Process and Form

Perspectives on the application of predetermined systems to sectional forms in music composition.

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Abstract

Two compositional concerns are prevalent and interrelated in my recent music. The first is an interest in the use of predetermined decisions, and in many cases rule-based systems, to influence the organization of events in a piece. The orientation towards predetermined systems reflects a desire to avoid well-established musical tendencies, which is achieved to the extent that decisions are removed from moment-to-moment compositional activity, thereby evading perceptual intuition and factors of musical acculturation. The use of predetermined systems also reflects a concern for clarity of compositional intention, as processes tend to produce structurally coherent developments due to their gradual and systematic progression. The second characteristic that is prominent in my music is an interest in recurrent sectional forms, which not only divide time but also offer listeners additional opportunities to absorb the musical ideas explored in a piece. These two concerns, predetermined systems and sectional forms, are brought together through the use of interleaved structures, whereby developments with distinct identities are divided into segments and alternated in succession. Interleaved structures are uniquely continuous; upon the return of each process, the development resumes from the point at which it was last suspended. Consequently, each segment represents just a portion of the whole, and the full development of each process is only revealed over the duration of the piece. When developments are transformed to the extent that their surface qualities are significantly altered then dynamic relationships are likely to arise between them as the piece unfolds. Interleaved structures suggest a shift in compositional concerns from the vertical to those that are oriented horizontally. In my own music this has resulted in a greater emphasis on the relationships between processes, and more specifically, on how those relationships evolve over the duration of the piece.

Introduction

Two compositional concerns have been particularly prevalent in my music over the past few years. The first is an interest in the use of predetermined decisions, and in many cases rule-based systems, to influence the organisation of events in a piece. The second is an interest in sectional forms. This writing is divided into these two main topics, which are brought together by the fact that they constitute important aspects of the original works discussed. Although they may at first seem unrelated, and perhaps even at odds with each other, this writing will show that predetermined systems offer the ability to design and control structures with distinct identities that can be combined and arranged in unique ways to produce sectional forms.

The act of composing music often involves making decisions from moment-to-moment in the context of an explore-audition scenario, whereby the composer sounds out various ideas and then makes judgements as to their fitness based on what is heard. Put simply, we might say that such decisions are made 'by ear', and they tend to lead to a highly subjective musical result, reflective of both the preferences and the musical history of the individual. Composing, however, also involves making decisions in advance, prior to any explore-audition activity. For example, choices pertaining to style, instrumentation or plans for development may all be made before any specific events are considered. The composer then enters an explore-audition scenario with some predetermined notion of the desired outcome, and this not only guides the ideas that are explored from moment-to-moment, but also influences subsequent judgement as to the fitness of those ideas.

Most music involves some balance between predetermined and moment-to-moment decision-making, yet the interaction between the two need not be a concern of the composer. For example, it seems quite reasonable simply to accept that music for brass ensemble can only contain brass sounds and that the behaviour of those sounds must be limited to that which can be performed using brass instruments. Important to my own interest in predetermined decisions, however, is the effect that they have on explore-audition activity, and ultimately, the resulting music. It may be

argued that the interaction between predetermined and moment-to-moment decision making activities influences inventiveness in as much as predetermined decisions can both stifle subsequent exploration or direct composers towards ideas that may not have otherwise been considered. In this sense, predetermined systems offer composers the ability to expand their creative potential.

Composers of Western art music have long been concerned with the application of predetermined, and often rule-based, systems to govern or prescribe the organisation of events in a composition or performance. The canon serves as just one early example, and in fact, through the Middle Ages and Renaissance periods, the term literally referred to a rule or instruction. The primary method for realising a canon was to derive one or more additional voices from a single, notated principle voice by applying the indicated rules to the notes of that voice during performance. Rule-based systems such as the canon were explored out of an interest in creating music that simultaneously engaged both affective and cerebral human inclinations. Composers of the Renaissance period became interested in "...writing music in which the audible structure was supported by another, concealed, rigidly calculated structure. The propensity to exercise technical virtuosity and publicly demonstrate professional skill... persist[ed] in the canon making of Ockeghem and his contemporaries" (Grout & Palisca, 1988: p.214). This interest in cerebral propensities has persisted in Western music; it can be found in the fugues of J.S. Bach, the etudes of Frédéric Chopin, the rhythmic-harmonic relationships of Henry Cowell and the strict serialist techniques of early electronic music, to mention just a few historical examples.

One particular lineage of music that exemplifies a shift towards predetermined systems is commonly referred to as Process music, and it grew particular strong in the United States during the twentieth century with composers such as Charles Ives, Henry Cowell, Conlon Nancarrow and Steve Reich serving as examples and leaders of the movement.[1] Process music tends to be concerned with

[1] Steve Reich was the first, at least formally, to describe this music as Process music in his article "Music as a Gradual Process" (1968). For the purpose of this writing, the word *Process* with a capital 'P' denotes a reference to the sub-genre, while *process* with a lowercase 'p' refers to a predetermined system.

unity achieved through logical coherence, and in what might be considered its purist form, is characterised by a reduction of musical ideas to a single deterministic system, which then generates the events as well as the form of a piece. The composer makes few, if any, decisions once the process is designed and the source material is chosen. Instead, the composer merely sets the system into motion. Put simply, the music is the process and the process is the music. In "Music as a Gradual Process" (1968), Steve Reich writes:

> I do not mean the process of composition, but rather pieces of music that are, literally, processes. The distinctive thing about musical processes is that they determine all the note-to-note (sound-to-sound) details and the over all form simultaneously (p.1).

In the early Reich pieces, this unity provides the music with a particularly coherent character, which is reflected at various levels of the music. Moreover, there is clarity of compositional intention; the composer's aims are unambiguous.

Turning our attention to architectural aspects of music, it must first be said that a conventionalised distinction between musical structure and musical form does not seem to exist in the literature, and a proper discussion of that issue is beyond the scope of this writing. However, it does seem necessary for the purposes at hand to make such a distinction, and therefore the following definitions are applied as they pertain to music only. *Structure* describes the raw shape of a segment of music in time and can be attributed to segments of any length, ranging from a single sound to an entire piece. *Form* refers to the holistic structure of a composition, and includes any self-referential associations made within that structure. Form, then, is a mental representation of music that is concerned not just with shape, but also with internal relationships. For example, the recognition of the music found at the end of a sonata as a return to that heard previously in the exposition makes an important contribution to the sonata form. Sonata form is not simply a particular ordering of musical ideas, but rather an ordering which concludes with a return to the music of the beginning, and this association is one important aspect of our understanding of

the form. Importantly, many compositions can be classified as sonata forms, even though their content is clearly different. This is because, at least in terms of classification, the content itself is less important then the relationships between the various content identities. To put the distinction in another way, we might say that structure refers to *frame* while form refers to *frame* plus *content arrangement.* This difference is illustrated in figure 1.1, where *a* represents a structure and *b* and *c* are two different examples of the same form.

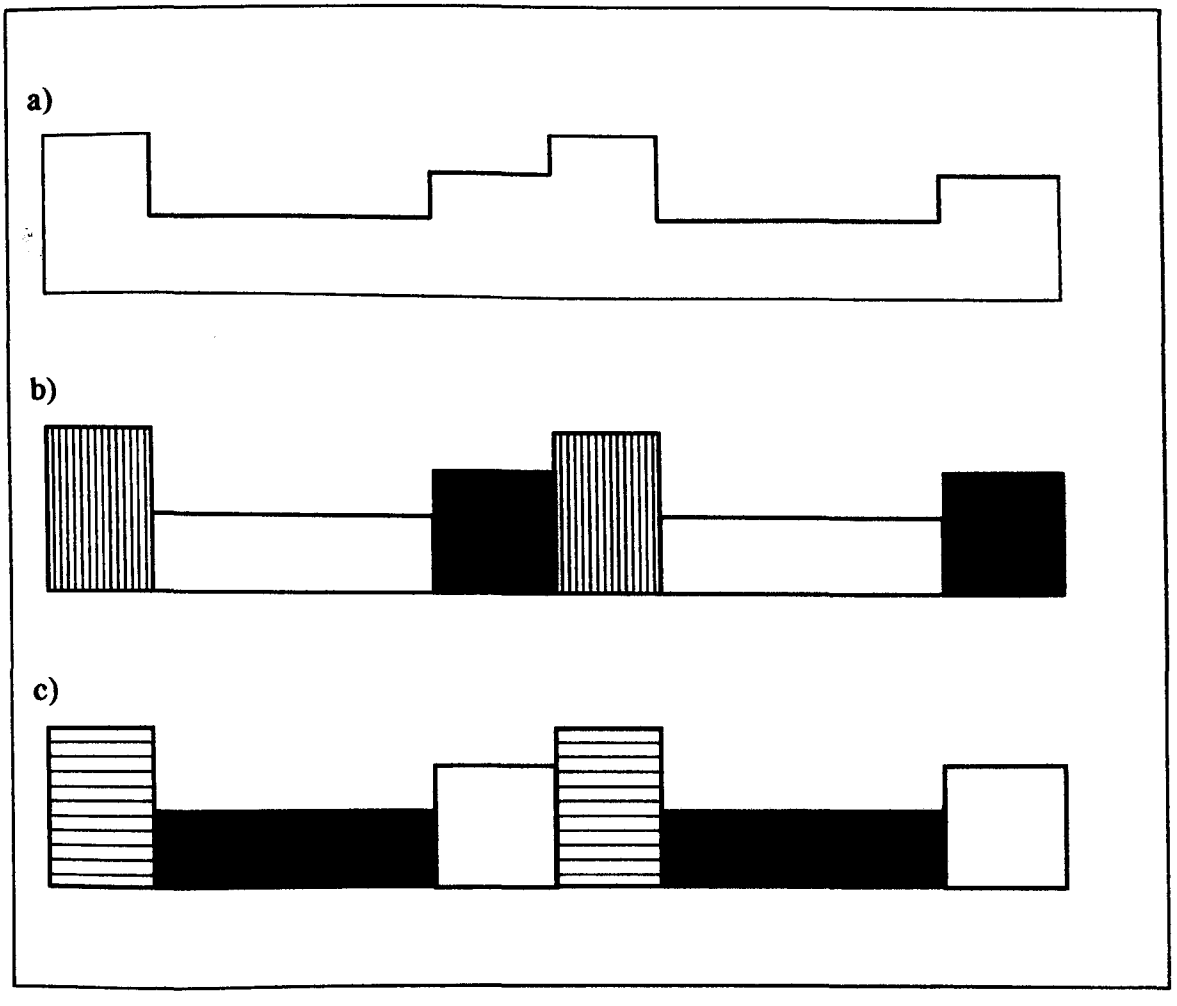


FIGURE 1.1 a) structure b) form example 1 c) form example 2

Three difficulties arise immediately in relation to the above distinction. Firstly, if structure is the raw shape of a musical surface then one might wonder what properties an assessment of that shape is to be based on? In order to answer this question a distinction must be made between perceived structure, which is a mental representation, and two-dimensional illustrations of structure such as those presented in figure 1.1. The illustrations representing both structure and form throughout this writing are intended to show only the prominent characteristics of a musical surface, and are thereby incomplete. Music is multidimensional, and each dimension carries its own structure. In some cases it may be that the mental representation of structure is more complex then a two-dimensional illustration can possibly suggest. At other times it may be that dimensions compete for interpretative influence, and as a result only the structures of the stronger dimensions are maintained. Considerable attention is paid to these issues later in the writing, and so further discussion of them will be delayed until that time. The second issue that arises is that the term 'form' is only used to describe entire compositions, but it seems like an equal distinction can be made concerning smaller musical segments, and even among single sounds. The reason for limiting form to a description of whole compositions is purely conventional; the common usage of the term as applied to music relates to entire pieces (eg. sonata form, binary form, rondo form, etc.). Lastly, if structure is 'raw shape' then it might seem to be presented as something that is objective while form, involving perceived relationships, is subjective. In fact, both generalisations are problematic. In the case of structure, the raw shape might be interpreted differently depending on what dimensions are focused on. Conversely, in the case of form, it is clear that various listeners will have different experiences of a piece, but the term 'form' is typically meant to refer to those that are shared rather than to individual interpretations. While we may accept that trained listeners will experience the first movement of Beethoven's 'Eroica' symphony differently, most agree that it is organised in a sonata form, otherwise that term would be far less meaningful. Despite these difficulties, the distinction between structure and form given above will be maintained throughout this writing, as it adequately serves the purposes at hand.

Sectional forms have long held a prominent position in art music, with binary, rondo, and sonata forms providing just three examples. The overwhelming majority of popular music is also sectional, most being songs that are divided into verses, bridges and choruses. Aside from being familiar, sectional forms have other important qualities that would seem to contribute positively to the listening experience. Firstly, they divide time, breaking up the music into shorter segments which can be more easily apprehended. Moreover, sectional forms are often recurrent, giving listeners additional opportunities to hear and absorb the musical ideas being explored. In the context of contemporary music, where so much of what is presented to the listener is new, it would seem that these qualities are significantly beneficial and comforting to a listener.

In terms of structure, individual processes tend to be relatively simple, illuminating a single, unified idea. It is rare that they lead to sectional forms because, at least where a purist attitude is adopted, the different sections would have to arise from the process itself, which is unlikely. Instead, processes generally create forms that gradually progress from one state to another, without sudden, drastic changes in the character of the musical surface. Through the combination of multiple processes, however, more complex forms can be created, and when the processes are time-distinct and sufficiently distinguishable then those forms may be sectional. While the use of multiple processes requires that the composer compromise the customary notion of unity associated with Process music, in fact, this need not neglect the desire for objectivity. There are ways of combining processes such that the result is equally deterministic and equally arrived at outside an explore-audition scenario, as will be shown in the forthcoming discussions.

This writing is divided into four chapters. Chapter one begins with a discussion of aesthetic perspectives relevant to composition that is based on the use of predetermined systems. A distinction is drawn between intuitive decision-making and predetermined decision-making and some of the characteristics of each are examined. Chapter two provides an in-depth discussion of processes, with a particular concern for their structure and motion. The relationship between process and source material is examined, and a classification of processes based on their

motion is presented. In addition, three concepts related to processes are introduced, namely sequential processing, process polyphony and convergence. In chapter three the concept of musical identity is introduced. The writing is directed towards issues of form, but focuses on the factors that make a particular section recognisable. Chapter four continues the discussion of sectional forms, beginning with a survey of several factors affecting the segmentation and subsequent grouping and association of musical sections. Interleaved structures are introduced, which are said to be uniquely continuous and particularly well suited to process-oriented composition.

The topics in the chapters outlined above are discussed primarily in the context of five original compositions:

1. *And Then, Romina...*, for prepared electric guitar and fixed electronics
2. *The 3 Faces of Karen Black, plus one face only for good measure,* for Bb clarinet and fixed electronics
3. *Seven Sisters,* for cello and acoustic guitar
4. *Flap Jackson,* for 2 flutes, piano and fixed electronics
5. *Slinky*, for acoustic guitar and fixed electronics

In addition, pieces by other composers and older original compositions will be referred to, both because they provide examples relevant to the particular discussion and because they reinforce the underlying compositional principles that constitute my own musical concerns.

Chapter One – Cognition and Aesthetics

The orientation towards predetermined systems in certain lineages of twentieth century music reflects a shift in aesthetics, a key aspect of which is a desire to avoid well-established musical tendencies, including both those relating to musical practice in general and those relating to self-expression and personal preference. In fact, such an aversion is achieved by moving compositional decision-making out of an explore-audition scenario and onto predetermined plans. Since the resulting music is not organised around perceived preferences, it often seems to come from beyond the intuitions of the particular composer, and can sound unlike any other style of music. In this way, predetermined systems are capable of generating a music that might seem to be stylistically disconnected from the past, and it is equally this sense of discovery that many composers find so attractive. Of course, the disconnection is only figurative; it is specifically the affective qualities of music that are disengaged from the past. Historically, the fact remains that Process music did occur and continues to do so.

The significance of an emphasis on predetermined systems in contemporary music is deeper than just a shift in aesthetics. It has real consequences for the ability of a listener to understand the music, and ultimately leads to fundamental questions as to the nature of music itself. Considerable evidence to support these claims is provided by existent and ongoing research in the field of cognitive science in general, and music cognition in particular. What follows is merely a brief overview of that research, but my feeling is that it is adequate to illustrate that reliance on 'the ear', that is, the explore-audition scenario, during the act of composition inevitably leads to a music that is strongly rooted in well-established tendencies.

Cognition and Musical Acculturation

The study of music cognition aims to explain how music is perceived, and more precisely, how that perception gives rise to musical understanding, or meaning. Perception has traditionally been divided, although perhaps somewhat superficially, into physiological and psychological layers.[2] The physiological layers involve the reception of a stimulus by the physical mechanisms of hearing—the auditory system—the structure of which determines important dimensions of our hearing potential, such as frequency response ranges, loudness curves, masking effects and the critical bandwidth surrounding each particular frequency. Psychological layers relate to the mental interpretation of a stimulus once it has passed the physical auditory system. Inevitably, both physiological and psychological layers are at work when listening to music, and we might summarise perception by saying that the physiological layer supplies the brain with raw data while the psychological layer attempts to interpret that data into a meaningful musical experience (Raffman, 1993). Studies in the field of music cognition provide an interesting understanding of what it is that listeners find preferable in particular pieces of music, and more generally, why people like music at all. Such research is important to any discourse on composition, but is particularly relevant to a discussion of processes because, as will be argued in the next section, the predetermined nature of decision-making in music that involves processes challenges contemporary cognitive theories in significant ways.

In his influential book *Emotion and Meaning in Music* (1956), Leonard Meyer investigates the nature of music perception from a psychological perspective. Meyer states that a stimulus has *embodied meaning* when, on the basis of past experience, it makes us expect a consequent musical event. For Meyer, meaning is firmly attached to expectation, of which there are two types: conscious and unconscious. Conscious expectations are intellectual experiences where the listener

[2] I say 'superficially' because the psychological layers surely have a physiological basis.

has a conscious understanding of the musical structures and relationships contained in a piece, and a conscious awareness of the expectation itself. Such conscious understanding relies on an intellectual rationalisation of perceived information, which is made in the context of a body of explicit knowledge that is based on long-term memory and acquired through the intentional and conscious study or deliberation on a subject or stimulus (Dienes & Perner, 1999). For example, a listener may appreciate a canonic piece because of the ingenuity applied to the composition of the canon itself. Such appreciation is often achievable through analysis of the score alone, without ever hearing the canon as manifested in sound. Undoubtedly, appreciation of this sort is conceivable only because the listener has some experience with, and explicit memory of, canonic composition, at least to the extent that it is possible to recognise the particular canon in question as being unique and interesting in some way. Importantly, in such circumstances, the listener is aware of the reasons behind the sense of appreciation felt; the understanding is conscious.

At the centre of Meyer's argument, however, is the idea that listeners maintain a specialised, unconscious understanding of music, whereby meaning is contained within the structurally important units themselves: the harmonies, phrases, melodies, and so on.[3]

> We are continually behaving in an intelligent way, comprehending meaning and acting upon our perceptions, cognitions, and evaluations without ever making the meanings themselves the objects of our scrutiny—without even becoming self-conscious about what experience means (p.38).

According to Meyer, as we listen to music, expectations regarding the probability of future events are continually being generated at various levels of the music's

[3] According to Meyer, there are two attitudes towards musical meaning. Absolutists are those who believe that meaning is contained in the relationships within the work itself. Referentialists are those who believe that meaning is found in references to the extramusical world (Meyer, 1956). Embodied meaning is associated with absolutism, while designative meaning is associated with referentialism. This discussion takes an absolutist position, unless specified otherwise.

structure. Expectations remain unconscious so long as the course of events satisfies them. They only become conscious when the probable outcome is either delayed or replaced with an unexpected consequent. Of particular importance to this discussion, these expectations are the product of each individual listener's cumulative experience with a musical style.

> Expectation...is the product of the habit responses developed in connection with particular musical styles and of the modes of human perception, cognition and response—the psychological laws of mental life (p.30).

Expectations are, in fact, simply the manifestations of the embodied meaning described earlier. Meyer goes on to state one of the basic hypotheses of his writing: that emotional or affective responses are aroused in situations where expectations are temporarily delayed or permanently denied.

The sort of unconscious understanding that is central to Meyer's argument is not specific to the perception of music. In fact, it is widely discussed across many areas of cognitive science, including linguistics (Chomsky, 1980), visual perception (Kosslyn et al., 1990) and social cognition (Carlston & Smith, 1996), to mention just a few. From a cognitive perspective, perception relies on unconscious frameworks of knowledge, referred to as schemata.[4] In a discussion of mental imagery, Nigel Thomas (1999) provides a complete and accurate definition of a schema:

> Schema... refers to a data structure, implemented in the brain, that functions to govern perceptual exploration of the world so that appropriate perceptual tests are applied at appropriate times and places, and that is continuously modified or updated by the results returned by those tests so as to be able to govern perceptual exploration in the future (p.1).

Literature in cognitive science portrays perception as a bi-directional system. Interpretation of a stimulus is made in response to the relationship between the

[4] In cognitive science literature *schema* is used to denote the singular, whereas *schemata* is used to denote the plural.

stimulus and the individual's schemata, which are acquired passively through repeated experience with the activity concerned. At the same time, a representation of that stimulus is added to the listener's acquired knowledge, so as to contribute to future interpretations.

The exact nature of schema-based knowledge is an issue of considerable debate, and there are two leading theories that attempt to explain it at a neurological level. The Classical view (eg. Fodor, 1975; Newell & Simon, 1976) maintains that information is stored in the brain as symbolic representations, much like a computer stores digital data on a hard disk. Accordingly, interpretation involves comparing a representation of the perceived input with those similar representations stored in the brain from past experiences. Connectionist theory (eg. Bharucha, 1987; McCulloch & Pitts, 1943; Rumelhart & McClelland, 1986; Rumelhart, 1989; Smolensky, 1988) argues that as we listen to music a network of highly interconnected neurones is activated, and the stronger the connection the greater is the level of excitement. Furthermore, the excitement of each particular neurone has the effect of strengthening its physical connections to other neurones. These connection strengths are the key to connectionist theory because it is in the relative weights of the nodes that musical knowledge is stored. It may be argued that these two theories are actually not in contrast, but instead provide a single explanation of perception. Simply put, the representations of the classical view may be nothing more than patterns of stimulation across a neural network. There are, however, some important differences between the two theories, but a proper investigation is beyond the scope of this writing.

Schema-based theories of perception have naturally been applied to music, perhaps most notably by Fred Lerdahl and Ray Jackendoff in their book *A Generative Theory of Tonal Music* (1983). According to Lerdahl and Jackendoff, the perception of music is similar to that of language, involving the unconscious construction of abstract structures (representations), of which the events of the musical surface are the only audible part. These abstract structures, which are formed from schema-based knowledge, are what account for a listener's understanding of music. The theory proposes various hierarchical descriptions of

musical structures that are reminiscent of Schenkerian analysis. Ultimately, it goes further to present a grammar that defines the abstract structures relating to tonal music that an experienced listener must possess, and relates those structures to musical surfaces in the tonal style by way of various well-formedness, preference and transformation rules.

Although schemata are individual to each of us, the degree to which we collectively engage in the same, or similar, experiences will result in a corresponding degree of similarity in our individual schemata. Such a consequence is indeed necessary for the development of a musical language. Cognitively speaking, musical language can be thought of in terms of the collectively shared schemata within a particular group of people, which exists by the fact that those in the group have had similar musical experiences to a sufficient extent that similar structures have formed in each individual. While it is difficult to define the boundaries of collective schemata, it is possible to be fairly confident that listeners will be familiar with many structures. Just as a person who does not know the meaning of the word 'house' can not be said to know the English language, equally in music, a person who does not understand, albeit unconsciously, the meaning of a V-I chord progression can not be said to know the language of Western tonality. We can refer to *musical acculturation* as the method in which the collectively shared schemata of a particular society are instilled in a person over time (Frances, 1988). Anyone who has listened to the music of a remote culture has most likely observed the importance that acculturation has on musical preference. Such experiences often give rise to a sense of confusion and even frustration, presumably due to a lack of understanding of the musical language. Regardless of whether such contact with exotic music is deemed to be enjoyable, it seems clear that the experience of the outsider is much different from the experience of the listener who has grown up in that culture, having listened to the music extensively and acquired the necessary schemata to interpret and properly understand it.

To summarise, research in cognitive science, particularly in the area of music cognition, provides us with an interesting and useful insight into the perception of music. The cognitive view of music perception is that a stimulus is interpreted

simultaneously on both conscious and unconscious levels. At the same time, the unconscious aspects contribute to schemata and the conscious aspects contribute to the listener's framework of explicit knowledge. What is important in the context of this writing is that the perception of music is a matter of comparing what is heard to what has been learned through past experience, and the relationship that the perceived music has to these internal schemata will determine the listener's preference for the music. More specifically, in such comparisons it is the similarities that are important because they provide meaning to what is perceived, either conscious or unconscious. Accordingly, it is through similarity that expectations are delayed or denied. Since composers of music are at the same time listeners, and often so at decision-making moments during the act of composing, this understanding of music perception has significant consequences with respect to certain approaches towards composition and the nature of the decision-making involved.

Perceptual and Conceptual Intuition in Composition Activity

At the outset of *A Generative Theory of Tonal Music* (1983), Lerdahl and Jackendoff state that the goal of their theory is to provide "...a formal description of the musical intuitions of a listener who is experienced in a musical idiom" (p.1). Musical intuition, in the context of its usage above, is simply another way of referring to a listener's response to a stimulus whose interpretation is formed in the context of that listener's acquired schemata. Such responses are intrinsically tied to the listener's preferences and an instinctive sense of what 'sounds right' when listening to music. Since the composer is also a listener, intuition of this sort certainly plays a role in the act of composition, but the difficulty with such a description is that it only accounts for decisions that are made through audition. That is, it only accounts for those situations where the composer sounds out a musical idea, either preconceived or arrived at through exploration, so as to listen to it and decide whether it sounds appropriate. In practice, many of the governing forces

present during the act of composition are the result of decisions made outside this explore-audition scenario, and in fact are often made before a single sound event is composed. Surely those decisions also involve intuition in the sense of some idea as to what the result will sound like. Intuition of this latter sort is fundamentally different, relying on a framework of explicit knowledge that is consciously accessible. We can distinguish between these two modes of intuition by referring to *perceptual intuition* as that mode which relies on unconscious, schema-based knowledge, and *conceptual intuition* as that mode which relies on a body of explicit, memory-based knowledge. The composer exercises both modes of intuition during the act of composition by way of two different types of decision-making, referred to as *perceptual decision-making* and *conceptual decision-making*, accordingly.

Perceptual Decision-making

Perceptual decision-making leads to the determination of some characteristics of the music in accordance with implications that arise from earlier events in the piece. Such decisions are made from moment-to-moment 'by ear', in the context of an explore-audition scenario, and presumably in relation to preferences of the composer. Assuming that preferences are formed in relation to schemata, it might be said that perceptual intuition looks to the past for guidance—both the immediate past, the events in a particular piece, as well as the experiential past, the events in the composer's lifelong musical development. As a consequence, reliance on perceptual intuition results in a music that is firmly connected with music of the past and one would expect it to be abundant with well-established musical tendencies, as manifested in similarities of behaviour, relationship or function at various levels.

If only for completeness, it should be mentioned that there are likely to be strong similarities between many musically preferred sonic gestures or phrase structures and sound events that are experienced outside of the scope of music. Indeed, sounds that are frequently encountered in everyday life also contribute to

schemata and it is possible that musical preference may be in response to these rather than schemata formed from previous musical experience. One example of such an extra-musical influence is found in the relationship between the harmonic spectrum of naturally occurring pitched sounds and the evolution of Western tonality, which not only divides the frequency continuum into specific pitches that correspond to the overtones on a given fundamental, but also places the importance of each scale degree in close relation to the prominence of its relative position in the natural harmonic series. To be specific, aside from the fundamental frequency and its octave equivalents, the 5^{th} and 3^{rd} harmonics are the more perceptible in the natural harmonic series and their corresponding pitches possess a comparable importance in Western tonal theory, as the fifth and third scale degrees respectively. Harry Partch (1949) lends more weight to the argument by claiming that these three "...are the most important scale degrees in nearly every musical system worthy of the name that the world has ever known" (p.87). Hermann von Helmholtz (1863) was perhaps the first to propose that before the development of tonal music people would have been familiar with these harmonies because of their prevalence in naturally occurring pitched sound, including those of the human voice. It is no surprise, then, that people would have been attracted to these intervals when music began to be concerned with harmonic relationships. A proper investigation of the use of everyday sounds in music would need to account for whether the same schemata are engaged when listening to music as when listening in non-musical contexts. It may be that particular schemata are activated or their interpretive role heightened when an individual decides that he/she is listening to music, and as a result, normal listening may be different than musical listening in fundamental ways.

Reliance on perceptual intuition during composition provides significant benefits to the resulting music. Foremost, it conforms to the predominant understanding of what it is that we like about music—that we like it when it 'sounds right.' A reliance on perception directs composition towards structures that are meaningful to the composer, and because that composer is a member of a social group and shares in the collective schemata of that group, one would expect that other listeners would also find those structures meaningful. Pursuing this line of

argument one might presume that it is important for composers relying on perceptual intuition to remain 'in-tune' with the collective schemata of their population, which is accomplished by remaining familiar with music trends. On the other hand, however important collective schemata might seem to be, in reality they represent only the most common aspects of musical language. Returning to Meyer, it is largely the breaking of expectations that causes an emotional response to music. It may be more accurate to say that the collectively shared language provides a common set of expectations that can be broken, and the particular way in which they are broken is what identifies individuality amongst composers. At any rate, if musical preference is dependant on acquired musical language, then a strong argument can be made that working within the context of a musical language should be the aim of music composition, and the essence of music itself. In fact, to argue to the contrary one must be willing to accept music on fundamentally different terms.

Conceptual Decision-making

Conceptual decision-making refers to the predetermination of some characteristics of the music outside explore-audition activity. These decisions can take the form of rational processes or other conscious, intentional plans that influence the organisation of musical materials. In contrast to perceptual decisions, conceptual decision-making is not performed in response to a stimulus, but rather requires the ability to imagine a situation and anticipate its needs. Accordingly, such decisions are not dependent on schemata, but instead rely on explicit knowledge that is rooted in the intentional study or deliberation on a subject and brought into consciousness during this imaginative planning stage. Conceptual decisions generally have implications for the role that perceptual intuition will play during the act of composition. This interaction is largely one-way, simply because the predetermined nature of conceptual decisions means that they are made before

arriving at the explore-audition activity.[5] Conceptual decisions can be applied to a wide range of musical parameters and the nature of such decisions varies greatly. This being the case, it is useful to further divide conceptual decisions into three primary categories:

1. Environmental decisions
2. Developmental decisions
3. Deterministic systems

Environmental decisions relate to the general setting in which a composition is to be formed, defining holistic parameters such as instrumentation, musical style or duration, to name just a few. These decisions create the boundaries within which a piece exists, and inevitably affect the role of perceptual intuition in composition by acting to guide, or limit, exploration from moment-to-moment. This guiding/limiting effect can be made clear through the use of a hypothetical example. Imagine that a composer sets out to create a three-minute piece of tonal music for string quartet, and that the piece is to be composed 'by ear' within the context of an explore-audition scenario. Although the composer will rely largely on perceptual intuition during the composition activity, a number of environmental decisions have been made that will limit and guide exploration. The sound world will be limited to those sounds capable of being produced by the specific stringed instruments making up the quartet. Having decided that the piece is to be in a tonal style, the range of musical sounds is largely restricted to twelve-tone equal tempered pitches, and presumably those seven contributing to a specific tonality. Because a string quartet consists of four players, some limit is also placed on the density, or number of different parts, that the musical texture can contain. Finally, the decision that the piece is to be

[5] It is possible that moment-to-moment decision-making in one portion of a piece can influence conceptual decisions applying to later portions. For the sake of simplicity, this discussion is limited to the interaction between both modes of intuition when they concern the same portion of a piece.

limited to three minutes is likely to have durational implications for the composition of sub-structural entities such as melodies, phrases and sections. During the act of composition the composer may explore various musical ideas, for example by sounding them out on a piano or other instrument. However, this exploration is guided, and in significant ways limited, by the environmental decisions made at the outset.

Predetermined decisions may be made that prescribe developmental plans, such as how a piece, or a section of a piece, will unfold over time. *Developmental decisions* also limit or direct perceptual intuition in much the same way as environmental decisions. However, environmental decisions are global and static, meaning that the influence that they have on exploration remains constant over the entirety of the piece. In contrast, developmental decisions can be applied to sub-structures of a piece, and more importantly, the fact that they describe development suggests that the implication that they have on perceptual decision-making is dynamic; the particular effect may change according to the stage of development. Again, the governing consequences of such decisions are best illustrated by way of example. Let us suppose that a composer makes the decision that a particular textural section will increase in intensity and that such growth will be achieved through the combined effect of a steady increase in activity, a parallel increase in dynamics and a gradual transition from consonant to dissonant harmonies. Again, the specific sequence of events may be composed within an explore-audition scenario, but if the conceptual plan for development is followed than a number of restrictive rules must be applied. Firstly, the average density of events will need to increase over time. Secondly, at any given point in the development the pitch material will be restricted to a set of intervals that occupies some range on the continuum from consonance to dissonance, and that range will shift from being more consonant to more dissonant as the development progresses. Lastly, the decision that the section is to increase gradually in volume has implication for the sounds that can be chosen for each stage of the development. For instance, sounds that are naturally soft would be less suitable for later stages, and vice versa.

The conceptual decisions discussed so far have had the effect of guiding or limiting moment-to-moment exploration during the act of composition. It is possible however, to incorporate a system that determines a specific sequence of events, thereby taking the place of moment-to-moment decision-making all together. The distinguishing feature of *deterministic systems* is that they organise musical parameters according to data which itself has been determined by forces outside of perceptual, moment-to-moment exploration. Such a system can be implemented as a data-generating algorithm, or may already be in the form of a collection of data that can be mapped to specific musical parameters. In the absence of perceptual decision-making, the composer's intentions are restricted to those that are conceptual, and these intentions are reflected directly in the design of the system. This inevitably results in a heightened compositional emphasis on formal and conceptual concerns. Furthermore, by abandoning reliance on the ear, deterministic systems can create a kind of disconnect from the music of the past, leading to relationships that are outside any conventional musical language, a characteristic which might be seen as both their finest achievement and their most obvious point of criticism.

The idea of composing music that intentionally avoids reliance on perceptual intuition has been met with considerable opposition by listeners and composers alike, primarily because it contradicts common notions regarding the nature of music itself. A piece that manages to disconnect itself from the past and from any known musical language may be understood and appreciated in a cerebral sense, but is likely to be meaningless in terms of schema-based understanding. Consequently, it may not create the same sort of affective response that perceptually composed music is capable of producing. This being the case, conceptual intentions cannot be evaluated fairly in terms of perceptual intuition, but rather must be judged using other criteria that are more aligned with the nature of the decision-making involved. This is not to say that perception does not play a part in evaluating deterministic music; music is inherently a perceptual activity. However, where conceptual intentions are concerned it may be that the function of perception is not to produce an affective response, but rather to act as a channel over which the concepts in a piece are communicated. The desire, then, is to create a system in which the concept

is most clearly perceived, and an evaluation of the music should take clarity of compositional intent into account. At this point it is instructive to examine some of the motivations for emphasising predetermined systems in composition.

Predetermined Systems and Musical Aesthetics

The orientation towards predetermined systems in certain lineages of contemporary music reflects a shift in aesthetics, which can be broadly characterised as consisting of three primary concerns:

1. Logical experimentation
2. Objectivity
3. Discovery

Logical Experimentation

Humans have an inherent propensity for logic, and it is not surprising that such inclinations should find their way into the creative arts. An interest in the application of rule-based systems to music is not a twentieth century phenomenon. However, the importance placed on the listener's awareness of those systems in Process music is a notable development. As James Tenney once commented, "...then the composer isn't privy to anything" (cited from Reich, 1968: p.1). Steve Reich describes his thoughts on perceptible systems in *Music as a Gradual Process* (1968):

> I am interested in perceptible processes. I want to be able to hear the process happening throughout the sounding music. To facilitate closely detailed listening a musical process should happen extremely gradually. Performing and listening to a musical process resembles:
>
> pulling back a swing, releasing it, and observing it gradually come to rest;

> turning an hour glass and watching the sand slowly run through to the bottom;
> placing your feet in the sand by the ocean's edge and watching, feeling, and listening to the waves gradually bury them.

> ...I don't know any secrets of structure that you can't hear. We all listen to the process together since it's quite audible, and one of the reasons it's quite audible is, because it's happening extremely gradually... Even when all the cards are on the table and everyone hears what is gradually happening in a musical process, there are still enough mysteries to satisfy all. These mysteries are the impersonal, unintended, psycho-acoustic by-products of the intended process. These might include sub-melodies heard within repeated melodic patterns, stereophonic effects due to listener location, slight irregularities in performance, harmonics, difference tones, etc. Listening to an extremely gradual process opens my ears to it, but it always extends farther than I can hear, and that makes it interesting to listen to that musical process again (p.1).

Process enthusiasts, whether composers, performers or listeners, usually maintain both affective and cerebral interests in music, while the degree to which they orient themselves towards one or the other varies. One might argue that music is an audible art form, and therefore its audible qualities should be a composer's primary concern. Accordingly, the implementation of any system is aimed at creating a sonic outcome that is preferable in the context of a schema-based interpretation, and if that does not result then such composers are inclined to either change the system, modify the outcome or discard the idea all together. Other composers maintain a more strict, experimental philosophy, and thus resist being overly concerned with the outcome. This latter attitude is largely rooted in John Cage's consideration of experimental music "...not as descriptive of an act to be later judged in terms of success or failure, but simply as an act the outcome of which is unknown" (Cage, 1961: p.13). Influenced by Cage, experimentalists often approach the use of predetermined systems as an experiment in which an intellectually attractive idea is translated into sound. As with any experiment, one

first develops a hypothesis—a reason to believe that such an experiment may produce an interesting sonic result. Along with an orientation towards experimentation comes an acceptance that not all experiments are successful. Christian Wolff once compared the situation to that of a baseball game, explaining that we attend with the hope of witnessing a good game, but many times the game is lousy. This, however, does not diminish our general enthusiasm for attending baseball games (Wolff, personal communication, 1999). Moreover, an experiment can result in various levels of success. Although a piece may not be deemed successful as a whole, it may contain wonderful moments, or prove to be inspirational in specific ways. It is entirely possible that one might find interest in a piece of music, yet never wish to hear it again. On the issue of acceptance, Steve Reich (1968) writes:

> Musical processes can give one a direct contact with the impersonal and also a kind of complete control, and one doesn't always think of the impersonal and complete control going together. By a "kind" of complete control I mean that by running this material through this process I completely control all that results, but also that I accept all the results, without changes (p.1).

Objectivity

Perhaps the most overt avoidance of previous tendencies in much contemporary music is found in its rejection of self-expression. In the article *New and Electronic Music* (1958), Christian Wolff makes the following observations:

> One finds a concern for a kind of objectivity, almost anonymity... For at least some of these composers, then, the final intention is to be free of artistry or taste. But this need not make their work 'abstract', for nothing, in the end, is denied. It is simply that personal expression, drama, psychology, and the like are not part of the composer's initial calculation: they are at best gratuitous (p.24).

By restricting compositional decision-making to the design of a process, which then generates the music, one senses that there is less of á focus on individual expression. It is not, however, that the music expresses nothing, but rather that the concepts and relationships that are expressed are external to the composer; they seem to have been discovered rather than expressed.

> While performing and listening to gradual musical processes one can participate in a particular liberating and impersonal kind of ritual. Focusing in on the musical process makes possible that shift of attention away from he and she and you and me outwards towards it (Reich, 1968: p.2).

This avoidance of self-expression also helps to explain the acceptance of any outcome that is associated with Cagean experimentalists. To the extent that the composer imposes judgement on the outcome of a deterministic system, that composer is expressing personal preferences. After hearing the result of a musical process it may be that the composer decides to modify the system in order to enhance the perceived structure of the process. However, if one is to avoid 'self', in as much as that is possible, then the aim should be to restrict any judgements and modifications of the system to those that contribute to a greater expression of the system itself—to those that illuminate the intrinsic qualities of the process.

Discovery

Deterministic systems effectively take the place of moment-to-moment decision-making, thereby diminishing the role that perceptual intuition plays in governing the organisation of events in a piece. This not only evades tendencies of the individual, but in more extreme cases can also create a disconnection with the music of the past, in the sense that the resulting music may be difficult to categorise in terms of language or style. Deterministic systems are likely to produce musical relationships that would not have emerged as a result of perceptual exploration, and

it is this sense of discovery—of venturing into uncharted territories—that many composers find most interesting about them. The resulting music can be as surprising to the composer as it is to a listener with no knowledge of the piece.

The extent to which predetermined systems create a music that is disconnected from the past varies depending on the rules of the system and the nature of the source material. The music of Steve Reich provides an example of a moderate disconnection, where processes operate on phrases and tend to control aspects of the large-scale development. Significantly, the source material in Reich's music is almost always tonal and composed by ear. As a consequence, the music retains a sense of familiarity, even if the manner in which it develops is innovative. A greater disconnection is created when predetermined systems either operate on less familiar source material, or on individual elements of a source set. In the case of the former, it is clear that if the material itself is unconventional, then it is less likely that any organisational process will render it familiar. In the latter case, unfamiliarity comes from the fact that no perceptually intuitive decisions are retained in the organisational process. The sequence that is generated is determined entirely by the process at the event level. When processes are used in this way, the result is likely to be a music that does not resemble any known musical style or language, which can pose challenges for the listener. Such systems demand a modification of one's listening strategy, or at least of the criterion by which the music is judged. Rather than considering the music from a purely schema-based, affective interpretation, greater attention should be given to the compositional intention, the character of the process and the structure of its development.

Chapter Conclusion

The aim of this chapter has been to examine some of the motivating factors behind the use of predetermined systems in contemporary music, and to consider the significance of such an aesthetic shift in terms of cognition. Music has long been concerned with both affective and cerebral human propensities. One significant

development in contemporary music has been the shift towards conceptual concerns and the degree to which composers have attempted to elude their own musical preferences, turning moment-to-moment decision-making over to predetermined systems or plans. The willingness of composers to abandon a reliance on perceptual intuition reflects more than just a shift in aesthetics. When viewed in terms of cognition, it suggests that the very essence of what music is and why people enjoy listening to it is being questioned, and more importantly, altered. It is this challenge to the fundamental nature of music that makes such an emphasis on predetermined systems one of the most significant musical developments of our time.

At this point it is worthwhile explaining how the original pieces discussed in this writing relate to the view of predetermined systems that has been outlined thus far. To begin with, these pieces do not represent Process music in any pure sense. Although they take inspiration from process composers, two factors prevent them from being typical examples of Process music. Firstly, there is not the same concern for unity at the formal level as there is in Process music. Unity is compromised in order to make sectional forms a possibility. However, the desire for unity is often retained at the process level, as this contributes to clarity of compositional intent, which is a high priority. Secondly, many of the predetermined systems used in these pieces are not deterministic, but instead are developmental, intended to guide or influence perceptually intuitive decision-making. While there is a deliberate effort to evade personal tendencies, that does not necessarily equate to a desire to avoid personal preferences. This music is intended to be affectively appealing and I rely on my own perceptual intuition for judgements. In the context of developmental processes, there is no commitment to the logic, so when the results are not appealing the system is modified or abandoned altogether.

The primary concerns with predetermined systems in these pieces are threefold. The first can be described as a desire for clarity of compositional intent, and it is maintained that such clarity can be achieved in complex forms through the combination of simple, clearly defined structures. The second is to explore the ways in which processes can lead to musical relationships that are beyond my own perceptual intuitions, that is, ideas that would not have arisen through explore-

audition activity. This not only produces interesting music, but also adds a sense of surprise and excitement to the composition process itself. It is important to me that the act of making music is rewarding, and not just concerned with reaching the final product. Finally, predetermined systems are used to create musical surfaces with clearly defined structures that are capable of contributing to large-scale musical forms. In this respect, then, the predetermined system is merely a means to end, and not the end in itself.

Chapter Two – Processes

A *musical process* may be defined as a predetermined system or plan that influences the organisation of events during the act of composition or performance. As they relate to decision-making, processes can be either *deterministic* or *developmental*, that is to say, they can strictly prescribe or simply guide events in a piece. Apart from this difference, the two are closely related in that they both provide a method for the organisation of materials that diverts decision-making away from explore-audition activity. Perceptually, they both contribute to an orderly and coherent progression of events, which hopefully provides clarity to the formal intentions of the composer and adds to the particular identity of the music.

Processes can be applied to any quantifiable musical dimensions, and in many cases, the manner in which a dimension may be transformed can vary significantly. This is clearly demonstrated by examining the ways in which a process might be applied to pitch. One method is to allow the process to determine the pitch height—whether each pitch is high or low. Alternatively, the process can transform the active pitch range; a performer might be asked to play notes at random within a given range, which may increase or decrease over time. One final example, although surely not the only remaining possibility, is that a process can be used to modulate between pitch sets, for instance from one key or tuning system to another. Pitch is, in fact, a simple case because it exists along a single continuum. Many musical dimensions are more complex and involve a number of primitive dimensions all working together. For example, a transformation of intensity, assuming that to be a musical dimension, might be achieved through diminishing event attacks, increasing dynamics and timbral modifications all happening concurrently. Figure 2.1 lists some of the dimensions commonly affected in the pieces discussed in this writing, along with various transformations that could be applied to them. These dimensions and transformations have been chosen largely because of the important contribution that they make to the identity of a musical surface, and the fact that changes in them are easily recognisable. This is not intended to be a complete listing of the dimensions available to processes, or even of those effected in my own work. It is,

however, indicative of the wide range of possibilities available to transformation by processes.

Dimension	Transformation
Pitch	Height
	Range
	Set
Duration	Rhythm
	Event elongation/truncation
	Phrase elongation/truncation
	Sectional elongation/truncation
Intensity	Attack
	Dynamics
	Density
	Consonance/dissonance
	Timbre
Timbre	Brightness
	Attack
	Spectral flux
	Graininess
	Formant
Event sequence/melody	Sequence generation
	Reordering
	Pitch
	Rhythm
Harmony	Consonance/dissonance
	Tonality
Tempo	Accelerate
	Decelerate
	Modulate
Component relationships	Unified
	Interdependent
	Independent

FIGURE 2.1 Some of the more common dimensions effected by processes in the pieces discussed in this writing, along with various possible transformations.

Deterministic Processes

A *deterministic process* consists of a specific set of instructions that is applied to source material in such a way that the process strictly determines the resultant events. Importantly, it organises parameters entirely according to forces outside explore-audition activity, and as a consequence, compositional attention is inevitably focused on the design of the process and the selection and construction of the source material. Once these are established, the system generates or transforms the targeted parameters without the composer's involvement. From a compositional perspective, deterministic processes can be divided into four main categories:

1. Mapping processes
2. Generative processes
3. Reordering processes
4. Combinatorial processes

Mapping processes describe a method for assigning the values of a collection of already existent data to specific musical parameters, and they are commonly used to translate extra-musical entities into sound. The data set may be thought of as a found object of which the composer does not control the structure, but instead chooses based on the hypothesis that the 'readymade' structure will produce an interesting result.[6] Compositional craft, then, is expressed in the method of relating the data to specific musical parameters, and it would seem to be aesthetically consistent to assume that this should be done in such a way as to contribute to the clarity of the inherent structure of the data. George Logemann's multimedia work *SETI* is a clear example of a mapping process. It consists of a mapping of stellar coordinates from black and white x,y radial images directly to sound, with a third

[6] The term 'readymade' is taken from Marcel Duchamp, who used it to refer to found objects in the visual arts (Duchamp, 1966).

dimension, luminosity, mapped to intensity (Logemann, 1992). *SETI* allows the listener to 'hear' the constellations.

My own *Wiring Sequence* (1995), for three Bb clarinets, two oboes and Radio Shack '130 in One' provides another example of a mapping process. The '130 in One' is a teach-yourself electronics kit, allowing the user to build 130 different projects by connecting wires to various numbered transistors, capacitors, diodes and so on. Some of the projects generate sound, and the one used in *Wiring Sequence* is the Light Harp, which produces a sine tone with pitch controlled by a light-sensitive resistor. For each project, the order in which the numbered connections should be made is given in a list referred to as the 'wiring sequence', and by convention, these lists progress from low numbered connections to high numbered connections, offering an inherent and consistent structure. The wiring sequence for the Light Harp is reproduced from the instructions in figure 2.2. In this piece, the ensemble is divided into two groups, separating the acoustic instruments from the '130 in One.' A conductor directs the piece by displaying the wiring sequence instructions on large cards, one at a time. While the '130 in One' uses these numbers as instructions for how to connect the various electronic components to build its sound, the woodwinds interpret them as indications as to the duration of their notes. In this way, both ensembles are using the wiring sequence to generate music, although with two very different approaches. *Wiring Sequence* is a light-hearted theatrical metaphor for some of the different ways that music is made.

1-29, 2-30, 3-16-41-109, 4-120, 5-106-110, 15-87, 40-105-88, 42-137, 119-138

FIGURE 2.2 The wiring sequence for the Radio Shack '130 in One' Light Harp used in *Wiring Sequence*.

Generative processes produce an event sequence by prescribing an ordering of elements taken from a source material set. Unlike mapping processes, the composer has control over both the rules of the process and the source material, and subsequently, over the resultant structure. In the A-identity of *Seven Sisters – Kelly* the order of pitches in both the cello and guitar parts was determined by applying the generative process outlined in figure 2.3a to the chromatic scale. The first two iterations of the resultant pitch sequence are illustrated in figure 2.3b.

	Intervallic Description	Numeric Description
Step 1:	Up a minor 10th	+ 15
Step 2:	Down a major 3rd	- 4
Step 3:	Down a minor 6th	- 8
Step 4:	Repeat	Repeat

FIGURE 2.3a The generative process used to determine the pitch sequence in the A-identity of *Seven Sisters – Kelly*.

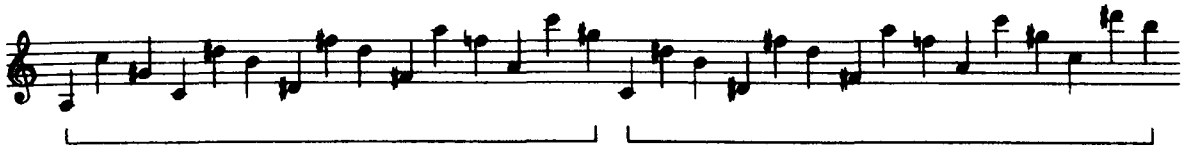


FIGURE 2.3b The first two iterations of the pitch sequence that results from the generative process outlined in figure 2.3a.

Reordering processes are those that prescribe a method of rearranging an existing event sequence, such as a melody or rhythmic pattern. Unlike generative processes, which build up the resultant sequence at an event level, reordering processes generally include the entire source set in each iteration, so the output is created in blocks of material. The melodic A-identity in *The 3 Faces of Karen Black, plus one face only for good measure* (*3FKB+*) provides an example of a reordering process. The melody appears in ten variations, each consisting of twenty-six quaver events, and an event may be a note or a rest. Each variation is determined by interchanging two events from the previous iteration. Starting in the centre of the melody, the selected events to be interchanged move outward with each successive iteration until eventually, in the final variation, the first and last events are interchanged. This process has the effect of gradually reversing the melody; the final variation is an exact retrograde of the first.[7] The initial melody is designed so that the contour is easily recognisable, beginning with the largest intervallic skip at the start and gradually closing the gap from both directions to end on a single note roughly in the centre of the pitch range. The hope is that the recognition of contour in the initial melody might aid in the perception of the process by providing the listener with an easily memorable reference against which variations can be compared. Figure 2.4 shows the ten variations of the melody in the A-identity.

[7] One variation is omitted because both events are rests, and interchanging them would produce no variation of the theme.

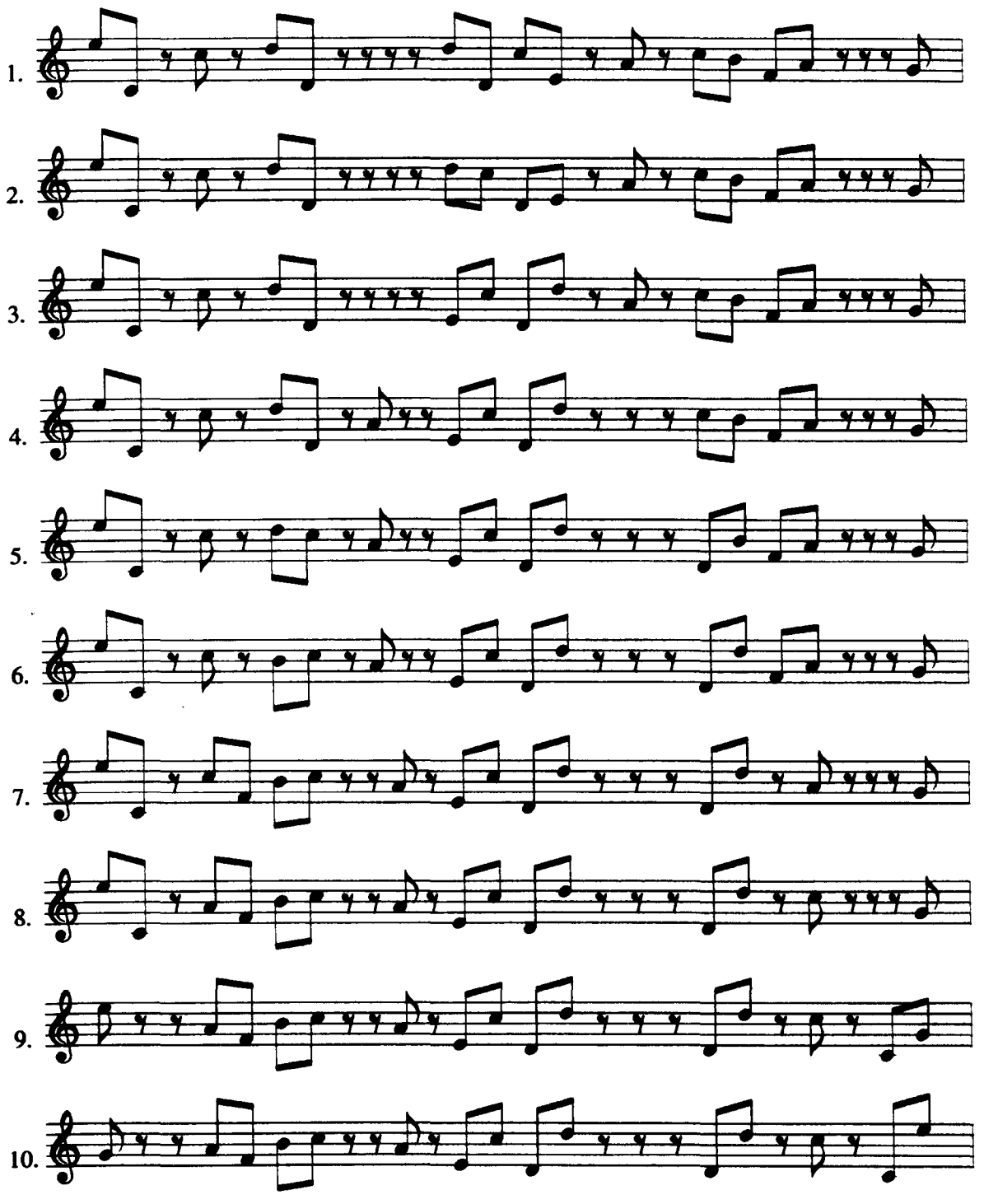


FIGURE 2.4 The ten melodic variations in the A-identity of *The 3 Faces of Karen Black, plus one face only for good measure.*

A *combinatorial process* defines a fundamental relationship between multiple components, a component being an individual part, voice or stream of events. Significantly, the contents of each component are determined by means outside of the combinatorial process. The process only defines the relationship of the different components to each other. This makes the nature of combinatorial processes somewhat different from those previously discussed. However, such processes are deterministic to the extent that the fundamental relationship that is established fixes the relationships of all subsequent events between the parts. Conlon Nancarrow composed more than fifty *Studies for Player Piano*, and almost all of them serve as clear examples of combinatorial processes. One of the better known pieces, *Study No. 36*, is a four-voice canon, with the voices in tempo ratios of 17:18:19:20. The canon ends half-way through the piece, with the last beat of each voice synchronised. Consequently, the entrance of each voice is offset by a factor determined by its temporal relationship, with the slowest voice entering first and the fastest entering last. The second half of the piece is an exact retrograde of the first half. Figure 2.5 illustrates this four-voice canon structure. Each voice in the piece performs the same material, which is tonal in character, yet the voices contain a strong sense of independence due to the fact that they are in remotely related tempi. The most striking aspect of the piece is the vertical relationships, or 'points of synchrony', that emerge out of this independence (Tenney, 1988). As with traditional canons, events in the first voice are echoed in the other voices at a time interval determined by the amount that the entrances are offset. However, because the voices in *Study No. 36* are in successively increasing tempi the echo interval diminishes as the music approaches the middle of the piece. This effect has interesting consequences, as gestures and phrases that were once separated in time begin to aggregate vertically. The best examples of this are found near the middle of the piece, where chromatic glissandi seem to travel from the lowest voice straight through to the upper most voice.

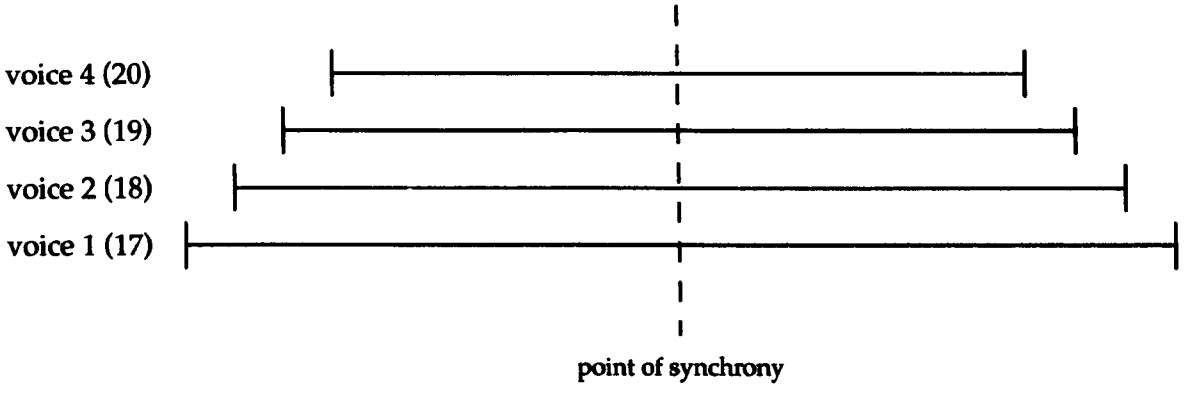


FIGURE 2.5 Four voice canon structure of Conlon Nancarrow's *Study No. 36.*

The phasing technique often used by Steve Reich, where one performer maintains a steady tempo while the other slightly accelerates or decelerates until a new phase relationship is reached, is another example of a combinatorial process. An interesting aspect of the early phasing pieces is that the systematic manner in which the voices alternate phasing makes future relationships predictable. This sort of predictability is significant in that it allows the composer to design source material that will lead to a particular result when the phase relationships reach a certain state. Reich manages to unify these two aspects, process and material, with great effectiveness, as exemplified in *Violin Phase*, for 4 violins (or 1 violin and pre-recorded tape). The piece consists solely of a repeated 6/4 bar that suggests two harmonic structures. The most prominent is an F#m7 chord, which is implied in the quaver rhythmic figures. The second, E, is implied principally in the sustained dyads. By the middle of the piece the phase relationships are such that, between the four voices, the E tonality is sustained over the entire 6/4 bar. The fact that the two harmonic structures are differentiated by their rhythmic attributes adds to the clarity of the process. The gradual modulation from F#m7 to E, along with a transition from rhythmic pattern to sustained drone, defines the form of the piece. Figure 2.6 is a reproduction of an excerpt from the score.

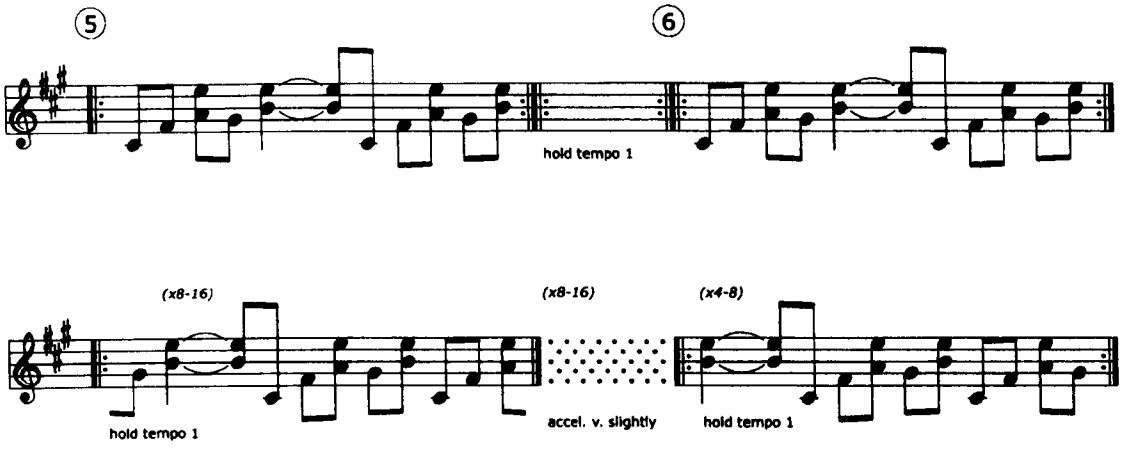


FIGURE 2.6 Excerpt from Steve Reich's *Violin Phase* (reproduced by author).

In both the Nancarrow and the Reich examples, the voices in the combinatorial process contain the same source material. This is perhaps a reflection of the emphasis on unity that is commonly associated with Process music. Moreover, the use of the same material draws attention towards the process, highlighting the logic of the development. In contrast, *Seven Sisters — Tina* consists of a combinatorial process between the cello and guitar parts, yet the material in each part is different. The guitar part is derived from a four-bar phrase, which is repeated with transformation five times. The cello part is derived from a three-bar phrase, which is repeated with transformation seven times. The combinatorial process, then, is a four-bar phrase structure sounding against a three-bar phrase structure, resulting in a pattern of phase shifting downbeats, as illustrated in figure 2.7a. The initial iterations of both the guitar and cello parts are shown in figure 2.7b.

Guitar	1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
Cello	1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

FIGURE 2.7a The phase shifting phrase structures of the guitar and cello parts in *Seven Sisters — Tina,* where each number represents a bar.

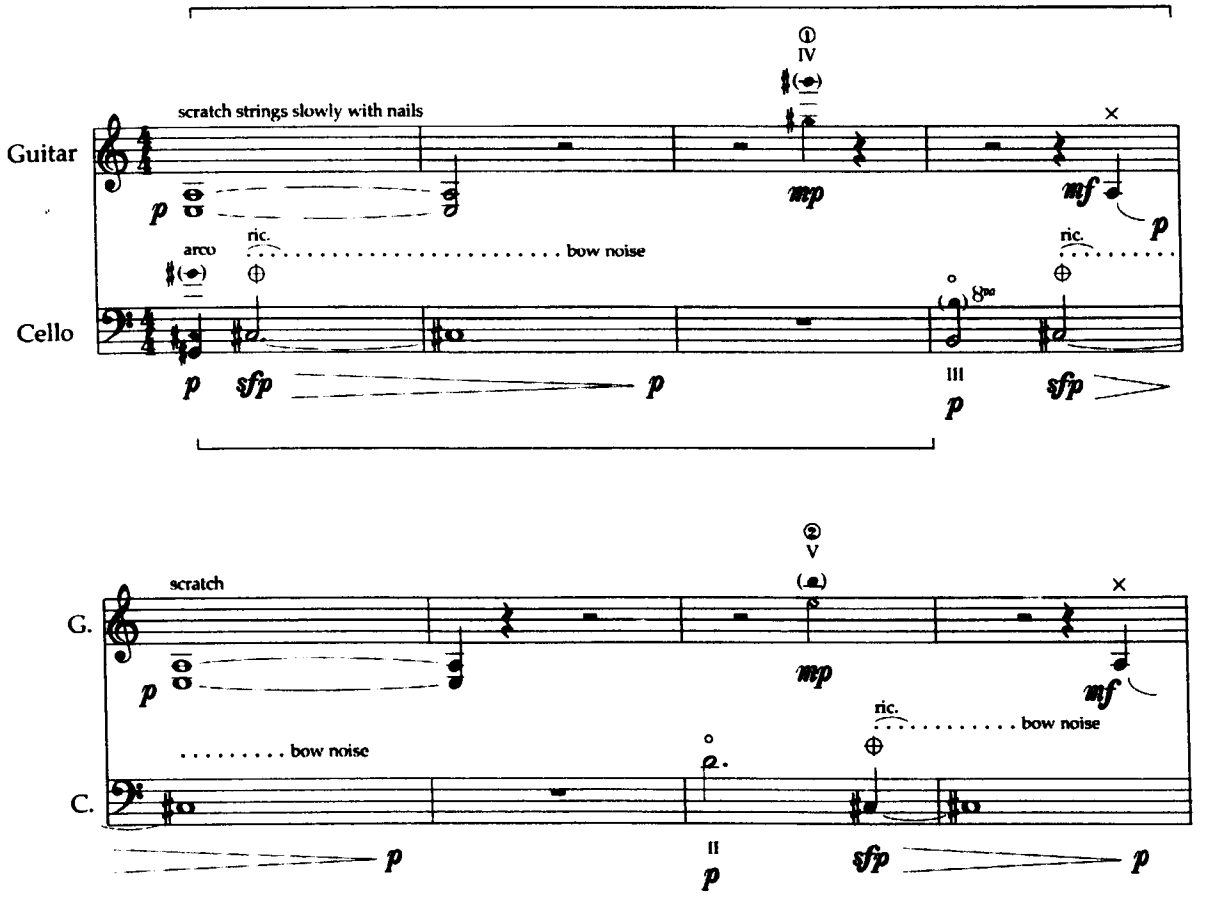


FIGURE 2.7b The initial iterations of the two parts in *Seven Sisters — Tina,* showing a combinatorial process of 4 bars against 3 bars.

Developmental Processes

If developmental decisions prescribe overall plans for how events will unfold in time then *developmental processes* can be thought of as the system of implementation for those plans. Such processes are manifested in a general, coherent manner of operations that directs the organisation of events, but are not reducible to a series of specific steps. Instead, events are decided upon perceptually from moment-to-moment, while being governed by the predefined developmental constraints. Technically speaking, any non-deterministic plan for development can be considered a developmental process. This, however, is not the spirit in which they are introduced in this writing. Here, development processes focus on defining the behaviour of a musical surface, often in highly specific terms, yet they are not presented in a manner that prescribes an event sequence. They are treated much like deterministic processes, except that some aspects of the music are left to perceptual intuition. Moreover, they are designed with the specific intention of influencing moment-to-moment decision-making, and thus evading personal compositional tendencies. The fact that they are not strictly deterministic introduces unexpected variation, breaking the rigidity that is often associated with deterministic systems. Aesthetically, developmental processes might be viewed as a reflection of a non-purist interest in predetermined systems. The significance of logic and unity are reduced and emphasis is shifted towards coherence and continuity of structure

The developmental process listed in figure 2.8a governs the pitch sequence in the guitar part of the A-identity in *Seven Sisters – Karen.* The pitch sequence is almost entirely prescribed by the process, but a few aspects are left to perceptual intuition during the act of composition, such as when the sequence changes direction. Even this, however, is governed by rule 4, which states that the overall pitch sequence should descend. The output is characterised by an alternating motion at the local level, and a descending motion over time, both of which are prescribed by the process instructions. Figure 2.8b shows the pitch sequence in section A1 of the piece.

Process Instructions:

Rule 1: Pitch movement is always by a semitone ± two octaves, except when changing direction.

Rule 2: The pitches jump octave ranges by alternating 1st and 6th strings

Rule 3: Whenever the direction is changed the same note is played in the alternate octave.

Rule 4: Overall, the sequence should descend in pitch.

FIGURE 2.8a The developmental process in the A-identity of *Seven Sisters – Karen.*

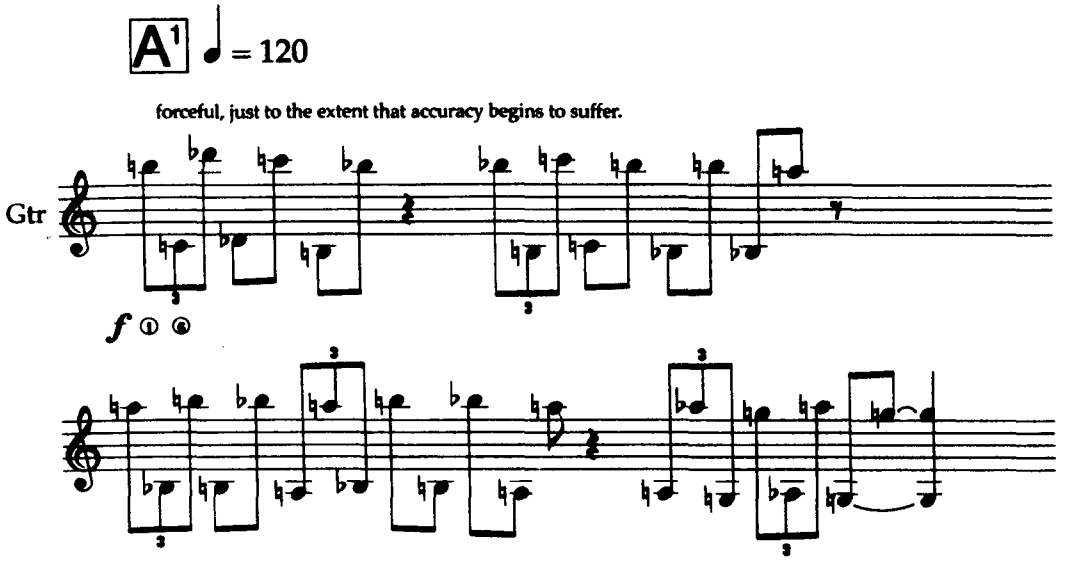
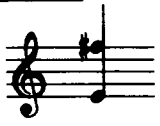


FIGURE 2.8b The guitar part from section A1 of *Seven Sisters – Karen,* showing the output of the developmental process in figure 2.8a.

Another example of a developmental process is found in the A-identity of *Seven Sisters – Flo.* In this case, the source material is a single item—a major ninth dyad—that is transposed upwards and downwards by the process. The degree of transposition, referred to as the skip size, progressively increases, resulting in a gradually widening harmonic window. The process is deterministic in certain ways: the skip size always increases by one and there is a half-step movement of the dyad

inserted whenever the skip size is increased. Again however, decisions as to when the motion should change direction were left to perceptual intuition during composition. There are three instances of the A-identity in *Flo*, and each consists of the same sequence of dyads. The process instructions are listed in figure 2.9a and a graph of the output is given in figure 2.9b.

Source Material:



Process Instructions:

Rule 1: Initial skip size = 1 (a minor 2nd)

Rule 2: Transpose the dyad by a skip size in a single direction repeatedly, then reverse the direction ad lib.

Rule 3: With few exceptions, when the direction changes the transposition skip size should also increase by 1.

Rule 4: A step size motion (±1) is inserted between each increase in skip size.

FIGURE 2.9a Developmental process in the A-identity of *Seven Sisters – Flo.*

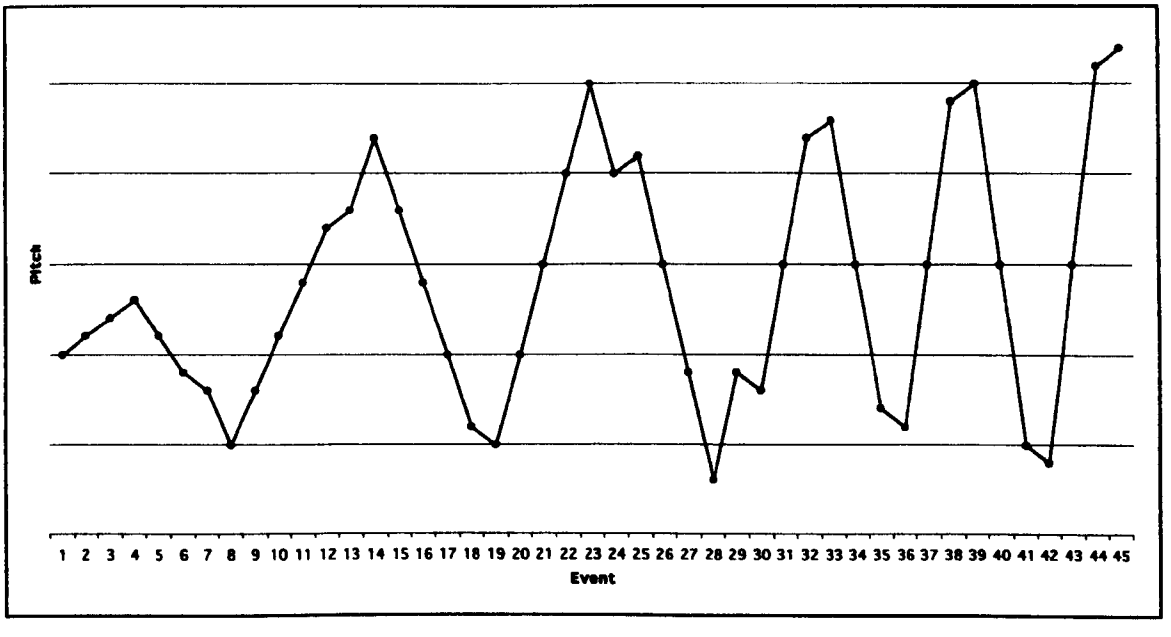


FIGURE 2.9b Motion of the single dyad in the A-identity of *Seven Sisters – Flo.*

Performer implementation

Unlike deterministic processes, which are necessarily implemented by the composer, developmental processes can be performer-implemented, resulting in a sort of controlled improvisation, whereby the player makes decisions within a predefined context. This, of course, raises a wide variety of issues, ranging from those regarding the role of the composer and that of the performer to questions as to the very nature of a piece of music. Those issues, as important as they are, fall beyond the scope of the discussion of processes undertaken here. However, another consequence of performer-implemented processes more relevant to the topic at hand relates to a practical difference in notation. Composer-implemented processes, whether developmental or deterministic, are generally expressed in a strictly notated score that contains a representation of the output of a process. The specific instructions that define the process are only exposed through analysis of the output. By contrast, when developmental processes are performer-implemented the score expresses the process itself. It will contain the source material and the instructions for how to organise that material. These instructions often describe not only the smaller details of performance, but also make explicit the required long-term developmental goals. Examples of performer-implemented developmental processes can be found in the C-identity of *And Then, Romina...* (score 2, 5). In section C2, the guitarist is given two pitch sets and one set of rhythmic figures and is instructed to apply the pitches to the rhythms in a seemingly random way, while modulating from one pitch set to the other in alternation. Five modulations are indicated, coinciding with repetitions in the electronic part. This section is characterised by a fluctuating and cyclic half-step motion, which is inherent in the process. An excerpt from the score is provided in figure 2.10, showing the first modulation in the guitar part.

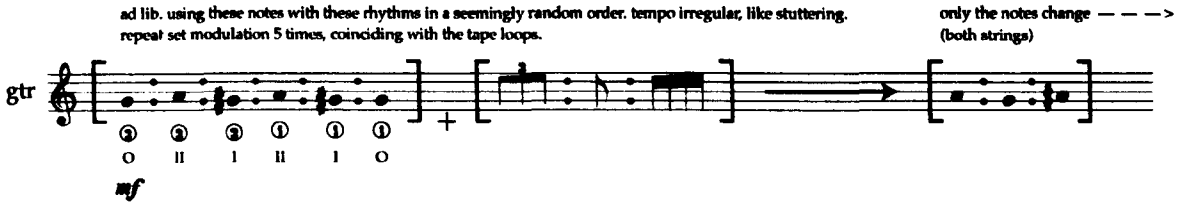


FIGURE 2.10 Score excerpt from section C2 of *And Then, Romina...*, indicating a performer-implemented developmental process.

Processes, Structure and Motion

Abstract Processes

When considered as abstract constructs, apart from their application to source materials, processes possess an inherent structure that is established by the relationships manifested in their instructions. As the instructions are carried out these relationships determine both local and structural motions, and as the process unfolds in time both motions are revealed. All processes have an abstract structure, regardless of whether they are deterministic or developmental. However, it is easier to examine abstract structures in the context of deterministic processes since the output is more concrete, and for this reason, the following examples are all deterministic.

Figure 2.11 illustrates the local and structural motions present in the first two iterations of the generative process implemented in the A-identity of *Seven Sisters — Kelly*. It can be described as having an alternating, or zigzagging, motion at the local level, while at the larger structural level there is an implied motion in a single direction at a constant overall rate. Generally speaking, local motion contributes to the behavioural characteristics of a musical surface and tends to play an important role in defining its identity, while structural motion reflects developmental concerns and tends to be more pertinent to issues of form. More will be said about identities

and formal implications of structural motion in subsequent chapters. For the moment, this discussion will concentrate on defining categories of structural motion.

If development implies a coherent transformation from one state to another, then put simply, a process can either develop or not develop, and it is on this basis that the first distinction between structural motions can be made. *Directional processes* are characterised by a continuity of structural motion, starting at an initial state and developing in a direction away from that state. The local motion may change frequently, as in figure 2.11, as long as a larger and prolonged continuity of motion is maintained. In contrast, *static processes* are those with no implied structural motion, and there are several reasons why a process may be perceived as such. Firstly, the level of activity in the output may be low, as is the case with a drone. Secondly, the activity may lack continuity, as with random number generators or other statistical distributions. Finally, it may be that the activity is strictly repetitious. Although static processes do not actually contain motion, per se, it is important to recognise their reciprocal relationship to motion, just as one recognises black and white when speaking about colours. Perceptually, static motion is of parallel importance and can have an equal influence on the definition of form.

A third, and somewhat special, type of structural motion is *cyclic*, which is discussed as a unique case because it can be either directional or static, depending on whether numerous cycles are presented. *Cyclic processes* develop in such a way that their evolution eventually leads to a return to the initial state; they revolve rather than evolve. Within a single cycle the motion might be considered directional if the development is coherent, although uniquely directional because the transformation moves from one coherent state, through a development phase and back to its original state. When several cycles are presented, however, the structural motion is repetitive, and thus static.

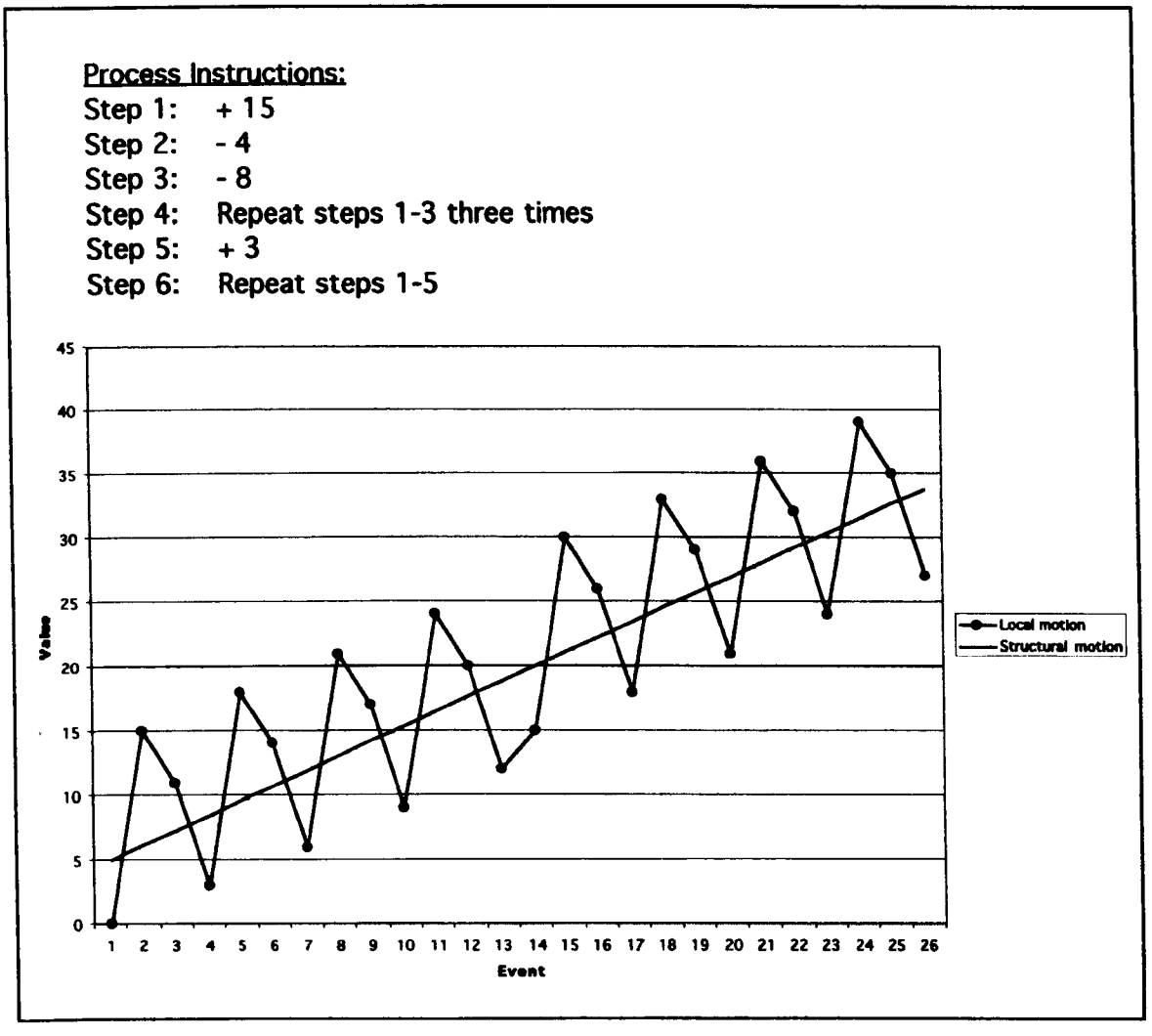


FIGURE 2.11 Local and structural motions of the generative process implemented in the A-identity of *Seven Sisters — Kelly*.

Processes Applied to Materials : Materials Applied to Processes

Examining processes in their abstract form is instructive, but it is only one of the factors contributing to the resultant musical structure. In practice, processes are applied to specific source material sets, the selection and construction of which have significant consequences for the result. Firstly, the source material provides the sonic dimensions that can be set into motion: if the material is tonal then the motion may be harmonic; a set consisting of elements of varying loudness suggests dynamic

motion; a process applied to the modulating frequency of an FM instrument suggests timbral motion. Secondly, a familiarity with the source material presents a framework in which expectations are generated, which can then serve as goals, or centres of gravity, for directional motion. Without such familiarity one must often rely on the clarity of the logic for the creation of expectation. Finally, and perhaps most importantly, the resultant structure of a process is not defined by the process alone, but rather by the relationship between the structure of the abstract process and the nature and initial state of the source material that it is applied to. The source material, in its initial state, has a structure of its own that can complement a process, accentuating its inherent structural character, or it can hide, diversify, or completely alter the structure of the output from that of the abstract process.

Jonathan Kramer, in his book *The Time of Music* (1988), introduces some terminology that is usefully adopted here to distinguish between different categories of directional motion, namely:

1. Directed
2. Goal-directed
3. Multiply-directed

Although these descriptions may also be relevant to abstract processes, they are more often associated with expectations that arise from the relationship between the process and the source material.

Directed processes are simply those that contain a continuity of motion in a single direction without suggesting a clear goal (Kramer, 1988).[8] Figure 2.12 illustrates a process where the source material is not in a familiar initial state, yet the output is directed because the local motion of the process generates a perceivable repetition of elements, providing a constant sense of location in the development. If the process is altered so that the repetition is less clear, as illustrated in figure 2.13, then the output loses its sense of direction all together. Rather than perceiving a

[8] Jonathan Kramer calls this form of motion non-directed. However, because it is a form of directional motion, as defined in this writing, the term non-directed seems misleading.

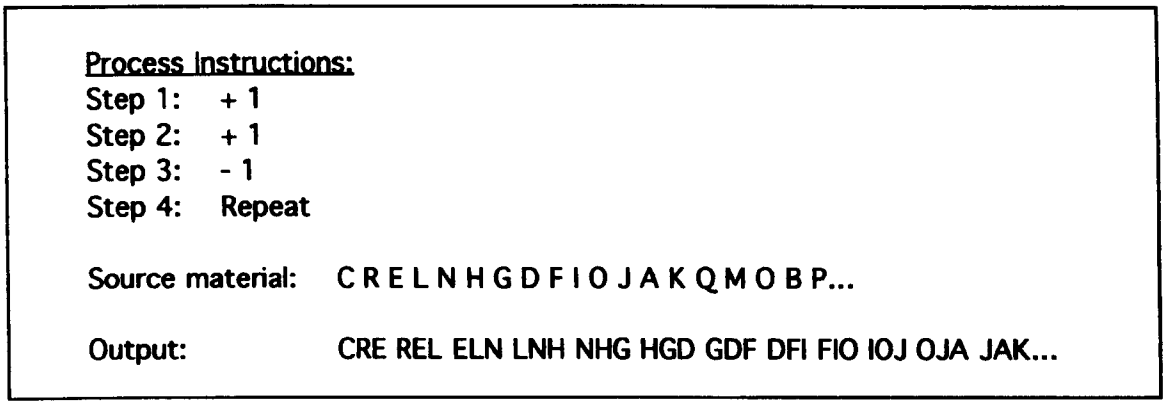


FIGURE 2.12 A simple directed process.

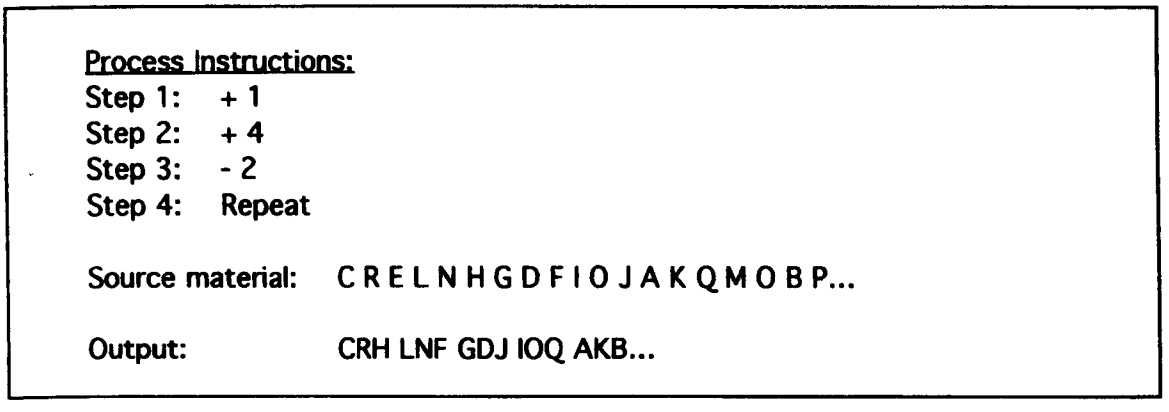


FIGURE 2.13 A directed process that is perceptually static.

progressive motion through the source material one senses a seemingly random sequence of elements. Through analysis we may consider the process to be directed, but perceptually it would appear to be static.

Goal-directed processes are characterised by a continuity of motion towards a clear goal (Kramer, 1988). It is not reaching the goal that makes the structure goal-directed, but rather the sense of motion towards a goal during the development, and accordingly, motion can be goal-directed even if it never reaches its expected target. Such processes imply the presence of expectation, which may arise from either a familiarity with the source materials, the recognition of a particularly meaningful ordering of those materials or from the perceived logic of the abstract process. In

figure 2.14 the same source material used in the previous examples has been rearranged into a familiar sequence, specifically, the ordered alphabet, and applied to the same process outlined in figure 2.12. A familiarity with the alphabet makes the output of the example goal-directed; there is a sense that the motion is moving towards the letter 'z'.

Process Instructions:
Step 1: + 1
Step 2: + 1
Step 3: - 1
Step 4: Repeat

Source material: A B C D E F G H I J K L M N O P Q R...

Output: ABC BCD CDE DEF EFG FGH GHI HIJ IJK JKL KLM...

FIGURE 2.14 A goal-directed process, developing toward the letter 'z'.

A third, and somewhat more complex form of motion is what Kramer (1988) describes as *multiply-directed.* It subsumes the forms of directional motion discussed above. However, it implies simultaneity of either developments or goals. Kramer outlines three forms of multiply-directed motion, as illustrated in figures 2.15a-2.15c. Figure 2.15a represents a number of directed or goal-directed developments that remain independent. Figure 2.15b represents a single directed development that implies a number of possible goals. Figure 2.15c represents a number of independent, directed developments that all imply the same goal. In addition to Kramer's forms of multiply-directed motion, one more is added to account for interleaved structures, as illustrated in figure 2.15d. Interleaved structures allow multiple components to be developed concurrently, although each is repeatedly suspended by the introduction of others. These structures are discussed in greater detail in the context of sectional forms in chapter four.

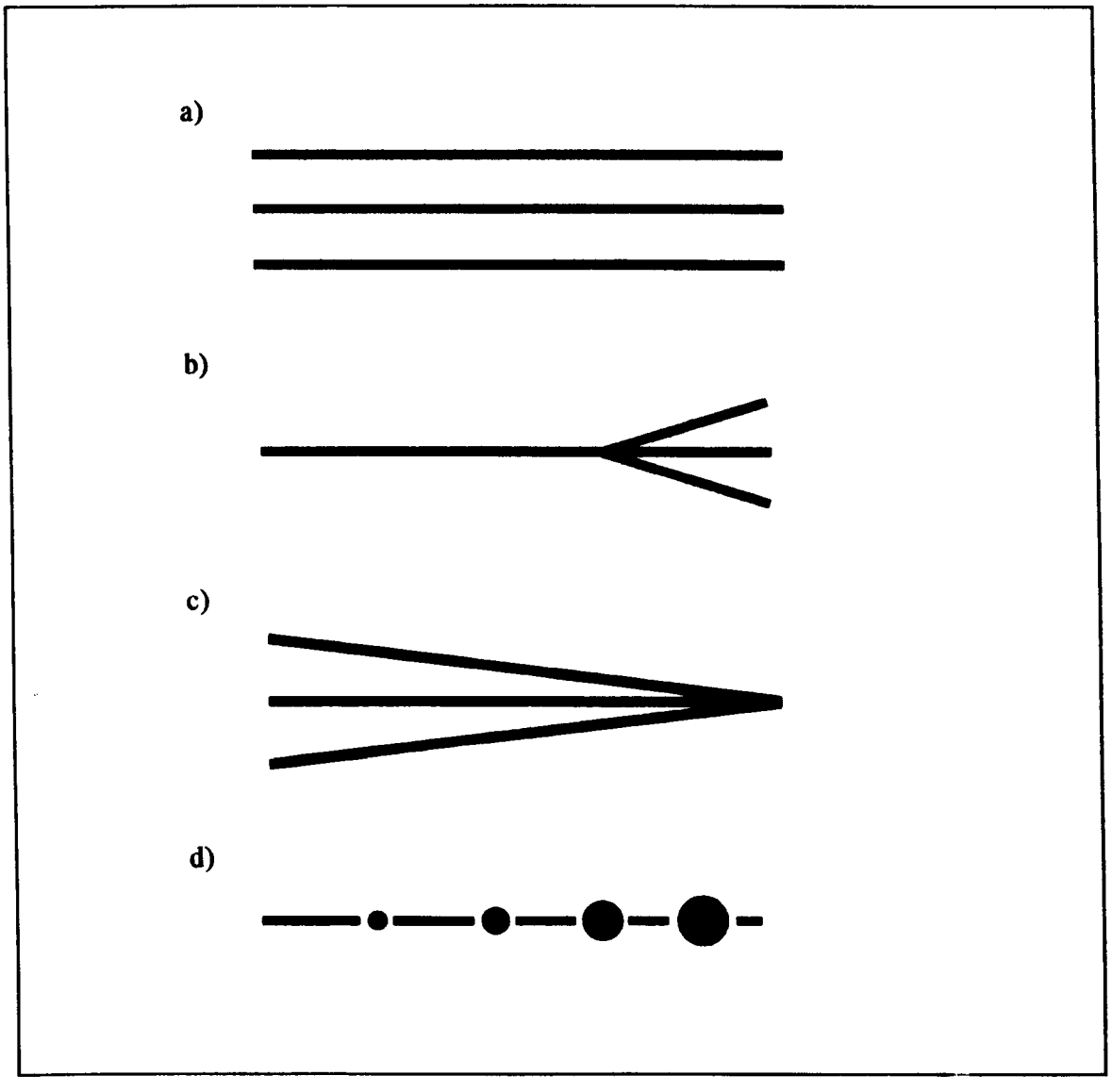


FIGURE 2.15 Various forms of multiply-directed motion: a) multiple independent developments, b) a single directed development implying multiple goals, c) multiple independent developments that all imply the same goal and d) multiple interleaved developments.

Sequential Processing

Sequential processing is a technique whereby a number of distinguishable processes are applied in ordered stages such that the output of one becomes the source material of another, and so on. The processes in the various stages might affect the same or different musical dimensions. In the case of the former, such re-processing obscures the structure of each individual stage, which may be desirable if the aim is to reduce predictability. When applied to different musical dimensions, the processes in each stage are much more independent and tend to retain their individual characteristics and structures, leading to multidimensional transformations. Figure 2.16 illustrates a simple hypothetical two-stage sequential process, where stage one reorders the source material and stage two inserts spaces in a way that creates gradually larger groupings. Importantly, sequential processes are generally not commutative; the order of the stages has an effect on the output. Assuming that spaces are treated as transformable elements, it is easy to see from this particular example that processing the source material in the opposite order, applying the second process first, would produce a different final result.

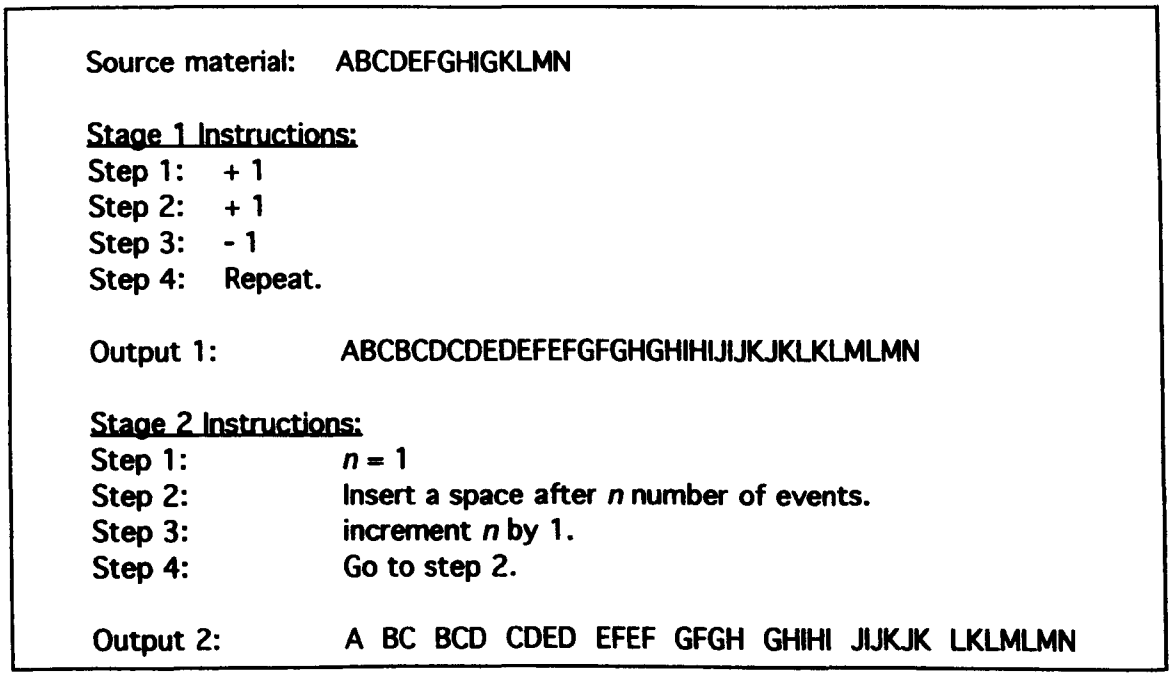


FIGURE 2.16 A hypothetical two-stage sequential process.

Sequential processing is abundant in the five pieces discussed in this writing, with *Seven Sisters – Kelly* providing one of the clearest examples. The guitar and cello parts in the A-identity are both derived from two-stage processes operating first on pitch, then on rhythm. The process that determines the pitch sequence was discussed earlier as an example of a generative process (p.30) and it is used in both parts, although each begins on a different pitch. Each part then takes the pitch sequence and applies a different process to the rhythm. In the guitar part, the rhythmic pattern is determined by a simple reordering process, whereby the crotchet event in each bar is shifted one event to the left upon each return of the A-identity. In the cello part, one additional note is added to every bar upon each return of the A-identity, effectively creating a terraced acceleration by systematically decreasing the note durations. Score excerpts from sections A1 and A2 are provided in figure 2.17, showing the first two iterations of the two-stage processes in both parts.

The C-identity in *Slinky* (score 2, 6, 10) is composed around a descending four-chord phrase and involves a number of different processes that complement each other structurally. The first acts to elongate each recurrence of the section by adding one more phrase (four more chords) to the end of the sequence. The second can be described as a motion from dissonance to consonance; each additional phrase consists of chords more consonant than those in the previous phrase. The remaining processes all affect intensity. The first acts to increase the starting intensity of each recurrent C-section, while the other two serve collectively to diminish intensity over the duration of each section, one by a reduction in activity and the other in dynamics. However, the reduction of intensity is not continuous; with the start of each four-chord phrase a degree of energy is re-introduced such that the chord phrases seem to come in waves. The combined effect of these processes is that the C-identity begins more forceful on each recurrence, but takes longer to come to rest, since each recurrence contains more phrases. Figure 2.18 illustrates the form of *Slinky*.

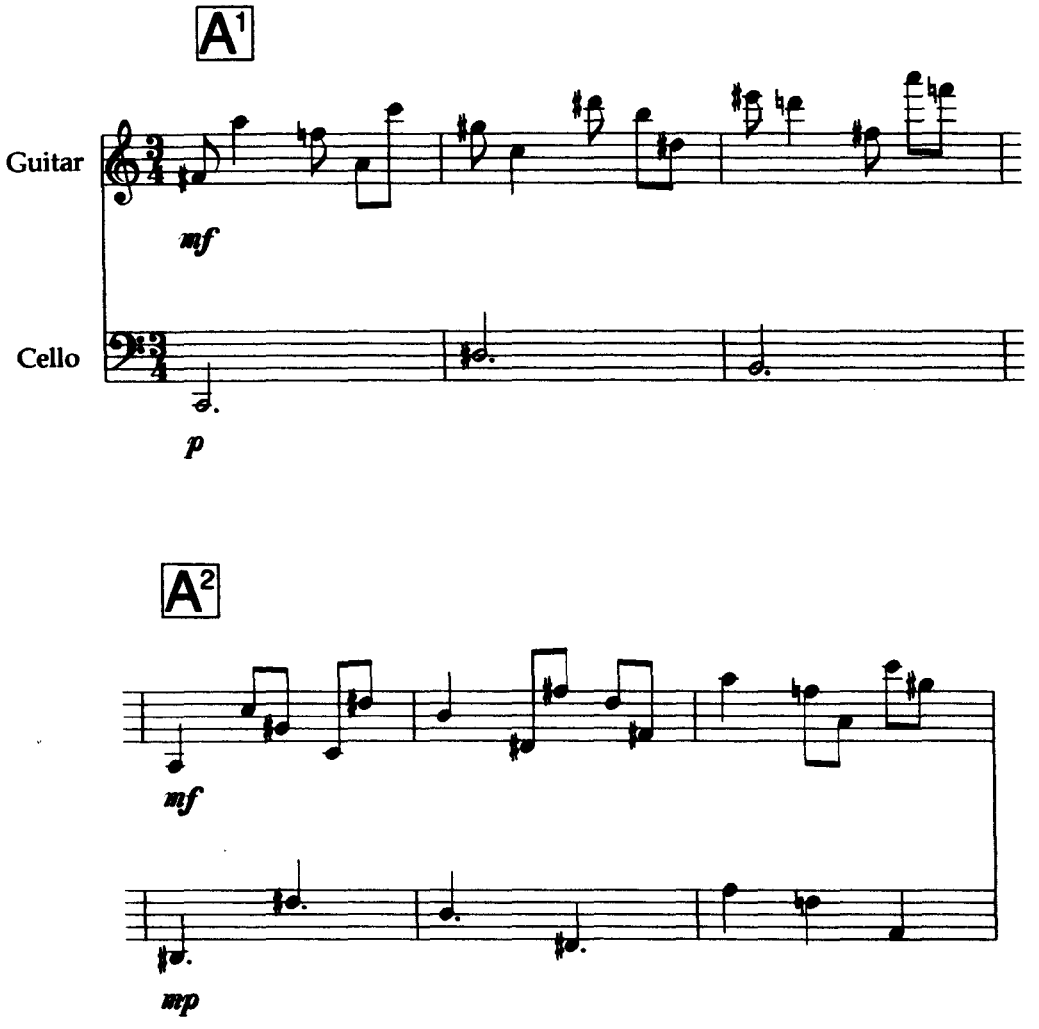


FIGURE 2.17 Score excerpts from *Seven Sisters – Kelly*, showing the first two iterations of sequential processes in both the guitar and cello parts.

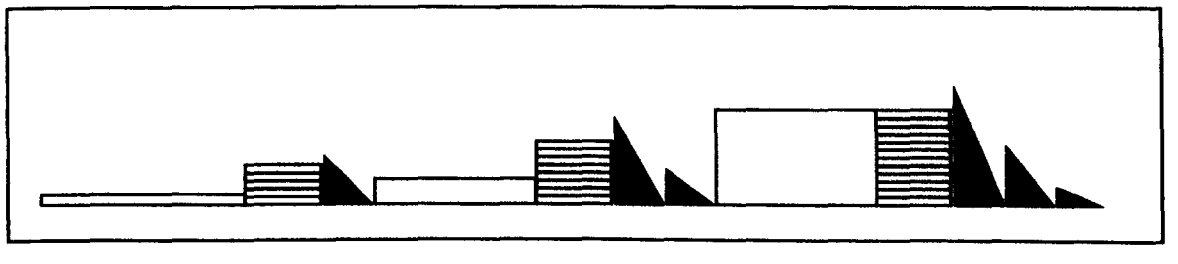


FIGURE 2.18 The form of *Slinky*.

Process Polyphony

In the case of sequential processing, several processes implemented in stages lead to a single output, which essentially functions as one component of the musical surface. In contrast, *process polyphony* is descriptive of a condition where different processes govern distinct components that are developed concurrently. There are two fundamental ways in which developments can progress concurrently, and these are distinguished by the temporal relationship between the components. The first is to present the processes simultaneously, with each placed in a separate voice or part. Simultaneous development suggests that the musical texture is polyphonic, and the components are likely to be highly independent if governed by unrelated processes. Alternatively, the processes can be interleaved such that each is segmented into relatively small time slices and alternated in quick succession. If interleaved processes are to be perceived as developing concurrently then the fragments must be relatively short. When the segments become so large that their presence is no longer sensed at the same time then the interleaved structure begins to exert influence over form. More will be said about the formal implications of interleaved structures in chapter four. Of compositional significance, through the use of interleaved processes, a number of concurrent developments can take place within a single voice. The following examples demonstrate simultaneous and interleaved process polyphony, respectively.

Simultaneous Development

The guitar and cello parts in *Seven Sisters — Sally* are guided by distinct processes, which are presented simultaneously. The guitar part contains a sequence of dyads selected from a finite set according to the two-stage process presented in figure 2.19a. Stage one is effectively a durational transformation; it modifies the number of dyads in each iteration by first including, and then later by removing, elements from the source set. Stage two identifies a single event in each iteration to

be repeated. Technically speaking, the process is cyclic. However, only one cycle is completed, so the return to the initial state is more likely to serve as the goal for an arch-shaped development if the motion is perceived. Figure 2.19b shows the source material for the process and figure 2.19c illustrates the entire structure of the guitar part, assigning numbers to represent each element in the source set and displaying each iteration on a separate line for clarity. Several bars from the beginning of the piece are provided in figure 2.19d.

Stage 1 Instructions:
Step 1: Start with item 1 from the set.
Step 2: Add the next item in the set to the end of the sequence. If all elements have been added, then remove the last used element in the set from the sequence.
Step 3: Repeat

Stage 2 Instructions:
Step 1: Repeat the n element in the sequence, where $n = n+1$.

FIGURE 2.19a The two-stage process used in the guitar part of *Seven Sisters – Sally*.

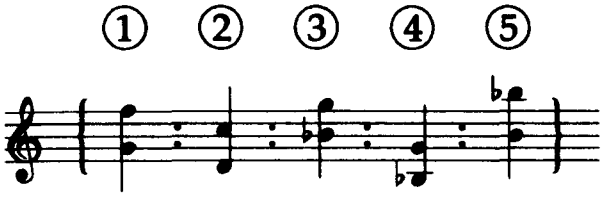


FIGURE 2.19b The source material used in the guitar part of *Seven Sisters – Sally*.

```
1
1  2
1  1  2
1  2  2  3
1  2  3  3  4
1  2  3  4  4  5
1  2  3  3  4
1  2  2  3
1  1  2
1  2
1
```

FIGURE 2.19c The complete sequence structure of the guitar part in *Seven Sisters — Sally*, illustrating the output of the two-stage process.

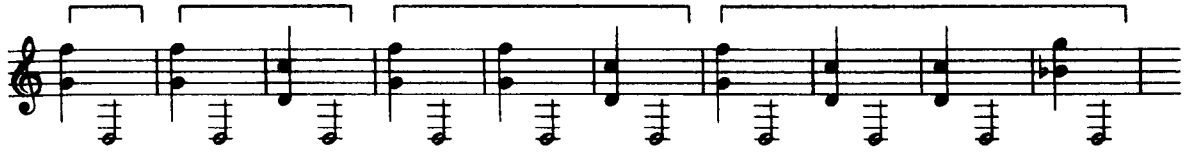


FIGURE 2.19d Excerpt from the guitar part of *Seven Sisters — Sally*, illustrating the first four iterations of the process.

The cello part in *Sally* is derived from a reordering process that is logically independent from those that govern the guitar. It consists of a repeated eight-bar phrase containing six elements. With each iteration, the second element is moved to the last position in the sequence, and this then becomes the source for the next iteration. The initial sequence is provided in figure 2.20a, with numbers assigned to the individual elements in the set. Figure 2.20b numerically illustrates the sequences for the four iterations that appear in the piece. Figure 2.20c shows the first two iterations of the cello part, pointing out the reordering action for that particular instance. The cello process serves to provide variation in the sequence, yet the logic is obscured by the fact that it is the second element that is moved. Coherence is

retained because the changes in each iteration are few and all variations consist of the same limited set of sounds. The compositional aim of *Sally* is largely to explore the emergence of unintended relationships, and in both parts processes are used to maximise the number of different vertical relationships that arise between the cello and guitar.

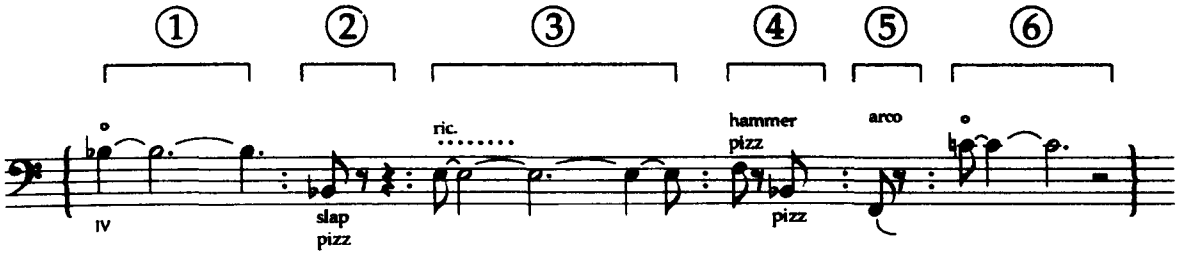


FIGURE 2.20a The source material used in the cello part of *Seven Sisters – Sally.*

1	2	3	4	5	6
1	3	4	5	6	2
1	4	5	6	2	3
1	5	6	2	3	4

FIGURE 2.20b The complete sequence structure of the cello part in *Seven Sisters – Sally,* illustrating the output of the process.

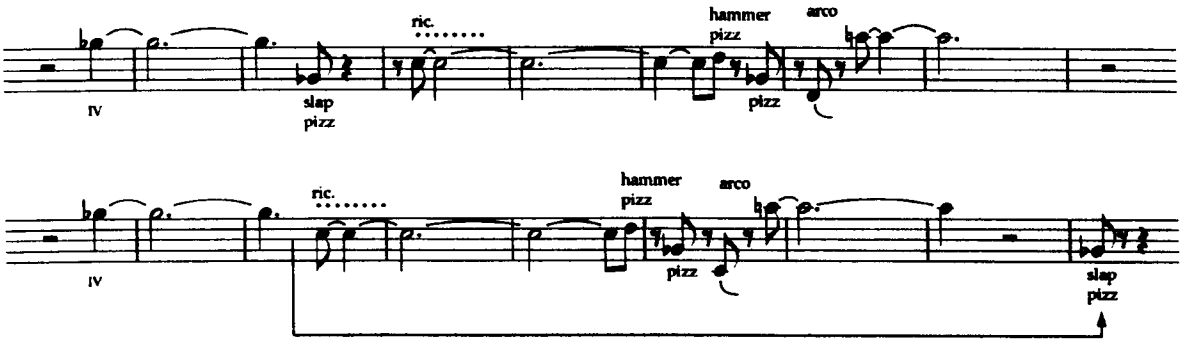


FIGURE 2.20c The first two iterations of the cello process in *Seven Sisters – Sally.*

Interleaved Development

The C-identity in *Flap Jackson* (score 7, 15, 20) comprises three interleaved processes. The first is recognised as a triplet phrase of rising and descending tritones, which occurs at the start of each interleaf cycle and is distributed across all three instruments. With each instance the phrase grows in duration, initially by adding notes, then by separating the parts temporally. The second process is characterised by short, staccato gestures, again dispersed amongst all instruments. The gestures are initially sparse, but gradually increase in density over the course of the piece. Each gestural instance has roughly the same quantity of events, so as the activity increases the duration of each instance naturally diminishes. The material in the third process is a whistle-tone played by a single flute, which serves to interrupt the activity of the other components. With each instance it decreases in duration, until the end of the piece when it disappears altogether. In section C1 there is little sense of concurrent development amongst these components because each is maintained for a considerable amount of time. However, as the whistle tone and gestural components get shorter, the structural pace accelerates and the C-identity is transformed from a quasi-sectional structure, containing time-distinct entities of its

own, to an interleaved structure with three seemingly concurrent developments. The individual structures of the three C-sections are illustrated in figure 2.21.

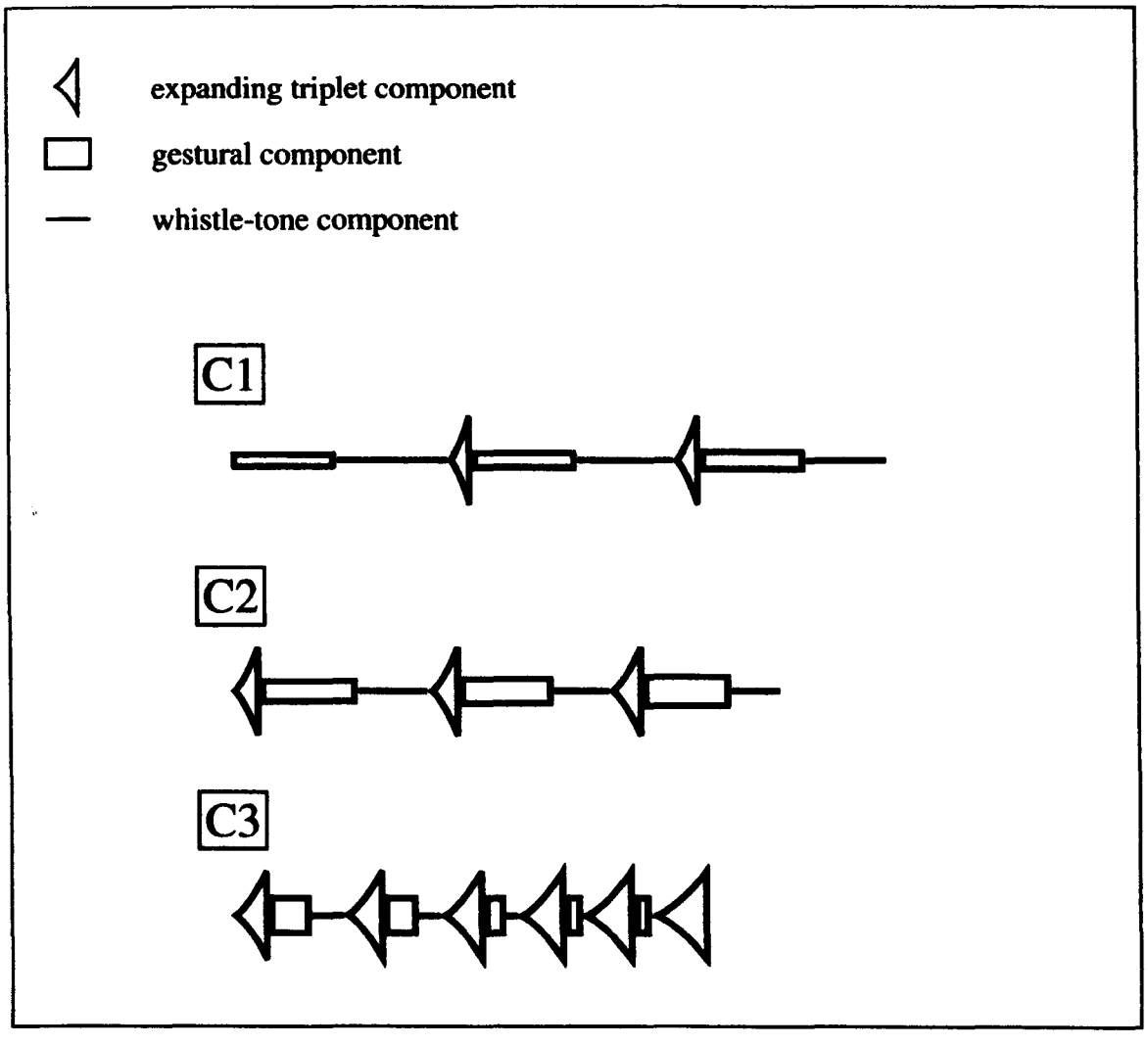


FIGURE 2.21 The structures of each C-section in *Flap Jackson,* illustrating a three-process interleaved structure.

Convergence (Divergence)

Convergence describes an intersection of independent components. More specifically, it refers to a condition where an element belonging to one component is momentarily united with an element from a separate and independent component, creating a unified gestalt, or *converged object.* The elements that converge may be single events, gestures or even extended phrases, and they possess a dual functionality in that they simultaneously belong to both their native components and to the converged object.

A great deal of polyphonic music consists of individual parts that are both vertically and horizontally coherent. However, the separate parts are typically unified vertically with such frequency that they are better described as interdependent than independent. By contrast, convergence implies that the different components are highly independent before they converge, and that the co-existence of individual developments is more important than the relationships between them. As a result, an elevated perceptual significance is placed on events when they do converge. Such moments can be important with respect to musical structure, functioning as memorable landmarks or as goals for concurrent developments.

Two important, yet somewhat unrelated distinctions are made regarding convergence. The first recognises a difference between local and structural convergence and the second between vertical and horizontal convergence.

Local Convergence

Local convergence describes a condition where specific elements from independent components aggregate to form a unified object. The qualifying attribute of local convergence is that the converged object does not play an integral role in the structural motion of either of the contributing components. Instead, such

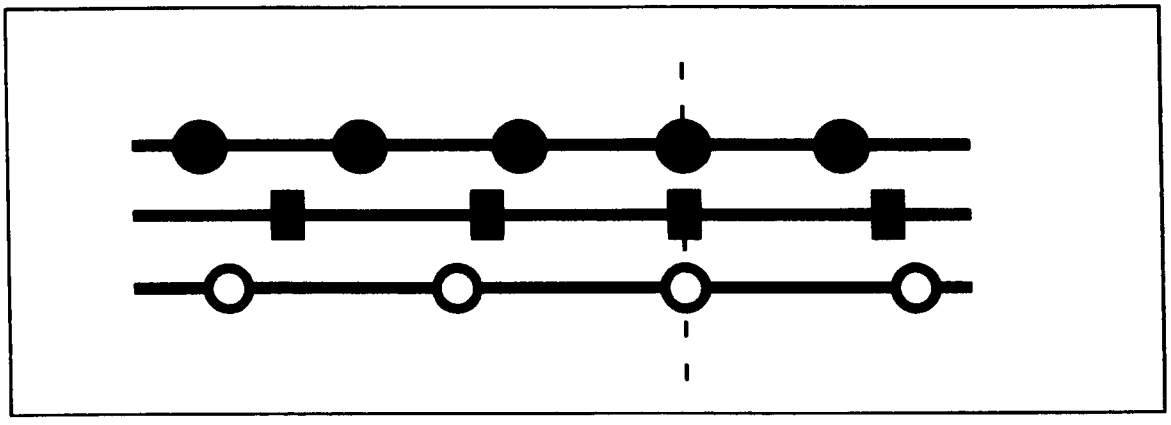


FIGURE 2.22 Local convergence.

convergence is likely to arise unexpectedly and seemingly by coincidence.[9] Accordingly, the different components retain their individuality throughout, as illustrated in figure 2.22.

Local convergence can occur surprisingly often by coincidence, as Merce Cunningham and John Cage revealed with respect to music and dance. A typical Cunningham/Cage performance involves music that has been composed without knowledge of the dance steps that it will accompany. Likewise, the dance steps are composed without knowledge of the music that they will be set to. When experiencing one of these dance events it is remarkable how frequently the visual motions appears to fit with the music. A dancer might move an arm and a sound is heard at what seems to be the precise time, duration and dynamic corresponding to the dancers motion.[10] That convergence arises by coincidence is significant because it provides evidence that, at least in the context of music and dance, the mind naturally searches for it. It is reasonable to assume, then, that convergence can be easily perceived and comprehended when used intentionally.

[9] The build up of long-term expectations would tend to suggest the presence of a significant structural motion.

[10] It is worth noting that this sort of convergence often arises from two fixed sequences, and thus could be predicted. It is only by the fact that it was not calculated or intended that it can be described as arising by coincidence.

If moments of convergence are to be preconceived then the composer must be able to predict and design when they will occur. It is not impossible to create convergence through perceptually intuitive composition. However, the risk is that the components may deviate from their natural course of development and gravitate towards the converged object, thereby sacrificing the integrity of the individual components. In this respect deterministic processes are particularly useful for creating convergence because they act as a regulatory force over development, allowing one both to predict and design moments of convergence while retaining individual trajectories, and thus independence.

Seven Sisters – Tina provides a clear example of a local convergence of events. The guitar and cello parts are governed by logically unrelated processes, each acting to transform individual events in various ways. The guitar material contains three types of events that are distributed over a four bar phrase, referred to as scratch, harmonic tone and percussion, and it develops in such a way that the scratch decreases while the harmonic tone increases in duration. The percussion event does not change, but rather serves as a structural indicator in the development, marking the end of each iteration. The cello material consists of a harmonic tone and a decaying ricochet bowing gesture, and it develops in such a way that the tone increases while the ricochet bowing gesture decreases in duration. The two parts maintain a high degree of independence due to the combination of processes and the juxtaposition in phrase lengths of three against four bars. In the midst of such independence, however, there is a clear convergence at the end of the piece, where similar events in both parts are vertically aligned. The last four bars of *Seven Sisters – Tina* are illustrated in figure 2.23, showing the converged phrase.

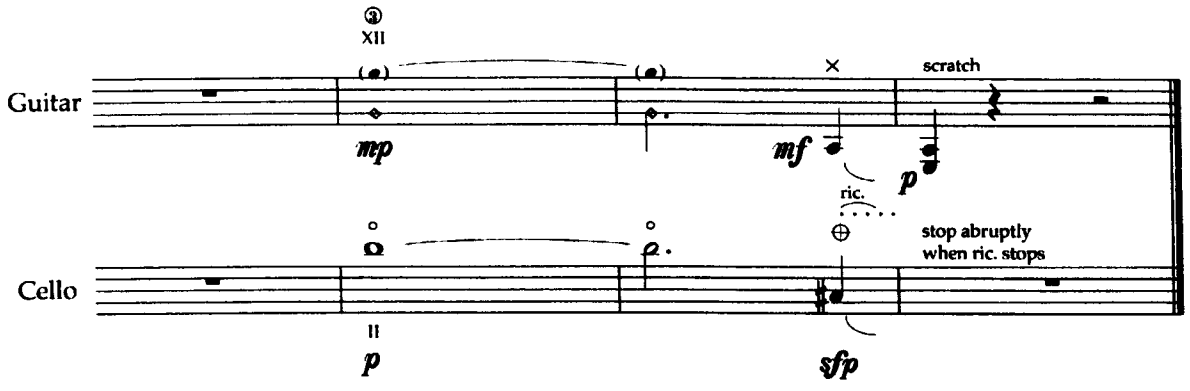


FIGURE 2.23 The last four bars of *Seven Sisters — Tina*, illustrating local convergence.

Structural Convergence

Structural convergence refers to the manifestation of a coherent or otherwise meaningful relationship between the structural motions of independent components. If those motions are perceptually prevalent then the convergence will likely be anticipated; it becomes a goal. Unlike local convergence, structural convergence does not create an 'object' per se, and in this sense is less concrete. Indeed, time is often required for motions to be perceived and expectations to form, and so moments of structural convergence may be impossible to isolate. Structural convergence relates to the form of multiply-directed motion that is concerned with creating unity out of multiple independent components, as illustrated in figure 2.24. It can provide a goal for concurrent development, and when the components develop over an entire piece, a goal for the formal development of a piece.

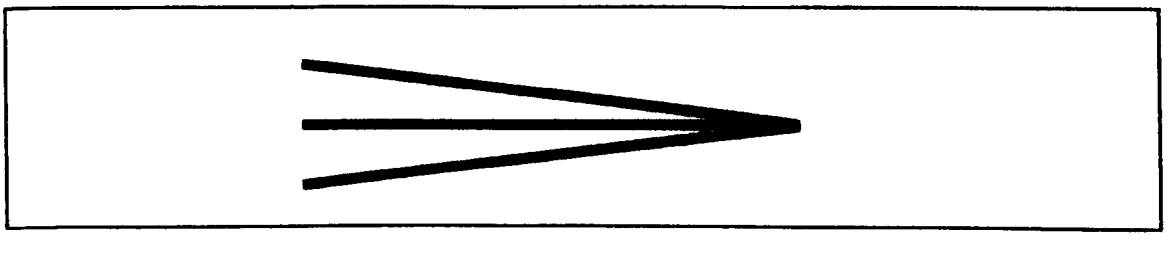


FIGURE 2.24 Structural convergence.

Polyrhythmic Modulation Studies (Frengel, 1999) is a series of process driven pieces that explore the possibilities of accelerating and decelerating voices, often simultaneously.[11] In effect, the voices modulate between different polyrhythmic relationships. A single convergence of structural motions constitutes the main idea of *Polyrhythmic Modulation Study No. 6 – Spectral Canon,* for computer-generated sound (sound example 1). The piece consists of eleven voices that are tuned to the harmonic series built on 100Hz, roughly a G. The voices all enter successively from low to high and always at a tempo of 25 bpm. As the piece progresses each voice accelerates independently until they all simultaneously fall into temporal relationships reflecting their harmonic number. For example, voice 2 represents the 3rd harmonic of the series and ends up at a tempo that relates to voice 1 as 3:2. Likewise, voice 3 represents the 4th harmonic in the series and ends up at a tempo that is a 4:3 relationship with voice 2 and 4:2 with voice 1. The result is a convergence of harmony, rhythm and timbre out of seemingly unrelated tempi. The score for *Spectral Canon* is provided in Appendix II.

Vertical and Horizontal Convergence

Up to this point, the discussion of convergence has involved components that are sounded at once. Alternatively, it may be that adjacent, time-distinct elements are momentarily grouped into a unified gestalt. This leads to a distinction between vertical and horizontal convergence, which refers specifically to the fundamental temporal relationship between the two components before they converge. Like its vertical counterpart, elements that converge horizontally will at once belong to the individual components as well as to the converged object.

Horizontal convergence can occur locally, within musical sections, and even within a single process, as demonstrated by way of a hypothetical example. In figure 2.25 the elements that converge belong simultaneously to their position in the

[11] The *Polyrhythmic Modulation Studies* are not part of this dissertation submission, but are included in this discussion because of their relevance.

generative process and to the grouped gestalt (IIII) as a perceived entity in itself. Convergence of this sort imposes structure onto the output that is only apparent in the combination of process and source material, and therefore often arises unexpectedly.

Horizontal convergence can also occur at larger structural levels, such as the point at which two adjacent sections meet. In local situations the elements that converge are typically located at or near the start and end of the two sections, respectively, and there is a sense that, at least momentarily, the two sections share the same material. This may potentially provide the necessary conditions for a transition, making it possible to smoothly connect two contrasting sections without discontinuity. A simple hypothetical example of local horizontal convergence is illustrated in figure 2.26, where the last element of one process is also the first element in the subsequent process.

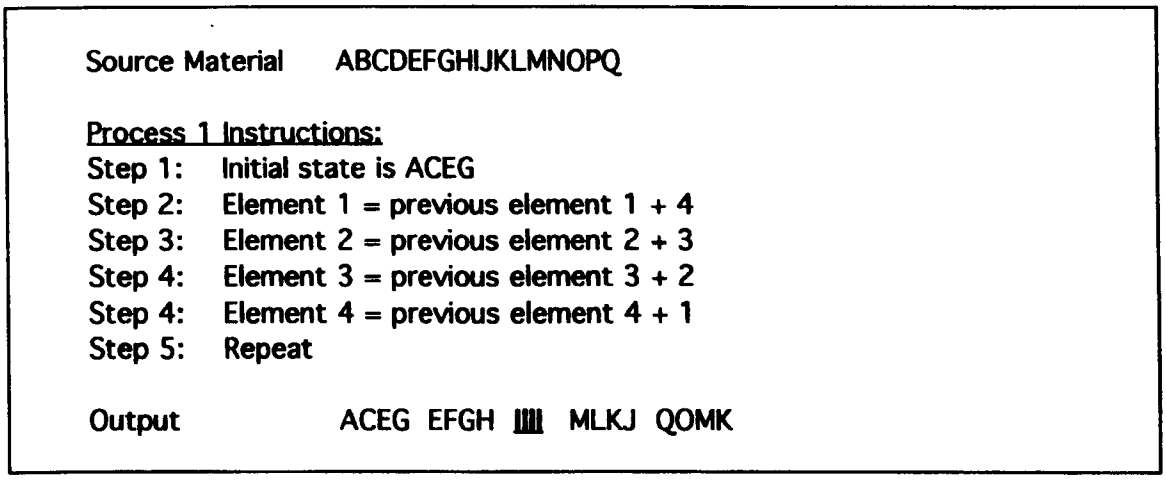


FIGURE 2.25 A hypothetical example of horizontal convergence within a generative process.

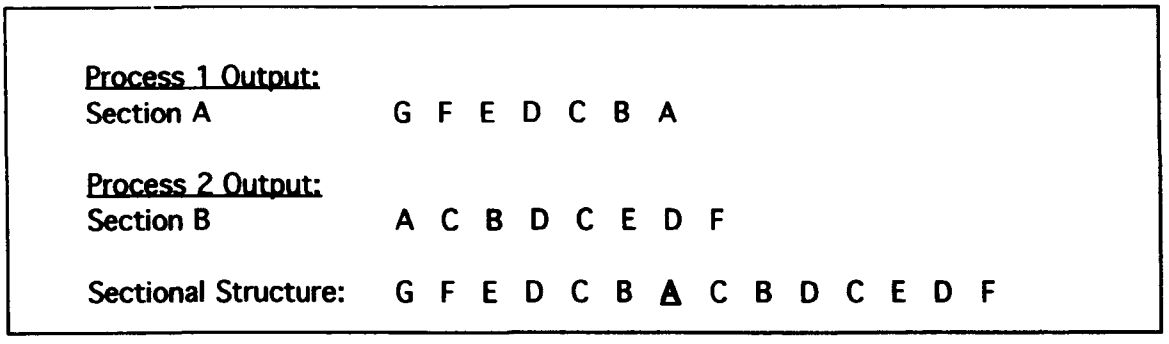


FIGURE 2.26 A hypothetical example of horizontal event convergence at the point where two processes meet.

Horizontal convergence of structural motion is common in music, with a typical tension and release formula providing one example. The transitions between the B- and C-identities in *Slinky* (score: 2, 6, 9) provide instances of such a convergence of individual structural motions. The B-identity consists of glissandi gestures, and although the activity tends to fluctuate, the structural motion increases in intensity over the course of each section. In contrast, the subsequent C-identity is characterised by a series of chords that always begin loud and decline in intensity over the course of each section. At the juncture of each B- and C-section, a familiar tension and release formula is felt, as if the energy created by the glissandi gestures is relieved in the subsequent section.

A similar example of a tension and release formula is found between sections D2 and B6 in *3FKB+* (score 9: sound example 2). In this case, a section characterised by a series of polyrhythmic modulations makes a transition into an arhythmic, textural section comprising air timbres. The polyrhythmic modulation accelerates, creating a growth in tension. On the contrary, the arhythmic textural section that follows starts dense and becomes thinner. Where these two sections come together, it is as if the tension created by the accelerating rhythms is relieved in the subsequent section. The use of air sounds, perhaps expressing a release of energy, reinforces this interpretation.

Divergence

When speaking about convergence it is equally important to recognise the reciprocal form, divergence. Where convergence is concerned with constructing coherence between elements of independent components, divergence is concerned with disassembling coherence into independent streams. It can be thought of as a transition from a singular motion into a multiply-directed situation where individual motions are present simultaneously. Although divergence and convergence are not co-dependant, they are often found together, as in a transition from one coherent state to another. This is precisely the conceptual intention of many of the *Polyrhythmic Modulation Studies,* with *Study No. 3 – FMe,* for four-part computer generated sound providing one example (sound example 3).[12] In this piece, voices 1 to 3 simultaneously undergo a series of independent temporal modulations, diverging from specific polyrhythmic ratios to converge on new ratios. The carrier:modulator ratios for each of the three voices vary dynamically, with the modulating frequency changing in direct relation to the tempo.[13] This results in complex inharmonic spectra during transitions and simple harmonic spectra that reflect the temporal relationships during stable sections. In *FMe,* rhythm and timbre are derived from the same process, which manages to have a similar and simultaneous consonant-dissonant transforming effect on each dimension. Figure 2.27 illustrates the temporal structure of *Study No.3 — FMe.* The complete score is included in Appendix II.

voice 1:	1	2	3	4	6
voice 2:	6	4	3	2	1
voice 3:	3	3	2	3	3

FIGURE 2.27 Ratios of tempi in of *Polyrhythmic Modulation Study No. 3 – FMe.*

[12] The *Polyrhythmic Modulation Studies* are not part of this dissertation submission, but are included in this discussion because of their relevance.
[13] Modulation frequency = tempo (ms) / 100.

Chapter Conclusion

Processes are often associated with an interest in logic, yet they offer a great deal more than logic for logic's sake. Firstly, they contribute to the coherence of a musical surface by regulating the behaviour of components, thereby giving the music a particular character. Secondly, processes can guide the music into areas that are beyond the composer's own perceptual intuition, and they manage to do this on both local and structural levels. They not only influence events at the musical surface, but they also have a significant impact on the way one thinks about large-scale formal issues. In my own music, an interest in processes has led to a heightened concern for gradual development, and more specifically, a concern for the transformation taken by musical ideas, that is, how their character changes over time. Furthermore, processes lead to developments with clearly defined structures that can play an important role in defining the form of a piece. The clarity of such developments comes from the fact that the transformation is gradual and systematic. When processes are completely deterministic then one is able to plan for their future state at a given point in time, leading to interesting possibilities for goal-directed developments and convergence. Lastly, processes lead to music with an emphasis on clarity and objectivity because compositional intentions are often more tangible; they are more likely to be explicit in the music, there to be analysed and evaluated as and integral part of the musical experience.

A compositional difficulty with processes is that they ca n be overly systematic, making the music too predictable. The allowances made for perceptually intuitive decision-making in developmental processes are often enough to break the rigidity of the logic and introduce unexpected changes. In the context of deterministic processes, predictability may be overcome by applying multiple processes sequentially. Sequential processing also provides interesting possibilities for multidimensional development when the processes in each stage are applied to different musical dimensions.

When writing about processes there is a risk of misrepresenting the way that they are actually considered during composition. This discrepancy stems from a

desire to describe accurately the process in the clearest possible terms, and in this writing an approach has been taken where instructions are stated in numbered steps. While composing, however, processes are not always conceived in such numerical terms, nor are they necessarily laid out on paper in advance. These points are particularly true where developmental processes are concerned. To take just one example, the process governing the guitar part in *Seven Sisters – Karen* was conceived essentially as a fingering pattern that alternates positions and strings in a particular way. It is only when it comes to describing the process accurately and in writing that it is thought of as the series of steps presented in figure 2.8a (pg 38), that is, as a movement by a semitone, plus or minus two octaves, and so on. As a result, processes often appear more complex on paper than they are when grasped mentally during composition.

Chapter Three – Musical Identities

Compositions are constructed from musical ideas, which consist of a selection of sound material and a specific approach to the organisation of that material. The nature of musical ideas is complex, and a proper discussion of the subject would need to account for differences between those that are germinal, primary, supporting, referential, conceptual and so on. For the purposes of this discussion it is sufficient to consider musical ideas as subsuming all of these distinctions, so for instance, a melody along with its supporting harmony and any other subordinate components and extra-musical references is one example of such an idea. Musical ideas exist along sonic dimensions that provide the materials to be organised, and importantly, they generally involve multiple dimensions—a melody, for instance, involves at least pitch and rhythm dimensions.

Another distinction can be made between attributes of an idea that are *procedural* and those that are *perceptual.* The former refers to the underlying organisational principles of a musical surface, whereas the latter refers to the perceived characteristics of that surface. For example, from a procedural perspective, the melody in the A-identity of *3FKB+* is the result of a generative process that gradually reverses the pitch sequence in a systematic way. Perceptually, however, it might be described as a tonal melody comprised of large intervallic leaps, and possibly one may take notice of the contour. Since it is inevitably the organising principles that govern the events perceived, this distinction is merely one of perspective, that is, whether the idea is considered from the point of view of the composer or the listener. Procedural attributes are more likely to be revealed through analysis, while perceptual attributes are transmitted through the experience of listening to music. That said, as an increased compositional emphasis is placed on predetermined systems the procedural attributes can play such a heightened role in the ideas that they themselves may enter into immediate perception.

Every musical idea contains an *identity* comprising all aspects that contribute to its recognisability. While identities are closely correlated with the perceptual attributes of musical ideas, it would be inaccurate simply to define them as such.

Musical surfaces can involve sounds at various levels from background to foreground, and although they all might be perceivable, the contribution that they make to the recognisability of the idea may vary, with some not contributing at all. Reverberation provides an obvious example of sound that makes no meaningful contribution to the recognisability of a musical surface, unless a particular ambient setting is only associated with that surface. Moreover, some actual parts may make little contribution to the identity of an idea, such as, for example, one that doubles another voice. The perceptually predominant attributes of a musical surface can be described as *surface qualities*, and they play a central role in the definition of identities because of their contribution to making it recognisable. The concept of surface qualities is a vague one, as it is difficult to define precise criteria by which one determines whether an attribute is sufficiently predominant. To some extent, it is a matter of where the listener chooses to direct attention. There are, however, usually salient characteristics of an identity that will be reliably recognised by listeners and the term surface quality is used in this spirit.

Musical form, particularly when it is sectional, is built upon the arrangement of and relationships between identities. The ability to interpret form as sectional at all, that is, to segment the continuous musical surface into discrete extended units, is fundamentally dependent on the ability to distinguish a change in identity. The comprehension of sectional forms is, however, more complex than a mere interpretation of the segmented structure. It is common in music for the same idea to appear in more than one position in a piece, and the ability of a listener to recognise the return of an idea through its identity, and associate it with previous instances in the piece is equally critical. This chapter will examine musical identities with a specific concern for the role that they play in defining musical form.

Criteria for a Form-bearing Dimension

If the interpretation of musical form relies on the ability to detect a change of identity at the musical surface, then to a large extent it is dependent on the ability to discriminate changes in the musical dimensions that identities engage. Stephen McAdams (1989) has investigated some of the dimensions commonly found in music to evaluate their 'form-bearing capacity.' A dimension has form-bearing capacity if transformations along it can induce an interpretation of identity change, and consequently, sectional change. For example, pitch has a high degree of form-bearing capacity, as demonstrated by the fact that various sections can be easily distinguished by different melodies. Critically, McAdams' investigation is concerned with factors affecting the ability of a single given dimension to contribute to form on its own. Implicit is the assumption that the identities in the various sections of a piece will be defined principally by activity along the same musical dimension, and consequently, form must be derived from changes along that single dimension throughout the piece. It does not take into account circumstances where different identities consist of ideas that are organised along different dimensions, a condition that will be discussed shortly. Nonetheless, the criteria that McAdams presents seem to be accurate within the scope that they were intended, and are still relevant to sectional forms that are organised around a plurality of different dimensions.

McAdams (1989: p.12) concludes that there are three constraints for an effective form-bearing dimension:

1. A potential form-bearing dimension should be closely correlated with the sensory dimensions that effect perceptual grouping.
2. A potential form-bearing dimension should be susceptible to being organised into perceptual categories.
3. Relations along the dimension should be susceptible to being acquired as abstract knowledge.

Perceptual Grouping

Perceptual grouping refers to the ability of a listener to combine events at the musical surface into meaningful units and it occurs at various levels, including individual events, gestures and phrases and larger segments of the holistic form. The latter, referred to as segmentational grouping, is a necessary step towards the interpretation of form because it will ultimately be extended segments that are recognised as sections of the larger structure. While discussing grouping in greater depth McAdams states the requirement more simply, and precisely, as follows:

> ...an important criterion for a form-bearing dimension is that changes along it should be able to induce distinctive transitions or contrasts at the musical surface (p.2).

Criterion one, then, simply states that changes in a dimension must be perceivable if that dimension is to make a significant contribution to form. If the listener can perceive change at the musical surface then the conditions are right for the various levels of grouping to occur. McAdams suggests that listeners can discriminate changes in timbral brightness, pitch, duration, dynamics and spatial location, and therefore, these dimensions have strong form-bearing potential.

Dimension Categorisation

Many of the dimensions commonly used in music are continua in physical nature, yet in practice they are approached discretely: frequency is divided into pitch classes, rhythm into quantised durations, dynamics, at least with respect to notation, into a small handful of indications, and so on. Categorisation is perceptually beneficial because listeners can remember discrete entities more easily than those that are not clearly demarcated, thereby serving to maximum information with the least cognitive effort (Rosch, 1978). On categorisation, McAdams states:

> A dimension can bear form if configurations of values along it can be encoded, organised, recognised and compared with other such configurations (p.1).

In accordance with criterion one, it is necessary that the categories themselves can be easily distinguishable, otherwise the use of one rather than another cannot create a perceivable difference in structure. It is also important that there be a relatively small number of categories, which is reasonable if the cognitive aim is to facilitate category recognition. Miller (1956) estimated that immediate memory is limited to 7 ± 2 items, a theory known as Miller's Magic 7. It is fair to suspect that beyond this number the ability of listeners to discriminate between different categories is likely to diminish. In fact, a brief look at the dimensions of pitch, rhythm and dynamics in terms of common Western practice does reveal restrictive tendencies that correlate closely with Miller's theory. In tonal music the pitch dimension is divided into twelve classes, only seven of which are used in a given diatonic tonality. There are seven rhythmic categories ranging from a sixty-fourth note to a whole note, not including dotted values. The number of dynamic indications between ppp and fff is eight.[14] It is not that these dimensions are strictly limited to seven or eight values in actual performance, but rather that the categories act as nodes of reference to which non-conforming events are related (Wishart, 1996). In other words, the significance of an accidental is not so much the tone that it creates, but rather the node that it implies. Equally, a dotted rhythmic value may not be a rhythmic category of its own, but instead the joining of two adjacent durational categories, or the extension of one by the other. The use of a small number of categories is also not a reflection of the perceptual limitations of humans, as numerous studies have shown that the ear can discriminate very small changes in frequency, duration and amplitude (Dowling & Harwood, 1986). Actual musical practice, however, does suggest that a relatively small number of categories acting as nodes of reference is beneficial to the perception of organisational principles.

[14] Dynamics differ from pitch and rhythm in that gradations are relative rather than absolute. Nonetheless, the fact that there are only eight dynamic markings from ppp to fff would seem to be indicative of the ability to discriminate categories of loudness.

Schema Susceptibility

McAdams argues that the perceived qualities of musical events are anchored to learned schema-based systems of relations, which he refers to as:

> ...abstract knowledge about the structure of the music of a given culture that one has acquired through extensive experience (p.2).

After offering scale, metre and harmonic field as examples, he goes on to state that:

> [A schema-based system of relations] is perhaps the most important for the consideration of form-bearing capacity because it is clear that if a system of habitual relations among values along a dimension cannot be learned, the power of that dimension as a structuring force would be severely compromised (p.2).

Undoubtedly, many of the dimensions found in music, such as pitch and rhythm, are highly schematised in the minds of listeners. Such acculturation adds to the form-bearing capacity of a dimension because it can alter the function that a listener assigns to events, thereby affecting the interpretation of grouping structure. However, the importance that McAdams places on schematisation seems to be overstated. Much simpler distinctions can be made along dimensions that are surely not dependent on learned abstract knowledge, at least not at the high level of acculturation that McAdams is referring to in the examples that he gives. For instance, along the frequency dimension, differences between low tones and high tones can easily be discriminated, regardless of whether the tones are fixed at any known pitch relationships. In the domain of rhythm, one can easily distinguish between long events and short events, or textures of varying density, regardless of whether the durations or rhythms match any known structure, metrical or otherwise. In contemporary music, where the aim is often to avoid common musical languages, composers may be more likely to rely on such fundamental distinctions along dimensions. The importance of schematisation should not be underestimated, as it not only affects grouping and structural interpretation, but also significantly

influences listener preferences, as was discussed in chapter one. The point made here is simply that musical ideas can engage dimensions in a manner that is not particularly susceptible to schematisation, or for the sake of the current argument, in a manner that has not already been learned, and form can be interpreted in those pieces. Schema susceptibility, then, need not be a critical criterion for a dimension if it is to bear form.

Dimension Plurality

In his investigation, McAdams is concerned with the ability of single given dimensions to bear form and so he makes a critical assumption that throughout a piece different identities will be defined by different configurations along the same dimension. For instance, if a given section A is identified mainly by a melody then it is assumed that a subsequent section B will also be identified by a melody, although distinctly different. While such an assumption is valuable to the examination of the form-bearing capacity of individual dimensions, it is only reflective of how form is interpreted in pieces that actually remain focused on the same dimension throughout. In practice, it is often the case that identities are associated with a switch in the set of dimensions that carry the musical idea rather than by transformations along a consistent set of dimensions. To use *3FKB+* as just one example, the A-identity is characterised primarily by melody, the B-identity by texture, the multiphonic C-identity by timbre and harmony, and the D-identity by highly coordinated polyrhythmic modulations. Working with distinct dimensions in different identities reduces the requirements that the dimensions are categorisable and susceptible to schematisation, as these criteria are principally beneficial for distinguishing two ideas along the same dimension. Instead, it may become increasingly important to be able to acknowledge which dimensions are carrying the musical idea. When ideas exist along different dimensions, it seems reasonable to assume that this shift alone would be sufficient to invoke segmentation, thereby providing the opportunity for an interpreted change of identity. Having said that, categorisation, and to an extent

schematisation, still play an important role in recurrent forms, contributing to the ability to recognise an identity upon its return and associate it with previous instances in the piece.

Primitive and Higher-order Musical Dimensions

The basic psychological dimensions of sound are frequency, duration, loudness, timbre and spatial location (Dowling & Harwood, 1986).[15] These can be considered *primitive musical dimensions* because they are present in every sound and therefore any musical idea must inevitably involve and co-ordinate them, even if not intentionally. In practice, however, musical ideas are generally composed and interpreted along higher-order dimensions, which may consist of either selected materials from the primitive dimensions or a specific approach to the organisation of those dimensions. Pitch is one example of the former; the set of musical pitches relevant to any tuning system is comprised of a subset of tones along the frequency continuum. An example of the latter is a generative process, such as a mathematical algorithm, applied directly to a primitive continuum. Although the process may be applied to the entire continuum without restriction, it is not the continuum that the composer engages, but rather the process. Higher-order dimensions may themselves engage several dimensions; a melody, for instance, involves at least pitch and rhythm (duration). A formal proposal for a system of analysing musical dimensions might distinguish between, for example, secondary dimensions such as pitch and rhythm, as subsets of primitive dimensions, and ternary dimensions such as melody and harmony, which engage multiple secondary dimensions. For the purposes of this writing the distinction is not important and so they are all referred to as higher-order dimensions.

[15] Dowling and Harwood do not include spatial location in their initial statement of the main psychological dimensions of sound, however, later they discuss it. Spatial location is a property that is present in every sound and spatialisation is clearly an important aspect of much contemporary music, particularly electroacoustic music. Spatial location must, therefore, be considered one of the basic psychological dimensions.

In terms of their contribution to identity and structure of a musical surface, primitive dimensions seem to have varying levels of perceptual significance, with frequency and duration (or temporal placement) being stronger than timbre, loudness and spatial location. On this subject, Boulez (1971) writes the following:

> Pitch and duration seem to me to form the basis of a compositional dialectic, while intensity and timbre belong to secondary categories. The history of universal musical practice bears witness to this scale of decreasing importance... (p.37).

Although no experimental evidence has been found to substantiate this claim, the hypothesis appears to hold up under a number of hypothetical examples involving melody (frequency and duration):

- If half way through a melody, modifications are made to the timbre, loudness or spatial location then the whole melody is likely to still be grouped as a single unit.
- If a melody is repeated twice, and on the second repeat the timbre, loudness or spatial location are modified, then the two repeats are likely to be grouped. This is unlikely to be interpreted as a change of identity.

Similar statements seem to hold true in non-melodic contexts:

- If a low frequency, rhythmically irregular texture changes in timbre, loudness or spatial location, but the general frequency range and the nature of the rhythmic activity persist, then it seems unlikely that a listener would interpret a change of identity.

The perceptual significance of timbre must be considered as a special case. In the context of traditional music, it may be fair to say that timbre is a weak dimension, on a par with loudness and spatial location. However, the emphasis that

composers place on timbre in much contemporary music not only elevates that dimension's perceptual significance, but has also led to new ways of viewing timbre that extend beyond its traditional function as orchestration. Even in this new music, my own feeling is that, in most cases, the principle factors that define identities are still frequency and duration, if those terms are allowed to refer to general notions regarding how low or high a sound is and its temporal placement, respectively. Nonetheless, I do not discount the possibility that timbre can be used in such a way as to make it a more significant dimension than frequency and duration in terms of form-bearing capacity, but many compositional freedoms would need to be sacrificed in order to create such conditions. Considerably more will be said about timbre later in this writing, including a survey of modern approaches to the subject.

The reasons for the perceptual dominance of frequency and duration are unclear. One possible explanation is that it is due to acculturation—the mere fact that most music is organised primarily around pitch and rhythm and so listeners learn through experience to give these dimensions greater priority. Wishart (1998) argues that it is the notability of pitch and rhythmic values that has led to their importance, since these dimensions can easily be codified and formalised. There is also mounting evidence that suggests that evolutionary factors are at least partially responsible for determining the significance of the frequency and duration dimensions, as these are central to communication, not only with respect to human languages, but also amongst animals (Shepard, 1981).

Dimension Competition

Identities usually engage multiple dimensions and each suggests a segmented structure based on the values along that dimension. Ultimately, the listener's interpretation of the segmentational structure of the musical surface must take into consideration all dimensions involved, and it is here that the relative significance of dimensions is critical. When the various dimensions suggest a sectional division at the same point in time then the boundaries of an identity are clearly defined and

unequivocal. However, when confronted with dimensions that suggest conflicting segmentational structures then interpretation will most likely be derived from those that are perceptually stronger, regardless of whether they are the compositionally important dimensions.

The practical implications of the perceptual strengths of dimensions are noteworthy. Firstly, all higher-order dimensions must affect the organisation of primitive dimensions, since those are ultimately what are perceived. As a consequence, the perceptual significance of any higher-order dimension and the ability of that dimension to contribute to form is relative to the strength of the primitive dimensions that it engages. Furthermore, weaker form-bearing dimensions, such as those primarily affecting loudness, spatial location, and at least in traditional contexts, timbre, are only likely to be the defining factors of form if a perceptually stronger dimension does not suggest a conflicting structure. Accordingly, if the desire is to use weaker form-bearing dimensions as the sole indicators of structure in a piece then it would seem necessary to normalise the stronger dimensions, thereby removing them from the perceptual equation.

This is clearly not a scientific investigation of the perception of musical dimensions, but rather an intuitive understanding based on personal experience. A proper investigation is needed, backed by experimental evidence, to provide a sufficient understanding of the perceptual significance of each primitive dimension as well as how the interactions between dimensions are calculated to arrive at a segmentational structure. Although such an investigation may reveal exceptions to the rules presented here, it does seem that the general principles are correct, and that any deviations would be few and occur under specialised circumstances.

Identity Transformation and Dimension Modulation

Gibson (1979), in the context of visual perception, refers to properties that persist over distinct regions or patterns as *invariants*. Similarly, it is through aural invariants that previously heard identities are recognised. Upon the return of an identity the musical surface must bear some relation to the previously heard surface if they are to be recognised as the same idea. If we assume that the surface qualities of an identity remain unchanged upon each recurrence then identity recognition is fairly straightforward; the invariants are simply the surface qualities associated with the identity. However, musical ideas are often developed over time, leading to transformations along some or all of the dimensions that the idea engages. As a result, the surface qualities associated with an identity may change over the course of a piece, and these changes can be drastic. Under such dynamic conditions, identity recognition cannot only be dependent on a static description of the surface qualities, but may instead rely on the recognition of a congruent behaviour along specific dimensions. In extreme cases, the process of development itself can serve as the sole invariant of an identity.

The B-identity in *Seven Sisters — Karen* provides an example of a transformation that significantly alters the surface qualities of the identity. The B-identity begins with loud, highly energetic, metrically syncopated rhythms in both the guitar and cello parts. This activity diminishes gradually over the course of the piece so that, by section B4, it is characterised as soft, sparse and almost pointillistic. The beginning and ending bars of the B-identity are provided in figure 3.1, which shows by comparison the extent of this transformation. If listeners were presented with section B1 followed immediately by B4 the change in musical surface might be enough to lead to a segmented interpretation, with the two being heard as distinct identities. However, in the context of *Karen,* these sections retain their association mainly because of a persistent transformation process that occurs gradually and systematically through clear and directed development. Listeners are able to track developments and continuously redefine the surface qualities that are attributed to

the different identities in a piece in order to compensate for such dynamic transformations.

As identities are transformed, not only can the surface qualities change, but also the very dimensions that the musical idea exists along may appear to change, or modulate. *Dimension modulation* is made possible by the fact that, in certain cases, a continuum can be drawn between normally separable higher-order dimensions. For example, a low frequency oscillator is heard as rhythm up to the point where the cycles per second enter the frequency range of human hearing. The fact that these modulations occur along single dimensions provides interesting possibilities for the application of predetermined systems since a simple directed process applied appropriately is capable of invoking a modulation. Figure 3.2 lists a number of potential modulations between distinct dimensions.

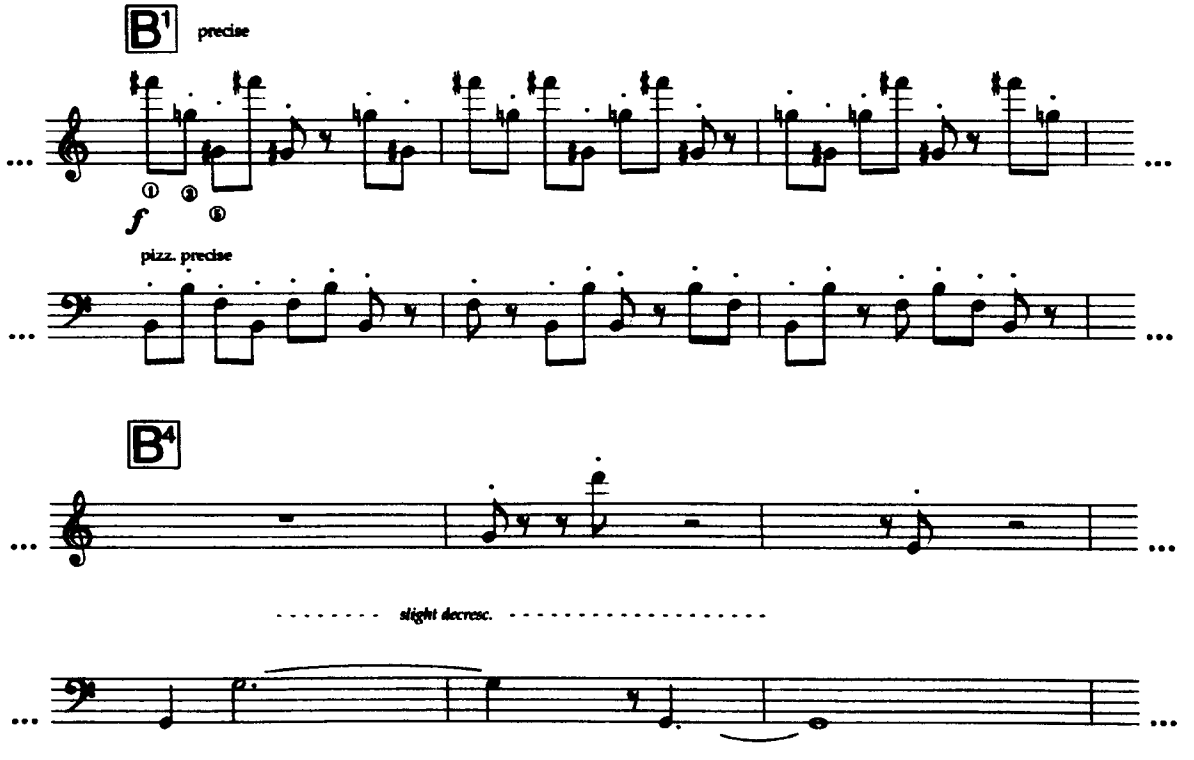


FIGURE 3.1 Excerpt from *Seven Sisters — Karen*, showing the extent of transformation in the B-identity.

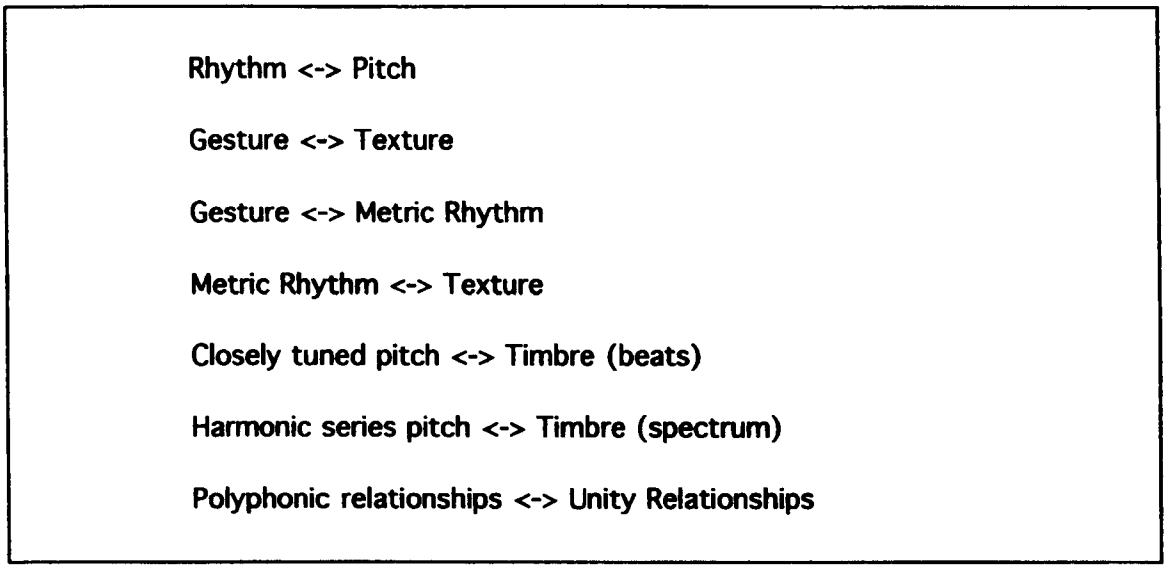


FIGURE 3.2 Potential modulations between higher-order musical dimensions.

A Survey of Less Conventional Musical Dimensions

In contrast to the fixed number of primitive dimensions, higher-order dimensions encompass a broad range of compositional concerns, including scale, harmony, metre, melody, tempo and style, to name just a few common to traditional instrumental music. A search for new musical aesthetics and organising principles in modern music has led many composers to be concerned with less conventional dimensions, or unconventional approaches to conventional dimensions. In the survey that follows, several of the less conventional dimensions found in the pieces accompanying this writing are examined considering the form-bearing constraints previously outlined.

Timbre

Timbre is a dimension that has received much attention in contemporary music, yet the notion of timbre has always been somewhat ambiguous. The

traditional view is that timbre describes those characteristics of a sound that allow it to be distinguished from other sounds having the same frequency, loudness and duration (Campbell & Greated, 1987; Plomp, 1976; Winckell, 1967). Under this definition, or others similar to it, the term timbre has served as a catchall, encompassing a wide variety of sonic attributes that do not fall into one of the other primitive categories. Apart from a lack of specificity, several other points must be made with respect to the traditional usage. First, frequency, loudness and duration can be measured on one-dimensional continua, whereas timbre is multidimensional; any given sound has a number of different qualities associated with it. Moreover, there is not a fixed set of qualities important to all sounds. Krumhansl (1989) has found that in dissimilarity judgements between timbres musician listeners tend to base their judgements on three main qualities: onset time, brightness and spectral flux. Grey and Gordon (1978) suggest that the noisiness of attack is an important factor in timbre discrimination. Plomp (1976) has demonstrated that formant placement is a dominant perceptual component in periodic timbres. The second point to make is that the traditional view of timbre is innately concerned with periodic sounds, and has therefore been applicable primarily to music oriented around pitch. The increasing acceptance of aperiodic sounds in music has led to revised views of timbre, some of which seem to broaden the meaning of the term significantly. This discussion will focus on three compositional approaches to timbre, each indicative of the function that it serves in the music, namely as orchestration, as symbolic reference and as abstract spectro-morphological content. Although these approaches are discussed separately, in practice they are not mutually exclusive and may be incorporated simultaneously.

In pitch-based music, timbral concerns often serve as orchestration, providing colorations to the musical surface or novel extensions to an instrument's natural sound. This is not to say that timbre cannot be a primary compositional concern in such pieces, but rather that an elevated emphasis on timbre essentially amounts to an increased emphasis on orchestration. However, despite compositional priorities, when pitch and rhythm are present it is highly unlikely that another dimension will gain greater perceptual strength. Hypothetical examples were

previously used to demonstrate the perceptual dominance of pitch and rhythm, and it is useful to call upon similar examples in the context of timbre:

- In the presence of characteristic pitch-based activity, modifications made to timbre alone are unlikely to invoke a segmented interpretation.
- In the presence of characteristic rhythmic activity, modifications made to timbre alone are unlikely to invoke a segmented interpretation.

Note that the above examples have been qualified with the word 'characteristic.' It would seem that the degree of change, timbral or other, necessary for segmentation is context dependent. If the pitch and rhythmic activities never varied throughout a piece then perhaps a modification of timbre would be enough to invoke segmentation. However, where clearly distinguishable pitch and rhythmic treatments exist at different temporal units in a piece, those divisions are likely to have a greater significance in terms of grouping and segmentation. Consequently, timbre seems to be a weak form-bearing dimension when used as orchestration and is only likely to make a significant contribution when working in collaboration with other dimensions. That said, the contribution that it can make when coordinated with other dimensions should not be underestimated. Timbre can play a central role in defining the character of an identity, giving it essential qualities that help set it apart from others in the piece.

In contrast to the traditional view, new approaches to timbre have arisen in the latter half of the twentieth century, primarily in connection with electroacoustic music that embraces aperiodic sounds. Much of this change in attitude has been a result of advances in technology, which offer composers two important potentialities that did not exist previously, at least not to the extent that they have existed since the introduction of electronic devices and computers. The first is the ability to capture sounds from outside the concert hall and pull them into a musical composition. The second is the ability to completely control all aspects of sound, including its subcomponents (Emmerson, 1986). These two potentialities contribute to two

distinct approaches to timbre in aperiodic music, namely as symbol and as abstract spectro-morphological content.

Emmerson (1986) has considered the relationship of sounds to associated objects or evoked images in the minds of listeners. He uses the term 'mimesis' to refer to the musical imitation of nature or extramusical aspects of human culture. A mimetic approach to musical materials views timbre in close connection with object identification, since it is timbre that provides information pertaining to the source of a sound; it is what differentiates a flute from a trombone or a forest from a city soundscape (Handel, 1995). Through mimetic discourse, sounds become symbols that evoke images or impressions of objects or actions external to music. These images can be literal, such as the sound of a train, or they may be more vague and unspecific, such as the impression of something large and metallic. They may suggest objects, such as a train, or actions, such as something being closed or scraped.[16] To take one example, the raucous A-identity in *And Then Romina...* is likely to evoke an impression of danger. The music is chaotic, containing sounds reminiscent of alarm bells and siren wails. *And Then, Romina...* is not a programmatic work and there is no concrete meaning to be found in these associations. Nonetheless, the A-identity is likely to conjure up vague images or feelings of eminent threat, which surely contribute to its character and recognisability.

A symbolic approach to timbre makes it an exceptionally effective form-bearing dimension. Apart from music, the ability to associate sounds with sources is a highly developed skill necessary for survival. If form is to be based on symbols and their meanings then grouping merely involves differentiating concrete, or semi-concrete, objects, actions or impressions. However, one must be willing to exchange the abstract qualities of music for those that are more concrete. In doing so, emphasis is shifted from a perceptually-based value system to one that is conceptually-based, just as it is through the use of predetermined systems, albeit

[16] In terms of the symbol being communicated, the distinction between object and action is somewhat ambiguous. Whenever an object is concretely identified through sound it must have been activated in some way, otherwise it would not have produced sound. However, when objects are vague and unspecific then it would seem that the emphasis might be shifted towards the action.

with different aesthetic aims. The musical language is no longer reliant on unconscious schema-based knowledge, but instead is engaged in a cognitive discourse with tangible objects or impressions and their meanings. Furthermore, to attribute symbolic reference to timbre is a significant augmentation of the traditional usage of the term. The terms 'sound' and 'timbre' are not synonymous. While it may be true that information regarding source is transmitted through timbre, other dimensions are also present in sounds. For example, there are rhythmic and density differences between the sounds of a forest and a city. There are durational differences between the sound of something closing and that of something being scraped. It would be an oversimplification to say that these differences are timbral. Moreover, in the context of mimetic discourse it is debatable whether timbre is itself an important compositional dimension in any direct sense. Even if it were accepted that object identification could be attributable to timbre alone, it would seem that timbre merely serves as a vehicle through which symbols are communicated, and that symbols are the primary compositional objects, leaving timbre for its own sake inconsequential.

Denis Smalley (1986) proposes a spectro-morphological approach to composition, which is rooted in the Schaefferian concept of reduced listening. Reduced listening is characterized by the intention to hear a sound simply for its own sake, removing any relationship to its source and the meaning it may convey. Spectro-morphology is an approach to musical materials that focuses on their spectral energies, and how they change over time. It would seem that such an attitude encourages detailed listening that draws attention to local activity, lending itself well to forms that develop organically. Lerdahl and Jackendoff (1983) claim that timbre is not a hierarchical dimension, meaning that it does not support grouping at various structural levels. The issue is not so much that timbres cannot be grouped, but whether grouping based on timbre is sufficient to lead to segmentation in the presence of other competing dimensions. As with orchestration, it may be that a spectro-morphological approach to timbre is limited to a contributory role with respect to large-scale form. In terms of performance, spectro-morphology is best

suited for music delivered over loudspeakers. When a live performer is involved it becomes much more difficult to divorce a sound from its source.

Of the three approaches to timbre presented in this writing, spectro-morphology seems to be the closest to what might be called 'timbre composition.' However, as with a symbolic approach, it is difficult to ascertain the extent to which spectro-morphology engages timbre. While most views of timbre take into account spectral changes over time, they are usually limited to short duration onset and decay characteristics (Krumhansl, 1989; Grey & Gordon, 1978). When spectral changes are slow enough for the ear to follow then one might argue that they no longer contribute to timbre, but rather begin to constitute rhythmic or gestural qualities. An obvious example is an oscillating low pass filter, resulting in a clearly pulsating tone due to timbral modulations. In this instance it is debatable whether the whole sound is timbre or whether the timbre is varying in a rhythmic manner. This of course says nothing about the music or the spectro-morphological approach itself. It merely has consequences for how we discuss it.

Non-tonal Pitch

Most of the musics of the world identify either a limited number of fixed pitches along the frequency continuum, or similarly, a limited number of fixed relationships, allowing the pitches themselves to vary. Pitch is a higher-order dimension as it describes a subset of the frequency continuum and is traditionally linked with systems of tonality, which include scales and hierarchical harmonic relationships. The desire, however, to avoid tonal systems in much contemporary music has naturally led to a number of non-tonal motivations for the selection of pitches. Two approaches to non-tonal pitch found in my own works are considered nodal and timbral.

Pitch can be organised around fixed nodes of resonance that serve as centres to which other tones resolve. A nodal approach de-emphasises intervallic relationships, either by only using pitches very close to the node or not using pitches

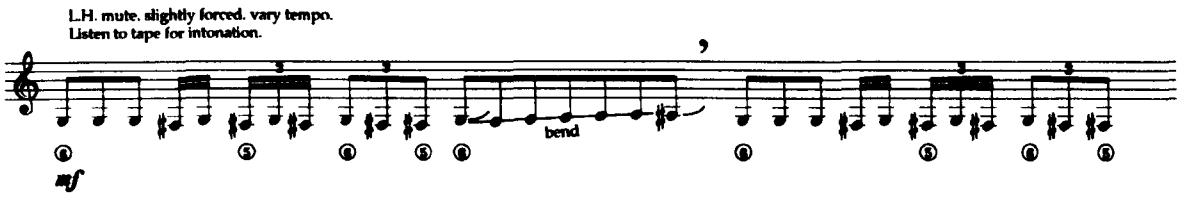


FIGURE 3.3 Excerpt from section C1 of *And Then Romina...*, showing a nodal approach to pitch, centred around a low G.

other than the node at all. A steady drone, in the absence of other pitch material, is an obvious example of a nodal treatment of pitch. However, it is not necessary that the node remain fixed throughout. In section C1 of *And Then Romina...* (score 2: sound example 4), nodal concerns governed the selection of pitches, but over the course of the section the node is shifted upwards in stages. Each stage, however, is characterised by a similar rotational activity around a central pitch. Figure 3.3 provides an excerpt from the introduction of section C1, showing the initial node established on the low G, around which other pitches are placed.

If more than one node is established then interval relationships inevitably emerge. Yet the presence of a persistent interval may not fully constitute an intervallic concern. A single persistent interval, in the absence of other intervals, loses a large degree of its significance in terms of tonality and simply becomes a quality with a measure of consonance (or dissonance)—essentially a harmonic drone. The multiphonic C-identity in *3FKB+* (score 3: sound example 5) provides an example of such a drone. The identity comprises a sequence of repeated multiphonics, each held for roughly 12 seconds. Beneath these multiphonics there is an electronic drone derived from a recording of the same sound, allowing the performer to fade out, breathe, and fade back in with the next multiphonic without interrupting the continuity of the drone. The C-identity could be analysed in terms of harmony, since the multiphonics consist of several tones. However, the rough quality of the sounds coupled with the beating that occurs due to intonation differences between the electronics and the clarinet, and the fact that, harmonically,

the C-sections are practically static, all allude to timbral rather than harmonic concerns.

In terms of their capacity to contribute to form, nodal pitch treatments would appear to be highly effective, assuming that few and different nodes are used to distinguish identities. The perceptual skills required to detect changes are simply a reduced set of those needed for pitch and interval discrimination. These dimensions are highly categorisable and susceptible to schematisation, and if conventional intervals are established between nodes then such qualities will already be familiar. However, as was shown in section C1 of *And Then Romina...*, a simple change of node may not be enough to warrant a new identity. The ability to differentiate identities is likely to depend on other activity, such as differences in the behaviour of events around the nodes.

In a variety of ways, pitch can also be organised around concerns for timbre. When two closely tuned tones are sounded together a phenomenon called beating occurs, with the rate of beats being equal to the frequency difference between the two tones. Beats between near unison tones are called first-order beats. Beating can also be heard between tones that are a fourth, fifth or octave apart, and these are referred to as second-order beats (Truax, 1978). Beating can result in complex and interesting timbral effects, particularly when the tones slightly drift in frequency, causing the beat rate to also accelerate or ritard. The electronic interlude between sections D1 and E1 in *And Then, Romina...* (score 4: sound example 6) provides an example of the use of beating as a timbral effect. Examples involving live instruments and electronic sound can be found in section A3 of *Flap Jackson* (score 18: sound example 7) and the multiphonic C-identity of *3FKB+* (score 3, 7: sound example 5).

Another means of organising pitch around timbral concerns is to treat the pitches as individual harmonic partials of a larger sound. For example, *Polyrhythmic Modulation Study No. 6 – Spectral Canon* consists of eleven voices that are each tuned to a partial of the harmonic series built on 100Hz. At the end of the piece, where the rhythmic activity is synchronised and all voices sound at the same time, the eleven voices fuse into a single tone at the fundamental frequency of 100Hz.

Alternatively, single pitches can be treated as resonant tones of a larger sound. Section A1 of *Flap Jackson* (score 1: sound example 8) is characterised by a sequence of loud, forceful chords separated by silence. With most events, soft tones are sustained by the two flutes and electronic part in such a way that they appear to be residual elements of the chords. In naturally occurring sounds, such resonant tones are usually harmonics of the fundamental. However, when creating this effect artificially they can be any tones.

Timbral approaches to pitch have been discussed here because they are achieved through the deliberate use of pitches, which must be determined by the composer, and in the case of instrumental music, played by performers. However, such approaches might just as well have been considered during the previous discussion of timbre. In fact, if the result is perceived as timbre then it is reasonable to assume that the capacity of such dimensions to make a significant contribution to form is essentially equivalent to that of timbre, which has already been discussed.

Event Sequences

Event sequences are simply arrangements of musical events where the order is a significant aspect of the identity. Melodic sequences are the obvious example, since it is the specific order of pitches, along with their associated rhythmic values, that defines a melody. However, event sequences are not restricted to pitches, but instead can comprise any sonic events, including sound-objects, words, tone clusters, and so on. *Seven Sisters – Tina* consists of event sequences in both the guitar and cello parts. Processes are applied to individual events in the sequences such that they grow or diminish in duration, but the order remains unchanged, allowing the sequence itself to contribute to the recognisability of the identity. Figure 3.4 compares the first three iterations of the guitar sequence in *Tina*.

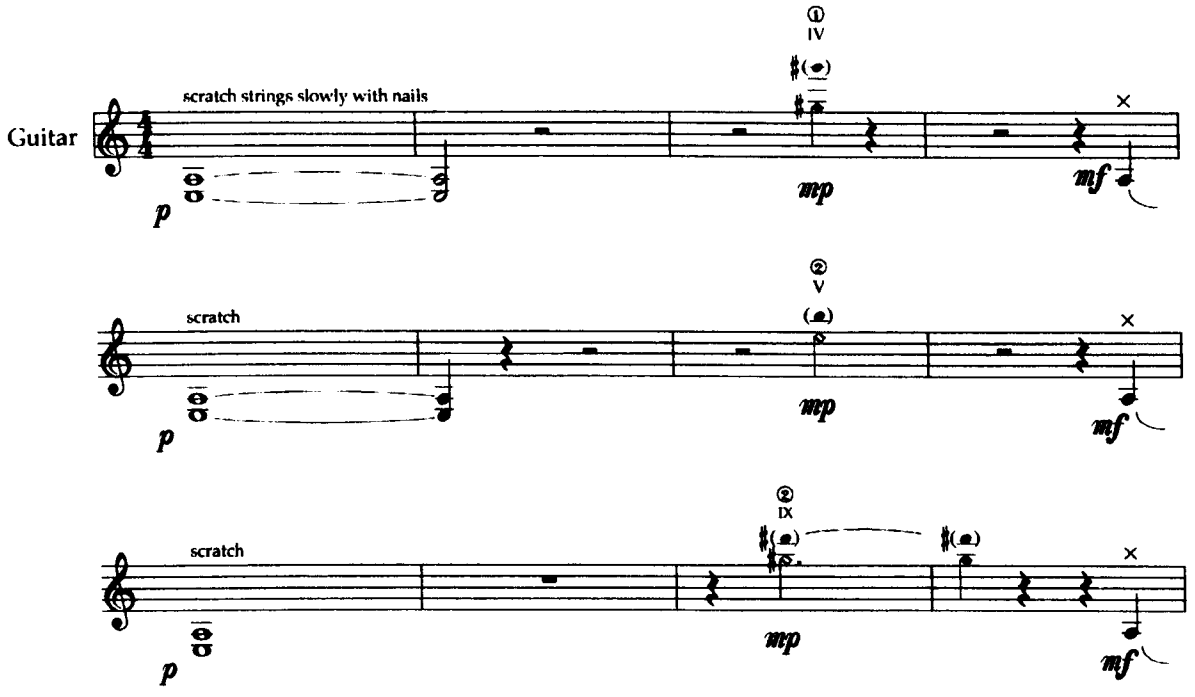


FIGURE 3.4 The first three iterations of the guitar sequence in *Seven Sisters – Tina.*

Melodic sequences clearly have tremendous form-bearing capacity. However, there are important differences between melodic and non-melodic sequences that are likely to impact the form-bearing potential of the latter. Firstly, sound-object oriented events are generally less categorisable than pitch events, due to their complex, multidimensional nature and lack of octave-equivalence property. Secondly, considerable evidence shows that contour is a prominent contributor to the recognition of melodies (Frances, 1988; Dowling & Fujitani, 1971; Dowling, 1978). When sequences are not organised along a one-dimensional continuum then contour is not a relevant property, and cannot be used by listeners in recognition and discrimination judgements. Finally, the complexity of sound-object events makes it unlikely that they are susceptible to schematisation to an extent comparable to pitch. Despite the relative shortcomings when compared to melody, non-melodic event sequences can be easily recognised and seem to be capable of making an important

contribution to form, particularly when the sequences are short and repeated, as in the case of *Tina*.

Texture - Density

In its conventional usage, the term musical texture refers to melodic and harmonic relationships between parts, such as those that are monophonic, homophonic and polyphonic. However, in the context of this discussion, texture describes conditions where the density of activity is sufficient to cause the whole to seem more important than the individual events. The application of processes to texture is a highly effective means of generating structural motion. Textures can grow or diminish; they can be directed or goal-directed. Denis Smalley (1986) suggests that texture is self-propagating; it seems to continue on its own, without the need of an external stimulus. It may be precisely this sense of self-perpetuation that makes the motion generated so effective, since it seems to come from within. Texture can serve as a backdrop for other musical activity or become the focus of attention itself. An example of the former can be found in section A3 of *Slinky* (score 7: sound example 9). An example of the latter, where the structural motion occurs over a relatively short duration, can be found in section B6 of *3FKB+* (score 9: sound example 10).

Listeners are able to perceive relatively subtle differences in density, as can be demonstrated by tracking the development of a gradually changing texture such as the one in the B-identity of *3FKB+*. Yet it would seem that the ability to categorise such changes is considerably weak. Categorisation is tied to the ability to recognise a particular state when it appears, and although extreme differences in density can clearly be identified, the number of distinctly recognisable levels between extremes is likely to be quite low. However, a musical surface that is perceived as texture is highly distinguishable from other surfaces that are not. Therefore, the time-distinct juxtaposition of texture with other non-textural ideas is an effective strategy for differentiating identities.

Component relationships

Where a musical surface consists of multiple parts, voices or streams, the relationship between those components is a dimension worthy of compositional consideration. Component relationships can be described as *unified, interdependent* or *independent. Unified relationships* are those where multiple components contribute to a single, musically inseparable sound event. Interdependent and independent relationships are both forms of polyphony, referring to conditions where multiple components maintain a degree of individuality while present simultaneously. In *interdependent relationships* the different components function to support each other musically, such as a chord progression supports a melody. In *independent relationships* there seems to be no functional relationship between the components; they merely coexist, as in the performance of two different songs simultaneously.

Changes in polyphonic relationships result in obvious transformations at the musical surface, particularly by altering the component that demands focal attention. For instance, in *Seven Sisters — Pam,* the guitar occupies the foreground in the A-identity and the cello occupies the foreground in the B-identity. One difference, then, between the A-identity and the B-identity is that in the former the guitar carries the weight of the musical idea, whereas in the latter, it is the cello. Although this distinction is difficult to overlook, it is critical to note that the musical idea itself changes between the A- and B-identities. If all other dimensions remained unchanged then it is unlikely that a transformation of the component relationships would be sufficient to invoke a segmented interpretation. Despite their perceptual clarity, the ability of component relationships to function as form-bearing dimensions would appear to be limited because they essentially result in changes of orchestration, which have already been discussed as being weak contributors to form.

Chapter Conclusion

To summarise, musical ideas have identities that are characterised by all aspects that contribute to the recognition of the idea, including those that are procedural and those that are perceptual. Since identity is linked with recognisability, it is the perceptually dominant characteristics of the musical surface—the surface qualities—that make the primary contribution to their definition. The ability to distinguish musical identities is central to the interpretation of musical form, since it is changes of identity that define sectional boundaries, and it is the ability to associate related sections by a similar identity that allows one to construct a mental representation of the form of a piece.

Identities are derived from musical ideas that exist along particular dimensions, some of which are primitive and relate directly to the basic psychological properties of sound, while others are considered to be higher-order dimensions that embody various subsets of primitive dimensions. Musical ideas are generally composed and interpreted along higher-order dimensions. However, these ultimately affect the organisation of primitive dimensions because they necessarily encompass them. Since primitive dimensions are unequal in terms of their perceptual significance, the import of any higher-order dimension is dependent on the primitive dimensions that it engages. Moreover, musical ideas are multidimensional and each dimension suggests a segmented structure that is derived through the grouping of values along that dimension. Segmentation of the surface as a whole must ultimately be ascertained by comparisons of the segmented structures of each dimension involved. When those dimensions suggest conflicting structures, the perceptually stronger dimensions will determine the interpreted segmentational structure.

Development of musical ideas also takes place along dimensions, and this can potentially lead to a dramatic transformation of the identity. However, in *Seven Sisters — Karen* it was shown that it is possible to transform all the primitive dimensions of an identity and drastically modify its surface quality without altering the perceived identity if the development is gradual and systematic. In such cases, the process of development itself becomes the invariant dimension, suggesting that

the procedural attributes of an identity can function as the sole invariants, and identities can retain their recognisability even when all the perceptual dimensions have been transformed.

A formal system of identity analysis has not been proposed as it is beyond the scope of this writing. However, such a system would clearly be useful and should include methods for specifying the higher-order dimensions of an identity, ranking dimensions according to their importance for recognition, presumably based on the perceptual significance of primitive dimensions, specifying any invariant dimensions in the identity and the establishment of precise criteria for a surface quality. Such a system provides a promising opportunity for future research.

Chapter Four – Sectional Forms

Building on the concept of musical identities presented in chapter three we are now in a position to examine sectional forms in greater depth. A *musical section* refers to a temporal unit of the holistic form that contains a single or complex identity, distinct from those immediately adjacent to it, and that is perceived as being one hierarchical division below the holistic form. Two issues arise with this definition that deserve some attention. Firstly, several sections may be grouped, as shown in figure 4.1, and in terms of structural hierarchy such units would seem to lie between sections and the holistic form. However, the grouping of multiple sections cannot occur until a significant portion of the piece has been heard, and even in such cases, the individual sections are still perceived as being immediate divisions of the holistic form. Secondly, sections themselves may be subdivided into segments that are recognised by different identities. However, in such cases the segments are not interpreted as being immediate divisions of the form. Moreover, the group of identities that defines one section can be considered a complex identity and will be distinct from those that define surrounding sections.

Sectional forms, by definition, contain multiple identities. However, sections and identities are not analogous and the distinction between them is important. A musical section refers to one contiguous structural unit, and therefore only appears in one position in a piece. Where a return of previous music occurs it is not that the section is repeated, but rather that the music from one section is repeated in a later,

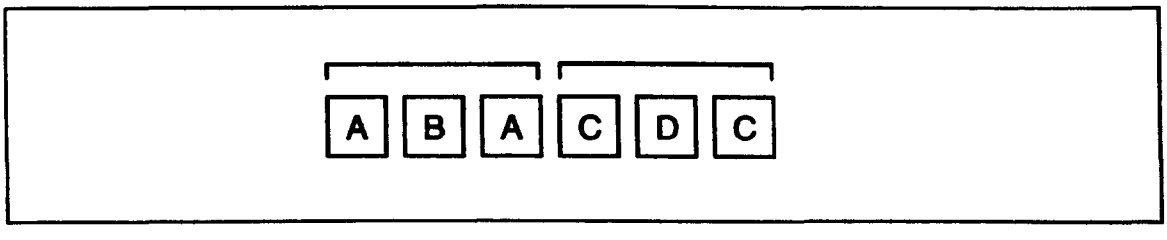


FIGURE 4.1 An example of a sectional form, where sections A-B-A are grouped and C-D-C are grouped.

separate section. Identities, on the other hand, refer to all of the characteristics that the listener associates with a particular musical idea, and that same idea, or some recognisable transformation of it, may appear in numerous instances throughout a piece. Accordingly, in figure 4.1 there are two A-sections but only one A-identity.

Recurrent sectional forms are characterised by the presence of a given identity in more than one section of the piece such that there is a return to the musical idea. They are found throughout Western art music and popular music, with the typical verse-chorus oriented popular song form providing just one common example. Figure 4.2 illustrates the forms of three well-known songs: *Can't Buy Me Love* (Lennon & McCartney, 1968), *Ring Of Fire* (Carter & Kilgore, 1963) and *Like A Rolling Stone* (Dylan, 1965). In this figure, the V-sections represent verses, the C-sections are choruses, I signifies an interlude and S a solo section. The reader may note that repeated passages in *Can't Buy Me Love* and *Ring Of Fire* are grouped together and considered as single sections, even though they are clearly segmented. The reasons for such an interpretation will be made clear shortly.

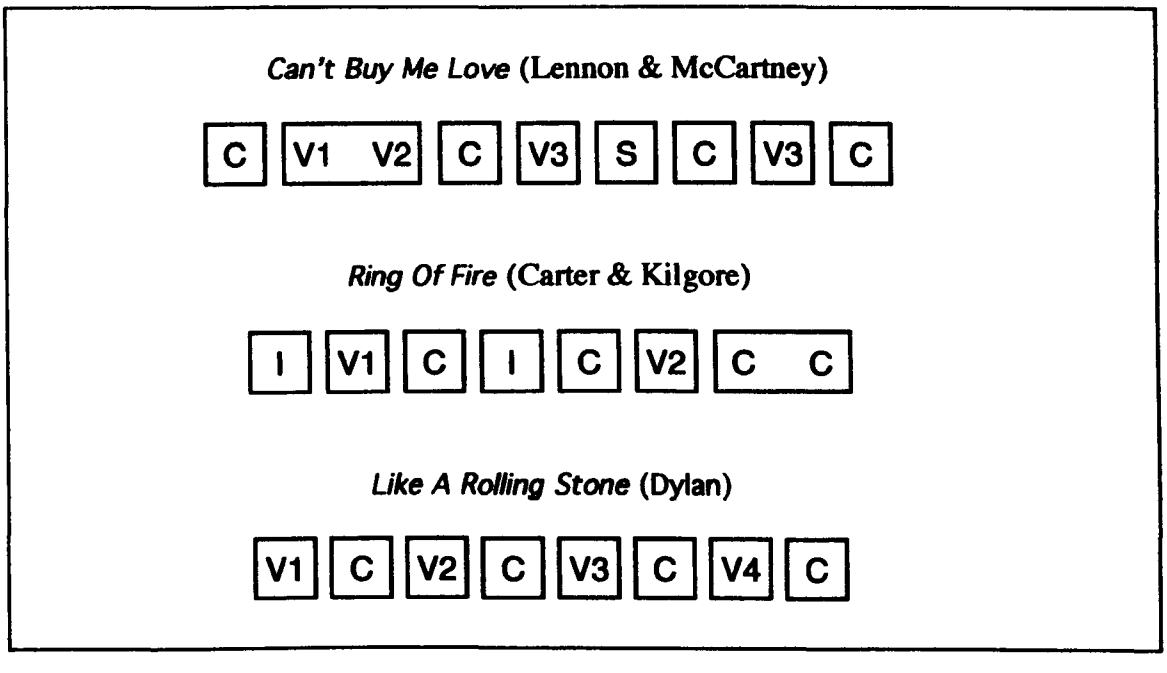


FIGURE 4.2 Three examples of popular songs with recurrent forms, where V represents a verse, C a chorus, I an interlude and S a solo section.

The recurrence of an identity can be described as one of *repetition, variation, recapitulation* or *continuation. Repetition* refers to an exact reiteration of the material from an earlier section, thereby generating another section that is a duplicate of the previous, at least in terms of an event-by-event comparison. The fact that the repetition appears in a later position in the piece demands that it be re-evaluated in terms of everything that has transpired since the previous occurrence, and this can lead to very different interpretations of the same music. *Variation* describes a transformation of material from a previous section while maintaining the identity of that material. If the transformation were to a degree that the identity were lost, then the section would not be associated with the previous one and so could not be considered a recurrence, at least not in terms of how the music is perceived.[17] *Recapitulation*, at least for the purposes of this writing, refers to a return to previously heard material, but the material is now presented in a concise, compacted form.[18] In actuality, recapitulation is merely a special category of variation, but it is used so often in music that it is worthwhile to deal with it individually. In terms of development, repetition, variation and recapitulation are generally self-contained, partitioned units; their development seems to begin and conclude within the boundaries of a single section. *Continuation* is distinguished from the others by the fact that the development of a given identity occurs over a number of sections, and therefore, upon each return it resumes from a state similar to that at which the previous instance was suspended. Continual developments form the basis of interleaved structures and play a unique role in shaping the form of a piece. These will be discussed in more detail later, as they are central to formal considerations in the pieces presented in this writing.

[17] Analysis may still reveal the variation.

[18] In music, the term recapitulation has other attributes associated with it, such as those commonly found in the context of sonata form, which are not discussed here because those forms do not influence my own musical thinking.

Grouping Structures

Interpretation of sectional forms is dependent on the ability of the listener to individuate sections of the holistic structure and, when the form is recurrent, the ability to correlate sections with similar identities, even when they are disjunct and remote. These two mental representations, defined as *sectional* and *associative structure,* are accumulated in the mind of the listener as the music is experienced, and describe their understanding of the form up to a given point in time. However, later events can alter previous interpretations and therefore these mental representations may change over the course of the listening experience and from one listening to another.[19] The interpretations of sectional and associative structures are highly interrelated activities since it is usually remote sections that are associated. However, these two mechanisms seem to be quite different from a cognitive perspective, and therefore it is useful to examine them separately.

Segmentational Grouping

When confronted with a sequence of events the listener spontaneously 'chunks' them into groups. Common to many areas of cognition, grouping occurs instinctively and spontaneously and is largely accomplished before any conscious evaluation of the stimulus begins (McAdams, 1996). The ability to perform this operation may be explained in part by Gestalt principles such as temporal proximity and qualitative similarity (Koffka, 1935). Significantly, however, it also depends on the acculturation of the individual listener, in other words, how well the structure of the input matches their acquired schemata (Lerdahl & Jackendoff, 1983).

Grouping occurs at various levels of the musical surface. McAdams (1989) distinguishes between three grouping mechanisms that function to organise the continuous acoustic surface into individual events, connect those events into streams

[19] For the most part, this chapter is concerned with first-time hearings of music.

and integrate those streams into larger, time-discrete units, referred to as *simultaneous*, *sequential* and *segmentational grouping*, respectively. The segmentational structure is particularly relevant to the perception of sectional forms because it is ultimately some of these larger units that are interpreted as sections of the holistic structure. A number of factors may contribute to segmentational grouping, including *temporal isolation, closure, transitional indicators, duration* and *variance.*

Temporal isolation

Temporal isolation describes a condition where segments of the music are physically separated in time by the presence of a pause or rest. Perceptually, this sort of grouping may be explained by the Gestalt principal known as the 'law of proximity', which states that elements grouped closely together are likely to be perceived as a single unit (Koffka, 1935). While isolating material in time imposes a segmented interpretation onto the musical surface, it does not necessarily lead to the perception of distinct sections. For example, if the same material were to be repeated after the pause then the two segments are likely to be grouped together.

Closure

Closure refers to a sense that an identity has reached a developmentally stable state, at least momentarily, and can be suggested by various attributes of a musical surface, including harmonic and rhythmic motion, metric division, duration and goal-achievement. Leonard Meyer (1973) has proposed that the various cues for closure are multifunctional, and expectation and forward momentum in music are created when these cues are placed out of phase. For instance, the rhythmic motion may reach closure at a moment when the harmonic motion does not, suggesting the necessity for continuation. Conversely, segmentational grouping occurs when the

various cues for closure are synchronised. The argument proposed by Meyer is not unlike the concept of dimension competition presented in chapter three. There, it was argued that identities exist along numerous dimensions, each suggesting a segmented structure, and perceived segmentation of the musical surface is ultimately dependent on the interaction between these various dimension structures. When the dimensions suggest a segmentation at the same point in time then a strong sense of closure is likely to be produced. Conversely, when confronted with dimensions that suggest conflicting segmentational structures then the necessity for continuation may be felt. When viewed in terms of closure, the above arguments suggest that conflictive dimension structures serve an important function in music because they generate forward momentum.

Transitional indicators

A sectional transition refers to the manner in which two adjacent sections are joined when there is a sense of continuity from one to the other.[20] A distinction can be made between two basic types of transitions: *propelled* and *blurred. Propelled transitions* connect two clearly demarcated sections in such a way that the first is directed into the second. This is often achieved by means of a gesture, and it is not uncommon for the last event to create a strong sense of downbeat that marks the entrance of the new section, a phenomenon referred to as a structural downbeat (Lerdahl & Jackendoff, 1983). *Blurred transitions* connect two sections by slowly introducing a new idea while at the same time diminishing the presence of the old material, in effect, blurring the sectional boundaries. They can be created by gradual transformations in event qualities, cross-fading of material or through the use of replacement processes, whereby increasing numbers of events are systematically interchanged with other events that will constitute the new identity. Both propelled

[20] Transitions may be differentiated from discontinuous junctures such as interruptions or closure-rest scenarios, where the two sections are totally separated.

and blurred transitional indications prompt the listener to search for segmentation by generating the expectation that sectional change is imminent.

Duration

Sheer *duration* can give rise to the expectation of change or the inhibition of such expectation. According to Lerdahl and Jackendoff (1983), a group is preferentially divided into parts that are of equal lengths. Assuming this to be true, if a given section is a particular duration then it would be expected that subsequent sections would be roughly the same. This suggests that durational expectations are context-dependent; once a listener has reached the end of the first section of a piece expectations are created for subsequent durations. In addition to context dependency, it seems reasonable to assume that there are both short and long durational limits beyond which one would not expect sectional change. For instance, it seems unlikely that one would expect a sectional change after only a few seconds, even if all of the cues where contributing to such an interpretation.[21] Conversely, when a piece develops in a coherent manner for a long period of time then one may begin to expect that the form is monolithic, containing only a single identity. Duration is particularly relevant in static sections where there is no overt development or motion expressed because no other dimensions are likely to generate expectations of sectional change.

The factors discussed so far contribute to the segmentation of a musical surface into a chain of coherent, time-discrete units. However, even when taken together, they are not enough to guarantee that a unit will be perceived as a musical section. The main reason for this is that segments and sections are not synonymous entities, and in particular, sections can contain numerous segments. To give an example, a binary form is said to contain two sections, but it is common for each to

[21] There are exceptions, such as where a gradual process of development transforms the section to such a short duration, as is the case with the A-identity in *Seven Sisters – Karen*. Another exception might be when the listener knows in advance that the piece is very short.

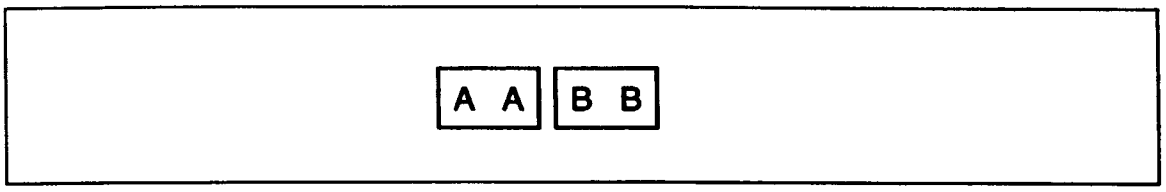


FIGURE 4.3 A simple binary form with repeats, showing the distinction between segmentational and sectional grouping structure.

be repeated. Assuming that each repeat of the A- and B-identities is clearly distinguished then the segmentational structure would contain at least four units while the sectional structure only contains two, as illustrated in figure 4.3. There is a need, then, to add a fourth grouping mechanism to those proposed by McAdams, namely *sectional grouping,* to account for those units that are perceived as sections of a musical form.

Sectional Grouping and Variance

Interpretation of the sectional structure of a piece is central to understanding the musical form. It serves to provide a mental representation of the important large-scale structural units, identifiable by specific surface qualities, and establishes the basis for a further understanding of how those identities relate. Sectional grouping is firmly tied to identity invariance. As long as the material continues in a persistent way then it is likely to be interpreted as belonging to the same section, even when it contains clearly segmented units. Conversely, sudden changes in behaviour or surface qualities are the primary factors leading to a perceived sectional change. Note however that a change of identity does not necessarily constitute a sectional change. It may be that tightly interleaved identities exist within a unit that is perceived as a single section. An attempt will be made shortly to address the issue of why some changes of identity are perceived as sectional while others are perceived as sub-sectional. Putting this question aside for the moment, it is true to say that every sectional change, by definition, must consist of a change in identity.

Associative Structure

Segmentational and sectional grouping occur between adjacent musical units. However, when sectional forms are recurrent, a strong correlation is also made between remote instances of each identity, giving rise to an *associative structure* (Lerdahl & Jackendoff, 1983). The formation of these associations is dependent on the ability to recognise an identity upon its return and relate it to previous instances in the piece. Like sectional grouping, associative grouping relies largely on perceived invariants in the dimensions that define the surfaces. Upon the return of an identity the surface must bear some similarity to a previously heard section if the two are to be associated. The associative structure effectively represents the recurrence in a form. A re-analysis of the song *Ring Of Fire* (Carter & Kilgore, 1963) is illustrated in figure 4.4, showing the segmentational, sectional and associative structures.

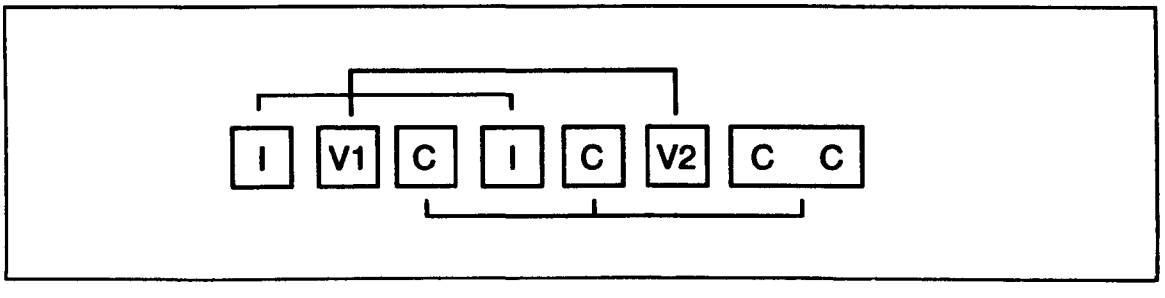


FIGURE 4.4 The segmentational, sectional and associative structures of *Ring Of Fire* (Carter & Kilgore, 1963).

Cognitively speaking, associative structures would seem to be fundamentally different from segmentational and sectional structures in that the former relies on long-term memory and identity recognition, whereas the latter are dependent primarily on gestalt principles and schema-based interpretation. Segmentational and sectional grouping mechanisms function primarily at a subconscious level,

generating a mental representation of the structural units as the piece unfolds in time. Consequently, segmentational and sectional grouping can easily pass without the listener paying conscious attention to their significance in the larger form. On the contrary, consciousness is implicit in associative structures because it is required to make the association. In cases where a recurrence exists but goes unnoticed then there would simply be no association made to the previous instance, and thus no associative structure. It would seem, then, that issues of recurrence in musical form are particularly appealing to conceptual propensities, since they are likely to be consciously evaluated.

Interleaved Structures

The term 'interleaved' is used in computing and electrical engineering to describe a method of delivering multiple continuous streams of information over a single signal. This is achieved by dividing each stream into small segments and alternating them in succession. The Audio Interleaved File Format (AIFF) commonly used to store digitised sound on a Macintosh computer system is one example of such a structure (Apple Computer, Inc., 1989). Stereo sound files require two data streams in order to represent the left and right audio channels. When stored on a hard disk it is advantageous to save these two streams in a single file, that is, as a single data sequence. The AIFF file format describes a method for interleaving multiple audio streams on a sample-by-sample basis, as illustrated in figure 4.5.

In terms of composition, musical identities can be interleaved in much the same way that AIFF data is stored. To achieve this, the identities must exist as contiguous units, which are divided into smaller segments such that each is only a fraction of the whole. Theoretically speaking, interleaved structures can combine any number of streams. However, as more are added the time between recurrences of each stream is increased, and this has perceptual consequences when applied to music, as will be discussed shortly.

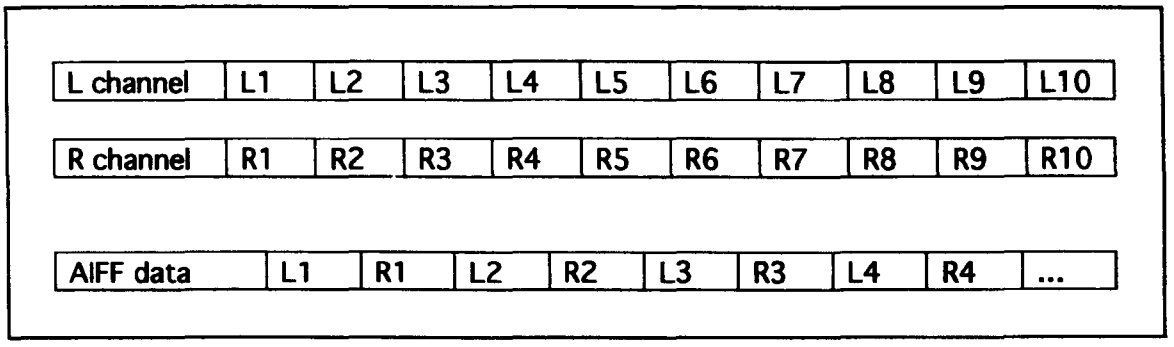


FIGURE 4.5 An example of the interleaved data structure of a stereo AIFF sound file, where L_n and R_n are individual samples.

Seven Sisters – Karen provides an example of a three-identity interleaved form where each identity is developed continuously over the duration of the piece. The A-identity undergoes a process of truncation; with each return the same material is performed from the beginning, but is always halted at an earlier position. The B-identity is transformed from being active and dense to being slow, quiet and sparse. In addition, upon each recurrence of the B-identity four-bars are added to the end in a new, and always lower tonality. The C-identity also undergoes a process of durational elongation, with the principle phrase repeated one additional time upon each return. The complete form of *Seven Sisters – Karen* is illustrated in figure 4.6.

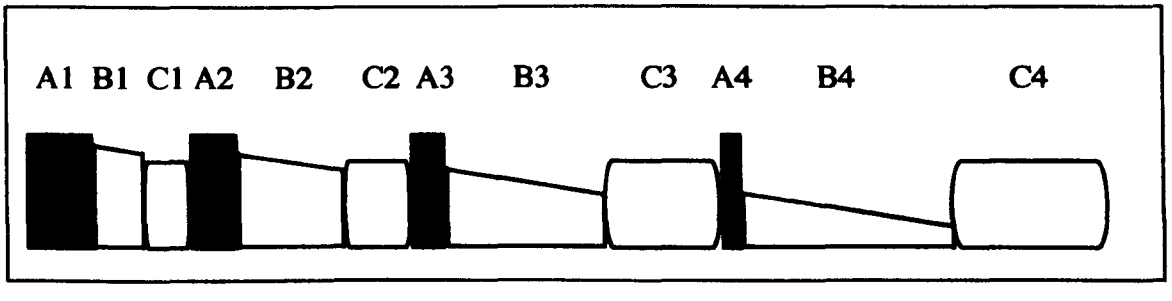


FIGURE 4.6 The three-identity interleaved form of *Seven Sisters — Karen.*

Interleaved structures lead to recurrent musical forms that are unique in that the material associated with each identity is continuous, albeit disjunct. As a consequence, each segment of an interleaved identity only represents a portion of the whole, and the complete nature of the identity is only revealed as the entire structure unfolds. In this sense, interleaved structures are multiply-directed and the development of the individual identities is experienced concurrently.

Continuation

There are three possible descriptions of a listener's perceptual experience of continuation: *implicit*, *explicit* or *unconscious*. Implicit continuation is felt in an immediate sense and is most likely to occur in tightly interleaved structures where the duration of each segment is short. Explicit continuation is characterised by a conscious awareness of the presence of continuation, yet it is not felt in an immediate sense, most likely because the segments of the interleaved structure are rather long. When the listener is conscious of continuation, whether implicit or explicit, it is likely to play a direct role in their expectations and understanding of the form. However, the fact that identities are interleaved does not mean that the listener is aware of continuation at the musical surface. On the contrary, the divisions of a continuous identity may themselves suggest closure, thereby misleading interpretations. An example of such a case is found in the melodic A-identity in *3FKB+*, where each segment consists of a well-formed phrase that ends with a cadence-like gesture followed by a rest. Although a coherent process transforms the A-identity continuously throughout the piece, it does so in stages and each segment is likely to be perceived as partitioned. When the listener is unconscious of continuation then it is neither felt nor apparent; it simply passes unnoticed as 'continuation' per se. It may, however, be indirectly perceived through its influence on the form of the piece. The listener is likely to be aware of the development and the shaping of the piece as it unfolds in time, and that shape is attributed, at least to some extent, to the continuous development of the various identities.

Formal Arrangement

The number of different identities that a musical form contains and the manner in which they are arranged has significant consequences for the perception of continuation. If diversions from an identity are brief then it is more likely that the identity will be heard as continuing when it returns, assuming all other factors work sufficiently to this end. Refrain forms, such as the one shown in figure 4.7, provide a particularly good arrangement of sections for the perception of continuation. They are characterised by the alternation of strophes with a repeated identity that can serve to carry the continuous development. Refrain forms allow many different identities to be included in a piece without increasing the time span between segments of the continuous refrain identity. However, simple refrain forms such as this are only suited for one continuous identity applied to the refrain itself. The other identities, serving as strophes, would require a partitioned treatment.

Another means of adding identities to a form without jeopardising the perceived continuation is to use broken interleaved structures, whereby the interleaved structure itself is periodically halted to allow for additional identities to be introduced. This is precisely the formal strategy taken in *3FKB+*. In this piece, the A- and B-identities create an interleaved structure that is continuous, but suspended in three positions to allow the C- and D-identities to be heard. Moreover, the C- and D-identities are also continuous, resulting in a complex multi-tiered interleaved structure with the A-B interleaved structure serving as a single component. Figure 4.8 illustrates the form of *3FKB+*.

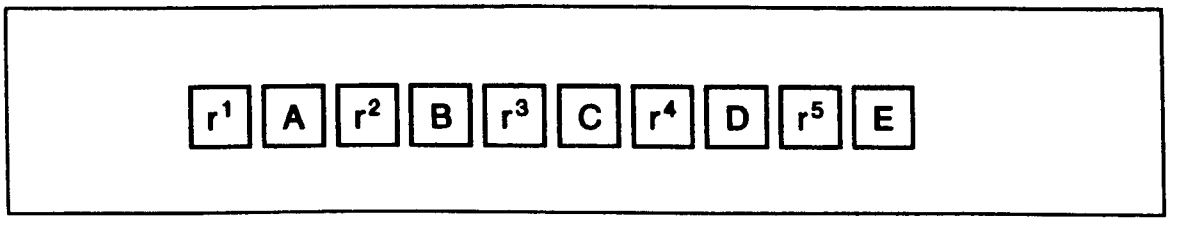


FIGURE 4.7 A simple refrain structure.

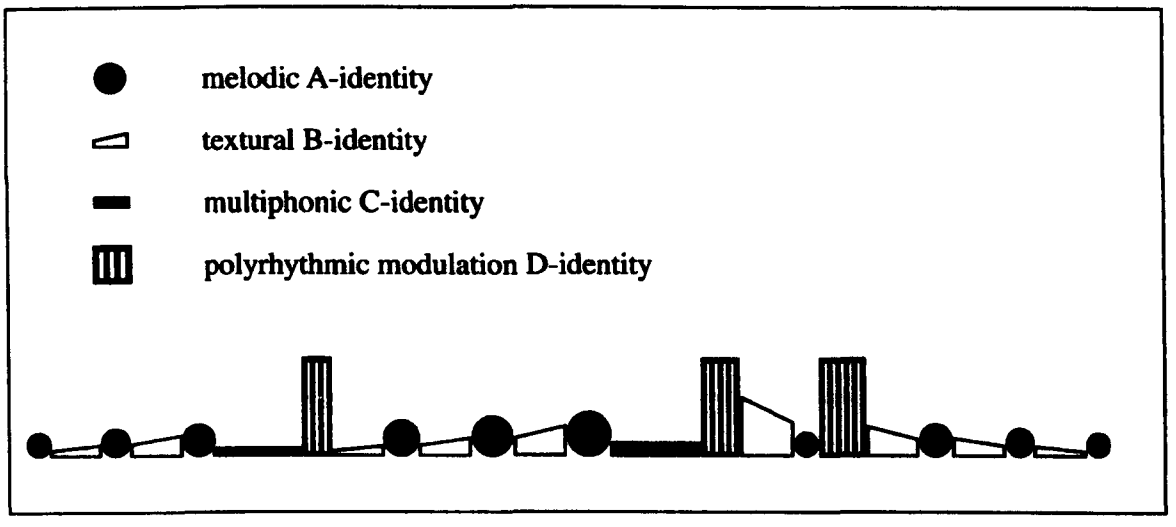


FIGURE 4.8 The form of *The 3 Faces of Karen Black, plus one face only for good measure.*

Interleaved Structures and the Psychological Present

A concept found in psychological literature, and one that is fundamental to the following hypothesis, is that of the *psychological present.* It refers to that part of a person's cumulative experience that is currently accessible to consciousness (Dowling & Harwood, 1986). For example, after hearing a sound we are usually able to hear a trace of that sound in our 'minds ear' for a brief period of time (Levitin, 1999). Atkinson and Shiffrin (1968) have referred to these immediate sensory memories as being held in a sensory buffer, which can be thought of as a sliding window in time that corresponds to the psychological present. Stein (1962) claims that immediate memory is limited in duration, with a timespan of roughly twelve seconds. More influential is Miller's (1956) argument that it is limited by the quantity of information, and specifically that limit is seven items, plus or minus two. There have been ongoing debates in the field of cognitive psychology regarding the validity of these limitation claims on immediate memory. However, all agree that there is some limit to the amount of information that can be stored, and once this limit is reached events are transferred into long-term memory. This is likely to have

important cognitive consequences for music because it would seem that perception based on long-term memory is significantly different than that based on immediate sensory perception, both in terms of mechanics and experience.

The capacity of the psychological present is not inflexible, but rather seems to be context dependent. Fraisse (1982) has found that the ability of a listener to group events can significantly extend the capacity of immediate memory because each group can then be treated like a single item. This seems particularly evident in the case of repeated material, as can be demonstrated by examining the typical 12-bar blues progression illustrated in figure 4.9. Assuming that the progression is in 4/4 and, for the sake of simplicity, only contains a chord on every beat, then the total number of events in the progression would amount to 48, well in excess of Miller's claim about the capacity of immediate memory. When listening to a 12-bar blues, however, the entire progression does seem to remain in the minds ear, most likely because the listener is able to chunk repeated material into larger units. Figure 4.9 suggests a likely grouping of a 12-bar blues progression, and viewed as such, the actual structure stored in memory is: I-I-IV-I-V-IV-I. Perhaps not surprisingly, this structure contains seven items.

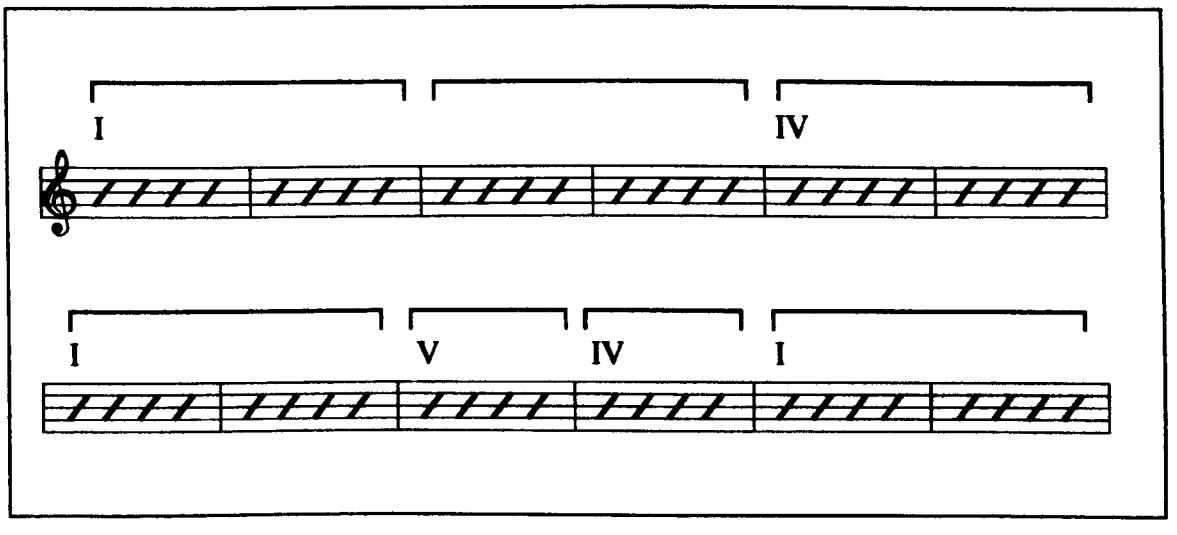


FIGURE 4.9 A 12-bar blues, with indications of a likely grouping interpretation.

The hypothesis proposed here is that segments of an interleaved structure will be interpreted as either sections or sub-sectional entities depending on whether they can be held in their entirety in immediate memory. When individual segments are within the scope of the psychological present then continuation is likely to be perceived as implicit and the segments as sub-sectional entities. Conversely, when individual segments are beyond the scope of the psychological present, either because their duration is longer than the maximum time-span or their information content exceeds the maximum capacity, then the segments are more likely to be perceived as distinct sections of the larger form. This hypothesis is speculative, based on personal experience obtained through my own composition activity. Admittedly, it may not be precise in its criteria or inclusive of all factors contributing to the perception of sectional and interleaved structures. Although formal perceptual studies are required before one is able to make definitive claims about the role of immediate memory on the perception of interleaved structures, it is maintained that the psychological present is, at the very least, one important factor.

Shaping Form with Predetermined Systems

Musical sections may be thought of as building blocks used in the construction of larger forms, and the structure of each section is significant because it defines one segment of that form. The structure of any section is largely determined by the manner in which the musical ideas are developed, and in my own music development is often controlled by predetermined systems.

Development that is contained within a single section is regarded as partitioned; it concludes either before or at the end of the section.[22] In such cases, and when the development is process-driven, the structure of the process is the structure of the section. One way of shaping form with predetermined systems, then,

[22] Although short-duration developments may occur that do not even last for the duration of the section in which they exist, it is when development at least occupies the entire section that it begins to make a direct contribution to the form of the piece.

is to use processes, and in particular, their motion, to create partitioned developments with clearly defined structures that can serve as individual musical sections. An example of a partitioned development with a clearly defined structure can be found in the C-section of *Seven Sisters —Pam* (score 5). The C-section functions as a coda, and is the result of a two-stage sequential process that produces a stair-stepped crescendo along with a timbral transformation from pitch to scratch tone in both the cello and guitar parts. The form of *Pam* is illustrated in figure 4.12, which shows the structure of the C-section at the end of the piece.

The continuous nature of interleaved structures offers an alternative to partitioned development. However, the segments of an interleaved structure may be perceived as sub-sectional entities or as distinct sections of the form, and this difference significantly affects the role that continuation, as well as local and structural motions of the processes involved, will play in shaping the form. Consequently, it is useful to make a distinction between *sectional* and *sub-sectional* interleaved structures, referring to the perceived relationship between the segments of the interleaved structure and the form.

Sub-sectional Interleaved Structures

Sub-sectional interleaved structures are those where the individual segments of each identity are perceived as sub-sectional entities. The entire interleaved structure may be confined to a single section, essentially acting as a partitioned development, and in such cases the combination of all developments defines the structure of that one section. As a result, the effect that continuation has on the larger form is limited to providing a sense of multiply-directed motion to that one section only.

Alternatively, sub-sectional interleaved structures can span across recurrences of an identity, in which case continuation may have a significant effect on the form because it now governs the development of each identity over large portions of the piece. In terms of perception, continuation has perhaps the greatest

potential in the context of sub-sectional interleaved structures that extend beyond a single section because the development of each identity is likely to be felt both implicitly at the local level and over the course of the piece. The C-identity in *Flap Jackson* (score 7, 15, 20) provides an example of a three-identity sub-sectional interleaved structure that is extended over the duration of the piece. The first identity consists of a triplet phrase of rising and descending tritones that grows in duration with each iteration. The second is characterised by short, staccato gestures that begin sparingly and increase in activity over the course of the three C-sections. The third identity is a single whistle-tone played by one flute, which serves to interrupt the activity of the other components. With each instance it decreases in duration, until the end of the piece when it disappears altogether. Figure 4.10 illustrates the structures of the three C-sections, with each of the identities represented by a different shape, so as to illuminate the continuation. The identity can be described as a transformation from scarcely gestural activity to a more dense and energetic texture, combined with a sense that the structural pace is accelerating due to the diminishing presence of the whistle-tone. Taken as a whole, the continuous development of the C-identity is one of the major factors affecting the growth of intensity that occurs in the piece. The entire form of *Flap Jackson* is illustrated in figure 4.11.

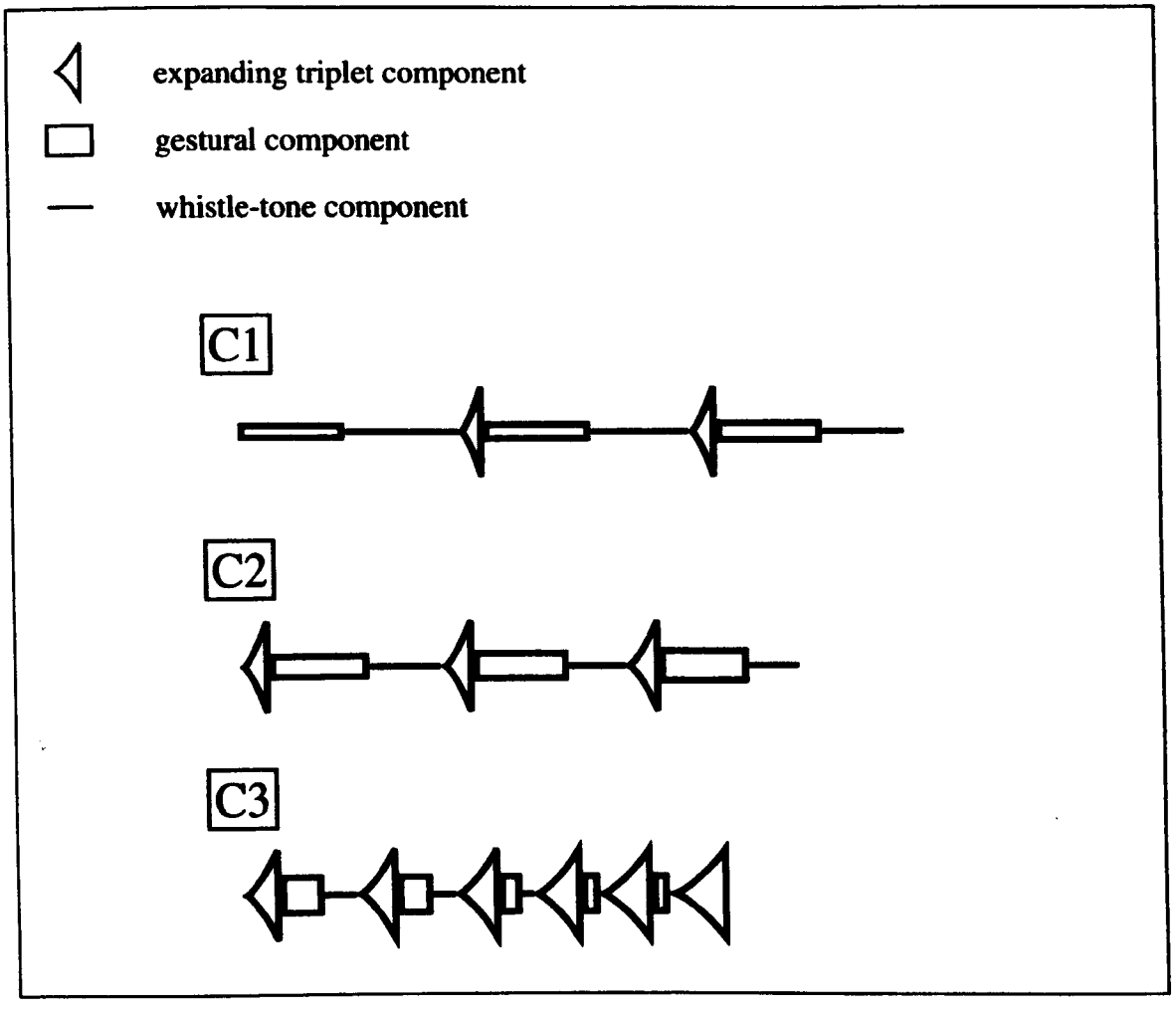


FIGURE 4.10 The structures of each C-section in *Flap Jackson,* illustrating a three-process interleaved structure.

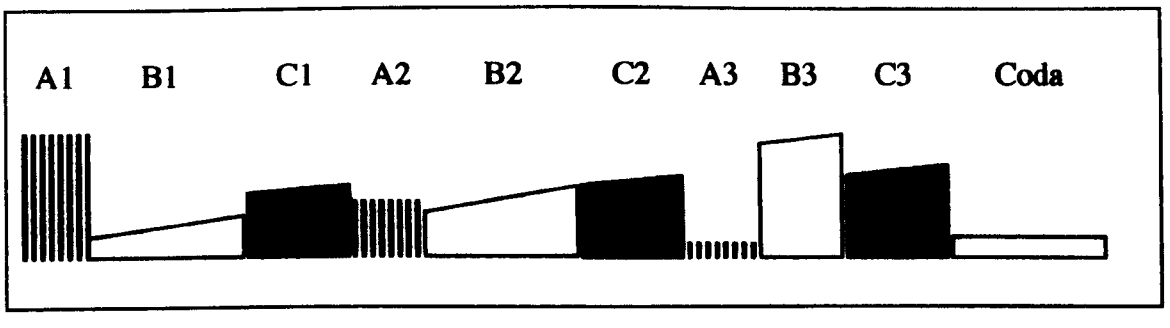


FIGURE 4.11 The form of *Flap Jackson.*

Sectional Interleaved Structures

An interleaved structure can be described as sectional when the segments of each identity are perceived as individual, recurrent sections of the holistic form. In such cases the interleaved structure represents the form of the piece, or some significant portion of it, and continuation plays a direct role in shaping that form because it defines the global development for each identity. Any sense of direction or motion that is projected from the identities is attributed proportionally to the piece as a whole. *Seven Sisters – Pam*, illustrated in figure 4.12, offers an example of a two-identity sectional interleaved structure with a third partitioned identity at the end. In *Pam*, the motions of the interleaved identities are in contrast, creating a tension in the form. The listener is likely to feel that the A-identity is increasing in intensity while the B-identity is decreasing over the course of the piece.

Assuming that the identities of a sectional interleaved structure are process-driven, one might be tempted to say that the local motion of each process makes a significant contribution to the structure of each section, while the structural motion plays a central role in defining the form of the piece. Although this claim is attractive, and indeed often true, there are exceptions. It is common for the structural motion of a process also to play a central role in defining the structure of each section, as is the case with the two identities in *Pam*, discussed above. If enough of the process is presented within a single section to sense the structural motion then it seems likely that the structure of the section will largely be defined by that motion.

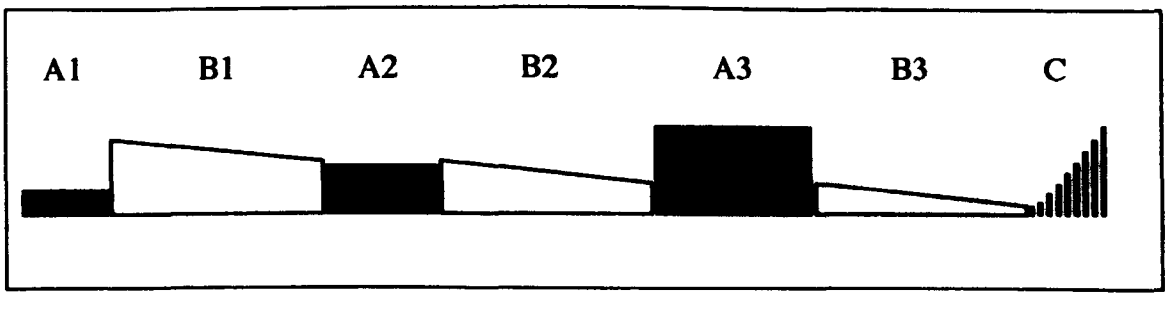


FIGURE 4.12 The form of *Seven Sisters – Pam*, consisting of a two-identity sectional interleaved structure.

Despite the difficulties that arise when trying to access the influence that structural motion has on sections, the role that it plays in shaping form in the context of sectional interleaved structures is unequivocal. It will contribute significantly to defining the form because it is now effective over the duration of the piece.

Dynamic Identities: Dynamic Relationships

When recurrences of an identity are treated as repetition, variation or recapitulation they often possess relatively constant surface qualities, although variation may result in an exaggeration or attenuation of them. As a result, the relationships between such identities tend to remain stable. For example, given two recurrent identities, X and Y, X may be the stronger of the two, and if its recurrence is one of repetition, variation or recapitulation then is likely to remain stronger throughout the piece. On the contrary, dynamic relationships are likely to emerge between identities when the nature of at least one of the developments significantly alters the surface quality. Although a given identity X may have been stronger than Y at the beginning of the piece, by the end Y may become the more dominant. When such developments are continuous and occur over large portions of the piece then this dynamism can have significant effects on the form. As the piece unfolds, the relationships between adjacent identities are re-evaluated and redefined by the current state of development in each. In *Flap Jackson,* the relationships between the A-, B- and C-identities are dynamic. Each identity appears in three instances in the piece, and always in the same order: A-B-C. The A-identity consists of a sequence of isolated events, which is repeated with each instance. In section A1 they are chordal, loud and forceful, with percussive attacks and a considerable amount of electronic extension. However, the intensity of these events diminishes with each recurrence of the identity so that by section A3 they have been transformed into soft single flute tones, lacking any sense of power. Conversely, the B- and C- identities are characterised by gradual increases in intensity, although they are brought about by different means and grow to different extents. The B-identity consists of a single

development while the C-identity is itself an interleaved structure. Of particular relevance is the change in relationship that occurs between the A-identity and the B- and C-identities over the course of the piece. Towards the beginning, the A-identity is by far the strongest, functioning as a pillar for surrounding sections. However, by the end of the piece the pillar role has been transferred to section B3, and in fact, A3 is the weakest in the entire piece. The form of *Flap Jackson* is illustrated in figure 4.11.

Structural Pillars

Structural pillars refer to high points of intensity that carry a perceptual importance in the form of a piece. They are usually some of the most intense or active moments. However, it is their perceived prominence that ultimately gives them their pillar status. For example, the goal of a directed development can function as a pillar, and even though it may be weaker then other moments or sections in the piece, it can win perceptual dominance because of its formal significance. Ideally, the number of pillars in a piece is small. As a general rule, one can say that the more pillars there are the less significant each becomes. There are, however, other limiting factors to the number of pillars, perhaps most notably the relationship between the pillar and the motion of surrounding identities. If the pillar is to satisfy expectations or serve as a goal for directed motion then adequate time may be needed for developments to unfold and those expectations to be established.

Instances of the A-identity in *And Then, Romina...* function as structural pillars in the piece. The A-identity appears in four variations and the surface quality of each can be described as loud, distorted and highly active, with a large amount of forward momentum. The fact that the A-identity is the first heard contributes to its pillar role. By simply being the first identity in a piece, subsequent appearances tend to feel not only like a return to familiar ground, but to where the journey started—a return home. Perhaps more significant, however, is the influence that the A-identity seems to exert over other sections in the piece. The motions of surrounding sections

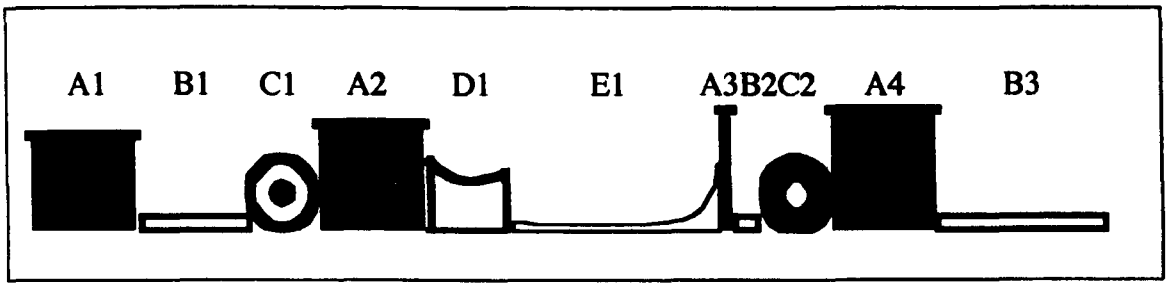


FIGURE 4.13 The form of *And Then, Romina....*

are either directed towards or away from the pillars, causing them to function as the goal of growing tension or as the turmoil out of which subsequent release is derived. In particular, sections C1, C2 and E1 contain structural motions that grow towards sections A2, A3 and A4, respectively. Conversely, the B-identity that follows three of the A-sections may be described as soft and sustained, with much less activity in comparison, and they contain structural motions that diminish in intensity, directing the listener away from the A-identity. This correlation of motions between sections creates a sense that the pillars function to hold up the piece; they act as centres of gravity that exert influence over surrounding activity. Consequently, there is a sense that the overall strategy of the piece is to depart from and return the A-identity. There are three complete A-sections in the piece (score 1, 3, 6), plus one incomplete instance (score 5). The form of *And Then, Romina...* is illustrated in figure 4.13.

Conclusion

Dramatic changes have occurred in music during the twentieth century. Of these, one of the most significant has been an interest in deterministic systems, which effectively remove the composer from moment-to-moment decision-making during the act of composition. As a result, musical decisions that were once motivated by judgements made by ear, in response to actual sound, are now replaced by decisions taken for conceptual reasons during the early planning stages of a work. This shift in aesthetics from affective to cerebral concerns raises important questions

as to the essence of music and why people enjoy listening to it, and it is for this reason that an emphasis on predetermined systems is such a significant development.

The ideas and original music presented in this writing are clearly influenced by twentieth century American Process music, and in this respect two concerns are of central importance. The first is a concern for the inseparability of content and form, which are inextricably linked in deterministic systems because the process generates both the local events and the overall structure. This unity can provide the music with a particularly coherent character and clarity of compositional intent. There is little ambiguity; the ideas are on the table, so to speak, to be objectively discussed and evaluated. Moreover, form is no longer merely a container that holds the musical ideas, but instead it becomes an inseparable aspect of the compositional intention of the piece. As a listener, I find that tangible and objective qualities are valuable in the comprehension of music, particularly in avant-garde contexts where much of the content is new, and I would like to offer the same in my own works. Secondly, I am interested in musical exploration and discovery, which I pursue by purposely evading my own perceptually intuitive tendencies. This is readily accomplished through the use of deterministic processes because the composer is removed from the moment-to-moment decision-making. There are, however, alternative and less extreme methods that can be deployed to evade such tendencies, and I refer to these as developmental processes. They exploit the fact that any rules made in advance of the moment-to-moment composition inevitably influence subsequent moment-to-moment ideas and judgements. By defining the limits and behaviour of a piece up front, creativity is directed towards ideas that might not have otherwise arisen. The concept of developmental processes that has been presented implies a heightened concern for the specific interaction between decisions made in advance and the effect that they will have on moment-to-moment decision-making. In my music, developmental processes usually consist of a great deal of determinacy, but leave some aspects open to perceptual intuition from moment-to-moment, either by the composer or performer. Importantly, they share the same concerns for the inseparability of content and form and exploration and discovery as their deterministic counterparts.

Another primary concern in the original pieces presented in this writing is that of creating sectional, and in particular, recurrent forms. These forms have an effect on the way we perceive and understand a piece of music. The ability to recognise a sectional identity upon its return and associate it with other similar sections provides clarity to the compositional intent on a formal level. Furthermore, recurrences offer listeners additional opportunities to hear and comprehend the musical ideas being explored. Lastly, sectional forms divide time, providing relatively frequent change in the music. Again, in contemporary music, where so much of the content is new, it would seem that sectional forms are advantageous to the comprehension and appreciation of a work and its ideas.

Predetermined systems and sectional forms might seem to be unrelated, and perhaps even conflicting compositional interests if considered in the context of Process music. Although there are similarities between my music and Process music, both in terms of aesthetics and application, there is one significant difference that deserves some reiteration. Process music tends to be concerned with unity at the highest level. A piece tends to be one idea, a process, which generates all events and ultimately determines the form. Clarity of compositional intent in such music comes from its simplicity; everything is explained—nothing is left to subjective interpretation. As a result, however, form in Process music is usually simple and monolithic. In my music, unity is not a central concern, but clarity of compositional intent is one of the highest priorities, along with a concern for creating compound forms. It becomes necessary, then, to draw a distinction between unity and clarity, at least on a formal level. A basic premise is held, which is that clarity in a complex form can be achieved assuming that each of the involved components is clearly defined and unambiguous. One way, then, to bring predetermined systems and compound forms together is to utilise the ability of deterministic processes to create partitioned musical units, each clearly structured due to regulated and controlled developments, which act as building blocks in the construction of larger forms. While unity in not an objective at the highest level, it often persists at the process level, as this leads to clarity with regards to that particular identity. Note, however, that there is nothing in this solution that specifically addresses the issue of

recurrence. Although recurrent forms may be created by the repetition of a section, perhaps with variation, such decisions are not intrinsically linked to the system. Greater clarity could be achieved if the recurrence were derived from the same predetermined plans.

Recurrence can be linked to predetermined systems by interleaving multiple deterministic or developmental processes. Interleaved structures are recurrent by definition, and when the segments of each identity are presented for a substantial amount of time then this can create a form with recurrent sections. Interleaved forms re-introduce an aspect of unity to the piece to the extent that form is determined by the combination of the processes involved, and each of those is, to some degree, deterministic. These forms arise out of the inevitability of the changing relationships between the deterministic processes involved. As with Process music, the composer is removed from moment-to-moment decision-making, at least in the most deterministic cases. The difference is that the composer chooses the processes to combine, and that decision is likely to be subjective.

Interleaved structures have a number of interesting qualities beyond simply serving as a mechanism by which predetermined systems and recurrent forms can be linked. Firstly, each identity maintains its independent structural motion, which continues through recurrences and over the duration of the piece. The full nature of an identity is often only revealed once a considerable amount of the piece has transpired. In this way, recurrence offers not only additional opportunities to hear the identity, but each return provides more information as to the character of that identity. Secondly, since an independent process governs the development of each identity, the structural motions can conflict, leading to a multiply-directed form. As a result, it is often not possible to describe interleaved forms as single developments, for example, that grow or diminish from A to B. Instead, they may develop from A to B, C to D and E to F all at the same time. Thirdly, developments can transform identities to the extent that their characters are significantly altered. With each recurrence, the segments of adjacent identities are compared and re-evaluated according to the current state of their respective developments. Since each segment of an interleaved structure only represents a small portion of the larger development,

these transformations lead to dynamic relationships between the identities as the piece unfolds. Lastly, having taken an interest in the potential dynamism of identities I have found that my compositional concerns have shifted, to a large extent, from vertical to horizontal. Rather than setting out to create distinct units of music that function as individual sections, the focus is on the relationships, with an understanding and intention of their dynamics. An approach to form can then be taken that is largely open to influence by the motion and structure of the processes involved. It is how the identities in a piece develop over time that defines form in these pieces.

APPENDIX I – COMPACT DISC CONTENTS

Process and Form: Music Examples

Example 1: Vertical convergence of structural motion in *Polyrhythmic Modulation Study No. 6 – Spectral Canon.*

Example 2: Horizontal convergence of structural motion in *The 3 Faces of Karen Black, plus one face only for good measure.*

Example 3: Divergence in *Polyrhythmic Modulation Study No. 3 – FMe.*

Example 4: Pitch as fixed nodes of resonance in *And Then Romina....*

Example 5: Harmonic drone in *The 3 Faces of Karen Black, plus one face only for good measure.*

Example 6: Electronic timbral beating in *And Then Romina....*

Example 7: Instrumental beating in *Flap Jackson.*

Example 8: Pitch as resonant tones in *Flap Jackson.*

Example 9: Texture as backdrop in *Slinky.*

Example 10: Texture as foreground in *The 3 Faces of Karen Black, plus one face only for good measure.*

Process and Form: Recordings

Track 1: *And Then Romina...*

Track 2: *The 3 Faces of Karen Black, plus one face only for good measure*

Track 3: *Flap Jackson*

Seven Sisters

Track 4: *Karen*

Track 5: *Flo*

Track 6: *Sally*

Track 7: *Pam*

Track 8: *Tina*

Track 9: *Kelly*

Track 10: *Jane*

Track 11: *Slinky*

Process and Form: Electronic Parts (Disc 1)

Track 1: *And Then Romina...* (cue)

Track 2: *3FKB+* (cue 1)

Track 3: *3FKB+* (cue 2)

Track 4: *3FKB+* (cue 3)

Track 5: *3FKB+* (cue 4)

Track 6: *3FKB+* (cue 5)

Track 7: *Flap Jackson* (cue 1)

Track 8: *Flap Jackson* (cue 2)

Track 9: *Flap Jackson* (cue 3)

Track 10: *Flap Jackson* (cue 4)

Track 11: *Flap Jackson* (cue 5)

Track 12: *Flap Jackson* (cue 6)

Track 13: *Flap Jackson* (cue 7)

Track 14: *Flap Jackson* (cue 8)

Track 15: *Flap Jackson* (cue 9)

Track 16: *Flap Jackson* (cue 10)

Process and Form: Electronic Parts (Disc 2)

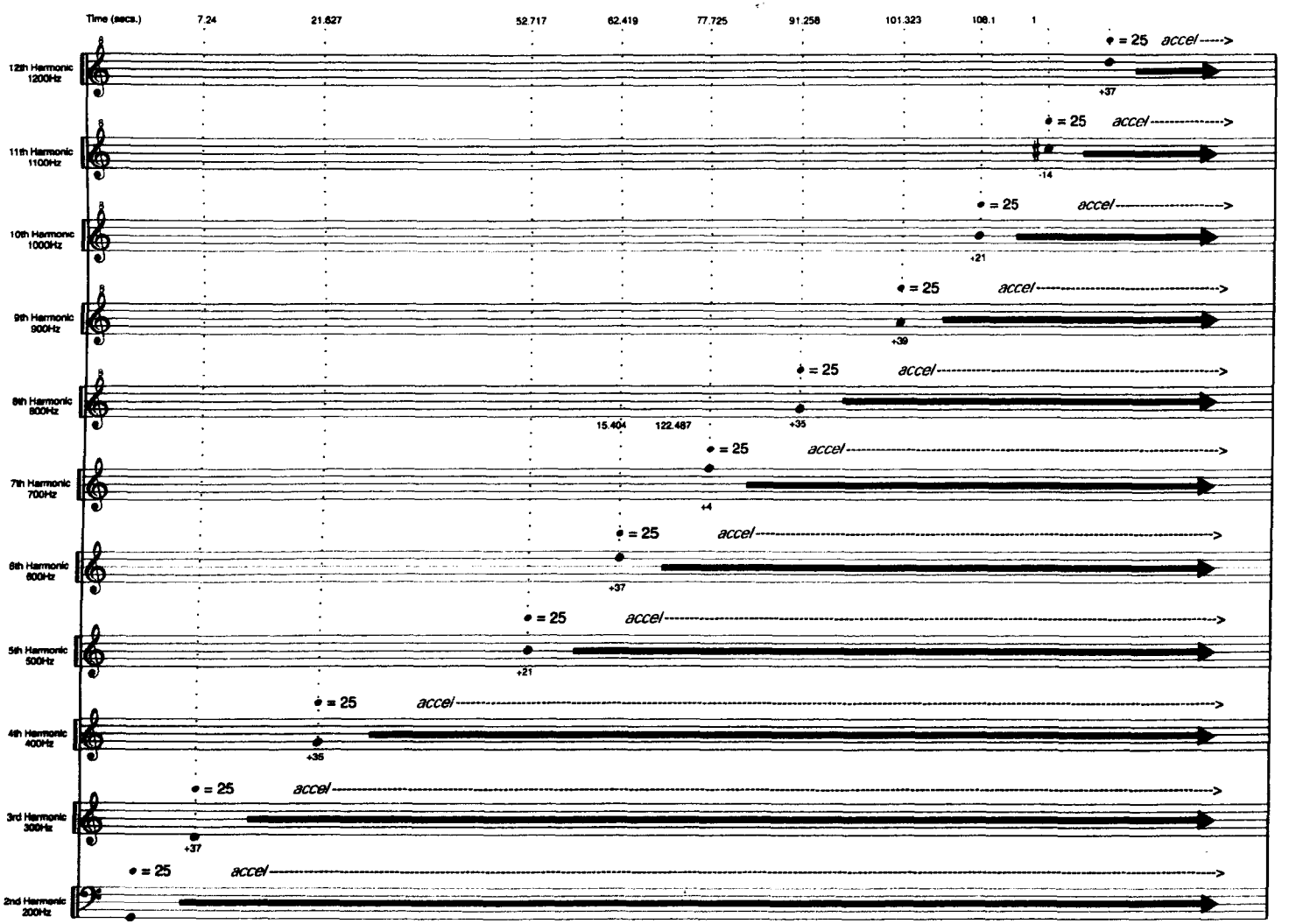
This is a Macintosh (HFS+) formatted CD-ROM containing the items necessary to perform the electronic part of *Slinky*. These include:

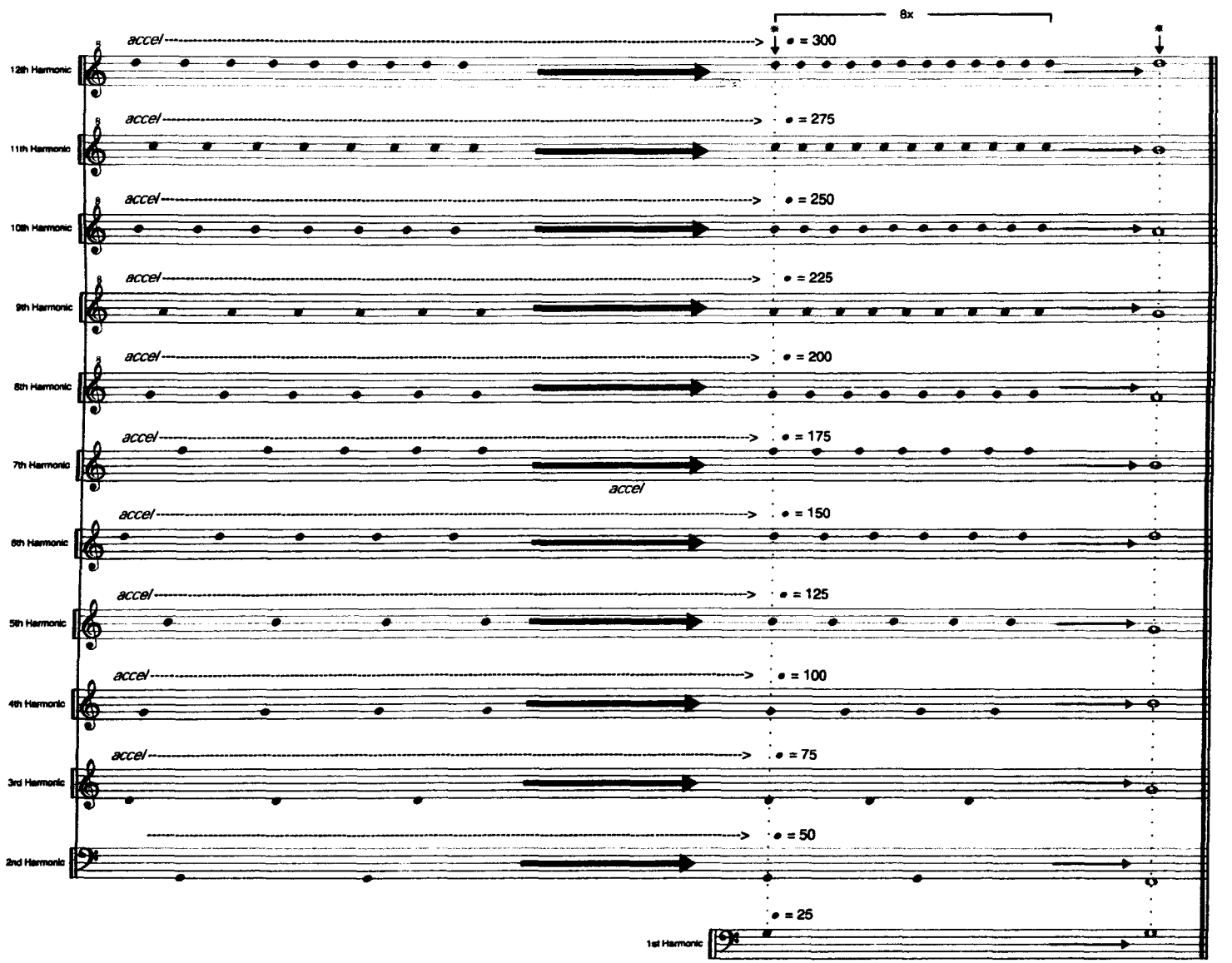
- 96 AIFF sound files, which serve as the individual cues indicated in the score
- A MaxMSP application, which is used by the performer to trigger the cues

APPENDIX II – SCORES

VI. Spectral Canon

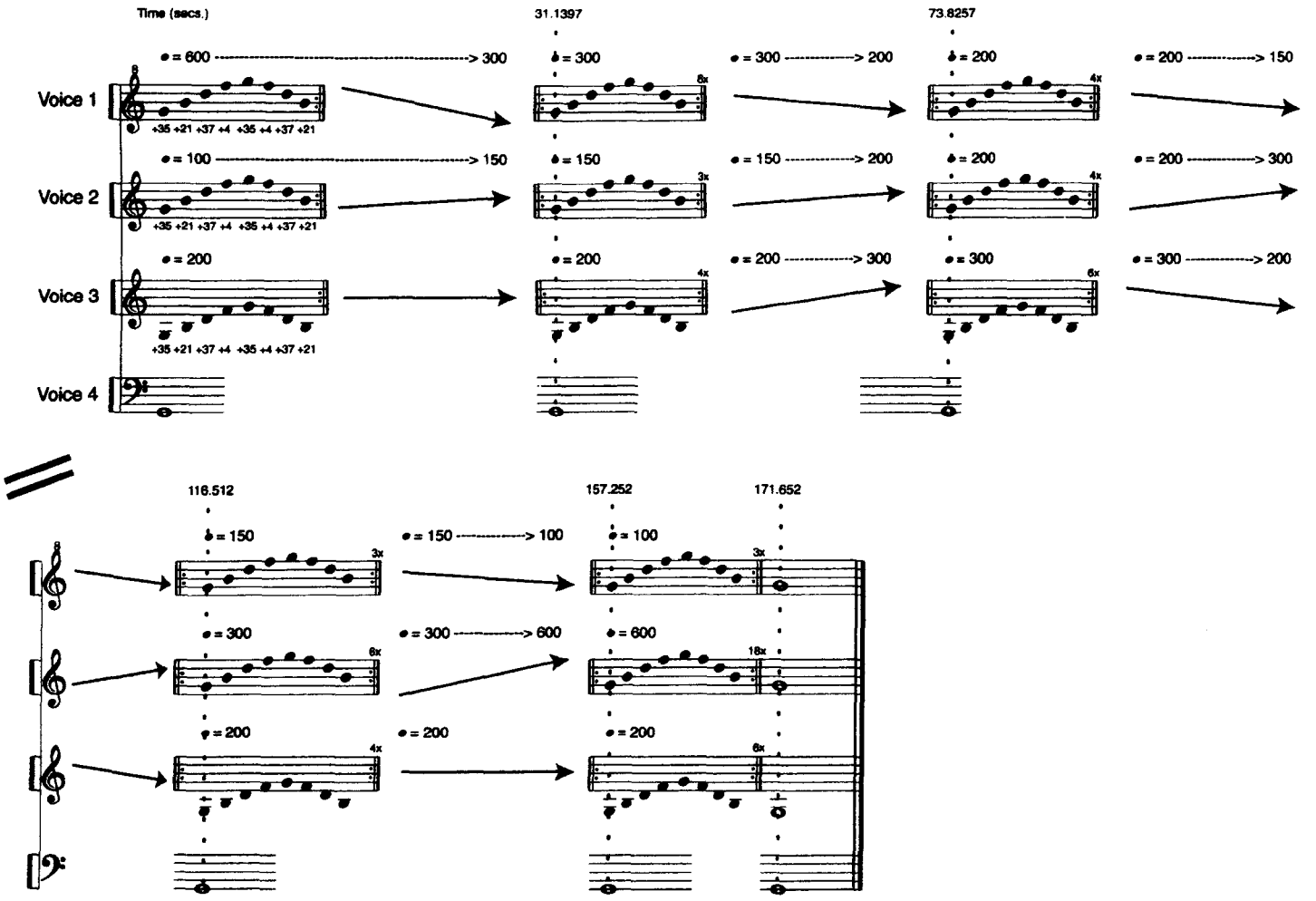
for computer-generated sound




8x
accel
♩ = 300
12th Harmonic
♩ = 275
11th Harmonic
♩ = 250
10th Harmonic
♩ = 225
9th Harmonic
♩ = 200
8th Harmonic
♩ = 175
7th Harmonic
accel
♩ = 150
6th Harmonic
♩ = 125
5th Harmonic
♩ = 100
4th Harmonic
♩ = 75
3rd Harmonic
♩ = 50
2nd Harmonic
♩ = 25
1st Harmonic

III. FMe

for computer-generated sound



REFERENCES

Allen, L. G. (1979). The Perception of Time. *Perception and Psychophysics*, 26, 340-54.

Apple Computer, Inc. (1989) *Audio Interchange File Format: "AIFF" — A Standard for Sampled Sound Files (version 1.3)*. California: Apple Computer, Inc.

Atkinson, R. C. and Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K.W. Spence and J.T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory (vol. 2)*. New York: Academic Press.

Bharucha, J. J. (1987). Music cognition and perceptual facilitation: A connectionist framework. *Music Perception*, 5, 1-30.

Bharucha, J. J. (1991). Pitch, harmony and neural nets: A psychological approach. In P. Todd and G. Loy (Eds.), *Music and Connectionism*. Cambridge: MIT Press.

Bharucha, J. J. (1993). Tonality and expectation. In R. Aiello (Ed.), *Musical Perceptions*. Oxford: Oxford University Press.

Bharucha, J. J. and Todd, P. (1991). Modelling the perception of tonal structure with neural nets. *Computer Music Journal*, 13, 44-53.

Block, R. A., George E.J. and Reed M.A. (1980). A Watched Pot Sometimes Boils: A Study of Duration Experience. *Acta Psychologica*, 46, 275-79.

Boulez, P. (1971). *Boulez on Music Today*. London: Faber and Faber.

Cage, J. (1957). *Experimental Music*. Hanover: Wesleyan University Press.

Cage, J. (1961). *Silence*. Hanover: Wesleyan University Press.

Campbell, M. and Greated, C. (1987). *The Musician's Guide to Acoustics*. New York: Schirmer Books.

Carter, J. and Kilgore, M. (1963). *Ring Of Fire*. Columbia Records (COL 66890).

Chomsky, N. (1965). *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. (1972). *Studies on Semantics in Generative Grammar*. Cambridge: MIT Press.

Chomsky, N. (1980). *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. (1986). *Knowledge of language: Its Nature, Origin and Use*. New York: Praeger.

Cone, E. (1968). *Musical Form and Musical Performance*. New York: W.W. Norton & Company, Inc.

Cutting, J. E. (1983). Four assumptions about invariance in perception. *Journal of Experimental Psychology: Human Perception and Performance*, 9, 310-317.

Dowling, W. J. (1978). Scale and Contour: Two components of a theory of memory for melodies. *Psychological Review*, 85, 341-354.

Dowling, W. J. and Fujitani, D. S. (1971). Contour, interval and pitch recognition in memory for melodies. *Journal of the Acoustic Society of America*. 49, 524-531.

Dowling, W. J. and Harwood, D. L. (1986). *Music Cognition*. New York: Academic Press, Inc.

Duchamp, M. (1966). Apropos of 'Readymades.' *Art and Artists*, 1, 4.

Dylan, B. (1965). *Like A Rolling Stone*. Sony Music (SNY03242).

Emmerson, S. (1986). The Relationship of Language to Materials. In S. Emmerson (Ed.), *The Language of Electroacoustic Music*. Basingstoke, UK: Macmillan Press.

Fiske, H. E. (1996). *Selected Theories of Music Perception*. Lewiston: Edwin Mellen Press.

Fodor, J. A. (1975). The language of thought. New York: Thomas Crowell.

Frances, R. (1988). *The perception of music*. Hillsdale, N.J.: Lawrence Erlbaum Associates. (Translation by W.J. Dowling of *La Perception de la Musique*, 1958).

Frengel, M. (1999). *Polyrhythmic Modulation Studies*. M.A. thesis, Dartmouth College.

Gibson, J. J. (1979). *The ecological approach to visual perception.* Boston: Houghton-Mifflin.

Grey, J. M. and Gordon, J. W. (1978). Perceptual effects of spectral modifications on instrumental timbres. *Journal of Acoustic Society of America*, 63, 1493-1500.

Handel, S. (1995). Timbre perception and auditory object identification. In B.C.J. Moore (Ed.), *Hearing*. New York: Academic Press.

Helmuth, M. (1992). Timbre Composition and Gesture. CCMRC Conference, Greece.

Hogan, W. H. (1975). Time Perception and Stimulus Preference as a Function of Stimulus Complexity. *Journal of Personality and Social Psychology*, 31, 32-35.

Jordon, D. S. (1987). Influence of the diatonic tonal hierarchy at microtonal intervals. *Perception and Psychophysics*, 41, 482-488.

Koffka, K. (1935). *Principles of Gestalt Psychology*. New York: Harcourt, Brace & World.

Kogan, N. (1997). Reflections on Aesthetics and Evolution. *Critical Review*, 11 (2), 193-210.

Kramer, J. D. (1988). *The Time of Music*. New York: Schirmer Books.

Lennon, J. and McCartney, P. (1964). *Can't Buy Me Love*. EMI Records (CDP 7 46437 2).

Lerdahl F. and Jackendoff R. (1983). *A Generative Theory of Tonal Music*. Cambridge: MIT Press.

Levitin, D. J. (1999). Memory for Musical Attributes. In P.R.Cook (Ed.), *Music, Cognition and Computerized Sound: An Introduction to Psychoacoustics.* Cambridge: MIT Press.

Meade, R. D. (1959). Time Estimates as Affected by Motivational Level, Goal Distance, and Rate of Progress. *Journal of Experimental Psychology*, 58, 275-79.

Meyer, L. B. (1956). *Emotion and Meaning in Music*. Chicago: University of Chicago Press.

Meyer, L. B. (1967). *Music, the Arts, and Ideas: Patterns and Predictions in Twentieth-Century Culture*. Chicago: University of Chicago Press.

Miller, G. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *The Psychological Review*, 63, 81-97.

Moore, B. C. J. (1997). *An Introduction to the Psychology of Hearing*. Cambridge: University of Cambridge Press.

Nattiez, J. J. (1990). *Music and Discourse: Toward a Semiology of Music*. Princeton: Princeton University Press.

Newell, A. and Simon, H. (1976). Computer science as empirical enquiry: Symbols and search. *Communications of the Association for Computing Machinery*. 19, 113-126.

Patel, A. D. and Peretz, I. (1997). Is music autonomous from language? A neuropsychological appraisal. In I. Deliège and J. Sloboda (Eds.), *Perception and Cognition of Music*. London: Erlbaum Psychology Press.

Partch, H. (1949). *Genesis of a Music*. New York: Da Capo Press.

Plomp, R. (1976). *Aspects of tone sensation*. New York: Academic Press.

Raffman, D. (1993). *Language, Music and Mind*. Cambridge: MIT Press.

Reich, S. (1968). Music as a Gradual Process. In *Writings About Music*. London: Universal Edition.

Reich, S. (1979). *Violin Phase*. London: Universal Edition.

Rumelhart, D. E. (1989). The architecture of Mind: A connectionist Approach. In M. Posner (Ed.), *Foundations of Cognitive Science*. Cambridge: MIT Press.

Rumelhart, D. E., and McClelland, J. L. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition (Vol. 1): Foundations*. Cambridge: MIT Press.

Slawson, A. W. (1968). Vowel quality and musical timbre as functions of spectrum envelope and fundamental frequency. *Journal of Acoustic Society of America*. 42, 87-101.

Shepard, R. N. (1981). Psychological Complementarity. In M. Kubovy and J.R. Pomerantz (Eds.), *Perceptual Organisation*. Hillside, N.J.: Erlbaum

Sloboda, J. A. (1985). *The Musical Mind: The Cognitive Psychology of Music.* Oxford: Clarendon Press.

Smalley, D. (1986). Spectro-morphology and Structuring Processes. In S. Emmerson (Ed.), *The Language of Electroacoustic Music.* Basingstoke, UK: Macmillan Press.

Smolensky, P. (1988). On the Proper Treatment of Connectionism. *Behavioral and Brain Sciences*, 11, 1-74.

Sparshott, F. (1987). Aesthetics of Music–Limits and Grounds. (1987). In P. Alperson (Ed.), *What Is Music?* University Park: The Pennsylvania State University Press.

Stein, L. (1972). *The ABC of Aesthetics.* New York: Horace Liveright.

Stein, L. (1962). *Structure and Style.* Evanston: Summy-Birchard Company.

Thomas, N. T. (1999). Are Theories of Imagery Theories of Imagination? An ActivePerception Approach to Conscious Mental Content. *Cognitive Science*, 23, 207-245.

Thoresen, L. (2002). Spectromorphologic Analysis of Sound Objects: An adaptation of Pierre Schaeffer's Typomorphology. The Norwegian Academy of Music.

Tovey, D. F. (1967). *The Forms of Music.* London: Oxford University Press.

Truax, B. (Ed.) (1978). 'Beats' in *Handbook for Acoustic Ecology* (p. 13). Vancouver: A.R.C. Publications

Winckell, F. (1967). *Music, Sound and Sensation.* New York: Dover Publications Inc.

Wishart, T. (1996). *On Sonic Art.* Singapore: Harwood Academic Publishers.

Wolff, C. (1998). Immobility in motion. New and Electronic Music. In *Cues: Writing and conversations.* Cologne, Germany: MusikTexte.

Wolff, C. (1999). Personal communication. Dartmouth College, Hanover, N.H.

Wright, A., Rivera, J., Hulse, S., Shyan, M. and Nelworth, J. (2000). Music perception and octave equivalence in rhesus monkeys. *Journal of Experimental Psychology,* 129, 291-307.