The Perception Of Timescales In Electroacoustic Music

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PhD Thesis

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Declaration

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Aki Pasoulas

Abstract

The purpose of this doctoral research is to explore the nature and perception of timescales in electroacoustic music, to examine modes of experiencing time, and to discover a method that uses this knowledge to the advantage of the composer. Although the main focus is on acousmatic works, much of the research presented here has a broader scope and is relevant to music and sound art in general.

This thesis is initially inspired by Deleuze's philosophical views on time to discover relationships between the flow of time and music, and continues to investigate time perception by exploring prevalent theories in the fields of psychology and psychoacoustics. In parallel, it identifies and systematically analyses a set of factors that influence time perception and the formation and segregation of timescales. Theoretical analysis, hypotheses and reasoning were practically tested in the five electroacoustic pieces composed for this particular research.

The study revealed and reinforced the importance of psychological time in perception and interpretation of structures in music, developed the idea of using parallel temporal forms in composition, and through an exploration of timescales, it necessitated a redefinition of microsound. Moreover, an analysis of extrinsic and intrinsic factors that affect our perception of time and thus our interpretation of a musical work reinforced the notion of acousmatic music as a holistic experience that comprises all its surrounding elements at the time of listening.

This research is useful for both the composer and the analyst because it offers insights into time structures, and a better understanding of the listener's response to temporal constructs.

Introduction

Music, and sound in general, exists through time. Music needs time to make us aware of the succession of events, their duration, their motion and change. The Grove Music Online defines time as "[t]he essential medium for music and musical performance, a non-spatial continuum of past, present and future in which music exists and is understood" (Justin London 2004). Although visual representations of music, such as scores and sonograms, occupy a spatial dimension that exists outside time, music as an aural construct needs the temporal dimension to organise auditory events and motion in a linear fashion. The assumption about the linearity of time is based on the actual propagation of sound outwards from its source. One also has to consider that some temporal constructs, such as music, need space to be realised, as for example the motion of sound from left to right. This thesis will focus on time, and will attempt to find ways to use the perception of this dimension to the advantage of the composer. It will explore the use of timescales in music, where 'timescale' is defined as the period of time in which a sequence of events takes place (OED 1989). In order to transform time into a useful compositional tool, our understanding of time needs to be analysed. Hence, the nature of time, the modes of experiencing it and the perception of time passing in music will be explored in the first chapter.

Society has found a convenient way to arrange events in a manageable way through having devised a method for measuring the passage of time. Units of time have been accepted and agreed upon, which determine fixed proportions by which we quantify durations. The standard unit of time is currently the SI second,[1] since months and years do not have a fixed time span, and the minute, hour and day do not use the decimal system; for that reason they are not believed to be accurate.[2] However, this unit is devised to assist humans in arranging their lives and does not mean that we necessarily perceive time passing in equal units of fixed proportions, as sometimes an hour feels like eternity, while other times it passes swiftly, depending on many factors such as our current psychological state and emotional responses. The objective and

[1] The SI second was defined by CGPM (Conférence Générale des Poids et Mesures = General Conference on Weights and Measures) in 1967 as being '9,192,631,770 periods of the radiation emitted or absorbed in the hyperfine transition of the cesium-133 atom' (Encyclopaedia Britannica 2006a).

[2] There is an occasional need for a leap-second, so that the larger time intervals (minutes, hours etc.) are corrected with the rotation of the earth around the sun.

subjective modes of experiencing time, their interrelationships, and the factors affecting our perception of time passing and estimation of durations will be explored in the second chapter.

Time in music has been thought of as linear, and as a result, attempts have been made to divide this linearity into several scales, starting with infinity and ending with infinitesimality, two ideal mathematical durations. However, durations that make sense in music cannot include extremes, even though extremes can be used theoretically to quantify unperceived proportions. In the third chapter, this thesis will explore the smallest timescale that the listener can perceive, which is the micro timescale, and subsequently will consider its relationship with larger scales. The micro level will be investigated through a perceptual analysis of the properties of microsound in relation to the mental mechanisms of time perception. Then, further temporal processes will be explored; in particular, distorted time perception, and the roles of expectation and complexity on time judgements.

The ideas presented in the first three chapters will be further expounded and attention will be paid to the use of perceptual tools to enhance the experience of slow and fast, long and short, haste and languor. The compositions produced as part of this research explore these ideas in practice, aiming to achieve a high degree of control through the organisation of sound material that establishes relationships among time levels. The last chapter will analyse these compositions, discussing the structuring of the sound material, as well as the perception and construction of meaning from the listener's vantage point.

In general, this research aims to contribute to the understanding of mechanisms of linking and controlling different time levels in composition. A better understanding of the perception and structuring of time in electroacoustic music will facilitate the composer's aim to direct the listener's attention to carefully considered temporal processes in a musical work.

Chapter 1

The Perception of Time

1.1 The Nature of Time

Time is not connected with a particular sense, and therefore we cannot perceive time as such. We can only notice its presence indirectly through the perception of events, the motion of objects, and changes that occur in a timeline. Even during seemingly stable states, we perceive time passing through internal physiological changes – our breathing patterns or our beating heart. Physiological shifts may also include alterations in two somatic senses – thermoception (sense of heat and cold) and nociception (sense of pain, which may originate in internal organs). Moreover, time passing can be sensed through psychological changes such as our increasing impatience or our deepening relaxation. Environmental changes also betray the passage of time; these comprise changes in the aural, visual, gustatory, olfactory, and haptic environments. In any case, time passing does not seem to be able to evade our perception.

Colebrook suggests that people usually think of time as "the joining up of movement" (2002: 40); time is what ties events into sequences, brings discrete points of experience together and gives the impression of unified actions. She suggests that people tend to understand time as a series of 'nows', a succession of discrete units that are glued together to make us perceive motion and continuity, like kinds of time frames that pass very quickly in front of our sensory organs.

Another point of view about our understanding of time passing is illustrated in the writings of the philosopher Gilles Deleuze who, in two of his books about cinema, discusses time extensively (Deleuze 1986 and 1989). He claims that instead of seeing separate events joined together through time, we perceive a continuous movement from one point to another, which afterwards we cut into isolated and discrete units. According to Deleuze, time cannot be viewed as a collection of 'nows', but as a process of change. Similarly, from a composer's perspective, Iannis Xenakis observed that the flow of time cannot jump from one frame to another, because even when the smallest time interval is involved, that jump takes time to be completed (Xenakis 1989).

These two points of view (time as collection of units and time as process of change) should not be seen as rivals, but as complementary. Time passing can be understood both as a flowing movement i.e. a process of change, and as a collection of units. We can frame time, or rather, events occurring in time, and concentrate through memory on tiny frames as they move towards history and become past, as well as observe events' motion as time flows steadily and continuously, focusing instead on change.

A similar duality can also be found in acoustics, where sound is considered as being transferred through waves, but is also regarded as a stream of particles. Both can be recognised as true, depending on the scale of measurement and the type of operations we apply to the sound (Roads 2001: 55). Interference and cancellation require sound waves in order to be realised and understood, whereas granulation needs us to consider and treat sound as an accumulation of particles.

Even though time is a non-spatial continuum, people have a tendency to spatialise time. We represent time by the rotation of the earth around the sun, the movement of the hands of a clock, or the 'x' axis in many reference systems based on coordinates, as for example in the graphic representation of sound.[3] Colebrook, in her analysis of Deleuze's ethics of philosophy in relation to time, asserts that by doing so we position time within our known world, a world of images. She claims that time does not take place *within* the world. "We imagine [our] perception as a perception of [a] stable and continuous world that is viewed through time" (Colebrook 2002: 43). She maintains that there is a complex temporal flow from which we have extracted our own interpretation, a subjective point of perception. Our world does not contain time; there is a flow of time from which different worlds are perceived; "… a flow of time, which produces 'worlds' of durations" (ibid: 42), that is, different perceptions of time, or else, variable timescales. The implication of this rationale is that people do not

[3] In most graphic representations of sound, time is the 'x' axis. The 'y' axis can be found either as air pressure, amplitude, or frequency.

necessarily perceive time passing in exactly the same way. The truth of this statement can be seen in many examples; an obvious one is that the older we become, the shorter the years seem to be, although objective clock time does not change. A week to a young child seems to last a lot longer than to a middle-aged person.[4] Moreover, to bring an example of a musical context, a piece of music to an uninitiated listener may sound boring, and as such it can be perceived as being much longer than it is to a person well versed in that particular style.

Based on the suggestion that we view time as a series of present moments or as a process of change, it can be surmised that time is linear. However, human beings do not necessarily perceive time in a linear way; through our power of thinking and memory, we are able to move in all directions through the flow of time. We can move backwards in the past, we can speculate forwards in the future, we can think of durations and access different timescales.

1.2 Time and Music

The way we view and perceive time has profound implications for the way we perceive music. By framing time, we mentally connect events in sequence, refer to sections that have already passed, form relationships between past and present and thus make sense of a musical piece. By focusing on change, we appreciate motion, and follow relationships between parallel auditory streams. By transferring time unknowingly into our more familiar spatial dimension, we tend to represent it in a manageable way and think of it as an abstract numerical entity, which has always been an invaluable tool for the composer. Finally, we – as listeners – do not seem to be able to avoid a subjective interpretation of durations, which, according to Colebrook, is drawn from a complex temporal flow (2002: 41). This biased

[4] There are many potential explanations for the differences in duration judgements involving various ages, or indeed different people of the same age. Among the proposed reasons that include both biological and cognitive processes, are: the changing of metabolic rate, brain temperature, internal pacemaker rate, psychological factors, new experiences, the amount of information being processed and the speed of processing, the person's allocation of attentional resources, keeping oneself busy or idle, impatience and waiting, etc. (This information is based on various sources from the bibliography; many experiments on the subject are summarised and analysed in Block et al., 1999.)

interpretation of time intervals is one of the main subjects to be explored in the remainder of this thesis.

Deleuze, in his debate about cinema (1986), makes certain observations that are transferable to music. He discusses the use of the camera and how this device has given us overt access to the idea of divergent durations. If the use of the camera is compared with that of audio recording devices (i.e. the recording and playback of time-based information), then many analogies with music can be detected. Deleuze asserts that because we scale the world according to our own duration, we tend to perceive a homogenised time that we project over the world around us. However, films do not take place in an ordered line of homogenised time. Colebrook, in her analysis of Deleuze's ideas on cinema, writes:

> By explicitly placing one point of view or flow of time alongside another, cinematic montage shows us the divergence of time, or the different rhythms that make up the whole of time (Colebrook 2002: 43).

Musical compositions work in a similar way to cinematic montage. Music, by incorporating sound sequences that operate on different time levels, has allowed us to see the divergence of time and to approach creatively the idea of multiple timescales. In music, timescales can be placed not only horizontally, in succession, as in cinematic montage, but also vertically, as superimposed layers of varied densities. This is made more explicit in electroacoustic works, where the composer is able to develop sound repertories that do not necessarily adhere to traditional notions associated with acoustic music. In instrumental and vocal music, timescales and pace are predominantly created by traditional musical means, for example, in various manifestations of pitch, such as contours and changes in note density, changes in dynamics, tempo, duration and rhythm. On the other hand, in electroacoustic music there is a combination of two types of suggestive temporal information. One is created by musical means as in acoustic music, and the second is carried by the pace and momentum implied by the associations of sounds with real or imagined sources.[5]

Deleuze's ideas about time in cinema, which is "impersonal, … [and] 'in' the apparatus" (Deleuze 1986: 1) can also be adapted to music. Like cinema, music gives

[5] Temporal information implied by real or imagined sources is explored in chapter 2.

us a time which is “in” the apparatus, time resides inside it, or in other words, musical time is connected to the listener through a physical means that projects its flow. In the case of recorded music, the apparatus is the device that stores and plays back the musical information, whereas in the case of live performance, the players become the apparatus, since music and its associated perceived time are projected through them. This fact also makes time in music impersonal and distant from the self; no action needs to be taken by a person who listens to music because his or her life does not depend on the sounds played. Consequently, time that is projected through the apparatus becomes detached from life itself.

However, there might be cases where part of a composition, or even an entire piece, is connected to real life through sounds that belong both to composition and to real life itself (for example, a real clock producing sounds accompanying an otherwise acousmatic composition). Are the objects (or people) generating sounds around an audience a part of everyday life, or are they apparatuses that project a pre-specified timescale and duration? These are ambiguous moments, where projected time is fused and confused with temporal information from everyday life. This issue is explored further in the last chapter, with examples extracted from my composition *Chronos* created as part of the present thesis.

Listeners may choose to concentrate on particular sound events, while ignoring others. Moreover, there are occasions where concentrating on particular sound information may be done instinctively, because attention tends to focus on events that are recognised according to past experiences (Pressnitzer and McAdams 2000: 54). However, while listening, we can neither stop sound events from happening, nor influence time passing. Time in music is indestructible, uncontrollable and unstoppable until the musical piece ends. This reveals an additional characteristic of time in music, which is the fact that the flow of time has a beginning and an ending; it is not perpetual, not even in extremely long pieces that last for centuries, as will be explained in chapter 2.

In music, time is not sensed as in daily life, and in particular, the relationship between music and the future is very different from that between actual life and the future. David Huron highlights the differences between expectations in daily life and those in music (2006: 98), pointing out that the goal of biological expectation is to form accurate predictions of future events, since those predictions can be of vital importance to survival. This is not the case with the goal of musical predictions, where the listener is allowed to guess wrongly; the future cannot hold nasty surprises.[6]

In addition to the goal of expectations there is one further significant difference between the future in life and the future in a musical piece. Their dissimilarity lies in the fact that whereas in daily life the future does not exist yet, in many types of music it does. Both fixed and indeterminate types of musical composition have, in one way or another, the future planned and designed. Based on further ideas by Deleuze (1986) about relationships between time, daily life and the cinema, it can be suggested that in music, time is sensed creatively, as an opening to the future, that is, it is sensed as having the ability to invent and develop ideas, which is different from our usual expectations of the future in daily life. In music the future is decided for the listener and the listener cannot normally intervene to change it. Nevertheless, the listener can vary receptivity in various ways, e.g. by changing position and adopting different listening vantage points, which affects the perception of perspectival space;[7] or by changing focus of attention, thus affecting the perception of horizontal and/or vertical structure of sound events and hence the decided future of a musical piece. However, in this case we encounter the following question, which is beyond the scope of this thesis: is the music what is projected, or is it what we – as individuals – perceive? In most circumstances when listening to a musical composition we anticipate a future that is initiated from a past; we expect the ideas to develop in some inventive way, and this is what makes the flow of time creative.

There seems to be a creative flow of time, even in cases where the performer and the composer have little or no control over the outcome of a performance of a composition. In pieces with minimum control over the content and duration of individual sounds, the unexpected way[8] in which sonic events sometimes appear often

[6] I do not regard a sudden burst of sound that can damage the ear of the listener as a 'musical' surprise. If a risky gesture is allowed in a musical piece, the composer should warn the audience beforehand or take the necessary precautions.

[7] Perspectival space refers to the "relations of spatial position, movement and scale among spectromorphologies, viewed from the listener's vantage point" (Smalley 2007: 56).

[8] Unexpected not only for the audience, but sometimes also for the composer and the performer.

resembles the mode of event occurrence in daily life. Yet musical time is sensed quite differently from the temporal flow in everyday life. An extreme example is John Cage's 'silent' piece *4'33''* (composed in 1952), where events – if they occur – are drawn completely from the 'real' world (as opposed to the 'musical' world, in a pre-Cage traditional sense). However, anticipation may still arise from various areas of the composition. While the performer stays silent, the tension of the audience may intensify, triggered either by the searching for sounds or slight changes in ambient noise, or by counting down mentally to the closure of the piece. David Huron declares tension as a prerequisite emotional response for an anticipated event (2006: 9). Pre-scheduled events anticipated in *4'33''* are the closure of each movement and that of the whole piece. Moreover, even though no sound or even total silence are pre-programmed, the listener is actively looking for an interesting listening experience based partly on indeterminate occurrence. Creativity is not only attributed to cognitive processes or some kind of divine intervention, but also to serendipity i.e. accidental discovery and chance. Consequently, even in cases of chance compositions where event occurrence resembles that of daily life, listeners may still sense a creative flow of time. It can be assumed that the same is also true for improvisations as well as for generative compositions, where sound events are not predetermined by the performer and/or the composer, although the systems followed in performances usually operate within predefined constraints.

1.3 Temporal Experiences and the Perception of the Present

1.3.1 Time Experiences

Ernst Pöppel points out that there is no such thing as time perception. Instead, there is only event perception, since time experiences relate ultimately to the occurrence of events. He maintains that "… time perception can be explained only if the different aspects of subjective time are first identified, before asking the question of how these relate to each other" (Pöppel 1978: 726). In his attempt to isolate the different aspects of time experience, which Pöppel believes to be independent of one another, he suggests a taxonomy of temporal experiences in relation to event perception, which he calls 'elementary time experiences' and which consist of (1) duration estimation, (2) temporal processing units or the experience of non-simultaneity, (3) time tags of events or order, (4) the feeling of 'nowness' or the subjective present, and (5) temporal organisation of future actions.

In addition to the above, psychologist William James had previously identified the experience of 'change'. "Awareness of *change* is […] the condition on which our perception of time's flow depends" (James 1890: 620). 'Change' is connected with the perception of the present, the fourth elementary time experience in Pöppel's list, but since 'change' is vital for auditory perception and in particular for the perception of musical development, for the purpose of this thesis 'change' will be kept separate from the experience of the 'present'.

From the above time experiences identified by Pöppel and James, those that seem relevant to the perception of time in music will be discussed below, omitting at this stage the experience of temporal organisation of future events, since this latter concerns preparation for future actions and is mostly unrelated to the perception of past and present sound events.[9] The key concepts or time experiences that are connected with the perception of auditory events comprise (a) duration estimation, (b) non-simultaneity, (c) order in sequences of events, (d) the present, and (e) change.[10]

The experience of (a) duration includes not only the duration of a sound or silence, but also temporal relations between sound events and temporal patterns generated by the sounds' positions in time. It is through this experience that different timescales can be accessed, and since duration and temporal relations are extended beyond the present, this experience involves the use of memory.

(b) Non-simultaneity and (c) order are two distinct experiences of time that have also engaged the attention of researchers and scholars who deal with the perception of

[9] The experience of temporal organisation of future actions is vital for identifying the expectations of the listener and preparing the actions for a performer; consequently, it is examined separately in a subsequent chapter (3.7).

[10] The Stanford Encyclopedia of Philosophy (Le Poidevin 2000), when discussing Pöppel's time experiences, incorrectly substitutes 'the temporal organisation of future actions' with 'change', presenting thus (wrongly) a similar list of concepts, as being the 'elementary time experiences' proposed by Pöppel.

auditory events. The distinctness of the two experiences can be shown through an experiment conducted by Richard Warren (1982: 123), concerning the identification of order of sound events. In one of his experiments, Warren presented a repeated cycle of four unrelated sounds to untrained listeners; these sounds had a duration of 200 ms each, and were a hiss, a tone, a buzz and the vocal sound 'ee'. When these sounds were played continuously in a loop, he and his colleagues reported that it was impossible for the subjects to detect the order of the events. This result is obtained when the intervals between the onsets, also known as IOI (Inter-Onset Intervals), are equal or less than 200 ms. Although listeners can aurally separate sounds whose IOI is as low as 30 to 50 ms, the order of those sounds cannot be determined.[11] I conducted my own experiments on the identification of order and found out that it is easier to identify the correct order when some of the sounds are pitched.[12] The pitched sounds form a short melodic line which makes it easier to remember, mentally repeat if needed, and correctly identify the order of sound events. I noticed that in this case, the threshold of recognition falls from c.200 ms to about 100 ms. My experiment goes slightly further than the aforementioned experiment by Warren, as it demonstrates four things. First, as Warren's experiment also shows, non-simultaneity and order are two distinct experiences of time. Second, it indicates that this distinction becomes particularly important for the perception of interrelationships between microsounds. Third, the inclusion of pitched material and the formation of melodic contours make the succession of events more memorable and thus easier to discern their order than when most of the events are non-pitched and unrelated to each other. And fourth, it demonstrates that memory plays a crucial role in recognising the order of events, even

[11] There is a discrepancy in various sources about the lowest interval that permits aural separation. Personal observations revealed that below 30 ms, forward masking occurs and the two sounds are perceived as one (the Max/MSP patch that was used for this particular research can be seen in Appendix I, and it is also included in the data CD2 accompanying this thesis [patch_1]). As the IOI becomes smaller, changes in timbre appear as a result. Subsequently I used this patch to demonstrate forward masking to my BA students at Middlesex University (Acoustics and Psychoacoustics module, 2006 and 2007).

[12] In addition to my own observations, I played initially the looping sequence to four people (in separate situations), only one of whom was a musician (autumn 2005); these initial experiments supported my argument, as all of the subjects were able to recognise the order with low IOI (c. 100 ms) with few errors. In winter 2006 and 2007, I used this patch in my Acoustics/Psychoacoustics class at Middlesex University to experiment further with my students (c. 25 people); the vast majority was able to recognise the correct order at IOI values well below 200 ms. As the IOI became smaller (below c.150 ms), errors of judgement were increased. However, training through repetition made order identification easier. Appendix II contains a picture of an improved version of the Max/MSP patch that was used in this experiment, and the patch is contained in the data CD2 [patch_2]. The recognition threshold should become obvious by launching and operating the patch.

when the sounds are so closely presented that the listener is not able to discern the correct order in real time.

The experience of (d), the present, presupposes that there is a distinction between the perception of past and present, a distinction that is connected with the perception of order. However, as was demonstrated in the previous paragraph, listeners cannot always identify correctly the order of events, although those events may still be perceived as a sequence regardless of their order. Does this mean that the present has a thickness during which we cannot perceive which event precedes another, although those events in question are non-simultaneous? If the present has a thickness, then how long is its duration and can it be clearly separated from the past?[13]

The time experience of (e) change in relation to the perception of sound events is linked with the motion of sound, either as spectral evolution, i.e. identified as motion of its internal structure, or as gesture connected with the sound's external morphological change. Denis Smalley has identified these two kinds of motion as the constituents of the energy of sound. He maintains that the distribution of this energy across a sound event is linked to the perception of time:

> The notion of gesture as a forming principle is concerned with propelling time forwards, with moving away from one goal towards the next goal in the structure – the energy of motion expressed through spectral and morphological change (Smalley 1997: 113).

In artificially created situations where there is no change in gesture and texture of a sound event (e.g. frequency bands held for a period of time without any change), time in music might seem to stand still. This can be experienced as a temporary suspension of progress or movement. The degree to which the listener experiences this 'time freeze' is a matter of choice of focal area and degree of attention, since, as discussed in section 1.1, time passing can still be sensed through our physiological and psychological changes, as well as through any environmental changes that may occur at the time of listening.

By recognising duration, order and change the listener understands structures, and therefore, when these experiences are encountered in a musical context, they bring

[13] A discussion on the experience of the present follows in section 1.3.2.

expectations. When certain durations, relationships among events and changes are encountered, the listener may expect certain auditory information to arrive from the future as a response. Anticipation is born through these three experiences of time, in relation to additional parameters, like certain preconceptions that the listener possesses, psychological states, or cultural and learned processes.

With regard to experiences that involve parallel sequences, it has to be noted that the details of temporal relationships between sounds that belong to different streams are usually lost (Bregman 1999: 143). When there are several streams of sounds, the listener focuses on the temporal relationships of events that belong to the same auditory stream. Bregman identifies auditory stream segregation as the process in which "… links are formed between parts of sensory data … [which] affect what is included and excluded from our perceptual descriptions of distinct auditory events" (ibid: 47).

1.3.2 The Present

Ernst Pöppel (1978: 713) cites St Augustine's *Confessions* as one of the earliest books that discussed extensively the nature and experience of time.[14] Augustine maintained that the present has no duration, because if a moment in time is extended, then it can be divided into past and future.

> If any fraction of time be conceived that cannot now be divided even into the most minute momentary point, this alone is what we may call time present. But this flies so rapidly from future to past that it cannot be extended by any delay. For if it is extended, it is then divided into past and future. But the present has no extension whatever (Augustine 1994: Book XI, Chapter XV, Ps. 20).

Augustine concluded that we measure the duration of an event in our memory, from which it can be recognised that the perception of duration is closely connected with memory.[15] Augustine's view that the present has no duration prevails until today

[14] St Augustine was born in Numidia, which is now Algeria, in 354 CE and died in 430. The discussion on time is included in Book XI of his *Confessions*, which comprises thirteen books.

[15] This view has been supported by various scholars and researchers. In 1990, psychologist William Friedman suggested that we deduce the duration of an event from the information of the exact time that that event started and he called this recollection 'time memory' (Friedman 1990).

and can be seen as the building block of the view that time is actually a process of change.

However, there is a second point of view, which introduces the concept of the specious present. According to William James "… the original paragon and prototype of all conceived times is the specious present, the short duration of which we are immediately and incessantly sensible" (James 1890: 632). The specious present is thus regarded as the time interval in which information is experienced as a single unit, and all events that occur within that interval are experienced as belonging to the present. James maintains that this interval has a constant duration, a 'duration-block' of which we do not feel first its beginning and then its end, but we experience it as a whole, with its beginning and end embedded in it. Based on experiments carried out by Estel and Mehner during the second half of the 19th century,[16] James concludes that the maximum duration we are distinctly and immediately aware of varies from 5 to 12 seconds and he attributes these differences to practice rather than to intuition (ibid: 610, 613).

However, James distinguishes between specious present and 'strict' present; he claims that the former is composed of past and future and is divided by an "invisible point of instant", which instant is actually the latter 'strict' present[17] (ibid: 607, footnote). The strict present is merely a *point* on the continuum of time, a moment where future is becoming past. In contrast, the specious present is the *period* during which events are organised in a perceptual unity that can be recognised immediately without resorting to memory.

Pöppel introduces the specious present as one of his elementary time experiences. He calls it 'subjective' present and he treats it as the interval of time in which we have a feeling of nowness. Pöppel suggests that there is a temporal mechanism related to the subjective present. After a series of experiments[18] he concluded that the subjective

[16] Published in 1885 in Wilhelm Wundt's *Philosophische Studien 2*, pp. 50 and 571 respectively. It is worth noting that the term 'specious present' was coined earlier by philosopher Robert Kelly, also known with the pseudonym E. R. Clay.

[17] Although James adds a part of future to the specious present, I prefer to think that the specious present starts from the strict present and extends itself towards the past, as it deals with the perception of events already happening.

[18] Details on these experiments can be found in Pöppel 1978: 723-725.

present is not a 'travelling time interval' of a constant duration as James believed, but it is rather organised as an oscillatory process that follows excitation and relaxation modes (Pöppel 1978: 716, 724). Pöppel also suggests that this interval is a few seconds long, although he points out that short time intervals (up to c.5 seconds) can be experienced as a temporal unit, whereas longer intervals are coded differently and cannot be perceived as such.[19]

Therefore, is motion through gesture in music heard because the listener is constantly aware of a time interval (the specious present) and because motion occurs also over an interval, or is it heard because the listener concentrates on the continuous movement of time, on the 'process of change'? Are these two ways of seeing the present very different from each other? Let us speculate that the specious present is a window hovering in front of our sensory receivers that oscillates, expands and retracts, in order to accommodate new experiences as they pass tirelessly behind it, thus following a continuous process of change. Instead of thinking about a durationless instant that moves through time, in music we can think of a larger block, where the mind is allowed to compare, measure and apprehend relationships between events as they pass from the 'strict' present to the past. An attentive listener cannot experience only a durationless instant that travels through time without having the mind wander through the recent past and search rapidly for relationships between events and for changes in textures and timbres. Without the experience of the specious present that allows an immediate process of comparison, we would not be able to apprehend and appreciate these relationships and states of events as they occur in a musical context and therefore we would be unable to comprehend a musical composition. We would also be unable to understand the meaning of phrases and words, as these would be perceived as series of incomprehensible phonemes.

There are at least two parameters that are very important in outlining the limits of the specious present. The first is the rate of speed of a stimulus, which determines the recognisability of a sequence. When spoken phrases are presented at a very slow speed, their elements do not constitute a perceptual unity, as they do not fit into the

[19] Curtis Roads notes that Fritz Winckel has calculated the 'thickness of the present' to be c.600 ms. (Roads 2001: 4). This is not to be confused with the measurement of either the specious present, or the present as durationless instant, as Fritz Winckel refers to the accumulated lag time of the perceptual and cognitive mechanisms associated with hearing.

relative simultaneity of the specious present. When phrases are presented at a high speed, they may become unrecognisable, as the listener is not given enough time to record perceptually the separate phonemic elements; in extreme high speeds, even the order of the phonemic elements may become difficult to discern.[20] The same is true for musical phrases, which entirely transform themselves when they are presented at a slow or a high speed that exceeds a threshold of recognition. A melodic line played in extremely slow speed will draw the attention to spectral texture rather than to succession of pitches, and at a very high speed, the melodic line may become a fast gesture, with attention drawn towards contour rather than towards pitch intervals.

The second parameter that partakes in setting the limits of the specious present is that of the number of chunks of information. Although it is not clear whether the specious present extends to the duration of short-term memory, there is experimental evidence that the capacity of information that we can hold at any time, without referring back to long-term memory to retrieve it, is measurable. George Miller's analysis based on experiments by different psychologists shows that there is a limit to the capacity of short-term memory, which is seven (plus or minus two) elements or chunks of information (Miller 1956). Miller's conclusion may be helpful if we think in terms of linguistic elements, or isolated pulses, but does not assist us in the more complex case of elaborate musical information. I believe this is where a quantitative approach loses its effectiveness. I speculate that the limits of the oscillating specious present are determined by the duration of segregated auditory streams and the rate of speed that the information they carry is perceived by the listener. The longer those sequences are, the lengthier the specious present becomes, so that the listener follows their interrelationships and inner changes. When sound sequences become extremely long and pass a threshold for 'longness' in our brains, then our attention is drawn towards texture, i.e. to small micro-changes, which means that the oscillating present has shrunk. Fast-changing textures guide the attention of the listener away from micro changes into larger gestures, effectively making the specious present longer. Figure 1.1 presents a sonogram of an asynchronous cloud of microsounds made by sawtooth waveforms (left sonogram), versus a fast-changing glissandi-like texture (right sonogram). The original sounds are four seconds each and cover the whole audible

[20] See section 1.3.1, discussion on non-simultaneity and order.

spectrum, from 20 Hz to 20 KHz, and are included in the audio CD3 accompanying this thesis (Audio 1.1 and Audio 1.2). In the first case the hypothetical specious present contracts so that the listener perceives the associations between the close elements; whereas in the second case, it elongates in order to register all necessary elements so that the listener understands the relationships between the more distanced frequency crests and troughs.

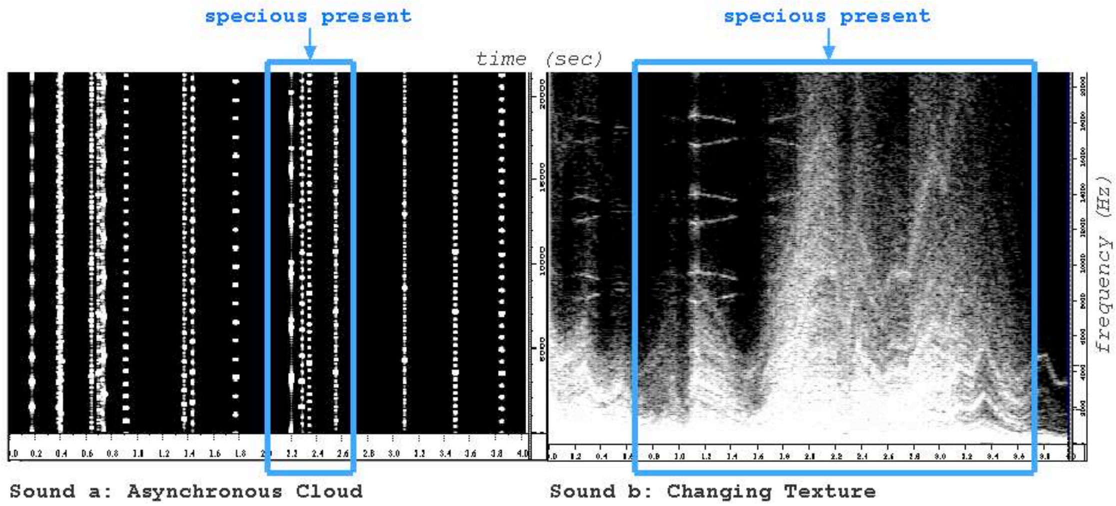

Fig. 1.1 **Specious present.**

Jonathan Kramer claims that the present (the 'now') is the meeting ground of memory and anticipation and that both of these affect our perception (Kramer 1988: 367). His statement seems particularly true when we consider the relationship of time in music with the future (see section 1.2) and the role that the temporal experiences of duration, order and change play in the expectation of events.

1.4 Summary

The investigation of the nature of time revealed that time can only be perceived through events, and can be thought of both as a collection of units and as a process of change. Through the use of thinking and memory, human beings have access to different timescales. In music, diverse timescales can be created and combined in different ways, so that they intersect, move in parallel, or interact.

Drawing ideas from Deleuze's writings on cinema, it has been suggested that time in music always reaches the listener through an apparatus, which renders time impersonal. The flow of time in music has a beginning and an ending, is uncontrollable and cannot be stopped until a musical piece reaches an end. Time in music is sensed creatively, because when we listen to a piece of music, we have expectations of a future that already exists.

Based on Pöppel's and James' suggestions on time experiences, five key temporal experiences have been identified as relevant to time perception in music. These are duration estimation, non-simultaneity, order, the experience of the present, and change.

Regarding the perception of the present, it has been stressed that the present can be seen in different ways; as a durationless instant, as a process of change, or as an oscillating interval called the specious present. In music the present can be regarded as a combination of specious present and process of change, because in order to understand timbral variations and relationships between musical events, one needs constantly to compare and judge the characteristics of a sound in relation to its neighbouring states and events.

Chapter 2

Physical and Psychological Timescales in Music

2.1 Preface

Time can be understood and experienced in two distinct ways. The first is through the notion of absolute or clock time, an objective way of counting mechanically durations via a universal type of measurement that divides time into equal units of fixed proportions, such as the microsecond, the minute, the year or the century. According to this notion, time flows at a constant rate, is independent of events occurring and is the same for every object, animate or inanimate, that exists.

The second way of experiencing time is based on a concept known as psychological time, by which we understand and experience the world around us, including music. Psychological time flow is elastic; we use expressions like ‘time drags’ or ‘time flies’ in order to describe our perception of time passing. Durations can only be estimated or ‘felt’ when compared with other remembered durations.

Both psychological and absolute time share two inherent characteristics; time passing and duration. Therefore each way of experiencing time relates to the other. Their relationship raises the questions of how different ‘absolute’ durations behave in certain compositional contexts, and what are the factors that affect the elasticity of the perceived flow of time in music.

2.2 Physical Timescales

Absolute time can be divided into several timescales, which I will be referring to as physical timescales, starting and ending with ideal mathematical durations, those of infinity and its opposite of infinitesimality. According to Curtis Roads (2001), in between those two extremes there are seven additional scales. The supra timescale extends beyond the musical composition, into months, decades, centuries and larger divisions of time. The macro scale is normally associated with musical form and extends from minutes up to several days in extreme cases. The meso scale comprises the musical phrase and is measured in minutes or seconds; this is not clearly differentiated from the next scale, which is the sound object, the basic unit of musical structure. Evidently, the timescales found in musical pieces are separated because of their function, rather than their measured duration. The sound object scale, which can also be measured in minutes or seconds, is followed by the micro scale that comprises durations extending from the threshold of timbre perception (several hundred microseconds) up to a short sound object. The micro timescale is a special category, since it can transform itself into one single object, or many – an accumulation of single objects that is perceived as a cloud, which becomes a single sound object in itself or a gesture through time. Roads mentions two more timescales, the sample (referred to as the 'atomic level of digital systems') and the subsample, which is measured in nanoseconds, durations too short to be perceived.

Durations that make sense in music start from the threshold of timbre perception and go up to the macro timescale, which is commonly connected with musical form. Composers sometimes employ timescales that exceed those limits. However, durations less than the micro timescale are musically usable only as mass events and durations that last more than the threshold of human body fatigue can be experienced only in part and not in their entirety. There are many examples of pieces that use the supra timescale. One of them is Jem Finer's *LongPlayer*, a generative composition that has run as a computer program (i.e. a set of instructions in a computer) in London since the 1st of January 2000 and is designed to play for one thousand years. Another example is a piece by John Cage called *As Slow As Possible*, which is currently played in Germany on a church organ and is designed to go on for 639 years. We can only experience a small part of those pieces of music, so we are physically able to perceive a fraction of them in the more accessible macro scale.

Even the macro scale, as defined by Curtis Roads (i.e. sometimes extended to several days), may surpass the limits of body fatigue. Composers have found a solution to presenting excessive macro durations to audiences by dividing their lengthy pieces into several sections that can be listened to at intervals. For example, Karlheinz Stockhausen's *Licht* (*Die sieben Tage der Woche*)[21] is an epic work divided into seven operas that last in total c.29 hours.[22] However, in cases where the duration of the piece is not as excessive as in *Licht*, we should consider that there is one further boundary, an important border after which we cannot use our concentration to fully understand and appreciate musical relationships. In relatively long pieces, some people may need to stop listening for a short period of time and then come back to the composition and continue listening, thus dividing the piece into manageable temporal slots. Consequently, long durations that belong to the macro scale cannot be perceived in their entirety. As a result, we need to consider that the macro scale is divided into two parts. The *lower macro*, which is the timescale that is perceivable in its entirety, it depends on the listener's individual limits of concentration, and may comprise either the whole or part of the musical form; and the *upper macro*, which extends to the entire duration of musical form, and it may exceed the human capabilities of continuous concentration. The amount of time that a person can concentrate on a single activity is called 'attention span' (Princeton University 2005). Depending on the strength of a person's attention span, there may come a point in time where all or part of the information transmitted by a musical piece is not registered or effectively processed by that person. Since the ability to concentrate varies from person to person, a piece that belongs to the lower macro scale for one listener, may belong to the upper macro scale for another.

Because of the subdivision of the macro scale, another problem emerges; the upper macro scale cannot be differentiated from the supra scale, because both comprise long durations that cannot be perceived in their entirety. It becomes apparent that dividing musical information into timescales is not a straightforward matter. Timescales can vary, not only according to the duration of a piece of music, a phrase, a gesture, or a sound event, but also according to other factors, such as the function of a sound in a

[21] *Light* (*The Seven Days of the Week*); it was composed between 1977-2002.

[22] *Licht* can be considered as one piece divided in seven sections, because its structure, based on Stockhausen's concept of 'superformula', stretches to include all seven operas. The 'formula' is Stockhausen's principle of organisation, comprising series of elements at different levels. The opera cycle *Licht* is planned around three principal formulas, associated with the three main characters Michael, Lucifer and Eve. The three formulas, which have different characteristics, are combined in the superformula, the basic statement of which extends throughout the whole work, so that each opera represents only a section of the superformula (Pasoulas 2001).

musical passage, or the attention span of individual members of an audience, as explained above.

Taking into account the difficulty of timescale division, we can conclude that listeners are only concerned with durations that make sense to them, which comprise the roughly defined scales of lower macro, meso, sound object and micro. The rest of them, i.e. supra, upper macro and the smallest sample and subsample, only have a theoretical value for the listener (although they can be used practically by the composer) and remain outside our observational limits.

2.3 Psychological Timescales

It has been mentioned in the preface of this chapter that sometimes time flies and sometimes it drags. Listeners perceive the observable timescales and the durations they comprise in different ways. Two sounds or two pieces of music that have identical actual durations – if measured in absolute time – may be experienced as having entirely different psychological temporal spans. If we play two sounds of equal actual duration one after the other, it is possible to perceive one of them as longer than the other. When we compare relatively short sounds (a few seconds each), the difference of their psychological temporal spans is negligible, no matter how spectrally different those two sounds are. When comparing contrasting sounds, for example a spectrally fast-changing texture followed by slowly evolving Shepard-Risset tones, the difference between their perceived durations becomes more pronounced when those sounds are long.[23] In cases where long sustained sounds are involved and there is little or no indication of long-term evolution, the listener becomes less aware of time passing. In such cases, time passing can be experienced through our biological clock, our physiological or psychological changes, or through changes in the environment. However, if there are no cues or clues in the sound itself to make us aware of its approximate physical duration, the sound in question seems continually long, or even static.

[23] Please refer to sound examples Audio 2.1 and Audio 2.2, in the accompanying data CD. The first pair of sounds comprises short durations, while the second consists of long sounds (30 sec each), as described in the main text above.

In addition to experiencing equal absolute durations as being uneven when sounds play in succession, we can experience diverse psychological durations when equally extended sounds play simultaneously, by directing our attention selectively to various layers of the sound structure. As an example, I will refer to a generative piece of music called *Turing 2*, composed by Anthony Moore, which was played at Goldsmiths College University of London in January 2005, during a talk by the composer. As a generative work, the piece is process-based; consequently, the music is not fixed and every performance gives a different result. On that day, the composition was not performed live; instead, we listened to a recorded performance of the piece that lasted around 50 minutes. There were three distinct layers of sounds. The upper layer, where most activity was taking place, consisted of hammer-like sounds with a relatively fixed tempo range; the tempo was continually changing, but remained within a pre-defined threshold. The middle layer had rather long, buzzing sounds within a low range of frequencies. And, the third layer was almost pink noise-based, continuous, mimicking the sound of a ventilator. The piece evolved slowly, until it reached a point of a rather vigorous activity of the hammer-like sounds, which signalled a return to the original state, and the piece continued in a similar manner. Three returns to the initial state were the only indication of time passing, although it was not apparent whether they were equally spaced within the structure of the piece. After about 15 minutes or so, I could not tell whether the piece was in its 25th or 40th or 50th minute. Even more interestingly, when I alternated my focus among the three layers, I had different experiences of time passing. Concentrating on the hammer-like sounds gave me the feeling of a quicker pace than when focusing on the second layer with the long buzzing sounds; whereas directing my attention to the ventilator sounds gave me the impression of near stasis. Naturally, my brain was constantly comparing the layer on which I was concentrating with the rest of the layers that were still there, although in the background of my attention. Because of this subconscious comparison, a layer would seem to run faster or slower when matched against its neighbouring layers, and consequently a time interval filled with music would accordingly seem shorter or longer.

This example points to a series of questions which are crucial when composing a piece of music. I perceived three layers at the same time, three different layers of identical actual temporal span, which each nevertheless gave a different impression of duration. When all layers are given a similar weight of attention – if this can ever be possible, (a) is there one timescale that dominates another? Or (b) do we perceive them separately, with no reference to their intrinsic actual duration? And, (c) was the comparison among the layers the only factor that changed my time perception?

Question (a) has at least two possible answers. First, a timescale dominates when the listener pays attention to it; and second, a timescale attracts the listener's attention if it contains important sonic material, although we cannot predetermine which characteristics sonic material must have to be important, as that depends on context. Questions (b) and (c) need further investigation, which will be attempted during the rest of this chapter.

2.4 The Psychological Time Continuum

Before delving into questions regarding relationships between different layers of sounds (or rather, between segregated auditory streams), we need to understand what makes us perceive a single sound as being long or short, and also whether there is any connection between the perceived feeling and the actual duration. When talking about psychological durations, I am tempted to substitute the word 'feeling' for the word 'duration' (or 'temporal span'). The reason is that when we discuss psychological time, it is not possible to use a metric system (e.g. two minutes, or ten minutes long). We substitute a qualitative for a quantitative model when we express our feelings about perceived durations and time passing (e.g. it feels long; it is hasty; it is monotonous). Hence, my temptation also extends to replacing the words 'long' and 'short' with 'haste' and 'languor'. The word 'languor' does not necessarily point to a negative feeling, as it indicates a feeling of lack of interest or energy (which may lead to boredom); it is also a relaxed and comfortable feeling, as well as showing inactivity and an unusual lack of energy.

Consequently, instead of dividing psychological time into a number of timescales, I propose a continuum as shown in Fig. 2.1, where haste and languor occupy the opposite poles. The listener subconsciously selects different positions on this continuum, resulting in differing perceptions of time passing and interpretations of actual durations. At the exact centre of the continuum there is balance, where actual (measured) duration equals psychological (perceived) duration. When the selection point tends towards languor, the listener perceives a time interval as being increasingly longer than it actually is; the opposite occurs when the selection point tends towards utter haste.

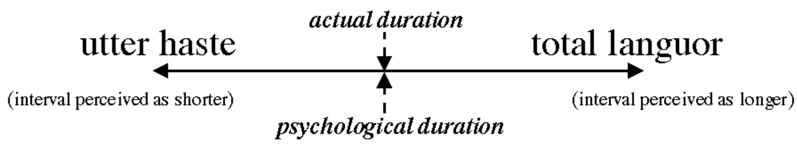

Fig. 2.1 **Haste/languor continuum.**

Absolute time represents objective durations which, as was demonstrated in section 1.1, rarely represent subjective durations perceived by separate individuals (see footnote 4, p.16). For this reason, the central point of the psychological time continuum is hardly ever reached at the same time by all members of an audience, even when it appears that they share neutral feelings of time passing.

2.5 Factors Influencing Time Perception

Perception of durations and time passing is influenced by several factors that emerge from music, belong to a listening environment, or exist as inherent conditions of the listener. Figure 2.2 shows the combination of these factors, divided into two main categories, those directly related to music and those that originate outside it.

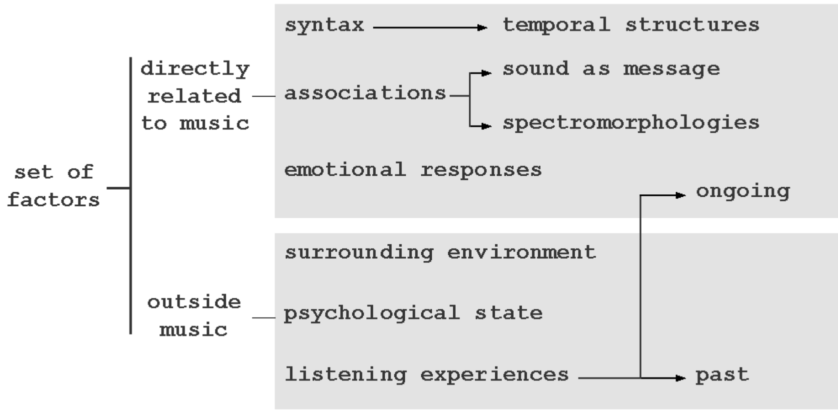

Fig. 2.2 **Set of factors.**

The factors are analysed in subsequent sections. Those related to music are the temporal structures at both local and higher levels, temporal associations of sounds carried through their semantic meanings and also through their spectromorphological characteristics, and the emotional responses of the subject to the object of perception. The factors originating outside music comprise the surrounding environment at the time of listening (which includes the aural, visual, haptic, gustatory and olfactory environments), and the psychological state of the listener. In this diagram, listening experiences are divided into two kinds. Past experiences originate outside ongoing music listening, arising from cultural tendencies, education and autobiographical experience. Ongoing cumulative listening experience is directly related to music because syntax and messages as well as emotional responses evolve with renewed meaning (depending on the analytic competence of the listener), formed by the accumulated experience of their context. A detailed consideration of visual, haptic, gustatory and olfactory spaces is beyond the scope of this thesis, and for this reason these factors are not discussed further. However, they are recognised as playing a role in shaping the time perception of the listener, and short examples are presented when appropriate. Some of the above factors can be further expanded and include supplementary factors. In the case of temporal structures, an auxiliary factor is complexity; and in the case of ongoing listening experiences, expectation is emerging as a supplementary factor. These auxiliary factors will be discussed in chapter 3, where temporal processes will be explored.

This combination of factors can be regarded as a group of filters that colour the temporal information of a musical piece. Because these filters may be adjusted uniquely for certain groups of people, or indeed for each person, subjective durations perceived by separate individuals may differ to various degrees. Before considering the idiosyncratic performance of the filters, we discuss their nature and the influence each has on the listener's perception of time.

2.5.1 Surrounding Environment: The Five Senses

One of the factors that influence our perception of time is the surrounding environment at the time of listening, which consists of the spaces recognised by our five senses. First, the surrounding *aural* space contains sounds that are heard at the time of listening, which do not belong to the music itself – the music is supposed to be at the centre of our attention. The aural space, which can also be called 'sounding environment', influences what the listener perceives from the music being played, by interfering with the flow of time that belongs exclusively to that particular piece of music. For an illustrative example I refer to Martin Stig Andersen's *Ring Road, Night in the Park*, a sound installation for electroacoustic sound for four channels, composed in 2005. The composition comprises sounds only below a particular low frequency,[24] which means that the piece is susceptible to unwanted high frequencies coming from the environment. In performances, the piece is played in a loop and listeners walk in and out of the space as they please, as is normal with sound installations. During a personal experience of a performance of *Ring Road*,[25] sounds coming from the environment that contained high frequencies were very noticeable, sometimes obtrusive. The sound of people walking in and out carried certain rhythms, which did not merely intrude on the piece, but the pace they imposed interacted with the pace of music. Since the composition lacks high frequencies, the footsteps stood out and at some points their tempi prevailed over those of music. However, there were many ambiguous moments, where the music seemed to borrow temporal elements from the outsider sounds and vice-versa; walking, as well as subtle noises of clothing, although they never lasted for long, seemed to become musicalised. Through superimposition of rhythms, as in this example, the sounding environment can

[24] The average spectral contour of the piece (measured with TC Electronic Assimilator) shows a maximum frequency of c.1.5 KHz (information supplied by the composer [Andersen 2006]).

[25] Presented on 16 December 2005 at City University, London.

influence the temporal rate of the piece; the listener cannot avoid comparing subconsciously two tempi heard simultaneously, one coming from the music and one from external causes. This subconscious comparison results in an emphasis on the temporal rate of our current focal field. One can speculate that in those cases where a second oscillating system appears along with the pace of music (e.g. rhythm of footsteps), entrainment occurs in our hypothetical internal pacemaker, trying to bring the two oscillating systems together.[26] Consequently, the slow oscillating system accelerates perceptually, whereas the fast one decelerates; the degree of acceleration/deceleration depends on the strength of each system and on how far apart these systems are. The listener can experience a change in pace of sound information belonging to the focal field, whereas the secondary oscillator remains unnoticed. As might be expected, the existence of diverse oscillating systems is context dependent, and might occur in situations where external audio events interfere with the music.

The surrounding environment also includes the *visual* sensory data that we receive at the time of listening. Visual information can greatly affect the perception of time in a musical piece; this influence may occur due to a superimposition and likely interaction between the visual and auditory timescales, and may result in a fused perception of time. For example, in audio-visual installations, a video with quick image changes interacts with the pace and rates of change of the music. Depending on the focus of the audience's attention, a fast visual tempo may either quicken a slow music tempo (while focusing on music), or emphasise the contrasting tempo of the musical piece (while focusing on visual information).[27] In the latter case, a slow piece of music may seem even slower, and therefore longer than it actually is, when compared with a fast visual tempo. The entrainment process, described in the

[26] The entrainment process, in relation to listener's attention, is analysed in Jones 2004. The hypothetical internal pacemaker is discussed in many writings, since at least the 1920s. Two early contributions on the subject can be found in: Francois M. (1927). 'Contribution à l'étude du sens du temps. La témperature interne comme facteur de variation de l'appréciation subjective des durées' in *L'Année Psychologique*, Vol. 27, pp. 186-204; and, Hoagland, H. (1935). *Pacemakers in Relation to Aspects of Behavior* (Wearden 1991: 60). In brief, the most prevalent timing theory today, the scalar timing theory, assumes that psychological time is produced by an internal pacemaker that emits pulses at some rate which follows the pace and changes of external stimuli.

[27] There may be certain points in a composition, where the attention of a person is drawn towards one of the two media. Reasons may vary; an interesting passage in either video or music can draw the attention to one medium (information from the other medium becomes secondary). Sometimes, extra-musical information may draw the attention to one medium; for example, knowing that Stockhausen wrote the music for the short film *In Absentia* (directed by Brothers Quay, 2000), certainly draws the attention of some people to the music rather than to the visual information.

previous paragraph, may still explain the reasons for this selective acceleration or deceleration. Consequently, rhythms suggested by visual data affect our listening perception and sense of duration and they can interact constructively or destructively with the pace of a musical piece.

The attention that listeners pay to absolute time passing relates to their attention to the visual and/or the sounding environment. If a clock with visible hands were displayed in front of listeners/spectators, or if the sound of a clock were heard at the same time with a piece of music (perceived as coming from an extra-musical source), it would make people pay attention to the absolute time passing. Consequently, perception of durations and pace of music would be influenced (either through visual or auditory stimuli). This may seem peripheral to music listening, but it can be used creatively in concert situations.[28]

Although the focus of this thesis is on acousmatic music and the interaction of auditory timescales, the account of the influence of the environment on music would be incomplete if I did not refer briefly to the rest of our senses that stay active throughout the duration of a composition. Although it is not clear how temporal information related to touch, smell and taste may influence our perception of time during music listening, information coming through these three senses might operate in distinct timescales, different from those of hearing and vision. This information, involved in a listening context, may have certain parameters that can be fine-tuned to emphasise particular qualities in electroacoustic music, either in acousmatic situations, in installations incorporating electroacoustic sound, or in concerts with live performers. We can envisage comparable examples of rhythms and durations between auditory, visual and tactile senses (e.g. a crackling sound, a flickering image and a tactile vibration) which may well be operating in different timescales, but it is difficult to find equivalent patterns in olfaction and gustation.

[28] My composition *Chronos* incorporates a clock, which is displayed in front of the audience and is revealed near the end of the piece. This will be analysed in a subsequent chapter.

There is currently continuing research on haptic devices,[29] which may prove to be useful tools for the composer. Haptic devices intended for mass production also arrive from the domain of computer games.[30] Such devices can be used to exploit the tactile dimension in works that engage the electroacoustic medium, such as interactive sound installations; users, by participating with their sense of touch (e.g. when moving the handle of a Novint Falcon controller in a hypothetical interactive setting), would combine aural and tactile perceptual experiences. Haptic devices can introduce durations and rhythms through dynamics, motion and vibrations, which would interact with auditory timescales. The gustatory and olfactory spaces, related to taste and smell respectively, have hardly been explored compositionally as yet, although there are accounts of artists and composers that have used either spaces in their works. For example, *Fado*, a Canadian artist-run centre for performance art, organised a festival in 2003, focusing on scents.[31] The olfactory dimension has a potential use in sound installations, since a system that emits different smells and can target audiences at different points in time, has become commercially available.[32] Devices like these can be used to mark important turning points in a piece, thus creating fluid durations that work in conjunction with auditory timescales. Since smelling cannot have an abrupt beginning and ending, durations created by scents are fluid. A sound installation piece I created in 2003 (called *Chewy & Crisp*), employed the gustatory space to intensify the impact of the recorded sounds. The piece also transfers the listener to the immediacy of the present moment, and self-awareness, using the dimension of taste to impose temporal information on the participant. During the

[29] For example by Joseph Luk and his team at the University of British Columbia in Vancouver (Luk et al. 2006), Vincent Hayward at McGill University in Montreal and Hiroyuki Kajimoto at Tokyo University (Marks 2006).

[30] As an example, Novint Technologies have produced the ‘Novint Falcon’, an interactive controller for computer applications, which has become commercially available since January 2007. It claims to let users feel ‘weight, texture, shape, dimension, dynamics, 3D motion and force effects’ (Novint Technologies Inc. 2006) by employing a set of motors which apply forces to a handle to create resistance in a 3-dimensional field (see Appendix III).

[31] The festival was called *Five Holes: ReminiSCENT* and ran from September 18 to 21 in 2003. The projects presented involved listening to soundscapes while smelling various scents (Fado 2003a and b).

[32] The Fragrance Communication (Kaori Tsushin) system developed by NTT Communications, uses special scent-emitting devices which can be programmed with information retrieved from the Internet. NTT Communications offer commercially a small version of that system which, as they claim, can be used in multimedia applications that combine visual or audio content with fragrances (NTT Communications 2006).

experience of the installation, real and musical time are equally important, as information from both interchanges and blends.[33]

Touch, taste and smell add further knowledge about a sound source. Recognising familiar sounds and connecting them with specific themes and events is frequently based on knowledge of their sources, i.e. information about size, material and tactile quality of sounding bodies, and possibly environmental contexts (and their associated scents). Consequently, temporal information that is linked to one of the senses (e.g. tactile) can be carried along to another sense (e.g. hearing).

2.5.2 Temporal Syntax: Local and High-Level Time Structures

There are several factors directly related to music that influence our perception of time passing and estimation of duration (see Fig. 2.2, p. 37). One of these factors is the reception of structural organisation that carries temporal information, such as suggestions about pulse, speed and duration. To enable our understanding of how structures operate and communicate temporal information, we must also analyse temporal syntax.

Syntactical arrangements form time structures at the local level, and at higher levels. In this discussion, the local level constitutes the spectromorphological structure of individual auditory images,[34] which form coherent entities. Higher-level time structures comprise organisations of two or more sonic entities, which may be separate, or overlap in time. In a more detailed categorisation, higher levels could be further refined by identifying degrees of relationship among various groupings of contiguous events and concurrent layers.

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[33] Details and the programme notes of the piece can be found in Appendix IV.

[34] According to Pressnitzer and McAdams, auditory image is the "… psychological representation of a sound entity that reveals a certain coherence in its acoustic behaviour" (2000: 49). Auditory images are formed by using the principles of auditory scene analysis, a process whereby the auditory system breaks down incoming sound information into groups; sound characteristics are bound together by various factors across spectrum (simultaneous integration) and across time (sequential integration) (ibid: 50; and Bregman 1999: 641-662).

In electroacoustic music, the difference between high-level structures and spectromorphologies at the local level is not always apparent, because entities are sometimes indistinct and therefore difficult to perceive as separate events. Sound characteristics that belong to different events may bind, so that auditory streams and vertical images (spectra) are reorganised. Consequently, related spectromorphologies behave collectively as one texture or gesture, or new spectromorphologies are formed, which do not necessarily correspond to the durations of the individual events.[35] On a shorter timescale, the agglomeration of microsounds may produce one larger object. Localities may cluster in dense formations (similarly to fusion of larger events), and saturate to a point where they are not be perceived as separate structures, but instead form one entity, a local structure constituted of coalesced smaller entities. Figure 2.3 shows this ambiguous relationship between local- and higher-level structures. Accumulation of local structures on one timescale may form a structure at a higher level, which, after becoming very dense, saturates and transforms into another local structure of a larger timescale.[36] The cycle may continue until the point where saturation is so high that quantity, that is, number of localities, no longer seems to increase. Congestion of localities may then lead to one developing texture.

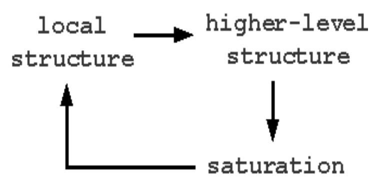

Fig. 2.3 **Relationship between local- and higher-level structures.**

At both local and higher levels of structure, we can distinguish two types of organisation, one based on *discretisation of time*, and the other on *processes of change*. Discretisation involves change articulated in successions of discontinuous units, as opposed to more continuous processes of change. We can identify two different kinds of discrete temporal organisation: periodic repetition and erratic behaviour.

[35] For example, characteristics near the end of one event may bind with characteristics from a second event, forming a spectromorphology of a duration different to both events.

[36] This probably explains why I use the word 'local' instead of 'low' structure; it would be confusing if higher-level structures led to low level.

Periodic repetition entails the immediate recurrence of exact or similar durations, or groups of durations that may form rhythmic patterns. Repetition of patterns may be recognised even with approximate durations, because there is a range of acceptable deviation, within which listeners still perceive 'the same' rhythm (Huron 2006: 191). Rhythmic patterns are formed when durations are grouped together; this grouping is marked by boundaries, which are identified by changes in characteristics of sounds, or by the presence of contrasting sounds (or silence) between separate groups. Repeated time intervals do not necessarily have identical aural content, although significant differences (e.g. in intensity, or frequency content) affect the perception and comparison of adjacent durations.[37] Spectral and dynamic elements may change, while at the same time durations and their established relationships repeat periodically. Although repetitions may develop in a relatively simple manner and have few changes if any, they can also evolve into less or more complex rhythmic relationships. Organisations of patterns may also evolve, expand and form adjacent streams of rhythms, running in parallel with their original source-stream. Arborescences may grow from one source-stream, and gradually disappear or transform into a different kind of organisation (see Fig. 2.4).[38]

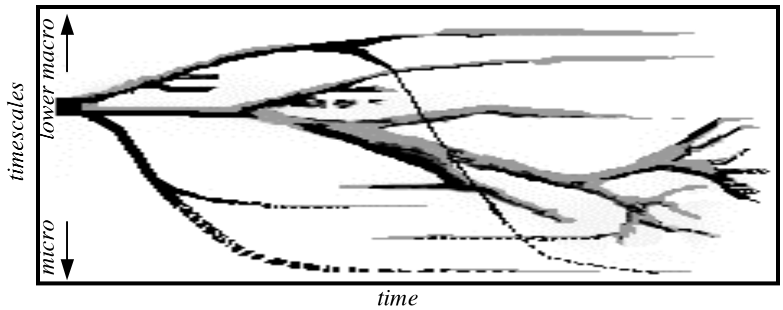

Fig. 2.4 **Arborescent temporal structures.**

Figure 2.4 shows hypothetical arborescent structures forming concurrent timescales. The thickness of arborescences indicates spectromorphological complexity of streams that constitute corresponding timescales. The figure shows how spectromorphologies may grow into auditory streams that occupy the same timescale (a branch), where part of the original sound undergoes a rhythmic development (dark areas), while another part demonstrates a more fluid, non-discrete motion (light grey

[37] This will be explored further when discussing complexity of stimulation and its impact on temporal judgements (chapter 3, section 3.6).

[38] The idea of timescales as arborescences has been influenced by Xenakis' method of constructing melodic lines and pitch contours based on tree-like shapes, used for the first time in his piano piece *Evryali* (1973) (Varga 1996: 88-91; Squibbs 2002: 100-103).

areas). Both parts exhibit the same rate of change (although expressed more sharply in the 'dark areas'), which binds them together in the same timescale, and may or may not segregate perceptually, depending on factors influencing auditory stream segregation.[39]

Rhythmic relationships may involve the succession of strong and weak elements (strength depends on context), and can also be articulated by the timbral content and melodic profile of sounds. Short periodicities that form intelligible rhythms are apprehended in the intermediary timescales, i.e. those of meso and sound object. Long periodicities that make up sections require long-term memory in order to be sensed. Perception of periodicities on a micro timescale depends not only on the degree of separation between successive microsounds (see section 1.3.1), but also on the shortest interval of rhythmic perception, known as *tatum*, which according to Justin London is c.100 ms (2006). IOIs shorter than the *tatum* and longer than the forward masking threshold, that is, between c.100 ms and c.30 ms, are perceived as trills at higher levels of structure, or as oscillations in local structures. Discretisation of time in microstructures may blur, thus causing a congestion of events to move from the micro to a longer timescale.

Continuous periodic repetitions of time intervals, involving the recurrence of the same recognisable sound,[40] may direct the mind to inner structural details. The apprehension of such details will depend on the degree of listening concentration. Exploration of these details is facilitated by cumulative listening, which allows the progressive assimilation of information regarding the content and arrangement of auditory images and their interrelationships. Schwarz, in analysing Reich's early phase pieces, notes that "… the lengthy contemplation of small details is in itself both consciousness-altering as well as time distorting" (1980: 378). With repetitive sounds, the listener is likely to experience a sense of stasis, invoked by the structure of material that seems to lack progression and direction towards a goal. Repetition seems

[39] Factors promoting sequential grouping include temporal and frequency proximity, fundamental frequency, timbral similarity, intensity and spatial position (Bregman 1999: 649; Pressnitzer and McAdams 2000: 51). In addition: Instances of arborescences are included in my compositions (e.g. in *Chronos*, at c.1:55 – 2:48), to be presented and analysed in the appropriate chapter.

[40] We must allow for the possibility of some characteristics to be slightly changed, without smearing the effect of repetition.

to suspend time; this is because experiences are relived through a cycling process, by revisiting moments that have just passed.

Erratic temporal behaviour occurs when discontinuities[41] create asymmetric temporal chunks. Juxtaposition of sound objects of dissimilar durations, irregular shifts in spectromorphological characteristics of sounds, densities and textures produce temporal segments of unequal duration. Transitions from one temporal chunk to another can be anything between smooth and coarse, and the degree of refinement is determined by the contrast of the temporal chunks' contents. Elisions of short durations at local level result in fluid or bubbling textures, while coarse transitions may fragment the sound. On intermediary timescales, the proximity of temporal chunks to the present moment means that we can easily follow any changes as they occur. Consequently, it is relatively easy to recognise erratic organisation, even when there are smooth transitions from one temporal chunk to the next. In these cases, aural images are constructed in the specious present, and in our short-term and most recently stored long-term memory. However, erratic temporal organisation on large timescales must display coarse discontinuities to be perceived as such. On the micro timescale, erratic temporal organisation has similar effects to periodic repetition. That is, if microstructures are very dense, they may blur and create larger events, turning their high-level structures into local-level spectromorphologies, through saturation (refer to Fig. 2.3).

The second type of temporal organisation is based on *processes*, which indicate change[42] and are often based on continua. Assemblages of sounds, or spectromorphologies that undergo a change regarding their volume,[43] e.g. a swelling of their dynamic content, a gradual filtering of partials, or a thinning of frequency density, might mirror a change in the characteristic behaviour of the time structures involved. This is because time experiences relate ultimately to the occurrence of events (section 1.3.1), and also because the aural content of time intervals is

[41] Discontinuities, in this case, are interruptions of structures.

[42] This does not imply that *discretisation* of time has nothing to do with change. As stated earlier in this section, although discretisation involves change through recurrence or discontinuities, it is based on 'units', and so requires comparison of different durations to understand change. On the other hand, *processes of change* involve continuous (that is, not in discrete steps) evolving situations.

[43] In psychoacoustics, the volume of sound is the psychological measure of its magnitude, that includes many parameters, such as spectral content, duration, loudness, and spatial properties (Truax 1999c).

connected to the perception of time, since it affects the estimation and comparison of durations (see footnote 37, p. 44). Certain types of spatial processing can also have an impact on time structures, as it becomes apparent with the so-called *Kappa effect*, which has been studied by psychologists in relation to the perception of time.[44] The Kappa effect states that differences in panoramic distance have a direct effect on duration estimation; when the horizontal distance between two successive sounds increases, then the estimation of duration between them also increases (Sarrazin et al 2004; Fraisse 1984: 14).[45]

Processes of temporal change may also have an effect on listeners' expectations. As an example, we may look at the continuum *acceleration/deceleration*, which is related to rate of progress and motion. Variable speed of presentation of sounds is used to create various gestures, and sometimes also plays with listeners' anticipation of events. Slowing down a succession of discrete sounds leads to the expectation of a consequent, e.g. the arrival of a final stop, or a pause (a hiatus), or a breakout of a new event or string of events – deceleration cannot continue forever. Expectation also elongates the psychological duration during time passing, in much the same way as "a watched pot never boils" (Fraisse 1984: 23). This 'pot' effect may add to the impression of temporal prolongation during slowing down, and also during constant rates, but the same effect does not seem to work in the same way with acceleration.[46] Increasing the rate of progress gives the impression that a consequent is fast approaching; acceleration increases momentum, and, depending on the sounds and the degree of involvement of the listener, it may also increase adrenaline levels. It might be possible to use other processes to induce a similar effect on listeners' expectations;

[44] First described in 1953 by Cohen, Hansel and Sylvester (Cohen et al 1953).

[45] The opposite is the *Tau effect*, whereby durational differences have a direct effect on estimation of distance; increase of duration between two spatially separated sounds results into increase of estimation of their distance (ibid.).

[46] I conducted several sound experiments while writing this section, trying to see if acceleration has the same effect of elongating time. I used a repetitive sound at a steady beat, that arrived at a different sound event after a fixed time interval. Then, the same repetitive sound was played at an increasing speed, and resolved into the same event as before, after the same fixed duration elapsed. Although the trials were inconclusive, the acceleration gave me the impression that I was moving faster towards the goal, and I did not even pay attention to time passing, which was what I expected. Knowing that the durations are the same in both cases may have destroyed the trial. It may work differently when the listener does not know the exact durations, and is not required to judge any durations, which is normally the case when listening to a piece of music. Perhaps time elongation should be recognised by paying attention to its effects, i.e. to the degree of detailed information that can be recollected after the event finishes, because the amount of information influences the estimation of durations (Fraisse 1984: 19-22). This point is made clearer in the next chapter, where complexity of stimulation is examined.

for example, a gradual thickening of texture and an increase in dynamic level might lead to the expectation of a consequent, depending on context. Sometimes, increasing speed may gradually lead to new textures, as sound objects overlap and their spectromorphologies merge. In such cases, temporal acceleration seems to settle down, arriving progressively at steadier pace.

The categorisation of time structures helps us understand the successful prediction of onsets in accelerating and decelerating sequences. David Huron (2006: 187) claims that periodicity is not necessary in order to form temporal expectations, presenting the accelerating rhythm of a bouncing object as one of his examples. However, by analysing the gesture into its time structure components, that is, discretisation and process of change, we are able to see that periodicity is one fundamental aspect of that gesture. When periodic, and therefore predictable, events are combined with accelerating curves that do not change direction irregularly and in a potentially surprising manner, they result in predictable gestures, as shown in Fig. 2.5 (a). In (b) and (c), unpredictable gestures are shown to arise from a combination of a periodic rhythm with an irregular curve, and an erratic rhythm with a regular curve respectively.[47]

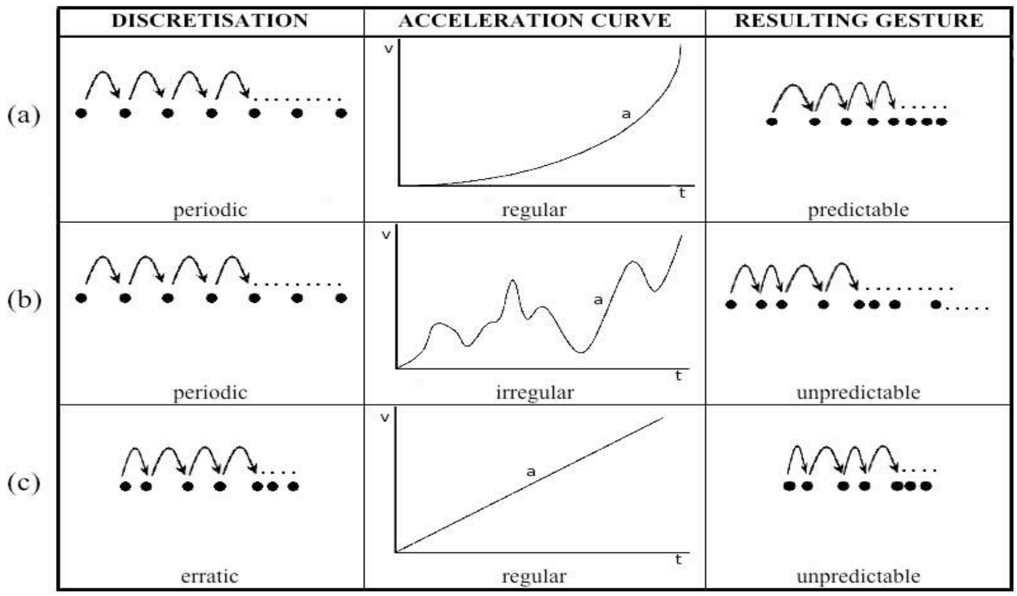

Fig. 2.5 **Acceleration curves and resulting gestures.**
Acceleration (middle column graphs) equals the change in velocity (vertical axis) divided by the change in time (horizontal axis).

[47] Mari Riess Jones (2004) examines attention and timing extensively. She maintains that successful prediction of onsets is achieved by phase correction in reactive attending, which is the "… time shift of attentional focus … which occurs in response to an expectancy violation" (ibid: 61).

Note structures, spectral and melodic profiles of sounds will not be analysed here, but it should be mentioned that both work in conjunction with temporal structures, in the same (or similar) way that other parameters of the sound do. Melodic lines and melodic profiles of sound images may either follow discrete steps, or appear as continuously changing gestures. The general contour and the proximity of frequency zones or collective notes have a decisive effect on the temporal perception of a passage. When pitch curves are combined with acceleration or deceleration, the effect of slowing down or speeding up seems to be more pronounced.[48] In addition, a change in proximity of pitches, as well as in time intervals between onsets (IOI), reflects on a change in the perception of the temporal structures involved.[49]

In summary, we have seen that concurrent timescales can run as arborescences. Considering that on each timescale sounds could move at a different pace, and that arborescences could move apart and then meet again, we can speculate on the complexity of relationships among timescales. For the sake of simplicity and clarity, syntactical arrangements have been considered as forming two basic kinds of time structures: at local (one sound image), and at higher levels (more than one sound images). At both possible settings, two types of organisation may occur, one based on discretisation of time and the other on processes of change. In the context of electroacoustic music, the distinction between local and higher levels can be ambiguous. In addition, types of organisation most often mix together in situations where periodicities may turn into erratic behaviour and the opposite, undergoing a number of processes of change at the same time. Temporal structures that we experience in music seem to be inseparable from their context. However, a distinction between different types of time structures may help the composer to construct, and the analyst to examine them in greater detail.

[48] This technique has been employed in my composition *Chronos*, which is discussed in the last chapter.

[49] This is further investigated in section 3.6, when examining stimulus complexity and time judgments. See especially notes on rhythmic and melodic complexity, as well as on harmonic complexity.

2.5.3 Temporal Associations, Semantic Content, and Source Bonding

The previous section (2.5.2) on temporal syntax was concerned with the poietic process as well as the esthesic. However, when examining temporal associations, the focus shifts towards the esthesic dimension, where meaning is constructed upon reception (Nattiez 1990). Before venturing into temporal associations, this section describes briefly the relation between sounds and extra-musical associations in general.

Recognisable sound events carry extra-musical associations that draw on listeners' experiences. A sound coming from an identifiable source has an explicit meaning, or at least, a meaning broadly agreed upon by members of the same culture. This denotational meaning of the sound is the direct reference of the sonic image to the source-cause. For example, the sound of a clock points to the existence of a clock; the reference to the object 'clock' is the denotation that the clock sound carries. Listeners are able to detect the source-cause, because the sound reveals through its spectromorphology many properties of the medium with which it was produced. For example, the sound of a bell has several qualities of the source-cause imprinted: source and excitation material (metal, revealed through its resonance), size, thickness and heaviness connect the sound to the image of the bell. This denotational meaning is shared between the composer and the listener; in this case, the poietic and the esthesic meet. As Nattiez points out, '[…] denotation designates a constellation of interpretants[50] that are common to the poietic and the esthesic' (1990: 24).

Recognisable sounds can also generate sets of associations, connotational meanings, in addition to their denotational ones. The sound of a bell denotes the metal body of a bell, but it also connotes, at least for western society, some form of religious worship and connection with the sacred. Connotations may vary because of socio-cultural and personal associations, they can be related to particular generations and eras, and they are subject to change over time.

[50] According to Charles S. Peirce's philosophy of language, an 'interpretant' is the effect of a sign on someone who receives/interprets it (Oxford English Dictionary). Nattiez follows Peirce's definition (op.cit.).

Recognisability of source-cause is not always straightforward, because there are different degrees of source bonding (Smalley 1997). The less a sound appears to be connected with a known source-cause, the more ambiguous the denotations are, and the more the connotations are left to be influenced by the imagination of the listener and the particular context of a composition.

The previous section 2.5.2 dealt with temporal qualities connected with musical syntax, which, in summary, include timescales, durations, rhythms, metre (when it exists), tempi, density, order (or succession), and change. However, temporal qualities are not only connected with musical syntax, but can also be suggested by particular sound images through their extra-musical associations. In this case, it is difficult to name all possible temporal qualities, because temporal information depends on the sound. Different sounds may carry different temporal messages through association, or even none at all; it is the responsibility of the composer to select sounds that carry specific temporal associations. Three temporal qualities are introduced below, which certainly do not constitute an exhaustive list. They include *temporal setting*, *duration*, and *order*, and have arisen from examining particular pieces, and studying audio fragments composed specifically to test related hypotheses.

A *temporal setting* (i.e. a sense of place in time) can be suggested through association. For example, the characteristic sound of the nocturnal cricket that lives in Mediterranean countries connotes night; it implies night-time when one knows the sound and can therefore deduce the setting. This is a message that targets a specific group of people, who are familiar with this particular sound.

Two well-known compositions that use cicadas and crickets to connote day and night are Luc Ferrari's *Presque Rien* N^{o} 1 and N^{o} 2 (composed in 1970 and 1977 respectively). Ferrari uses the sound of these two species to differentiate between day and night, in addition to other associative material, such as scops owls in the night scene, and human activity in the day scene. In *Presque Rien* N^{o} 1, the cicadas connote day. They start at around 1 min and 10 sec in the second part of the piece and last for 13 minutes, until the end of the composition (the entire duration of the piece is about 20 minutes). In *Presque Rien* N^{o} 2, Ferrari presents crickets and owls to connote night. The crickets start from the beginning of the piece (quickly followed by the owl) and last for the entire first part, which is about 12 minutes long (the entire piece lasts for 21.5 minutes).

In the case of cicadas and crickets, as in many cases involving recorded environmental sounds, the temporal setting is incorporated into a *spatio-temporal setting*, because information about time *and* space is embedded in the sonic material. The temporal setting cannot be separated from its space. The two audio examples (Audio 2.3 and Audio 2.4) demonstrate the loss of temporal setting when space changes. In Audio 2.3, the original recording of a cricket is presented, with the environment left intact.[51] In Audio 2.4, the surrounding environment of the cricket is artificially removed in the studio, and only the isolated sound of the cricket remains. The nocturnal cricket is thus positioned in a virtual room, and the sound is deprived of its original environment. The resulting sound is more likely not to have been caused by a nocturnal cricket, but in this particular case, by sound synthesis.[52] When the spatial setting changes, any temporal connotations regarding the sense of time also change. There is no more 'open space', but 'enclosed environment'; no more 'night', but 'any time'; no more 'countryside' but 'laboratory'. Because the environment is missing, and we normally connect the sound of the cricket with open spaces and additional distant sounds, it is difficult for the listener to associate the isolated sound with a familiar place and time.

Temporal setting not only relates to day and night, but also to musical characteristics. Suggestive temporal information is carried by the *pace* and *momentum* implied by the associations of sounds. For example, recognition of day and night is associated with light versus dark, clear versus obscured vision, safe versus threatened or vulnerable, awake versus asleep, and busy versus calm. If we consider the last juxtaposition, we can detect similarities between busy/calm and opposite states of sonic material densities. In a music composition, a dense section combined with a sense of daytime (e.g. busy traffic) would imply a more hurried feeling than if the same section were combined with a sense of night (e.g. nocturnal crickets). A dense section combined with the relative tranquillity of night attempts to mix the opposites

[51] The original recording (Audio 2.3) of the crickets was made in Greece and has been downloaded from the Freesound Project website (www.freesound.org) for the purpose of the demonstration.

[52] Similarities to synthesized sound are due to regularity of grains and to narrow and concentrated frequency content between c.2.4 and c.3.4 kHz (see Appendix V).

'busy state' and 'calmness' (haste and languor), which present contrasting meanings. Contrasting haste and languor leads to the separation of timescales; that is, if there is *different* material representing each state. The listener then shifts attention between the two extremes – the two timescales do not support each other in terms of pace. One can think of sound environments, for example dense and distant crickets, where the association wins over density and the listener perceives a nocturnal tranquil scene. However, in this case, density and association are presented by the same material (crickets). My intuition is that density and a quick succession of events usually wins attention when it is juxtaposed with associative tranquillity (when each state is expressed by different material), unless the associations are particularly strong. There must be a thin borderline where the attention wavers between the extremes; this idea is tested and discussed in the analysis of my composition *Paramnesia*.

The second temporal quality examined here is *duration*. The sound image of the sea offers a suitable example, as it refers to the everlasting existence of the sea. Murray Schafer, in his book *The Tuning of the World* introduces the sound of the sea as an archetypal image, symbolic of eternity and ceaseless presence (1977: 170). However, the association between the sea and its lasting duration does not simply mean that the listener will refer to that particular temporal characteristic while listening to sea sounds. Whether a reference to the temporal quality of 'duration' is made depends on how this aspect is used in a composition, and whether the listener is drawn to that aspect. Suitable structures are needed in order to emphasise this symbolism of permanence. Examples of temporal associations regarding duration and the sonic image of the sea, where structures play a primary role in emphasising permanence, have been drawn from my piece *Vessel@Anchor*, and are discussed in the last chapter of this thesis.

The composer can effectively employ different techniques to allude to permanence, or to long duration. Hildegard Westerkamp and Barry Truax examined below, may not have used their techniques intentionally to suggest a lasting temporal quality, but their tactics can provide useful paradigms for our purpose.

Hildegard Westerkamp, in her composition *Kits Beach Soundwalk* (1989), uses narrative to guide the listener through different sounds recorded at the Kitsilano

Beach in Vancouver. The spoken voice not only narrates, but also influences the listener's perception of the soundscape by guiding the attention to various sonic images. It is not only the quiet splashing that gives the impression of a permanent soundscape, but also the distant sounds of the city; the listener, based on experience, postulates that the environmental and man-made sounds are still being generated and were being generated before the making of the recording. The attention is drawn to the city through the narrative at 1:29 minutes. At 3:03 minutes, the piece moves from the documented sound to the processed material in the studio. However, it still feels that the seashore does not disappear, and that the area of Kitsilano Beach continues to produce sounds very similar to those already heard in the piece. When the city sounds are no longer audible, Westerkamp informs the listener that this is because she has erased them in the studio: "Luckily, we have band-pass filters and equalisers. We can just go into the studio and get rid of the city; pretend it's not there…" (Westerkamp, 3:03 min; transcribed from the CD recording). Her statement makes a reference to the city sounds and reminds us that they have not really disappeared; her words emphasise their permanence.

Barry Truax's *Pacific Rim* (1990) follows a different strategy to allude to permanence. The piece is in four movements ('Ocean', 'Fog', 'Harbour' and 'Dragon'); the first uses time-stretched ocean waves, and creates resonances by overlapping different granulated versions and by using filtering techniques. Due to the continuous repetition of long gestures and the reference to sea, the listener (after having followed the piece for a while) does not expect any major changes. The first movement ('Ocean') has a perpetual quality. Perpetuity must have been in Truax's mind, as he hints in the analysis of his work; regarding the second movement, Truax states that "[t]he sustained boat-horn sounds are stretched even further to create a texture of seemingly timeless proportions" (1992: 38). It could be argued that this is the case for most of Truax's acousmatic pieces due to time-stretched material and the granulation techniques involved. However, his time-stretching technique combined with repeated long gestures are a matter of interest and importance when examining temporal processes. Environmental associations urge the listener to think beyond the sounds and make connections with the real world, and ultimately with the conditions of the source-cause in actuality. Combining these associations with prolonged structures emphasises the temporal span of the sounds and their state of continuity in the real world.

Associations can link successive sound events together and generate a temporal linearity, a narrative, through natural development and interrelations. Events may connect to each other in a *chronological order*, which is the third temporal quality addressed in this section. Associations bind material together temporally and are involved in the formation of timescales.[53]

However, maybe even more interestingly, associations can also disturb the chronological order of events by rearranging them. Disturbing the chronological order can be achieved by introducing flashbacks of previously presented material, by interjecting scenes that take the narrative back in time, or by quoting older compositions.

Francis Dhomont's *Cycle du Son* (1998) provides a suitable example of engagement with this temporal quality. The work consists of four acousmatic compositions; *Objets Retrouvés*, *AvatArsSon*, *Novars*, and *Phonurgie*. Dhomont employs material from older compositions (by Pierre Schaeffer, Michel Chion, and Pierre Henry amongst others), while making cross-references among his four pieces. Part of the sound material used in all four compositions is drawn from Schaeffer's *Étude aux Objets*. Dhomont states that "… these four pieces go through a process where they develop out of each other, question each other, and complete each other through allusions, commentaries, metonymies, and continuations" (Dhomont 1998, CD booklet). This type of recurrence forces the mind to visit past events, thus breaking the linearity of time; the perceived flow of time is affected by memory. At some points the quotations are clear for the initiated listener, but in other instances the allusion is obscured. Disturbance of order depends entirely on how familiar the listener is with the quotation, and on how obvious the quotation, or the flashback, or the interjected scene is made within the work. In other words, it depends on the clarity

[53] As has been stated earlier in the thesis, timescale is the period of time in which a sequence of events takes place. This binding of sonic images into timescales occurs in all three temporal qualities examined in this section: temporal setting, duration and chronological order.

of the material, and the listener's familiarity with it. Associating a series of sonic images with a particular past event, binds those images together.

Recurring themes and musical ideas that retain their identity even if modified (e.g. leitmotif) occur in most types of music, including electroacoustic music. Moreover, recurring images can be based on extra-musical associations and meanings. Sound events may have different spectromorphologies, yet still retain their common identity; for example, water drops have different spectromorphologies from the continuous flow of water, and they operate in different timescales regarding their temporal structure, but they connect to each other through their extra-musical relationship. Sometimes, extra-musical relationships and autobiographical experiences may link sound images in unexpected ways thus rearranging their structure, resulting in a personalised interpretation of a musical section.

Sound events carry extra-musical associations, not only through their conspicuous or ambivalent semantic meanings, but also through their spectromorphological characteristics. That is, their references depend on intrinsic form, rather than on narrative content or representation. Dynamic patterns of spectromorphologies can display characteristics that relate to human gesture, or to motion unfolded in various source-cause patterns. Real, implied, or imagined gestures are *dynamic spatio-temporal trajectories*, and as such, they display energy and various degrees of urgency. This type of extra-musical association, which is related to spectromorphology, emerges more clearly when semantic meaning is missing, is illusive, or ambiguous, or is suppressed. There can be combinations of semantic meanings and dynamic patterns that work together and complement each other; e.g. a dense music section combined with sounds of busy traffic results in an implied perceptual increase of speed. Complex spectromorphologies combined with sounds carrying connotations of intense activity should result in an increased feeling of haste because there is no clash between messages, since they all point towards one type of rate, that is, high speed.

Lack of explicit meaning may cause the listener to direct attention to the spectromorphological characteristics of sound events.[54] Therefore, it can be argued

[54] The listener, as might be expected, may choose to do so, despite the presence of explicit meaning.

that there are sounds that encourage 'reduced listening', where the listener may choose to disregard causal references of sounds (where causal references carry less weight) and engage with the intrinsic morphological qualities of the sonic material.

Extra-musical associations and relation of sonic material to real or imagined events depend on structure and context. Spectromorphologies stretch out through associations and connect to neighbouring events, expanding their original meaning, or even acquiring a new meaning. The audio examples (Audio 2.5, 2.6 and 2.7) demonstrate the acquisition of meaning through three sounds, seemingly unrelated in their initial isolated stage. Audio 2.5 presents the first sound event, which is a short broadband noise that fades in and out quickly; no associations arise automatically by listening to the event at this stage. In Audio 2.6, the broadband noise is quickly followed by an impact sound; associations with known situations and past listening experiences start to build. The broadband noise becomes a 'whooshing' noise, the sonic portrayal of the moving action of an object;[55] the gesture ends after the first object comes forcibly into contact with another. Audio 2.7 brings in a third sound (a short human cry denoting pain) that gives us information about the object being hit. The associations are now clear. Three very different sounds (a broadband noise, a percussive sound and a voice) refer to a specific event when they are placed together; the image of a person hit by an object, possibly a punch, is very likely the widespread interpretation. Qualities of the first sound are carried to the second, and from there to the third, giving a meaning to the sequence. The velocity of the hitting object is relatively easy to interpret, based on the duration of the broadband noise and the force of the hit deduced from the energy of the percussive sound. One can also notice that the implied space has changed from the first example to the last. Whereas the space involved with the isolated broadband noise is vague and undefined, in the complete sequence the size of space becomes clear. From what we hear, the space involved must be proportional to a human, and the initial position of the object that hits the person should be more or less at arm's length. Association creates spaces and compels the listener to recognise spatio-temporal trajectories.

[55] For the contemporary listener of a westernised society, associations are made with action movies or video games.

2.5.4 Listening Experiences, Psychological States and Emotional Responses

The accumulation of *listening experiences* is a process that operates in two ways: as a long-term action that depends on place, era, and individual learning activities, and as an ongoing cognitive activity that allows new sonic experiences to be absorbed and used in the continuing process of listening. The first operation can be regarded as forming part of the intangible cultural heritage[56] of the listener, because the same sonic experiences that define a place and an era are shared by the listener's community. However, individuals develop additional repertoires of sound experiences, depending on their activities.

Past listening experiences are largely responsible for the interpretation of acoustic environments and sounds. They depend partly on cultural tendencies, which are not objective, although they relate to large numbers of people. As stated in section 2.5.3, both semantic suggestions and spectromorphological attributes of a sound can relate to extra-musical references, and their interpretation depends on the upbringing and the accumulated experiences of a person. Foghorns mean nothing to people who come from countries where there are no harbours (or no fog), and bells of London routemaster buses are unknown to people who have never visited the city.[57] When listening to a piece of music, our experience of hearing events in everyday life compels us to interpret semantic references and morphological characteristics into representational images, based on our acquired knowledge. Sounds set up contexts and define places and times.

Cultural tendencies are not borne only by geographical associations, but also by associations with particular historical periods. There are sounds disappearing from large areas, thus rendering certain sonic environments obsolete (Truax 1999a); those sounds make sense only to generations that have experienced them at certain periods and places (e.g. air strike alarm). Memories of past listening experiences and their

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[56] According to UNESCO convention, intangible cultural heritage consists of non-physical characteristics and knowledge that define a cultural group. Among others, it includes oral traditions and language, social practices, music and rituals, and knowledge concerning nature. It is transmitted through generations, and is renewed by communities in response to changes in their environment (UNESCO 2005).

[57] Murray Schafer refers to the sounds which are unique to geographical locales as 'keynote sounds' (1977: 58).

interpretation are present even before the music is heard, which means that certain sounds are preconditioned by the listener to be perceived in a certain way.

However, new listening experiences are continuously absorbed as a cumulative process both in everyday life activities and while music is heard, which allows for these new experiences to engage in the interpretation of the sonic material. The analytic competence of the listener, which arises from the educational background and previous experiences, influences the interpretation of material, and selects convenient messages (temporal or otherwise), favoured by the listener's experience.

The *psychological state* of the individual at the time of listening affects the way that time passing in music is perceived. Mental and physical tiredness, as well as anger, happiness and sadness influence the time perception of the listener, inducing a state where a person becomes agitated, relaxed, or inundated with information (in the case of mental tiredness), resulting in a distorted judgement of durations and time passing.

Psychologist Allessandro Angrilli and his colleagues cite several studies from 1960 onwards (1997: 973) offering evidence that both positive and negative emotions affect time perception.[58] Angrilli based his own experiments on the dimensional analysis of emotions, which is a leading theoretical approach to analysing emotional states. Basic emotion theories are based on the presence or absence of emotional states, whereas dimensional theory considers a multi-dimensional space, where various factors that affect emotions vary along a continuum (Scherer 2004: 246-8). Angrilli claims that there are two main factors responsible for most of the variation in emotional judgements; affective valence (that corresponds to direction, i.e. attraction or repulsion that correlate with positive or negative reaction to a stimulus) and arousal (corresponding to intensity of the emotional state) (op. cit.: 972). His results demonstrate that there are two different mechanisms for duration estimation, one activated at low arousal levels and the other at high ones, which generate opposite responses at positive and negative affective valence. At low arousal situations,

[58] Among the studies cited are Watts and Sharrock's experiment in 1984, which demonstrated that spider-phobic individuals overestimate durations when watching spiders; and the study by Langer, Wapner and Werner in 1961, which showed that people overestimate durations when looking at unpleasant (e.g. angry) facial expressions.

positive valence induces overestimation of durations, while negative causes underestimation. At high arousal situations the behaviour is opposite; positive affective valence leads to underestimation, while negative to overestimation of durations. Angrilli maintains that when the arousal level is low, the mechanism is attention-driven, and when it is high, the mechanism is emotion-driven. He claims that the dual mechanism is in accordance with a biologically adaptive function, because the attention-driven mechanism optimizes the collection of relevant information from the environment during low information conditions, while the emotion-driven mechanism facilitates the reaction to possibly dangerous or gratifying situations, without delay (ibid: 980).

Although Angrilli's experiments were conducted with visual stimuli which were used to induce emotional states, his evaluation is focused on the relationship between emotions and psychological durations – the nature of the stimuli becomes irrelevant. Hence, his observations can apply to many contexts, including listening situations, where emotions affect duration estimation in different and sometimes contrasting ways; for example, members of an audience may have a predisposition to underestimate durations due to their current low intensity negative emotions, compared to overestimated durations experienced by other members of the same audience with low intensity positive emotions.[59]

Gerald Gorn et al (2004) offer alternative explanations for the overestimation of durations under stressful situations. (1) Under pressure or emotional stress, the (hypothetical) internal clock accelerates, so that more time is experienced through that clock than it is in reality, which results in a perception of time passing slowly;[60] and (2) people in general wish for unpleasant situations to pass quickly, and so the anticipation created makes it seem that time drags (ibid: 216).

[59] Note that overestimation is always relative to underestimation, and it does not necessarily mean that the psychological (experienced) duration exceeds the physical duration. Angrilli reports that "in all conditions tested, time was underestimated" (ibid: 977). The experiments were based on the prospective judgement paradigm, where subjects knew beforehand what was expected from them. Angrilli notes that under these conditions "a general underestimation of the experienced interval is expected" (ibid), mentioning several studies that confirm this. Prospective paradigm relates to experienced duration, in contrast with the retrospective paradigm which relates to remembered duration (Block et al, 1999: 186).

[60] For a brief explanation on the internal clock (pacemaker) see p. 39, footnote 26.

Hawkins et al (1988) measured the subjective time passing on depressed people and concluded that time for them passes more slowly than for people on neutral and elated states. Mental illnesses that alter the psychological state of patients, as well as psychoactive drugs such as marijuana and cocaine, slow down and speed up time perception respectively. Music theorist Jonathan Kramer cites psychiatrist Roland Fischer who claims that drugs arouse symptoms already "present within the cerebral organisation" (1988: 381). Kramer's point is that experiences of slowing down or speeding up auditory images are available to the human mind and so it is possible to be induced.

Personality traits can also influence time judgments. According to psychologist Wayne Hogan, extroverts need and tolerate more stimulus input than the introverts, because their sensory threshold is higher.[61] Consequently, extroverts experience time filled with least degree of complexity as longer than the same interval experienced by introverts (Hogan 1978: 423-4).

Another factor that influences the perception of musical time is the *emotional responses* of the listener to sounds. Denis Smalley, based on Ernest Schachtel's autocentric perceptual mode, discusses the "reflexive relationship" between the listener and sounds, stating that in this subject-centred relation "the object has no real identity separate from the subject's emotion" (Smalley 1996: 82). He maintains that in this particular case, there is little or no exploration of the sound material, only subjective responses of enjoyment or displeasure. These emotional responses to sound material can induce certain psychological states manifesting attraction or aversion in various intensities, which alter the perception of time passing (as explained above).

A concern for many composers has been whether and how music can induce emotions in listeners. David Huron (2005) explores the possibility of evolutionary adaptations influencing musical experience through our emotional reaction to sounds. We can deduce from his suggestion that biological trends may become compositional tools with which composers can influence emotional responses and, by extension, the experience of time passing and perception of durations. Huron illustrates his argument by referring to examples that evoke positive feelings that accompany parenting

[61] This view is supported by many studies, cited in Hogan 1978: 420.

behaviours. The sounds he used in his experiments to verify his suggestion displayed characteristics of what he calls 'auditory cuteness' (ibid: 6), and included the sounds of little bells, small animal calls, music boxes, ocarinas and squeeze toys; these sounds were played against other sounds that were identified by his subjects as 'not cute' (closing doors, electrical appliances and other sounds that displayed spectromorphological characteristics dissimilar to 'auditory cuteness'). All his 'cute' sounds displayed high pitch, high spectral centroid and low amplitude. Huron maintains that the experience of the characteristics of 'auditory cuteness' stimulate positive feelings and "a distinctive psychological state that includes nurturing and protective behaviors" (ibid). Moreover, he affirms that cuteness is not an objective property of sounds, but a "disposition of the mind designed to enhance adaptive fitness. […] [The] ability of musicians to evoke auditory cuteness is made possible only because of a preexisting evolved sensory filter" (ibid: 6-7). It is possible that other types of sound material can evoke certain negative or positive primary feelings, based not on the recognisability of the sound source, but on the spectromorphological attributes of the sounds. Spatial position can also influence emotional responses, as noted by Wishart (1996: 199-200). Frightening sounds (e.g. low frequency loud impacts) heard from behind are more startling, threatening or stressful than if they were heard from the front.

François Delalande (1998) examines reception behaviours and encounters three main types that can be combined dynamically during listening; taxonomic listening behaviour (concerned with structure), empathic listening (related to experienced sensations), and figurativisation (where certain sounds are likened to living beings). Delalande emphasises that these are not the only listening behaviours, noting that "listening adapts itself to the object" (ibid: 59). He also notes that the resolution of a conflict between two behaviours, as well as the changing of listening strategies during audition (possibly because the behaviour of sounds changes and the adopted strategy does not work anymore) result in "observable emotional responses" (ibid: 63). Considering the research cited previously on the effect of psychological states on duration estimation, it is very likely that these emotional responses partly account for variations in perceived structural balance of the same piece of music among listeners who may follow different combinations of listening strategies. Moreover, the emotional responses due to changing of listening strategies in the midst of audition may partly explain why we sometimes perceive disparate sections that otherwise have similar physical durations as extremely unbalanced. The composer has to work on psychological durations to achieve the desired proportions, especially when the behaviour of the sound material changes dramatically during the piece; acquiring the right balance can be problematic considering that listeners may adopt a different listening strategy (or combinations of strategies) to that of the composer. It may be possible to anticipate certain listening behaviours by targeting specific audiences, for example in concerts of acousmatic music only, or in controlled listening environments (e.g. organised meetings at universities).

With regard to empathic listening, Delalande reports that listeners describe various gestures "not as if they have witnessed a scene from a distance but rather as if they have been subjected more or less to these movements themselves" (ibid: 37). His subjects point out that they almost feel the gestures physically. It is interesting that they experience the piece chosen by Delalande (Pierre Henry's *Sommeil*, composed in 1963) in a combination of specious present and process of change, without trying to establish relationships with past material (ibid: 38).[62] While listening to the piece, his subjects described sensations as physiological products of the sounds; stomach-blow impact, weightlessness, heaviness, thickness, rubbing sensation etc. Sometimes, they used complex descriptions of narrative images that clarified their own reactions; for example, "karate in slow motion" and "blows thrust at you by a wooden sabre" (ibid: 38-9). Delalande admits that one cannot know whether such images were present during listening or they were fabricated later to verbalise the felt sensations. However, what is important for our argument is not the presence or the absence of an image, but the felt sensation. Considering the main theories that examine the connection among sensation, somatic experience and emotion, it is reasonable to assume that the felt sensations of the listeners are frequently – if not always – connected with certain

[62] For a discussion on specious present see section 1.3.2. Delalande mistakenly identifies the fixation with the specious present as stasis (1998: 38), which does not agree with the continuous process of change experienced by his subjects. Moreover, Delalande believes that "the piece is perceived as an instant" (ibid: 42). However, when the article later examines form perception (ibid: 45), he comes close to admitting the presence of an interval surrounding that instant; it is this extra duration around the strict present that forms the specious present.

emotional responses.[63] However, sensations may not connect to similar emotions when experienced by different persons; for example, weightlessness may be associated with euphoria for one person, but with fear for another. Nevertheless, the experienced emotions in the specious present will affect the perceived durations of sound events. Ultimately, time perception will leave a certain impression about the pace and momentum of the piece of music. Delalande points out that empathic listening does not favour the perception of sections (1998: 41), which implies that, although pace may be affected, the overall structural balance will not necessarily be influenced by the changing time perception due to emotion. In other words, in empathic listening, time perception (related to the experience of the present) is affected, while duration estimation (related to remembered durations) is not.

An interesting characteristic of empathic listening behaviour (which connects to the spatio-temporal trajectories examined in 2.5.3) is that, because sounds are interpreted as movements related to the body of the listener (i.e. the space is given), the temporal scale of the gestures is interpreted accordingly. In view of the fact that human movement (of feet, head or arms) at normal speed does not exceed in general one second, longer gestures are perceived as extremely slow (ibid: 47). The impression of slow and fast motion can be extended to listeners that do not necessarily apply empathic listening, by deliberately using sounds that create certain speed expectations when resemble those of body movements. An extreme example can be considered in multi-channel surround sound, when a series of short gestures that display spectromorphological characteristics of footsteps is moved in a circle around the listener. The speed of execution of the circular motion determines the perception of distance between two steps of the virtual walker; the normal speed is dictated by the distance between successive loudspeakers. Very slow speeds make the virtual person seem as if he steps too many times around the same spot, whereas high

[63] It is understood that physiological arousal provides a necessary basis for sensation; e.g. an external stimulus such as low atmospheric temperature generates a nerve discharge from the -involuntary- sympathetic nervous system, which causes a contraction of hair erector muscles that elevate the hair follicles above the skin, and we experience piloerection or gooseflesh (MedicineNet 2009). Psychological research shows that emotions are often associated with reaction to such sensory information (de Sousa 2007). The most important theories on the relation between physiological arousal and emotion have been developed by William James and Carl Lange in 1884 (arousal leads to emotion), Walter Cannon and Philip Bard in 1927 (emotion occurs at the same time as the physical response), and Stanley Schachter and Jerome Singer in 1962 (two-factor theory: physiological arousal and its cognitive label lead to emotion) (from various sources, including Reisenzein 1983 and Encyclopædia Britannica 2009).

speeds result into huge steps in space; anything beyond the normal speed sounds unnatural, and it takes practice and patience to adjust the spatial motion to the pace of the walk.[64]

2.6 The Time-Influencing Set

When acousmatic music is seen from an ecological perspective, it can be recognised that there are interrelationships between music and the listening environment. As a result of this observation, the impact that listening environments have on musical works should be questioned and carefully considered. Although acousmatic music may appear to invite a pure listening experience, that is, not directly involving other senses, it has a more holistic nature. Acousmatic music incorporates, mostly unintentionally, all its surrounding elements at the time of listening.

Our perception of duration and time passing changes according to a mixture of numerous and sometimes disparate elements. The combination of these elements, which are the factors explored in section 2.5, produces certain results in the psychological domain. Together, these factors may collectively be regarded as a 'time-influencing set' (referred from now on as a T-I set).[65] The process whereby the T-I set influences listening is shown in Fig. 2.6. The T-I set is placed between the listener and the music (EA) and acts as a filter, which is in constant flux, and which shapes the time perception of the piece.[66]

[64] I regularly use this demonstration in my classes on multi-channel composition to show the consequences of motion and speed expectation created by the associations of sounds. The influence that this simple demonstration has on students' thinking about gesture and space is profound.

[65] Where 'set' is a collection of distinct factors, each one serving the same purpose in this case, i.e. to influence the time perception of the listener.

[66] It will be made clear later why this filter is in flux.

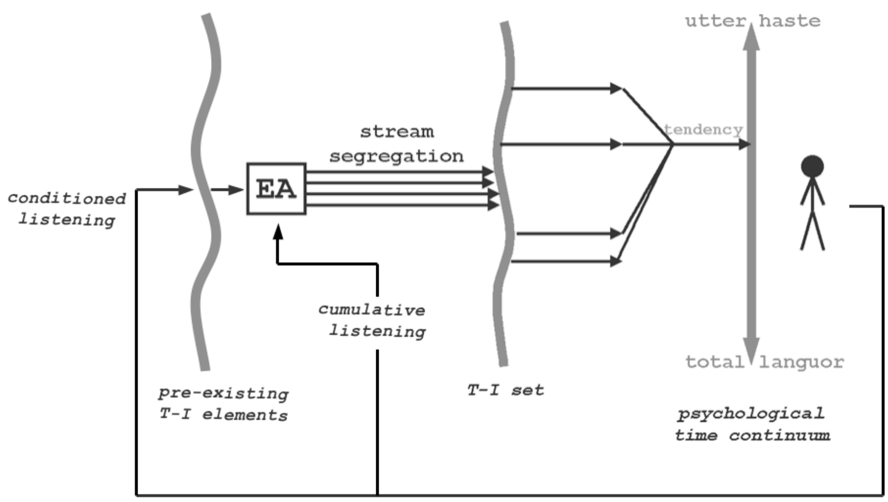

Fig. 2.6 **T-I set.**

Some T-I elements are already present even before the music is heard, because they constitute part of the individual person, for example, the psychological state of the listener and past listening experiences ('pre-existing T-I elements' in the above diagram). This means that auditory streams emerge out of the music already filtered, which implies that every individual is conditioned to perceive the timescales of a piece of music in a certain way, even before they emanate from their source. Then, further filtering will occur due to factors that shape the music. Ongoing cumulative listening experience is indicated by the feedback arrow that points to music.

The psychological time continuum is positioned graphically close to the listener, although it is inseparable from the person; different locations on this continuum correspond to subjective experiences of periods of time in which sequences of sound events take place. Sounds are grouped into auditory streams according to their characteristics (see stream segregation[67] in Fig. 2.6) and they pass through the T-I set, each stream occupying a timescale; streams may also interact with each other, thus forming composite, discrete timescales. After this information passes through the filter, the auditory streams acquire new values in terms of time perception. What we sense then, is a point of inclination, a tendency towards a qualitative value on the psychological time continuum that arises from the interaction among the filtered auditory streams. The process of entrainment (described in section 2.5.1) may explain

[67] For a definition of stream segregation see end of section 1.3.1, p. 24.

the merging tendency of the different streams, as these constitute oscillating systems that our hypothetical internal pacemaker attempts to bring together.

When the T-I set is analysed into its constituent parts (sound as message, aural, visual environment, etc.[68]), it can be speculated that auditory streams change their direction individually, pointing towards either haste or languor, while passing through the parameters of this multiple filter. The tendency point gives us a location on the time continuum graph, a qualitative measure for perceptual duration.

The T-I set is in constant flux because it is highly unlikely that all individual continua will stay fixed during a performance of a music piece; some will be unchanged, like the performance space, but will not be able to suspend the fluctuation of the tendency point. When the listener focuses on a particular auditory stream, then that stream has a stronger influence on the tendency point. Moreover, when a value in the T-I set changes (e.g. when introducing a sound that carries a new temporal connotation), the tendency point will change its position accordingly.

The T-I set works differently in cases where the listener can distinguish several rates of time passing. Perceptual segregation of timescales can be facilitated by cues used by the auditory system to differentiate among simultaneous sound images. Such cues include spatial position, common fate regularity (where several partials evolve in a similar way), partial onset (since the ear tends to group together partials starting at the same time), and the use of harmonic series (a harmonic series will probably derive from the same source) (Bregman 1990). For example, when timescales are clearly separated in the panoramic space, the listener is able to segregate the temporal streams and shift attention among them. Auditory scene analysis specifies that localisation is an important cue used by the auditory system for the organisation (perceptual fusion or separation) of simultaneous acoustic components (ibid: 311-2). During spatial segregation, timescales with very different pace will have their tendency points on the psychological time continuum move apart towards the opposite poles (haste/languor); consequently, the attention of the listener will shift between the qualitative values depending on the area of focus. Listeners cannot feel two rates of motion at once

[68] N.B. The order is not absolute.

(haste and languor), but are nevertheless aware of the existence of both because they can switch between them.

There is a perceptual threshold beyond which streams of temporal information carried by auditory streams are not merged. That threshold depends on the shared characteristic that brings the group together; for example, if the shared characteristic is the spatial position of the sounds, the threshold depends on spatial distance; if it is frequency, it depends on the distance between frequency bands, etc. Streaming in terms of time perception seems to work similarly to auditory streaming, that is, temporal streams are also organised perceptually according to their similarities. However, auditory streaming and temporal streaming are not the same thing; a number of segregated auditory streams may operate on the same timescale, since they can move forwards at the same pace and occupy the same period of time. Similarly to auditory streaming, there are several parameters in temporal streams that either compete or collaborate in order to determine grouping. These parameters are to be found in temporal syntax and associations examined earlier in this chapter, which establish temporal relationships – grouping – among sound images.

2.7 Summary

In this chapter, it has been acknowledged that there are two ways of experiencing time, the first through the notion of absolute time, and the second through psychological time. The latter is ultimately connected with our understanding of a musical piece. Absolute time can be divided into several timescales, but psychological time cannot be partitioned in the same way. A psychological time continuum has been proposed, where different positions represent differing perceptions of physical durations. The point of selection on this continuum depends on the time-influencing set.

By recognising the various elements that influence our perception of time in music, I deduce that although acousmatic music may appear not to involve other senses apart from hearing, it has a more holistic nature. The visual element can be present even though it is not always intentionally visible. The aural and physical spaces are also present, which may cause impressions of intimacy, distance or grandeur, indications of sound and image as messages. Timescales are formed through immanent structures and also through extra-musical associations. Moreover, the listener is conditioned through personalised factors (educational background, psychological state) to perceive timescales in a certain way, even before these emerge from music. All these factors can affect our perception of time passing and estimation of duration, and therefore our perception of a musical work. We need therefore to see acousmatic music as a holistic experience that incorporates all its surrounding elements at the time of listening.

Chapter 3

Perceptual Analysis of Sound at the Micro Level, and Temporal Processes

3.1 Preface

This chapter examines the properties of microsound, and identifies its differences from a short sound object. The behaviour of aggregates of micro events is analysed, and various stages of the fusion/fission continuum are inspected. Subsequently, subliminal perception at the micro level is evaluated, before the systems operating in short and long timescales are explored. The relationship between complexity and time perception, based on theories of Hogan, Priestly and Ornstein, is followed by an examination of complexity related to various parameters of sound. Finally, altered time perception is examined, before impatience and its effect on the experience of time passing lead to a discussion on relations between expectation and time perception.

3.2 Definition of Microsound

Curtis Roads defines microsound as 'a broad class of sounds that extends from the threshold of timbre perception (several hundred microseconds[69]) up to the duration of short sound objects' (2001: 20-1). Roads sets the durational limit for a short sound object to be around 100 milliseconds, although as will become apparent below, the border between a microsound and a sound object is not that straightforward, as it does not depend only on duration.

The problem with the above definition of microsound is that the border between the timescale of a sound object and the micro timescale is ambiguous, as it is context-dependent. A microsound, and its transition to the sound object status, is determined by psychological judgements carried out by a listener, which arise from relationships

[69] One microsecond is 1/1000th of a millisecond.

occurring within a setting that contains the sounds in question, rather than by a metric system that counts durations of isolated objects in absolute time. Sounds acquire different qualities depending on their duration and context.

The crucial difference between a sound object and a microsound is that the sound object demonstrates a spectromorphological behaviour, which bonds the sound with sounding or non-sounding experiences. This behaviour connects the sound with motion, growth and energy processes that can be interpreted symbolically or metaphorically (Smalley 1994: 37), thus giving an identity to the sound. Microsounds are too brief to be able to expose such behaviour, which needs time and duration to be unveiled. A microsound becomes capable of acquiring the status of a sound object, not when it passes a threshold of duration, but when it establishes an identity. What makes a microsound what it is, is that its identity is less stable than that of the sound object, as it greatly depends on the sonic environment where the microsound belongs.

In a composition, there is a hierarchy of interactions between different sounds and timescales. Each sound (and time level) interacts first with its most immediate environment and then gradually forms relationships that extend to levels beyond. When we consider the sound object, the closest level that influences the way we perceive it, is the larger gesture, or musical phrase, or cluster of events in which it belongs. Similarly, a microsound belongs first to its immediate sound environment (i.e. its neighbouring or overlapping sound events that may form a gesture or a texture) and borrows efficacies from it, that is, powers to produce an effect. As a consequence, it acquires an identity that depends to a greater extent on the environment in which it belongs and to a lesser extent on the microsound itself.

When micro events develop *dependencies* on neighbouring sound material, they become associated with sounding or non-sounding phenomena. Dependencies are determined by relationships between timbral, pitch and dynamic qualities of the microsound and those of its surroundings, and by the temporal distance between the microsound and the adjacent material. The closer the relationship and the shorter the intervening temporal gap, the greater the dependency of the microsound on its immediate environment. When sound material is granulated beyond a certain degree, the grains lose contact with each other and the identity of the original sound is lost.

For example, when the bond between the grains of a recorded seashore weakens, the result may resemble foliage. The greater the distance between grains, the harder it is to assign an identity to them and as a result, the spectromorphology from which they were derived becomes progressively a thin texture.

We can imagine a continuum where microsounds of different durations can be situated (see Fig. 3.1). This continuum represents a growing duration, where, at one end, microsounds become so brief that they cannot be heard, but only sensed at a subliminal level.[70] At the opposite end, sounds become large to a point where they acquire the power to become symbolic, semantic or structural objects without the need to borrow an identity; they become independent, self-referential events.

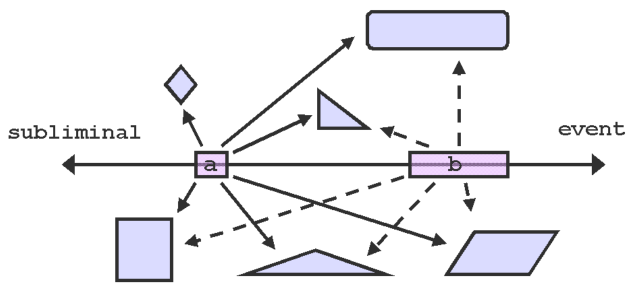

Fig. 3.1 **Duration continuum.**

The two sounds ‘a’ and ‘b’ placed on the continuum interact with the events that surround them. However, each interacts with its environment to a different degree. Object ‘a’ is very brief and its identity depends on its neighbouring sounds, whereas with object ‘b’ there is an interplay between its own growing identity and a borrowed one. (The lesser dependence is represented in Fig. 3.1 with broken lines.) Audio examples 3.1, 3.2 and 3.3 demonstrate microsounds’ dependencies. In Audio 3.1, a soundscape with chirping and short squeaky metallic sounds is presented. Since the metallic sounds are fewer than the bird sounds, they are mistaken for chirping. In Audio 3.2, the same soundscape is heard. However, from 0:16 onwards the metallic sounds become longer resulting in their growing independence. In both examples, only the metallic sounds (two knives rubbing against each other) are presented for reference after the soundscapes. In Audio 3.3, hammering precedes synthesised pulses. The pulses are source-bonded because of the previous material and they are

[70] Subliminal perception of microsounds is examined in section 3.4.

very likely perceived as hammering; the image of hammering action keeps following our listening experience. The synthesised pulses are presented alone after the soundscape for reference.

Encountering microsounds is part of a holistic experience, which is not only a listening experience, but encompasses a comprehensive perception that is affected, as analysed in section 2.6, by the T-I set. Considering micro events not as isolated objects, but as part of a totality, offers an ecological validity that helps us identify the properties and characteristics of the microsound.

3.3 Behaviour of Microsound

A microsound can be encountered in one of the following two situations. Either (1) it is an isolated sound event, that is, the temporal distance between that and its surrounding events is relatively large; or (2) it appears as part of a larger sonic image.

In the first situation, isolated microsounds are very likely to disappear from the field; when they are less than approximately 200 milliseconds long, they need to be a lot louder than longer sounds in order to be perceptible (Roads 2003).

When microsounds congregate and become part of a large event, the result is either fission or fusion. During fission, a sound breaks down into parts that are heard as separate microelements, bound together by close relationships. A fragmented sound has its identity changed dramatically, because its textural behaviour is no longer the same. When the gap between grains widens, their connecting bond weakens. The new sound might be associated with burning charcoal, foliage, or any other granular texture – depending on various parameters (e.g. grain envelope, density and duration, type of sample etc.), but it will have little resemblance – if any – to the original sound.[71] Furthermore, if the ingredients are shuffled, the object becomes unrecognisable; this is viable with sounds with changing spectral or dynamic

[71] Listen to example Audio 3.4. An identifiable sound (waves of the sea) is first presented in its original form, and then granulated. Because of the particular timbre of the original sound and the parameters used (synchronous grains, Gaussian envelope), when the gap between grains widens, the resulting sound resembles the rhythmic and timbral qualities of a steam locomotive.

behaviour, but shuffling has little effect on non-changing sounds (e.g. food blender) and long and slowly modulating gestures (e.g. passing aeroplane).[72]

In section 1.3.1, it has been demonstrated that recognition of order of micro events played in succession has a threshold of IOI at c.200 ms; this threshold falls to c.100 ms when some of the sounds involved are pitched (see pp. 21-22). The temporal order must be perceived correctly in order to judge causality. When microsounds are closer than c.100 ms to each other (and further than c.30 ms to avoid forward masking[73]), causality cannot be determined, unless the micro events are judged collectively. In that case, either their group is perceived as self-sufficient and associates directly to an event (e.g. foliage), or causality is identified as being connected with the preceding sound (e.g. when an impact is immediately followed by a cloud of micro events that appear to be its resonance).

When there are more than thirty-three short pulses per second, that is, when their IOIs are less than 30 ms, then they blend together and give the illusion of a continuous longer sound. Fused microsounds result into events that demonstrate a textural behaviour, and therefore they acquire an identity. Consequently, sonic physiognomy seems to be an emergent phenomenon, because –in the case of microsounds– it only makes sense for bulk matter.

The fusion/fission duality can be perceived as a continuum, although the distance between the two extremes is relatively brief. Fused microsounds create smooth textures. When they start separating, their continuous texture becomes progressively rough, then granular, until the individual microsounds separate enough to be perceived as isolated events.

Discrete microsounds and pulses can be used to influence perception of duration. Psychologist John Wearden has experimented with click-trains to manipulate the subjective duration of short sustained sounds. Series of clicks that precede either filled

[72] Listen to Audio 3.5. First, a sound with changing dynamic behaviour is presented in its original form and then granulated; because the grains are shuffled, the processed version loses the dynamic profile of the original. This is followed by a non-changing sound (food blender) and its granulated version, where the grains are shuffled; the processed sound is almost indistinguishable from the original.

[73] See footnote 11, p. 22, for information on forward masking.

or unfilled intervals increase subjective duration by speeding up our hypothetical internal clock. By removing those clicks, the internal clock decelerates, resulting in the shrinkage of psychological durations. Pulse trains produce very rapid shifts in internal clock speed and the effects wear off just after a few seconds. According to Wearden, the durations of those clicks have to be between 1 and 5 seconds to produce an effect (Wearden 1999b). Although this is an experiment carried out in the laboratory, it can be used creatively in music. However, in a music context, there are many forces in action influencing our time judgment that have to be taken into account, examined as separate elements of the T-I set (see Chapter 2).

3.4 Subliminal Perception of Micro Events

Very brief, barely detectable microsounds can be perceived subliminally. Curtis Roads mentions Reder's and Gordon's cognitive theory that states that a concept can be perceived when its activation is above a certain perceptual threshold.

> Magnitude of activation is partly a function of the exposure duration of the stimulus. A subliminal microevent raises the activation of the corresponding element, but not enough to reach threshold. The brain's "production rules" governing awareness cannot fire without the elements passing threshold, but a subliminal microevent can raise the current activation level of an element enough to make it easier to fire a production rule later (Roads 2003).

Roads points out that subliminal isolated microsounds can be embedded at crucial points in a music composition and therefore stimulate perception without the listener being aware of them. He claims that different values of certain parameters of a microsound, like its frequency, waveform and spatial position, can influence the perception of higher-level events. However, according to psychologist Philip Merikle (2000), subliminal perception of information presented below a subjective threshold of awareness is facilitated when it is preceded by a related stimulus. When the preceding stimulus is unrelated, the subliminal perception can be dubious. Merikle's examples are based on visual experiments, although he cites J. A. Groeger who tested successfully this hypothesis with auditory stimuli (Merikle and Daneman 2000: 1298). As a consequence of these findings, an unnoticed microsound will subliminally surrender its characteristics best when it is preceded by an audible sound that has similar or related characteristics. This makes redundant the use of subliminal micro-events, unless these are presented without any sounds preceding them.

Furthermore, there is the issue of temporary threshold shift (TTS), which is a shift to the threshold of hearing. This is essentially a temporary hearing loss to low level sounds that occurs when relatively loud sounds are heard.[74] TTS is more pronounced when loud sounds are between 2 and 6 kHz (Truax 1999d). Even without TTS, we can deduce from experience that exceptionally low intensity brief sounds barely attract our attention when they are preceded by sounds of average loudness. It is almost inevitable that if a subliminal microsound is to be used in a compositional context, it needs to be temporally distanced from its preceding sound.

So far, there has been no evidence based on controlled experiments to suggest that subliminal messages are an effective method to influence perception. Although significant information can be perceived subliminally, Merikle claims that the subject must be aware of the presence of stimuli to be able to respond to it (op. cit. 2000). In the context of music, this means that listeners have to be prepared for barely audible sounds, for example through programme notes. In this case, the distinction between conscious and subliminal perception is questionable.

Merikle and Daneman (1998) argue that conscious and unconscious perceptions differ qualitatively, and describe five previously conducted studies that demonstrate those differences. However, these studies are based on experiments with visual stimuli and it is not apparent whether their conclusions are valid in auditory perception.[75]

[74] This is a natural reaction of the inner ear to loud sounds. As a response to loudness, the blood vessels constrict and the blood that reaches the hair cells of the organ of Corti is reduced. As a consequence, the outer rows of hair cells that respond to low intensity sounds are overwhelmed by louder sounds. This leaves only the inner rows working properly, which need higher level sounds to be stimulated (Truax 1999d).

[75] As a matter of interest, according to Merikle and Daneman, subliminal perception differs from conscious perception in the following ways: a) Emotional reactions are more likely to be influenced by subliminal stimuli than by conscious; b) when a stimulus is subliminally perceived, semantics is the predominant code, in contrast to conscious perception where structural characteristics are more important; c) subliminal information leads to automatic reactions, whereas conscious perception allows for guiding one's actions; and d) conscious perception is constrained by context, whereas unconscious is not (ibid. 9-13).

When my composition *Arborescences* was in progress, tests with barely audible microsounds were conducted in order to incorporate them in the piece. Careful use of loudness and frequency content was required in order to achieve the desired intensity of subliminal perception. When a microsound was heard, the level was lowered slightly, so that it became just inaudible. Although controlling the levels in the studio is relatively easy, doing the same in the concert space is not straightforward; the distance between each listener and the sound source is crucial for the right listening level, and cannot be the same for all members of an audience. However, even in the studio, this was largely an experiment with unpredictable results. The material was susceptible to the slightest external noise, and it could not be made apparent that a sound was present unless its waveform was seen on the computer screen. The sound was being moved to different spatial points in the stereo field in order to attract attention to particular areas. When this was tested in the compositional context, the time interval involving the subliminal material seemed completely empty. After several failed attempts, the endeavour was abandoned. The presence of an audience might hinder subliminal perception even further due to unpredictable noise, such as clothing shuffle, or the customary coughing during seemingly silent periods. Consequently, it would be best if a composition intended for subliminal perception were designed to address very small audiences, using carefully selected material for the audible part, such as low intensity micro-events. Concerts should be held under controlled listening conditions because such compositions would be very fragile.

3.5 Micro-Macro Relationships

Perception of timescales is necessarily based on two operational systems. The first involves perception of duration, because the activity on short timescales occurs during the specious present. Local and higher-level time structures with changes occurring within approximately a five-second interval belong to this category.[76] The second system involves duration estimation and applies to timescales longer than the specious present.

[76] The specious present is calculated to be around five seconds long (see section 1.3.2, pp. 25-6).

Processes on the micro timescale generate structures and spectromorphologies at larger levels (unless microsounds are used in a composition as isolated events). For example, although granular synthesis operates at the micro level, the result of this technique is heard as iterations, clouds of grains, or elisions that belong to a longer gesture or texture. It can be surmised that both systems of duration awareness (perception and estimation) are in operation at the same time. On one level, we experience time passing through the perception of events occurring within the specious present; and on a second level, we estimate durations of longer intervals that are constituted by a conglomeration of the short changes occurring at the micro level. Ernst Pöppel asserts that continuity between successive specious presents is the consequence of "a semantic connection of what is represented within each subjective present. Thus, temporal continuity is based on mental content and its ongoing representation within the neuro-cognitive machinery" (1997: 60). The level of similarity between successive temporal chunks determines whether or not listeners perceive a continuous flow. This similarity depends on the horizontal organisation of auditory streams, the formation of which is based on several parameters examined by auditory scene analysis (Bregman 1999).

Curtis Roads believes that microsound techniques encourage a working method of building structures and sounds from the bottom up. He also maintains that "each time scale abides by its own rules" (2001: 331-2), making it almost impossible to retain the same perceptual properties across timescales. However, time stretching and shrinking provide useful means to transpose events to different timescales while preserving gestures. Local structure and internal rhythm may elongate or shorten, providing decelerated or accelerated trajectories of similar course. Internal rhythm can be altered as desired by moving transients (when transients are preserved) inside the sound event, providing opportunities to build complex structures and rearrange existing ones, while operating at both the micro and macro levels at the same time. Inevitably, when sounds are excessively stretched, textural characteristics become more prominent than the temporal evolution of gestures.

3.6 Stimulus Complexity and Time Judgments

After having examined the sonic physiognomy and the behaviour of microsound, some previously untested proposals for its use, and the operational systems that connect the micro and macro timescales, complexity can now be investigated. Originally, the research started on complexity arising from the combination of micro events. However, it soon became apparent that whereas complexity at the micro level is limited to event density and rhythmic behaviour, an investigation that was not restricted to one timescale could reveal a broader range of intricate systems.

In 1978, psychologist Wayne Hogan proposed that time perception is a curvilinear U-shaped function of stimulus complexity. At that time, there were two prevalent opposing views regarding complexity and time perception. One view, proposed by Priestly in 1968, showed that empty intervals are judged as longer than filled intervals; and the second view, proposed by Ornstein in 1970, claimed the opposite (Hogan 1978: 423). Hogan, in his paper, concludes that both views are correct, but they do not reveal the whole story; on the one hand, empty intervals are boring and are felt to be long, and on the other hand, sensory overload also leads to boredom. Hogan concludes that moderately complex stimuli are "experienced comparatively 'fuller' and shorter than either minimally or maximally stimulating time intervals" (Hogan 1978: 423). Subsequent studies point towards the same direction, and support Hogan's view (see Fraisse 1984; Grondin 2001). Experiments have been conducted with visual as well as verbal stimuli.

A modified version of Hogan's diagram can be seen in Fig. 3.2. Psychological time is shown on the vertical axis and stimulus complexity on the horizontal. Although there are many parameters affecting perceived durations (refer to T-I set, section 2.6), this diagram shows only complexity. Both very low and very high complexities cause lack of interest; consequently, intervals that belong to either end of the horizontal axis on the diagram are judged as longer than intervals filled with moderately complex stimuli.

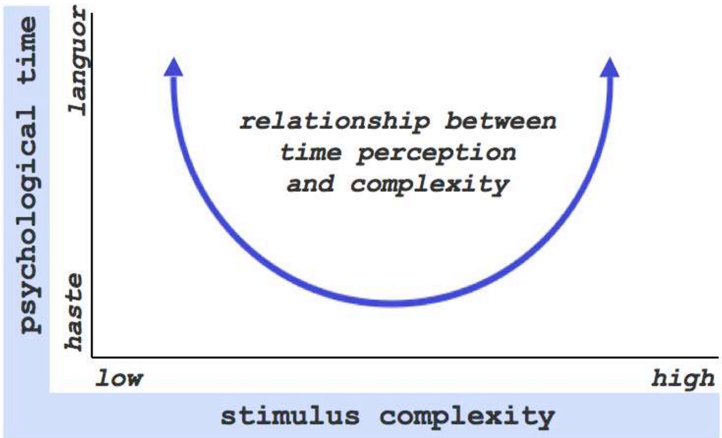

Fig. 3.2 **Stimulus complexity and time perception.**

Grondin points out that Ornstein's model, whereby empty time intervals are judged as shorter than filled intervals, is now generally recognised to apply to retrospective timing (2001: 27; also Pöppel 1997: 60). According to this model, the more changes occurring during a time interval, the more the memory is loaded with information. This affects remembered duration, which is proportional to the storage size occupied by events in memory. There are obvious implications in compositional structures, where busy sections are remembered as longer than they actually are, and idle sections as shorter. However, while experiencing those sections in real time, the listener may have a different impression, because time perception depends on the model proposed by Hogan (see Fig. 3.2). Ornstein's model applies to duration *estimation*, whereas Hogan's pertains to *perception* of duration.[77] Remembered durations can change the perceived proportions of a piece; consequently, careful balancing between sections is required, depending on level of complexity rather than physical duration.

A sound has many parameters, and complexity may occur in any one of them. Complexity must not cause a fusion of fluctuations, or of layers, into one unvarying event; for example through saturation, or by placing layers close together in a way that they cannot segregate. We must be able to perceive a multiplicity of events or contexts, or multiple changes. Complexity can be regarded as a structural construct of composite nature, which describes a condition difficult (in various degrees) to disentangle or analyse. Therefore, complexity can refer to variance and amount of

[77] Cognitive psychologists differentiate between estimation of duration, where memory is used, and perception of duration, which involves the experience of the specious present; see also previous section 3.5.

information within a parameter, and the degree of perceived complexity depends on the analytical skills of a person. Below is a non-exhaustive list of parameters encountered in electroacoustic music, in which complexity may occur:

(1) *Rhythmic and melodic complexity*. Judgements of melodic complexity are connected with the musical expectations of the listener. Melodies that create and fulfil expectancies are easier to recognise and reproduce, and so they are judged as less complex by listeners (Eerola and North 2000). Eerola and North (ibid), based on existing research on perception of music cognition and melodic expectancies, summarise the factors that contribute to complexity according to the expectancy-based model. They state that factors are divided into tonal, intervallic and rhythmic. Tonal factors include 'tonal stability', which is modified by 'metrical position' and 'duration'; these modifiers emphasise the position of notes, and lead to increased or decreased perceived importance of notes. Intervallic factors are based on Gestalt laws and include 'proximity', 'registral return', 'registral direction', 'closure', and 'intervallic difference'.[78] Rhythmic factors, which account for both rhythmic and melodic complexity, include 'rhythmic variability' that depends on individual durations of events (or durations defined by changes within a continuous flowing movement of a sound), 'syncopation' i.e. deviation from a regular pattern, and 'rhythmic activity' i.e. number of events (or durations of different states of an event) in a time interval. The expectancy-based model of melodic complexity considers only single melodic lines; the 'number of simultaneous melodic lines' and the complexity that arises from their interaction and contrapuntal relationships should be added to the above factors. The 'sharpness of onset' can be another added factor, because the less defined the onset is, the less clear the changes from note to note; sometimes melodic lines made of such sounds can be perceived as less complex – we tend to follow a generalised contour instead of attending to the minute detail of each step and leap between notes.

(2) *Spectromorphological complexity*. This refers to the number of spectromorphological changes of sound events occurring within a time interval.

[78] Eerola and North also include the intervallic factor of 'consonance'. However, since musical consonance refers to Western tonal harmony (as opposed to sensory consonance that refers to absence of roughness on simultaneous tones), and depends strongly on musical experience and culture, I omit this factor. In acousmatic music, consonant (i.e. agreeable) resolutions depend on context.

Spectromorphological complexity multiplies by the number of changing sound-shapes and/or internal textural changes developing at the same time as different auditory streams.

(3) *Spatiomorphological complexity*. This concerns multiple changes from one space to another, trajectories, or multiple zoned or nested spaces; that is, spaces that occupy different regions, and spaces within a space (Smalley 2007).

(4) *Referential density*. A short section referring to many source-causes has a high referential density, and can therefore be perceived as complex. Conversely, a section referring to few source-causes has a low referential density.

(5) *Referential discourse density*. Referents also interact with each other in a discourse, thus bringing a secondary level of complexity, which is the referential discourse density. For example, bells, choir and incidental noises from people in a large reverberant space refer to three different families of source-cause; consequently, the referential density is high. However, all these sounds seem to originate in the same setting; the *intended target message* is associated with one situation, which is a ritual ceremony in a church (listen to Audio 3.6). The referential discourse density, in this case, is low. The opposite would apply if a structure comprised layers of sounds semantically unrelated.

(6) *Harmonic complexity*. Concurrent notes in harmonic relationships may or may not segregate perceptually, depending on various parameters examined by auditory scene analysis. No studies have been located on harmonic complexity influencing time perception, so a conclusion cannot be drawn on whether a complex harmony of concurrent notes that form a perceptual unit can cause the feelings of haste or languor. However, harmonic density carries a supplementary factor, namely spectral space density. There are different ways in which spectral space is occupied and filled out as discussed by Denis Smalley (1997: 115-7); various motion and growth processes of gestural and textural nature may occupy and fill up spectral space, referring us back to spectromorphological complexity. In addition, harmonic density can affect time perception indirectly, as it influences perception of loudness; the more frequencies a sound occupies, the louder it is perceived (Howard and Angus 2006: 89-90). Because

quiet sounds are judged as shorter than loud sounds (Goldstone et al 1978, cited in Fraisse 1984: 13), a harmonically dense structure should be perceived as longer than a thin structure of the same physical duration.

3.7 Altered Time Perception and Expectation

It has long been recognised that body temperatures affect time perception; high temperatures cause the internal timing mechanism to run faster, making external events to be perceived as longer than they actually are (Wearden 2005).[79] In addition, David Huron claims that the experience of frisson is affected by temperature (2006: 35). Frisson is experienced by listeners when an unexpected sound event occurs, such as a sudden cluster of notes or a high-energy onset, and it is usually accompanied by a pleasurable feeling. Huron explains the experienced pleasure – which is in contrast with the danger evoked biologically by sudden changes in the environment – as the result of the antithesis between the awareness of the safety of the musical context and the biological alarm (ibid). He claims that when the temperature is lower than average, frisson is more intensely felt by the audience. It has been shown earlier (section 2.5.4) that positively valenced feelings affect duration estimation; it can therefore be deduced that regulating the temperature in concert spaces affects the audience's perception of time passing and duration. High atmospheric temperatures that raise the body temperature make events perceived as longer, while lower atmospheric temperatures enhance frisson, resulting in a high arousal level during positive valence experiences, which in turn leads to underestimation of durations.

Distortions of time perception have also been reported in a phenomenon called auditory chronostasis. This occurs in relatively short timescales, when attention shifts from the main sound event chain to another and then back to the first. Hodinott-Hill et al (2002: 1779) illustrate chronostasis with an experience in daily life. Imagine calling someone on the telephone and listening to the ringing tone waiting for a reply; when attention is distracted by a different task (e.g. changing channels on a television set)

[79] Wearden credits M. François for being the first psychologist to have documented the phenomenon in 1927.

and then attention shifts back to the phone, the time before the next ringing tone is perceived as longer; it may thus seem that the line is momentarily dead. In addition, Hodinott-Hill et al have observed that chronostasis occurs when concentration shifts from one point in space to another (ibid: 1779-81); when attention shifts between auditory events projected to one ear and then to the other, the time interval during the shift is illusorily elongated.[80] Chronostasis could be used musically to emphasise psychological elongation, especially when jumping between spatial positions. However, chronostasis can be a complication that composers may like to be aware of, especially when creating rhythms that split between symmetrically opposite spatial positions, as in the case of hard panning left and right during headphone listening; the perceived time stretch may reduce the accuracy of certain rhythmic patterns.

According to Fraisse, '[t]emporal information is all the more taken into consideration when it is emphasised in the task' (1984: 31). When listeners are compelled to attend to time, for example by listening to events that explicitly count time, their attentional resources are allocated to that task. Compare for example the sound of a passing car with the ticking of a clock. In the first instance, time passing and the exact duration of the sound may not seem important to the listener, as other characteristics are more prevalent, such as timbre and spatial trajectory. In the second instance, attention is drawn immediately to the passing of time, in such a way, that can be easily manipulated. We are used to the fact from daily life that clocks tick every second; elongating or shortening the gaps between ticks will result in a distorted judgement of time passing, and in compression or expansion of temporal structures.

Moreover, lack of events (both exogenous and endogenous[81]), and thus lack of perceived information makes one trapped in a situation where attention is focused on time passing. Boredom also induces a similar state of preoccupying oneself with counting the time. When concentrating on the passage of time, it appears that time drags (Pöppel 1978: 718). Impatient listeners may focus on the time when an event will end, which may increase their attention to time passing and consequently lengthen their duration judgments. Impatience has been examined in children, in

[80] There might be a link between chronostasis related to spatial position and the Kappa effect (see section 2.5.2, p. 47 for an explanation of the Kappa effect).

[81] Exogenous events relate to external factors such as sound events, and endogenous can be e.g. preoccupation with particular thoughts or with daydreaming.

various researches cited in Block at el 1999: 206. Impatience can be elicited in a composition context, by prolonging the end of an event or of a chain of events.

Listeners' temporal expectations are formed during periodic changes of sounds, and during transformations and developments that sound familiar. In case of periodic changes in some aspect of sound (e.g. oscillating textural thickness, spectral glissandi etc.), 'anticipatory attending' creates expectations based on our internal timing (Jones 2004: 51-62). Jones postulates that internal timing is inherently oscillatory and adaptive; it adapts and synchronises with an external rhythm through the process of entrainment (described in section 2.5.1). Any alterations of the external rhythm's periodicity result in expectancy violations, which trigger 'reactive attending' that re-orientates attention and moves appropriately the phase of the internal timing (ibid).

One of Ernst Pöppel's elementary time experiences (discussed in section 1.3.1) is the 'temporal organisation of future actions', which he suggests can also be called 'anticipation' or 'planning' (Pöppel 1978: 716). Pöppel maintains that anticipation is linked with periodicities produced by rhythmic temporal organisation of ongoing events. He refers to J. G. Martin's claim that speaking and listening are "dynamically coupled rhythmic activities" (ibid: 725). Further experiments with speech have shown that the listener enters the speaker's tempo to facilitate understanding of language (ibid).

Expectations are also formed by probabilities of event changes and patterns (Huron 2006: 60). Probabilities are based on statistical learning, and accordingly "[w]hat we expect might simply reflect what we have experienced most frequently in the past"; this process does not presuppose conscious awareness by listeners (ibid: 70-1). In the context of music, statistical learning depends not only on past listening experiences, but also on our ongoing cumulative register of sound events and their interrelationships within a particular composition. Expectation facilitates perception and this is thoroughly explored in Huron 2006. The purpose of this section is not to summarise the different types and operations of expectation analysed by Huron, but to point out the importance of expectation in making accurate or approximate time judgments about future events, which has implications for the perception of cause and effect, and for the ability to recognise event chains and form corresponding timescales.

3.8 Summary

It has been recognised that microsound is not defined only by duration, but also by the general lack of identity and idiosyncratic behaviour to depend on its immediate sonic environment. Hence, the definition of microsound relies on context. Microsounds appear either as isolated objects, or as part of a larger sound event. In the latter case, they belong to a continuum between fusion of micro-elements and fission of the larger sound. During extreme fission, a large sound loses its identity, whereas during fusion, microsounds acquire an identity, as the resulting sound demonstrates a textural behaviour. Very brief microsounds can be perceived subliminally, but their usefulness in composition is questionable; sound material has to be carefully selected and the concerts need to be held under controlled listening conditions.

There are two systems of duration awareness – perception and estimation – which are in operation at the same time. Duration perception applies to short timescales, whereas duration estimation to those longer than the specious present. It has been noted that stimulus complexity has implications for time judgements, involving both estimation and perception. Various parameters of sound can contribute to perceived complexity in acousmatic music. In addition, it has been discussed how time perception can be affected by temperature, and by the cognitive process of selective attention. Finally, it has been pointed out that expectation enables us to recognise event chains and timescales.

Chapter 4

Analysis of Electroacoustic Compositions

4.1 Preface

This chapter concentrates on the analysis and discussion of the electroacoustic pieces composed for the PhD. Five acousmatic works are analysed, of which two have alternative versions. *Ka-Boom!*, *Chronos*, *Arborescences* and *Paramnesia* are stereo acousmatic pieces; *Vessel@Anchor* is composed for six channels, with a stereo version called *Vessel@Anchor ST6* that lasts for half the time of the original piece. *Chronos* has an alternative ending with an audiovisual element.

The analysis will consider the compositions, focusing on the organisation of sound material that establishes relationships among timescales. Influenced by Nattiez's semiological tripartition and approach to analysis (1990), the discussion for each composition will consider the poietics, followed by an examination of the esthesic dimension where possible, and an evaluation of the processes. The poietic analysis will consider the ideas behind each piece, the general structure, the compositional procedures of particular sections of interest, and the connection with the theory developed in the previous chapters. References to collecting sound material, organising and processing will be made as appropriate in order to illustrate the thought processes that led to a particular investigation of temporal operations. The esthesic analysis will consider perception and construction of meaning, where appropriate, from a listener's viewpoint, alluding also to the neutral level, the "trace" of each piece. The separation between poietic and esthesic dimensions is not practical for every composition, as sometimes both sides of the analysis need to be discussed in the same section.

4.2 Ka-Boom!

Ka-Boom! (2004) was the first stereo acousmatic work to be composed for the PhD research. Even though the composition was highly speculative, as views were formed on the basis of information relating to time perception being collected, the process led to the development of ideas elaborated later in the second and third chapters. The piece lasts for 14:07 minutes and is based on recordings of fireworks displays, also employing recorded voices that imitate fireworks.

4.2.1 Poietic Processes: Aims

The central idea for the composition of *Ka-Boom!* was drawn from information processing theory – the dominant paradigm in cognitive psychology, a discipline studying how the brain perceives and structures information. According to this theory, the human brain assimilates the information that a listener receives by reducing the complex data into meaningful patterns and preserving these in memory. Subsequently, the listener is able to understand the surrounding world by synthesizing it from the chunks of information kept in memory. The structuring of the composition is influenced by this theory, rather than attempting to mirror the exact process of the human brain. Each section is constructed in such a way that particular sonic qualities extracted from the real-life event prevail in different sections, thus creating meaningful patterns that can assist the recollection of specific moments in the fireworks display. The piece aims to transfer the long duration of contiguous events into the time restrictions and temporal frame of the acousmatic work. Moreover, with the progressive addition of sections it attempts to communicate to the listener the general festive atmosphere of the pyrotechnics event, with a touch of parody.

Ka-Boom! frames chunks of information between a short starting and a similarly short ending section that link directly to the real-life happening. A recorded crowd and a voice counting down through a loudspeaker mark the beginning, while the end is manifested by a similar crowd of people and a loudspeaker voice asking the crowd (and supposedly the listeners of the piece as well) ‘did you enjoy that?’. In between the starting and ending sections, there are chunks of information; isolated events trigger chain reactions of sound material, until a new event is picked up and a new chain reaction takes place.

The composition is sectionalised, and most sections are interconnected, each having a dominant characteristic. Figure 4.1 shows the various sections, noting the most dominant events or characteristics in each one.

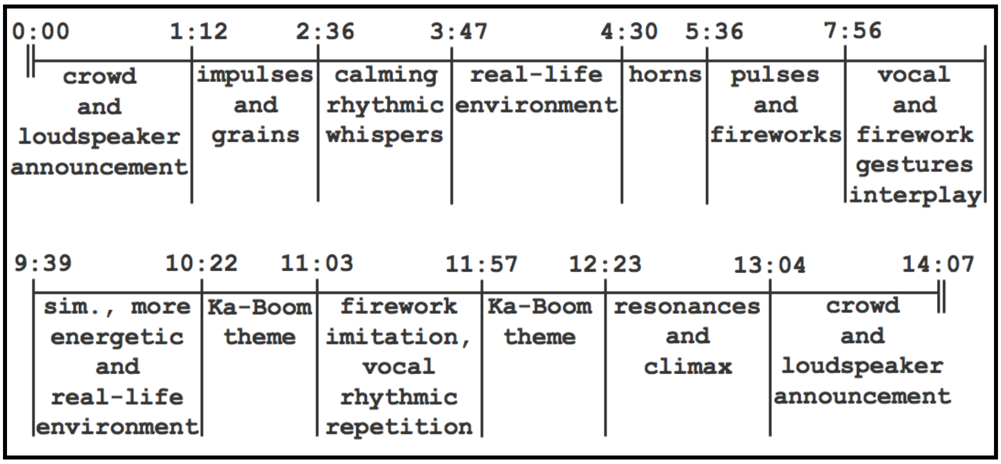

Fig. 4.1 **Sections in *Ka-Boom!***
The numbers at the top display the start of each section in the timeline. (N.B. The sections in the graphic representation are not proportional to the audio sections.)

Abrupt changes (for example at 3:47, 4:30 and 10:32) serve as surprises, as startling awakenings from the preceding calmness. The change from tension to calm and back again emphasises the sectionalised nature of the piece, and is repeated throughout the work.

Although changes are often abrupt, most sections are interconnected; sound events or characteristics of sounds that belong to a subsequent section start in the preceding section. An example can be heard at 4:11, where the first processed horns are heard, mixed with the recorded horns of the boats; the processed horns connect the real-life recorded environment with the following section (starting at 4:30) based on the timbre of the horns and the relatively short duration of each horn occurrence that brings about a rhythmic quality.[82]

[82] The pitched material resembling horns was acquired through physical modelling synthesis.

As can be seen in Figure 4.1, various dominant characteristics prevail in each section (pulses, fireworks, grains, vocal imitations, whispers, rhythmic activity). Characteristics are repeated in a cycling fashion, in order to connect distant sections and hold the disparate parts together; grains are mixed with pulses, pulses with fireworks, fireworks with voices, and voices with grains. The co-operation among fireworks, gestural processed material and voices is periodically alternated with crowd recordings, diverting from the studio environment to the outside and attempting to bring both realms together in interplay.

Some themes are repeated in modified versions to bring important events to attention. For example, the 'Ka-Boom' theme[83] appears at 10:22 and 11:57; in this particular case, the title of the piece is overemphasised in the vocal part and the co-occurring sounds. The process of arranging such recurrences led gradually to the concept of chronological order, its rearrangement, and the dislocation of time and place examined in section 2.5.3. Although it was my intention to cut linear time into fragments and bring them together, thus compressing a long happening and keeping only the essential elements, reorganisation with repeated themes matured as an idea much later.

4.2.2 Poietic Processes: Material

Two recordings of fireworks were made; the first in Marseilles, France, in the summer of 2003, and the second at Herne Hill in London, in the autumn of the same year. The two recordings have different characteristics because of the divergent equipment that was used in each situation, but also due to location differences; the Marseilles recording was made on the deck of a boat in the harbour, in the midst of surrounding hills that caused reverberation and echoes, whereas the Herne Hill recording was made in an open park area.

[83] The theme starts with a short curvilinear gesture, and continues with the time-stretched word Ka-Boom that culminates in a series of waveset beads accompanied by isolated fireworks; the theme ends with a long reverberant tail.

Since the aim was to transfer long series of contiguous events into small temporal frames, the focus fell on controlling the structural organisation at the micro and the lower macro levels. Hence, the recordings were cut and arranged systematically into smaller elements. Because there was more than one hour of continuous recorded material, the first task was to isolate and organise the various sounds. Fragments were arranged into lists according to their prevalent characteristic (see Fig. 4.2). The material was organised into sizzles, crackles and whistles; regular rhythmic groups of transients; single sustained sounds; single short sounds; and irregular patterns.

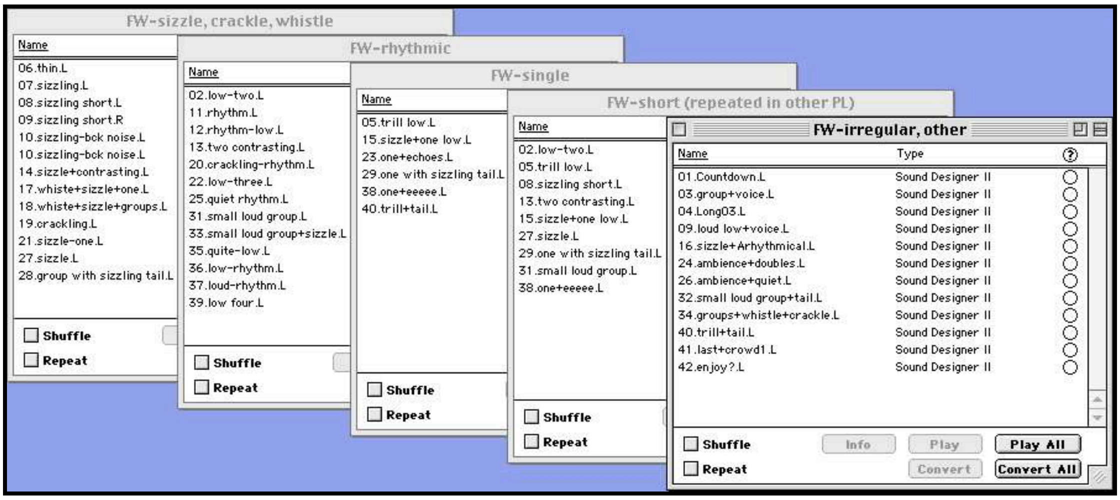

Fig. 4.2 **Organisation of sounds in *Ka-Boom!***
Organisation into lists of the Herne Hill recording (screenshot). The same process was repeated for the Marseilles fireworks. The lists were made in the software program SoundApp for PPC Mac.

The organisation into lists made it easier to work with different sections, concentrating on one characteristic, or on a combination of closely related qualities. This process facilitated the contrast between episodes and the sectionalisation of the piece. Fireworks consist mainly of attack transients with little sustained material. This particular aspect dictated the course of the composition, the material in the score for the subsequent vocal recordings, and the choice of processing and working with microsounds and transients.

The vocal parts mimic the pyrotechnics. The compiled text is a combination of onomatopoeia, made-up language and words used in comic books. In order to explore the micro level, both sound events and language were disintegrated, the first into microsounds, and the second into utterances, by deconstructing the words into their components. The fragmentation has been achieved both by editing and processing, and through the vocal rendition of a prepared text comprising disintegrated words. A score was produced for the performance in the recording studio, with typographical variations indicating changes in dynamics (see Fig. 4.3). Further instructions to performers[84] depended on their interpretation of the score, and were given verbally during the recording session. Instructions on the score were suggestive, and further improvisation on the text was expected. Call and response between the two performers was encouraged, as their interaction added energy to the rendition.

<u>**Onomatopoetic words**</u>:

BANG. * HISSsss… * sWOOOoosh.. * BOOM. * CRACK. *

<u>**Disintegrate**</u>:

B. * A. * BA. * ANG. * G. * HIii… * ISSs… * SSS… * SWOOo… * OOShh… * OOOMMm… * CR. * CRA. * RACK. * ACK. * CK. *

<u>**Designate extra loudness**</u>:

KA-BOOM. (…) * KA-POW. (…) * KA-BANG. (…) *

<u>**Comic-book and made-up words**</u>:

BAA-DOOOOW… * BAAA-ROOMM… * BADOOOMMmm… * BADABOOM… * BAOOOom… * BARROOOMm. * BHWOOom… * BLA-DROOom… * BLA-DABOOOOM… * BLAammm… * BRA-KOOOM… * BUDOOM. * BUH-BOOM. * BTOOOM… *

KADOOM. * KATOOM. * KA-WHOOM… * KRAkaDOOM… * KRAKATOWww… * KRAKKL. *

SHAAkkow. * SHAKOOM… * SHRACK-K-K-K-K… * SHRAKKAKA-KAKAKAKA. (*ff*, *p*) * SHRA-KABOOM. * ssSSSSSSWOSHhhh… * SWATHZzzZWHOUMmm…. * sSSHHFFOOoosh… * SSSHHABA-BOOOOM. *

DOOM… * FAH-BHAMMM… * FFT. * FFZT. * FOOSH.. * FTOOM. * FUH-WHOOM. * FWAKOOM… * FWATHOOM… * PTOOMM. * PWAKA-PWOOM.. * THWOOom… * VOOOSh…

<u>**Disintegrate**</u>:

D. * OOOW… * ooOOO. * AR. * A-ROO. * OO. * OOOOMm… * A-DOO . * DOO. * BADA. * DAB. * DABOO. * ABOO. * BOOM. * BH. * HWOO. * BL. BAL. * LAD. * ADR. * ADROO. * DROO. * LAA. * AM.* BRA. * RA. * RA-KOO. * KOOOO… * BU. * UDOO. * U. UDOOM. * BUH. * BT. * TOO. * OOM.*

KA. * ADOO. * KAD. * KAT. * M. * WHOOM. * KR. * KRA. * KRAKA. * KAD. * KADOO. * ADOO. * DOOM. * TOW. *
K. * K.K.K.K. * K.K. * (fast, regularly, then erratically)
T. * T.T.T.T. * T.T. * (sim.)
KL. * AKL. *

SHHHA. * AKOW. * AK. * OW. * AKoo. * AKOOM. * KOOM. * OOM. * OOMm… * SHR. * SHHHR. * SHRA. * AKAB. * WO. * OSHHH… * SWATH. * SWA. * ATH. * THZZZ. * zZZZzz… * ZWHOU.. * WHOU. (…) * OUM. (…) * SHHF. * FOO. * OOSH. * SSHABA. * BA-BOO. *

DOO. * FAH. * AH-BHAM. * ZT. * FOO. * FT. * TOOM. * WHOOM. * FWA. * THOO. * PT. * TOOM. * PWA. * WA. * WAK. * WAKA. * AKAPWOO. * PWOOM. * THWOO. * VOO… *

Fig. 4.3 ***Ka-Boom!* score.**
The score used in the performance of the vocal parts. The asterisk [*] separates utterances, and the three dots […] designate added duration.

The decision to work with microsounds, suggested from the attack transients of the fireworks, also informed the editing and processing of the vocal recordings, instigating the deconstruction of the spoken words into distinct units (see Fig. 4.3, under the underlined titles 'Disintregrate'). Disassembling a word into its phonemes

[84] I am indebted to Seth Ayyaz and Wan-Ping Yeh for performing my score.

destroys the semantics, in a similar way that granulating a sound event may destroy the original associations. Both the sound event and the word eventually lose their identities and allow the formation of new objects, and any gestures suggested by the complete onomatopoetic or made-up words (e.g. Ba-Room) collapse, and new gestural suggestions emerge (ar; a-roo; oo; oom). The deconstruction of language and sound events led to the development of the ideas on lack of identity of microsounds, described in Chapter 3.

The recorded words and vocal fragments were subsequently organised into lists according to their prevalent characteristics, similar to the process followed for the listing of fireworks. Deep resonant male vocal sounds were contrasted with thinner female utterances. While male vocal fragments mixed well with the bass components of the fireworks, the female and whispering sounds were suitable to combine with sizzling firework material. Utterances were categorised according to their attack sound (F, B K, S), because the attack gives a relatively measurable amount of energy, depending on the sharpness of the onset, i.e. the high frequency content of the transient (compare a voiced ‘B’ with a ‘K’). In addition, the prefix ‘Ka-’ delivers more energy in the word ‘Ka-Boom’, than the plain fragment ‘Boom’; it is the anticipation created in the short time difference between the two onsets and the accent on the second syllable that are responsible for the added energy. However, the energy depended also on the manner of execution. The objective was to create sections with different amounts of energy, where vocal parts and fireworks contribute equally to the activity, underlined by the processed material.

4.2.3 Poietic Processes and Esthesic Considerations: Structure and Processing

The overall structure was influenced by George Miller’s information processing theory (1956) and his concept of mentally organising data into familiar units to preserve in memory; the idea of organisation into chunks of information was approached by partitioning the work into sections that shared a certain quality (as seen in Fig. 4.1). Organising the recorded fragments into groups was the first stage of this approach. Subsequently, the recorded material was analysed and processed; the transient quality of most fireworks led me to explore the micro level, and that decision resulted in a series of thought processes, illustrated in Fig. 4.4.

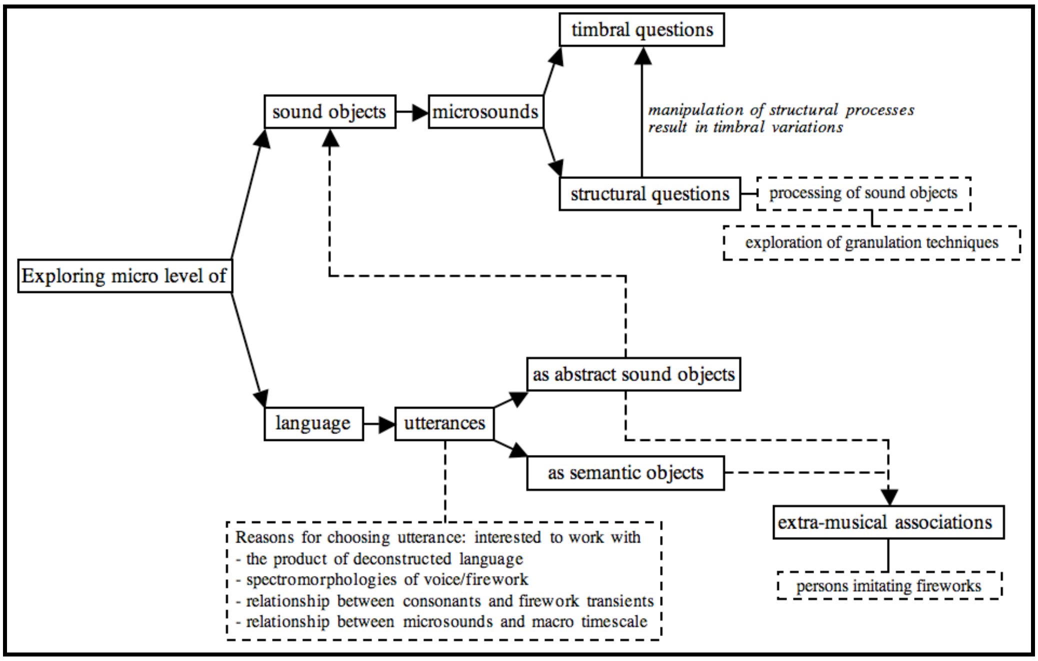

Fig. 4.4 **Exploration of the micro level.**

The exploration of the micro domain was conducted at two levels. At the first, the non-vocal sounds were considered primarily as phenomenological formations, independent of any referential qualities (i.e. as sound objects), whereas at the second level, vocalised sounds were treated either in their entirety as words, or they were cut into syllables and phonemes before they were further processed. Utterances were treated both as semantic and non-semantic objects.

Semantic meaning was created when utterances were clearly associated with fireworks; although their instrumental aspect was nonetheless in use, semantic relations prevailed. Vocal segments were mostly used as separate events, whereas occasionally, agglomeration of utterances and micro processing of voices created textures (e.g. from 7:07 to 7:40).

Non-semantic material was created by deconstructing and re-organising the mimicking words into syllables and phonemes. These phonological building blocks were initially treated as sound objects. However, intonation, stress patterns and the characteristic timbre of the human voice made it difficult to separate the utterances from their extra-musical associations (i.e. persons imitating the sound of fireworks). Consequently, in the context of this composition, links between fireworks and utterances could not be avoided; on the contrary, they were made stronger by the constant interplay between vocal and firework sounds.

Various degrees of convolution using diverse parameters attempted to create a continuum between the two different sound worlds, those of fireworks and voice. Additionally, the two sound domains were blended by separating audio files into their excitation and resonance characteristics, and recombining the excitation of fireworks with the resonance of voices to create hybrid sounds.[85]

Processing at the micro level included granulation of recorded sounds, granular and pulsar synthesis, micro montage, and waveset stretching. The resulting microsounds created both periodic and erratic rhythms, instigating a systematic investigation into micro-structures, which eventually led to the development of the section in temporal syntax (2.5.2). An example of periodic rhythmic activity can be heard in the section starting at 5:36, made of a mixture of synthesized pulses and fireworks. Erratic rhythms are prevalent in most sections; for example, the section starting at 9:44 was made using micro montage; and at 10:32, the erratic rhythm of the transients in the tail of the exclaimed 'Ka-Boom' was created with waveset stretching. While experimenting with microsounds, it was noted that granulating a sound changes the way its timbre is perceived; spectromorphologies change, as does their effect on their surrounding sounds, because their constituents disperse. These were also the first steps that initiated my ideas on separation of timescales using different rhythmic relationships.

4.3 Vessel@Anchor

Vessel@Anchor (2005) is an acousmatic piece for six channels, and lasts for 11:38 minutes. The plot on which the structure of the composition is based is simple; a boat approaches a harbour, the anchor is subsequently thrown into the sea, and the listener

[85] This was achieved with the software program MarcoHack for Macintosh PPC.

is presented with various sonic images which concentrate either on the sounds heard in the interior generated by the waves hitting the boat, or on those produced outside the vessel.

4.3.1 Poietic Processes and Aims

The sound material originates in various forms and combinations of water recordings (open sea, seashore, waves heard from inside a cabin, drops). The environmental recording was made in and around the port of Marseilles, while additional tap water recordings were made in an enclosed space in London. Most processing uses environmental sound as source material.

The initial idea was to separate concurrent timescales by using different rhythmic activity, which began to evolve while working on *Ka-Boom!* However, in *Ka-Boom!*, different rhythms were not used simultaneously. Because the material used in *Vessel@Anchor* derives mainly from one timbre, that of water, an early concern was that it might be difficult to separate timescales based on different rhythmic activity, since many of the sounds occupied a similar frequency range. The solution at that time was to work on a multi-channel piece, where divergent rhythms were assigned to opposite spatial regions (see regions A and B in Fig. 4.5).

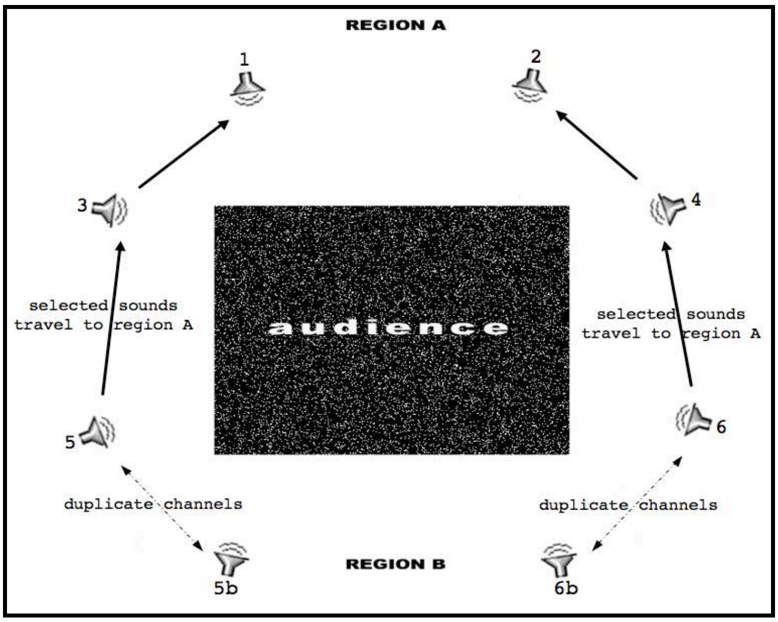

Fig. 4.5 **Diagram with speaker positions.**

The composition started as a 4-channel piece (speakers 1, 2, 5 and 6 in the diagram). However, that initial setup created a gap between front and back, especially during spatial transitions between regions A and B. Channels 3 and 4 were added to facilitate smoother transitions and uninterrupted trajectories. Spatial region B, at the back of the audience, was later expanded by duplicating channels 5 and 6 with 5b and 6b (see diagram) in order to make the region's presence more pronounced.

The overall structure is based on repetitive undulating gestures and intervening splattering textures. Short structures in the meso timescale form wavelike morphologies that repeat in different versions. Even though the content (spectrum) of the shapes may change, repetition of shapes (morphologies) emphasises the profile of undulation and the image of waves, and renders a sense of near stasis by revisiting the same contour repeatedly. As examined in 2.5.2, repetition seems to suspend time as experiences are relived through a cycling process. Fig. 4.6 shows a series of undulating gestures and meso structures encountered from 2:50 to 5:45 in the piece.

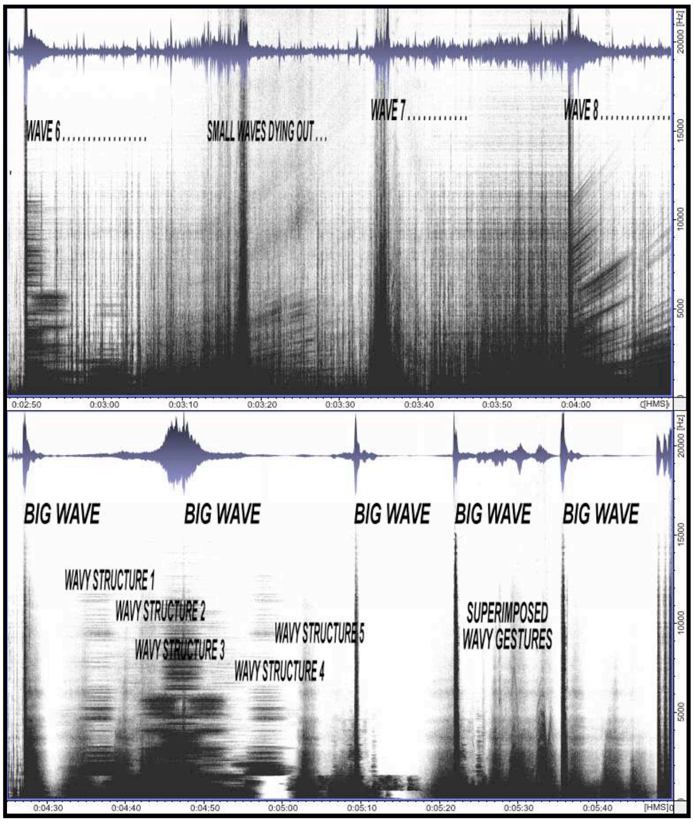

Fig. 4.6 **Undulating structures.**
Annotated sonogram (with waveform at the top) of undulating structures (2:50 - 5:45). At 2:50, the gesture is marked as 'Wave 6', because it is preceded by five similar gestures earlier in the piece (at 1:36, 1:41, 1:47, 2:02 and 2:21).

Wavelike contours repeat in a near-periodic fashion. Although details change, the image of repetition does not collapse.

At 2:21, an upwards glissando gesture is formed by a conglomeration of microsounds; this can also be heard as a restatement of earlier wavelike contours, mainly because it is surrounded by such shapes. Links are formed with surrounding material, and any resulting associations are hard to overlook. Connections with wave imagery persist even when individual grains are scattered at different spatial positions (2:23 – 2:35).

At various points in the piece, there is interplay between microstructures recorded directly from nature (splashing water) and those made with processing (granulation); an example can be heard between 3:18 and 3:33. The water sounds in most parts are recognisable; and if not, the material alludes to some form of water. While the composition was in progress, I noticed that timescales could be separated not only through rhythmic activity, but also through extra-musical associations. As expounded in section 2.5.3, timescales are formed because of semantic bonding. This is evident from the very beginning of the piece, in the passage with the anchor's chain. The metallic pulses, the dense iteration created by the boat's engine, and the rhythm of the waves belong to different timescales (listen to Audio 4.1; the sounds of chain, engine and waves are heard separately, and then in the context of the composition; each of the four excerpts is 16 seconds long). Figure 4.7 shows the sonograms of two of the sounds (chain and engine); the starting point for both is at 1:01.

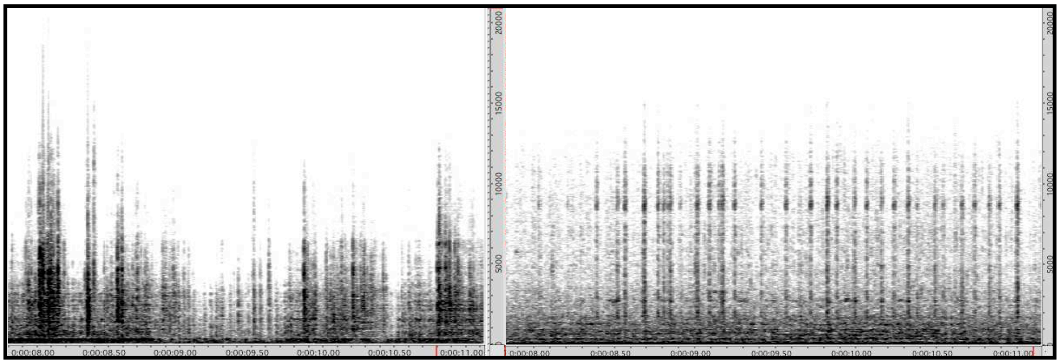

Fig. 4.7 **Chain and engine sonograms.**

Sonogram of the chain (c. 3 sec long). Sonogram of the boat's engine (c. 3 sec long).

The sea could not be separated in the sonograms as it was embedded in the recorded sound, but it clearly has a different pace, as can be heard in the audio excerpt. In order to emphasise the pace of the waves, a third sound with only the sea (from a different recording) was inserted in the passage. However, the engine's and the chain's paces are blurred, because the inter-onset interval (IOI) between successive transients is very similar in both sounds (see Fig. 4.7). A characteristic that differentiates one from the other is their timbral quality (the chain sounds brighter), and a second characteristic is their divergent source bonding. The fact that source bonding is a strong characteristic that segregates timescales becomes clearer when the sound events occupy a similar range of frequencies, as becomes apparent later in this section.

Two timescales are exposed at several points in the piece, and are separated spatially into two regions. Splattering water sounds at the rear give a texture that shows no signs of long-term evolution, creating a feeling of near stasis. Sounds in the front region act in their own timescale, while a third sound field consists of trajectories connecting the two regions. The two timescales exist simultaneously and the listener's perception of time passing changes, depending on the focus of attention, which the composition attempts to guide by using various strategies, e.g. by momentarily suspending the activity in one of the regions, or by emphasising certain sounds. An example of spatial separation of timescales can be heard at 3:59. Audio examples 4.2 and 4.3 present the sound events heard at the back and front regions respectively; the pace of the slowly evolving gesture at the front region contrasts with the near stasis figuring at the back.

A second example of spatial separation of timescales can be heard at 1:41; the two regions are connected at the beginning of the event by a trajectory starting at the back and travelling to the front via the sides. Figure 4.8 shows one second of the waveforms on all six channels, starting at 1:41.

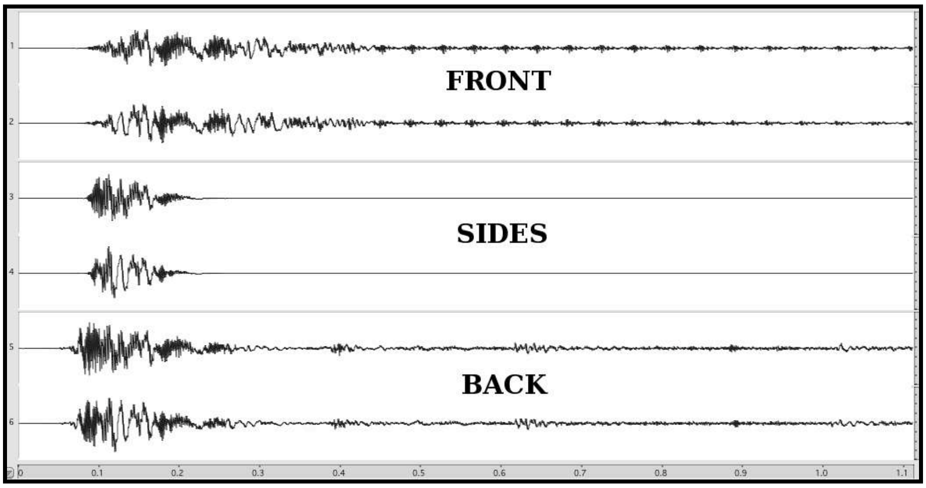

Fig. 4.8 **Trajectory from back to front.**

The impact starts at the back region first, and it continues with a slight delay at the sides and then at the front. In this way, a smooth transition from back to front is achieved. The two separate timescales created by the rhythmic activity in the front and back regions can be heard in Audio 4.4 and 4.5 respectively; Audio 4.6 contains the isolated impact sound heard at the sides.

At some points, sounds from the front and the back mix together, merging the two spatially separated time structures into one space, thus creating ambiguous moments. When the space barriers collapse, there are other properties that determine whether or not timescales are segregated. From 3:12 to 3:32, there are three concurrent rhythmic streams, where spaces converge. Two of the streams are less prominent and very close spectrally. However, one is the tail of a dense burst of low impacts, while the second is a periodic series of microsounds that underlines the event.[86] Although the passage is not long, it illustrates one point effectively; the cause-and-effect relationship of the first stream with the preceding burst of low impacts seems to be sufficient to segregate the rhythmic streams. Sound images connected together by an associative relationship (in this case cause-and-effect) stand out against other concurrent streams. At the very end of this fragment, the upwards glissando and the acceleration of the first stream separate further the two events. A similar process can be observed from 3:34 until about 3:44. However, in this case, after their separation the streams blend

[86] Audio 4.7 presents four excerpts; (1) the first stream, which is the accelerating rhythm starting amid a burst of low impacts, and which is accompanied by a series of erratic bursts of short bright events; (2) the second stream, which is the periodic series of microsounds; (3) the third stream of splashing sounds; and (4) all three streams as they appear concurrently in the composition (stereo reduction).

into one, and segregation collapses; water sounds with similar rhythmic activity can be heard from various spatial positions around the listener. (Listen to Audio example 4.8; stereo reduction of the section between 3:34 and 3:59.)

The concluding section, starting at 9:35, extends the recognisable sea into the domain of heavily processed material. This section was composed in order to examine practically whether material that is not explicitly connected with sea sounds, carries the same mental connections as previous passages. The construction of wavelike gestures that are far removed from sea sounds is an attempt to emphasise the temporal distance between the present and the past – the current position of the listener and the traces of the sea left in memory. Although the source and the cause of the sounds become unknown, vestiges of gesture related to the image of waves still remain;[87] memories of the recently heard material make this connection easier. Different frequency areas, which were carefully selected from larger events and passed through resonant filters, are scattered in space trying to engulf the listener, thus alluding to the magnitude of the space to which the sound refers (i.e. the sea). A circumspectral space is created (Smalley 2007: 51), which slowly shifts its weight among several spatial areas. This last section is musically prepared a little earlier (8:45), where slowly evolving pitched material appears amid splattering sounds.

4.3.2 Esthesics: Perception of Temporal Messages

Temporal messages through associations have been examined in section 2.5.3. In *Vessel@Anchor*, there are temporal qualities referring to the sonic image of the sea and its timelessness. Structures play a primary role in emphasising long durations and suggested permanence. The piece attempts to play with the listener's perception of duration by extending sections psychologically, which is conducted by exposing static textures and repeated gestures.

[87] See Smalley 1997: 112 for a discussion on *remote surrogacy* and its link to the psychology of primal gesture.

A particular case of interest is the last section which comprises the last two minutes of the piece; it employs a combination of (1) remembered connotational temporal information originating in previously heard sea sounds; (2) contrast with the previous section (current languor versus preceding haste); and (3) pace, manifested in slowly developing gestures, reminiscent of slow waves. These last gestures carry temporal suggestions of 'perpetuity', and the section has been invariably perceived as being much longer than it actually is, when heard in the context of the entire composition.[88] The result is not the same when the ending section is presented alone, because the connection between the slowly evolving gestures and the sea is not made apparent. In order to experience the everlasting quality of the sea, that is, the connotational temporal information it carries, one must listen to the entire composition. Previously heard sounds of the sea survive their disappearance. The last section does not contain any recognisable water sounds, but it alludes to them through the slow gestures and their carefully constructed spectromorphologies.

Section 2.6 elaborated on the T-I set, explaining that various auditory streams tend towards one point on the subjective time continuum, merging their psychological imprint into one quality between haste and languor. However, in cases where the listener can recognise several rates of time passing, attention may shift from one quality to another. *Vessel@Anchor* offers the opportunity for the listener to shift attention easily between timescales, due to the perceptual gap between them, marked by their difference in spatial position. Listeners cannot feel two rates of motion at once (haste and languor), but are nevertheless aware of the existence of both because they can switch between them. (Listen to the 6-channel version from 1:40 to 3:45.) Attention is drawn to one timescale prevalent in a specific region by silencing another (e.g. front region, 2:07 – 2:18), by reducing the presence of another (e.g. back region, 2:34 – 2:49), or by presenting prominent events placed so that they catch the attention.

Christian Zanési's composition *Courir* (1990) presents a good example for comparison with *Vessel@Anchor*. Although *Courir* is a stereo piece, Zanési still uses

[88] This was deduced from discussions during the presentation of the work in a composers' meeting at City University on 18 March 2005, and from subsequent discussions with colleagues and members of the audience, following the premiere of the piece at a City electroacoustic concert on 24 January 2006.

space at some points to separate two types of sounds, which form at least two concurrent timescales. The dominant streams of sounds (rhythmic breathing and non-vocal material) are heard concurrently for more than fifteen minutes.[89] The breathing pattern prevails during the entire piece and relaxes only just before the last minute. Although the two streams are presented through a frontal stereo image, and occasionally they share the same frequency areas, the listener does not have much difficulty in focusing on either of the two streams, as they are separated in two ways. First, the breathing pattern strongly relates to its source, i.e. a person, and thus differentiates entirely from the rest of the sound material. Even when breathing is briefly masked by other sounds (e.g. at 0:58 and 1:08 in Audio 4.9), we can imagine its apparition continuing until breathing is audible again. The second way that timescales segregate is through the use of space. The breathing pattern always sounds very close to the listener, while the rest of the sounds occupy a more distant space. It is the relation between proximate and distal spaces (Smalley 2007: 36) that creates the depth in which the timescales separate; in *Courir*'s case, multi-channel separation is not needed, because breathing creates a very proximate space that approaches the listener's personal space. This approach could not have been taken without difficulty in *Vessel@Anchor*, because none of the prevalent sounds creates such extreme proximity. In addition, in *Courir*, when the two spaces (distal and proximate) converge through changes in spectrum (the presence of high frequencies bring distant sounds closer to the listener), Zanési uses panoramic space to separate the two streams (Fig. 4.9).

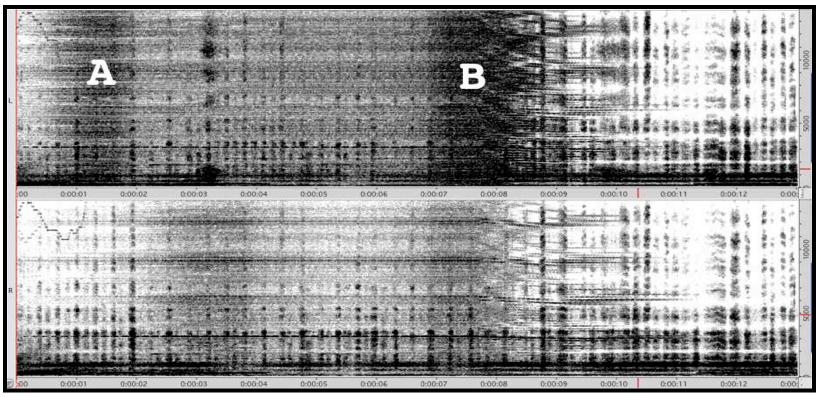

Fig. 4.9 **Christian Zanési's *Courir*.**
Sonogram of an excerpt, from 3:23 to 3:36. The rhythmic breathing can be clearly seen as dark beads that form thin vertical shapes.

[89] *Courir* is in two parts; the duration of the first part is 11:09 minutes and of the second 4:05 minutes. An excerpt of two minutes (01:00 – 03:00) can be heard in Audio 4.9, so as to give an idea of the material used in the piece.

The top and bottom sonograms display the spectral information on the left and right channels respectively. When the rhythmic breathing is partially masked (mark A) and entirely masked (mark B) on the left, the vocal sound continues uninterrupted on the right (listen to Audio 4.10).

Courir's example demonstrates that spatial separation of timescales can be successfully created in a stereo format, not only in panoramic space but also in the area between proximate and distal spaces, provided that the sound material is chosen carefully so as to create the basis for spatial control.

4.3.3 Vessel@Anchor ST6

Vessel@Anchor ST6[90] differs from the original 6-channel version in two areas. First, this version is in stereo; and second, although the two pieces use the same material in a similar structure, the stereo version lasts for six minutes instead of 11:38. Omission of sections and events has been applied, instead of time contraction, which was not deemed effective for retaining the general slow pace of the piece.

The stereo reduction posed a few problems, mainly related to the drop in energy compared with the multi-channel version; duplicate audio files, playing at the same time in various spatial positions in the original, were deleted, and only one representative was kept. As a result, most of the onsets did not have the same impact as when all sounds were present. Moreover, the dynamic level had to be decreased at many points, especially when different sound files were superimposed to create an attack; this attenuation resulted in attacks with less weight, and the overall effectiveness of those moments was diminished.

One type of information, which was considered important, indicates the source of the main sound material (water) and its general morphology (undulation); these characteristics maintain their presence throughout the piece. The second type of

[90] ST6 stands for *ST*ereo version, *6* minutes long (and also reduction from *6* channels).

information, of which several representatives have been omitted, contains variations of the first type. For example, the large wave at 2:21 and several undulating structures in the multi-channel version are excluded from *Vessel@Anchor ST6*, the result being that the first isolated big wave that originally appears at 4:27, now emerges at 2:42. Apart from omitting variations of gestures, the stereo version leaves out two sections highlighted in Fig. 4.10. Between the two sections, another omitted large wave is marked at the top sonogram, to emphasise the extent of large-scale editing in this part of the piece.

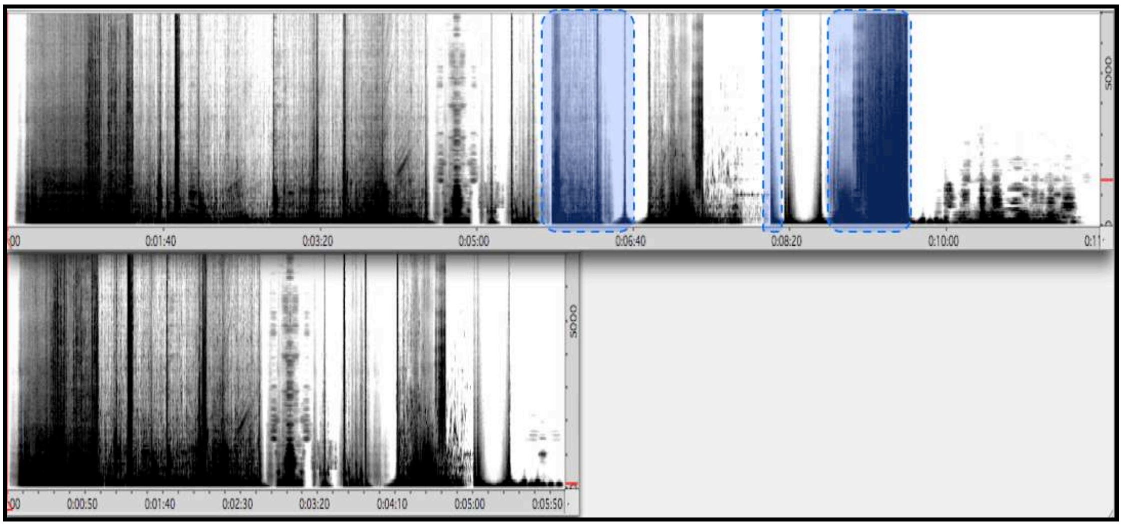

Fig. 4.10 ***Vessel@Anchor* and *Vessel@Anchor ST6* sonograms.**
The sonograms of *Vessel@Anchor* (top) and *Vessel@Anchor ST6* (bottom) are presented for comparison.

By omitting the first highlighted section (5:48 – 6:45), a relatively fast-paced section is excluded in order to allow the slow pace to dominate in the short version.

A second, fast-paced section is omitted (8:42 – 9:40), but for different reasons. There was a major constraint regarding the duration of the piece; *Vessel@Anchor ST6* was composed for IMEB (Institut International de Musique Electroacoustique de Bourges) for the overture project on water (H_2O), presented at Festival Synthèse 2006. One of the imposed limitations was that the piece should not exceed six minutes. The haste of the last highlighted section provided a contrast with the subsequent languor, as discussed in 4.3.2. Contrast would only work if the slow-paced section were presented in its entirety. Since this was not possible, part of the last section was connected with the large waves between 8:19 and 8:40 in order to maintain the languor near the end, and the last highlighted section was omitted.

It is difficult to conclude whether or not the short version succeeds in preserving the temporal perception of the original, especially because an examination of people's reactions is not possible. The two pieces are not meant to be played side-by-side for comparison. If they were, the first composition to be played would influence the perception of the second. Listeners would naturally reflect on differences thus influencing their responses.

Nevertheless, this study was useful for examining the effectiveness of repetition and variation, and for exploring the number of recurrences needed to maintain a particular temporal state in the specific case of *Vessel@Anchor*. Lessons learnt through this study in reduction were carried on to my compositions examined later in this thesis. Since then, I have made a conscious effort to apply the principle of Occam's razor to my forthcoming acousmatic pieces.

4.4 Chronos

Chronos (2006) allows for two possible versions. In live performances (where circumstances permit) it uses stereo electroacoustic sound, a third channel being dedicated to the recorded sound of a clock, and a clock is physically present on stage. This three-channel version lasts approximately 11:30 minutes, while the purely acousmatic stereo version lasts 11:08 minutes. The piece is framed between a representation of the beginning of time and the actual present, and exposes the main symbolic carrier of time, the sound of the clock.

4.4.1 Poietic Processes and Esthesics

For the purpose of this composition, sounds of clocks in different forms were recorded (chimes, ticking, alarms and winding mechanisms), in addition to further material with metallic quality (a tray inside an oven, and sleigh bells). The recordings have been processed to provide additional textures and gestures. However, the clock remains a recognisable element throughout the piece.

Microsound processing has been employed in order to explore qualities of micro events. A Max/MSP patch was used to create decelerating clocks heard after 2:14. The main patch incorporates a subpatch named '[slope]' (Fig. 4.11), where deceleration and acceleration can be controlled in real time.[91]

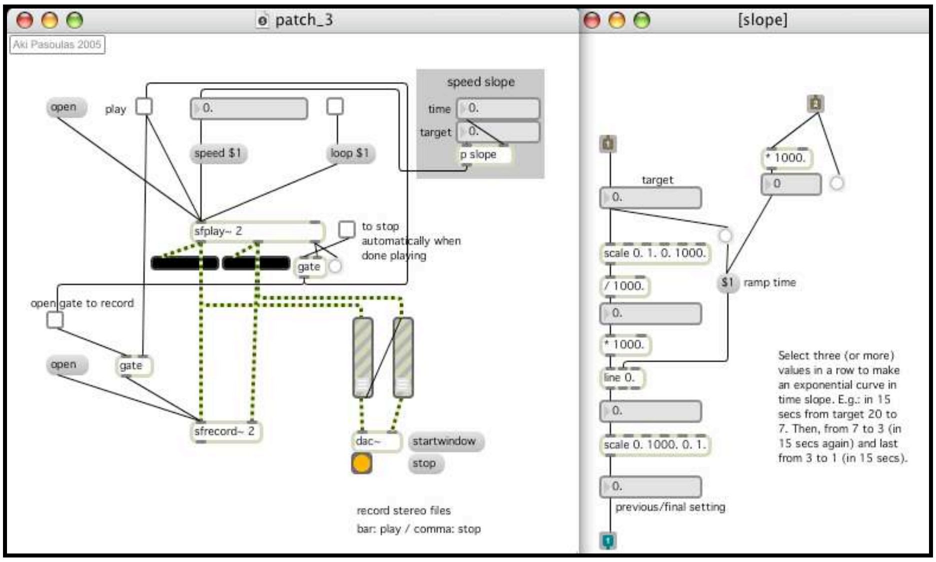

Fig. 4.11 **Acceleration/Deceleration Max/MSP patch.**

This composition started with an exploration of superimposed layers of sounds with different rhythmic activity. Rhythms were created mainly by regular clock ticks, which were then accelerated or decelerated to form various rates of time passing. When the durational patterns created by the IOIs in the superimposed layers formed a distinct pulse, they produced polyrhythms. Justin London (2007) notes that studies in polyrhythms demonstrate that listeners cannot hear many layers of rhythms at once, but they either select individual layers for attention, or they construct one composite rhythm from the present strata. His comment agrees with my observations while working with concurrent timescales, as will become clearer later in this section.

Chronos led to a comprehensive analysis of temporal operations, particularly to the investigation of *discretisation of time* as elaborated in section 2.5.2. In *Chronos*,

91 The patch I created is included in CD2, folder 2. In the grey square titled 'speed slope' (Fig. 4.11, in 'patch_3'), 'time' refers to the duration (in seconds) of the acceleration or deceleration ramp, while 'target' refers to the speed of the playback ('1' is normal speed). Speeding up and down is controlled by these two number boxes. Instructions: after opening a sound file and starting playback (looping is optional), insert a number in 'time', hit 'enter' on the computer keyboard, and then insert another number in 'target' and hit 'enter' again. The sound will reach the target speed in the specified time. Duration and direction of the ramp can change as often as required in real time.

periodic repetition and erratic behaviour have been created mainly with pulses, whereas in my subsequent compositions these operations are tested with elisions and bubbling textures. An example of superimposed layers exhibiting periodic repetition can be heard between 3:19 and 4:13 (listen to Audio 4.11). From 3:26 until 3:42[92] a layer of high-pitch resonant ticks echoes the pulses of the lower strata. At 3:45, a third layer with a slower tempo and low-pitch pulses appears; it gradually synchronises with the concurrent layer, before the two timescales move apart and then re-synchronise again at 4:02. After 4:04, there is interplay among discrete sounds, which – despite their timbral differences – retain the periodic repetition of the IOI already established.

Layers exhibiting periodic repetition behaviour are superimposed in various ways on different timescales. Figure 4.12 shows three groups of sounds on three different timescales appearing between 4:46 and 5:04 (listen to Audio 4.12). The transients in each timescale (marked as long, medium and short) are highlighted in the sonogram. The attacks that identify the slower rate of the long timescale are indicated with arrows.

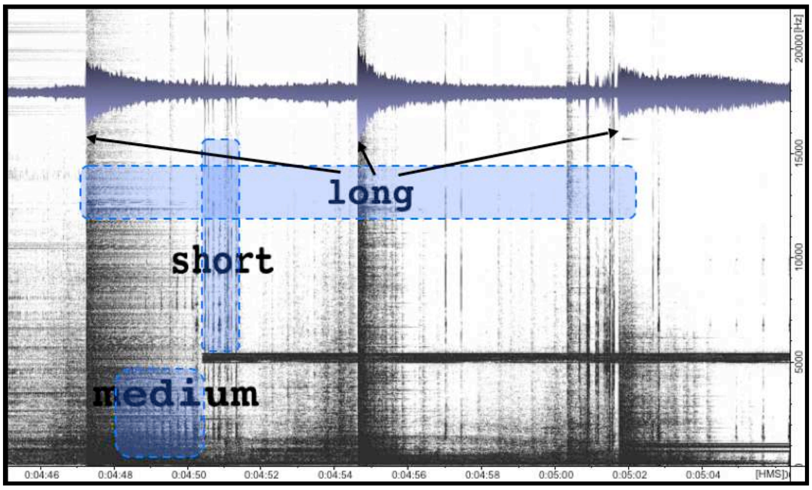

Fig. 4.12 **Three timescales.**
Highlights do not cover the entire frequency range, so that the timescales are clearly identifiable. Note that there are more than three sounds in the excerpt; the highlights indicate a medium (periodic ticks), a short (repeated rhythmic figure), and a long timescale (resonant attacks).

Discrete temporal organisation that demonstrates erratic behaviour can be heard in various sections of *Chronos*. For example at 7:40, two layers with erratic pulses

[92] All time tags refer to the corresponding composition and not to the Audio excerpts, unless otherwise indicated.

emerge from a dense formation of high-pitch sounds in periodic repetition. Audio example 4.13 presents the two erratic layers first in isolation, and then as they appear in the context of the composition (7:40 – 7:54). At the same time, another layer with discrete pulses and a regular acceleration curve[93] blends in the soundscape. From 8:07 until the end of the piece, various pulses appear erratically over a slowly evolving texture.

Processes of change (see section 2.5.2) take place in the piece, acting upon higher-level structures. There is an order according to which the higher-order temporal organisations function as metastructures, providing rules which establish changing relationships among lower-order organisations (see Fig. 4.13).

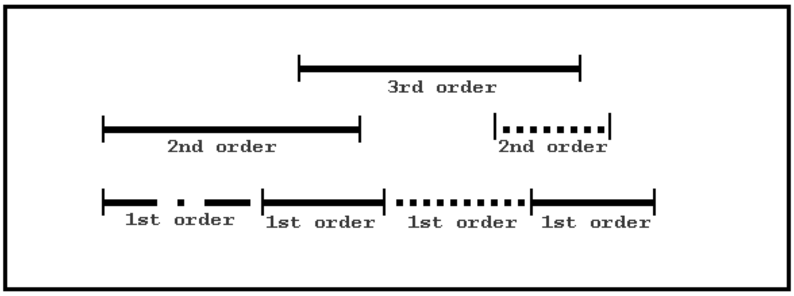

Fig. 4.13 **Order of temporal organisations.**

Figure 4.13 shows a schematic representation of hypothetical temporal structures in three orders. The first-order organisation represents a combination of discrete and continuous temporal structures. The second order comprises two instances of swelling dynamics that act upon part of the lower-order organisation. The third order (acceleration) acts on part of the second-, and part of the first-order organisations. On the practical level, this has been achieved by applying processing in layers one on top of another, each time choosing the appropriate sections to process. An example of these processes can be heard from 4:11 to approximately 4:41. Different event-chains have been processed as above, with varying settings, and were then superimposed (Fig. 4.14). The result is an undulating texture, comprising many accelerating and decelerating rhythms combined with the oscillating dynamics of sustained sounds (listen to Audio 4.14). Various combinations of the events marked in Fig. 4.14 have been used during group processing.

[93] See Fig. 2.5 in section 2.5.2 and the accompanying explanation of the acceleration curve (p. 48).

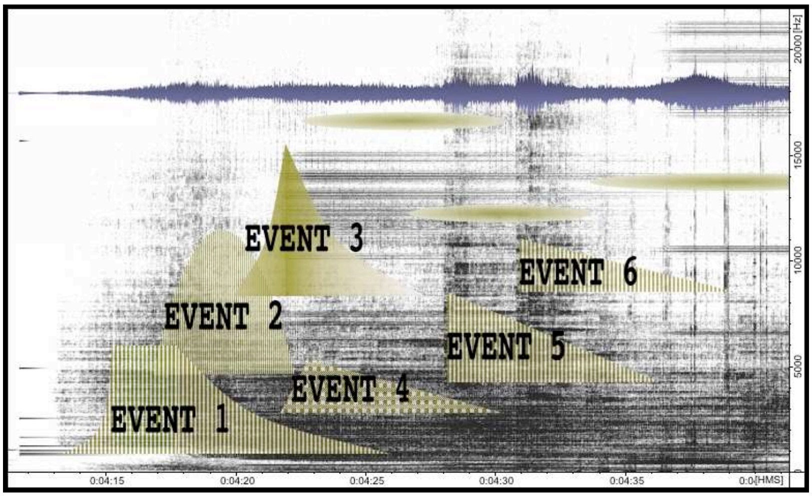

Fig. 4.14 **Event chains.**
Graphic score over a sonogram of a section of *Chronos* (4:11 – 4:41) numbering the main events that have been processed as event-chains. Vertical placement of images was made for the sake of clarity and does not relate to pitch or frequency.

At the beginning of the piece, accumulation of expectation is achieved through suspension of a sustained high-frequency sound, which finally resolves into the explosion. Although the expansion of sound energy is violent enough to cause surprise, care has been taken not to damage the ear in case of a loud performance. (See footnote 6, p. 19.)[94]

After the explosion, from approximately 0:43 onwards, streams of microsounds appear at intervals. At 2:15, fission of granulated textures discloses three decelerating streams of micro events, which are eventually revealed to be ticking clocks running at different rates (Fig. 4.15). Cloud disintegration (evaporation) leads to source recognisability when individual grains are isolated.

[94] The hearing system protects itself by contracting two muscles in the middle ear, when detecting impact sounds with levels greater than 75 dB (SPL). This protective mechanism (known as 'acoustic reflex') decreases the transmission of vibration to the inner ear and provides 12 – 14 dB attenuation. However, it takes around 60 ms for the muscles to respond (Howard and Angus 2006: 70). A firework sound (12 dB lower than the main explosion at 0:23) precedes the explosion by 70 ms, giving enough time for the mechanism to be triggered. This mimics shooting sports situations, where a loud sound is played before the gun is fired, in order to trigger the acoustic reflex; the first sound is not loud enough to damage the hearing system (ibid: 71).

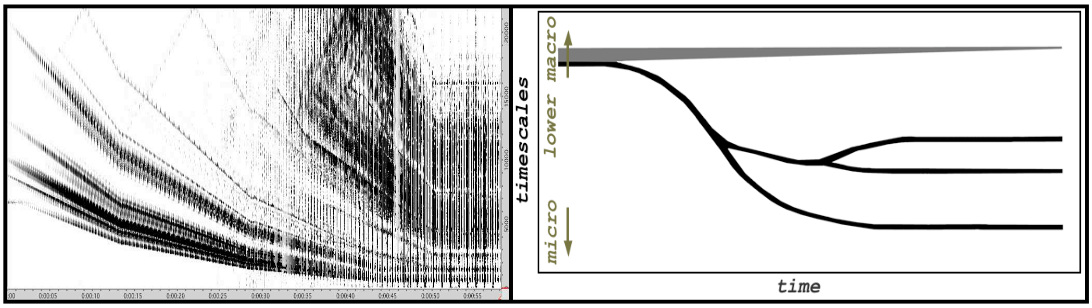

Fig. 4.15 **Decelerating clocks.**
Sonogram analysis (from 1:55 to 2:48). Timescale diagram (of the same section).

The curves in the timescale diagram do not relate to the curves of the sonogram, but rather to the transients which are visible, and can be seen elongating towards the end of the sonogram. The light grey line in the diagram area corresponds to the fluid, non-discrete motion of the low frequency texture, which has been omitted in the sonogram for the sake of clarity. In this part of the composition, we experience a dispersion of localities, where a local-level spectromorphology opens up revealing a high-level structure comprised of three temporal streams.[95] The effect of slowing down is emphasised by combining two unidirectional processes in one gesture – deceleration and downward glissando.

The three timescales display different rates of time passing, and they form three superimposed oscillating systems. Because the metrical relationship among the three streams is not stable (see Fig. 4.16), it is not possible to listen to one composite rhythm. Listeners select individual metrical streams, as they can neither pay attention to many layers of rhythms at the same time (Justin London 2007), nor follow – in this case – one composite rhythm. Audio example 4.15 presents the three layers separately, and then as they appear concurrently in the composition.

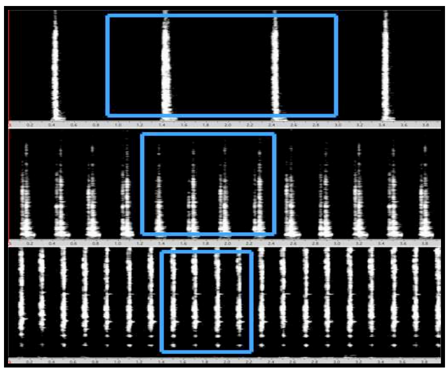

Fig. 4.16 **Concurrent oscillating systems.**
Separate sonogram analyses of the three concurrent streams (from 2:41 to 2:45). The hypothetical specious present is highlighted in each case.

[95] A dispersion of localities is the reverse operation in the saturation mechanism seen in Fig. 2.3, p. 42.

In addition, Figure 4.16 highlights the hypothetical specious present on each timescale, following the example in Fig. 1.1, p. 27. The longer the IOI is, the lengthier the specious present becomes, so that the listener can follow the relationships between neighbouring onsets and construct the resulting rhythms.

Chronos also explores the ambiguous nature of microsounds' identities. An event starts at 7:27, where short bursts of fireworks are intermingled with clock sounds. Because the fireworks are very brief sounds, and in addition, considering that the firework identity does not relate to the rest of the associations and images of the piece, the pyrotechnics borrow a new identity from their surrounding environment and are perceived as clock sounds (listen to Audio excerpt 4.16). If the firework events became more frequent, or if they brought some of their environmental context with them, then there would be a conflict between the two identities (clock and firework) until the listener perceived the fireworks for what they really are. In that particular section of *Chronos*, any microsounds that mix with clock sounds are associated with clocks even though their origin might be completely different; in this context, their primary source does not have any value and becomes completely insignificant.

Following the near stasis evoked by repetition on the meso and lower macro timescales in *Vessel@Anchor*, *Chronos* brings repetitive structures closer together on the sound object and micro timescales. An example of sound object timescale recurrence can be heard between 6:45 and 7:40 with the pendulum sound. The pendulum sound has been constructed from white noise through careful filtering and editing of the spectrum, frequency shifting, amplitude changes, and panning. Low frequencies are emphasised when the sound is at the centre of the panoramic space, so that it gives the impression of a heavy object following a semicircular trajectory. The association of the noise gesture with a swinging pendulum is assisted by concurrent clock sounds. Repetition of this particular gesture aims to create the impression of a pendulum, whose image remains stable for a while in the frontal space. (Listen to Audio example 4.17.)

From approximately 8:00 until near the end of the piece, different oscillating systems superimpose gradually, to a point where some of the high-level structures form local structures through saturation.[96]

4.4.2 The Live Version and Visual Information

In *Chronos*, temporal information is emphasised by incorporating identifiable clock sounds. Attention is paid to spectromorphological aspects, as time is presented through the perception of events in an acousmatic composition. However, in the live version, the 'veil' that hides the originating source of the sound falls near the end of the piece – or so the audience is made to believe as will become apparent below.

Near the end of the three-channel version, a real clock is revealed on stage, positioned on top of the central loudspeaker (Fig. 4.17), which corresponds to the third channel. A spotlight fades in slowly on the clock and brightens the previously dark setting (the clock is not initially visible to the audience). At the same time, the volume of a ticking sound heard through the third channel is gradually increased from zero.

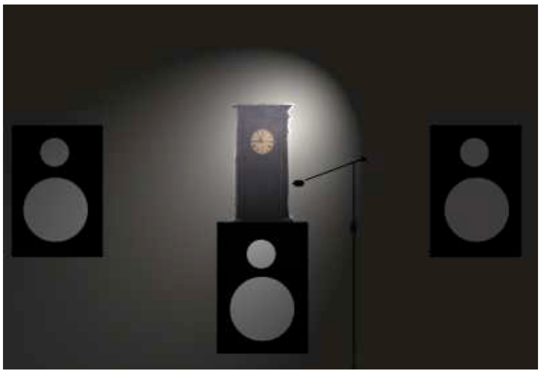

Fig. 4.17 **Position of clock.**

An additional external factor is thus introduced to the piece, a physical object in the visual environment that aims to induce a certain psychological effect. The audience starts paying attention to the physically present clock. Temporal information

[96] See Fig. 2.3, p. 43 and the accompanying text for analysis of local- and high-level structures.

is thus emphasised most, as the audience is attracted to *attending* to time passing.[97] Suddenly, time passing seems more important to the listener than other characteristics such as timbre, morphology or rhythm. Although these musical characteristics are still present, familiarity with the sound source and the visual confirmation of its origin drives the attention to the passing of time, especially because the ticking clock is the predominant sound in what would normally be perceived as a long time interval in a live situation (approximately one minute). Relative inactivity contributes to the perceived languor when compared to the fairly frequent changes heard earlier in the composition.

Figure 4.17 shows the actual clock used in the premiere of the piece.[98] A microphone was positioned in front of the clock, while the end of the microphone cable was plugged in an unused socket – the connection was fake. The sound of the clock was pre-recorded to avoid mishaps and accidental amplification of the final applause that would have otherwise been picked up by the microphone.

In the live version, the clock continues ticking when the lights are turned on after a pre-defined interval, and the sound projectionist walks on stage, bows and leaves. The recorded sound fades out unnoticed during the applause (an assistant is needed on the mixing console to pull the faders down), so that the ending of the piece blurs with reality. It symbolises a transition to the present, the awaking of the listener and that of the composition itself into the reality of the present moment and the actual flow of time. While manipulating time passing would be fairly easy at this point by elongating or shortening the gaps between events, I made the decision to keep the ticking on every second, because there seemed to be no structural need for changing it. Audio 4.18 contains the stereo reduction of the last 1.5 minutes of a simulated live version. The example starts at 10:00; the clock becomes gradually audible, and eventually its sound drowns in the applause from the audience.[99]

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97 See also Paul Fraisse's quotation in section 3.7, p. 84.

98 The dimensions of the clock are 43 cm (height) by 25 cm (width) by 11 cm (depth). The premiere took place on 12 December 2006, in the Performance Area at City University in London.

99 Note that in the stereo reduction the sound image of the clock is not stable, as it is a monophonic sound coming from both loudspeakers. In the live version, the third channel provided a stable localised image at the centre, which was effortlessly connected with the clock at the top of the central loudspeaker.

The live version presented its own problems. There were people in the audience who had their eyes closed and did not open them near the end to receive the visual information. In the premiere I noticed a few people slightly changing positions or moving their heads during the last comparatively inactive section – presumably opening their eyes due to the apparent change from unfamiliar to familiar and realistic sounds. Nevertheless, one cannot predetermine or predict whether a person chooses to listen with open or closed eyes. The predominately acousmatic nature of the piece prevented any early indication of a visual component (e.g. by directing light to the clock from the start), making it hard to introduce that element near the end. However, the relatively abrupt introduction of that aspect was deliberate in order to induce the intended psychological effect. The clock (its sound and physical presence) stands out because it is introduced very late in the piece; it almost seems not to be a natural part of it. In that sense, the sound of the clock could also be regarded as part of an aural environment other than the music itself, which makes easier for the audience to connect with the reality of the present moment and the actual flow of time.

4.5 Arborescences

Arborescences (2007-08) is a stereo acousmatic piece that lasts for 11:24 minutes, and it was created in order to systematically explore temporal syntax. Section 2.5.2 was further developed in parallel to this composition, and several hypotheses were practically tested.

4.5.1 Sound Material, and Arborescent Structures

Arborescences uses sound material derived from impacts, resonances and textures that were produced by striking, rubbing and scraping various Balinese, Sundanese and Javanese gamelan instruments.[100] One of the few sounds that did not derive from the recorded gamelan – and its source is still recognizable – is the distant church bell in

[100] I am indebted to Ambrose Seddon for his assistance in recording the instruments, which were treated with the utmost respect.

the last part of the piece, which was recorded in Marseilles. The source-cause of most of the material cannot be recognised because of the extended processing, which focused on developing gestures and textures based on micro-elements and groups of partials extracted from the recorded events. Although bell timbres are prevalent, the composition focuses on gestural suggestions detached from any known source-cause. This approach was decided so that extra-musical associations have a minimal influence on temporal perception.

The composition exploits the use of timescales as arborescent structures, which is how it obtained its title. Two instances of arborescences are discussed below, as examples of the most prevalent means to create structure in this composition. A common method for working up structures is to create relationships among sound events in the vertical domain i.e. in spectral space, and in the horizontal domain as events develop in time. These two domains – vertical and horizontal – co-exist, and the composer usually develops event relationships in both domains simultaneously. However, arborescent structures provide a different technique for the development and organisation of relationships, which, although they emerge in the time and frequency domains, are formed in a different system of coordinates. This system creates an additional vertical structure among streams of sounds; in this case, verticality can be seen as an added dimension to the time domain, where the horizontal axis refers to time passing and the vertical axis to timescales (please refer to Fig. 2.4, p. 43). Arborescent temporal structures encourage the development of streams, segregated by means of timescales.

Arborescent structures are most apparent in the section between 2:50 and 5:00. At times, arborescences established by the distinct rhythmic activity of each stream spring from their preceding sound material, and are superimposed, forming concurrent timescales. Audio 4.19 (taken from the composition from 3:35 to 4:55) demonstrates the co-existence of timescales.

(a)

(b)

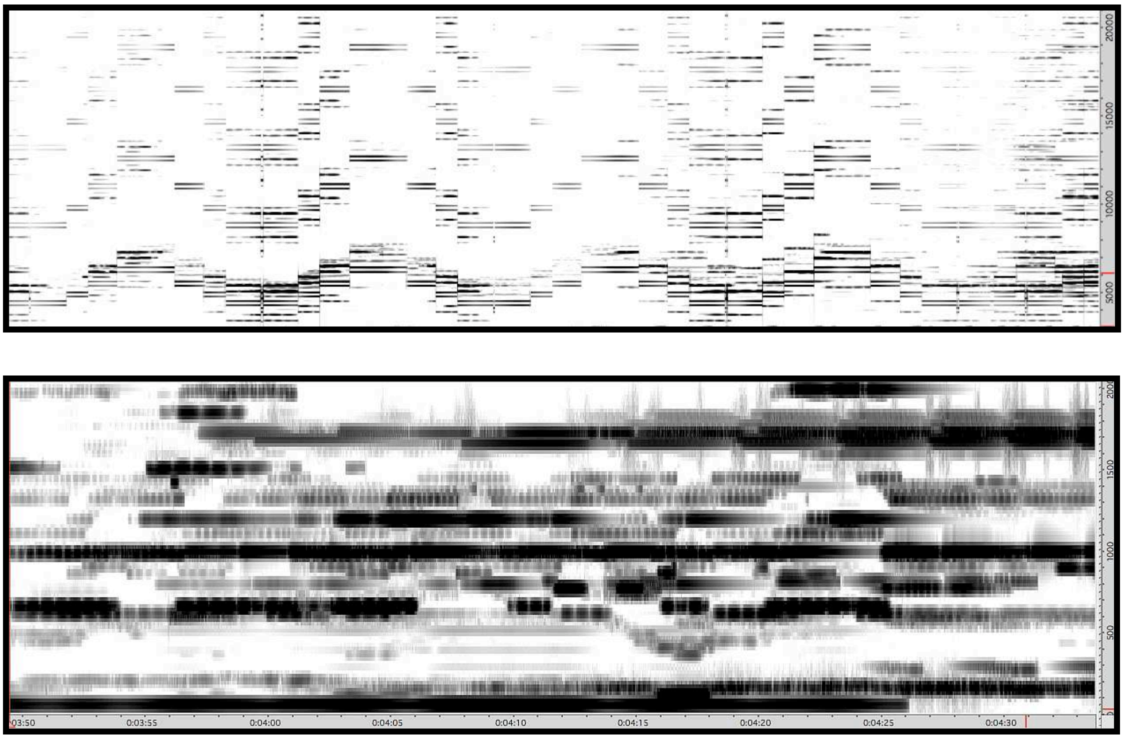

Fig. 4.18 **Concurrent timescales.**

Figure 4.18 shows the sonogram analysis of the section between 3:50 and 4:35; the top sonogram (a) displays events in the frequency region between 4 and 20 kHz, and the bottom (b) displays those below 2 kHz (magnified). The superimposed streams that display different rhythmic activity can be clearly seen through the transients and elisions appearing in different frequency bands.

Sonograms cannot be used to analyse psychological time, as they can only display physical time. Psychological time is elastic because time perception is influenced by various factors of the T-I set (see section 2.6, p. 65). Moreover, timescales cannot be separated visually in a sonogram, especially if they occupy the same frequency areas. In the above example (Fig. 4.18), streams are separated in the spectrum, so it is relatively easy to observe the rhythmic activity of different frequency bands. What cannot be seen (but the result can be heard) are instances when sound characteristics that originally belong to different events are brought together perceptually so as to cause a reorganisation of auditory streams and vertical images. As a result of the reorganisation, individual events merge to form the perceived spectromorphologies.

The section heard in Audio 4.19 (from 3:35 to 4:55) was composed by following a particular technique. Frequency areas that exhibited – what was subjectively judged as – interesting morphological development were extracted from a spectrally rich sound. In each extracted spectral region strong and weak elements formed rhythmic relationships; these elements were either dynamic (loud/soft), pitch-related (high/low), spectral space-related (partials occupied more/less spectral space in the chosen frequency band), or any combination of these three opposing pairs. Regions were selected from different time portions of the same sound for two reasons; (1) deriving segments from the same sound helped to maintain a timbral identity in the constructed section; and (2) using segments from different time locations of the sound meant that the extracted streams were not synchronised, but displayed rhythmic characteristics that sometimes demonstrated differing rates of time passing, thus forming distinct timescales. Groups of partials were further processed and shaped with filters, so that relationships between strong and weak elements were emphasized. Subsequently, the processed layers of spectral regions were arranged as arborescent structures, by focusing on the temporal development of each layer. At times, spectral and rhythmic characteristics of these layers meet, resulting in perceptual grouping through common fate regularity (Bregman 1999: 248-89; Pressnitzer and McAdams 2000: 50). Some of the transients were further emphasised when processing, for reasons which become apparent in the following example.

From 8:21 to 8:44 some of the crests and troughs of the events appearing at opposite ends of the spectral space have been synchronised (listen to Audio 4.20). The two streams that occupy the canopy and root of the spectral space create two arborescent structures that occasionally meet to form one timescale. The meeting points become more prevalent when transients are conspicuously present in the sounds involved, which led me to process parts of the sounds in such a way that their transients are stressed. During their course, the two concurrent streams display rhythmic activity which is more pronounced in the canopy, while the root displays a more fluid, non-discrete motion. In a diagram such as in Fig. 2.4 (p. 43), the canopy can be displayed as the dark part of an arborescence, while the root can be represented with light grey colour. Audio 4.21 presents the original recording of a gong being scratched, followed by the processed version which has been filtered and has its transients emphasised. The processed version can be heard starting at 8:30 in the composition. The low-frequency stream disappears around 8:50, and higher-frequency arborescences gradually appear to accompany the processed gong. The last arborescence coexisting with the gong transients appears near 9:10, and consists of recurring bell-like sounds.

4.5.2 Further Organisation of Time Structures

Organisation of time structures was considered at both the local and higher levels. The local level concerns the temporal evolution of spectromorphologies, while higher levels concern organisations of two or more sonic entities. Examples of discretisation of time and processes of change at both higher and local levels are discussed below.

Discretisation of time, which involves the succession of discontinuous units, is manifested in periodic repetition of durations, and in erratic temporal behaviour, where discontinuities create asymmetric temporal chunks.

An example of periodic repetition at local level appears between 5:43 and 6:07. The periodic repetition creates a pulsating spectromorphology which can be heard in the excerpt Audio 4.22. At the same time, a series of impact events takes place on a different timescale (listen to Audio 4.23; extracted from 5:44 to 6:15). Although Audio 4.22 contains only the streams involving periodic repetition at local level, the latter sound example presents all material as it appears in the composition, including erratic temporal behaviour at a higher level, as manifested through the impact events.

Swelling of dynamics, which is a process of change involving both higher and local levels, can also be heard in the same example. The swelling dynamics create an additional temporal stream with a rate of change which is slower than those of the rest concurrent timescales. Figure 4.19 shows the sonogram analysis of this passage; dynamic markings indicate volume variations of the pulsating spectromorphology, while the blue wavy line illustrates the swelling dynamics of the same sound. The slower pace – compared to the pace of the rest of the events – is detectable through the crests and troughs of the undulating line.

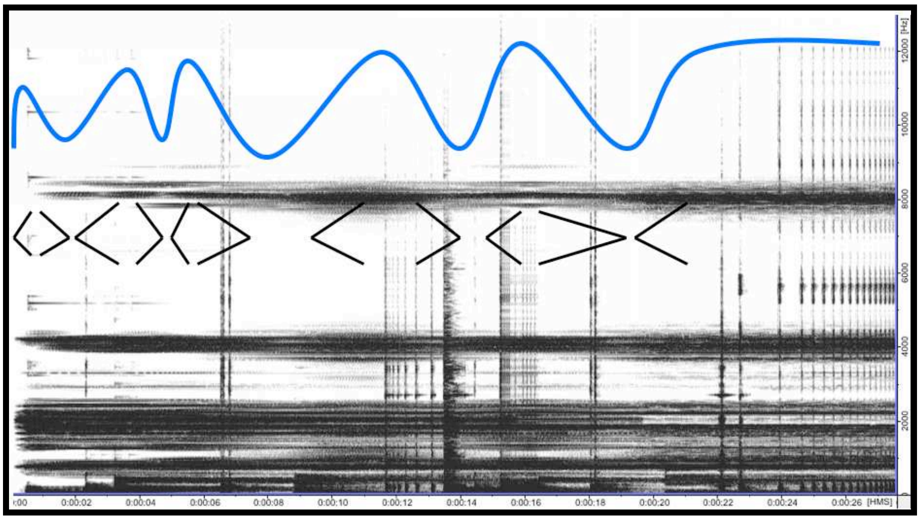

Fig. 4.19 **Swelling of dynamics.**
Sonogram analysis of Audio 4.22, highlighting the dynamic changes of the continuous sound.

Audio 4.24 (from the section between 5:09 and 5:47 in the composition) demonstrates three instances of discretisation of time. In the first instance, erratic temporal behaviour arises at local level; elisions gradually disappear until the underlying spectromorphology emerges as one continuous stream. The second discretisation is heard through an event which is at a higher pitch than the first; this is a periodic repetition of durations at local level, where elisions gradually become less pronounced and create a pulsating spectromorphology. The third instance is manifested through a series of events which appear at the highest pitch of this sequence; this is a stream of erratic elisions on a longer timescale. As in the previous two instances of discretisation of time, the elisions gradually disappear to reveal a continuous stream of sound. Although the first two instances clearly appear at local level, more complex temporal relationships are built at the higher level because of their combination. Figure 4.20 highlights the three different instances of discretisation of time.

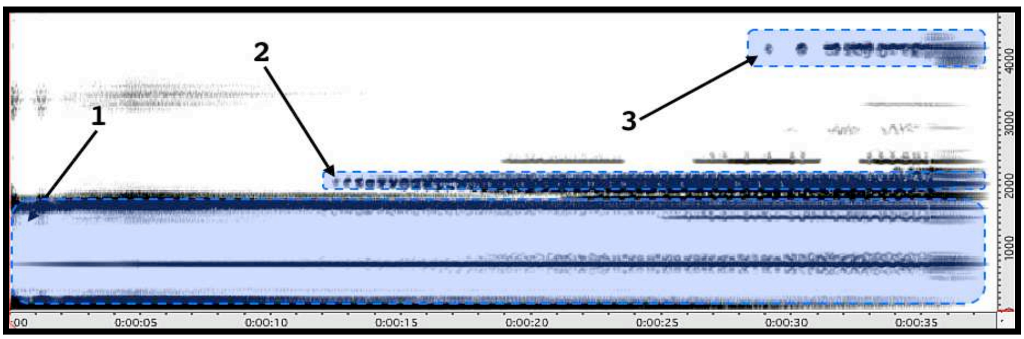

Fig. 4.20 **Discretisation of time.**
Sonogram analysis of the section between 5:09 and 5:47. The highlighted sections show the spectral areas where the three instances of discretisation of time are more pronounced. Some harmonics have been left unmarked, so that the diagram is as clear as possible.

An instance of dispersion of localities, where a local-level spectromorphology dissipates, revealing a high-level structure, can be heard starting at c. 1:16. Whereas in *Chronos* a similar dispersion released a periodic repetition on different timescales (see p. 111), in *Arborescences* it reveals an erratic behaviour of a single repetition. Audio example 4.25 presents only the streams involved in the dispersion of localities, omitting the rest of the material. Some characteristics of the sound (loudness, spatial position and duration of resonance) are altered, without smearing the effect of repetition. In addition, the deceleration during that sequence of discrete sounds lead to the expectation of a consequent, which in this case is the breakout of a new string of events as can be heard in the composition.

Arborescences uses events to create anticipation and expectation many times and in different ways. For example, in addition to deceleration described above, there are instances of suspension of time. Audio 4.26 contains an excerpt (4:52 – 5:09), where a relatively stable spectromorphology is prolonged aiming to create anticipation, which resolves in the impact sound at 5:06. The prolongation of the sound extends the psychological duration of that passage. Instances where acceleration arrives to a conclusion, according to the listener's typical expectations, can be heard at 2:26, 2:34 and 6:08. These three instances are included in Audio example 4.27; the first two are consecutive and are separated from the third with a short silence.

At 06:39, one can hear two different temporal processes. The first is a process of change, where the acceleration of a transient event with a bell resonance eventually decelerates leading into a new texture (listen to Audio example 4.28). The second relates to the Tau effect (see footnote 45, p. 47), where the duration of consecutive repeats of an event moving from one side in panoramic space to the other progressively decreases. According to the Tau effect, the estimation of the distance between the opposite ends of the panoramic space depends on the duration of the moving sound; when the duration decreases, the estimation of the distance decreases accordingly. My initial plan was to affect distance estimation between the opposite ends of the panoramic space. However, the multitude of sounds that accompany the repeated event, travelling bilaterally, sets up the context for the panoramic space, which cannot be easily dissipated. Audio example 4.28, which contains an extract from the composition (from 6:39 to 7:23), demonstrates this particular problem. The

Tau effect seems to occur when the travelling sounds alone make up the panoramic space, or at least when the co-existing sound events assist this illusion; sound example Audio 4.29 isolates the travelling sounds and makes the Tau effect clearer. In the composition, even though the velocity of the trajectories progressively increases, the panoramic distance remains unchanged because the perspectival space is created by the assemblage of all the sounds present in that section.[101]

Composing *Arborescences* involved extensive work on making families of sounds deriving from a single source, which facilitated the connection of sections and the preservation of the bell resonance identity throughout the piece. A large number of the resonances recorded for this project were relatively stable. There are various ways to create vigorous gestures from relatively stable resonances, e.g. by isolating and emphasizing relationships between strong and weak elements as described earlier in section 4.5.1. Another way to create energetic sounds used in *Arborescences*, was to record dynamic gestures made on non-metallic material, cross-synthesizing them with gamelan resonances. This facilitated the preservation of the time imprint of the vigorous gestures, their local temporal structure and internal rhythm. An example of maintaining the original state of the local structure of a non-metallic event can be heard in example Audio 4.30. The non-metallic gesture is followed after a short pause by the cross-synthesized and further processed version, which appears in the composition near 7:50.

Arborescences concentrated on developing temporal syntax based on evolving arborescent structures, while moving more deeply into organising local and higher levels, and experimenting further with discretisation of time and processes of change. Even though subliminal perception was explored during the composition process, such events were not used in the final composition for reasons explained in section 3.4. The consequences of spectromorphological and spatiomorphological complexities on time perception started to develop as ideas in this composition, and they were investigated along with other types of complexity during the making of the next piece.

[101] According to Denis Smalley, perspectival space is defined as the space created by 'the relations of spatial position, movement and scale among spectromorphologies, viewed from the listener's vantage point' (Smalley 2007: 56).

4.6 Paramnesia

This is a stereo acousmatic piece composed in 2008 and 2009, consisting of two connected movements, ‘Promenade’ and ‘Repose’. The word ‘paramnesia’ derives from the Greek ‘παρά’ and ‘μνήμη’[102] meaning ‘near’ and ‘memory’ respectively, and is a condition that causes confusion between reality and fantasy, resulting in distorted memory. Patients fabricate imaginary events to compensate for loss of memory, and they also experience déjà vu.

Paramnesia covers a wide range of the processes explored and discussed in the previous compositions, in addition to newer practices that were not previously considered. Section 4.6 focuses on these remaining practices, while examining – where necessary – instances that use methods and temporal processes discussed in earlier compositions.

4.6.1 General Structure and Aims

The first movement represents daytime, whereas the second represents night. Although day is usually associated with liveliness whereas night is mostly seen as its opposite connoting tranquillity, the composition employs energetic and calm sections in both movements. Events from recordings are taken out of their original context and re-assembled, so that there is no story unfolding apart from the distinction between day and night. Sounds of nocturnal creatures were heavily processed or imitated using diverse material to assemble spectromorphologies needed for the night scenes, whereas human activity permeates the day scenes. The first movement’s climactic section is inundated with cars, which gradually distort and change into agitated violin chords that eventually disappear in the night setting of the second movement. Nocturnal tranquillity is replaced by busyness that fades out near the end of the piece to reveal the return of human activity manifested by the occasional car, which may be interpreted as the ending of the night.

[102] Pronounced pα:ˊrα: and ˊmnımı (with International Phonetic Alphabet symbols).

The composition examines temporal qualities suggested by sound images through extra-musical associations, as analysed in section 2.5.3, particularly suggestions of ‘order’ and ‘temporal setting’. Both movements explore disturbance of chronological order by employing recurring passages or gestures which are disguised in different forms, thus attempting to portray experiences of déjà vu.[103] In addition, the piece explores the potential of recognisable events to suggest temporal information through the pace and momentum implied by their extra-musical associations. Density of events and various forms of complexity are introduced in order either to emphasise or counteract associative temporal qualities.

The piece makes use of the beta *DejaVu* software program, which allows the user to construct databases of sound files and search them for similarities according to a number of criteria, including melodic profile and timbral content.[104] Similar segments were sought either within individual sound files, or among several, and sections were subsequently constructed by focusing on similarity groups. Because melodic profile is linked to temporal development, this procedure facilitated the construction of timescales by finding and bringing together similar profiles. Fig. 4.21 presents a snapshot of the main window of the program *DejaVu*.

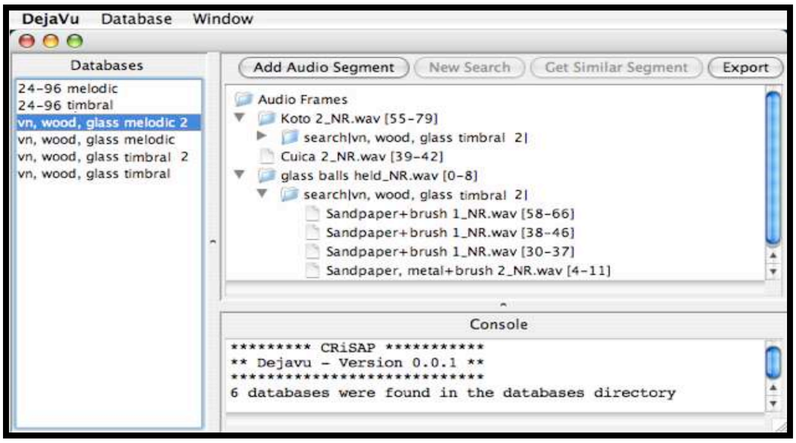

Fig. 4.21 **DejaVu software.**
Some of the databases assembled for developing sections in *Paramnesia* can be seen in the left column. At the top right, audio segments with similar melodic profiles appear, indicated by time tags (in seconds) in brackets that follow the names of sound files.

[103] Examples for all the processes mentioned here follow in the next three sections.

[104] The program was developed in CRiSAP (Creative Research into Sound Arts Practice) research centre by Ollie Bown, Michael Casey and Christophe Rhodes. *DejaVu* uses Chromogram for melodic analysis and MFCC (Mel-Frequency Cepstral Coefficients) for spectral analysis in order to extract a number of features to create the databases. Analysis based on MFCCs approximates the human auditory system’s response and is used mainly in speech recognition systems. (The program and further information can be downloaded at http://www.olliebown.com/svn/crisap/trunk/.) The first movement of *Paramnesia* was commissioned by CRiSAP, as a test project for their new software.

Because *DejaVu* does not work with high-resolution audio files, a laborious method was developed, where audio was downgraded to 44.1 kHz and 16 bits and was searched for similarities. Subsequently, the time tags produced by the program were used to identify the segments in sonograms of the original high-resolution files (96 kHz, 24 bit), and new sound files were created from those identified segments. Although this process required considerable time and effort, it enabled the collection of similar short segments that otherwise would have been difficult to single out. The segments were then processed in various ways, including time-stretching, in order to reach and construct longer timescales.

The process of concentrating on similarity groups is reminiscent of the playlists organised while composing *Ka-Boom!*. However, similarities in *Paramnesia* were used to build individual timescales and ensure smooth transitions between sections, instead of building contrasting episodes as in the early piece.

4.6.2 Organisation of Time Structures in 'Promenade'

The first movement 'Promenade' is based on a recording made in the promenade of Alghero in Sardinia, which provided much of the associative material needed for the composition.

Temporal setting is suggested by the source-causes of sounds selected from the original recordings. Events carrying extra-musical temporal associations with day scenes involve human activity, which usually takes place during day – especially activity involving children. Voices of children playing were layered with exaggerated gestures of rolling balls to create a playful atmosphere, while conversations were cut into smaller segments, superimposed to become mostly unintelligible; thus, attention is drawn to human presence, but away from any subject matter existing in the dialogue.[105] Additional sounds that imply presence of people include footsteps, cars, motorcycles, and a horse-drawn carriage.

[105] Note that the recorded conversations are in the Italian language.

Non-associative sounds can become part of a soundscape where a strong temporal identity is established, while they may also heighten the impression of a particular temporal setting. For example, the rolling sounds between c.1:40 and c.2:10 do not carry any specific temporal associations if played alone, but as they are mixed with children's voices, they integrate into the soundscape acquiring an almost playful character as if they were sounds of toys. A little later (2:10 – 3:00), rolling gestures in lower pitch are mixed with squeaky sounds from a cart and the clatter of the horse's hooves, emphasising the circular motion of the wheels, and thus acquiring a different possible meaning; they evoke the cart's wheels as they drag on the road. (Listen to Audio example 4.31; taken from 1:40 to 3:07.)

Rhythmic complexity occurs in most sections, as polyphony of structures is used extensively. Audio example 4.32 presents the timescales of the section between 0:40 and 1:28 in four parts separated with silences. In the first part, erratic temporal behaviour in three different spectral areas can be heard (see also Fig. 4.22, section marked 'A'); the lower two strands are gradually synchronised and converge in one timescale. The second part introduces a slow undulating gesture, and the dispersion of a microsound cloud in decelerating grains (Fig. 4.22, section 'B'). Sounds heard in the third part include mostly transients of the grainy textures made by rolling balls and people's voices (Fig. 4.22, section 'C'), whereas the final part presents the excerpt as it appears in the composition with all its components. Note how the slow swelling dynamics in most streams support each other, so that there is no overload of timescale information.[106]

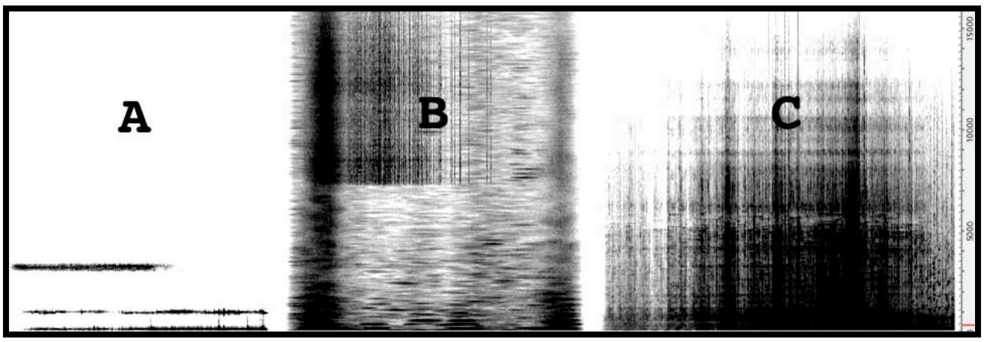

Fig. 4.22 **Sonogram in three sections.**
Sonogram of an excerpt (0:40 – 1:28), where sounds are grouped in three sections (A, B, C). Note that the fourth part of the Audio example 4.32, where all three sections are played simultaneously, is not shown above.

[106] The temporal organisation of swelling dynamics may cause the formation of additional timescales, as analysed in 2.5.2. The text in *Arborescences* connected with Fig. 4.19 presents an example of timescales formed by swelling dynamics.

The high energy implied by the established temporal setting (day) gradually grows and culminates in the section between c.3:55 and c.4:50 (Audio example 4.33). Heightened tension is created from the combination of the spectral density of the passage, the persistence of a violin chord, and the spatiomorphological animation of the cars' trajectories which is contrasted with the relatively stable spatial image of the violins. Musical tension is supported by the liveliness suggested from extra-musical associations with busy street scenes and with mental images of physically active violin performers. Successive associations create connotational chains, which emphasise the briskness of the scene; dense traffic implies day, which in turn connotes a period of light, wakefulness and busy activity that underline the high energy of that section.

The prolonged violin passage that persists on one chord might induce agitation and elicit impatience because its resolution is continuously postponed and the closure of the event is delayed. The source-cause of the violins becomes clearly recognisable at the first time the bow changes direction (4:29), and is reaffirmed subsequently at various points (4:31, 4:35, and 4:39). Different recordings of violin sounds were made, and notes were combined digitally to form tense composites creating spectral and harmonic density.[107] The chords were constructed by superimposing double stops and moving transients from different audio files to concurrent positions. Fig. 4.23 shows the violin files before and after selective time-stretching and contraction were applied to synchronise the bow changes. Synchronisation was required to achieve harmonic density without breaking the flow of energy and momentum gained by single bow changes.

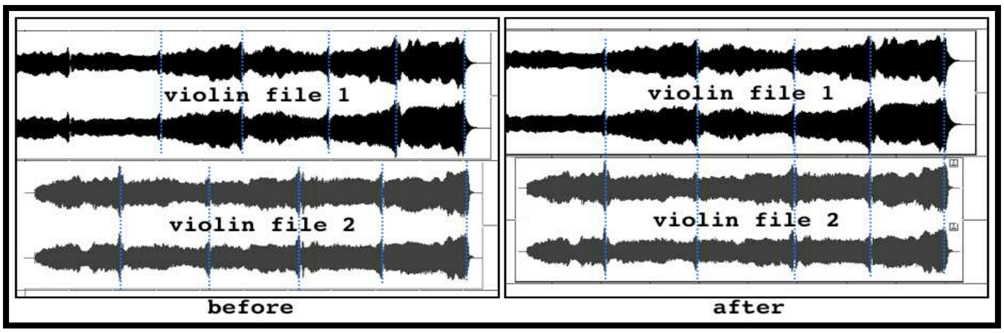

Fig. 4.23 **Violins before and after synchronisation.**
Vertical dotted lines mark the transients.

[107] I am indebted to Peiman Khosravi for his loose violin performance around my score instructions and verbal directions. Heavily processed violin sounds have provided additional material throughout the composition. The rough score can be seen in Appendix VI.

The passage finally resolves in a long fade-out of groups of partials emanated from cars and violins, connoting relaxation and reconciliation.

4.6.3 Poietic Processes in 'Repose'

The transitional section of a prolonged texture that consists of slowly disappearing thin spectral layers, connects 'Promenade' with the second movement 'Repose'. Vestiges of cars and violins gradually change into a superimposition of long partials that move at different rates, until they become stable, merge together and fade, finally integrating with an imaginary night scene.

Spectromorphologies of unrecognisable and ambiguous source-causes become part of the night scene, because they are framed between sounds created to resemble screeches of nocturnal birds. (Listen to Audio example 4.34, taken from 6:30 to 6:57.) At the very start of 'Repose' we hear what appears to be the cry of a night bird (6:30) that eventually flies away from the scene towards the edge of the panoramic space (6:52). Apart from very few conspicuous sounds that carry temporal associations, source-causes of gestural and textural material are rarely apparent because they play with ambiguity, and so liberate the imagination of the listener. Extra-musical mental connections appear intermittently from uncertain sources; for example, the events at 7:05 and 13:32 might be heard as sounds of passing cars or fragments of sweeping broadband noise. (Listen to Audio example 4.35; the two events are separated with a short silence.[108]) The continuous iterative texture from 8:08 to 8:53 can be heard as an insect, a night bird, a synthesised or a recorded pulsating periodic sound. (Listen to Audio example 4.36, taken from 8:08 to 9:10.) However, the listener is guided through preceding material (night birds) to hear connections between the iterative texture and nocturnal creatures (possibly crickets), thus reaffirming the sense of night-time.

[108] However, regarding the gesture at 13:32, the subsequent clearer sound of a car at 13:45 helps to give it (retrospectively) an identity; this is the last (third) sweeping gesture heard in Audio 4.35.

The temporal setting of night is further emphasised by a lack of human activity, which contrasts with the prevailing human presence in the first movement. Associative sounds also carry spatial references, although these are not always explicit because of the ambiguous source-causes. If one hears the sweeping noise of the previous Audio example 4.35 as cars moving at a distance, the distal space is pushed further back and away from the position of the listener since the gesture associates with past aural experiences and real-world images. In addition, the limits of the panoramic space might broaden because a wide horizon can be evoked as a result of extra-musical associations.

Arborescent temporal structures encourage the development of streams segregated by means of timescales, evident in the polyphonic structure of the piece, which is especially prevalent in the second movement. One example that incorporates layers of timescales displaying periodic and erratic rhythmic activity in both discrete and fluid motion can be heard in the previous Audio example 4.36.

Various superimposed timescales are also obvious between 7:07 and 8:08 (see Fig. 4.24), where a periodic repetition of a bell sound is juxtaposed with (1) elisions of short durations at local level that result in a bubbling texture at low frequencies; (2) irregular shifts in the melodic profile of a high-frequency event (between 4.6 and 6.3 kHz) that create rhythmic relationships and form the canopy of the spectral space; and (3) a slow undulation of dynamics that connects a combination of passing sounds to a broadband texture, and forms the longest timescale in this arborescent structure. (Listen to Audio example 4.37.)

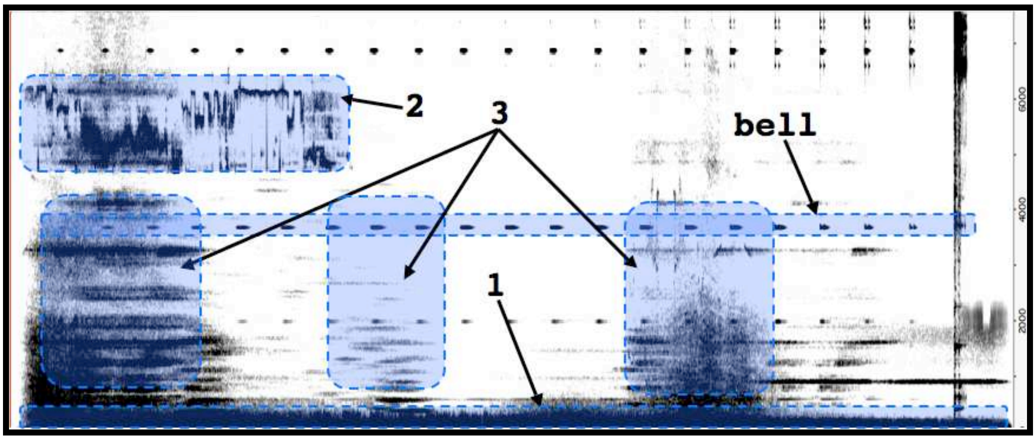

Fig. 4.24 **Four timescales.**
Highlighted timescales between 7:07 and 8:08. Annotations follow the indications in the text above. Note that some harmonics have been left unmarked for the sake of clarity.

The climactic section of 'Repose' is reached through an accelerated rhythm (11:10) that ends up in irregular beats before the spectral space opens up with a large swelling gesture. Even in its peak, the night scene does not include fast rhythmic figures, but instead it uses concurrent pulsating streams of sounds and slowly moving textures, thus creating a complex superimposition of spectromorphologies. (Listen to Audio example 4.38; taken from 11:10 to 13:40.) Night is generally associated with tranquility because it has invariably been the time of rest and sleep for humans, as little activity can take place in the dark. In this climactic section, structural tension is used in contrast to connotational tranquility. However, musical tension prevails and wins attention because it overwhelms the scene, and so tranquil associations become insignificant and fade.[109]

4.6.4 Recurrences and Complexities

Events are rearranged throughout the composition so that they introduce flashbacks of previously heard material, suggesting experiences of déjà vu which are connected with the condition of paramnesia. Gestures are disguised in different forms, bearing some degree of resemblance to their earlier shapes. Audio example 4.39 presents a swelling gesture which appears at 0:27, 0:41, 11:02, 11:45, 12:19, and 12:58; the excerpts are separated with short silences. In addition, the same recurring bell-shaped gesture is morphologically very similar to the passing car heard at various points in the piece. Even though durations of the swelling gestures and the passing cars are not identical, their general shape and spatial motion bear close resemblance, so that sometimes they evoke each other. (Listen to Audio example 4.40; excerpts are taken from 7:05, 7:48, 13:32, 13:45, and 14:25.)

The rolling gesture that accompanies the children's voices recurs many times throughout 'Promenade', while there is a reminder in 'Repose' at 10:02. Audio example 4.41 presents six recurrences of that sound in different forms, taken from

[109] The fact that musical density wins attention when juxtaposed with connotational tranquility was regarded as most probable when discussing 'temporal setting' in section 2.5.3 (pp. 52-3).

0:50, 1:40, 2:01, 2:25, and 2:47, which are followed by the reminder that appears in the second movement at 10:02.

Among the obvious instances of flashback is the bouncing attack that starts the piece and occurs two more times in the composition, at 1:28 and 8:07 (Audio example 4.42). Whether self-referencing is successful depends on how obvious the recurrence is to the listener. It is inevitable that there are different degrees of recognisability which depend on the competence of the listener and familiarity with the work. Repeated listenings make it easier to recognise disguised and distanced recurrences, although some of them, such as the bouncing attack, are easily noticeable from the first listening for various reasons, which include contrast with the surrounding sounds, and prominent position in the piece.

There are particular moments in 'Repose', some of which were heard in the audio examples of this section, where the listener is taken back to 'Promenade'. Although not as intricate as Dhomont's *Cycle du Son* regarding recurrences (see section 2.5.3, p. 55), *Paramnesia*'s flashbacks attempt to disturb the order of events in the mind of the listener by bringing memories of the day scenes in the nocturnal setting. Moreover, it is ensured that the importance of those events is established by using enough recurrences in the first movement before the flashbacks are introduced in 'Repose', so that they do not pass unnoticed, at least for the attentive listener.

Section 3.6 on stimulus complexity and time judgements was developed in parallel with this composition. Different types of complexity discussed in that section were approached at various degrees in *Paramnesia*.[110] Complexity levels waxed and waned to aid the general pace and the impetus gained by the development of event chains. However, fluctuating complexity does not necessarily follow tension and release patterns, as calm sections may also display high complexities. For example, the arborescent structure in Audio 4.37 (heard previously) displays a relatively high rhythmic complexity that arises from the combination of four timescales, and takes place in a relaxed section.

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[110] Types of complexity have already been visited with previous sound examples and discussed in the text. High rhythmic complexity can be heard in Audio 4.32 and Audio 4.36, spectral and harmonic density in Audio 4.33, and spectromorphological complexity in Audio 4.38.

There were times when complexity was purposely made greater so as, according to Hogan's model (see pp. 79-80), a section might be judged as longer because of sensory overload. For example, the tense nocturnal scene (Audio example 4.38 – heard previously) attempts to overwhelm the senses by incorporating several auditory streams that develop at the same time, each involving various changes from the micro to the lower macro level. Such sections, with entangled lines and planes, create spectromorphological and rhythmic complexities, which invite further listening to disentangle them, if possible, by shifting attention and hopping among auditory streams. In addition, remembered durations are longer, as the chunk of memory that refers to those particular time intervals is loaded with information.

Attention was paid to the way spectromorphologies behave spatially, taking into account source-bonded spaces that arise from extra-musical associations, although high spatiomorphological complexity is nowhere overtly prominent. Referential density at times is high, as demonstrated with the separated strands presented in Audio example 4.43, taken from the section 2:24 to 2:53. This excerpt refers to many source-causes, and is divided by silences in four parts; (1) contains children and distant voices, (2) comprises a horse walking, exaggerated squeaks of the cart's wheels and voices at different distances, (3) includes different layers of rolling gestures, and (4) presents all sound events together as they appear in the composition. In general, the referential discourse density in the piece is low, because sound events do not create conflicts regarding their target messages, and they refer to a very small number (when more than one) of situations or settings at any time.

The balancing of sections in *Paramnesia* took into account levels of complexity arisen from superimposing arborescent time structures, which affected the durational relationships between neighbouring sections in long timescales. Although it has been demonstrated through research in section 3.6 that various degrees of complexity alter time perception, it is difficult to measure the extent to which they affect the listener's subjective experience, and interpretation of time passing and duration estimation in the context of the composition. In order to analyse time perception, a listener's reception behaviour has to be simulated, which is difficult to know or predict.[111]

4.7 Structured Time and Behaviour of Timescales in Electroacoustic Music: Concluding Remarks

4.7.1 Summary of Issues Explored in the Compositions

Exploratory operations in the compositions were inspired from the original research, and led to the development of particular sections in this thesis. A summary of topics investigated in each piece is useful because it highlights important aspects of the research as explored practically, even though the practical examination did not always follow the order that those topics were presented in the first three chapters.

Ka-Boom! investigated episodic organisation of sound material based on remembered time of a real-life event. It explored microstructures in language in the form of utterances, pulses and granulation techniques. Observation on similarities between deconstructed sound events and words led to further research on microsound, while the technique of grain dispersion instigated an investigation into separation of timescales using divergent rhythms.

Vessel@Anchor explored spatial division of timescales in a multi-channel format, and timescale segregation based on source bonding. It investigated psychological duration, the concept of haste and languor, relative stasis through textural behaviour, and the temporal quality of 'duration' through extra-musical associations. *Vessel@Anchor ST6* – the short stereo version of the original – explored compressed time by retaining essential temporal elements, thus making a useful study on repetition, variation and reduction.

Chronos investigated the ambiguous nature of microsound identity, it explored discretisation of time through the use of periodic and erratic pulses, and the behaviour

[111] The importance of listening behaviours, selective attention, and expectation were explored in sections 2.5.4 and 3.7.

of superimposed oscillating systems. The composition investigated processes of change that function as metastructures, and the effect of acceleration and deceleration on expectation and time perception. It examined how time elongates through repetition on relatively short timescales, and how temporal information is emphasised when listening to sounds associated with the passing of time. Moreover, *Chronos* experimented with transition from time in music to time outside music, which embraces the experience of the present moment.

Arborescences involved further investigation into micro timescale, exploring subliminal perception during the compositional process, although for reasons discussed in section 3.4, subliminal events were not used in the final piece. Organisation of time structures at both local and higher levels was investigated further, and the composition experimented with the Tau effect, and expanded on the notions of anticipation and expectation. The most important study conducted while working on *Arborescences* was on temporal syntax, which focused particularly on the use of timescales as arborescent structures. The piece made extensive use of the innovative system which incorporates two dimensions of time – one existing on the vertical axis (timescales) and the other on the horizontal (time passing), thus encouraging the development of streams segregated in layers of timescales.

Paramnesia was the most thorough of the five compositions, incorporating many of the elements studied during the course of this doctoral research. In addition to making extensive use of superimposed time structures based on both discrete units of time and processes of change, it explored temporal information implied by obvious and ambiguous source-causes, disturbance of chronological order by means of recurrence, and the effect of various forms of complexity on time judgements.

4.7.2 General Remarks and Key Findings

The aim of this doctoral research was to understand how timescales behave in electroacoustic music, and to develop a compositional and analytic approach that would assist and encourage the creative use of temporal structures. Extensive research on time perception helped to better formulate the ideas surrounding timescale recognition and construction. Although controlling psychological time in music is an ambitious enterprise, it might become possible as a result of knowing more about the behaviour of timescales.

Topics explored in each composition propelled the development of the theoretical part of this research, and the theory encouraged further experimentation and influenced the progress made in the musical works. Through this continuous cycling process, the thesis managed to achieve its aims to uncover and understand the main mechanisms of time perception in electroacoustic music, and to use this knowledge to construct intricate temporal relationships in the accompanying compositions.

The thesis demonstrated and built on a number of main issues. It showed that physical time, where the flow is constant and durations are measurable, is different from psychological time, where time passing is elastic and remembered durations are estimated. It was deduced that listeners sense time passing through the oscillating specious present, which led to further investigation on variations at local and higher levels of time structure. Moreover, it was explained that activity in the specious present is understood through the operational system of time perception, whereas timescales that are longer than the specious present, or have already passed our immediate perception, are approached through duration estimation involving memory.

The research described in this thesis is concerned with the exploration of the value of psychological time in music, which centres on the investigation of the Time-Influencing (T-I) set of factors that shape the listener's perception of time passing and estimation of durations. Throughout the course of this investigation, a number of supplementary concepts was developed, such as the idea of the psychological time continuum, the categorisation of time structures that influence the formation and segregation of timescales, the introduction of the time reference frame with its two coordinates (timescales and time passing), and the redefinition of microsound based on its acquisition of identity instead of using arbitrary durations to define its limits. In addition, the T-I set emphasised that acousmatic music assimilates all its surrounding elements at the time of listening and becomes a holistic experience.

The findings of this research are useful for the composer and the analyst because they relate to the essential medium in which music exists, develops, and is understood. This research suggests that composers and theorists should consider a number of parameters (both intrinsic and extrinsic to music) when structuring and analysing works, because they affect our understanding of structures and balancing of sections, our perception of gestural and textural development, and the interconnection of concurrent, near and remote events. Consequently, we need to treat time and the parameters that shape timescale perception as fundamental to our understanding of music.

4.7.3 Future Directions

This research scratches only the surface of what lies beyond in the topic of timescale perception. The study dealt with cross-disciplinary issues, thus allowing for collaboration opportunities among cognitive psychologists, scientists, analysts, musicologists and composers for potential future projects and further research into time perception in music. Interdisciplinary collaborations in this study area have already been proven fruitful, as demonstrated for example with the International Society for the Study of Time (ISST), founded in 1966 by Julius T. Fraser. Members of ISST include physicists, mathematicians, philosophers, psychologists, biologists, sociologists and musicians (Rowell 1996: 79-80), who publish a series of articles after their triennial conferences to further the discussion of the interdisciplinary study of time. However, electroacoustic music is profoundly missing its voice so far.[112]

This thesis opens up the possibility of exploring forms of visual models in graphic scores and software programs for composition and analysis that might represent time as a multidirectional vector, where the point of reference moves across several directions. For example, it may move forwards by following time passing in combination with the specious present interval, backwards by using self-referencing and also by utilising a number of memory models developed in cognitive psychology,

[112] The titles of all the articles published between 1972 and 2010 can be seen at http://www.studyoftime.org/ContentPage.aspx?ID=8 by following the links on the page.

it may jump ahead in future by evaluating anticipation and expectation based on analysis of preceding material, and it may move outside the current work through references and quotations. Time might also be represented as an elastic parameter, indicating haste and languor stages in a music piece.

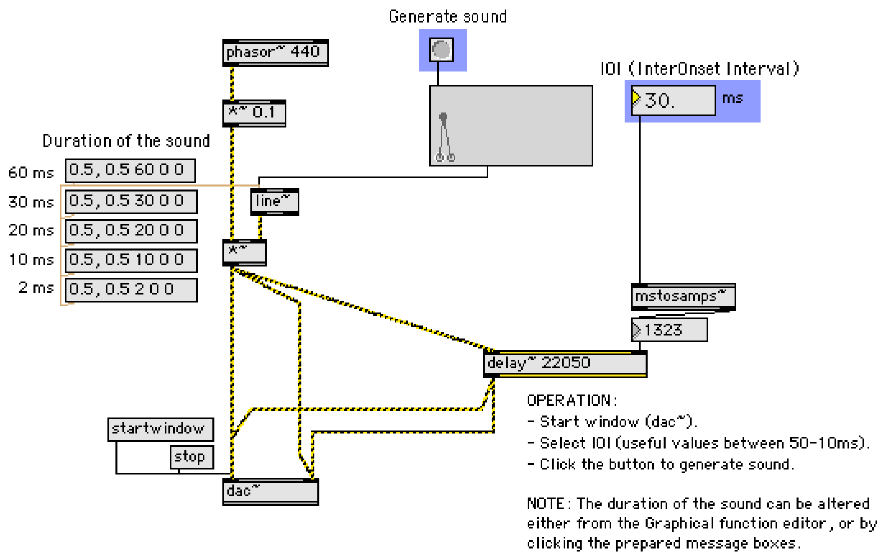
This research is useful for interactive music in situations where the control of the composer is reduced. Factors of the T-I set which are external to music become important parameters that composers might be able to adjust so that they arrive to controllable results, when this is desirable. External T-I variables can be used in many different situations, such as in live performance, and in sound or audiovisual installations, where factors that affect any of the five senses become compositional elements. Visual, haptic, gustatory and olfactory spaces can be thoroughly investigated and used in conjunction with this thesis in order to expand the T-I set.

Devices with accelerometers offer opportunities for further development. Such devices could detect and record motion information that reflects real-life gestural properties, which can be used to construct specific timescales and spatio-temporal trajectories for acousmatic composition or live performance, directly derived from movements of the performer/composer. Implications for speed expectations when sounds relate to human motion were explained in section 2.5.4, where empathic listening was examined. The advantage offered by accelerometers is that information obtained is quantitative instead of qualitative, which might lead to collecting precise data regarding spatio-temporal trajectories that can be used in analysis, or to increase accuracy in composition and performance.

The development of a graphic notation system of timescales as arborescent structures will give this theory greater value as an analytical and compositional tool, and might further expand the potential of this research into practical areas of software building.

Appendix I

Aural Separation

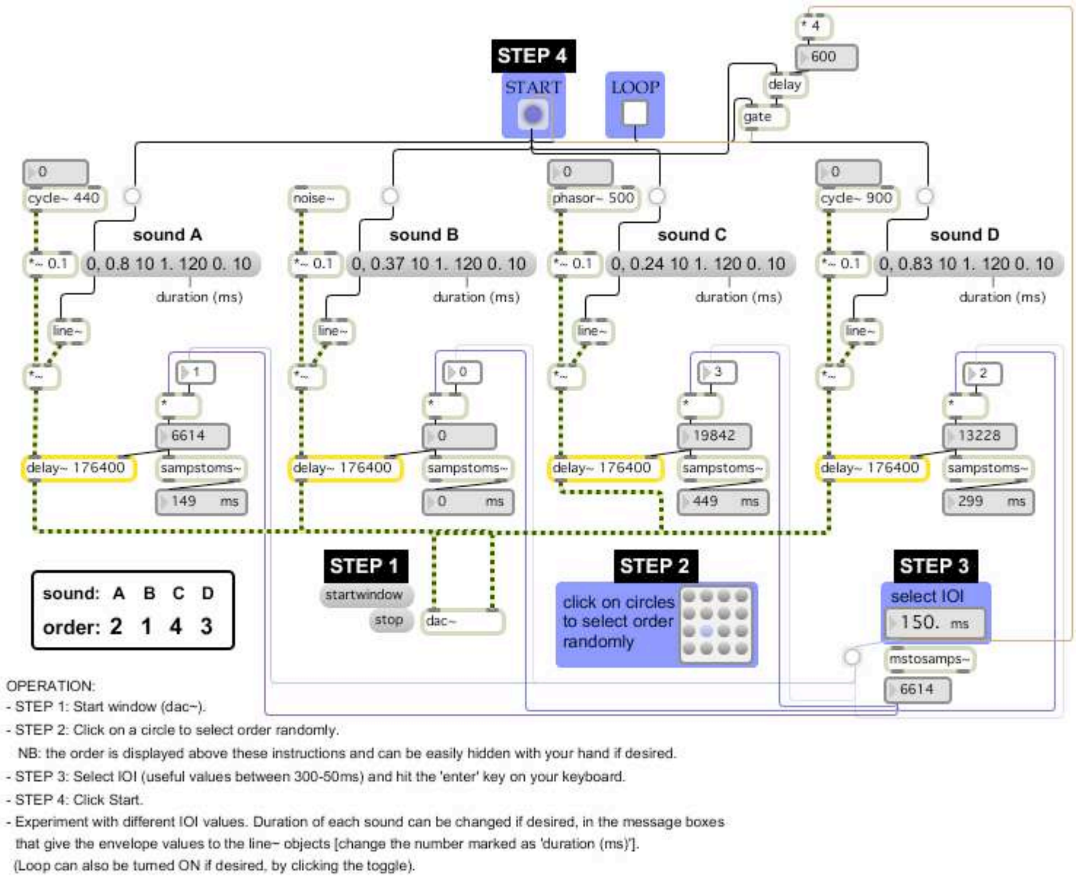


The Max/MSP patch used in the experiments to establish the lowest IOI for aural separation.

The patch is included in the data CD (2) accompanying this thesis [patch_1]. Note that when the duration of the sound is less than the selected IOI, listeners can aurally separate the repeated sound, sometimes when IOI is as short as 20 ms; training through repetition makes this task easier. However, for sounds larger than 30 ms (that is, for any sound other than short microsounds) there seems to be a lowest limit of IOI at c.30 ms, to allow aural separation.

Appendix II

Recognition of Order



An improved version of the Max/MSP patch used in the experiment for the recognition of order of sound events is shown above. Three of the four sounds form a simple melodic line that makes it easier to identify the order. The sounds are two sine tones with different frequencies (sounds A and D), a sawtooth wave (sound C) and white noise (sound B). The duration of the events was changed in several experiments between 100 and c.200 ms, depending on the IOI that was selected.

The patch is included in the data CD (2) accompanying this thesis [patch_2].

Appendix III

Haptic Devices

The Novint Falcon

[source: Novint Technologies Inc. 2006]

Information from the company's website: "Users hold onto the Falcon's handle, which moves left and right and forwards and backwards, like a computer mouse, but also moves up and down. The interchangeable handle, or "end effector" can come in many shapes and forms and the device includes a quick disconnect feature which lets users change handles for specific uses or types of game play. As the Novint Falcon handle is moved, the computer keeps track of a 3D cursor. When the 3D cursor touches a virtual object, the computer registers contact with that object and updates currents to motors in the device to create an appropriate force to the device's handle, which the user feels. The computer updates the position of the device, and updates the currents to the motors a thousand times a second (i.e. at a 1 kilohertz rate), providing a very realistic sense of touch. The three electrical motors are connected to the three arms extending out of the device, with one motor connected to each arm. The three arms are connected to the device's handle. At any given cycle, or 1/1000th of a second, the device can create a force on the handle in any direction of any magnitude, up to the maximum force" (Novint Technologies Inc. 2006).

Appendix IV

Chewy & Crisp (composed in 2003)

Instructions for the setup

The installation needs

a) A triangle or a bell with a beater.
b) A CD player (with volume control) and a pair of closed headphones.
c) Cereal bars, crisps and the CD recording (contains both unprocessed and transformed sounds made by crisps and cereal bars).
d) A bowl, or something similar to place the crisps and the cereal bars (beside the CD player).

Note: At two performances (at Saatchi Gallery, November 2003 and at Goldsmiths College, June 2003) the bell was replaced by two glockenspiel bars suspended by two pieces of wire of different lengths.

Programme Notes

The participant is meant to be engulfed by similar sounds, from the outside as well as from the inside of his or her body and is immersed into a sound world that connects directly to the taste inside his or her mouth. Taste becomes an identifiable sense, a fragment floating in its own sea of sound.

The resonating bell directs the attention of the participant to the piece and provides definite start and end points in the composition.

Instructions for the listener

From the moment you start following the procedure, you must pay great attention to the sounds you are producing, since the piece begins with and includes your own sounds.

Prelude

Strike once the bell using the beater.
While the bell vibrates, pick up the headphones and put them on.
You can either choose to eat a cereal bar, or crisps. If you prefer a cereal bar, open it.

Main Section

Have the first bite and hit the play button on the CD player. Pay attention to three things:

a) the sounds *you* are making while chewing;
b) the *recorded* sounds; and
c) the *taste* in your mouth (you don't have to like what you are eating; loathing provides also an interesting experience).

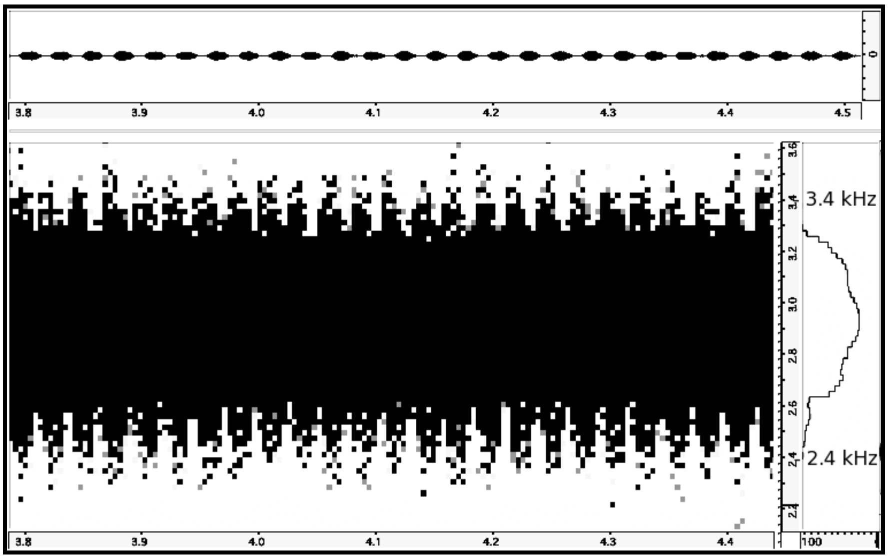
Close your eyes until you finish eating the bar, fed up with eating crisps, or until the recorded sounds stop.

Postlude

When your mouth is empty, stop the CD player and take off your headphones. Strike the bell once again with the beater. When the sound stops, the piece has finished.

Appendix V

Cricket Sound



Sonogram analysis of a cricket sound (c. 0.7 sec long. Horizontal line: time in seconds). The waveform at the top window shows the regularity of grains. The spectrum at the right shows the average amplitude (from c. -110 dB to 0 dB) of the frequencies between 2.4 and 3.4 kHz.

Appendix VI

Score Instructions for Paramnesia

Appendix VII

Compositions/Programme Notes

VII.i

Ka-Boom!

Electroacoustic sound, stereophonic (composed in 2004)

(14'07")

Ka-Boom! is based on a recording I made of a fireworks display. The composition employs recorded voice that imitates fireworks and the text I compiled is a combination of onomatopoeia, made-up language and words used in comic books.

According to information processing theory, the information that a listener receives is assimilated by the human brain by reducing the complex data into meaningful patterns and preserving these in memory. Then, the listener is able to understand the surrounding world by synthesizing it from the chunks of information kept in memory.

The structuring of the composition attempts to parallel the human brain's process. There is a clear sense of a start and an end of a real-life happening, while in between there are chunks of information; isolated events trigger chain reactions of sound material, until a new event is picked up and a new chain reaction takes place. All these sections are interconnected and each has a dominant characteristic that can be anything from a rhythmic fragment to a pitched quality, a sparse texture, a sizzling, crackling, whistling kind of timbre, anything that could dictate the creation of a different meaningful pattern in memory.

VII.ii

Vessel@Anchor

Electroacoustic sound, hexaphonic (composed in 2005)

Duration: 11'38''

This acousmatic piece is composed for six channels. Its structure is informed by a simple plot: a boat approaches (a harbour or a beach), the anchor is thrown into the sea and the listener's attention shifts between different scenes. The piece concentrates initially on the waves splattering on to the boat's sides; the listener/passenger stays inside the cabin while the waves hit the exterior of the boat; imagination plays some tricks on the mind and transforms certain sounds. Then, attention is drawn to the waves on the shore and briefly back to the inside of the boat, before a momentary turmoil gives way to tranquility, which slows down the pace of the composition considerably, culminating in the long sustained textures that end the piece.

The initial environmental recording was made in and around the harbour of Marseilles, before being processed in the studios of City University, London, where the composition was realised.

VII.iii

Vessel@Anchor ST6

Electroacoustic sound, stereophonic (composed in 2006)

Duration: 6’00’’

Vessel@Anchor ST6 is a stereo re-composition of the six-channel piece *Vessel@Anchor*. Whereas the multi-channel version lasts for more than 11 minutes, its stereo sibling almost halves that duration, resulting in a different perception of the timescales involved. The structure of the piece is similar to the original, but the durations of the sections change; only essential elements are retained to preserve the proportions.

Vessel@Anchor ST6 has been composed for IMEB’s (Institut International de Musique Electroacoustique de Bourges) overture project on water (H_2O), and it was presented at the Festival Synthèse 2006 in Bourges, France; it was selected by the audience for a subsequent concert at the Festival Synthèse 2007.

VII.iv

Chronos

Version 1: electroacoustic sound, stereophonic (composed in 2006)

Version 2 (live): electroacoustic sound, three channels and a visually displayed clock.

Duration: 11'25''

Although this electroacoustic piece lasts for c.11.5 minutes, symbolically, it lasts for nearly an eternity. The composition is framed between a representation of the beginning of time and the actual present.

Chronos starts with an anticipation that resolves into the cosmic explosion which marks the beginning of time. The composition then exposes the main symbolic carrier of time, the clock, which appears in many forms and takes up numerous disguises. It measures time in various speeds, accelerates and decelerates time, and forms rhythmic fragments and varied textures.

Chronos allows for two possible versions. In live performances (where circumstances permit) it uses stereo electroacoustic sound, a separate channel dedicated to the recorded sound of a clock, and a clock physically present on stage. In the latter situation, the ending of the piece symbolises a transition to the present, the awaking of the listener and that of the composition itself into the reality of the present moment and the actual flow of time. Without the clock on stage, the piece acquires a different ending, fading out with a distant rumble to leave the listener at the mercy of time in daily life.

Aki Pasoulas was selected for the composer shortlist for the period 2008-2011 by the SPNM (Society for the Promotion of New Music) for the acousmatic version of *Chronos*.

VII.v

Arborescences

Electroacoustic sound, stereophonic (composed in 2007-8)

Duration: 11'24''

Arborescences is a stereo acousmatic composition. The sound material derives from particular resonances and timbres produced by striking, rubbing and scraping an assortment of gamelan instruments. Most of the sonic images in the piece are not recognisable as instrumental sounds because of the extended processing, which focuses on developing particular gestures and textures based on micro-elements and groups of partials extracted from the recorded events.

The composition explores temporal syntax based on my research on timescales. Timescales at various points in the piece move at different paces, so that arborescent structures move apart and then meet again, forming two main types of organisation; one is based on discretisation of time and the other on processes of change, such as swelling of dynamic content, thinning of frequency density, and rate of progress and motion. Periodicities turn into erratic behaviour and the opposite, undergoing a number of processes of change at the same time.

Arborescences received a special mention in the Métamorphoses 2008 international acousmatic composition competition, and was selected for the International Computer Music Conference (ICMC 2009) in Montreal, Canada, the 6th Sound and Music Computing Conference (SMC 2009) in Porto, Portugal, the Sonoimágenes 2009 international acousmatic and multimedia festival in Buenos Aires, and the 2010 ISCM World New Music Days festival in Sydney, Australia.

VII.vi

Paramnesia

Electroacoustic sound, stereophonic (composed in 2008-9)

Duration: 15'07"

The word 'paramnesia' derives from the Greek 'παρά' and 'μνήμη' meaning 'near' and 'memory'. It is a condition that causes confusion between reality and fantasy, resulting in distorted memory. Patients fabricate imaginary events to compensate for loss of memory, and they also experience déjà vu.

Paramnesia consists of two connected movements ('Promenade' and 'Repose') that represent daytime and night respectively. It explores timescales based on connotational chains, and the relation of stimulus complexity to temporal judgements. Additional forces occur in the temporal syntax, an interplay among durations, rhythms, tempi, and changes in pitch contours and dynamics. Both movements explore disturbance of chronological order; passages or sounds are repeated, disguised in different forms (feelings of déjà vu). In *Paramnesia* there is no story unfolding apart from the distinction between day and night. Events from recordings are taken out of their original context and re-assembled.

The first movement is based on a recording made in the promenade of Alghero in Sardinia and it was commissioned by the research unit CRiSAP (Creative Research into Sound Arts Practice). *Paramnesia* was shortlisted at the Concours Internationaux 2009 (Musiques Electroacoustiques et Arts Electroniques) in Bourges, France, and was selected for the Sonic Artists in Wales (SAW) Electroacoustic Symposium 2010 in Cardiff, and the International Computer Music Conference (ICMC) 2010 in New York. The composition is also selected for the ICMC 2010 CD, published by the International Computer Music Association.

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