differences during the compositional process.

The spatial aspect of acousmatic music[41] rarely connects to the stationary instrumental source. Live spatialisation effects can be used to overcome this difference by relocating the *visually* produced sound away from the performer, such that both sound-types move in a similar manner throughout the performance space, and subsequently furthering musical possibilities of association and counterpoint. Through visual cues is it evident that the performer is stationary.

In 'Buoyant Charm', characteristics of the ensemble facilitated the link between visual source and acousmatic sound. The instrumentation consists of bass clarinet, bass flute doubling saxophones, double bass, violin, mixed percussion, and piano. The number of performers and the sizes of their instruments result in a relatively large spatial occupation, and subsequently a natural spatialisation of the acoustic sound-world. The idea of natural spatialisation can be very effective, while conversely, live spatialisation using sound effects, unless carried out from the composer's directions, can oppose the spatialisation in the acousmatic material. A concert performance of 'Sprung'[42], a work by Peter Otto for solo cello and real-time

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[41] Sounds moving throughout the performance space such that sound-types are rarely associated with any single spatial location.

[42] Performed by Peter Otto on the 30th September 1997, Ceremonies Hall, Thessaloniki, Greece.

interactive computer music system provided one of my most musical experiences of live spatialisation. This work is a study exploring the use of spatialisation as a primary compositional concern. The computer part, generated in real time by sampling material played by the live performer, contains a varied and interesting sound-world normally only found in pre-prepared tape material. However, because there is no tape part, the live and computer generated sound-worlds are spatialised such that they constantly relate on a musical level, through the interaction of spatialisation and live instrumental gestures.

When visual and non-visual sound-sources are similar, a sense of 'temporary' paradox may be evoked through the listener hearing a source and seeing an action, then attempting to reconcile the two. The effect often serves to focus the ear on the music, and occurs frequently throughout 'Buoyant Charm'. The ear is presented with the *extra* task of working out which instrument has produced the live sound, in addition to the task of distinguishing between the acousmatic and live material, or alternatively, accepting both as fused aspects of the music. This effect is however difficult to demonstrate without the viewer seeing a concert performance.

Apart from the spatial relocation of sound, it is impossible to resolve directly the differences between visual and non-visual listening strategies. However, the *perceptual* difference may be reduced through resolving further issues discussed below.

4.3 The Sound-worlds

4.3.1 The intrinsic content of the sound

The differences between the intrinsic content of acoustic and computer-manipulated sound may further disrupt the listening experience. Acoustic instruments have specific qualities inherent to tuned resonating bodies, which produce many complex frequency relationships. Whether articulated in a conventional performance style or by some extended technique, the instrument maintains its specific formant and envelope characteristics. When a computer is used to manipulate the acoustic source, original characteristics can be re-weighted; often the original formants and envelopes are destroyed, and the frequency content of the spectrum altered. The result is a sound that may appear alien to its original instrumental source, and the likely simplification of spectral characteristics[43] may further disassociate the sound from any hypothetical resonating body. In 'Imago' the instrumentation was partly based on these considerations. For example, while processing the raw material, it was normal for a computer-transformed cello source to sound like a cross between cello and clarinet timbre. Sound example 4.1 (track 64) takes a short extract from 'Imago's acousmatic part, followed by the same section in the mixed recording (bars 10-12). The acousmatic material consists of a spectrally stretched[44] cello sound. This transformation produces a new timbre that approximates to both cello and clarinet characteristics (a hollow sound produced by the emphasis of odd harmonic components of the spectrum, while maintaining the bowed qualities). When the live and acousmatic parts are mixed, after the cello line has ended, the clarinet only stands prominent from the texture after leaping to a higher register, (at the end of bar 11). Throughout 'Imago', the acoustic instruments provided the sound-sources for all acousmatic material, serving to assist numerous instances of timbral fusion. Computer

[43] Spectral detail is often 'smeared' through application of phase vocoder transformation techniques. Further information can be referred to in Appendix 2.
[44] For a description of spectral-stretching refer to Appendix 2.

manipulation of the original source was designed to re-weight the spectral characteristics in a musically positive manner.

In 'Surf' the problem was approached differently. The pluck of a guitar string combined with the resonance of the instrument has relatively simple spectral characteristics. In many instances, the original guitar sounds were significantly transformed resulting in greater spectral detail, and subsequently, different live and acousmatic sound-worlds. To overcome this difference, one solution involved fragmenting the transformed material such that it resumed the attack characteristics of the real instrument. The duration of each individual articulation was then reduced, and resulted in a texture of tiny 'attacks', which reflect the original guitar performance characteristics. Sound example 4.2 (track 65) illustrates this idea with an extract from 'Surf' (bar 89–97), first the acousmatic part, followed by the live mix. A second solution adapted the instrumental writing. In numerous instances, the tape part contains large sweeping gestures impossible to realise on the guitar, which instead performs tremolo effects, resulting in a continuity imitating the tape characteristics. Sound example 4.3 (track 66) takes an extract from 'Surf' (bar 63_2–70), first the acousmatic part, then followed by the mixed recording.

The above methods of assimilating intrinsic attributes of the both sound-worlds serve to integrate the different media.

4.3.2 Transformational and gestural qualities

In general, it is impossible for an acoustic instrument to take on the transformational and gestural qualities of computer-manipulated sound prepared in non-real-time. To obtain this quality would require real-time processing of a live signal to the extent achieved in non-real-time in the composition studio. The composition 'Sprung' by Peter Otto referred to earlier provides one example. However, the available technology (complex real-time transformation processes requiring fast computer systems) and the compositional aesthetic (it is often desirable to use source material other than that produced by the performance instruments, and to break the visual cause-effect relationship) together result in very few satisfactory applications of live signal processing. An alternative method to unite instrumental and acousmatic sound-worlds applies a compositional methodology that reduces the musical parameters to terms common to *all* sound material - attack, resonance, direction and gesture.

In 'Imago', the acousmatic and instrumental materials associate in different ways. Acousmatic material enhances that played by the live instruments, extending gestural and timbral characteristics of the phrase. In other instances the sound-worlds are woven together, for example during the opening of the second movement, where both parts extend over long, synchronous note- and noise-phrases. This co-ordination often involves a general association of articulatory characteristics, or simply a counterpoint of pitch, tessitura and gesture.

Pitch integration is achieved by three methods:

(i) The live instrument enhances the pitch centre of the transformed sound; for example, the opening 12 bars of movement two (sound example 4.4a, track 67, bars 165-169), contain long phrases of semi-pitched material in both acousmatic and instrumental parts. The clarinet focuses from 'air-based' to 'pitched' notes, and by synchronising with the acousmatic part, serves to clarify the resulting pitch articulation. In instances lacking this combination, the pitch centre may be heard subconsciously due to the 'distraction' of stronger extra-musical or acoustic features.

(ii) Harmonic co-ordination is achieved through the combined, often meandering flow of pitch layers. Pitch counterpoint, or in other words a pitch contour fragmented between the live and acousmatic parts, achieves a similar effect. An example occurs between bars 65-81 (sound example 4.4b, track 68) where clarinet, 'cello and acousmatic parts all contain sustained material, each 'surging' between pitch-noise focuses, effecting a pitch and harmonic contour shared between parts.

(iii) Use of frequency extremes in the acousmatic part adds depth to the instrumental range and vice-versa. For example, the clarinet b-flat in bar 57 'pulls' the combined sound-world down to a low, velvety pitch-space. Sound example 4.4c (track 69) is an extract from bars 55_4-58.

Two methods are used to integrate phrase and gesture:

(i) The relationship of gestural material between parts creates a gesture counterpoint. An example of gesture counterpoint can be found between bars 7-13, (sound example 4.7c, track 74, discussed in connection with figure 4.1, section 4.5.1). The acousmatic and live parts together create an ascending melodic line through bar 9, consisting of b-flat, b and f-sharp, which is terminated by a loud, acousmatic 'clarinet sounding' injection, and quiet tail based on f-sharp.
(ii) The acceleration and deceleration of instrumental material assists the direction of the total phrase. For example between bars 46-54, (sound example 4.7f, track 75, discussed in connection with figure 4.1, section 4.5.1) clarinet and cello both accelerate, enhanced by an increase in the live effects, and at the same time, the acousmatic material swells and gains in presence.

In general, 'Imago' approaches the musical language from the acousmatic perspective: instrumental ideas are worked into the computer-manipulated sound-world such that, overall, they lose their instrumental identity.

In 'Buoyant Charm', the instrumentation embodies the essence of the sound-world. The notation combines conventional and improvisatory elements, which result in a movement between two types of live material. Bars 36-42 in movement two (movement two) illustrate the use of conventional notation, and the accompanying sound example 4.5a (track 70) closely approximates to the score. Bars 52-65 in movement two, (sound example 4.5b, track 71, movement two), illustrate free, time proportional notation, where the selection of graphic symbols indicate the type of gesture, while pitch or rhythmic notation indicate important material or 'backbones' upon which the improvisation is based. Although both examples are flowing in character, example 4.5b is more free and meandering in conjunction with the acousmatic part. This is partly due to the performance instructions requesting material that blends with the acousmatic sound-world.

The instruments are chosen for their extremes of register and timbre. (Instrumentation consists of bass clarinet, bass flute doubling saxophones, double bass, violin, mixed percussion, and piano.) The expanded acoustic sound-palette facilitates, and fuses with, a similarly expanded acousmatic sound-world. This is evident by observing how lengthy, and therefore significant, solo ensemble passages integrate with the acousmatic part without implying an independent timbral sound-world. The score reveals durations of over one minute in length containing no acousmatic material, and when listening 'acousmatically' to the combined recording, there is no clear movement between acousmatic and instrumental timbre. Sound example 4.6 (track 72) contains an illustrating extract from movement four, bars 7-11 (movement four).

Because of the performers' ability to achieve a wide selection of extended techniques, it was necessary to understand the diversity and limitation of the live sound palette. Throughout, one must have a complete knowledge of the combined instrumental and acousmatic sound, even when working with one element in isolation. This is a skill learned through experience, or through analysis of past works, which is difficult to achieve due to the lack of repertoire available for study purposes. (Recorded material alone is not suitable for full study when investigating the performer's role.) Consequently the learning curve is potentially slow, and based on personal experience.

4.3.3 Control over the sound material

The majority of my music (both instrumental and acousmatic) results from the interaction of one or a number of abstract ideas, combined with the aural development of the sound material. In acousmatic composition, this method of working often leads to unforeseeable structural changes occurring throughout the compositional process, and a problem arises when one is incapable of exercising the necessary degree of control over the *developing* sound material to follow through ideas suggested by *existing* material. Although hypothetically sections can be re-mixed, such compromise can be an infinite process.

Two problems concern the composer's accurate control over acousmatic sound, which subsequently may inhibit the realisation of a pre-conceived or through-composed musical goal:

(i) The composer as poor listener

It is difficult to identify aurally the cause of 'musical' problems, particularly when the structure unfolds over many minutes, or when the ear is tired of reassessing the same sound material. Sometimes a graphical representation of the musical structure (such as a score or time-line of events) is necessary to overcome this problem, and may exist even before the sound development stage. In other words, a graphically represented abstract syntax may overcome the problem of reduced listening when evaluating a long-term musical structure. In instrumental music, the score alleviates this problem. In the acousmatic works, a graphical representation often assisted decisions over material duration and layer organisations, although final decisions were made aurally. In 'Imago', the combined visual reference of the graphic score and instrumental material assisted the structuring process outlined later in section 4.5.1, and was of particular importance when making decisions as to the development of micro-level detail.

(ii) An unsuitable medium for control

Acousmatic sound can consist of acoustic or synthesised sound-sources. The former are characterised by a complex timbral evolution and a level of detail which may evoke primary allusion (section 1.3), but can be difficult to 'shape' exactly to the contextual musical requirements. Sound material synthesised from computer-generated building blocks (such as through the use of 'Csound') may be accurately controlled by the composer, yet often a programmer's skill is required to achieve the level of detail and associated capacity for allusion common to acoustic sound-sources. As mentioned above, in 'Imago' the instrumental part was composed around the gesture and phrase-shape of the acousmatic material. Figure 4.1 contains extracts from the score illustrating how the live parts fit around the acousmatic to form combined phrases. On the whole, these results were due to it being easier to change the instrumental music to fit the acousmatic than vice versa, thereby leading to a pre-dominantly acousmatic work.

In 'Buoyant Charm', the instrumental material is the dominant component, and therefore carries the main structural information on both macro- and micro-levels. Subsequently, the acousmatic part is designed to fit around the total musical requirements initiated in the instrumental material. This called for a different compositional method and resulted in the acousmatic material drawing from attack and decay characteristics of the instruments. Examples are found throughout the score and enlarged upon in section 4.5.3.

4.4 Different Composition Languages

> "Compositional strategies are different to those found in instrumental music. The original compositional method begins with the concrete (pure sound matter) and proceeds towards the abstract (musical structures)... the opposite of instrumental writing, where one begins with the abstract and ends up with the concrete." (Dhomont, 1995: 49).

Integrating compositional strategies in mixed works causes a problem. In general, the creative process irrespective of the medium, often consists of the responses to, or discovery of, some sequence of events, circumstances, situations or emotions, expressed personally through the music - if not using a deterministic or algorithmic device. In the acousmatic medium this expression may be manifest in the sound-world, where the use of identifiable source-sounds and sound-environments are mimetic approximations to the source inspiration. In the instrumental medium the composer may attempt to express a similar idea but the restraints of instrumental timbre prevent a mimetic approach to the material. In other words there will be an increased level of abstraction from the source inspiration: the listener, who already recognises the instrumental source-sound, will attend primarily to the relationship of notes, phrases, timbral variation and other abstract musical events.[45]

4.4.1 Defining a universal language and applying personal experience

Some approaches to electroacoustic composition are concerned with the manner in which material is created and organised. Simon Emmerson (1986) explains the composer's approach in terms of 'syntax' and 'discourse', defining categories of syntax as abstract, abstracted, and a combination of the two, which can be organised in an aural, mimetic or combined discourse. These distinctions are useful for a retrospective approach to analysis, or as considerations before composition has begun

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[45] Although it is important to recognise that acousmatic music also potentially embodies a similar level of abstraction.

when the composer is designing the 'language' of the work. However, during the compositional process this approach may become subconscious, lost amidst 'hands-on' experience, where the conscious manipulation of material is more likely to draw on the composer's personal knowledge of sound behaviour. Personal knowledge is partly based on experiences commonly shared amongst individuals, suggesting that a level of collective comprehension may exist. Although this idea may sometimes be wishful thinking on the part of the composer, it is a trend found in other art forms, where for example, a visual artist may design paradoxical relationships by distorting commonly perceived visual perspectives. This trend is less true with instrumental music. Although the compositional approach may draw from the personal experience of sound behaviour, musical results are mainly restricted to the use of an abstract syntax, a knowledge of which, from a listener's point of view, is more likely to be based on an inhomogeneous experience of past instrumental music.

In the three live works, the compositional language explores common experiences of sound behaviour and a combination of aural and mimetic discourse. This approach is non-specific to either acousmatic or instrumental materials. In 'Imago', the compositional process involved some 'chance' co-ordination between the different media. After realising more 'lucid' musical ideas, I then experimented with the 'chance' method of bringing materials together. The results were too vague to use in their initial form, and were clarified by recomposing any potentially useful combinations of material. Common results from the chance method focused on terms normally attributed to instrumental music: phrasing, pitch, gesture, timing and rhythm. The co-ordination of pitch and gesture between the different materials was particularly common. This was due to the acousmatic material containing melodic contours, variations in tessitura and strong gestural trajectories fundamental to the musical structure, considered in detail in section 4.5.1.

4.4.2 Information Content

> "When a sound is the conveyer of information it functions in a quasi linguistic sense as a 'signifier' of that information... Once that

> information has been received, the sound itself is discarded." (Truax, 1994a: 147)

This statement by Truax was made with reference to environmental soundscapes. Nevertheless, it suggests a two-tiered system of perception for combined acousmatic and live sound-worlds. On one level resides perception of the sound – its acoustic content and immediate allusive associations, and on another level, the mental processing of this information irrespective of the original source. (This is similar to the distinction between primary and secondary allusion described in section 1.3.) The use of acousmatic sound to evoke aural allusion may subsequently lead to the 'mental disposal' of the original *acoustic* source material, while memory for the conveyed message is sustained. Instrumental music on the other hand has a lower capacity for specific aural allusion due to the meaning being conveyed by the relationships between notes, timbres, rhythms and so forth. The 'message' is an inherent part of these relationships, and is subsequently rarely separable from sound's acoustic content. Therefore, it is more likely that a memory for the 'meaning' relies on a memory for the original sound.

The effect of the combined sound-world may vary. It may call for the listener to maintain a memory for the instrumental material, while being able to forget the acousmatic source, only remembering the perceived message[46]. Alternatively, the instrumental material may associate closely enough with acousmatic material to be remembered in the same way: drawing on the 'source disposal' listening method. Likewise, the opposite situation may occur.

4.4.3 The composer's aural feedback and experimentation

The acousmatic composer, who is also a listener, if unable to express a certain idea, can search for it through an emotional reaction to the sound material. With instrumental composition, the composer, even though mentally capable of hearing the

[46] The idea of 'source disposal' in connection with acousmatic sound is detailed in section 1.3.

music when reading the score, is less likely to adopt an aural feedback method of experimentation. In 'Imago' the need for aural feedback caused numerous problems. It was impractical to draw continuously on the performance resources, such as performers, computer and loudspeakers, to test the interaction of new material, and only when the work was in its final stages could rehearsal and subsequent editing commence. Due to the weight attributed to the acousmatic part, which was mainly composed using constant aural feedback, the importance of also using aural methods to edit the instrumental music became evident.

The composition of 'Surf' approached the problem from a different angle. The method concentrated primarily on the instrumental material, followed by an expansion of the acousmatic sound-world. In the studio, because I am myself a guitarist, I was able to test the instrumental material against the acousmatic such that a continual feedback of results was gained from the combined sound-worlds. However, this method also proved problematic. The intimate and dry acoustic conditions of the composition studio give a false impression, where the guitar, which is a quiet, chamber instrument, acquired the illusion of size and presence. In the recording, the combination of materials blend to form an acousmatic work, while in the live situation, one questions the instruments' role, because they appear lost in the gesturally strong acousmatic sound-world. This problem is less evident in the current recorded version, where instrumental and acousmatic parts have been re-edited, a process described in section 4.2.2.

Despite these problems, the aural feedback method produced interesting musical combinations. In 'Imago', when composing the instrumental parts the trend was to follow the gestural shape and contour of the acousmatic material, due to my being unsure about more diverse material combinations. In 'Surf', it was possible to join disparate sound-worlds while maintaining musical coherence because the ear had immediate access to evaluate the musical interaction. This is most prominent from bar 89, (2'52 abs), where the guitar material is derived from earlier gestures. The only similarities in live and acousmatic parts are 'tempo' and phrase which gradually accrete detail, yet both parts join comfortably in a background-foreground relationship. The material in both parts gradually increases in texture and pitch detail up to bar 129, (4'27 abs), where the sound-world changes, and without visual clues, the distinction between live and acousmatic parts is lost. (Figure 4.2, sound examples 4.11a-e, tracks 80-84, and the discussion in section 4.5.2 provide further detail).

4.4.4 The capacity for detail

Despite the different strategies unifying live and acousmatic materials in 'Imago', there remains a problem created by the polyphonic limitations of the instruments, which is fundamental to some solo or duet electroacoustic works. The acousmatic part contains a large amount of detail, much of which is concerned with the development 'across' time (synchronic time), and embodies a layered structural capacity similar to that of an orchestral work. In 'Imago' the live instruments are intended to create an 'active surface' to the music, crystallising ideas developed at length in the acousmatic material. The detail in the former generated an excessive detail in the latter, which was complex and difficult to perform, and gave insufficient space for musical phrasing and timing. To achieve equal balance, subtlety of detail, and counterpoint in both parts, I increased the polyphonic capacity of the live instruments. The classical guitars used in 'Surf' provided scope for a high level of detail, particularly when performing the rapid articulation of events characteristic of the guitar style. The ensemble used in 'Buoyant Charm' increased this polyphony further.

4.5 Structural Co-ordination Between Acousmatic and Live Parts

Sections 4.2 to 4.4 considered some methods of integrating live and acousmatic parts. The following considers how bringing together the two sound-worlds has direct influence on the structure of the work.

4.5.1 Imago

Trends established at the outset are developed throughout the work:

(i) Pitch centre emphasis and counterpoint

The live instruments often serve to emphasise or focus the pitch content of the acousmatic material. For example, through bars 7-13 (example 4.7c, track 74) the use of pitch counterpoint (discussed in section 4.3.2), forms one continuous phrase, or gesture, between the live and acousmatic parts. Clarinet and cello begin the phrase, then the acousmatic and live parts combine, and finally the acousmatic part terminates the phrase. During the phrase of combined materials (bars 10-11), the cello and clarinet provide focus to pitch attributes ambiguous in the acousmatic part. Both methods of interaction are fundamental to the development throughout the second movement.

(ii) Phrase and gesture

From the opening, the *combined* phrase slowly lengthens, and maintains similar detail characteristics. Figure 4.1 illustrates the consistency of this process, taking extracts from 'Imago' and using a vertical arrangement to identify the expansion method. Each phrase consists of three parts: sustained material increasing in intensity, a detailed live instrumental texture mixed with smooth acousmatic material, and an attack articulation serving to terminate the previous material. Initial examples include:

Example 4.7a, (track 73) bars 1-3.

Example 4.7b, (track 73) bars 4-72.

Example 4.7c, (track 74)bars 7_3–13.
Example 4.7d, (track 74)bars 14–23. This example lacks the terminating articulation.
Example 4.7e, (track 75)bars 28–36.
Example 4.7f, (track 75) bars 36–45.
Example 4.7g (track 75) bars 46–54.

The idea of an enlarging gesture composed through the interaction of live and acousmatic parts, is fundamental to the expression behind 'Imago', and assists in unifying the process behind both acousmatic and instrumental materials. The expression behind movement one draws from the physical approach of a rotating, translucent object or 'personality'. Phrases gradually lengthen, enlarging and developing internal details. Without wanting to indulge in a lengthy analysis, the 'rotation' aspect of the development process is concerned with changing pitch, timbral and gestural relationships. An example is best illustrated by first presenting a visual analogy: when looking at a bunch of sowing pins length-ways, they appear smooth and long, yet when the bunch is rotated by 90 degrees, a foreshortening emphasises the sharp points. Towards the end of the first movement (from bars 150), this change is revealed in the musical material. Sound example 4.8 (track 76) is a short extract from this section (bars 150-153). The whole of movement two (no separate sound example) magnifies this subject such that the listener feels 'inside' the world of the object initially viewed - an idea partly expressed through the timbral development of sustained sound-worlds previously suggested in movement one.

4.5.2 Surf

In 'Surf', the composition of instrumental material preceeded the acousmatic material. The effect on musical structure is manifest in a number of ways:

(i) Live guitar gestures are 'enlarged' in the acousmatic part, for example by increasing amplitude, lengthening sustains, and by enriching the spectrum. The opening attack provides an example where the live and acousmatic parts fuse into one spectrally rich articulation (sound example 4.11a, bars 1-7, contains the opening attack followed by subsequent material). Combinations such as this serve to emphasise important locations in the music, such as at bar 32 (sound example 4.9a, bars 31-33), at bar 127 (sound example 4.9b, bars 127-129), and the combined articulations through bars 182–196 (sound example 4.9c takes a shorter extract, bars 82-86). (Tracks 77-78).

(ii) The acousmatic material 'extends' the direction of live gestures. The accumulation of texture during bars 13–18 (sound example 4.10, track 79), and the ascending version of the bass 'string-scrape' at bar 124 (sound example 4.9b, track 78) illustrate two examples.

(iii) The live guitar articulates similar material to that developed in the acousmatic part. For example, at bar 130 (sound example 4.11e, track 84, bars 129-131) the guitars' percussive, iterative texture blends with similar material in the tape part.

(iv) Figure 4.2 illustrates the synchronic and diachronic relationship between layers of diverse and similar material. The material in each part develops earlier material from the same part; and at different instances, each part contains varying degrees of cohesion with the other. This results in the association of materials that initially appear to have little in common. For example, in figure 4.2, the first extract (example 4.11a, track 80, bars 1-7) contains both live and acousmatic material. The only common characteristic is the attack part of the gesture and the initial tessitura. In the second extract (example 4.11b, track 81, bars 89–92), the live and acousmatic materials associate through similar tempo and phrase, and with an opposite articulation such that the fragmented guitar material articulates the textural character of the acousmatic part. In the third extract (example 4.11c, track 82, bars 98–102), similar iterative and phrase characteristics provide a strong co-ordination between parts. The fourth extract (example 4.11d, track 83, bars 108–110) presents a similar development to extract three, this time including co-ordination of gesture, and a more exact co-ordination of phrase. Finally, in extract five (example 4.11e, track 84, bars 129–131) both parts fuse through an iterative articulation and timbral range. Throughout all the extracts, the guitar material is developed chronologically. This link associates live and acousmatic materials that initially appear to have little in common, and is suggested in figure 4.2 by the column indicating material relationships. The acousmatic material also shares common characteristics between extracts, and likewise forms a subsequent bond between vaguely related live and acousmatic parts.

4.5.3 'Buoyant Charm'

As with 'Surf', the acoustic instruments provided the source material for the acousmatic part. The recording process resulted in a wealth of solo and ensemble material, as well as an accretion of gradually focused musical ideas. The percussion and double bass were recorded first because these performers were experienced in playing together. I described verbally ideas such as physical states, emotions, gestures and duration, specified the instrument range, or percussion materials, and then requested the performers to respond with improvisations based on these directions and on a reaction to each other. Computer transformation of these initial recordings developed the musical ideas, and the material was then used to stimulate a further response. The rest of the performers in turn recorded solo or combined sessions in response to selected material.

When developing the acousmatic part, it was clear that much of the source material existed in its most appropriate state before any artificial transformation. Consequently, the initial recording process not only provided a wealth of acousmatic source material, but also suggested musical ideas for the instrumental parts.

The work is in four movements:

<u>Movement one: 'Charms and Darkness'</u>

Two types of material are presented, consisting of the smooth interaction of ensemble and acousmatic textures, such as between bars 6-13 (sound example 4.12a, track 85), and the synchronisation of surge-attack articulations, which begin delicately, for example between bars 40-42 (sound example 4.12b, track 86), and then become more aggressive, for example between bars 63-67 (sound example 4.12c, track 87).

Movement two: 'Escaping Rapids'

The interaction takes place at a more dynamic pace than movement one, and the combined sound-world becomes flowing and dynamic, growing in spectral richness. From the beginning of the movement, the material gradually builds up to bar 89 (3'16 abs), and subsides from bar 121 (5'36 abs) to the end of the movement into a synchronisation of slow bass articulations. This development is continuous throughout the movement, and every moment from bar 15 onwards displays these characteristics. (There is no separate sound example, and the reader needs to refer to the score and the movement two recording.)

Movement three, 'Lost and Let Go' and movement four, 'Afloat and Buoyant', contain similarities to movements one and two. The variety and number of associations amongst these four movements are too numerous to outline in full. The main associations and an example of each are detailed in the following:

(i) Time duration

The duration of each movement is as follows:

Movement one = 5'18

Movement two = 7'47

Movement three = 4'23

Movement four = 7'49

There is a clear similarity in length between movements one and three, and two and four.

(ii) Integrated gesture

Gestural articulations in the acousmatic material are often short (approximately four to eight seconds) and consist of a smooth surge towards an articulated climax, which then tails to silence or low amplitude. In movements one and three, the ensemble enlarges both the duration and dynamic range of this type of gesture. For example, similar material to that played between bars 47_4-50 in movement one, can be found between bars 22-24 in movement three. Sound examples 4.13a (track 88, movement one) and example 4.13b (track 89, movement three) illustrate this similarity.

(iii) Combined sound-worlds reflected in the solo ensemble material

The combination of acousmatic and instrumental material in movement two is reflected in the solo ensemble material in movement four. For example, between bars 1-9 in movement two (sound example 4.14a, track 90 movement two), and bars 1-6 in movement four (sound example 4.14b, track 91, movement four), the score displays similar instrumental material. In movement two, this material is pointillistic and combines with the acousmatic part in an articulatory manner. In movement four, the ensemble plays without the acousmatic part, and material becomes less pointillistic through addition of sustained instrumental characteristics. This style serves to achieve the same effect as the combined sound-world in movement two.

(iv) Degree of polyphony and interaction

The sound-worlds interact in two main ways: through a layering of linear textures, and through the interaction of attack articulation and gesture. Movements two and four display a bias towards the layering aspect. In movement two, this is prominent from bar 20, illustrated in sound example 4.15a (track 92) by an extract from bars 20-25 (movement two). In movement four, layering is clear from bar 10, illustrated in sound example 4.15b (track 93) by an extract from bars 16-21 (movement four), and resumes from bar 65 depending on the nature of the improvisatory element. Movements one and three are biased towards the articulatory aspect, in both small and large details. For example, small-scale articulation interaction can be found in the opening of movement one through the combination of violin, piano and acousmatic material, (sound example 4.15c, track 94, movement one) and in movement three between bars 62-80 (example 4.15d track 95, movement three) through the interaction of rhythmic articulation. Large-scale articulation interaction can be found in movement one through the extended tutti articulations from bar 63 (sound example 4.12c, track 87, bars 63-67, movement one), and similarly from bar 73 in movement three (sound example 4.15e, track 96, bars 73-78 movement three).

An example of how similarities in material influence the structure is illustrated in figure 4.3. The horizontal rectangles represent proportional extracts from movements two and four, and the arrows indicated areas of material association. Bar numbers as well as recorded time have been marked on the diagram, the reader needs to refer to both score and recording for detailed musical examples. The first similarity can be found between bars 1-9 movement two (example 4.14a, track 90), and bars 1-6 movement four (example 4.14b, track 91), marked in figure 4.3 with the letter 'A'. The similarities between these extracts are discussed above in section iv, considering how combined sound-worlds reflect in the solo ensemble material. The second similarity can be found between bars 26-36 movement two (example 4.16a, track 97, movement two), and bars 25-32 movement four (example 4.16b, track 97, movement four), marked in figure 4.3 with the letter 'B'. Instrumental material is common between movements, in this instance mainly displayed by a downward transposition in the piano part. Also the solo ensemble reflects the combined sound-world in movement two, where articulations, instead of existing between live and acousmatic material, are formed between the instrumental lines. For example, the piano and tape synchronisation at bar 30 movement two is reflected in the ensemble synchronisation at bar 31 movement four. The third similarity can be found between bars 89-115 movement two (movement two 4'13-5'24 abs) and bars 37_4-44 movement four (movement four 2'35-3'10 abs), marked in figure 4.3 with the letter 'C'. In this instance, the association is vague. There are similarities in both acousmatic and instrumental material, displayed through pitch motion, gestural curve and timbral density. The duration of this section has been substantially reduced from 1'08 in movement two, to 0'28 in movement four. The associations become clearer when reading the score, and due to the length of these sections of material, for a sound example the reader needs to refer to the musical context in each movement. In the context of the entire work, the compacting of musical ideas can be seen to influence the macro relationship between the two movements. In this instance it effects a dramatic reduction in the length of the compared extracts, thus allowing scope for further material development throughout the rest of movement four.

4.6 Summary

Seeking to integrate the media of a mixed electroacoustic work may alter the structural organisation of the composition, or locally affect a specific musical idea. This is evident when comparing the different types of examples taken from the four compositions. Some examples illustrate ideas consistent throughout the work, such as the triggering performance method, while other examples consist of isolated, local instances, such as gestural counterpoint. The consistent application of a locally effective idea may indirectly influence the long-term organisation and the character of the work.

The effect on structure may occur in different temporal domains. In some instances, an integration method may be predominately linear, such as the method of triggering sound (which in the three live works takes on a similar linearity as rubato and other performance expression), while another method may remain unchanging throughout the work, such as the spatial distribution of performers.

Conclusion

This thesis addresses the significance of structuring processes in acousmatic and mixed electroacoustic composition which are relevant to the listener's perception and imagination. Consequently, they should be of prime importance for the composer.

The role of memory provides a foundation for the discussion. A knowledge of the ways in which information may be categorised and structured in memory, and methods of 'remembering' through association, influence the way in which a composer may enhance memory of the sound material. These considerations contribute to a method of creating a musical structure that can be perceived in many ways, over the short-term and in the context of the complete work. The investigation focuses on three main areas: (1) the relationships between sound materials, from both musical and allusive viewpoints (2) control over composed and perceived structure, and (3) structure and the complete work.

1. The storing of information in memory may be organised hierarchically. Information is categorised by many methods, such as through the grouping of similar characteristics and through direct or indirect information association. Organising material in the composition by similar methods may enhance memory, and influence the listeners' perception of material relationships. In the folio of compositions, different classes of structural hierarchy can be identified. These include:

(i) In 'Earth Haze', a pitch-sound hierarchy is established through the work. The position of 'synthetic' sound attributes in fore- mid- and background aural focuses is associated with specific pitch intervals.

(ii) A hierarchy of repetitive cycles is established through 'Racing Unseen', where the repetition of different duration segments, ranging from one minute to one second, are revealed through the relationships between sound characteristics.

(iii) In 'Earth Haze', the structure contains a hierarchy of allusive associations, where parent allusive categories give rise to numerous associative sub-groups.

(iv) In 'Imago', an expanding cycle of material is formed through the combined live and acousmatic sound-worlds, which gradually accrete detail and expand in duration and gestural attributes.
(v) In 'Earth Haze', macro- and micro-levels of musical and extra-musical sound association facilitate numerous possible listening strategies. Changing the significance of a sound during the course of the music may re-direct perceptual focus towards a different listening strategy. Likewise, a change in listening strategy will alter the position of the sound in the perceived musical hierarchy.

In the construction of long compositions like 'Racing Unseen', methods to enhance memory are of particular importance. It is inevitable that a listener will forget much information present in the acoustic material or in imagined allusive association. When a composer selects the most significant sound attributes, it is necessary to consider that a listener may forget intrinsic acoustic qualities, while stronger allusive associations may remain active in memory, linking to a 'parent' sound or a prototypical model. The composer can guide and enhance memory by considering the following sound relationships:

(i) Grouping mechanisms serve to reduce the number of discrete items of information necessary to remember a musical idea.
(ii) Sound materials are drawn to the prototype with which they have the strongest connection. A change in context may change the most significant feature, and the sound may associate more strongly with a different prototype.
(iii) Paradox in sound unfolds over time. A paradoxical ambiguity may actively involve, and therefore maintain, the listener's attention over the period during which it is unresolved. Examples were drawn from 'Racing Unseen'.
(iv) The perception of visual and sound information is different. Methods of attributing equal structural weight to each type of material were illustrated with examples from 'Receive'.
(v) The prolongation of underlying sound attributes such as pitch can serve to unify materials. The pitch analysis of 'Earth Haze' provides examples of this application.

(vi) Allusion exists on a continuous scale between explicit source recognition and general implications of sounding flow. 'Earth Haze', 'Racing Unseen' and 'Little Animals' provided examples of allusive association. In all examples the juxtaposition and association of real-world situations - such as sounding time-flows, actions and scenarios, with the sound-world of the music - were of importance. Juxtaposition and association involve indirect visual as well as sound analogies.

(vii)Holistic ideas governing the development and organisation of material may enhance memory for the work. Examples from 'Racing Unseen', 'Little Animals' and 'Puzzle Wood' suggest that flow characteristics, and the articulation and physical activity of events, are important aspects of this holistic outlook.

2. If the relationships between sound materials contain sufficient variation in musical and extra-musical attributes, the listener may be presented with numerous structural choices. It is rare for the composer to be able to present a non-biased path through the different structural options, although there is often scope for freedom and prescription in the listening process. The composer can prioritise a path through the structure in a number of ways:

(i) In Earth Haze, these choices are partly dependent on the level of aural focus. By controlling the level of focus, the composer can guide the ear through a selection of structural choices.

(ii) Weighting emphasises one sound or sound attribute at the expense of another, and is the basis for distraction tactics that deceive the ear about the significance of change.

(iii) By controlling the contextual relationship amongst materials, the composer can partly control the perceived structure. These relationships may exist internally or externally to the music. Examples of internal relationships were drawn from 'Puzzle Wood' and 'Earth Haze', such as where a change in context affects whether a sound is perceived as texture or object. Examples of external relationships are drawn from 'Racing Unseen' and 'Little Animals', such as where the contextual relationships existing between sound materials within the music and sound in the real-world may be strong enough to cohere materials throughout the work. In both circumstances, conflicting or paradoxical frames of reference common to a single parent sound may re-direct a particular context.

(iv) The role of acousmatic pitch is important as an underlying trait, clarifying and controlling higher level structure.

3. When the complete work is considered, aspects of composed structure are of different priority. The significance of duration and concepts governing the whole work gain in importance:

(i) The real-time flow of the music may gradually reveal structural attributes to a listener, such as in 'Racing Unseen', where a comparison of materials gradually results in a hierarchy of time cycles.

(ii) When listening to the complete work, real duration and experienced duration may be different. Changing rates of flow influence the experience of relative duration, and are of significance when composing real time relationships between materials, and when attempting to direct the ear towards structurally significant points by use of material associations.

(iii) Holistic concepts govern the complete work, and serve to unify what initially might be regarded as disparate materials.

(iv) The use of similar sound sources and transformation procedures may create stereotypes. Selecting strong allusive attributes in the source recordings, characterising sound through contextual change, or the application of a broad definition of 'space', may assist in avoiding cliché.

(v) In the mixed electroacoustic works, the manner of integrating different materials affects the structure. The approach attempts to fuse live and acousmatic gestures, integrate the different intrinsic sound-worlds, and achieve greater flexibility in performance. The structural co-ordination between live and acousmatic parts is based on the mutual extension of each medium's attributes, such as pitch, phrase, gesture and expanding cycles of material. In order to achieve a unified musical language, the methods draw on a personal experience of sound behaviour and the ideas on memory outlined above. Composition of 'Receive' focuses on the link between sound and vision (see section 4.2). Relative strengths of visual and sound images are re-weighted such that they combine to express the character of the allusions.

In each composition, the results of my structuring procedures are manifest to different extents. When described in the thesis, certain methods are more clearly illustrated with musical examples, and to a listener, will appear more evident in the compositions than other methods. This does not necessarily mean that they are of greater importance in the compositional process, during which I often find ideas are mutually dependent, and difficult to identify clearly. The methods of realising ideas change in the context of each work, and there is rarely any definitive approach, although trends are evident during the process of composition. In some instances, the experience of composing reveals fragments of an approach, which may be realised with conscious intent in a later work. However, an intuitive evaluation of musical material prevails over any other compositional method.

Appendix 1

Programme Notes to Accompany Compositions:

In Date Chronology.

Puzzle Wood — Solo tape.
Duration 13'15
1995

'Puzzle Wood' is the name of a small forest nestled within a Medieval iron-ore mining region in the Southwest of England. Although the wood does not cover an expansive area, locals believe many lost souls wander its confused and ambiguous pathways.

An alluring aspect of acousmatic music is its ability to indulge in a multi-faceted and paradoxical listing environment. Here, the products of our imagination interact and coexist with the sonic material. As perception gradually discovers deeper levels within the music, new allusions jostle to the front of one's attention. Some tiny fragment of sound may shatter the existing context to reveal an even stronger 'Trompe L'Oeil', or sweep it aside in favour of some personal or emotional reminiscence.

Lose oneself within 'Puzzle Wood', and repeatedly escape deeper into one's own thoughts and imagination.

Imago — For bass clarinet, B flat clarinet, cello and acousmatic sound.
Duration 14'30
1995

The nature of this work is designed to allow an expressive interaction of live and acousmatic materials. The performers, who trigger the sound from a computer hard, disk control articulation points in the acousmatic part. The performers have a freedom similar to when playing in an instrumental ensemble, while still achieving accurate synchronisation as indicated in the score. With the help of live signal processing and careful diffusion, the listener should experience a fusion of elements where differences in sound production recede to a background level - allowing the listener to focus on the music.

Imago... what is image, what is reality and what is substance?

Receive — for acousmatic tape and film. A collaboration between Natasha Barrett and Michael Cleary.

Duration 9'00
1995

'Receive' is a collaborative work using acousmatic tape music and film. It is conceived as a sound-video concentrating on the human voice and portrait. The performance takes place in a thoroughly blacked out space. The film is projected onto a large screen, and the sound diffused over a multi-speaker system. The effect is to be surrounded by images and sound-worlds penetrating through the dark.

Earth Haze — Solo tape.
Duration 13'54
1996

'Earth Haze' journeys through a landscape of dissolving images and events, breaking open enclosed sound-worlds to reveal huge spaces filled with wraith-like figures. It attempts to fuse the musical and connotative nature of sound, and draws from the interaction of physical objects, people and the surrounding world.

Racing Unseen — Solo tape piece in two movements.
Movement one: Racing Wide
Movement two: Racing Inside.
Total Duration: 20'20
1996

Racing through,
Racing amongst,
Into new spaces,
Away from old emotions,
Racing high, racing low,
to escape, to seek,
racing into the eddy... racing forever... racing unseen.

Surf — for two classical guitars and acousmatic sound.
Duration 9'50
1997

Surf: to ride the waves; surging water. 'Surf' presents episodes from the metaphorical life of an object in a strange habitat: exploration, fear, overcoming instability, surprise, survival and contentment, and the need to escape - very much like an animal's first attempts to swim in the sea.

Little Animals Solo tape.
Duration 12'53
1997

A forest of small creatures gradually expose their expressive selves through the juxtaposition, transformation and mutual interaction with their surrounding environment. Slowly, sound fragments lose their acoustic source-bond to leave the bare essence of their expressive content, and gradually unfold an abstract musical discourse.

Flow characteristics, both intrinsic to the sound and freely imposed by the listener's own natural sense of time, gradually unfold, leaving an impression of personal interpretation combined with the feeling of being a passenger, carried through the music.

Buoyant Charm for mixed ensemble and acousmatic sound, in four movements.
Movement one: 'Charms and Darkness'
Movement two: 'Escaping Rapids'
Movement three: 'Lost and Let Go'
Movement four: 'Afloat and Buoyant'
Total duration 25'50
1997

On a technical level, 'Buoyant Charm' explores the relationship of instrumental timbre and acousmatic sound-worlds. However, the most important aspect of this work is its expressive content - a subject difficult to describe from the composer's point of view, but hopefully in part, evoked by the titles. The opening material suggests the 'nature' of the 'charm', which attempts to maintain 'buoyancy' throughout the composition, even through the necessary transformation of intrinsic characteristics.

Appendix 2
The Phase Vocoder: Application and Undesirable Effects

The phase vocoder is a tool for frequency domain processing of audio signals. Its applications include time-scale and pitch-scale modification. Two versions of the phase vocoder have been used to process sound in the folio of compositions, one ported from the CARL computer music package to the CDP (Composer's Desktop Project), and the other released by IRCAM as part of the SVP (Super Phase Vocoder) sound processing package. All current versions produce an artefact resulting in the loss of sound detail, or clarity in the output. Describing the operation of the phase vocoder is a complex affair, and the reader can refer to Dolson 1986 for a detailed description. The following outlines *in brief* the cause of the 'phase' artefacts.

Phase vocoder transformation techniques involve three stages: analysis, modification, and re-synthesis. The Fast Fourier Transform (a principal describing how all complex periodic waveforms can be modelled by a set of harmonically related sine waves added together) is used to analyse the sound at successive time-instances, over a 'windowed' portion of the signal - called a short-term Fourier transform. The re-synthesis stage involves setting synthesis time instances, and at each instance, a short-time signal is synthesised. All the short-time signals are the summed together, after applying and optional synthesis 'window'. A long window has better frequency resolution, but worse time resolution. This is partly solved by overlapping the windows. However, this means that the stream of short-term Fourier transforms must be consistent, especially with regard to phase, which varies within as well as between different windows. If phase-coherence is not preserved in the synthesis, the 'phasiness' is heard - and this becomes worse the more complex the waveform, smearing detail in the sound. Methods of applying 'phase-locking' may overcome the problem (Laroche and Dolson 1997).

The spectral transformation techniques used in the composition folio, process sound by a similar method. A unit of the source (the window size) is analysed by Fast Fourier Transform, and then the user can apply any transformation equation to this data before the re-synthesis stage. The 'CDP (Composer's Desktop Project software)', 'Audiosculpt' (released by Ircam) and 'SoundHack' (by Tom Erb), proved useful front ends to this transformation technique.

Appendix 3
Sound Examples – CD III

Shorter examples are grouped on a single track

PW = 'Puzzle Wood'.
EH = 'Earth Haze'.
I = 'Imago'
R = 'Receive'.
RU = 'Racing Unseen'.
LA = 'Little Animals'.
S = 'Surf'.
BC = 'Buoyant Charm'.

Example	Track no.	Original ABS	Description.
1.1a	1	12'30 – 13'20	End section from PW
1.1b	2	0'14 – 0'45	Extract from PW
1.1c	3	0'57-1'01	Extract from PW
1.1d	4	5'13-5'36	Extract from PW
1.1e	5	---	Source recording PW
1.2a	6	0'00 – 00'30	Extract movement two RU
1.2b	7	1'40 – 2'11	Extract movement two RU
1.3a	8	4'20 – 4'35	Extract movement two RU
1.3b	9	2'18 – 3'18	Extract movement one RU
1.4	10	5'43 – 7'27	Extract movement one RU
1.5a	11	3'57 – 5'42	Extract from PW
1.5b	12	4'26 – 4'1	Extract from PW
1.5c	12	4'55 – 5'00	Extract from PW
1.5d	12	5'02 – 5'08	Extract from PW
1.6a	13	---	Source EH
1.6b	13	---	Spectral transformation EH
1.6c	13	---	Spectral transformation EH
1.6d	14	---	Spectral transformation EH
1.6e	14	---	Spectral transformation EH
1.6f	14	---	Spectral transformation EH
1.6g	15	---	Spectral transformation EH
1.6h	16	3'22 – 3'32	Extract EH
1.7a	17	---	Water droplets, source EH
1.7b	17	---	Water droplets, source EH
1.7c	17	---	Transformation EH
1.7d	17	---	Transformation EH
1.7e	18	3'49 – 4'17	Extract EH (later version)
1.8	19	4'45 – 6'00	Extract PW
1.91a	20	---	Source EH

1.91b	20	---	Transformation EH
1.92a	21	---	Source EH
1.92b	21	---	Transformation EH
1.93a	22	---	Source EH
1.93b	22	---	Source EH
1.93c	22	---	Transformation EH
1.93d	22	---	Transformation EH
1.94a	23	---	Source EH
1.94b	23	---	Transformation EH
1.95a	24	---	Source EH
1.95b	24	---	Transformation EH
1.96a	25	---	Source EH
1.96b	25	---	Source EH
1.96c	25	---	Source EH
1.97	26	---	Source EH
1.98a	27	---	Source EH
1.98b	27	---	Transformation EH
1.99	28	---	Source EH
1.910a	29	---	Source EH
1.910b	29	---	Source EH
1.911	30	---	Source EH
2.1a	31	---	Source EH
2.1b	32	3'36 fragments	Extract EH
2.2a	33	0'00 – 0'34	Opening LA
2.2b	34	---	Element from 2.2a
2.2c	35	---	Element from 2.2a
2.3a	36	---	Sequenced source EH
2.3b	36	---	Granulated source EH
2.3c	36	12'24 – 13'02	Extract EH
2.4	37	4'22 – 4'55	Extract EH
2.5a	38	8'02 – 8'32	Extract LA
2.5b	39	11'22 – 11'52	Extract LA
2.6a	40	7'26 – 9'02	Extract EH (early version)
2.6b	41	8'22 – 8'32	Extract EH (early version)
3.1	42	0'00-1'02	Extract LA
3.2a	43	1'13-2'02	Extract LA
3.2b	44	---	Source LA
3.2c	45	---	Source LA
3.3a	46	2'34 – 3'00	Extract LA
3.3b	47	4'46 – 5'06	Extract LA
3.3c	48	8'02 – 8'41	Extract LA
3.4	49	10'42 – 12'05	Extract LA
3.5	50	---	Layer from RU
3.6a	51	---	Source and transformation LA
3.6b	52	---	Source and transformation LA
3.6c	53	---	Source and transformation LA

3.7a	54	---	Texture extract LA and S
3.7b	55	3'47-4'25	Extract S
3.7c	56	---	Compilation LA
3.7d	57	8'02 – 9'02	Extract LA
3.8a	58	---	Reverberation
3.8b	59	---	Transformation example
3.8c	60	---	Transformation example
3.8d	61	---	Transformation example
3.9	62	6'10 – 7'23	Extract movement one RU
3.10a	63	---	Source PW
3.10b	63	3'10 – 4'00	Mixed layer PW
4.1	64	0'28 – 0'40	Acousmatic and live extract I
4.2	65	2'55 – 3'16	Acousmatic and live extract S
4.3	66	1'37 – 2'02	Acousmatic and live extract S
4.4a	67	7'28 - 7'53	Extract I
4.4b	68	2'58 – 3'41	Extract I
4.4c	69	2'40 – 2'49	Extract I
4.5a	70	1'52 - 1'23	Extract movement two, BC
4.5b	71	2'46 - 3'14	Extract movement two, BC
4.6	72	0'32 – 0'42	Extract movement four BC
4.7a	73	0'00-0'14	Extract I
4.7b	73	0'14-0'22	Extract I
4.7c	74	0'21-0'40	Extract I
4.7d	74	0'42-1'02	Extract I
4.7e	75	1'29-1'53	Extract I
4.7f	75	1'56-2'06	Extract I
4.7g	75	2'14-2'38	Extract I
4.8	76	6'23-6'38	Extract I
4.9a	77	0'47-0'51	Extract S
4.9b	78	4'29-4'36	Extract S
4.9c	78	5'49-6'00	Extract S
4.10	79	0'17-0'30	Extract S
4.11a	80	0'00-0'12	Extract S
4.11b	81	2'54-3'02	Extract S
4.11c	82	3'14-3'25	Extract S
4.11d	83	3'40-3'46	Extract S
4.11e	84	4'29-4'33	Extract S
4.12a	85	0'25-0'53	Extract movement one BC
4.12b	86	2'26-2'45	Extract movement one BC
4.12c	87	3'52-4'08	Extract movement one BC
4.13a	88	2'56-3'06	Extract movement one BC
4.13b	89	1'04-1'16	Extract movement three BC
4.14a	90	0'00-0'33	Extract movement two BC
4.14b	91	0'00-0'30	Extract movement four BC
4.15a	92	1'03-1'24	Extract movement two BC
4.15b	93	1'15-1'32	Extract movement four BC

4.15c	94	0'00-0'17	Extract movement one BC
4.15d	95	2'46-3'02	Extract movement three BC
4.15e	96	3'15-3'29	Extract movement three BC
4.16a	97	1'47-2'26	Extract movement two BC
4.16b	97	1'44-2'22	Extract movement four BC

Appendix 4

The Computer Tools Used for Composition

Two computer platforms were used, running different software programmes:

The Macintosh Quadra 640

- *Digidesign's 'Protools II'* - four track digital mixing used for 'Puzzle Wood', 'Imago' and 'Receive'; eight-track digital mixing used for the rest of the compositions.

- *GRM Tools* – sound fragmentation and filtering transformation processes, used in all works.

- *Arboretum System's 'Hyperprism'*- sound fragmentation, filtering and spatialisation transformation processes, used in 'Racing Unseen', 'Little Animals', 'Surf' and 'Buoyant Charm'.

- *IRCAM's 'Audiosculpt' and 'SVP'*– phase vocoder transformation applications, used in all works.

- *IRCAM's 'Modalys'* – physical-modelling application used in 'Racing Unseen'.

- *IRCAM's 'MAX'* – application to transformation MIDI data used in all live works.

- *Tom Erb's 'SoundHack'* - phase vocoder transformation applications, used in all works.

- *Mark of the Unicorn 'Digital Performer'* – MIDI and audio sequencing application. Used in all works except 'Puzzle Wood' and 'Buoyant Charm'.

A 486DXII66 PC platform

- *Syntrillium Software 'Cool Edit'* – stereo sound editing programme for the PC, used in all works.

- *Composer's Desktop Project (CDP) software* – segmentation and spectral transformation applications, used in all works.

Other Hardware:

- Akai S1100 sampler.

- Lexicon PCM80 reverberation and effects unit, used in 'Racing Unseen', 'Little Animals', 'Surf' and 'Buoyant Charm'.

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