# COMPOSING AFTER COMPUTERS:
## The Application of Computational Metaphors to Musical Thought

by

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## Abstract

This thesis uses theory from cognitive science, artificial intelligence, the psychology of music and ethnomusicology to explore the evaluation and construction of compositional and listener music models.

Through comparative studies I provide differing systemic views of traditional and contemporary musics based on the assumption that problems of music interpretation across cultures is equivalent in form to the problems of interpretation of experimental music. In both cases, musical abstractions must be shared in order for music to be expressive.

I use Senegalese drumming to illustrate differences in western and African concepts of rhythm and aesthetics. Psychoacoustic evidence and cognitive theory are used to construct and evaluate compositional heuristics. Finally, the cognitive merits of works by the composers Igor Stravinsky, Luciano Berio and Pierre Boulez are evaluated.

The envisioned audiences for the thesis includes composers, music software designers, musicologists and cognitive scientists.

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*I dedicate this thesis to my father and mother  with love*

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# Composing After Computers
**Gregory M. Gargarian, June 1987**

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# Introduction

## The New "Common Practice"

The body of knowledge which accumulated in the centuries of western music writing from the late Renaissance to the turn of the century was called *common practice* writing. Shared by composer and listener alike, no other practice was desirable or conceivable. While many non-musical events have contributed to trends away from "common practice" writing, two conspicuous ones are (1) the emergence of 12-tone composition, and (2) the growing awareness in the west of non-western compositional alternatives.

These two events (around WWI) resulted in a variety of new compositional practices. Composing involves not only the writing of music but the practice of designing compositional method itself, indeed, thousands of methods, each more different than those encountered in the past. The variety of methods has increased due to the growing presence of technologies for synthesizing sound.

The design of compositional methods has become the new "common practice". Composers need a new theory to support the design and evaluation of compositional methods -- "compositional theory".

## Interpretation

For a new music to be successful there must be some agreement between the composer and listener about what is going on. For a given piece, a listener model is the collection of arguments the composer makes for how the effects and systemic coherence he has intended are recognizable to the listener. In traditional culture the composer and listener shared a common experience of musical meaning. Embodied in the notion of common practice writing was a listener model by which composers and listeners determined the intelligibility of musical works. Evaluation wasn't an issue because everyone knew what "success" meant. A composer's innovations were always framed in an established musical system and could be evaluated in terms of it. In contrast, composing and listener models are either absent or poorly articulated in experimental music. These issues are complex. They are based on a composer's personal experience, beliefs about human psychology, and understanding about the role of music in culture. Compositional theory should not be prescriptive. Rather, it should assist composers in formulating their questions over and over again about how compositional methods shape musical experience.

One way it can do this is by encouraging composers to make listener models. While composers are their own primary audience, their roles as composer are different from their roles as listener. The listener constructed model approximately reflects the composer's own model. But of the two roles, the listeners have the more demanding job because they have little access to the knowledge which gave rise to the composed work. Because listeners have only the evidence composers have given them, composers have to persuade themselves that the musical evidence provided the listener is, itself, recognizable. Compositional models must incorporate listener models. Compositional theory teaches us how to talk to ourselves in compositionally productive ways.

## Culture

A folk music which has survived the test of history, embodies clear listener models. Yet, in the 70 years of western ethnomusicology there are numerous demonstrations of musical misunderstanding in cross-cultural studies. Faced with a foreign musical tradition, the ethnomusicologist is in the same position as a listener of contemporary music.

In fact, listener models are culture specific. Each musical tradition has a corresponding "common practice", defining the meaning of musical concepts like "melody", "harmony", "rhythm" or "coherence". Each also describes the relations between concepts and their status in a musical system. Therefore, there are both conceptual and systemic differences which distinguish one tradition from another. Experimental composers who write works using unconventional systems must tackle the additional problem of transmitting the set of instructions by which a work is composed with the work itself! This requires fast learning during listenener modelling. Given the relatively short durations of real-time listening as compared with the much longer durations of armchair reflection, this is quite a challenge.

## Composer Evaluations

Musicians are sensitive to the fact that musical knowledge is hierarchic: musical elements combine into patterns, patterns into phrases, phrases into longer phrases, into sections and into pieces. Yet, a new problem arises when we compare the break between older and newer musical concepts, like 12-tone music's break from tonal music, or the problems of western-centered interpretations of non-western music. We find that our musical concepts and organizations are misleading.

From a compositional view, composers need ways of evaluating compositional systems, both those that have been built and those they are thinking of building. By looking at how systemic differences alter the meaning of musical concepts and how differences in the structure of concepts reflect the operation of a different musical system, composers may be able to acquire more control over the compositional methods they use.

One of the goals of a compositional theory is to marry notions about listener models with criteria for designing potentially expressive musical systems. Such a marriage may give rise to a common meta-language for discussing issues of aesthetics.

**Computational Metaphors**

Traditional cultures didn't have computational ideas and the power they provide for representing process-knowledge. The world of computation provides a variety of new metaphors for discussing the process knowledge by which concepts and systems are constructed and used. Such power is invaluable in thinking about composition because all the facts about a composition are not available to the composer until a work is nearly completed.

Current theory and experimentation in the brain as well as in computer sciences show that the mind performs its tasks using many concurrent and relatively distinct processes working in parallel. My approach to a computational formulation of music borrows assumptions made by these scientists. I assume that composition involves the use of many kinds of interactive problem-solving strategies and that musical interpretation involves the interaction of many kinds of recognition strategies.

The interactive and dynamic qualities of concepts in musical thought are difficult to pin down. It is useful to think of concepts as many parallel processes either controlling or controlled by others. I make a distinction between the musical abstractions (or ideas) which are used in evaluating a music's expressiveness and the compositional issues which are associated with constructing them. In the latter case, there is not one issue (or question, problem, etc.) to be addressed but several concurrent ones, each formulated so that its relation to others is not undermined. We can represent the control structure of these processes hierarchically with processes which are more important higher and those less important lower. "Hierarchy" is a way of representing the control structure of process-events. In contrast, "heterarchy" describes the succession of hierarchic changes;

that is, the system of controls over time. Such representation schemes capture the expressiveness exhibited by interesting thought.

Systems are always interactive. Faced with this complexity we can organize our inquiries into two types. We can ask questions about system: what are the musical parts, how do they function and how do they interact; and we can ask questions about the environment: how do changes in the environment change the properties of the system/s enclosed by it. These are complementary approaches.

### Audiences for this Thesis

Experimental composers are an important audience for this thesis. We seem to be living in an age in which all conventions are questioned. I believe that a music theory must respond to this climate of thought if it is to be in tune with its time.

Music software designers are another, equally important audience. I offer images at the intersection of musical and computational thought in the hopes of influencing the design of future music software. Most music software has either been driven by traditional musical ideas or conventional computing ideas but never by the synergy which might result from a bold re-construction of musical knowledge in computational terms. I believe that future music software, founded on such re-formulations of music, could result in composing environments and compositions as different from the music of the past as classical music is different from pre-notational music.

My approach should provide musicologists a different sort of analytic tool. A musical tradition establishes itself because it has found the most cognitively productive means for producing its music, given the available technologies. We should be able to ask questions like: "what is the best way to think about making music X?" Music analysis would involve the construction of synthetic models whose schemes for representing the production of the music would become the source of cognitive data about the musical tradition. In this way, the distinction between analytic and synthetic perspectives would disappear.

Compositional theory should be of interest to cognitive scientists. It is a discussion of the methods composers construct for doing things, strategies we construct for constructing methods for doing things, etc. A compositional theory attempts to provide a cognitive formulation of creative behavior.

## Chapter Summaries

Chapters 1 and 2, divided into listener and compositional models (respectively), are primarily theoretical and borrow ideas from cognitive psychology, artificial intelligence, music theory, the psychology of music and ethnomusicology. Chapters 3 and 4 demonstrate theory using African (Senegalese) and contemporary western music.

Chapter 1: Listener Modelling. A musical system is tied to non-systemic elements which are impossible to study without an understanding of extra-musical and cultural influences. Similarly, the composer's compositional strategy, tastes and beliefs inform the design of a musical system.

Listener models require the listener to discriminate between data which is more or less interesting. I describe how classification concepts give rise to definitions of interest, musical objects and the relations between musical objects. I describe the role of recurrence in establishing objectness and give examples of kinds of recurrence criteria. From a parallel view, there are many recurrence criteria that can operate simultaneously. Musical objects are transient things: the more kinds of criteria we have for recognizing them the more solid are object recognitions.

Modelling can be represented as a process of abstracting features from lower level objects to form objects and patterns at higher and higher levels. In my formulation, higher levels of abstraction lead to the patterns of thought which we experience as musically expressive. I connect affective issues to musical structure and argue that musical experience is like a game of hide-and-seek where processes which orient listeners are set against processes which disorient them.

Chapter 2: Compositional Models. Because concepts organize lower-level sonic elements and share attachments to them, musical concepts are mutually defining and interactive. Differences between musical traditions can be described as differences in the structure and status of concepts in the system. I compare the structure of western tonal music and 12 tone music to illustrate and argue that, because of conceptual and systemic differences, the kinds of problems which a composer must address and the heuristics used to solve them are often system-dependent.

In order for a music to be expressive, listener models must mirror compositional models. For this reason, I introduce bridging concepts to link compositional solutions and listener recognitions.

Musical experience is constructed from a sequence of moments. The communication of the whole from its temporal parts is supported by the kinds of musical concepts and heuristics which are used. I introduce strategies for evaluating a method's ability to relate parts to wholes.

Chapter 3: African Musical Concepts This chapter is based on data collected in Senegal (West Africa) in January 1987. I use this data (and supplementary readings) to illustrate conceptual and systemic differences between African music and western tonal music and how these differences reflect a different aesthetic and experience of music.

Chapter 4: Examples of Musical Modelling. The main task of compositional theory is to design and evaluate compositional methods. I provide four demonstrations using ideas found in chapters 1 and 2.

# Theory Overview

Chapters 1 and 2 are the pieces of my compositional theory. I view them as a toolkit of ideas to be applied in chapters 3 and 4.

### Object and Operational Representations

A relationship between compositional and listener modelling is necessary in order for music to be expressive. My compositional theory explores a variety of representations for describing compositional and interpretive musical thought. These forms of representation can be divided into two main types; those which are object-oriented (only metaphorically in the programmer's sense) and those which are operation-oriented. Both types of representations are designed to explain our experience of musical pattern by describing the concepts which make the construction and recognition of pattern possible.

> In the object-oriented approach, the recognition of pattern requires the mental ability to test for differences in the properties of objects. Two objects are identical if there are no recognizable differences between relevant properties. The relevance of properties is determined by the classification system used. From this view, a musical concept is a

classification system which describes an object according to a particular set of properties. These classifications describe the kinds of thoughts a composer and listener share.

In the operation-oriented approach, the recognition of an operation requires the mental ability to test for the transformational equivalence of two objects, where changes made in relevant properties of the first object result in the second object. Once again, relevant properties depend on the system of classification used. But here, a musical concept is viewed as an abstraction which places two objects in a causal relation. These relations between objects describe the patterns of thought which composers and listeners share.

## Parts and Wholes

While music is quite complex and expressive, compositional problem-solving and listener modelling are surprisingly narrow and shallow. I attempt to account for the connection between parts and wholes in a number of ways:

• Symbolic attachments, conflict-resolution patterns and networks of interest connect systemic elements, patterns and musical system to the extra-musical environment.

• The local theory constraint illustrates how moments can be constructed into wholes. For example, patterns are described in terms of the criteria which mark their recurrence.

• Distributed complexity illustrates how concepts interact to give rise to system. It requires concept modularity so that some issues can be considered without all issues having to be considered at once; and connectivity so that problems and solutions are mutually constraining.

• Retro-predictions and classification illustrate the processes of constructing musical abstractions. Retro-prediction results in the construction of operational definitions between related objects and classifications organize relations into types.

• Compositional constraints, heuristics and problem-solution chains illustrate how abstractions become compositional problems and how problems are made narrow and solvable as a result of their connectivity to other problems and solutions.

## The Structure of Musical Experience

The notions of "concept" and "system" are invariant across cultures even though the definitions of concepts and the character of each musical system vary widely. The following tries to capture the composer-listener models in one meta-hierarchy. It contrasts the **composer** (in **bold**) and *listener* parts (in *italics*). (Note that meta-levels #1 and #8 attempt to connect a musical system to non-systemic elements.)

lower-levels

↑

**Attachments constrain the choice of details.** **;composer**
*The culture shapes what musical detail is interesting.* *;listener*

**Concepts are defined.**
*Musical detail is recognized.*

**Objects are defined.**
*Criteria which describe musical objects are recognized.*

**Objects/concepts are related.**
*Concepts which determine object relations are recognized.*

**Relations are organized.**
*Organizational concepts are recognized.*

**Systemic parts are defined.**
*Organizational abstractions are constructed.*

**System is defined.**
*System is recognized.*

**Ideas about system are considered.**
*Systems are compared.*

↓

higher levels

### The Psychology of Musical Experience

Other concepts operate at various levels within this meta-hierarchy. They are the notions of home, masking and pace.

- Any time a controlling process is being defined, used or recognized, home-structure is involved.
- Conversely, any time home-structure is being manipulated, contrasted or made difficult to recognize, masking-structure is involved.
- Pace is an abstraction for the interaction of home-structure and masking-structure.

The value of home-structure and masking-structure is determined by extra-systemic attachments and interests. A musical system is significant because it becomes a macro-symbol of cultural experience; i.e. the way people think about their local world. Music is not only a celebration of thought, it is a celebration of human relations in a particular cultural system.

# Chapter 1: Listener Models

## 1.1 Methods: Roads to Compositional Theories

### 1.1.1 Describing Process

Books on music theory describe the harmonic conventions of past composers. Authors caution students learning this theory not to from apply music theory to music composition as they might follow a recipe. One can learn the properties of musical elements and ways they combine, but be unable to combine them using music theory. The process of writing music is a matter of "personal taste" or "self-expression". This perspective is reflected in the following quote by Walter Piston [1].

> Mastery of the technical or theoretical aspects of music should be carried out by [the composer] as a life's work, running parallel to his creative activity but quite separate from it. In the one he is following common practice, while in the other he is responsible solely to the dictates of his own personal tastes and urge for expression."

From this view, composition is a creative activity and one cannot theorize about creativity. Similar statements had been made about mathematics though for different reasons until Polya outlined mathematical heuristics in How to Solve It [2]. Mathematicians use *heuristics* -- or "rules of thumb" -- to bridge informal methods and rigorous proof. As Polya says:

> "Mathematics presented in the Euclidean way appears as a systematic, deductive science; but mathematics in the making appears as an experimental, inductive science."

Marvin Minsky finds a parallel in the traditional formulation of music theory [3]. Most people agree that traditional music theory is really music grammar, emphasizing musical syntax rather than musical semantics. Minsky argues:

> "At best, the very aim of syntax-oriented music theory is misdirected because they aspire to describe the sentences that mind produces without attempting to describe how the sentences are produced."

Later, he says:

> "A.I. [artificial intelligence] research seeks procedural descriptions first, which seems more appropriate for mental matters than formal syntax."

Before computers, it was difficult to imagine how complex processes could be fully modelled and tested. Mathematics served that role. Since computers, it has become possible to make rigorous models of qualitative processes by evaluating semantic issues in terms of how processes function in a model. "Procedures" are action-based descriptions. Heuristics are rule-based representations describing the behavior of these interactions. There are many other kinds of representations, each designed to improve our descriptions of qualitative thought.

### 1.1.2 From "Truth" to "Strength of Conviction"

Lerdahl's and Jackendoff's analytic approach to western common practice music is based on linguistics [4]. This work borrows its theoretical framework from the work of Noam Chomsky and the music theory of Heinrich Schenker. The earlier work of Schenker operates from the assumption that the practices of traditional composers reflect certain harmonic "laws" about human perception; for example, that the centrality of the I-V-I progression reflects the importance of the first few natural harmonics in a complex tone. Like Schenker, Lerdahl and Jackendoff make similar assumptions. Unlike Schenker, they attempt to describe how aspects of harmonic music contribute to the stability of these laws using *gestalt* grouping principles; for example,

> *proximity* : elements close in time are grouped together;
> *similarity* : elements that look alike are grouped together.

Lerdahl and Jackendoff introduce the notion of *preference rules* as a way of talking about the interaction of elements [5]; for example,

> Elements which are temporally close but dissimilar are grouped *less strongly* than elements which are close and similar.

The notion of preference relies on the important assumption that listening is an active, not passive, process. The incorporation of the notion of preference in analytic music theory is the most powerful contribution Lerdahl and Jackendoff make to music theory. With a notion of preference, analysis (or interpretation) can be represented as a process of negotiated solutions between competing grouping principles. Preference rules add process control to Chomsky's formalisms and Schenker's rigid analytic approach. Because elements can be cognitively grouped in a variety of ways, musical structure can be callibrated at finer levels of description and model richer musical experiences.

From the contemporary composer's perspective, I have two general criticisms of this approach.

1. What these authors call *gestalt* principles are higher-level constructs already formulated within a tonal musical framework. Much of the music written today is producing new musical traditions for which Lerdahl's and Jackendoff's *gestalts* may be irrelevant.

2. It is still primarily an analytic perspective. Composers need a synthetic one.

While their work is masterful and ground-breaking, Lerdahl's and Jackendoff's theory draws from a tradition of music theory, assumes a western musical system and focusses on musical products. In contrast, my theory follows from a tradition of composition, looks at "system" at the meta-level and focusses on the musical processes which lead to both composer and listener models of musical products.

These differences become more apparent as we look at Lerdahl's article "Cognitive Constraints on Compositional Systems" [6]. Lerdahl uses Pierre Boulez's composition *Le Marteau* sans *Maitre* to discuss the merits of serial composition from a western harmonic and analytic perspective. Lerdahl's view is that there is no cognitive justification for serialism. This may be true but not on the grounds of his and Jackendoff's analytic theory. They admit that their theory cannot be used as a model of the compositional process of tonal music though, as they say: "it is conceivable that such an enterprise [i.e. a compositional theory] could dovetail with our theoretical paradigm" [7]). Lerdahl can only say that the analytic machinery which he and Jackendoff have designed for tonal music does not apply in the analysis of serial music.

I agree with Lerdahl that music can be represented hierarchically, but I believe that concept definitions and their operation in particular systems are extremely variable across systems. Yet, Lerdahl's definition of "pitch space" rates transposition of scale high in status regardless of the music system used. I disagree. While it is certainly important in harmonically modulated music, it is less so in serialism and in many other non-western musics [8]. Similarly, Lerdahl's notions of "intervallic uniqueness, scale-step coherence and transpositional simplicity", which he borrows from Balzano [9], are all system-specific. I agree with Lerdahl that notions like "uniqueness, coherence and simplicity" are invariant characteristics which make "system" productive and accessible. However, I disagree that the particular concepts which demonstrate these characteristics are also invariant.

Lerdahl argues that a metrical grid strengthens one's ability to locate musical events, yet he takes for granted the fact that meter is inforced by higher level processes which can be traced to the control structure of tonal music itself. A "sense of meter" is defined by the functional role played by meter in tonal music and is not a primary perception. While a "sense of meter" is productive in listener models of harmonic music, it is not necessarily productive in other musical systems; indeed, it is even misleading in highly rhythmic music.

Lerdahl discusses how *gestalt* grouping principles contribute to the stability of musical objects and relates the interaction of "stability conditions" with preference rules. I agree with such arguments in form alone. Notions of musical recurrence, which determine the stability of musical objects, are rooted in recurrence criteria which are also system-specific.

Many contemporary scientists shy away from the perception/cognition distinction finding that "interpretation" happens near the points of sensory input [10]. From this view, *gestalt* principles are culturally shaped primitives to be distrusted during evaluation though, during practice, they may be fully embraced. In fact, I find it helpful to divide compositional theory into two strategies, one for evaluation -- i.e. those strategies which make invention easier to hear; and another for practice -- i.e. those strategies which make invention easier to do. These two strategies are not necessarily the same.

Lerdahl argues that compositional methods are becoming less and less attached to listener models. I agree that this is a problem though I disagree with Lerdahl's prescriptive approach. He argues that artificial grammars do not arise easily in human language. By "artificial" he means contrived as in serial technique. I view the natural-artificial distinction as unconstructive. Spoken language is full of invented slang expressions which violate conventional grammar. One of the most exciting features of poetry is that the poet shapes new metaphors through violations of conventional grammar and meaning [11]. Systemic violations are serious because they have implications for other pieces of the system. The notion of compositional constraints as well as Lerdahl's and Jackendoff's preference rules point to this. Yet, in interesting works, systemic violations are clues that other systems are in operation.

### 1.1.3 Incommensurability

New traditions continue to be established and no previous theory is likely to be adequate for very long. Not only are new theories gradually replacing older ones, concurrent theories and musics exist that are *incommensurable* [12]. Even the most casual readings in ethnomusicology illustrate this point. For example, Nettl's term *centrality* was introduced into ethnomusicology to draw attention to the problem of compositional pluralism [13]. He writes:

> "In any musical style, one or several features are more central than others and function as hallmarks."

Listeners unfamiliar with the musical conventions demonstrated by a piece cannot evaluate it on its terms. Evaluations are misguided because what is central to one's own tradition may not be central to the one being judged.

### 1.1.4 Methods

Traditionally, theorists have had to wait until a consensus formed around a compositional technique before they could describe what features were important, what devices composers used to write them, and how one was expected to respond to the music [14]. In contrast, composers occupy themselves with methods: they run musical experiments and compare their results to those run by other composers. If asked how they write a piece of music, composers answer by describing their methods; and if asked how they constructed their methods, composers compare them to previous methods they have used.

Don't such comparisons fall prey to the problems of incommensurability? They do if we think of method as formal rather than procedural theory. Unlike formal theory, compositional methods are practical. Each is a piece of knowledge -- a rule, constraint, strategy, heuristic, a memory, etc. -- used to build a musical system. Because the parts are somewhat separable, it is possible to inspect them against other pieces of knowledge. Only when they are joined with other pieces to perform some musical job does "system" arise [15]. The formalisms used to describe system are clear and rigid. In contrast, the methods we use to construct system are messy and flexible. Methods preceed theory. Only formal theory introduces the threat of incommensurability.

From the composer's perspective, the formulation of theory can be postponed indefinitely; however, without methods, composers have no way to think or work. They are lost.

# 1.2 Exceptional Thought

### 1.2.1 Musical Thought

A composer's musical thought is a process of negotiation among compositional methods. The system by which a piece is constructed is itself constructed along with the work. This openness of system is characteristic of human thought as well as natural systems [16]. Indeed, part of what music transmits is its structure from which we infer a compositional process [17]. The patterns, exceptions and patterns of exceptions reflect a composer's way of reasoning and are used in the construction of listener models.

The contemporary composer-theorist Arnold Schoenberg describes a musical *theme* as resembling a scientific hypothesis which "does not convince without a number of tests, without presentation of proof" [18]. Unexpected listening predictions can surprise us because we have learned that the musical features which lead us to making the predictions were misguided. Surprises put in question features which lead to them. The identification of features, the process of testing them against new musical evidence and the identification of new candidate descriptions can be thought of as the "musical logic" exhibited by a piece and listener models. The composer's job is to construct this logic and the listener's to model it.

Leonard Meyer's descriptions of music tend to be psychoanalytic, though they are remarkably similar to Schoenberg's [19]. His most interesting discussions concern how the composer shapes the listener's emotional responses to the music by either providing or withholding what the listener expects the music to offer.

> "Emotion or affect is aroused when a tendency to respond is arrested or inhibited" (Meyer).

Listeners form expectations about where the music is going as they listen to it. Meyer's notion of *tendency* comes from the affective energy of these expectations, an abstraction of the tendencies the music exhibits. A commitment to any tendency is weak at first. The listener constructs hypotheses about what will happen in the music and revises these hypotheses based on later evidence [20]. The listener also re-constructs the past based on present events.

In Meyer's view, expectations which are confirmed increase states of arousal. Tendencies which are in conflict inhibit each other, weakening arousal. That's why, he argues, music which is rich in conflicting tendencies is unable to have strong emotional impact.

> "The more equal the probability of different alternative consequents, the more likely that the musical progression will seem ambiguous." [21]

While strong tendencies dominate, weak ones grow as their presence becomes useful in predicting future events.

> "The deviants as well as the norms are finite in number, and it is both possible and likely that a deviant through constant employment may become so fixed, so common in its recurrence in particular situations, that the probability relationships of the system become modified by this recurrence." [22]

Detours through Schoenberg's "musical logic" provoke new listener models and emotional responses. Meyer's comments take Schoenberg's a step further. The identification of the arousal pattern -- the *logic of the exceptions* -- shapes one's affective experience. Arousal is a way of describing the listener's response to the rate composer's introduce new music structure. For arousal patterns to have an effect, they have to be set against structures and patterns already established. Exceptions break old patterns, and new patterns incorporate them [23].

### 1.2.2 Constraints

The reason musical thought isn't formal, isn't purely logical, is that "system" is a side-effect of the accumulation of incompatible methods. The reasoning in the development of a compositional system can be described best by the notion of *constraints*, a term borrowed from computer science. A compositional system becomes more and more rigid as problems are solved and choices and relations become binding. A system becomes less rigid if the rules which have been established are broken, leading to exceptions. As exceptions accumulate it becomes necessary to establish rules which determine when certain kinds of exceptions are acceptable. Establishing rules, breaking them, organizing exceptions, breaking them, etc. results in higher and higher levels of organizations which can support inconsistencies among sub-systems without undermining overall coherence.

Meyer's arousal patterns reflect the introduction of new levels of organization and new method in the system-building process. The disorienting effects of local inconsistencies are arrested by global coherences.

From this view, listener models approximately mirror the process of system construction in which the composer is engaged. At the psychological level, there is a correspondence between compositional structure and interpretive structure; otherwise, music could not shape human experience. The constraints which operate on the compositional process make listener modelling less difficult. Both composers and listeners need to narrow choice in order to organize events.

We might view *methods* as "constraints which give rise to concepts". From this view, a method has a musical justification and the collection of organizations a systemic justification. This approach places reasoning, rather than emotion, at the center of the discussion: "arousal" seems to occur when things don't go as planned and is "arrested" when new plans reflect how things are going.

A musical tradition, like a piece of music, has compositional conventions, constraints at a higher level still. Musically successful exceptions are incorporated into a musical tradition and give rise to changes in that tradition. These exceptions and the systemic changes provoked by them are what give each tradition its unique historical character.

## 1.3 Symbolic Attachments

Musical elements and structures are likely to have origins in systems of thought and action which are not strictly musical. The following three illustrations are rooted in extra-musical culture. Some elements and structures give rise to exceptional musical methods and systemic change. The term *symbolic attachments* suggests that their musical significance depends partly on their symbolic value in culture. Example 1 describes how images from nature and folk psychology have been symbolically attached to the elements of Korean musical figures. Example 2 describes how notes in a Chinese scale are attached to and reflect a social system of values. Finally, example 3 describes how a re-structuring of meter is used to induce trance-states among the Hausa in Nigeria.

### 1.3.1 Example 1: A Korean Musical Figure

In a lecture on Korean music in the fall of 1986 [24], Professor Byung Ki Hwang, a visiting scholar to Harvard's School of Music, stated that the use of melody in classical Korean music is contructed from melodic figures which are, themselves, quite complex musical

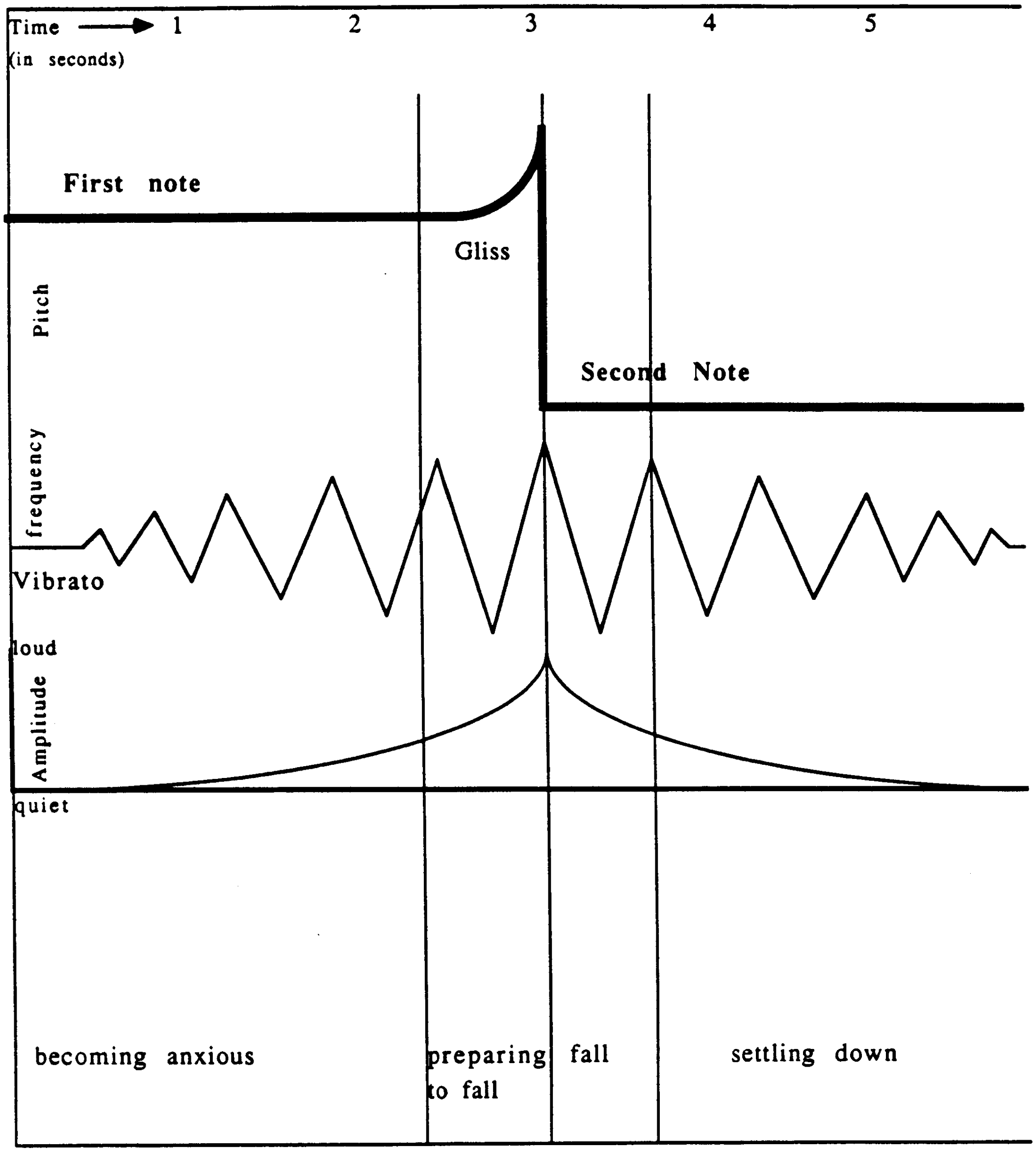



Figure 1: Anatomy of the Waterfall Figure

entities. The shape of each figure is controlled by construction rules which are different for each musical mode, by the text, and by aesthetic rules drawn from ancient Chinese court music. For the listener, the musical figure is a musical entity rich with meaning. I call this meaning *compiled knowledge*, again a term I borrowed from computer science, because listeners have no access to the lower-level detail which contributes to the richness they experience. In contrast, musicians, schooled in Korean music, do have access to these lower-level descriptions. They need them in order to produce the musical figures the listener hears. Again, borrowing from computer science, the term *interpreted knowledge* describes the musician's access to the lower-level detail. The distinction between compiled and interpreted knowledge is a useful one. We recognize the <u>effects</u> of compiled knowledge; in contrast, we investigate the <u>causes</u> of interpreted knowledge [25].

Prof. Hwang drew a graphic figure on the blackboard which he calls a waterfall (also the word used in the song-text where this figure appears). It represents a musical figure (figure 1) with two parts, each corresponding to a note and an upward slide (glissando) separating them. Prof. Hwang demonstrated the sound of the waterfall-figure with his voice. It was 6 seconds long and included a vibrato which became increasingly wide towards the glissando and decreasingly wide towards the end of the figure. Similarly, the figure became loud and quiet, peaking at the sliding note.

Prof. Hwang proceeded to describe the emotional response the waterfall-figure has by using the metaphor of a person sitting in a raft floating down a (note)stream. Figure 1 divides the waterfall-figure into the four parts described by Prof. Hwang: the growing anxiousness as the waterfall comes into view, the preparation for the fall, the fall itself, and the final settling down along the lower (note)stream.

A westerner might say "There's just two notes and a funny vibrato in the middle. What's the big deal!" However, the musical figure captures a great deal of expressive detail about the interaction of pitch with vibrato and amplitude which is of little importance in western traditional writing.

### 1.3.2 Example 2: Notes in a Chinese Scale

The following rules are a sample of those used by Chinese composers of traditional (Confucian) melodies [26].

**Some Rules for Writing Chinese Melodies**

1. A melody must use the notes of one of the Chinese modes.
2. The root note in the mode should begin and end the piece.
3. Measures and phrases are grouped in fours.
4. The notes that end a four-bar phrase should be the same as those which begin the four-bar phrase which follows it.
5. The notes in the last measure of a melody should descend.

There is little guidance from these rules to distinguish Chinese melodies from non-Chinese melodies. These rules gain power when applied to a system of scale notes which have symbolic significance in Chinese society.

**Symbolic-Attachments**

C = emperor
D = officials
E = people
G = events
A = things

Combining rule #2 with C = emperor we can construct the symbolic-attachment which I call the *emperor's rule*: out of respect for your emperor, melodies should begin and end with the emperor's note. Violating the emperor's rule is an act of treason.

Violations of this kind were occasionally accepted when they were musically extraordinary. My conjecture is that cultural constraints can give way to musical ones when exceptions result in new symbolic attachments rather than violations of old ones.

### 1.3.3 Example 3: The Hausa Trance Symbol

In Hausaland, located in the northern part of Nigeria, live the Hausa. Their society is highly stratified, usually according to occupation. A cult among the Hausa has institutionalized the practice of altered states of consciousness, *possession-trance* or what is called *bori* by the Hausa. *Bori* is believed to have curative power for people who are physically or psychologically afflicted. The afflicted are selected by *iskoki* -- supernatural spirits -- for cult membership. Those selected are called "mounts for the spirits" or "horses" which are "ridden" during cult initiation. Members of the cult are usually at the fringe of Hausa society; for example, divorced women ("prostitutes"), homosexuals and transvestites. Old members become mediums for new members of the cult. Mediums consult with native doctors for minor ailments such as clumsiness, impotence, infertility, rashes, stomach trouble, headaches, insanity, paralysis and leprosy. Mediums also cast horoscopes and occasionally seek advice from *malams* (Moslem teacher-scholars).

The cult musicians are not *bori* initiates. They stand as mediators between the "horses" and the gods who "ride" them. The trance induction process during *Bori* depends heavily on music; no ceremony is performed without musicians. Drawing from Besmer, I outline three trance inducing elements of the ritual [27].

Acceleration of tempo. Besmer identifies an evolution of tempo from 104 mm to 200 mm. The duration and tempo of the ceremony often lead to physical exhaustion making participants susceptible to trance states.

Increase in musical density. This is a side-effect of the increase in tempo and the introduction of rhythmic accents in the music. Perhaps, the increasing sound activity stimulates the mind in preparation for trance states.

Rhythmic shift from triple to duple meter. This is the most interesting point because the re-formulation of metric structure coincides with the trance-induction.

Figures 2, 3 and 4 are three examples of the evolution of rhythmic patterns during *Bori* (taken from Besmer). Figure 2 is played by a *garaya* , a two-stringed lute which is strummed. Figure 3 is played on the gourd players (of which there are many types). The first two show how a phrase evolves incrementally. In figure 2, the 3rd beat is swapped with another also in triple pattern, but with greater "density" (i.e. more notes). The 4th beat is swapped with one in a duple pattern. In figure 3, the 4th beat is the only one swapped, with a triple pattern being replaced by a duple one. The beat by beat exchanges lead to either the duple pattern or to an increase in activity. In either case, the middle two lines in figure 4 (in 3/4) give rise to the 2/4 measures.

Possession-trance is found in many cultures and is usually considered culturally patterned behavior. Initates of *bori* have to be taught trance behavior. Their speech patterns, songs, rhythms, dances and other distinctive body movements are acquired in the culture. Since trance behavior is learned, it follows that the changes in metric structure have become symbolize changes in mental state. Many cultures, like our own, do not have this particular symbolic-attachment between sound structure and psychological state. From this view, such associations are culture specific.

### 1.3.4 Remarks

Like the Korean musical figure, many musical concepts are opaque lto listeners. The Chinese example suggests that musical considerations gave rise to a relaxation of cultural constraints and new kinds of symbolic attachments. In contrast, the Hausa example

Figure 2: Rhythm pattern played on two-stringed lute

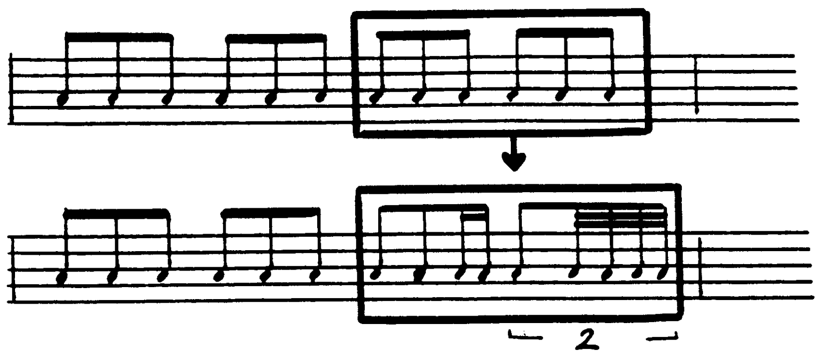



Figure 3: Rhythm pattern played on gourd

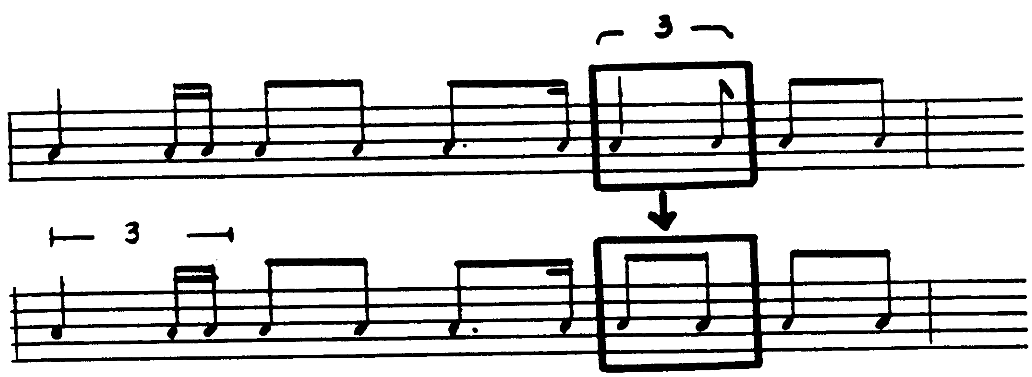
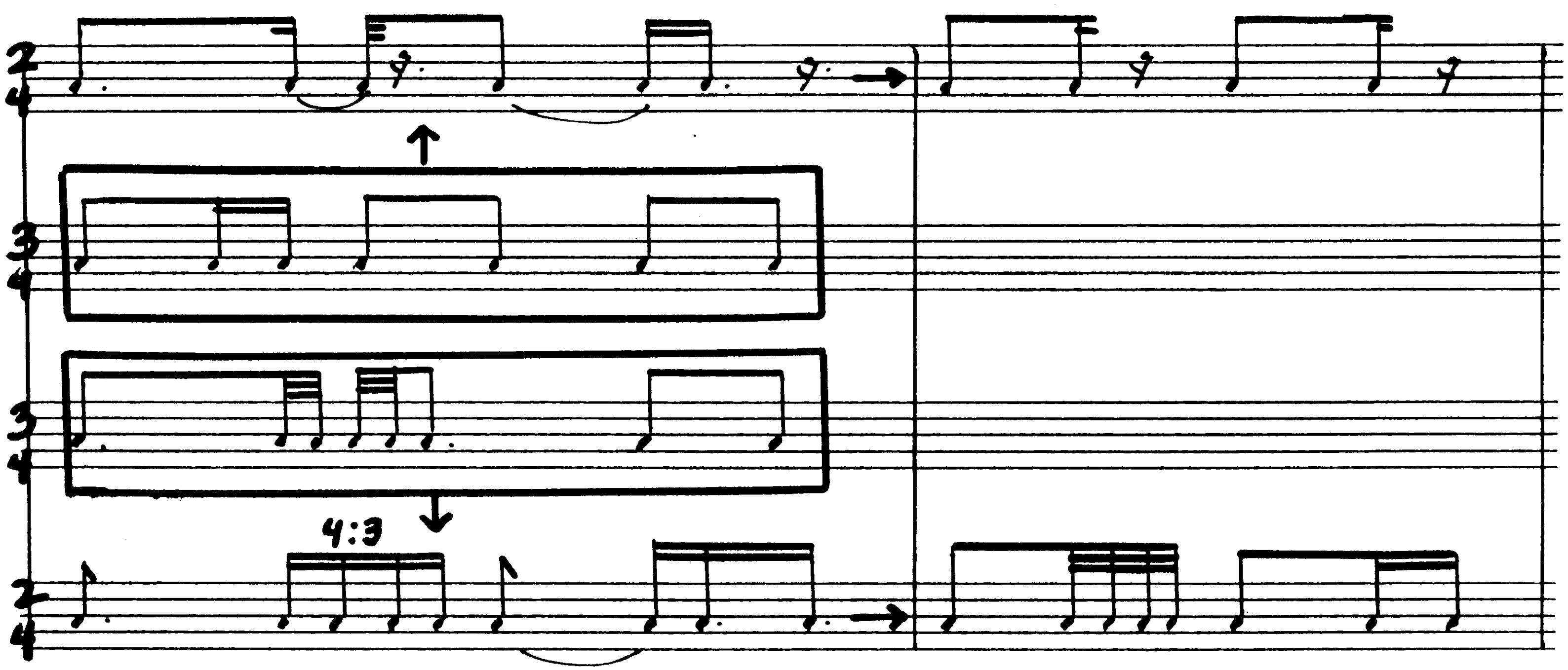


Figure 4: Tempo change during trance induction



illustrates a resistance to systemic change. Tempo and meter constrain lower-level music structure and are constrained by the cultural environment which they support. Possession-trance ties musical structure to stable pieces of non-music culture.

# 1.4 Discriminating Interest

## 1.4.1 Piaget's Cognitive Psychology

A listener model explains how the passing moments of sonic detail combine into musical primitives and how a complex musical experience is constructed from these primitives. For this reason I find the constructive approach of Jean Piaget illuminating. In his words,

> "Genetic epistemology deals with both the formation and the meaning of knowledge" [and attempts] "to explain how the transition is made from a lower level of knowledge to a level that is judged to be higher." [28]

Piaget's research shows how thought is bound to the psycho-genesis of intelligence. His perspective is applicable to musical thought; in particular, to the formation of sonic data into primitive notions of musical interest.

## 1.4.2 Actions, Drives, Evaluation

Objects can be defined in terms of the actions taken upon them. This is how Piaget describes the child's understanding of objects even in the first few days of life, during what Piaget calls the *sensori-motor* stage. At this time, the child's performance is genetically determined, given *actions* (or reflexes) are driven by inherited *drives*.

Initially, children apply actions to their environment in a relatively random way. These random sequences of actions become increasingly differentiated between those which satisfy drives and those which don't. Very quickly the most adaptative reflexes form into "habits" (or motor patterns). In Piaget's view, this differentiation is a result of children's evaluations of the effects of their actions. For example, when newborns are hungry, the sucking reflex is activated by any object touching their skin. After only a few days They refrain from sucking objects other than those which provide nourishment. They distinguish nourishing objects, those which satisfy hunger drives, from others [29].

### 1.4.3 Object Permanence, Goals, Procedures

At later stages of development, what Piaget calls the stage of *concrete operations*, children are able to build mental representations of concrete objects and evoke them in the absence of the objects themselves, what Piaget calls *object permanence* . The ability to differentiate between motor patterns requires mental machinery for selecting and organizing among drives and motor patterns. From this view, *procedures* are patterns of motor patterns, and *goals* are patterns of procedures, each giving rise to higher and higher levels of organization.

Reciprocally, goals can be defined in terms of the procedures which must be executed in order to satisfy them, and procedures as the motor-patterns which must be executed in order to satisfy them, etc. This process of building up and breaking apart higher-level structure provides the child possibility for control over complex actions and descriptions without the process-parts becoming much more complex than they already are. From this view, the <u>position</u> of process in a structure gives rise to new mental power.

### 1.4.4 Describable Properties of Objects

Piaget uses the experiments of Jerome Bruner and Lambercier to shed light on the notion of interest [30]. In Bruner's experiment, children were asked whether a collection of metal discs were the same size. In each collection of discs was a silver dollar. While all the discs including the silver dollar were the same size, subjects consistently over-estimated the size of a silver dollar in relation to the other metal discs. Bruner attributed this to the subject's greater *interest* in the silver dollar.

Also quoted by Piaget is an experiment of Lambercier using rod's of equal length instead of coins. Each time a child was presented two rods and told that one was "the standard" by which the comparison was to be made, the child saw the standard rod as longer. Piaget describes these results as an example of "perceptual *centration* " and argues that affectivity plays a role in the selection of the operations of thought not in their structures.

What could this role be? In the silver dollar experiment the attraction to the silver dollar the child's ability to say (think) more about it than about the metal disc. The silver dollar was both a metal disc and everything the child might be able to say about money; whereas the metal disc was only a metal disc. Similarly, Lambercier's rod was a rod plus what the child could say about the notion of "the standard". In both cases the objects with the greatest number of describable properties was the one of most interest.

However, the notion of "describable properties" requires a structuring of mental-objects into property classes. In both of the comparison experiments given above, children used their personal experiences in the evaluation of the objects of choice. Bruner and Lambercier asked the children to make quantitative judgments -- "how big? How long?" -- and got responses which they interpreted in a qualitative way -- "I think this one's more interesting". The children's experiences were not structured in a way which would help them to distinguish between the notion of "interest" and the notion of "bigger".

### 1.4.5 Classification

If a metal disc or the non-standard rod had been much bigger than the other items, the children would have pointed to them. "Interesting" and "bigger" become competing notions at a certain level of detail, giving way as the differences between the size of the compared objects became noticable. In the absence of the appropriate conceptual machinery, the children had no other choice but to consider the objects in a less discriminating way; say, as objects of "bigger" or "smaller" interest. The children couldn't tell what *evidence* mattered. The notion of "measurement" the experimenters were using would have told them that only a certain kind of knowledge was relevant to the question; namely, knowledge about the objects' size. The right answer to the experimenters' questions required that the subjects classify properties in terms of the relevant properties. Without this ability, the subjects were not able to answer the pre-requisite question; namely, what counts as evidence.

### 1.4.6 Musical Interest and Evidence

In order to identify and relate musical events a recognizable pattern must exist. The notion of object permanence describes the stability necessary for such recognition to take place. The more we can say about a musical pattern (or object) the more interesting it is. The different things we can say about it have to do with how many properties a musical object has. It is because these properties are classified that we are able to identify relevant properties and object relations.

-----------A Classification of Properties---------

| Objects | Property 1 | Property2 | Property3 |
|---|---|---|---|
| Object 1 | X | X | - |
| Object 2 | | X | X |
| Object 3 | X | X | X |
| etc. | | | |

For example, the above hypothetical objects are classified according to three properties. The first two objects have two properties, the last one three properties. All the objects share at least one property with all others, namely property 2 which becomes "most interesting" with respect to this classification system. The classification system makes the objects interesting because of the number of ways objects are related by it. A different classification system may feature other object properties and other object relations.

*Classification concepts* serve the role of connecting objects by properties deemed relevant by that classification. Classification concepts which are interesting are those which produce many relations.

Musical interpretation requires a knowledge of how consecutive events relate to each other. Productive classification concepts reflect music organizations because the events recognized relate to each other. Productive class concepts will often do more than show familiar relations. They can lead to the discovery of new properties and provoke the use of other classification concepts. For example, we may recognize property 2 shared by objects 1 and 3 (above) and property 1 which we recognize only in object 3. Through comparisons to object 3 we can discover property 1 in object 1. Identifying musical objects, properties or classifications provides evidence which can be used to detect other musical objects, properties or classifications. We use this evidence to build our musical models and to structure our experience.

## 1.5 The Structure of Experience:
### Retro-Prediction, Classification, Conflict-Resolution

From an object-oriented view, the more properities one is able to recognize the more one is able to capture similarities from which relevant musical relations can be constructed. From an operation-oriented view, the more one knows about the musical operations which connect musical objects the more one will know about the objects themselves. To say "that was a transposition" is to describe the relation of two objects at a higher level of abstraction. Operations can acquire the status of objects at a higher level; for example, *transposition* is an operation which we recognize.

### 1.5.1 Musical Causality

The 20th century composer Igor Stravinsky was asked by some writers to describe his creative process [31]:

> "It's not the composer who is creative. He knows exactly what he is doing. Rather, it's the listener who, with little evidence to go on, has to exhibit creativity in order to identify what the composer has put in the music."

Because of the difficulty of constructing models, the listener uses whatever means available to recognize objects and object relations. An object-oriented approach looks only at the objects. An operational approach tries to model the production process itself by getting to relational knowledge.

The operational view is a process of *retro-prediction* where "causes" are built, evaluated and revised until they match recognized effects. Retro-prediction is supported *causal pairs*, the pairing of sequences of musical events in lawful relations (e.g. transposition). Retro-predictions are constructed from causal pairs and classifications of causal pairs at higher and higher levels of abstraction until a musical model is built which accounts for all interesting evidence.

There has been a great deal of discussion about whether it is appropriate to look at the relations among thoughts as "causal" relations [32]. "Causality" can be described what what it isn't.

> -The relations among causal-pairs are not random. Thought exhibits too much coherence to think of these relations as random.
>
> -It's impractial to think in terms of the "billiard ball causality" of physics. There are too many options and too much hidden complexity in mental activity and in the environment's affect on this activity to equate recognized mental events with physical principles.
>
> -Causal relations are not purely intentional relations of the "free will" sort. Composers are not free to do whatever they want. Theirprevious choices and the system they construct strongly constains their current choices.

Composers have characteristic patterns of thought usually described as their compositional style . The composer seeks compositional coherence. Coherence brings aesthetic balance, makes problems easier to solve, interactive, rich, etc. *Musical causality* is equivalent to phrases like "reasoning paths" or "characteristic patterns of thought". They are abstractions which attempt to describe the composer's ordering of events.

### 1.5.2 Retro-Prediction

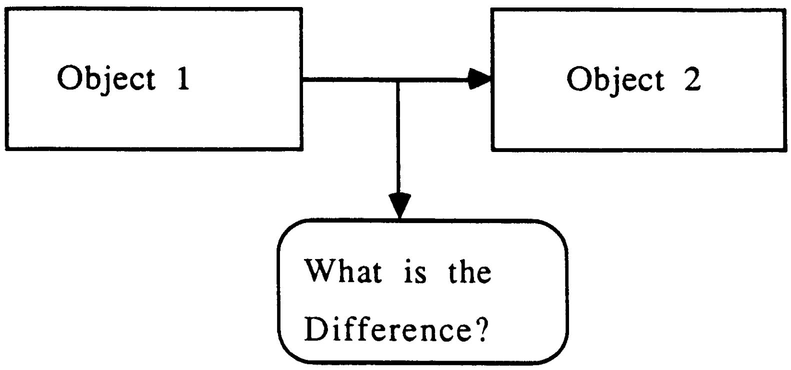
Identifying patterns and constructing models of our experience is difficult. Most "real world" interactions are full of ambiguity and conflict. Indeed, the music theorist Leonard Meyer spends a lot of time discussing musical interpretation as a process of reducing ambiguity by revising interpretation [33], much like retro-prediction. In figure 5, point #1 shows two objects which we suppose are similar in many ways and different in others; for example, object 1 may be a melody and object 2 a very similar melody starting on a different pitch. Let's assume that melody 2 (object 2) is a transposition of melody 1 (object 1). The question we ask ourselves is "what is the difference between these two objects?". We already recognize that one difference is the starting points of each melody. We may discover that there is a one-to-one correspondence between the notes in each melody which brings us to point #2. We identify the difference between objects 1 and 2 as a constant pitch-interval. We now wish to identify an operation which might account for this difference. We are wise to select transposition as the operator which brings us to point #3 where we test our hypothesis about transposition by, mentally, applying transposition to object 1. Since we find that the result matches with object 2 we are confident that our *causal pairs* theory reflects the musical reality we hear.

To recognize that a melody has been transposed may take a fraction of a second. Still, the ability to construct this model is supported by a kind of *difference* (i.e. pitch-interval) and facilitated by an abstraction of a pattern of differences into a kind of operation (e.g. transposition).

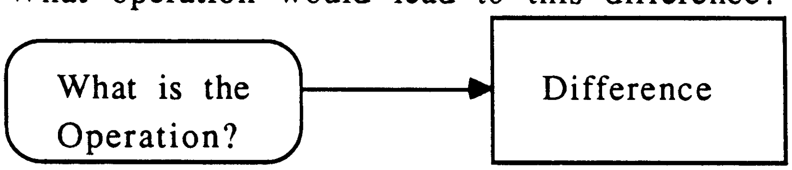
In a more complex musical situation, our predictions may not work the first time because many kinds of differences are involved. Still, the operational approach is interesting because it is a way of constructing higher level abstractions which are close to the compositional idea which generated the musical result. As listeners, we hope to move increasingly towards the composers patterns of thought using lower level abstractions to construct higher level ones.

Figure 5: Retro-prediction: making causal pairs

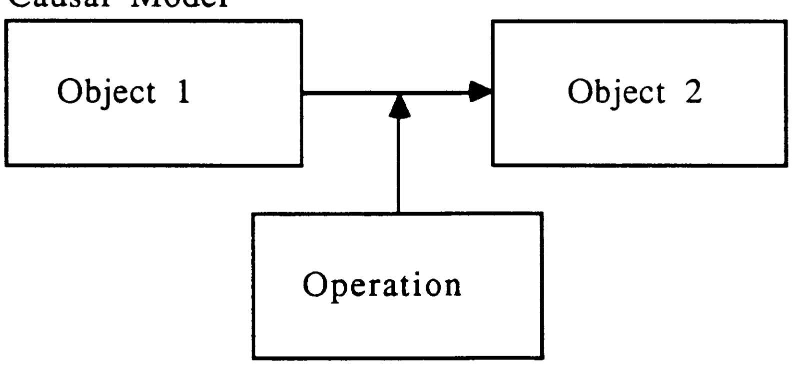
**1** What is the difference between objects 1 and 2?




**2** What operation would lead to this difference?




**3** Causal Model



### 1.5.3 Resolving Conflicts Among Models

Perhaps, the source of this emotional response is when there is a mis-match between a model and reality. The model building process has a construction sub-process and an evaluation sub-process. An unsuccessful match requires the construction of new models and new models require further evaluation. The complexity of music causes frequent conflicts between expected and observed effects. The presence and resolution of conflict determines our emotional responses and the way conflict-resolutions are patterned determines the shape of our musical experience at the higher level.

### 1.5.4 Abstractions: Cause-Classes and Classed-Causes

Causal-pairs are naturally organized by the order in which they appear. Time organizes causal-pairs just as it organizes pitch-pattern or rhythmic-pattern at the lower level. Yet, temporal order is not sufficient. Causal-pairs are classified into types, or *cause-classes.* When many cause-classes have been made it is necessary to organize them. Such an organization requires a classification system at a higher level which groups causal-pairs into types, or *classed-causes.* When such a classification accounts for all the interesting evidence it is again possible to organize them into causal patterns, etc.

This recursive process makes the output of one process of abstraction the input of the other. The conceptual utility of such a model is that parts never become very complicated before new levels of abstraction are produced. In addition, macro-descriptions help us to recognize complex events like a musical climax, recapitulation or transition.

### 1.5.5 Conflict-Resolution Patterns: The Musical Fairytale

The child psychoanalyst Bruno Bettelheim writes about the importance of fairytales in the emotional development of children. In Bettelheim's book he says:

> "For a story truly to hold the child's attention, it must entertain him and arouse his curiosity. But to enrich his life, it must stimulate his imagination; help him to develop his intellect and to clarify his emotions; be attuned to his anxieties and aspirations; give full recognition to his difficulties, while at the same time suggesting solutions to the problems which perturb him." [34]

The safety of fairytale thought is symbolized by phrases such as "once up a time", "a thousand years ago", or "at a time when animals still talked". Bettelheim says that because the child is unable to deal well with conflicts, the fantastic quality of fairytales, signalled by the way they are introduced, makes the child an observer of the conflicts they portray. The fact that fairytales make clear the differences between "right" and "wrong" makes the conflict easy to see. Children recognize "right" and "wrong" and situations of conflict by drawing from their personal experience. They believe that they are good and take sides in the conflict, though they also experience, through the characters, the fact that the good characters often behave in a manner which becomes the source of conflict.

In the world of fairytales conflict is always resolved with "right" winning and everyone living "happily ever after". This is very comforting to the child. Still, it is through exposure to conflicts and a resolution of them that children gain knowledge about the organization of their own feelings. Children are matching situations of conflict in the fairytale with those in their own lives. The fairytale organizes these situations as a story. By remembering the story, children acquire a *conflict resolution pattern* they are unable to generate on their own.

According to Piaget, pre-adolescent children cannot reflect on the experience of others. Instead, they experience the world only from their own perspective. What Piaget calls *egocentration* is the child's inability to generate a multiplicity of perspectives necessary for conflict-resolution. Piaget's *decentration* is the process by which children acquire this ability.

For Piaget, fairytales fullfill the function of "symbolic play". Through symbolic play children "bend reality" to their wishes without having to endure the effects of their actions [35]. The conflict-resolution patterns proposed by fairytales are memory episodes which children imitate and gradually modify through interactions with their environment.

The idea of a musical conflict-resolution pattern is a way of theorizing about "musical reality" which uses retro-prediction to build cause-classes and classed-causes. The previous description of the interaction of causes and classes used a bottom-up approach wherein operations formed objects and objects formed operations at a higher-level. A top-down viewpoint reverses this process. From this view, a conflict-resolution pattern is a proposed theory about the musical organization. This organization is evaluated and refined using lower-level descriptions as confirming or refuting evidence.

Seeing conflict-resolution patterns as theories about a music's organization is similar to what Papert calls a *transitional object* (or theory), borrowing from clinical psychology. In

Papert's computer-based learning environment a graphic object, called the "turtle" is used to draw graphic shapes in response to instructions given in the Logo programming language. A Logo programming environment places the child in contact with important mathematical ideas before the child is able to describe them in formal mathematical terms. The turtle is a transitional object which gives the child access to mathematical experiences [36].

A conflict resolution pattern is a mental object or pattern memory which allows the listener to make contact with the music through which deeper knowledge can be obtained. For example, a musical transition is a collection of processes which Schoenberg characterizes in the following way:

> "The structure of a transition ordinarily includes four elements: establishment of the transitional idea (through repetition, often sequential); modulation (often in several stages); liquidation of motival characteristics; and establishment of a suitable upbeat chord." [37]

Each aspect of Schoenberg's definition of a transition is, itself, a complex process. We must be able to build abstractions which account for the salient features of a transition so that we can "fill in" the details from the current work to which we are listening. When we have a theory that a musical event is a kind of transition, we evoke recognitions systems which are appropriate for investigating them. Even if we are wrong, there are only a few options which remain because our hierarchic model controls the number of available choices.

### 1.5.6 Hidden Causality

Retro-prediction does not always work. Processes which lead to the results one hears can be quite hidden. The ethnomusicologist Bruno Nettl describes the evolution of Appalachian folk tunes from an original tune [38]:

| | |
|---|---|
| | with the parts, |
| [A B C D] | abbreviated in later versions to |
| [C D] | with new parts (E and F) added still later to, |
| [C D E F] | and, finally, abbreviated in the final version to |
| [E F]. | |

The evolution,

[A B C D] ==> [E F]

cannot be detected from listening alone. The final form shows no hint of the cause-effect chain which lead to it. From a listener's point of view, hidden causes can be revealed by modelling the composer's intentions as well as the music he writes.

The musicologist Willi Apel shows how "bar form" represents a convergence of two entirely different evolutionary paths [39]. The evolution of *bar form* to *rounded bar* form is shown by the notation in Case I, while the evolution from *rounded binary* form to *sonata* form is shown by the notation in Case II.

| | | |
|---|---|---|
| Case I: | a a b ==> | [: a :] b a |
| Case II: | [: a :][: b a:] ==> | [: a :] b a |

The problem here is that the resulting form hides its ancestry. Most of the knowledge we use is in this form. One of the jobs of cognitive science is to re-construct knowledge from hidden roots.

# 1.6 Recognizing Pattern and Recurrence

## 1.6.1 Recurrence

The term *recurrence* is used to describe the way time is regulated by lower-level patterns. Time can be structured with varying degrees of regularity depending on the kinds of patterns which are being constructed and how they interact [40]. This point is demonstrated in figure 6 in which are found three patterns. Time goes from left to right. The uppermost pitch-shape pattern is represented by a line connecting a sequence of pitch-dots. These pitch-dots define a shape regardless of the content of the pitch-dots. Beneath is a pattern of strong (>) and weak (•) accents. Beneath this is a dynamic pattern (< = louder, > = softer).

Recurrence defines object by presenting object elements in a particular order many times; for example, in defining a pitch-shape the "up" and "down" elements are organized into a sequence which forms the ordered pattern:

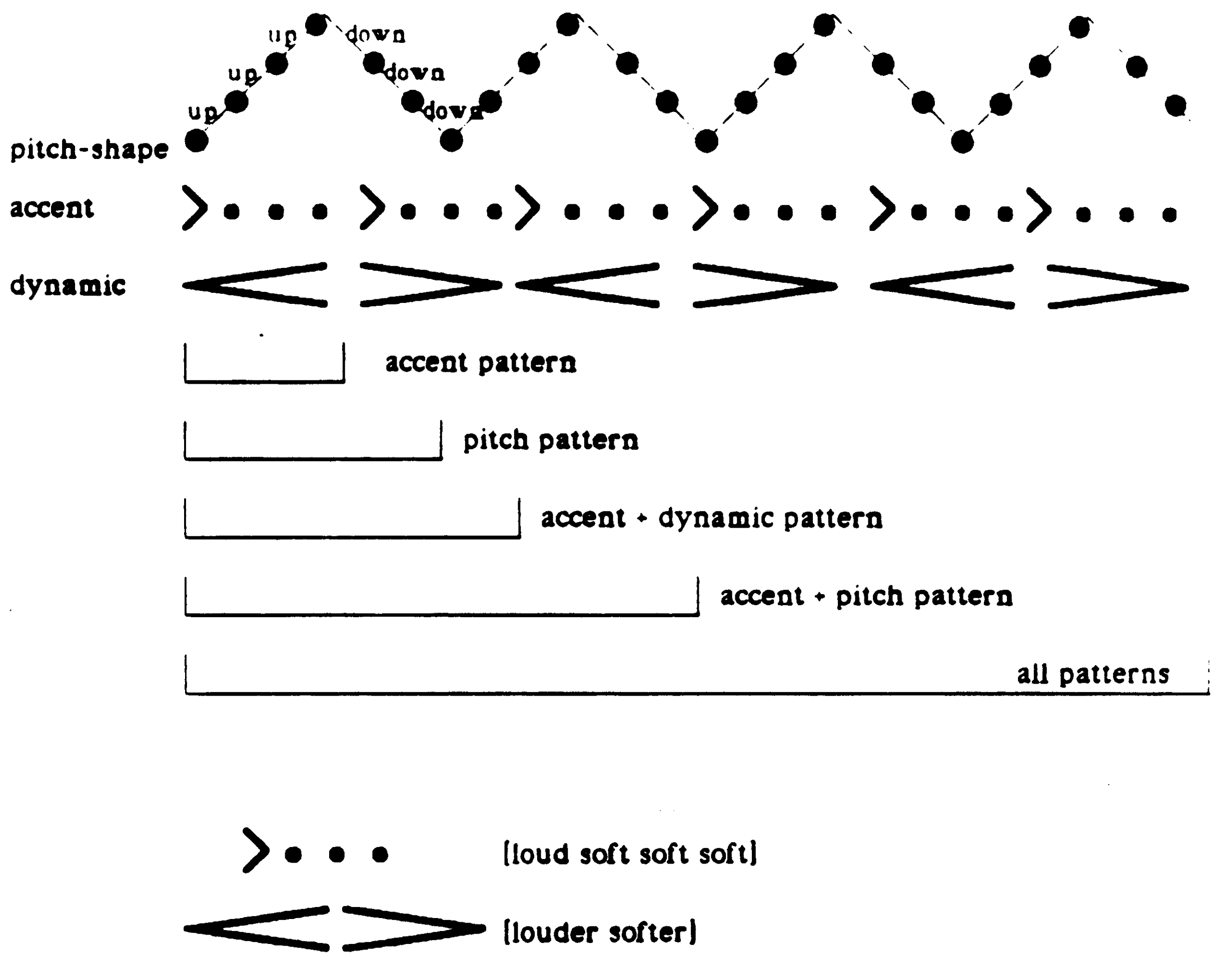
[up up up down down down]

Each recurrence is recognized by specific *recurrence criteria.* We can separate pitch-shape from pitch-frequency because different recurrence criteria are involved in each. Pitch shape is defined by a pattern of upward and downward steps. When consecutive [up up up down down down] matches occur, shape is recognized. Similarly, when recurrence matches occur for the accent pattern [loud soft soft soft] or the dynamic pattern [louder softer] corresponding recognitions occur.

Most musical patterns result from coincident recurrence criteria. "Simple" musical objects exhibit complex lower-level patterning. Conversely, complex musical objects can be

Figure 6

**Recognizing Pattern**



constructed by scattering recurrences so that they coincide in temporal periods which exceed the duration of any one of them (much like the effect of an *isorhythm*). For example, the illustration shows measured distances below the three patterns. The first two outline the accent and pitch patterns while the remaining three outline complex combinations of them.

The shape and accent patterns line-up in time in a succession of moments from 1 to 12 corresponding to the "accent + pitch pattern" outline in figure 6.

**A shape-accent object**

time ->
1 2 3 4 5 6 7 8 9 10 11 12
pitch-shape pattern
[up up up down down down] [up up up down down down]
[loud soft soft soft ] [loud soft soft soft] [loud soft soft soft ]
accent pattern

Recurrence from a local view requires a description of pattern recognition from a succession of moment to moment evaluations. From this view, pitch-shape matches "when the last moment was down and the current moment is up"; that is, from moments 6 to 7, and 12 to 1. For accent, a match occurs "when the current beat is loud", or from moments 4 to 5, 8 to 9, and 12 to 1. The shape-accent object combines all three criteria and recurs only from moments 12 to 1); that is, when,

1. the last moment was down
2. the current moment is up
3. the current moment is loud

For the dynamic pattern in figure 6 longer durations are required to recognize recurrence. This adds to the previous recurrence criteria the one for the dynamic object; i.e. when,

**A dynamic-object**

4. the last moment was quieter than the second to the last moment
5. the last moment was quieter than the current moment

Rules #3 and #5 reinforce each other since the current moment has to be louder for both. The other criteria are neutral with respect to each other and can be added in.

**A shape-accent-dynamic object**

1. the last moment was down
2. the current moment is up
3. the current moment is <u>very</u> (#5) loud
4. the last two moments were less loud than the current one

### 1.6.2 The Stability of Musical Objects

The listener has several ways to identify a musical object because several recurrence criteria are usually involved at once; indeed, the *stability* of a musical object can be measured by the number and kinds of coincident recurrence criteria present. Musical objects which are hierarchically deep are not necessarily more difficult to recognize. They may even be easier to recognize because there's more evidence on which to base one's listening judgments.

### 1.6.3 Interrupts and Junctions

Patterning occurs at higher and higher levels through the use of musical concepts, each with its own recurrence criteria. For example, if the above pitch-shape constrained the selection of two different pitch-patterns new higher-level recurrence criteria would be necessary based on the properites of each pitch-pattern.

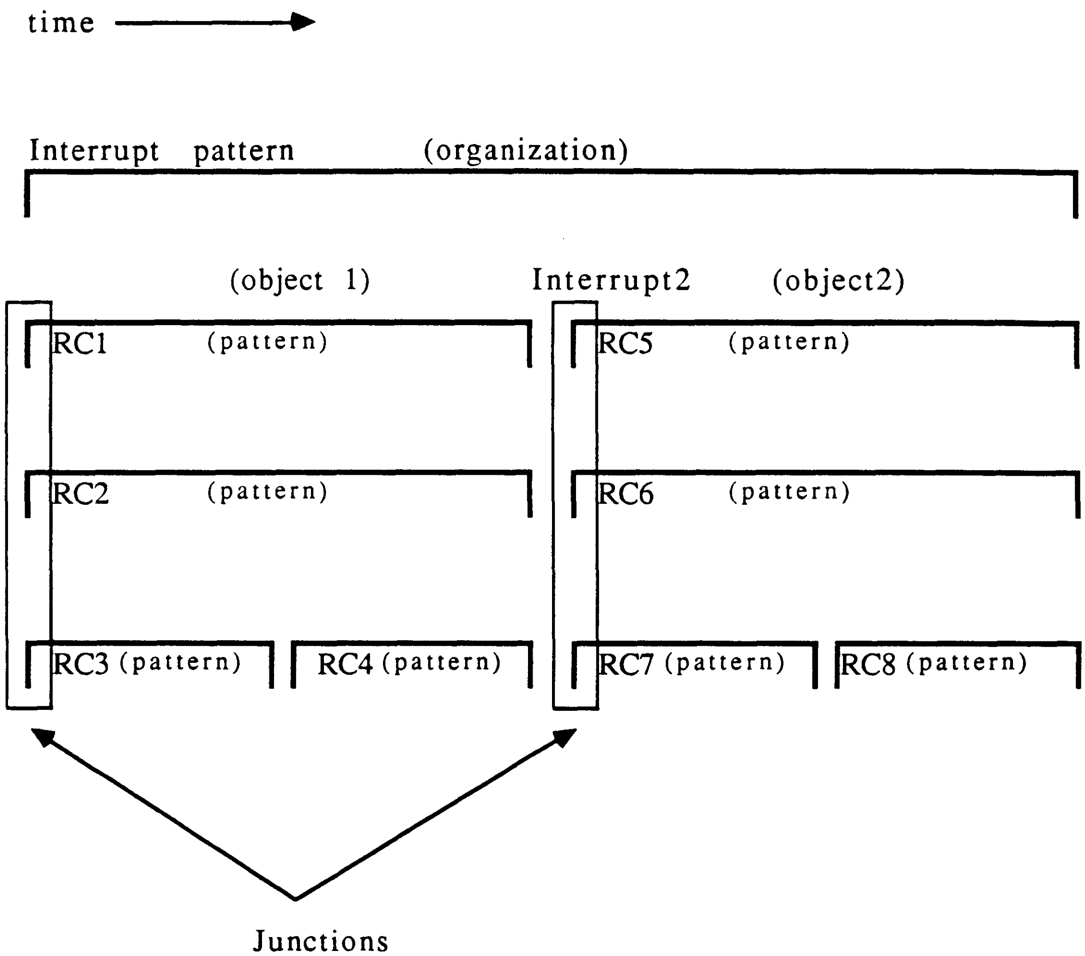
Is it this?
    [pitch-pattern1 [up up up down down down]]
or this?
    [pitch-pattern2 [up up up down down down]]

As these pitch-patterns become numerous they tend to be regulated by additional concepts. For example, *harmonic rhythm* is a musical term which describes how scale-patterns are regulated by key-patterns to shape time.

We recognize matches partly by recognizing mis-matches. The more often previous matches succeeded the more interesting it is that current one's do not. The computer science term *interrupt* is applied to mean large mis-matches between previously successful matches [41]. Interrupts are interesting as are the musical features which lead to them. The characteristics of a particular interrupt are the recurrence criteria for object organizations rather than criteria for recognizing simple or complex objects. Musical organizations are stable because many kinds of recurrence criteria can be used to confirm our recognition of them. Interrupts surprise us because previously made recurrence matches have failed, <u>all at once</u>.

The term *junction* describes the clustering of recurrence criteria in time. Whereas, an interrupt is the psychological response to a mis-match between predicted and realized junctions, a junction is the temporal point where recurrence criteria intersect.

Figure 7: Constructing organizations from interrupt patterns




RC = recurrence criterion

### 1.6.4 Interrupt Patterns: Constructing Organizations

Interrupts which are not predicted can be traced back to earlier junctions which could have signalled their occurence. With a recognition of interrupts comes a stability which includes the interrupt in an additional level of organization. The phrase *interrupt pattern* describes the means for constructing higher and higher organizations of musical time from interrupts. As figure 7 shows, objects 1 and 2 are each complex objects comprised of four recurrences, each with its own recurrence criterion (RC). The objects are complex because they are comprised of smaller patterns which exhibit weak recurrence (RC3-->RC4 in object 1, and RC7-->RC8 in object 2) in contrast to the strong recurrences they exhibit at their junctions (RC1, RC2 and RC3 in object 1; and RC5, RC6 and RC7 in object 2). There is an interrupt between these two objects shown by the coincident recurrence mis-match at the temporal point marked interrupt 2. It has precise characteristics; namely,

[RC1, RC2, RC3] --> [RC5, RC6, RC7]

which can be used by the listener to predict future interrupts of this kind. Recurrence criteria, interrupts and interrupt pattterns describe the construction of musical hierarchies from a succession of musical changes.

**Deconstruction (top-down)**
Interrupt patterns -->
Interrupts -->
Junctions -->
Recurrence criterion -->
**Construction (bottom-up)**

These concepts suggest bottom-up and top-down strategies for constructing and revising musical models. The revision of models requires a deconstruction of higher level descriptions into lower-level parts and a new construction based on new recognitions of recurrence.

## 1.7 Three Psychological Concepts

Using the concepts of *pace*, *home* and *masking* ties emotional issues to structural ones. Pace results from trying to preserve one's orientation to home-structure against the disorienting function of masking-structure. Music listening is like a game of hide-and-seek. We seek home-structure which is hidden by masking-structure. Pace is the experience of playing the game.

### 1.7.1 A Psychology of Musical Experience

How is it that one musical tradition has spread at the exclusion of others? How can musics be so different and still be music? Musical traditions are structurally different and structurally incompatible. The function harmony serves for the western listener is served by rhythm in African music. Denying that something could take the place of western harmony rejects musics and musical experiences which operate in the absence of western harmony.

Concepts which are tradition-independent are needed at the meta-level to describe how musical structure shapes emotional experience. The meta-concepts of pace, home and masking serve this role [42].

After surveying the literature, Rowell states that, in every culture, people sing songs, they don't just sing. He also says that every culture uses some form of variation [43]. For a music to have variation, some "thing" has to be varied; and if collections of variations are organized as song, all music cultures have hierarchy at least two-levels deep, with simple thing-objects and a complex song-model [44]. The question is: how does the connectivity among parts lead to a musical experience of the whole?

### 1.7.2 Pace

If we say a piece of music is "dramatic", "energetic", "static", "gentle", "bold", etc. we are making statements at a very high level of abstraction. From the listener's perspective, any new change in the complexity of objects and organizations makes them more troublesome to model even though these changes may serve a higher (systemic) goal. I use the word *home*-structure to describe listener models which succeed and *masking*-structure to describe those musical details which put current listener models in question. *Pace* is an abstraction for the patterns of model revision the listener performs in order to incorporate masking-structure into new versions of home-structure.

### 1.7.3 Home

The difference between musics is determined by how the notion of "musical objects" and "organizations" are defined. *Home*-structure (or home) describes one's orientation in "musical space" and the features found in the music that contribute to it. Answering home-questions from consecutive listening moments; questions like,

what's the key?
where's the tonic?
what's the rhythm?
where's the beat?
what's the scale?
is this the same pattern?
what's the connection?

results in new orientations to the music or stronger commitments to old ones. In western music we ask ourselves "where's the tonic?" to callibrate our distance from the home key but we also ask ourselves a variety of local questions like "where's the downbeat", "is this melody related to the last one", etc. Many traditional and contemporary musics rely primarily on local home-questions; for example, in African drumming, the relation of concurrent metric structures demands listener comparisons between two simultaneous representations of time which are made more or less clear depending on the accent patterns which weave between them. While "place" would avoid the unnecessary commitment to western musical concepts like "musical direction" (implied by a western notion of home), home conveys the sense of urgency associated with these questions. We might care about a place, but home is special because one's musical experience depends on it.

### 1.7.4 Masking

Home is also special because composers make it interesting to find. The term *masking*-structure (or masking) describes the way home-questions are made more difficult to answer; reciprocally, *unmasking*-structure (or unmasking) describes the way home-questions are made more easy to answer. While home is an orienting function, masking is a disorienting function [45].

Consecutive events can be masked to different degrees.

less masked
Repetition
Changing more secondary properties (Schoenberg's "variation")
Changing more primary properties (my "contrast")
Changing all properties (my "interrupt")
more masked

It's easiest to recognize that a second pattern is a repetition of the first; indeed, repetition is the quickest way a musical object can be defined because masking is absent. In contrast, if the melody, rhythm, timbre, tempo, instrument, articulation, etc. all change from one event to the next, the two events are related only in their temporal proximity. Across these extremes degrees of masking and unmasking which regulate our experience of home.

Masking regulates object stability. From an object-oriented perspective, masking results from adding kinds of recurrence and unmasking results from deleting or repeating kinds of recurrence.

Masking regulates organizational stability. From an operation-oriented perspective, masking results from adding new causal relations and unmasking results from deleting or repeating them.

### 1.7.5 Summary

Pace is the effect of trying to preserve one's orientation to home-structure against the disorienting function of masking-structure. Beneath these psychological descriptions are those which distinguish among traditions. The kinds of home-questions asked and the kinds of recurrences and organizations valued are culture-dependent. "Pace" describes the universality of musical experience without denying that experience is culture-specific.

## 1.8 Modelling Intentions

### 1.8.1 Networks of Interest

Pieces of music exist within a music culture and are partially defined by the musical practices, ideas and products of that culture. In preliminary listening, the sounds are compared to other musical pieces. When they approximate current musical events they serve as transitional theories for the kinds of objects and operations which one might find relevant. Like transitional theories, the listener gradually finds that preliminary descriptions become unnecesary as the evidence they produce become more and more rooted in the details of the current work. The phrase *network of interests* describes these collections of pieces and ideas. It is similar to what the anthropologist Clifford Geertz means by the importance of local cultural meaning [46].

### 1.8.2 Modelling Composers

Some of these ideas are descriptions of the composers themselves. Two composer models follow. The first describes those compositional strategies the composer chooses to share with his listener and draws from Karlheinz Stockhausen's comments about the construction of *Hymnen* . The second describes composer beliefs and draws from the writings of John Cage [47].

### 1.8.3 Compositional Heuristics: Modelling How

*Hymnen* is a collage of national anthems and folk music which have been electronically modified and mixed with instrumental sounds. Over an hour long, the composition is quite complex on the surface. But its composer, Karlheniz Stockhausen, shares some of the higher-level heuristics used in its construction [48].

1. Hide what you compose in what you hear
2. Cover what you hear
3. Place something next to what you hear
4. Place something far away from what you hear
5. Support what you hear
6. Continue for a long time an event you hear
7. Transform an event until it becomes unrecognizable
8. Transform an event that you hear into the one you composed last
9. Compose what you expect to come next
10. Compose often but also listen for long periods to what is already composed, without composing
11. Mix all these instructions
12. Increasingly accelerate the current of your intuition

As listeners we are able to use these heuristics as a means of inspecting the piece. We know that the piece is a collage of anthems and we can tell from Stockhausen's heuristics that he is concerned with making them more or less easy to recognize. The anthems are the patterns which we are asked to track in all of their manipulated forms. We also know that Stockhausen is concerned about the order of anthem-patterns.

Changing the location of a pattern and its neighbors changes how it is heard. Overlaying one anthem on another responds to the issues of masking and order both. Finally, Stockhausen tells us that his transformations are recursive: a transformation applied to an anthem-pattern can also be applied to its result. This suggests that there are not only musical patterns but patterns of transformations.

In *Hymnen*, anthems are chopped up into fragments, mixed, filtered, sped-up, slowed-down, etc. As listeners, we find ourselves trying to recognize anthems when we hear parts of them; or anthem-patterns if we don't know the anthem but recall the pattern.
One of the questions Stockhausen might have asked himself during the design of his method is "what processes will promote or hinder these recognitions?"

Of course, the transformations are also easier to identify for listeners familiar with the possibilities of electronic processing than for those who aren't. As listeners we might want to know more about how the compositional methods are shaped (or constrained) by analog synthesis. Stockhausen's compositional method is implied in his compositional heuristics; yet, it can also be misleading to think of them as being equivalent. For example, when transformation processes are applied to the same fragment several times it becomes increasingly unrecognizable. This is an additive technique. There is no way to reverse this process using analog equipment: one can't "un-filter" or "un-mix" a sound. Stockhausen's heuristics address the subtractive result, not the additive method that produced it.

*Hymnen* can be accessible to a listener for different reasons than those discussed so far. Stockhausen assumes knowledge about national anthems, world geography and history not common to all listeners. Certainly, this knowledge improves the recognition of pattern and inferences about what a musical transformation is. This knowledge also makes listeners sensitive to the allegorical meanings Stockhausen has intended.

### 1.8.4 Belief Heuristics: Modelling Why

The following example draws from the avant-garde composer John Cage who has summarized the themes which have been important in his life in the book Theme and Variations [49]. Cage places a great deal of emphasis on the individual listener, more than he does on music itself. Traditionally, the listener looks to the music for a kind of "answer" whereas, with Cage, the music is the question, the listener is the answer. For Cage, it's not a question of how many people like a particular piece of music; rather, it's how many kinds of music a person is able to like. While he approaches this spirit of thought from the position of Eastern philosphy (Zen, in particular) similarities can be seen between this point of view and that of the epistemologist. It's the listener and not the music which dictates whether a piece of music succeeds or fails. This leads listeners to questions about the nature (structure) of their own aesthetic judgment.

From Cage's view, if certain beliefs about music prohibit certain sounds (or sound-organizations, etc.) from being music, we might wish to inspect our system of beliefs rather than prohibit the "music" (and, therefore, the beliefs which lead to it). It may be more interesting -- more mind-expanding -- to find ways of thinking about beauty that match the sounds we hear than to demand that these sounds conform to our current notions of beauty.

This stance is reflected in Cage's themes which can be seen as a system of belief heuristics. Some important definitions taken from his themes are:

*Art* : imitating nature's manner of operation; self-alteration
*History* : story of original action
*Love* : leaving space around loved one
*Religious attitude* : world consciousness

A very important super-theme is his life long commitment to inventing methods and experimentation. We can think of the elements of (music) culture as being permutable. Many combinations have not been tried. Cage might say "let's try some of them". However, in order to get to the elements, we have to relax the theories which hold them together. Cage's frequent use of counterexamples and conceptual "opposites" attacks traditional theory much like the Zen *koan* attacks rationality. A sample of such opposites, taken from his themes, are,

| | |
|---|---|
| Differences | Unity |
| Need | Uselessness |
| Purpose | No Purpose |
| Vision | No Vision |
| Music | No Music |
| Mobility | Immobility |
| Activity | Inactivity |
| Knowing | Working |
| Utility | Uselessness |
| Change | No Change |

Changing one's premises leads to new structures, new musics and new experiences. Cage might say that if we change the conditions of the (musical) environment we change the kinds of experiences we can have.

He has certain <u>preferences</u> which inform the compositional methods he will use; for example,

Quantity not quality
Process not object
Activity not communication

and statements which suggest strategies for constructing works:

A music that needs no rehearsal.
Principle underlying all of the solutions = question we ask.
No rules, no boundaries.
Constellation of ideas.

While these themes are sketchy, they suggest the importance of method in Cage's music. One of the things we look for in the music of Cage is the method which he used to produce it. To make a radical assertion, the sound can be a distraction from the identification of an inaudible method. Going into a Cage concert requires exploring the scope of one's aesthetic judgments. One starts from the assumption that music is happening and attempts to find a logic that is responsible for it. The music is not limited to what one hears: it includes the environmental conditions which give rise to it.

As Stockhausen felt a need to provide listeners advice on how to hear *Hymnen* , Cage felt a need to articulate a philosophical position which informs the methods he constructs. These supplied beliefs replace those which might have been shared if the match between Cage's and our own notion of music was stronger.

## Notes for Chapter One

1. Piston, Walter. From the introduction to his book Harmony. Revised and expanded by Mark DeVoto. W.W. Norton. New York. 1978.

2. Polya, G. How to Solve It: A New Aspect of Mathematical Method. Princeton University Press. Princeton, New Jersey. 1973. Pg. 117. Elsewhere, Polya says "If you take a heuristic conclusion as certain, you may be fooled and disappointed; but if you neglect heuristic conclusions altogether you will make no progress at all" (pg. 181) . Polya exploits the power of the metaphor in the heuristic "seek a related problem" (pg. 98) through which a problem-solver can transfer skills from solved problems to problems which are not solved. Sometimes more general problems or more ambitious plans have a better chance of succeeding, what Polya calls the *inventor's paradox* (pg. 121).This style of discourse has become prophetic of a growing interest in method in the latter half of this century.

3. Marvin Minsky's "Music, Mind and Meaning" is an example of the application of his own parallel-processing theory of mind to the domain of music. The article quoted can be found in the Computer Music Journal (Volume 5, Number 3. Fall, 1981. MIT Press. Cambridge, Massachusetts); and Minsky's theory can be found in his book The Society of Mind (Simon and Schuster, 1987.) His theory has greatly influenced the style of thought I exercise in this thesis.

4. The composer-theorist Fred Lerdahl and the linguist Ray Jackendoff collaborated on the book A Generative Theory of Tonal Music (MIT Press. Cambridge Massachusetts. 1983).

5. At the same time of Lerdahl's and Jackendoff's book, Jackendoff was writing a separate book entitled Semantics and Cognition in which he attempted to tie grammatical constraints (syntax) to cognitive constraints (semantics). In it Jackendoff uses preference rules to show the interaction of syntax and semantics in the structuring of concepts. (MIT Press. Cambridge, Massachusetts. 1985).

6. More recently Fred Lerdahl has written the article "Cognitive Constraints on Compositional Systems" which reflects his interest in tieing listener models to compositional models. (In Generative Processes in Music. To be published by Oxford University Press.)

7. Generative Theory of Tonal Music. Pg. 112.

8. The notion of *centrality* illustrates one of many heuristics which Bruno Nettl provides for penetrating cross-cultural analytic barriers. See his book The Western Impact on World Music: Change, Adaptation, and Survival. Schirmer Books. New York. 1985. Pg. 156.

9. Gerald J. Balzano. "The Pitch Set as a Level of Description for Studying Musical Pitch Perception. In. M. Clynes, ed. Music, Mind and Brain. Plenum Press. New York. 1982.

10. The primate retina is organized into several cell types: photoreceptor, biploar, horizontal and amacrine cells. The pathways between cells within layers and across layers are quite complex. Both horizontal and amacrine cells send synapses back to cells from which they receive inputs. As Stephen W. Kuffler, John G. Nicholis and A. Robert Martin have noted:

> "From such structural and physiological considerations, one can conclude that horizontal cells and amacrine cells modify or influence the transfer of information through the retina. (pg. 30)"

Such lower-level processing makes it impossible to draw the line between where "perception" stops and where "cognition" begins. From Neuron to Brain. Sinauer Associates Inc. Suderland, Massachusetts. 1984.

11. The Russian poet Vladimir Mayakovsky wrote a little book entitled How to Make Verse which discusses the construction of revolutionary poems from street language, slogans and signboards. It's thesis is the opposite of Lerdahl's; namely, for language to be alive it has to be re-created. Poetry which imitates other poetry is artificial. This is to be distinguished from poetic invention which is alive because it reflects the function served by successful poetry in the past. (Curbstone Press. Connecticut. 1976.)

A more radical assertion is expressed by the A.I. scientist Roger C. Schank regarding teaching language to children (pg. 56):

> We do not want to teach a child who already knows how to use language, to know that he is using certain items, particularly when, far from being like physics, theories of language are at this point in a muddle. No theory has been shown to be correct as of this writing. Why teach children aspects of a theory of syntax that have never been proven and are in no way relevant to the development of skills that they will need?

See his Reading and Understanding: Teaching from the Perspective of Artificial Intelligence. (Lawrence Erlbaum Associates, Hillsdale, New Jersey. 1982.)

For a delightfully written account of the evolution of thought through the construction of metaphor see Julian Jayne's book The Origin of Consciousness in the Breakdown of the Bicameral Mind. (Houghton-Mifflin Company. Boston. 1976.) Pgs. 48-52.

12. There is a lively debate among historians of science about the issue of incommensurability. One argument is that scientific theories can be compared because they are constrained by a scientific tradition which has a method for determining the relevant observations, experiments, and even the aims of science. Another is that in order for this to be the case the scientific tradition cannot have a describable method. Other arguments focus on the relevance of problems which a scientific theory attempts to solve, the values of individual scientists or the shared values of a community of scientists. For me discussions of scientific "truth" share with discussions about artistic "beauty" the relativity of evaluations and the problems this relativity poses. See The Structure of Scientific Revolutions by Thomas Kuhn (Chicago, 1962); Criticism and the Growth of Knowledge edited by Imre Lakatos and Alan Musgrave (Cambridge University Press, 1970); Against Method by Paul Feyerabend (Verso Edition, Lond, 1975); and Progress and its Problems by Larry Laudan (University of California Press, Berkeley, 1977).

13. Nettl's Western Impact on World Music, note 8. Also see Bruno Nettl's The Study of Ethnomusicology: Twenty-nine Issues and Concepts. Chapter 5. University of Illinois Press. Urbana, Illinois, 1983.

14. This is the argument Charles Rosen makes in his discussion of *sonata form* during the classical period. His discussion, which I view as re-constructive, is a sharp contrast to the typically rigid view we normally apply using a retrospective analysis. See his book The Classical Style: Haydn, Mozart, Beethoven. The Norton Library. New York, 1972.

15. Levi-Strauss talks about primitive man as being interested in *total understanding*: i.e. a way of thinking in which "if you don't understand everything, you don't explain anything". In contrast, the aim of scientific thinking is "to divide the difficulty into as many parts as are necessary in order to solve it" (pg.11). In my view, our discussions about creativity until Sigmund Freud are examples of primitive thinking. See Claude Levi-Strauss' book Myth and Meaning. Schoeken Books. New York. 1979.

16. Open systems are self-maintaining systems with inputs and outputs to other systems. Because of these inputs and outputs they are dynamically stable. From a systems theory view, the processes of natural evolution include human thought and culture, and exhibit *openness* . My discussions take this perspective for granted. See Ervin Laszlo's book The Systems View of the World. George Braziller, Inc. New York. 1972.

17. The question "what does music 'communicates'" is tricky. Roederer says that "music conveys information on emotional states". We can recognize our emotional states and trace them back to the recognitions of musical pattern. At the lowest level we can argue that pattern recognition is valuable for just about everything we do. Indeed, Roederer argues that one of the functions of music is to give us practice in exercising our pattern recognition machinery. At the highest level we can argue that the experience of emotion has a structure which reflects the way people exercise their feelings in a culture. From this anthropological perspective, music is a social institution which exists in order to regulate the behavior of its members. See Juan G. Roederer's article "The Search for the Survival Value of Music, in Music Perception (vol.1, No. 3. Spring University of California Press, 1984). Also see "Towards a Theory for Ethnomusicology", Chapter 2 of The Anthropology of Music by Alan P. Merriam (Northwestern University Press. Illinois. 1964).

18. Schoenberg, Arnold. Fundamentals of Musical Composition. Edited by Gerald Strang and Leonard Stein. Faber and Faber. London. 1967. Pg. 102.

19. In my view, Leonoard Meyer captures more than any other pre-computational thinker the important ideas about musical meaning and emotion. I have three general criticisms of his approach. Meyer needs to believe that all music is basically tonal (in the western sense) because his descriptive language has no way to deal with radically different musical paradigms; i.e. criticism one is that he is not an epistemologist even though he has been concerned about issues of musical relativity. He leans heavily on culture's role in transmitting normative behavior and the principles of *gestalt* psychology and leaves untouched problems of lower-level recognitions and representation; i.e. criticism two is that he is an innatist. Finally, his use of probabilities to explain listener expectations is never the source of higher-level structures; ie. criticism three is that he is not a constructivist. In a sense, I am criticizing him for not being what I would want him to be; yet, I believe he would agree with these criticisms if he was a young theorist today. Still, his book Emotion and Meaning in Music (The University of Chicago Press, 1956) is a rich source of good ideas. Also see his article "Universalism and Relativism in the Study of Ethnic Music", Ethnomusicology: Journal of the Society of Ethnomusicology.

I very recently discovered the book Beyond Schenkerism: The Need for Alternatives in Music Analysis by Eugene Narmour (The University of Chicago Press. Chicago. 1977). It provides a clear discussion of the limitations of a linguistic approach in which Schenker's theory can be included. Like Polya and Minsky, Narmour criticizes the deductive approach saying that "musical function is always formative as well as transformative" (pg. 134).

"one needs a theory in which the logic of the rules of inference can be studied separately from the musical structures generated in the analysis" (pg. 135).

Narmour criticizes Schenker for placing the harmonic parameter higher than all the other parameters (pg. 210). This is an interesting criticism which I have felt comfortable making about experimental and non-western music but hesitated to make about tonal music. But, in fact, if listener models are made up of many parallel recognitions, this point would also apply to tonal music. For example,

"..the use of metric accent (or nonaccent) as an hypothesis to identify patterns of implication and realization results in the generation of processes from the summarization *above*, as it were, instead of from the individual parameters themselves" (pg. 139).

Narmour's *implication-realization* model, a structuralist reformulation of Leonard Meyer's approach, describes music as many lower-level parameter-parts which are evaluated separately and summarized into increasingly more abstract musical models (pg. 142, pg. 164).

"Within any one part, multiple implications would sometimes diverge, sometimes compliment. A part would, moreover, display implications in varying strengths for each operative parameter -- harmonic, melodic, metric, rhythmic, registral, dynamic, and so on" Pg. 127).

His point about *summarization* and, later, about *closure* suggest a concern for the processes by which compositional and listener abstractions (my term) are constructed, as the following quotes illustrate.

"The recognition of a form testifies to the presence of closure. And such closure is not imposed 'externally', from a higher level, though our evaluation of it may depend on prior learning, but is the *internal* result of the specific way parameters interact in the creation of patterns" (pg. 105).

"the listener always favors closure over nonclosure because this is the most efficient way he can continue attending to the piece intelligently" (pg. 155).

As Narmour says, "transformational grammar's failure to account for "ill-formed" sentences and deny the importance of anything but the "ideal speaker". Therefore, the linguistic approach suppresses the individuality of works (pgs. 168-69). Narmour's approach, like mine, emphasizes the evolutionary character of particular musical models. It suggests that choices are made from a variety of possible choices and constrain future choices. "Ill-formed" sequences are paths of construction which are possible but not conventional, what Narmour calls *idiostructures* to capture the idiosyncratic content of individual works which, he argues, is responsible for the evolution of musical styles and traditions.

I have nothing critical to say about Narmour's approach. Like mine, it tends to blur the distinction between analysis and synthesis and is designed to accommodate paradigm shifts. (Narmour argues that the pre-tonal ancestry of tonal music puts in question Schenker's "idealistic rationale" about tonal music.) While Narmour was not writing from the perspective of the design and evaluation of new methods as I am trying to do, we are in agreement about the nature of the analytic enterprise.

The question really is: what do we want to describe and for what purpose? Do we want to describe the stability (or coherence) of a finished musical product, or do we want to describe the processes by which this stability is attained? In my view, it is the latter which is of most importance because the problems of composition and listening give rise to stable models only after they are solved. Paradoxically, while it is the stability of the completed model for which the composer and listener strive, there is almost nothing which is in the solution which reveals its cognitive content.

20. Meyer says: "Hypothetical meanings are those which arise during the act of expectation" Emotion and Meaning in Music. Pgs. 37 and 49.

21. Meyer's Emotion and Meaning in Music. Pg. 52.

22. Meyer's Emotion and Meaning in Music. Pg. 65.

23. R. Pfeifer and D.W. Nicholas have written an interesting article entitled "Toward Computational Models of Emotion" which describes arousal as changes of physiological state. They call these changes of state *interrupts,* drawing from computer science. The term *arousal image* is used to describe the stored state and emotion which provoked the interrupt. This gave me the idea of interrupts and interrupt patterns which I introduce in the section entitled "Recognizing Pattern and Recurrence". Pfeifer's and NIcholas' article can be found in Progress in Artificial Intelligence (editors Luc Steels and J.A. Campbell, John Wiley and Sons, New York, 1985).

24. Professor Byung Ki Hwang was a visiting Scholar at Harvard University's School of music in the fall of 1986. He is from the College of Music, EWHA Woman's University in Seoul, Korea.

25. Many of the computer terms are taken from Harold Abelson's and Gerald Sussman's book Structure and Interpretation of Computer Programs. With Julie Sussman. MIT Press. Cambridge, Massachusetts. 1985.

26. Joseph Lam is a teaching fellow at Harvard University's School of Music. This example draws from my notes of a short lecture which he gave in Professor Rulan Pian's course "Topics in Ethnomusicology" in the fall of 1986.

27.Besmer, Fremont E. Horses, Musicians, and Gods: The Hausa Cult of Possession-Trance. Ahmadu Bello University Press. Zaria, Nigeria. 1983. Pgs. 91-106.

28. Piaget, Jean. Genetic Epistemology. W.W. Norton and Company. New York. 1970. Pgs. 12-13.

29. Ackerman, Edith. "How Does Sensori-Motor Intelligence Develop from the Infant's Reflexes?" 1986. In press.

30. Piaget, Jean. Intelligence and Affectivity: Their Relationship During Child Development. Annual Reviews, Inc. Palo Alto, California. 1981. Pgs. 6-7.

31. Leacock, Ricky. A Stravinsky Portrait. b/w film. duration: 60 minutes. Leacock Pennebaker, Inc.

32. Polkinghorne, Donald. "Systems and Structures" in Methodology for the Human Sciences: Systems of Inquiry. State University of New York Press. Albany, N.Y.

33. Meyer's Emotion and Meaning in Music. Pg. 52.

As listeners, we not only recognize that a musical event implied a particular "realization" we are aware of the many possibilities which were not "realized", what Narmour calls "unrealized implications" in his implication-realization model.

> "behind the actualized events of every work, there exists a "structure" of unrealized implications which contribute to the "depth" of the piece and to the richness of our experience with it" (pg. 184).

(Eugene Narmour Beyond Schenkerism: The Need for Alternatives in Music Analysis. The University of Chicago Press. Chicago. 1977).

I describe this as the listener's ability to use classification concepts in making predictions (e.g. "I expect the next musical event to be a kind of x"). From this view, musical content is a product of the relations between objects and possible relations: constrained by the classifications used.

34. Bettelheim, Bruno. The Uses of Enchantment: The Meaning and Importance of Fairy Tales. Vintage books. Division of Random House. New York. 1977. Pg. 5.

35. Ginsburg, Herbert and Sylvia Opper. "The Years 2 through 11". Piaget's Theory of Intellectual Development. Prentice-Hall Inc. New Jersey.

36. For a discussion of Seymour Papert's approach to the design of computational environments for children see his book Mindstorms: Children Computers and Powerful Ideas. Basic Books. New York. 1980.

37. Schoenberg's Fundamental of Musical Composition. pg. 179.

38. Apel, Willi. Harvard Dictionary of Music. Harvard University Press. Cambridge, Massachusetts, 1978.

39. Apel's Harvard Dictionary of Music.

40. Piaget takes the physicist's perspective of connecting time to space through motion. "Space is a still of time, while time is space in motion -- the two taken together constitute the totality of the ordered relationships characterizing objects and their displacements" (pg.2). See his book entitled The Child's Conception of Time (Ballantine Books, New York, 1969.)

41. Pfeifer's and Nicholas' "Toward Computational Models of Emotion". See note 23.

42. The notions of pace, home and masking operate at each hierarchic level and try to capture relations between structure, style and affectivity. This approach is influenced by a book entitled Neurotic Styles by David Shapiro (Basic Books. New York. 1965).

43. Rowell, Lewis. Thinking About Music. The University of Massachusetts Press. 1983. Pgs. 25-28.

44. Rowell's Thinking about Music. Pg. 97.

45. In psychoacoustics "masking" refers to the way spectral information can be covered; for example, by white noise or other spectral information. I use the term in a broader sense to include concepts which are tied, indirectly, to spectral change.

46. Regarding the particularity of meaning, Clifford Geertz says:

> "Theoretical formulations hover so low over the interpretation they govern that they don't make much sense or hold much interest apart from them. This is so, not because they are not general....but because, stated independently of their applications, they seem either commonplace or vacant." (pg. 25)

> "We must, in short, descend into detail, past the misleading tags, past the metaphysical types, past the empty similarities to grasp firmly the essential character of not only the various cultures but the various sorts of individuals within each culture, if we wish to encounter humanity face to face." (pg. 53)

See his book The Interpretation of Cultures, chapter one. Basic Books. New York. 1973.

47. We have a right to inspect (and suspect) what composer's say about how or why they write their music; perhaps, in the same sense that a clinical psychologist inspects the comments of his patients. Given these words of caution, a composer's comments, in conjunction with his music, provides data which is not available in either the music or the comments alone.

48. Stockhausen's comments were taken from the record jacket of the Deutsche Grammophon recording of *Hymnen*. SLPM 139 421/22.

49. Cage, John. Themes and Variations. Station Hill Press. Barrytown, New York. 1982.

# Chapter 2: Compositional Models

## 2.1 Micro-Composition:
### Demontrating the Construction of a Musical Concept

"Vibrato", used as the center of a composition system, demonstrates that between the physical properties of sound and the musical concepts used are fine layers of intermediate structure, *micro-structure*. Vibrato is a good example because it is deceptively simple. In practice, all a composer has to do is write the word "vibrato" and a performer will know what is meant. However, if one unpacks the musical concept one find's a great deal of detail; indeed, it is because so much micro-structure is shared between the simplest of musical concepts that concepts are so useful. For example, the oscillation pattern of a vibrato in Armenian folk music often reflects the underlying pulse of the music. A 2/4 meter can have an underlying meter of 10/16 made up of two 5/16 groups. The vibrato and melodic ornamentation will be in 10/16 (played primarily by the lute or clarinet) while the dance beats and melody are in 2/4. In Vietnamese music at least 6 kinds of vibrato can be recognized, each used to add its own kind of richness depending on the ornamentation context. Vibrato is not an isolated musical concept. When it is added to the musical fabric other musical features are affected.

#### 2.1.1 The Anatomy of a Concept: Vibrato

There are at least five levels of structure from the raw properties of sound to the highest level of abstract musical idea; namely, (1) the attributes of physical sounds, (2) micro-structures, (3) organizations of them into simple musical concepts, (4) complex musical concepts, and (5) meta-musical concepts.

meta-musical concepts
^
|
complex musical concepts
^
|
simple musical concepts
^
|
micro-structure
^
|
attributes of physical sound

Vibrato is produced in different ways within as well as across cultures. Production differences are a result of different organizations of the physical attributes of sound; yet, we call them all "vibrato" because six properties remain invariant:

(1) Vibrato is a way of masking pitch [1]
(2) The masking process involves regulating the mixture of sound attributes which are considered important for vibrato.
(3) Regulations involve alternating between two organizations of physical sound attributes (or two physical-sound states).
(4) These states have the same duration.
(5) We must be able to produce these alternations with apparent ease.
(6) We must be able to hear these alternations easily.

These six invariances are the meta-concepts of vibrato which are system independent. The task before us is to identify pitch-masking aspects of sound which are easy to produce and hear.

The first three pieces of the micro-structure identify <u>kinds of masking</u>.

- amplitude vibrato. Change the loudness of a pitch.
- frequency vibrato. Change the frequency of a pitch.
- timbral vibrato. Change the spectrum of a pitch.

<u>How much</u> should amplitude, frequency and timbre change? These questions are constrained, on one hand, by the ease of production and, on the other, by the ease of hearing (i.e. meta-concepts). If the change is too difficult to produce or too subtle to detect it won't be vibrato. So there is a range of change. Some value from that range (most to least) is state 1 while the absence of change is state 2 (no masking).

| Kind of Masking | State 1 | State 2 |
|---|---|---|
| • amplitude vibrato | Most <--> Least | No masking |
| • frequency vibrato | Most <--> Least | No masking |
| • timbrel vibrato | Most <--> Least | No masking |

Alternations between state 1 and state 2 require temporal definition. Assuming that the duration of state 1 equals the duration of state 2 (a meta-concept) I will call the combined duration of states 1 and 2 the <u>oscillation rate</u>. The oscillation rate is also constrained by ease of production and ease of hearing; i.e. it is a range from most to least oscillations between states. The oscillation range determines how often the masking occurs and the state 1 range determines how much masking is to be used.

| | **Oscillation Rate** | |
|---|---|---|
| | Most <---> | Least |
| **Kind of Masking** | **State 1** | **State 2** |
| • amplitude vibrato | Most <--> Least | None |
| etc. | | |

For the purpose of illustration, we can arbitrarily pick (reasonable) values from within the ranges to define when and how much masking is to occur. For example, vibrato 1 is an amplitude vibrato. Masking is applied 5 times per second and the amount of masking involves doubling the normal amplitude.

| **Vibrato 1** | |
|---|---|
| Kind of Masking: | Amplitude |
| Oscillation Rate: | 5/second |
| Amount of masking: | Twice the normal amplitude |

| **Vibrato 2** | |
|---|---|
| Kind of Masking: | Frequency |
| Oscillation Rate: | 6/second |
| Amount of masking: | quartertone deviation from pitch |

| **Vibrato 3** | |
|---|---|
| Kind of Masking: | Timbre |
| Oscillation Rate: | 4.5/second |
| Amount of masking: | Enhance upper harmonics/spectra (e.g. raise center freq of formant filter one octave) |

Most natural vibrati depend on inputs from other micro-structure. These dependencies give vibrato the dynamic quality we find most natural. Below, I describe one set of dependencies as *production rules*, borrowing a concept from artificial intelligence [2].

**Given vibrato 1 (amplitude)**

Rule #1

| | |
|---|---|
| IF | Note durations are less than .5 seconds |
| THEN | Cancel vibrato |

Rule #2

| | |
|---|---|
| IF | Note durations are between .5 and 1 second |
| THEN | Lessen the masking |

Rule #3

| | |
|---|---|
| IF | Note durations are greater than 1 second |
| THEN | Use Rule #2 for first second and normal masking for remainder of duration |

**Given vibrato 2 (frequency)**

Rule #1

| | | | |
|---|---|---|---|
| IF | Note duration is less than .5 seconds | | |
| THEN | Cancel vibrato | | |

Rule #2

| | | | |
|---|---|---|---|
| IF | Note duration is greater than .5 seconds | | |
| THEN | IF | Note amplitude is less than X | |
| | THEN | lessen masking | |
| | ELSE | Normal masking | |

**Given vibrato 3 (Timbre)**

Rule #1

| | |
|---|---|
| IF | Note duration is less than .5 seconds |
| THEN | Cancel masking |

Rule #2

| | |
|---|---|
| IF | Note amplitude is less than X |
| THEN | Lessen masking |

Rule #3

| | |
|---|---|
| IF | Note frequency is above Y |
| THEN | Cancel masking |

The rules for each vibrato are simple because they connect to other clusters of rules. For example, the "note durations" are inputs from other processes which suggests that the processes which control note durations control vibrato. At the same time, vibrato outputs values to lower-level sonic elements involved in the masking process.

The above examples represent simple musical concepts. The way vibrato is applied depends on its duration, frequency or amplitude as well as other musical concepts. It's no wonder that it is difficult to get a straight answer to questions like "how does vibrato work?". An honest musical answer would almost always be "it depends".

### 2.1.2 Musical Figure

Vibrato is one of many simple musical concepts which are used in ornamentation, articulation and phrasing. Complex forms can be found in many non-western musics. Musical figures contribute to the expressiveness found in Japanese music which, in most other respects, lacks <u>relational</u> structure; for example,

- The different kinds of scales found in Japanese music can be derived from a small number of fixed note-patterns [3].

• Many other aspects of Japanese music are rigidly defined. In Noh music, drumming is stereotyped to support the voice as are musical patterns which support the dialogue [4].

• The relations between musical sections are often quite weak. In Kabuki dance form each of the musical parts are primarily connected by tempo. Parts are not thematically or tonally related [5].

While this rigidity of structure is important for the recognition of pattern, other mechanisms are required to account for the relational micro-changes which lead to subtle differences of expression. Indeed they are present in:

-how melody is constructed,
-in textual meaning (not discussed), and
-how variations in musical figure are formed

In the case of melody, there are tone rules in Japanese music concerned with the regulation of distances between central pitches and all others. These guiding rules regulate melodic expressiveness. Malm calls the central pitches *satellite pitches* [6]. Satellite pitches have a home function in Japanese music: "what is the melody's distance from a satellite pitch?" Melody is one important means by which Japanese music conveys expressiveness.

Small differences in vocal ornamentation can have dramatic results. Malm describes the subtle interactions between pitch, articulation and inflection with the phrase *word painting* and compares it with the western notion of *parlando* (or "spoken music") [7]. Not much is said about how these figures are constructed. An analysis of figure requires an analysis of the properties of articulation and inflection. One piece of micro-structure which contributes to the construction of "word painting" is vibrato.

### 2.1.3 Summary

If we can unpack a musical concept into its micro-structural components we can also construct new musical concepts from sonic parts. Contemporary composers do just that, though there is no particular method associated with the task. Perhaps, an appropriate name for the task is *micro-composition.*

# 2.2 Representing Musical Objects

## 2.2.1 Musical Objects

Each musical object is an organized collection of features. Perhaps, the features are melody, harmony, rhythm, articulation etc. or, perhaps, they are finer still; for example, pitch, pitch-shape, phrasing, beat, etc. Certain features are more important than others which we can represent with the following hierarchy.

more important
- chord pattern
- pitch pattern
- pitch shape
- beat pattern
- voicing
- phrasing pattern

less important

The 20th century composer-theorist Arnold Schoenberg describes variation as "modified repetition where *features* of the music which are *less important* are changed" [8]. From this view, variations will result by changing features near the bottom of the hierarchy. Such changes preserve the important characteristics of the musical object.

The reason why musical variation is found worldwide is because it is the easiest way to change pattern without destroying hierarchy. It is possible to change the features near the top a little bit and those nearer the bottom a lot without jeopardizing recognition. Changing less important phrasing patterns may go unnoticed; whereas, changing the more important chord patterns may make the object nearly unrecognizable! A notion of variation which takes into account Schoenberg's definition suggests that there are many operators, each appropriate for modifying distinct features of the musical object in question.

## 2.2.2 Musical Opposites

As a complimentary term to Schoenberg's notion of variation, *contrast* can be defined as "an operator which selects the most <u>important</u> feature of a music and changes it". Changing important features will have an effect on features which depend on it. A contrast operator will, indirectly, evoke variation-operators which will do some of the lower-level work. Schoenberg expressed the importance of dialectics in musical thought [9]. He describes musical themes as hypotheses whose significance grows by being subjected to tests and proofs during the compositional process. But what could it mean for a musical segment to be the <u>negation</u> of another? What are musical opposites? "Opposite" can be given definition if musical *contrast* is viewed in the terms described above. It is a musically relevant formulation because it ties Schoenberg's "tests and proofs" to which a theme is subjected to an ongoing musical development [10]. Coherence is preserved by a controlled method of diversification.

### 2.2.3 Problem-Solution Chains

From a constrained-oriented view of compositional processing, changing a chord may change a melody though changing a melody may not change a chord yet it may change a melodic shape, etc. Solving a problem sets off a *problem-solution chain* because problems are constrained by each other. Solving the right first problem will dictate the character of that chain. A composer can control the length of the chain by solving problems which have the least affect on their neighbors.

Problem-solution chains lead to relations among musical objects. My notion of retro-prediction requires that problem-solution chains are inforced by musical concepts. Problem-solution chains accumulate to create effects which listener's can use in the construction of listener models.

### 2.2.4 Changing Perspective

We may want concepts for evaluating or changing the status of concepts. The idea of re-organizing concepts is a functional description of what is meant by a change in perspective. For example, in Senegalese music, "rhythmic" concepts are more important than "harmonic" concepts. Rhythm retains ultimate control over processes positioned lower in the hierarchy. This results in musical notions of "harmony" or "rhythm" which are different. Senegalese "rhythm" serves the same role harmony does in the west. Re-organizing concepts is a meta-cognitive process which makes the recognition of systemic structure a pre-requisite for musical recognition.

### 2.2.5 Comparing 12-Tone and Tonal Music

Much of the work that has gone into the development of 12-tone technique focusses on organizing pitch. Attempts have been made to give equal footing to other aspects of music; for example, by serializing rhythm, amplitude, and articulation techniques. Still, it is clear that these battles have been secondary to replacing the authority of harmony with a new organization of pitch. "Harmony" and "the organization of pitch" are at the top of both

12-tone and harmonic musical systems; yet, the concepts which support their use reflect differences at both micro-structural and hierarchic levels.

Wuorinen's "compositional remedies" for revising a 12-tone piece reflects the importance of hierarchy [11]. As he suggests, we want to be able to revise a piece of music in the simplest way possible. We prefer to begin with those changes which have the least impact on the other decisions we have made by changing features found at the low end of the hierarchy first. Only when it is absolutely necessary do we make changes higher up. Wuorinen's remedies form a hierarchy which is the reverse of the hierarchy which organizes the music itself.

**Remedy hierarchy**

less-important

- **register**: we can change the octave in which a sequence of notes are played without changing either the pitches or the rhythm of the music.
- **timbre**: we can change the instrument being used without changing other aspects of the music.
- **articulation**: we can change the nature of the attacks on notes without changing either the rhythm or the pitch.
- **dynamics**: we can change how loud notes are without changing their duration or pitch.
- **overlapping**: we can change how long a note is played without altering the sequence of attacks which define the pitch sequence being used. Here, durations are modified without modifying pitches.
- **duration**: we can change the rhythms so that the pitches change, but when we do, those pitch relations which depend on the previous pitch organization must also change.
- **pitch**: pitch is organized and modified using a variety of operations; for example, transposition, inversion, retrogression, rotation, partitioning, segmentation, and combination.

more important

Notice that when we get to pitch, we are talking about operators which control the other concepts. This is an additional clue that pitch is at the top of a hierarchy, the reverse of the above list; namely,

more important

- pitch
- duration
- overlapping
- dynamics
- articulation
- timbre
- register

less important

The status of features isn't the whole story; if it was, 12-tone music would sound more like traditional harmonic music. The micro-structure determines what constitutes an object and what musical concepts are necessary to control them. There are musical concepts which are shared between harmonic and 12-tone music; for example, transposition -- same pattern of pitch-intervals moved up and down the tuning system; inversion -- a pitch-sequence (melody) played upside down; and retrogression -- a pitch-sequence played backwards. There are concepts found exclusively in 12-tone writing -- e.g. set transformation operations; and traditional ones which are not -- e.g. harmonic modulation. An obvious difference is that harmony constrains melody in western traditional music while melody constrains "harmony" in 12-tone music. The patterning techniques which depend on "what's on top" determine how lower-level processes are organized.

**Traditional Western Pitch**

more important

Techniques of constructing harmonic patterns (modulation operations)

Melody restricted by key

less important

**12-Tone Pitch**

more important

Techniques of constructing melodic patterns (12-tone operations)

Chord restricted by the order of pitch-intervals

less important

The question "where's the tonic?", found in western traditional music, is replaced in 12-tone writing by the question "where's the pitch-pattern?". These are home questions. The masking operations which cause patterns to be changed, disguised, re-introduced, etc. are home-dependent.

In 12-tone writing, melodies are looked at as ordered sequences of pitches (*sets*) which can be cut (*segmented*), shuffled (*rotated*) and re-combined (*partitioned*). Patterns can be more or less masked by regulating the "degree of ordering" during the segmentation process. These degrees of ordering determine the difficulty one will have in recognizing patterns [12]. (The numbers in the following example correspond to the 12 pitches of the chromatic scale confined to an octave.)

**Degrees of ordering.** Given an ordered set, from 0 through 11, the whole set can be strictly ordered, or sub-sets can be ordered while the elements of the sub-sets remain free.

strictly ordered

[0 1 2 3 4 5 6 7 8 9 10 11]

[1 0] [3 2] [5 4] [7 6] [9 8][11 10]

[0 2 1] [5 4 3] [8 6 7] [9 10 11]

[0 3 1 2] [7 6 5 4] [11 8 9 10]

less strictly ordered

Elements or subsets can be re-shuffled using rotation to produce new sets on which previous operations can be applied.

**Rotation.** Rotate either the <u>elements</u> of a set or the <u>sub-sets</u> of a set.

Elements

[0 1 2 3 4 5 6 7 8 9 10 11] -->

[1 2 3 4 5 6 7 8 9 10 11 0]

Sub-sets

[ [0 1 2] [3 4 5] [6 7 8] [9 10 11] ] -->

[ [3 4 5] [6 7 8] [9 10 11] [0 1 2] ]

Element rotations will probably appear less masked, but it depends on how strongly the sub-sets have been established as recognition patterns. In general, each change is small in order to preserve enough of the character of the previous pattern.

The preservation of pattern is the way the listener maintains a sense of home. As listeners, we don't explicitly identify similarities among patterns just like we don't explicitly trace the harmonic motion in traditional western music. Only an approximate accounting is necessary to recognize objects, their order and rate of change which contributes to our experience of a music's pace.

**Partitioning** is an important way of tying issues of pitch to other features found in the music. It is a way of constructing new pitch patterns from previous ones by "tracing new linear paths through the whole array of pitches.

### Examples of partitioning paths

*register-paths* -- Use all the notes from the previous set which fall in register X as the new set of ordered pitches.

*timbre-paths* -- Use all the notes from the previous set which are played by instrument X as the new set of ordered pitches.

*stressed beat-paths* -- Use all the accented notes from the previous set as the new set of ordered pitches.

In traditional harmonic writing, the choice of musical instrument has a very low status. In contrast, since instrument selection has a musical function -- e.g. in defining timbre-path (above) -- it has a high status. It adds a new dimension to pitch, what Wuorinen calls *pitchiness*. This can become an organizing function. Wuorinen gives a nice example of this which I describe as the *pitchiness spectrum* [13].

more pitchy
- low-register flute
- mid-register bassoon
- viola played with a ponticello bow
- chimes

less pitchy

Any other musical concepts which result in the use of instruments which are not in play is likely to have timbre-path side-effects. If the use of a second instrument is necessary in order to preserve the organization of pitch, this second instrument becomes a potential source of new timbre-path partitioning, new pitch organization, etc. Because musical concepts are interactive, exercizing one concept in the course of solving a musical problem can set off problem-solution chains.

### 2.2.6 Conceptual Change

Figure 1 compares harmonic music with 12 tone music. Features/processes nearest the top and farthest left are most important (most in charge); conversely, those farther right or lower are less important (least in charge). There are three conspicuous differences between the two hierarchies.

1. Harmonic modulation drops out of the 12-tone hierarchy. In its place is melody, pitch-pattern and those operations associated with manipulating pitch-pattern (e.g. transposition, inversion, retrogression, rotation, etc.).

Figure 1: Conceptual change from tonal to 12-tone music: the emergence of *texture*

**Harmonic Music**

- Harmonic Modulation
  - Tonic
  - Scale
  - Pitch
- Melody
  - Pitch
  - Phrase
- Meter (Repetition)
  - Beat-pattern
  - Phrase
  - Articulation
- Orchestration
  - Voicing
  - Register
  - Dynamics

**12-Tone Music**

- Melody
  - Pitch-pattern
  - Degrees/Kinds of Ordering
- Texture (Partitioning)
  - Voicing
  - Register
  - Timbre (pitchiness)
  - Dynamics
  - Articulation
- Duration (Recurrence)
  - Phrase-patterns
  - Texture-patterns

2. The notion of an audible meter, found in harmonic music, is replaced with the more general notion of recurrence in 12-tone music. In harmonic music, melody orients harmonic motion and rhythm is kept simple to support both. In contrast, texture orients pitch-patterning and rhythm is used to weave texture threads.

3. Orchestration, which plays a relatively cosmetic role in harmonic music, has an important status in12-tone music through the introduction of partitioning and other notions, like pitchiness. This new structure gives rise to the concept of *texture*.

This comparison highlights the most important conceptual differences between the two approaches. From the perspective of compositional theory, it is important to recognize the consequences of introducing new concepts. Concepts reflect new organizations of musical material and require new heuristics for addressing new compositional problems. In addition, musical organizations must be constrained by non-systemic factors, the most important of which is a listener's ability to recognize them.

## 2.3 Local Theory Constraint

Many new and important musical questions can now be asked about the relation of compositional and listener models because of the presence of computational metaphors. "How many musical objects are in piece X?" [14]; "what is the duration of a moment?" [15]; or "how is music parsed? [16]. Poppel and Turner have argued that based on the rate at which the brain processes temporal signals and what we know about short term memory the notion of the temporal *moment* is between about 2 and 4 seconds. This argument is constructed from the hypothesis that the "auditory information buffer" stores simultaneous events at a rate of 1000 hz, separated sequences at 100 hz, and human reactions ("responses") at 10 hz. Whether their numbers are off is irrelevant. What's interesting is that, since temporal processing occurs in discrete buffer-size chunks, we might want to ask what processes contribute to the appearance of continuous time.

### 2.3.1 Local Theoretic Evaluations

Musical concepts must support the bridging functions which connect moments to continuous time if this postulate is correct. The *local theory constraint* is a meta-test for evaluating compositional method. If a compositional theory cannot account for wholes by a succession of local processing heuristics than it probably is necessary to add new structure or re-formulate one's compositional method until it can. It is a necessary but not sufficient test: while a local theoretic evaluation does not guarantee success, it eliminates approaches which are likely to fail.

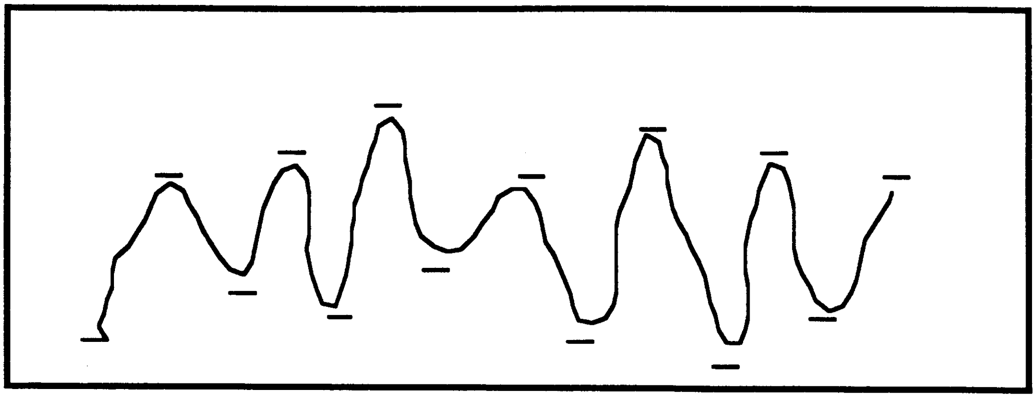
The following suggests a method for constructing local compositional theory from psychoacoustic evidence. Based on listening experiments, Bharucha claims that, given a tonal scheme, a listener is able to select the appropriate relationships between tones using *melodic anchoring* . Tones which are stable are those which fit unambiguously in the current chord scheme. Tones which are unstable -- tones which might fit into a variety of chords -- are evaluated by observing the next musical event. (Chromatically altered tones tend to follow this idea of anchoring.) Other experiments of Bharucha's show that anchoring can be delayed; that is, if the next event does not resolve the ambiguity, the event after it will. Bharucha calls this *delayed anchoring* . Anchoring and delayed anchoring are local definitions of harmonic tension [17].

Bharucha also provides a statistical definition of tonality which describes how the continuous is structured; namely, "the greater the total number (or duration) of tones in a melody that are component tones of a particular chord, the more strongly that chord is implied." But this time, "counting pitch" is tied to higher-level processes which organize them into classes [18].

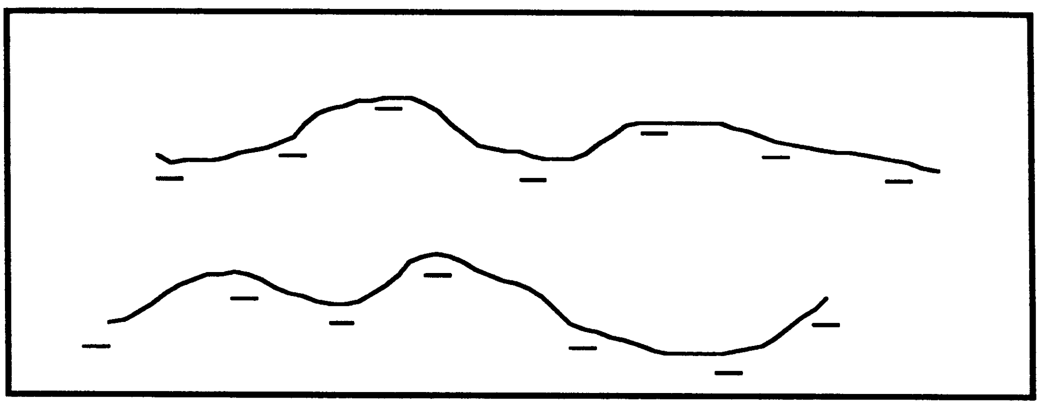
Here's where the composer can step in. By implication -- replacing "tones" with "chords", and "chords" with "tonal system" -- he might say that: the greater the total number (or duration) of chords in a tonal system that are component tones of a particular tonal system, the more strongly that system is suggested. If we assume, for the moment, that the composer writes tonal music, it is a simple step to convert this listening principle into a compositional strategy. We can use Bharucha's formulation as an argument for how chordal and harmonic evidence are recognized as patterns, and how these patterns lead to the construction of musical schemes. The composer might ask himself: "The tonal system is really organizations of scales; and pitch-patterns can be thought of as kinds of scale. What kind of compositional method can I construct which results in the statistical information Bharucha thinks relevant for the development of schemes for representing this system?" When the composer wants to strengthen a particular scheme he knows he must observe the "anchoring constraint"; namely, "don't violate the scheme more than two temporal events in a row". We can think of anchoring as a constraint on the number of exceptions which are allowable without hindering listener recognitions.

McAdams and Bregman suggest that the listener has a propensity to organize musical material in terms of what they call *musical streams* [19]. A melody of slowly alternating

Figure 2: Musical Streams (from McAdams and Bregman)



Notes (-) as one stream in slower tempo



Same notes as two streams in faster tempo notes spread a large frequency distance apart will be organized as one stream; however, if the tempo is increased (to, say 6 notes/second), the collection of notes will be divided into two streams (see figure 2).

The stream idea is based on the hypothesis that there are a variety of ways to describe a musical object and that they are in competition with each other. Our preferences for particular descriptions depend on cognitive laws which are constructed over our signal-processing machinery. The "streaming idea" suggests that evaluations happen at higher organizational levels. Streams can be formulated as local theory; for example figure 2 can be informally expressed with the following heuristics.

If streaming by frequency proximity is desired
Then increase tempo

If streaming by temporal proximity is desired
Then decrease tempo

Composing and listening happen step by step, moment by moment and local theory is a way of producing a compositional method which incorporates a listener model. Heuristics are compiled compositional models which make composing easy to do. If they incorporate local theoretic constraints they also can make music easier to hear.

### 2.3.2 The Soundness of Heuristics

A heuristic may be paradigm-dependent. The ability to refine heuristics relies on the soundness of the heuristic in new situations. The streaming idea depends not only on the shape of the melodic line but the concept of "melody" which has been established in a piece of music. These concepts will either increase or cancel the effects streaming may have.

The following example reiterates this point about heuristic soundness, using the following definition.

*octave equivalence*: pitches whose frequency ratio is 2:1 are equivalent.

"Octave equivalence" assumes a compositional system which places timbre low in the compositional hierarchy. Traditionally, the orchestration of chords is less important than the pitches used. In a different musical paradigm, orchestration issues may have a high status. Since 12-tone writing has to do with the structuring of register, octave does matters. Octave equivalence does not hold across paradigms. The way musical data is conceptualized during the modelling process may lead to irrelevant comparisons and inferences (or none at all!).

# 2.4 Designing Intuition

## 2.4.1 Inheritance

The connectivity of concepts gives rise to systemic coherence. Using a term from computer science, we can say that melody *inherits* its harmonic orientation from the scale in which it is written which, in turn, inherits its harmonic orientation from the tonic-key and its relation to the possible keys making up the system. A musical concept, like scale, is not a completely modular entity. Its connectivity to other musical concepts causes it to inherit part of its definition from the system of musical concepts in which it operates, and the system in which this system operates, and so on.

## 2.4.2 Papert's Mind-Size Bites: A Simple Constraint System for Producing "Melodies"

The combination of musical concepts comprise a system of musical thought whose complexity is distributed through its concepts and who's concepts inherit meaning from each other. The degree of complexity which is productive in any usable musical concept is captured in Papert's phrase "Mind-Size Bites" [20]. It is the heuristic which reminds us that for concepts to be functional they must be in modular <u>and</u> coherent chunks.

In the following imaginery interaction I give a composition student advice about composing. This advice is designed to produce increasingly more musical effects and demonstrate how opaque the theory which supports one's heurstics can be.

If I give a "student" the advice "just hit the black keys between here and there" (say, within one octave) the student is surprised to find that he can produce sounds which are "musical". The reason is that the advice contains concealed musical content. Reformulating the advice will reveal what its content is.

- A melody operates in a pitch-system. The black keys serve the role of this system.
- A melody is usually within an octave. The "hit from here to there" was the definition of an octave.

The student's random hitting of the keys is constrained by musical notions. His playing at the piano will be more or less musical depending on what keys he hits given my hitting-constraints. I might give him additional advice; for example, "any time you hit a key, hit it twice". Assuming that the student uses a constant hitting motion, this advice can be formulated to expose its musical content:

• Melodies include little patterns. "Hitting twice" produces little repeating patterns.

• Melodies are usually in either a duple or triple meter. "Hitting twice" creates a duple pattern.

While the student may not know why the advice works, each new piece of advice brings him in contact with new pieces of controlling structure and hidden musical content; for example,

"Sometimes strike notes twice and at other times strike four times before changing".

• If every note is hit the same number of times each is as important as the others. Hitting either twice or four times preserves the duple pattern but creates two classes of notes.

"Make the first note you strike the lowest one and use it at the very end."

• Melodies often begin and end on the same note to indicate to the listener that they are over.

• A melodic line often has a symmetrical shape. By making the first and last note the lowest note, distances away from and towards the lowest note will tend to produce a symmetrical shape.

The advice could continue;

1. "play the first and last note louder than the rest",
2. "count up to eight out loud and always play the first note when you count 'one'",
3. "sometimes count and don't play, except on count one",
4. "try to repeat a pattern of four strokes which you have previously produced",
5. "try to repeat a pattern of eight strokes which you have previously produced",
6. "apply these instructions to patterns 16 counts long",
7. "try to remember a pattern 8 strokes long and repeat it",
8. "try to remember two 8-counts long and put them together",
9. "try patterns 32 counts long",

Each piece of advice limits the randomness in the student's activity and introduces new concealed musical relations which dictate kinds of recurrence and produce levels of recognizable structure.

| | |
|---|---|
| (1) | Dynamic shape |
| (2) | Measure |
| (3) | Rest |
| (4-7, 9) | Complex patterns |
| (8) | Compound patterns |

The above imaginary session results in the construction of a constraint system for producing melodies. Each is a meaningful unit -- a mind-size bite -- which draws its systemic power from the collection. Within the limits of the collection, anything is possible; yet, less and less is possible with the addition of new constraints.

### 2.4.3 Debugging

The above advice satisfies the mind-size bite requirement but violates another important requirement; namely, that it should be possible to evaluate process, or what Papert calls *debugging*, borrowing from programming culture [21]. The student in the above example acquired about a dozen heuristics without understanding why they did or didn't work.

Composers must be prepared to design their own heuristics if they want to evaluate their effects. But then, why should we construct heuristics at all? Heuristics are an efficient way to control the explosion of musical detail: uncontrolled, this detail would make composing prohibitive. The heuristics facilitate production, capture a variety of musical concepts and contribute to a rich assortment of musically coherent connections.

### 2.4.4 Improving Compositional Method

A large part of the compositional process requires the construction of boundaries. John Sloboda talks about composing as "relaxing and tightening constraints" [22]. From the perspective of constraints, the "musical idea" is a particular constraint system constructed from old and new musical concepts. An ideal compositional problem is one in which the choices which could be made are so few that each could be considered one at a time.

If problems are so vaguely formulated that too many possibilities are acceptable and no particular one is obvious the system is insufficiently constrained. New constraints are required to make the system *robust*, as computer people say. Conversely, if the situation becomes too constraining, pieces of advice must be thrown out. Knowing which constraints are the most appropriate to sacrifice is determined by the status of each constraint in the system. Drawing from the imaginery interaction above, a new piece of meta-advice might be:

"Whatever you do, don't throw out the counting rules (i.e. the 8, 16 or 32-beat phrasing rules) if the system is overly constrained."

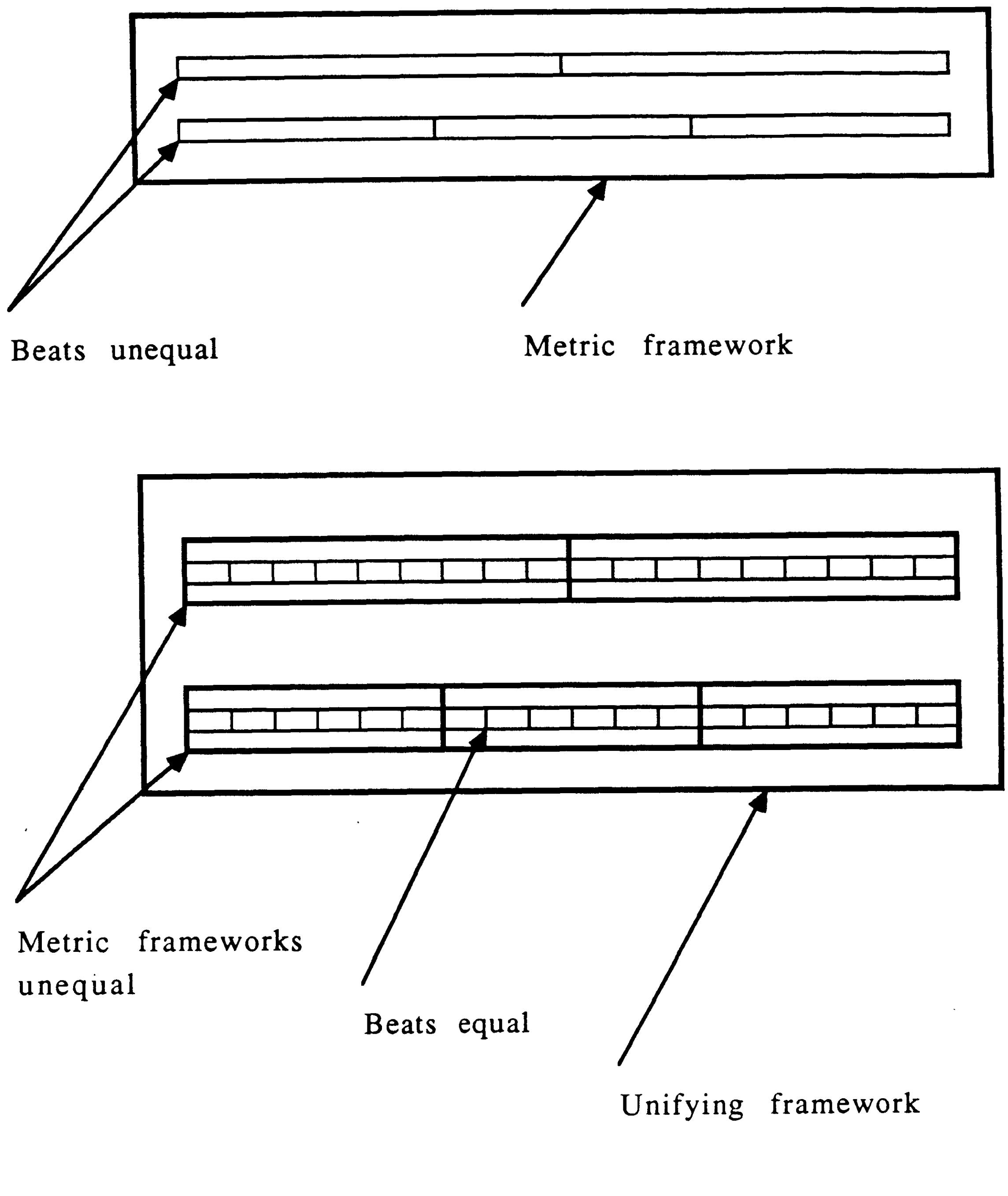
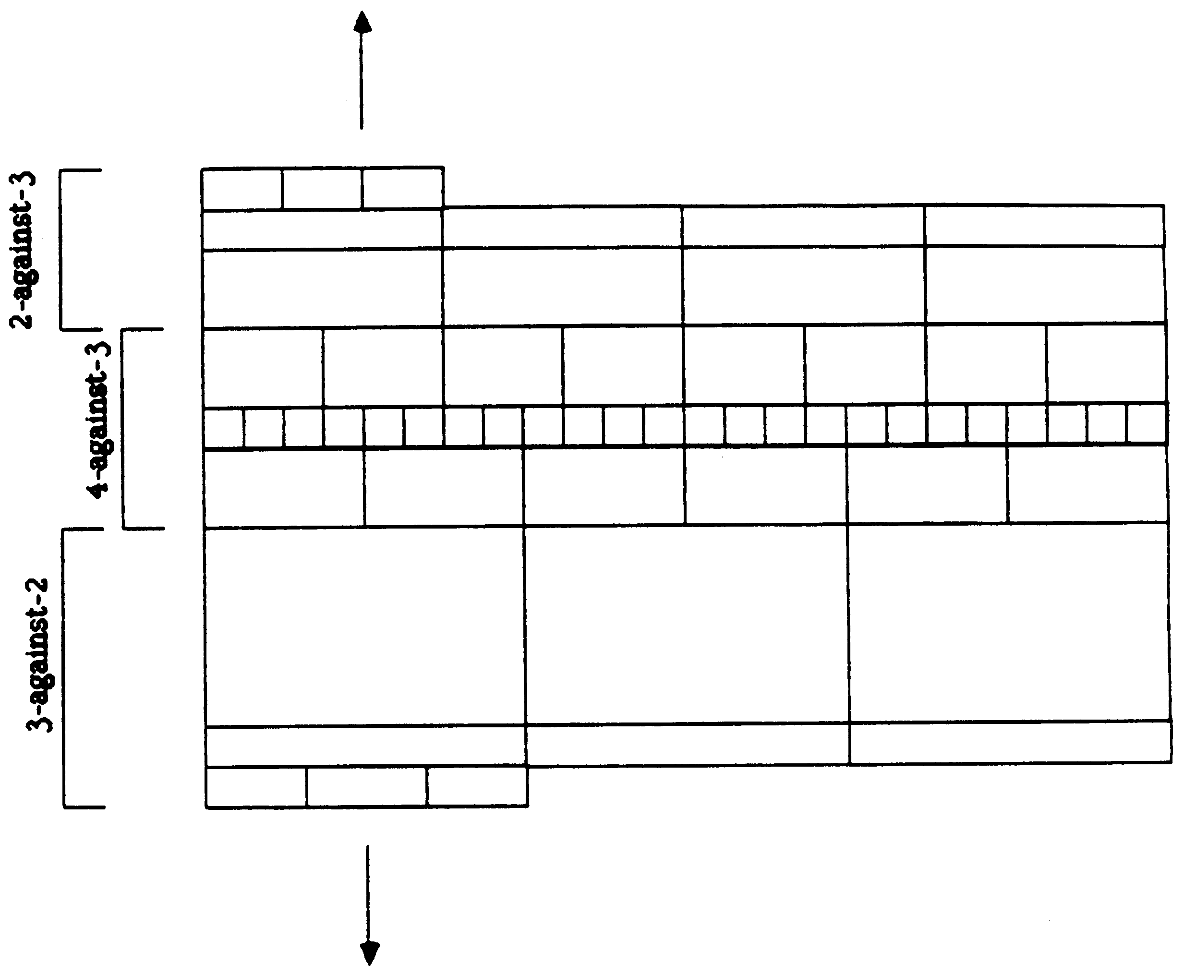



Figure 1: Groupings of 2 against 3. 1a: Metric durations are equal, sub-division of beats are unequal. 1b: Metric durations are unequal, sub-division of beats are equal.

Figure 2: Evolutionary paths from lower-level beats to higher-level groupings of them.



The status of constraints is evaluated during the compositional process. Any constraint which reduces the possibilities to a managable number will do. The process of adding and deleting constraints provides data for evaluating the importance of a constraint in the collection.

A system is robust because its complexity has been distributed so evenly across the system that each problem does not exceed Papert's mind-size bite requirement. Robustness is a requirement for a system to be intuitive to use.

In an age such as ours where so much attention is placed on the design of systems of composition, there is a need for criteria of design. The idea that problems test constraints and provoke the construction of new ones reflects the evolutionary character of the compositional process. However, for problems to be musical problems listener models have to be incorporated in compositional models. In my session with the imaginary student (above) it so happened that the advice I gave had musical content. The situation could have been quite different. I could have been on the receiving end of bad advice and unable to evaluate my own performance. As a composer, I want to be able to invent new kinds of compositional problems and evaluate them. If I can evaluate the advice I give myself I will be able to add to my current methods the ability to change my own intuitions.

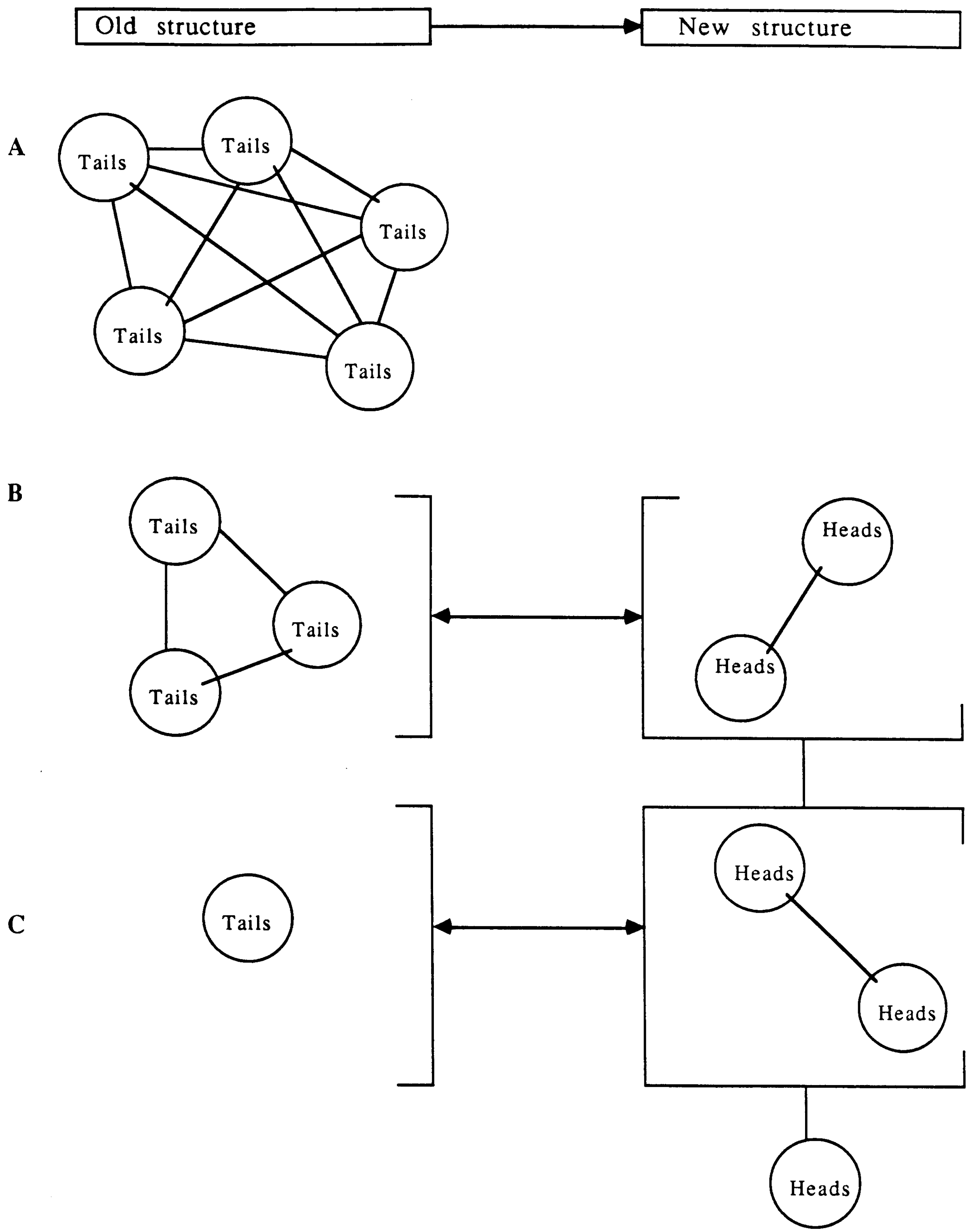
## 2.5 Distributed Complexity and Expressiveness

### 2.5.1 Distributed Complexity

The formulation of new methods from heuristics is constrained by previously used methods and heuristics. A new heuristic does not have to be evaluated for its completeness, just its soundness with respect to the questions it attempts to address. Bharucha's advice about establishing a tonal scheme complements McAdam's and Bregman's advice about musical streams. Streams are neutral with respect to tonality and tonality is neutral with respect to voicing; yet, each constrains the organization of note. A balance between modularity and connectivity in the construction of heuristics is a requirement for good system design as the following comments from Ashby illustrate.

In Ashby's discussion of biological systems he points out that an animal injected with sex hormone will have a radical change in behavior. The fact that such complex behavior can result from such a simple control mechanism (i.e. hormone injection) seems disturbing.

Figure 3: Distributed Complexity. A modular and connected coin tossing strategy. (Flip non-heads coins; if all are heads, stop; otherwise, collect all non-heads coins and repeat procedure)



But Ashby reminds us that:

> "the complexity is not to be related to the hormone-parameter but to the nervous system that is affected by it." [23]

It is the connectivity between modular parts that allows small changes in significant parameters to have such dramatic effects. Ashby goes on to say:

> "Adaptation demands not only the integration of related activities but the independence of unrelated activities." [24]

After Ashby's example [25], imagine several coins with a random distribution of heads and tails facing up. The goal is to flip the coins until all heads are facing up. He asks us to imagine three different strategies for obtaining this goal.

Procedure #1: Where everything is connected to everything else.

1. Flip all coins at once.
2. If all coins turn up heads stop.
3. Otherwise, go to step 1.

It is very likely that procedure #1 will be abandoned because success requires a large number of tosses as the number of coins (N) increases (approximately $2^N$ tosses).

Procedure #2: A highly modular syistem where nothing is connected to anything else.

1. Flip coin.
2. If it is tails, go to step 4.
3. If no coins remain, stop; otherwise,
4. Go to the next coin .
5. Go to step 1.

Procedure #2 will work pretty well. The number of tosses goes up at a constant rate no matter how many coins are used (approximately 2N).

Procedure #3: A system of modular and connected parts.

1. Flip non-heads coins.
2. If all are heads, stop.
3. Otherwise, collect all non-heads coins.
4. Go to step 1.

Procedure #3 is better still. The number of tosses goes up at approximately N . Procedure #3 is a balanced problem solving strategy. Each solution in the sequence of solutions is not only simple, it leads to proportionally less difficult solutions.

Figure 3 reinforces this point. At the first stage (marked A) all five coins are connected to all others. After the first toss, two coins have turned up heads while three remain tails. They are two modules or groups, a "heads" group and a "tails" group; yet, the first is connected to the second's success, the second to the first's failures. Each remaining tossing problem is richly connected, yet among fewer elements; and each success can be put aside as a solved piece of the problem.

The balance between modularity and connectivity is conveyed in the phrase *distributed complexity*. If complex problems can be formulated as simpler and related problems, solving one partially solves others. Distributed complexity helps the composer to control the difficulty of compositional problems.

### 2.5.2 The Expressiveness Goal

The local theory constraint assumes that the listener can benefit from distributed complexity. Problem-solution chains, which are a consequence of distributed control, lead to recurrence through which listeners identify objects and operations, and form listener models.

However, other tests are required if a piece of music is to be expressive. Local theoretic tests must capture coherent pieces of problems. This coherence requires musical parts of interest and connectivity among parts. My conjecture is that a system is maximally expressive:

1. when the parts of a system are attached to extra-musical elements of interest,

2. when a local theoretic test succeeds on each of the pieces of a compositional method,

3. and when a system is structured in a distributed way with conceptually coherent parts which are small and connected.

In such a system the patterns of compositional abstractions and listener abstractions are likely to be shared. I call this the *expressiveness goal.*

## 2.6 Diversification and Control: The Notion of "Scale"

Looking at the scales used across the world we find that no traditional scale has scale steps which are all equal distances from each other. The notion of "scale" illustrates the parts-whole relation described by distributed complexity.

### 2.6.1 The Notion of "Scale"

A melody which is *transposed* -- slid up or down the even-tempered tuning system -- will sound the same in spite of its initial starting point. Western musical scales would produce melodies with the same stepwise uniformity if they were as uniform as the tuning system itself. But they aren't. Differences in melody are inforced by the irregularity of scale.

Melodies are attached to the notion of "scale" just like scales are attached to to the notion of "tuning system". In some traditional cultures, like in Senegal, the notions of "tuning system" and "scale" are equivalent. But it is the irregularity of scale and not the uniformity of tuning which is important for melodic production because of the diversity which results from simple changes in the point of melodic departure.

In the absence of scale irregularity, a culture might have increased the number of melodies by increasing the length of the pitch-patterns made. Given a fixed collection of pitches, increasing the <u>number</u> of pitches can also increase the melodic possibilities. However there are memory constraints: there is a limit on how long one can listen to something and still think of it as a melodic entity. Similarly, there are processing-rate constraints which prohibit the recognition of patterns which happen too quickly. Whatever the actual values are for these constraints, they reduce the number of melodies which can be produced. These constraints also operate on the irregular scale. All things being equal, the irregular structure is more productive by a factor which may be as much as the number of steps in the scale but is usually a factor of 2 or 3! (This depends on how much duplication is found in the interval-patterns making up the scale <u>parts</u> and there usually is some.)

Each Greek mode serves the function of scale as described above. [24] Each mode can be generated by shifting upward one step from the previous one; for example,

```
  D E F G A B C D                 ;Dorian
shift up->
    E F G A B C D E               ;Phrygian
shift up->
      F G A B C D E F             ;Lydian
shift up->
        G A B C D E F G           ;Mixolydian
shift up->
          A B C D E F G A         ;Aeolian
```

The irregularity of scale provides added structure which makes it possible for a melody to trace different paths through scale points. Starting the same pattern at a different point on the scale results in a different pitch-pattern because the pitch-intervals found in the scale are not equal. At the same time scale helps to relate these different paths to each other. Scale promotes melodic variation and the coordination of this variation which is why it is such a powerful systemic idea.

### 2.6.2 The Mutual Exploitation of Scale and Melody

There are patterns of pitch-intervals which may have been used in the evolution of scales. Perhaps, these scale parts were suggested by the production process itself. For example, the stretch of the hand on most string instruments covers pitch-distances which are about a half-octave in length. Similarly, most primitive wind instruments require two hands to cover an octave. The notion of octave is quite strong in all cultures; maybe, because men and women are designed to recognize one from the other by the octave difference in their voices (a biological trick of halving vocal cord length). In any case, these "handfuls of notes" combined with the recognition of octave could have led to the primitive notion of scale [27]. Similar conjectures are made about other systems of measurement and scale which use the body as a point of reference; for example, the "hand", "foot", and number systems in base 5 or base 10. The irregularity of scale may have been a side-effect of the irregularity of hand and preserved because of its musical productivity.

The following chart shows a small sample of typical scales and scales parts [28]. The chart gives both a note-sequence and an pitch-interval sequence (in smaller print) highlighted by continuous or dotted lines. The pitch-interval separating scale parts ("interval separating parts") is also given. Note that a pattern of two pitch-intervals defines three consecutive pitches and three intervals define four pitches.

| Scale Name Parts | Pitch Pattern | Interval Separation |
| --- | --- | --- |
| Aeolian | C D Eb F G Ab Bb C | P4 |
| (interval pattern) | (M2 m2 M2 M2 m2 M2 M2) | |
| Major Scale | C D E F G A B C | P5 |
| (interval pattern) | (M2 M2 m2 M2 M2 M2 m2) | |
| Chinese | C D E G A C | P4 |
| (interval pattern) | (M2 M2 m3 M2 m3) | |
| Hindu | C D E F G Ab Bb C | m3 |
| (interval pattern) | (M2 M2 m2 M2 m2 M2 M) | |
| Japanese | C Db F G Ab C | P5 |
| (interval pattern) | (m2 M3 M2 m2 M3) | |
| Mohammedan | C D Eb F G Ab B C | P4 |
| (interval pattern) | (M2 m2 M2 M2 m2 m3 m2) | |

One would expect to find the use of scale-parts in the construction of melody. Conversely, one would expect to find melody as furthering the cause of scale. Any time two processes are *mutually exploitive*, changes in one precipitates changes in the other.

## Notes for Chapter Two

1. In using the term "masking" I am blurring the distinction between composer and listener models. This may be a mistake which I will try to rectify here. Sometimes the composer attempts to introduce ambiguity. Other times, ambiguity is a side-effect of a composer's attempt to add more structure. In the long run, the ambiguity is in the service of constructing *richness* (by which I mean "coherent complexity"). Both cases amount to listener disorientation and re-orientation.

2. For an easy to read book on expert systems see Paul Harmon's and David King's Expert Systems: Artificial Intelligence in Business. John Wiley and Sons, Inc. New York. 1985.

3. Malm, William P. Six Hidden Views of Japanese Music. University of California Press. Los Angeles. 1986. Pgs. 39-41.

4. Malm's Six Hidden Views of Japanese Music. Pgs. 42, 56, 66.

5. Malm's Six Hidden Views of Japanese Music. Pgs. 37-38.

6. Malm's Six Hidden Views of Japanese Music. Pg. 38.

7. Malm's Six Hidden Views of Japanese Music. Pgs. 68-69.

8. Schoenberg, Arnold. Fundamentals of Musical Composition. Edited by Gerald Strang and Leonard Stein. Faber and Faber. London, 1967. Pg. 8.

9. Schoenberg's Fundamental of Musical Composition. Pg. 94.

10. This idea is supported by comments about *transition* and *contrast* made by Arnold Schoenberg and Charles Rosen (respectively). For Schoenberg, transitions involve the process of liquidation where motive-forms are gradually deprived of their characteristic features (see note 3). For Rosen, "at a very fast rate of change, a transition disappears and becomes a contrast" (see his The Classical Style: Haydn, Mozart, Beethoven). Using my terminology, the difference between transition and contrast are the rates at which recurrence criteria change. These comments argue against a Schenkerian analysis which is insensitive to the relation of temporal change and musical semantics.

11. Wuorinen, Charles. Chapter 6: Revision. Simple Composition. Longman Press. New York. 1979.

12. Wuorinen's Simple Composition. Chapter 2: Fundamental Principles and Definitions.

13. Wuorinen's Simple Composition. See note 12.

14. Antoni, Giovanni Degli. "Music and Causality". Proceedings of the 1982 International Computer Music Conference. Venice, Italy.

15. Turner, Frederick and Ernst Poppel. "The Neural Lyre: Poetic Meter, the Brain, and Time". In Poetry. Vol CXLII, Number 5. August. 1983.

16. McAdams, Stephen and Albert Breman. "Hearing Musical Streams". In Computer Music Journal. 3(4) 26-43, 60, 63. 1979.

17. Bharucha, J.J. "Anchoring Effects in Music: The Resolution of Dissonance". Cognitive Psychology. 16, 485-518. 1984.

18. Probabilities must be tied to higher-level processes. We need to have a rough idea of what the probabilities are about before we can use them to make inferences. As observers, we need an interpretive framework for filtering out data which is not relevant; reciprocally, we need to revise frameworks until data can be productively formulated as probabilities which inforce new inferences. For example, Kyburg places probabilities in a framework of utility and belief. (In Henry E. Kyburb's "Two World Views", Epistemology and Inference. University of Minnesota Press. Minneapolis, Minn. 1983.)

> [When an observer] "observes over and over that the sun rises after a certain intuitively assessable period, it is rational for him to have a relatively high degree of confidence that the sun will almost always appear after such a period."

> "The development of personal probability is tied up with the development of a theory of utility, and both are based on the concept of preference. Preference is expressed in choices between actions, but the outcome is interpreted as a set of constraints on belief."

Holland, Holyoak, Nisbett and Thagard describe frameworks as "sensible inferential rules" and "categorizations". (See Chapter 1, "A Framework for Induction", in Induction: Processes of Inference, Learning and Discovery, by John H. Holland, Keith J. Holyoak, Richard E. Nisbett, and Paul Thagard, MIT Press. Cambridge, Massachusetts, 1986.)

> "...our approach is to deny the sufficiency of purely syntactic accounts of equivalences between inferences and to insist that sensible inferential rules take into account the kinds of things being reasoned about."

> "..search takes place not only in the space of potential 'next states' along a temporal dimension but also through a space of alternative categorizations of the entities involved in the problem."

Their comments illustrate how difficult it is to talk probabilities without talking frameworks (e.g. "next states"). Leonard Meyer understands this but never explicitly ties his comments about probabilities to his discussions about musical *context* (i.e. frameworks) which is one reason I have criticized his use of them. However, my criticisms of Meyer do not apply to Narmour because of his use of contextually constrained probabilities.

> "..the realization of any one pitch implication will always exclude the immediate realization of another" (pg. 126).

> "Strength of implication would be directly related to the number of times such and such a realization had followed such and such an implication" (pg. 127).

> "style may be imagined as a large circular pool with the most frequently recurring forms at the center and the least frequent at the periphery" (pg. 178).

(See Eugene Narmour's Beyond Schenkerism: The Need for Alternatives in Music Analysis The University of Chicago Press. Chicago. 1977). Also see chapter 1, notes 19 and 33.

19. McAdams and Bregman, "Hearing Musical Streams. See note 16.

20. Papert, Seymour. "Powerful Ideas in Mind-Size Bites". in Mindstorms: Children, Computers and Powerful Ideas. Basic Books. New York. 1980

21. Papert, see note 14.

22. Sloboda, John A. The Musical Mind: The Cognitive Psychology of Music. Clarendon Press. Oxford. 1985.

23. Ashby, W. Ross. Design for a Brain: The Origin of Adaptive Behaviour. Chapman and Hall. London. First published in 1952. Reprinted in 1978. Pg. 134.

24. Ashby's Design for a Brain. Pg. 157.

25. Ashby's Design for a Brain. Pg. 151.

26. *Modes* organize modal scales. This is to be distinguished from *keys* which organize the major and minor scales found in western harmonic music.

27. As I suggest in chapter 3, music can evolve from body language. John Baily discusses this in his article "Music Structure and Human Movement" (In Music Structure and Cognition. Edited by Peter Howell, Ian Cross, and Robert West. Academic Press, New York. 1985). In it Baily quotes the ethnomusicologist John Blacking who has studied tunes played on the African *kalimba* (or "finger harp"):

> "An analysis [of the tunes] reveals no patterns common to different melodies. But as soon as patterns of 'fingering' and of rhythm are compared, we see that several tunes differe only in so far as rhythmic variations are applied to certain nuclear, or total, patterns of 'fingering'...the most significant common factors of the kalimba tunes are not their melodic structures, but the recurring patterns of 'fingering' which, combined with different patterns of polyrhythms between the two thumbs, produce a variety of melodies."

In a similar spirit, David Sudnow describes his acquisition of knowledge about hand positions and arm movements as an improvising jazz pianist by using phrases like "a handful appreciation of a territory" or "essentialized distance achievements". (See his book Ways of the Hand: The Organization of Improvised Conduct. Harvard University Press. Cambridge, Massachusetts. 1978.)

28. Cohen, Charles and Don Schaeffer. Complete Encyclopedia of Scales. Published by Charles Colin. New York. 1977

# Chapter 3:
# African Musical Concepts

## 3.1 African Ideas About Rhythm

Most ethnomusicologists have learned that attempts to apply western musical concepts to non-western musics are often misleading, capturing only what is salient in the western concept. I provide two examples of rhythmic concepts -- one on "meter" and the other on "syncopation". By comparing their use in western and African contexts I show how conceptual differences can be captured through inspections at the micro-structural level.

### 3.1.1 "Meter": African Polymetrics

The terms usually used to describe the African sense of rhythm do not capture the richness of the African concepts of temporal change."Polyrhythm" is too broad, "the hemiola style" and "isorhythm" are too narrow for different reasons. However, the combination of these concepts can lead to a definition which I believe reflects much of African music's temporal reality [1].

Below is a simplified definition of the western terms presented above.

| | |
|---|---|
| *polyrhythm* : | The simultaneous presence of more than one rhythm (usually implies "structured by one meter"). |
| *hemiola* : | The simultaneous presence of duple and triple rhythm in a single metric framework. |
| *isorhythm* : | The use of a repeating pattern (*talea* ) inside of a metric framework of a different temporal length (*color* ). |

The hemiola is one metric framework subdivided in two beat-patterns. The beat-patterns add up to the duration of the metric framework but the beats across beat-patterns are not equal. This is not surprising since dividing the same unit of time into 2 or 3 parts will make the durations of the parts unequal.

In contrast, the durations of the beat-patterns in isorhythms are not equal though the beats are. Each beat-pattern in an isorhythm is a temporal cycle "tuned" to a different duration. If both cycles begin together, they will recur, increasingly out of phase, until they once again coincide. One can think of the duration from the time they start together and coincide as a third temporal framework which incorporates the first two.

The concepts of hemiola and isorhythm can be formulated so that they are actually two different ways of saying the same thing and it is this bi-formulation which captures its use in African rhythm. Perhaps figure 1 will help. As the illustration shows, the single framework of hemiola can be compared with the unifying framework of the isorhythm; and the unequal subdivisions of hemiola beat can be compared with the unequal isorhythmic parts.

Figure 1 uses groupings of 2 and 3 only. African music does not restrict itself to groupings of 2 and 3 nor does it restricts itself to one evolution of pattern. Figure 2 follows the same principles as graph 1 but demonstrates a few evolutionary paths from the middle of the graph outward (i.e. up or down). As in figure 1, time moves from left to right. Notice that the 2-against-3 near the top of the graph is not the same as the 3-against-2 near the bottom of it.

In African music, changes in tempo are strictly coordinated. The idea of changing tempi is defined rigorously unlike the traditional western idea. This is because polymetrics of African music serve the same role as I-V-I of traditional western music. What I have been calling home questions: "where's the tonic?" in tonality is served by the question "where's the beat?" in polymetric music.

In his book African Rhythm and African Sensibility Chernoff describes the way rhythm functions given that there are always two rhythms going on at once.

> "The diverse rhythms establish themselves in intricate and changing relationships to each other analogously to the way that tones establish harmony in western music" [2].

Chernoff contrasts this notion of rhythm with that found in the traditional west where music is simply divided into standard units of time. Chernoff introduces the idea *negative rhythm* where "the elements which are shared are not those which are audible." Rhythm comes from the implied temporal framework shared by both rhythms.

An analogy can be made with western melody which we can think of as "negative harmony" in that it suggests an inaudible harmony by its linear motion. Each music has a relational logic, different from the other mainly because of what aspects of the material that logic serves.

### 3.1.2 Syncopation: (Western) Metric Home

In the west, if a pattern of accents, 4 beats long, are established, like this:

```
1      2      3      4      1
strong weak strong weak  etc.
```

reversing the weak and strong beats of the measure can be represented as a momentary shift to the right, like this:

```
1      2      3      4
strong weak   strong weak
==>    strong weak   strong weak
```

But if the previous accent pattern is re-established, the interpretation of the measure returns to the initial metric framework, a shift to the left like this:

```
1      2      3      4      1
==>    strong weak   strong weak
strong  weak  strong weak   <==
```

and <u>not</u> another shift right.

```
1      2      3      4      1      2      3
==>    strong  weak  strong weak
       ==>    strong weak   strong weak
```

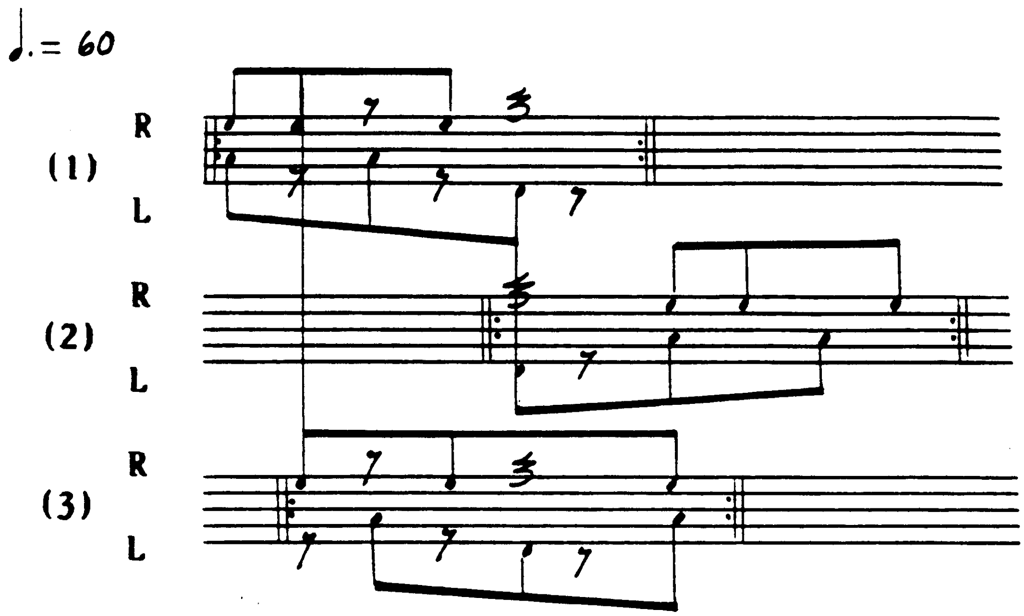
This is because syncopation is a particular shift from *metric* home: <u>returning</u> home is a shift in the opposite direction. The same argument would apply if the initial shift was left; i.e. an anticipation of the strong beat. A return home would be in the opposite direction (a shift right).

Syncopation arouses interest because metric home conflicts with the temporary home reflected in the shifted pattern. There is a continuous mis-match between "first beat" and "strong beat". A resolution of syncopation conflict results from a successful match, a return home.

### 3.1.3 African Revision of "Syncopation":

Figure 3 shows the more complex African version of this notion. If there are two meters in African "meter" one might say that there is a downbeat and upbeat for each. However, if the downbeat of one meter is often the upbeat of the other it might just be that "syncopation" is a

Figure 3: Downbeat/Upbeat Ambiguity



meaningless term. I show that the downbeat-upbeat ambiguity in African rhythm serves a different purpose; namely, as a temporal route between meters.

In figure 3 the top line (R for "right hand") is in 2 (or 6/8) while the bottom line (L for "left hand") is in 3 (or 3/4). Versions1, 2 and 3 are all the same repeating pattern starting at different points in the pattern. For all examples, there are strong-weak beat arguments which can be made by defining R in terms of L and vice versa. In addition, there are arguments which can be made for each rhythm separately; for example,

(1) R should start with the most active portion of the pattern, the two consecutive beats. The low note in L is the upbeat of the 3/4 measure.

(2) The low note in L is the downbeat of the 3/4 measure. The two consecutive beats of R is an upbeat-downbeat sequence on the second beat of the 6/8 pattern.

(3) The two consecutive beats of R is an upbeat-downbeat sequence on the first beat of the 6/8 pattern. L is an upbeat pattern in 3/4.

How does the listener solve this problem? In a sense it is not a problem to solve. There are two temporal reference points and two levels of tracking going on: one pattern's downbeat is often the other's upbeat. If one is always succeeding and failing to make matches, the western notion of syncopation becomes meaningless. This downbeat-upbeat is a route between metric structures; yet, it creates a tension which is consistent with the "opposition aesthetic" of African music.

## 3.2 Senegalese Movement

The use of "upbeats" and "downbeat" as routes between rhythms is reflected in Senegalese dance. This demonstrates a coherence between Senegalese physical movement and music. Here, I express this routing using the term *pivot* to represent a relation between temporal structuring and body knowledge. Papert's term for this relation is *body syntonicity* which he borrows from clinical psychology [3].

### 3.2.1 Dancing Around the Beats

In the documentary on Doudou H'Diaye Rose he makes the following comments regarding music and dance [4].

> "It's very hard to dance. Dancers have to know how to caress the tomtom. Sometimes I fix my eyes on the eyes of the dancer and we play together, me with the tomtom, she with her body."

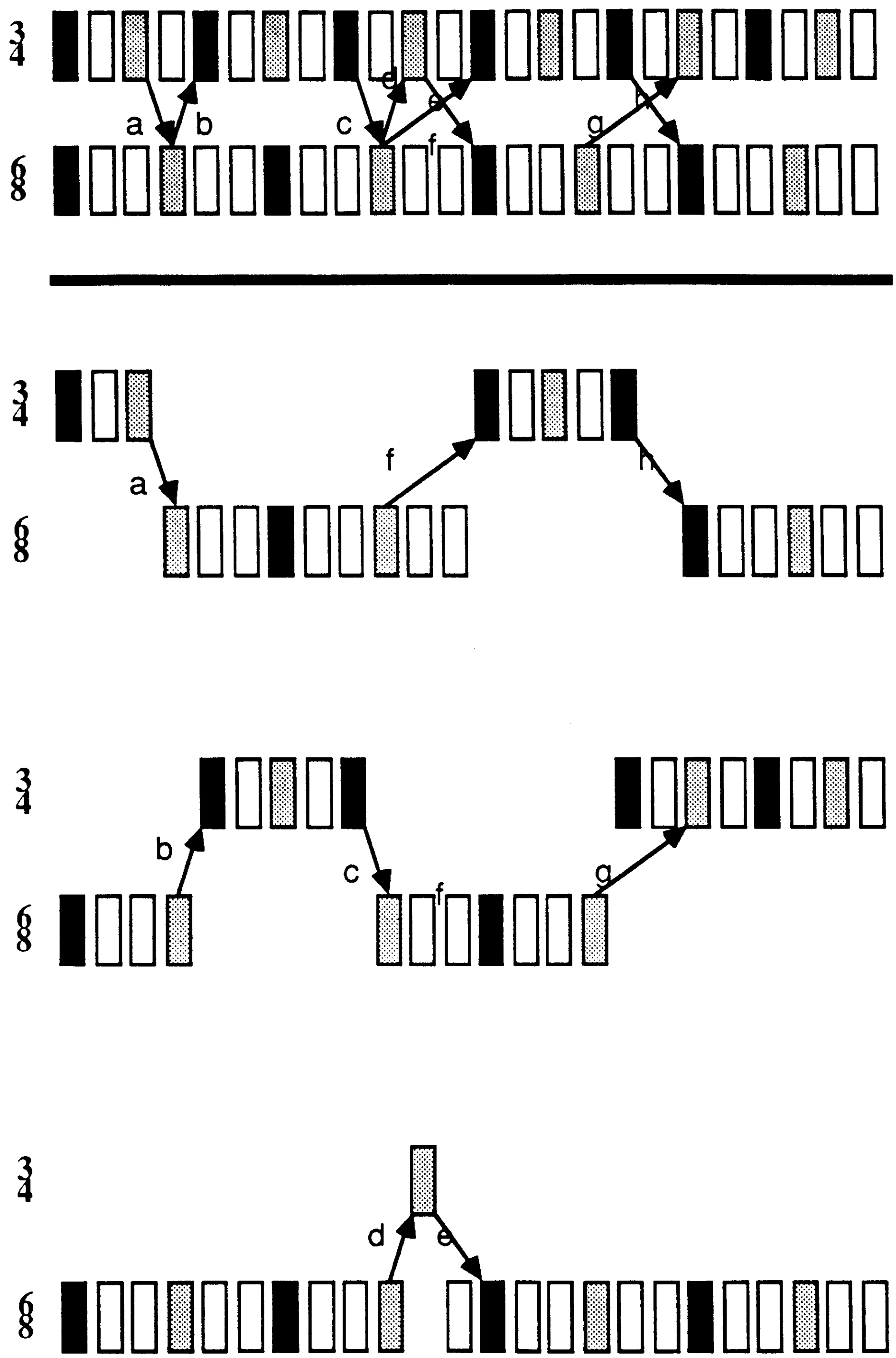
While I was in Senegal I had the good fortune to video tape an outdoor festival of Doudou H'Diaye Rose, his ensemble and dancers. The dancers were almost always women and made up of festival participants and members of Rose's family. The audience was a mixture of men and women, about 200 in all. Over the two hours of the festival approximately 50 women had danced, many several times, each spontaneously entering the circle of people which surrounded the musicians and the dance space. Most of the dances were solos, but occasionally as many as 6 dancers danced together. Dance improvisations were short ranging from a few seconds to no more than a minute or so.

The polymetrics of Senegalese drumming appears to be common knowledge. A dancer's movement phrases reflected a selection of particular metric structure as well as the patterns organized by it. A dance solo was comprised of several selections. Dance movements were used by Rose to inspire new drum patterning which, in turn, inspired new movement phrases. The relatively stable polymetrics of the ensemble served as a background to interactions among the solo dancer and Rose.

I'm calling the soloistic interactions with the rhythmic structure "dancing around the beats" which I illustrate in figure 4. This illustration shows two rows of blocks. Time goes from left to right. The blocks represent the implied temporal structure that unifies the two metric structures represented by the two rows of blocks, the upper one in 3/4 and the lower one in 6/8. For each metric structure, strong beats are in black and subdivisions in gray. The arrows (marked a, b, c, d, e, f, g, h) show the pathways to and from the rows. They only connect gray (upbeat) or black (downbeat) blocks to each other as described below.

| | |
|---|---|
| <u>No pathways</u>. | Dancer in 3/4 can stay in 3/4. A dancer in 6/8 can stay in 6/8. |
| <u>Arrow a</u>. | Dancer uses a subdivision in 3/4 as a shortened <u>upbeat</u> to a subdivision in 6/8. |
| <u>Arrow b</u>. | Dancer uses the subdivision in 6/8 as a <u>downbeat</u> in 3/4. |
| <u>Arrow c</u>. | Dancer uses a <u>downbeat</u> in 3/4 as a subdivision in 6/8. |
| <u>Arrow d</u>. | Dancer uses a subdivision in 6/8 as a shortened <u>upbeat</u> to a subdivision in 3/4. |

Figure 4: Dancing around the beats. Using the pathways (the labelled arrows) from two metric patterns (one in 3/4 the other in 6/8) to construct metric mixtures.



| | |
|---|---|
| Arrow e. | Dancer uses a subdivision in 3/4 as a shortened upbeat in 6/8. |
| Arrow f. | Dancer uses a subdivision in 6/8 as a prolonged upbeat to 3/4. |
| Arrow g. | Dancer uses a downbeat in 3/4 as a shortened upbeat to 6/8. |

"Shortened upbeats" are actually "upbeats of upbeats" or subdivisions at a finer level of detail.

*Pivot* is an abstract notion rooted in body knowledge. Many physical gestures are comprised of a preparation-part and execution-part.

| **Preparation (Upbeat)** | | **Execution (Downbeat)** |
|---|---|---|
| raising the knee | --> | stamping the foot |
| retracted arm movement | --> | motioning upward with the arm |
| rotating the knee inward | --> | rotating the knee outward (from the hip) |

These gestures correspond to upbeat/downbeat pairs. However, these pairs are reversible so that pivots can go from either the 3/4 to 6/8 metric structure. Shifting between metric structures corresponds to shifting body weight.

| **Preparation (Upbeat)** | | **Execution (Downbeat)** |
|---|---|---|
| stamping the foot | --> | raising the knee |
| motioning upward with the arm | --> | retracted arm movement |
| rotating the knee outward | --> | rotating the knee inward (from the hip) |

The relation of temporal structure to body knowledge makes this an ideal illustration of the notion of body syntonicity.

## 3.3 The Harmony of African Rhythm

### 3.3.1 The Drumming of Doudou H'Diaye Rose

Doudou H'Diaye Rose is recognized as the leading drummer of Senegal. Decorated by the president of Senegal, Abdul Diouf, Doudou H'Diaye Rose is known by everyone. His music is used as the background to the evening news, he organizes the music and dance in city parades, accompanies wrestling matches and other public events, and organizes outdoor

Figure 5 Metric modulations which take old groups of three (upper lines) and group them into fours (lower lines) to produce a new metric structure.

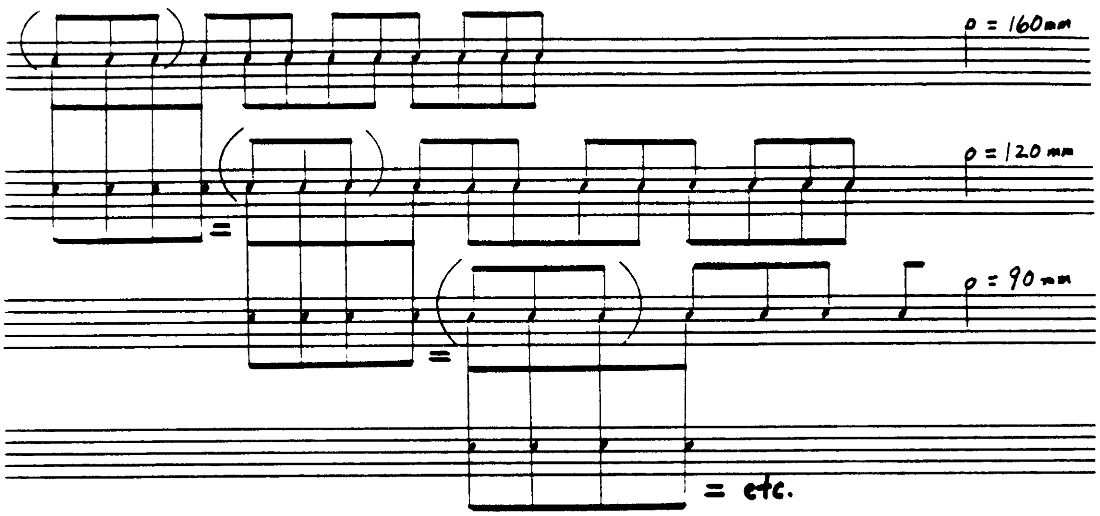


Figure 6 Graphic illustration of metric intersections from figure 4 with metric intersections at 90 mm and 60 mm. It assumes the "metric equivalence" of 60 mm and 120 mm.

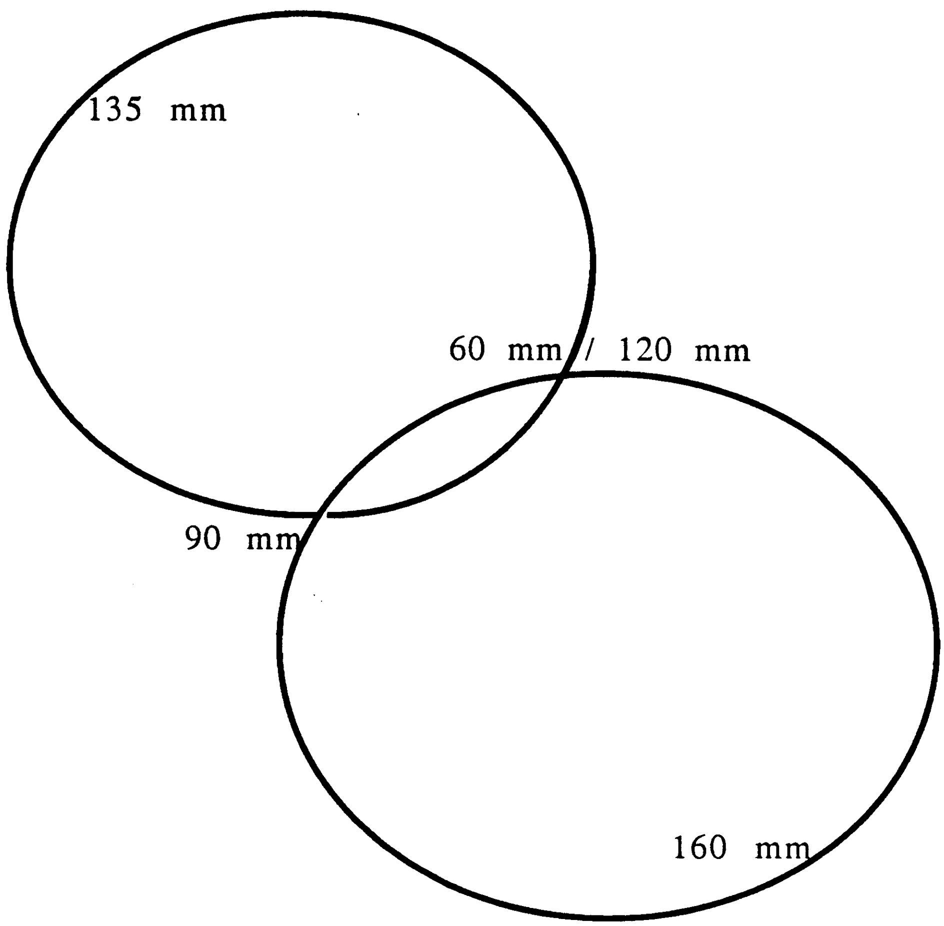


Figure 7 Complex metric intersections using music notation.

performances like the one I had the opportunity to see while I was in Senegal. He is approximately 55 years old but has the stamina, presence and enthusiasm of a 20 year old.

> "Music is a way of living: every occasion is an opportunity for music making". (Doudou H'Diaye Rose)

He is an untiring teacher of men, women, the old and the very young. He has an inexhaustible curiosity, playing with as many different musicians as possible and a preference for playing with vocalists.

An ensemble, under his direction, is divided into about 3 sub-groups each comprised of many drummers playing in unison. I personally saw a half dozen in each sub-group and noticed many more on the Rose documentary. His drummers learn a variety of patterns as well as the order in which they are to be played. He describes his pieces as compositions, not improvisations, though limited improvisation is observable in pattern repetitions, cues he gives to his musicians and in the solos he plays.

Informal performances, like the one I observed, seem to be designed primarily to support the improvising dancers. His drummers appear to be very advanced players. They are not only students in the usual sense but drummers who are well known for their playing in their own villlages or around Dakar.

### 3.3.2 The Harmony of Rhythmic Change

Drumming pattern one uses *metric modulation* patterns as well as sequences like the one shown in figure 5. In the first line of figure 5 one sees a pattern 12 units long. This pattern is not reducible to two-against-three but to three-against-four. Going down line by line produces the metric modulation sequence 160 mm --> 120 mm --> 90 mm --> etc. These temporal transformations can be reversed by going up from 90 mm to 160 mm.

What's especially interesting is that the two modulation patterns intersect at 90 mm. They also intersect at 60 mm and 120 mm if one accepts that patterns which are twice as long or twice as short as each other are easily transformable, one to the other. The 2:1 ratio of *octave equivalence* (discussed elsewhere) is similar in form to this idea; what we might call *metric equivalence*; i.e. "tempi which are doubles or halves of each other can be said to be equal".

Figure 8 Transcription of introduction to drumming piece one, played by Doudou H'Diaye Rose.

Figure 6 gives a graphic illustration of what these intersecting modulation patterns look like. Figure 7 does a similar thing with music notation. These intersections are audible and can play a role in cognitive space similar to that played by harmony in tonal space. Tempo changes are structured as relations among neighbors. This is similar to the role harmony plays in structuring relations between neighboring keys.

### 3.3.3 Priming the Listener

Figure 8 is a transcription of Doudou H'Diaye Rose's drumming introduction to drumming piece one. At first hearing, it appears that this solo is performed in a metrically free way. This impression is a result of the variety of tempo changes embodied in the solo itself. As one can see in figure 8, I hear the following pattern as a modulation pattern of: 60 mm -> 90 mm -> 120 mm -> (90 mm) -> 120 mm.

These metric modulations are found in the piece which follows the solo. Springer and Deutsch use *semantic priming* to describe how processing the meaning of a word effects the meaning of neighboring words [5]. I use the term *priming* to describe "actions or events which narrow the possible future actions or events". A listener who is able to recognize the patterns in Rose's solo will be primed for the composition which follows it.

### 3.3.4 Pace

The chart on the accompanying page entitled "Summary of Parts, Repetitions and Durations for Drumming Piece One" shows the sequence of parts to drumming piece one. The notation used here is Logo-like [6]. For example,

REPEAT 14 [A]

means "pattern A is played 14 times". The column labelled "unit duration" is the total time it takes to play a pattern (repeated or not). The column labelled "Running Duration" is the temporal position a pattern has in the overall length of the piece. One sees the pattern changes increasing with a peak between 2' 14" to 3' 15". The rate of pattern change contributes to the notion of musical pace. (Attached one will find a version of drumming piece one using traditional music notation.)

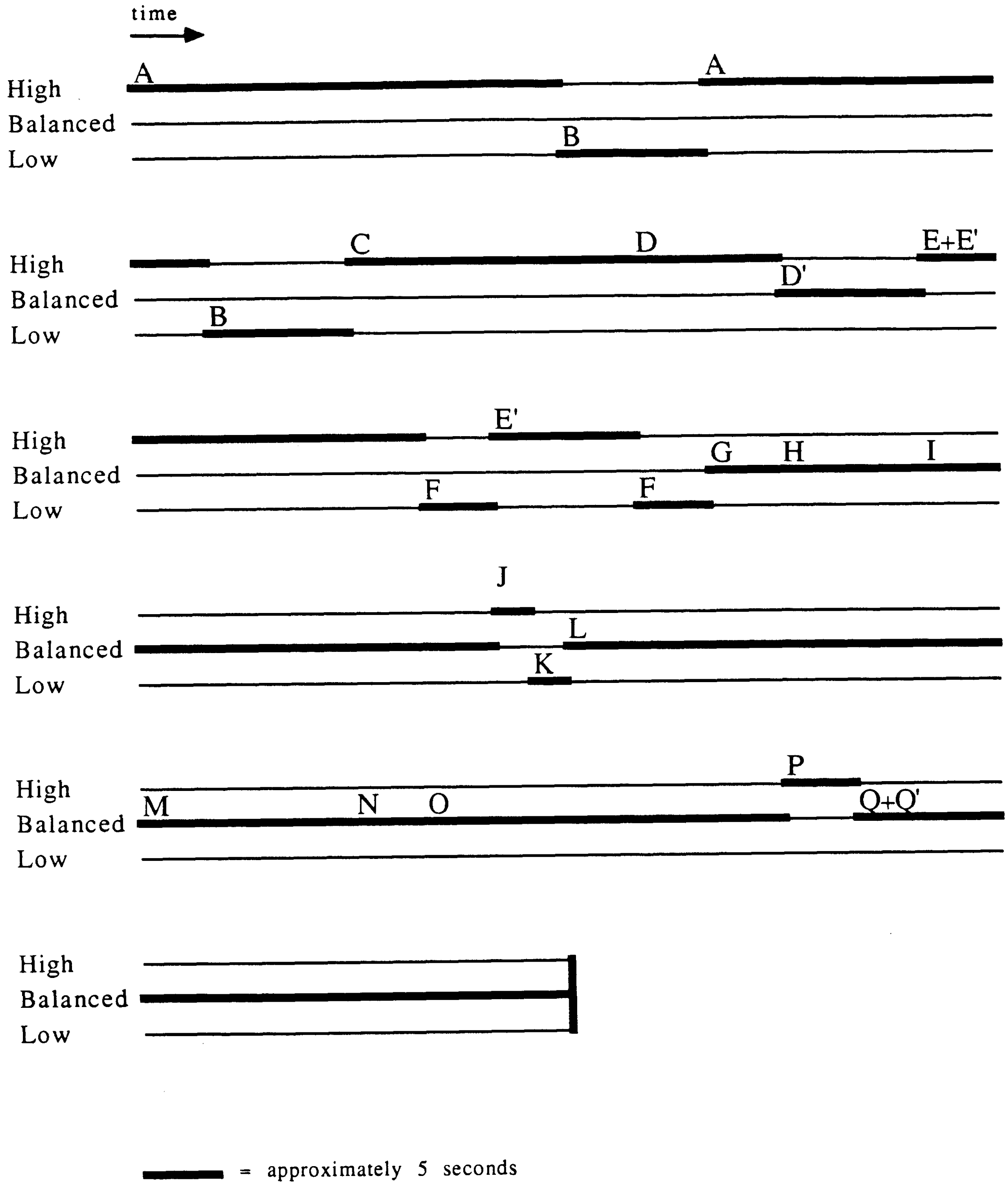
**Summary of Parts, Repetitions and Durations for Drumming Piece One**

| | | Unit Duration | | Running Duration |
|---|---|---|---|---|
| (page one of Example 10) | | | | |
| | | | | O" |
| Repeat 14 | [A] | 28" | 28" | |
| B | | | 8" | 36" |
| Repeat 13 | [A] | 26" | 1' 2" | |
| B | | | 8" | 1' 10" |
| (page two) | | | | |
| Repeat 9 | [C] | | 18" | 1' 28" |
| Repeat 11 [D] | | | 11" | 1' 39" |
| Repeat 11 [D'] | | | 11" | 1' 50" |
| (page three) | | | | |
| Repeat 4 | [E+E'] | | 24" | 2' 14" |
| Repeat 2 | [F] | | 4" | 2' 18" |
| Repeat 2 | [E'] | | 8" | 2' 26" |
| Repeat 2 | [F] | | 4" | 2' 30" |
| Repeat 3 | [G] | | 6" | 2' 36" |
| (page four) | | | | |
| H | | | 8" | 2' 44" |
| Repeat 21 [I] | | | 31" | 3' 15" |
| J | | | 2" | 3' 17" |
| (page five) | | | | |
| K | | | 3" | 3' 20" |
| Repeat 6 | [L] | | 27" | 3' 57" |
| Repeat 6 | [M] | | 18" | 4' 15" |
| (page six) | | | | |
| N | | | 5" | 4' 20" |
| (page seven) | | | | |
| Repeat 12 [O] | | | 24" | 4' 44" |
| P | | | 3" | 4' 47" |
| Repeat 10 [Q + Repeat 3 [Q'] ] | | | 40" | 5' 27" |

### 3.3.5 The Local Meaning of Pitchiness

Most drumming parts in piece one have a unique "sonority" -- or what I have been calling *pitchiness* -- which contributes to the music's pace. The graphic notation entitled "Sonority Contour" (figure 9) tries to capture some of the pitchiness of Rose's drumming ensemble. It

Figure 9 Map of "pitchiness" contour of drumming piece one. Alphabet letters refer to the composition parts.



is an abstraction of the different drumming colors into "high", "balanced" (or medium) and "low" sonorities. The changes in sonority frequently coincide with changes in rhythm, but not always; for example, going from part A to part B also results in a sonority shift from "high" to "low" while going from C to D does not. Drawing from my graphic notation, there are 22 part changes against 19 sonority changes.

Since the drums are struck with either the hands or sticks, there is considerable color and pitchiness not captured by my notations. A tomtom stroke is "bright" in timbre (i.e. has relatively loud high harmonics) when the drums are struck by sticks; or is "dark" (i.e. has relatively low harmonics) when the drums are struck by the hands. Even with these few differences there are the following pitchiness possibilities.

| **pitchiness in drumming** | **possibilities** |
|---|---|
| high | |
| -bright | 1 |
| -dark | 2 |
| medium | |
| -bright | 3 |
| -dark | 4 |
| low | |
| -bright | 5 |
| -dark | 6 |

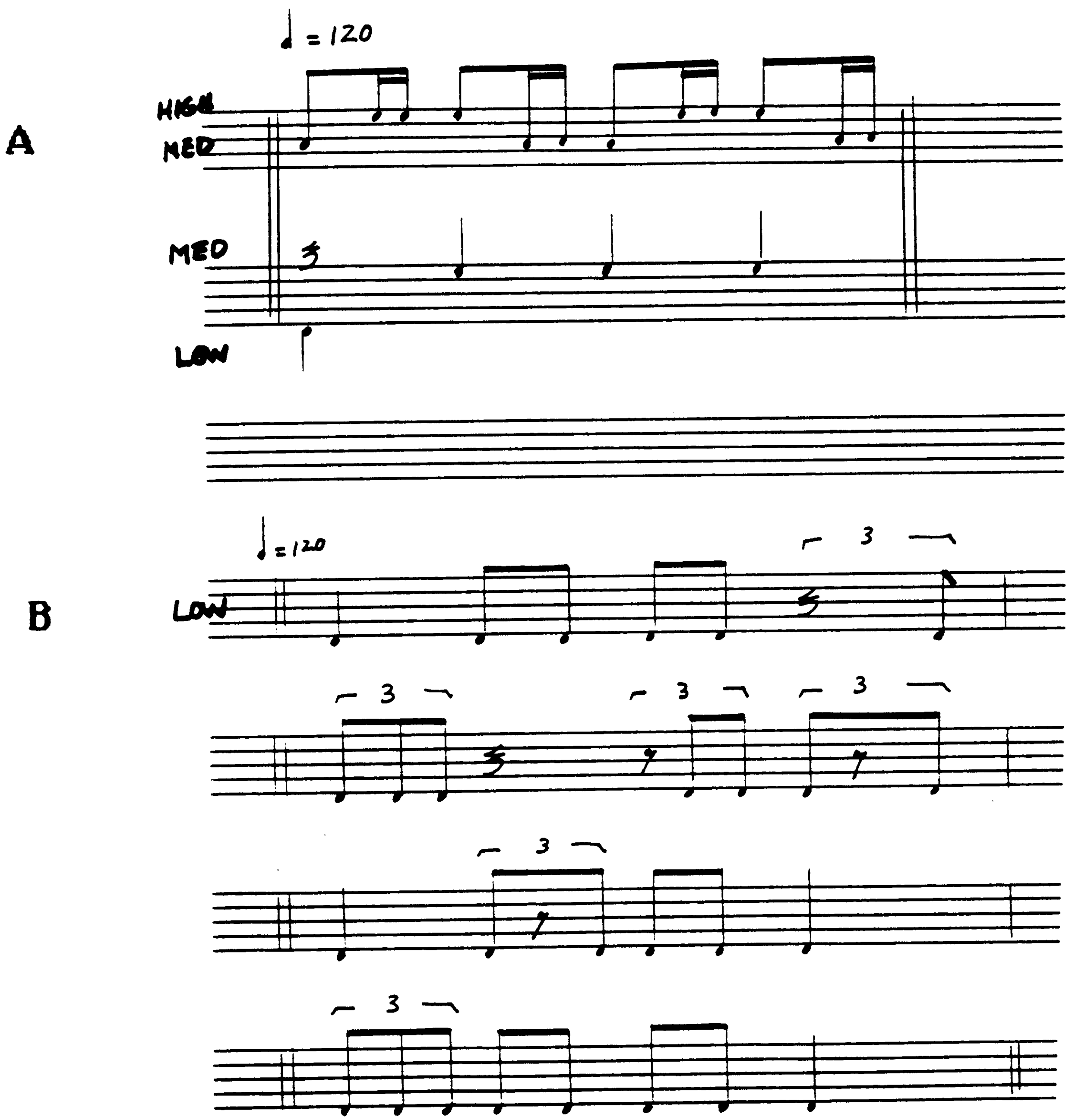
The pitchiness is rich enough to rank as high as "scale" in melodic music (See "Diversification and Control"). The different drumming sounds are imitations of environmental sounds which have gradually come to symbolize them (see "Symbolic Attachments"). This is supported by Rose's own comments.

> "I wanted to reproduce all the music I was hearing. Not only the sounds made by the women [beating grain] but also the sound of the wind, the leaves moving in the tree, a window which opens but doesn't close. I couldn't sleep at night. I was always trying to figure out how to reproduce these sounds. I registered all of these noises and then, in my bedroom, I practiced making sounds as light or as heavy as possible." (Doudou H'Diaye Rose)

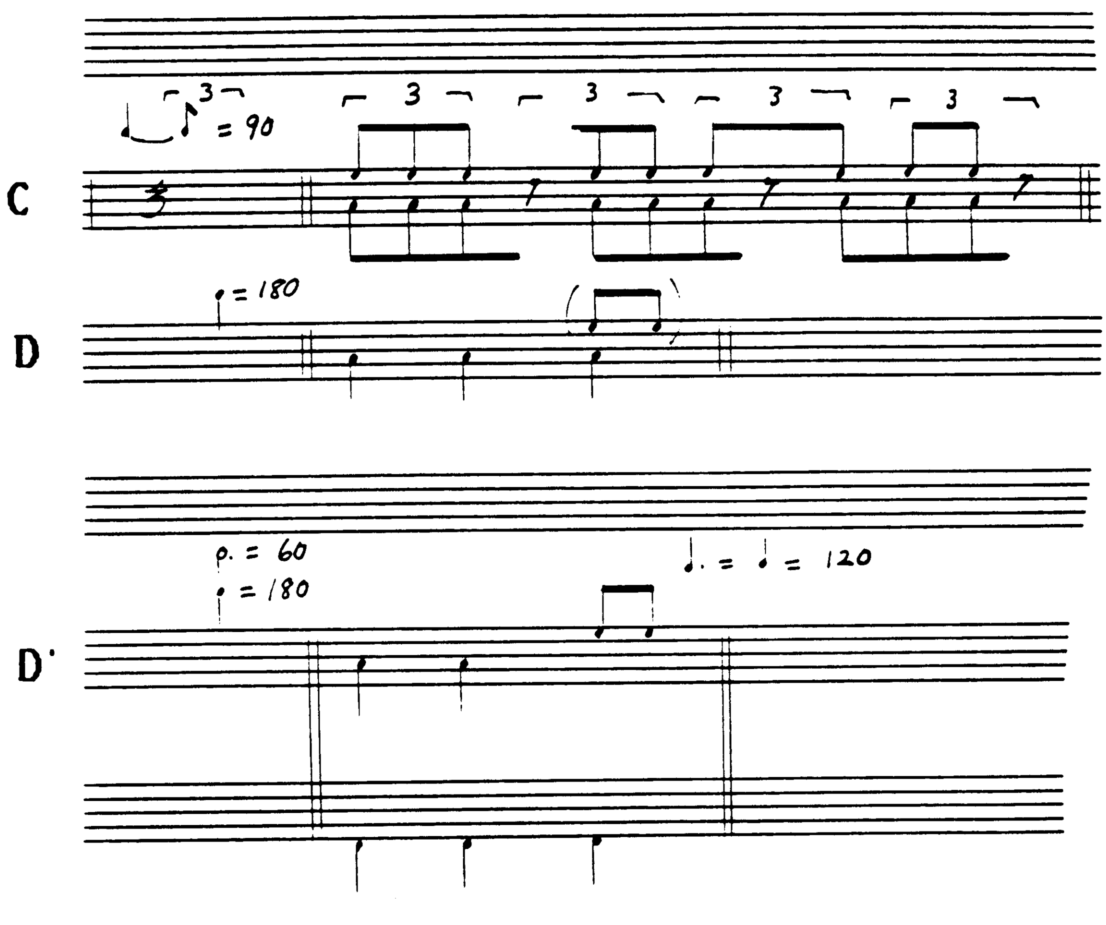
A Senegalese experience of drumming is enhanced if one is sensitive to the environment it models. These musical meanings are attached to extra-musical culture and depend on them for their significance.

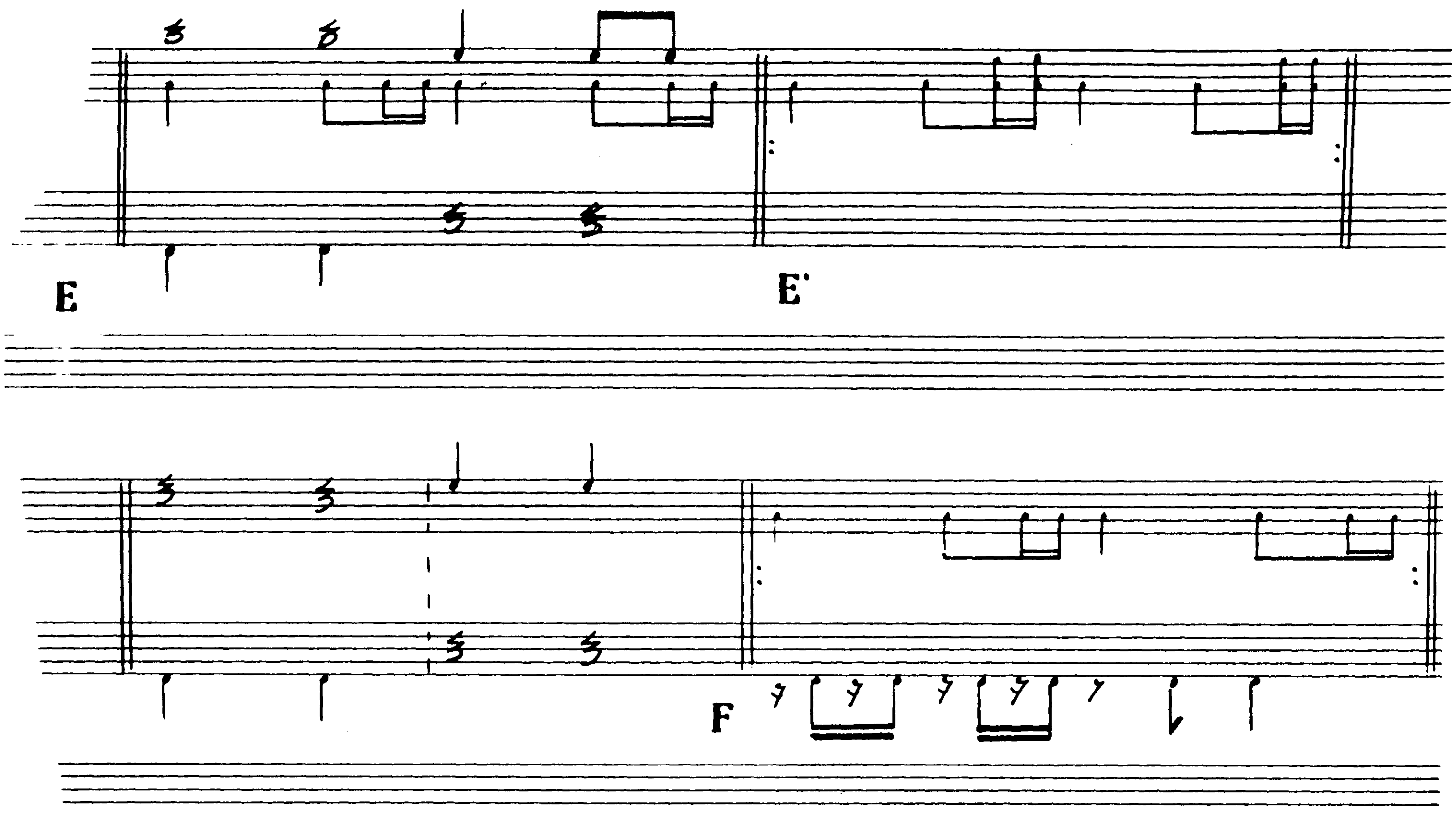
Repeat 14 [A]
B
Repeat 13 [A]
B

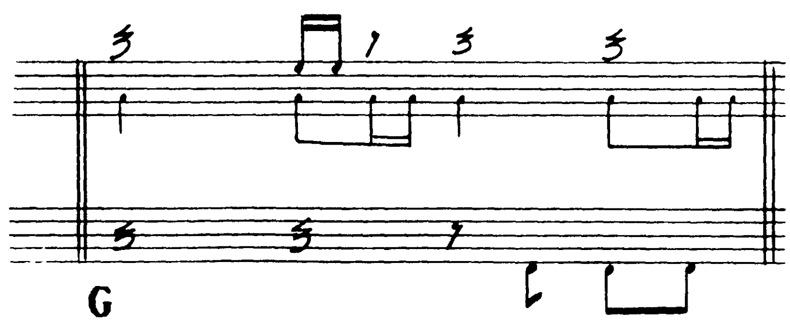
Figure 10 Parts and repetitions from drumming piece one.



Repeat 9 [C]
Repeat 11 [D]
Repeat 11 [D]





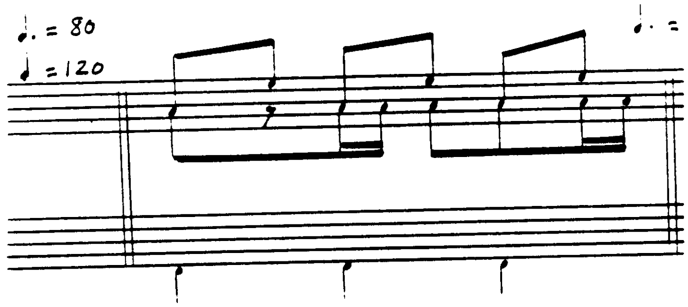




Repeat 4 [E+E']
Repeat 2 [F]
Repeat 2 [E']
Repeat 2 [F]
Repeat 3 [G]

H
Repeat 21 [I]
J

**H**

**I**

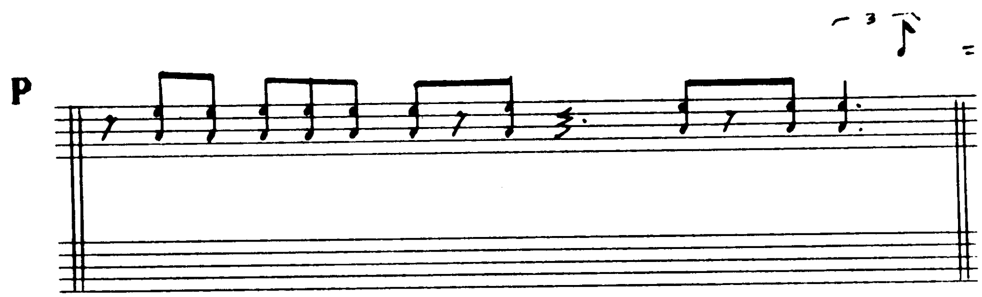


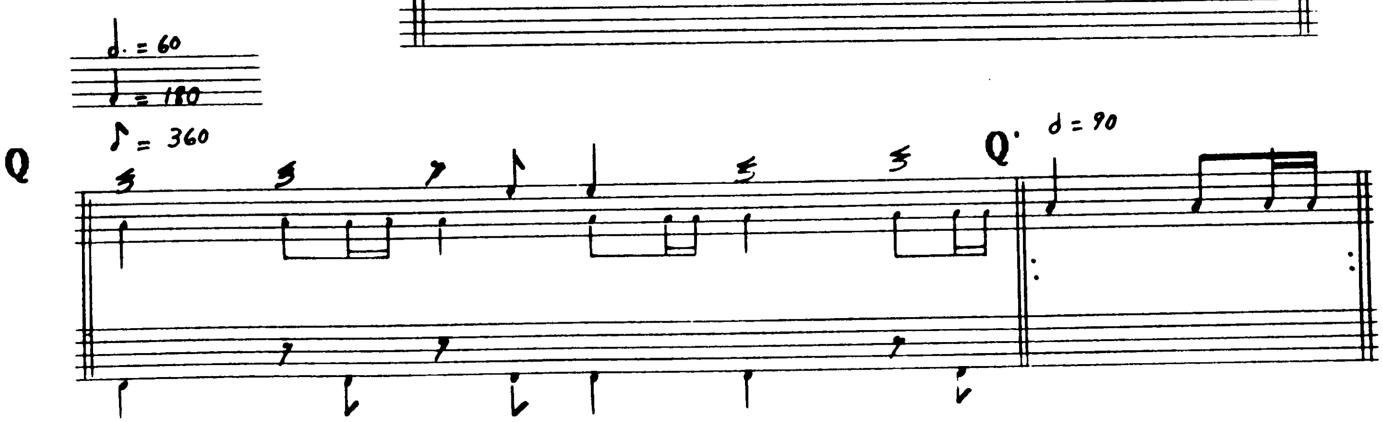

**J**

Repeat 6 [L]
Repeat 6 [M]

**N**

Repeat 12 [O]
P
Repeat 10 [Q +
Repeat 3 [Q']]

### 3.3.6 A Network of Interest

Music piece two (figure 11) shows musical strategies found in music piece one (figure 10), though drumming piece two is simpler and shorter. Both pieces have ostinato patterns (small notes) against which the changing patterns (large notes) are heard.

Section C is non-repeating and relatively long. The shifting duple and triple groupings are set against the ostinato pattern which serves as a frame of reference for pattern changes. Patterns are also similar in both pieces. Below is an outline of the beat structure from section to section.

**Music Piece Two**

| | | |
|---|---|---|
| Section A: | 10 beat groups + 6 beat groups | 16" |
| Section B: | 8 beat groups + 4 beat groups | 12" |
| Section C: | 12 beat group | 8" |
| Section D: | 4 beat groups | 21" |
| Section E: | End | 1" |

Figure 11 shows four patterns which are taken from drumming rehearsals shown on the documentary of Doudou H'Diaye Rose. Patterns 11a, 11b and 11c were each practiced by themselves over and over again. This confirms the conjecture that many patterns are memorized and not improvised. 11c and 11d, taken from a marching pattern used in a parade, are interesting because they have similar sub-patterns in them.

Because drumming patterns and compositional strategies are shared from piece to piece, pieces can be compared to each and used during listener modelling. Rose's production describes a network of interest: the more of his pieces one hears the more interesting each piece becomes.

### 3.3.7 Summary

Pace, in drumming piece one, was described as the combination of the pattern of temporal transformations from part to part using metric modulation, the duration of parts and the pitchiness of parts. Musical interest was described as the combination of local meanings resulting from the symbolic attachment of musical sounds to environmental sounds and a network of interest. These descriptions suggest that Senegalese rhythm serves the same functional role as western tonality.

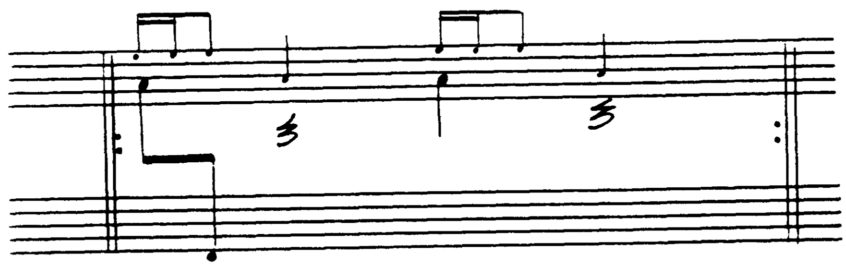
Figure 11 Parts and repetitions from drumming piece two.

**Repeat 3 [Section A]**

**Repeat 4 [Section B]**

Section C

**Repeat 16 [Section D]**

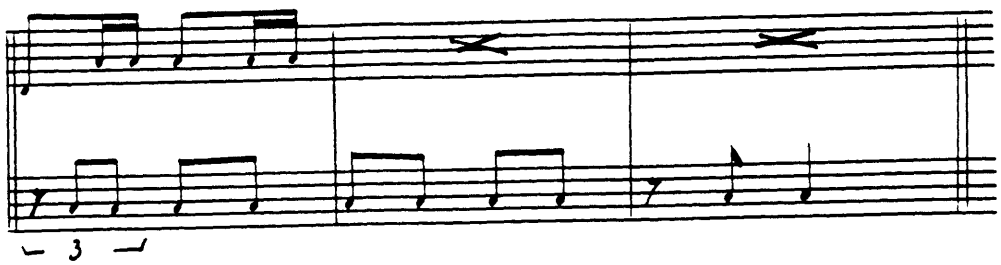


**Section E**

Figure 12: Drum patterns from other drumming pieces which are found in drumming pieces one and two.

**Drum Patterns**

A



B

**Drum Patterns**

C

D

**(Marching Pattern)**

## 3.4 The Opposition Aesthetic

According to the ethnomusicologist Daouda Gueye, African songs are constructed in the form of a theme and variations [7]. However, there can be a variety of themes and corresponding variations in each piece. Figure 13 provides two examples which he sketched out for me. Figure 12a shows themes A and B which are repeated in varied forms again and again. (The notation "a'" means "variation of a".) The variations on A form a series (a a' a" etc.) and the variations on B form a separate series (b b' b" etc.). We can think of each series as forming a group: group A and group B. One imagines that there must be a way for the listener to organize patterns into two prototypical objects comprised of a number of simple objects which are related through transformation rules.

Figure 13b is figure 13a taken one step further. It shows what happens when parts of theme A and B are combined. Instead of being seen as a variation on either A or B, the new combination forms a third theme, C. From then on, themes A, B and C repeat in variation with each forming a separate series. With this new structure it is possible to produce a number of new objects, each masking previously heard ones through the gradual addition of new elements. Daouda Gueye describes the first pattern in a series as the *mother structure* which has a constraining role on the offsprings which depend on it. Compositional skill involves regulating the rate at which objects are masked so that it corresponds to the rate at which listeners can recognize the objects being masked. The drummer Doudou H'Diaye Rose talks about this as "knowing when to change".

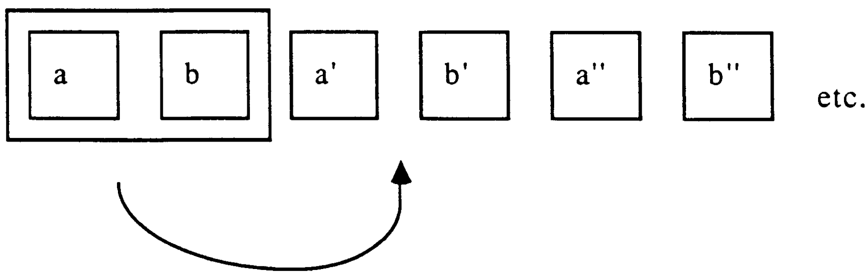
One imagines that as new structures are constructed out of ancestral ones the differences between them become less pronounced. For example,

If C = (A + B)
Then C is more like A or B than A and B are like each other.
If D = (C + B) = (A + B + B) and
If E = (D + A) = (A + B + B + A)
etc.
Then the As and Bs gradually converge

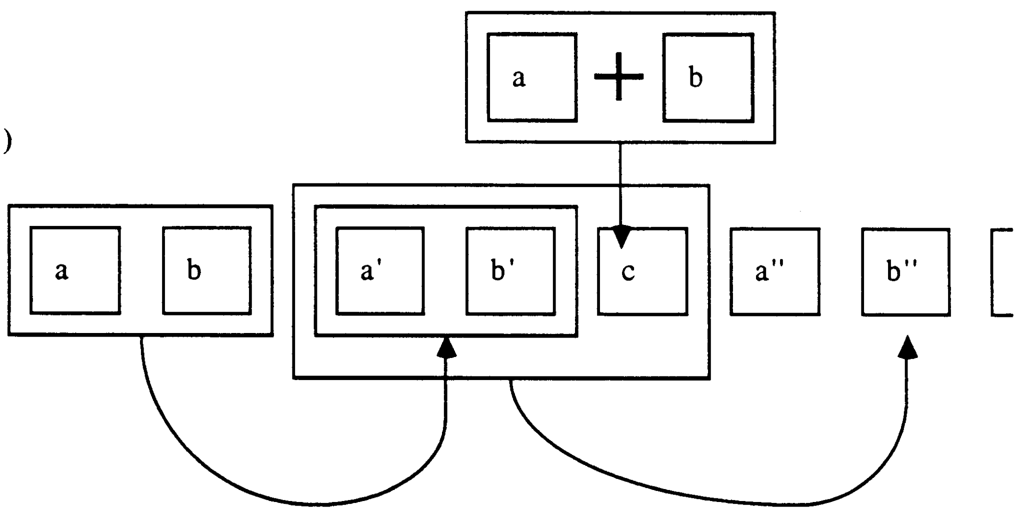
From this view, a piece will eventually result in variation parts which are more and more alike. This effect of combining patterns is <u>not</u> considered aesthetic by itself, according to Gueye. Variations are suppose to lead to new differences in a series; i.e. it is aesthetic for

Figure 13: Examples of African theme and variation structures (from notes taken during an interview with Daouda Gueye)

(a)




(b)



structures to become less and less alike with each tendency for them to become more and more alike. In fact, it is the opposition between combining structures and variation structures which is aesthetic. Using my terminology, unmasking and masking operations balance each other.

These oppositions are consistent with my previous discussions about downbeat/upbeat ambiguity, polymetrics and metric modulation. The question "where's the beat?" or "where's the mother structure?" evokes home questions which are mutually-inhibiting: recognizing the beat makes the temporal framework unrecognizable; recognizing a pattern makes the opposing pattern unrecognizable. It is perhaps for this reason that our attention to African music is so continuously alive.

In traditional western music, people speak of "tension and release" to describe the musical abstractions which my notion of pace tries to capture. However, the aesthetic operating in African music is not one of the tension and release but one of continuous opposition. It is a body-syntonic definition of musical balance which has to be fulfilled in time, all the time [8].

## 3.5 A Local Theoretic Approach to Rhythm

In the section entitled "The Harmony of African Rhythm" I describe temporal change using the notion of metric modulation, borrowing from contemporary western musical thought. Here, I show a metric modulated result from a production-driven description [9].

### 3.5.1 Execution Strategies

To review, there are two ways a metric modulation occurs and often both are used together:

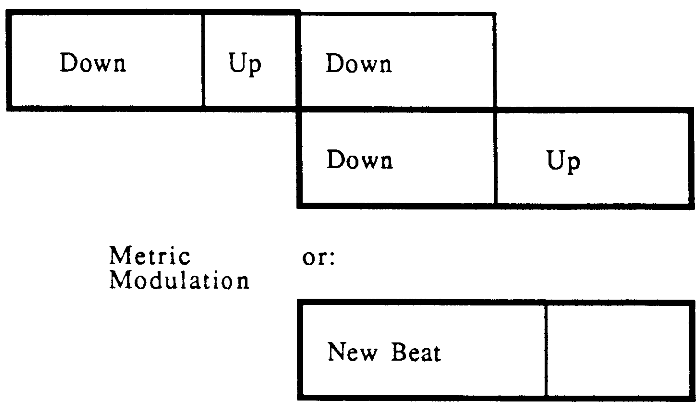
(1) A measure is divided into new subdivisions, or
(2) subdivisions are grouped into new beats.

The attached pages illustrate 4 local strategies for executing a change in meter which respects the principles of metric modulation. The downbeat/upbeat parts are either equal or in a ratio of 1:2. The first two pages (figure 14) are graphic and the third (figure 15) is musically notated. Time goes from left to right in all examples.

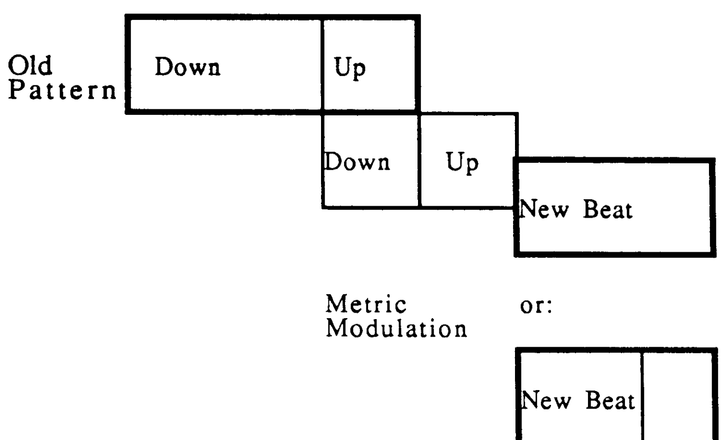
Figure 14: A local formulation of metric modulation. 14a=strategy one; 14b=strategy two, 14c=strategy three, 14d=strategy four.

## Execution Strategies

(a) Make new upbeat equal to old downbeat

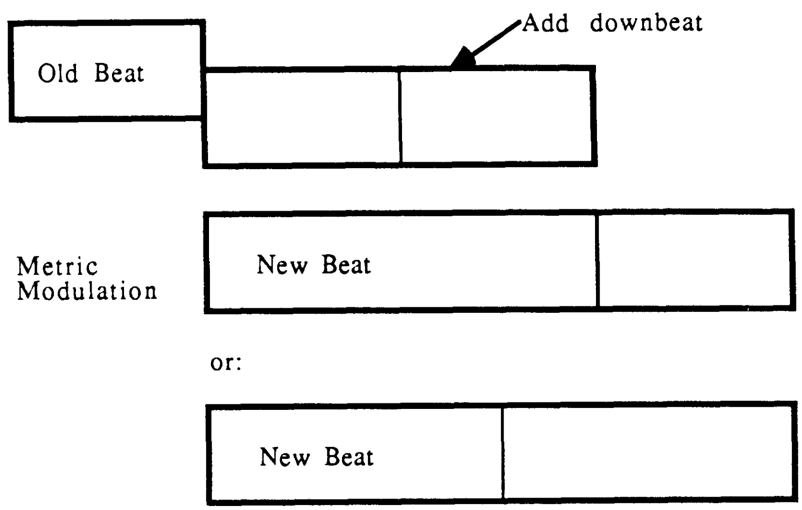



(b) Make new downbeat equal to old upbeat



## Execution Strategies (cont.)

(c) Make old beat the upbeat of new pattern




(d) Make old beat the downbeat of new pattern

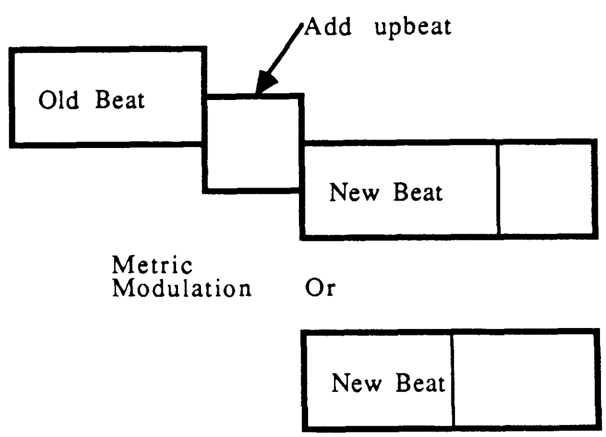


Figure 15: Figure 14 illustrated using music notation. (The four strategies correspond to the four lines of music notation.)

Strategy one (figure 14a) says: make the new upbeat equal to the old downbeat. In this example the downbeat is twice as long as the upbeat before the change and the upbeat acquires the duration of the downbeat after the change. (For now, ignore the "or:" patterns for all strategies.) This expansion of the meter is reflected in the notation:
[2 1] ==> [2 2]

Strategy two (figure 14b) says: make the new downbeat equal to the old upbeat. This has the effect of shrinking the old meter and is reflected in the notation:
[2 1] ==> [1 1]

Strategy three (figure 14c) says: make the old beat the upbeat of the new pattern. Rather than the old beat having parts, the old beat is a part of the a new meter, reflected in the notation:
[1] ==> [2 1]

Similarly, strategy four (figure 14d) says: make the old beat the downbeat of the new pattern. This is reflected in the notation:
[2] ==> [2 1]

If we keep the smallest box size constant throughout the four strategies and give the box a duration of 180 mm (beats/minute, or 3 beats/second) we get the resulting pattern-measures.

| Strategies | Transformations | Metronome Marking |
|---|---|---|
| 1 | [2 1] ==> [2 2] | 60 mm ==> 45 mm |
| 2 | [2 1] ==> [1 1] | 60 mm ==> 90 mm |
| 3 | [ 2] ==> [4 2] | 90 mm ==> 30 mm |
| 4 | [2 ] ==> [2 1] | 90 mm ==> 60 mm |

In all of the above strategies we are either adding or subtracting a "piece of time", using the downbeat or upbeat parts of the previous meter as a constraint. It is a *body-syntonic* constraint because the unit of measure is the last drumming strokes which were performed! The drummer can say to himself:

> "play the pattern over and over again, but when it's time to change,
> use the old upbeat as the new downbeat, then continue".

or:

> "play the pattern over and over again, but when it's time to change,
> drop part X of the pattern, then continue".

From the perspective of the listener, these pattern changes are auditory, visual and body-syntonic. The listener can draw from his physical experience of pattern to construct recognitions of new patternings.

In figure 14, each "modulation" is followed by the word "or:" and an alternative subdivision of the new pattern-measure. The "or:" patterns (figure 14) are very much like the metric modulation approach. If the new measure was a duple pattern the "or:" version is in triple. This is the case in strategies 1 and 2. Reciprocally, strategies 3 and 4 have "or:" parts which are duple patterns from their triple ancestors. The heuristic being used is:

| | |
|---|---|
| IF | The new measure is in two parts, divide it into three |
| ELSE | The new measure is in three parts, so divide it into two. |

The "or:" parts result in subdivisons which are different from the small box duration of 180 mm. A comparison of subdivisions for each strategy is provided below.

| <u>Strategies</u> | <u>Old subdivision</u> | <u>"Or:" subdivision</u> |
|---|---|---|
| 1 | 180 mm | 135 mm |
| 2 | 180 mm | 270 mm |
| 3 | 180 mm | 60 mm |
| 4 | 180 mm | 120 mm |

These strategies show how the 2-against-3 and 3-against-4 are a natural consequence of adding and subtracting beats and re-formulating meter.

# 3.6 Three Functional Roles of Music in Culture:
## An African Example

What follows are three functional roles of music in culture which draw from my Senegalese experience:

(1) music preserves knowledge about people and events,

(2) music classifies this knowledge so that it can be accessed,

(3) music preserves modes of social interaction.

Together they show how the environment in which music is made inherits significance from the culture.

### 3.6.1 The Three Functions

One of the functions music can serve is the <u>preservation of knowledge about people and events</u>. For example, the Senegalese *praise song* is sung by wandering minstrels ("griots", or *gewels* in Wolof) [10]. These musicians make their living by receiving gifts from villagers. In turn, they sing songs in praise of them, incorporating in their songs improvised text about the patron's family, friends or ancestors. In modern cities like Dakar , *gewels* do not have quite the same role as they had when no written language existed. Even so, the role served is similar.

While I was in Senegal, my hosts, Mamadou and Fatimata Sylla, and I paid some musicians to play for us; mainly, so that I could record some music. I was surprised to find the musicians mentioning our names and found out, through Fatimata, that they had described, among other things, the fact that I was a student at a university in the U.S., working on my thesis and had come to Senegal to visit my friends and record some Senegalese music. The music was played outdoors near my hosts' house, and friends and neighbors felt free to attend the event through which they learned about why I had come.

Knowledge can be classified according to song-type or scale. For example, a type of song, known as the *danne* , is used for the telling of historical exploits. Its song structure is divided into two parts: the *fodet* , which is the basic melody and rhythmic pattern; and the *tukull*, which is an improvised instrumental interlude used between fodets to give the singer a rest. There are two tunings for fodets. Listeners believe that certain songs sound better in one or the other tuning [11]. There are two levels of classification here: songs into type of song, and type of song into tunings in which songs can be sung. (Recall that, in Senegal, tuning system is equivalent to scale.) At least part of the reason a song is better in one tuning is because that's the way the song, and what it describes, is remembered.

Classifications, like the above, provide a means by which knowledge, once captured by a song, is organized into the collection. From a systemic view, "tuning system" is a region of memory in the culture-mind. Once a song is played using a particular "tuning system" that system is preferred, partially because of the *memory allocation function of classification.* Because preserving knowledge is important, the way knowledge is organized so that it can be accessed is also important.

The structure of a music reflects aspects of social interaction that are found within a community. The ethnomusicologist John Blacking says that "all songs are folk songs because they are associations between people" [12]. Not only factual knowledge but *knowledge about interaction is preserved.*

Elsewhere I discuss how African rhythm is constructed through the interaction of two simultaneous beat-structures. However, there is another way to talk about African rhythm which compliments this approach. Quoting Nketia,

> "A theory of "crossing the beats" or "multiple main beats" based on analysis of procedure in drumming may help in bringing order into what appears to others as "chaos". It may demonstrate the African musical art of achieving complexity through the use of relatively simple elements." [13]

The particular way complexity results matters. It's not that we want complexity, it's that we want to understand our world which happens to be complex. A cultural system is a byproduct of the interactions of individuals which serve as its simplest elements. A music will also exhibit a structuring of its parts which is more complex than the parts themselves. In Chernoff's book on African rhythm he describes his experiences learning how to drum [13]. A phrase he uses for describing the relation between drummers, relevant to the above discussion, is *mutual dependency* . As he says:

> "It becomes extremely difficult to play your part unless the whole ensemble is playing: you depend on the other rhythms for your time."

In a rhythmic system of two simultaneous beat-patterns the dependence of one drummer on another is required. The complexity of the music requires social dependencies during performance which reflect similar dependencies elsewhere in traditional African society. Once again, quoting Chernoff:

> "many activities -- paddling a canoe, chopping a tree, pounding grain, smashing up the yams for dinner, or simply moving -- seem set within a rhythmic framework which can and often does serve as the basis for music and songs" [14].

Doudou H'Diaye Rose makes the following comment which is in the same spirit.

> "The desire of learning how to drum came from women beating grain using a mortar and pestle. The women made different sounds with their voices, and their pounding produced a variety of high and low pitched sounds. You know by the noise made during the pounding when the women have turned the grain into pounder because the sound of the pestle against the wood of the mortar becomes more resonant. That's when people start dancing. This is how the tomtom was born" [15].

## 3.7 Imparting an African Musical Aesthetic:
### A Model of Learning

All of the drumming I observed in Senegal was led by Doudou H'Diaye Rose. As the master drummer, he determined when patterns should change by his body movements. For example, in commenting about a young popular Senegalese singer, Youssou Ndour, Doudou H'Diaye Rose said:

> "This boy has alot of talent because he knows when to change and that's the most important thing to know" [16].

By playing in the ensemble, the drummers experience Rose's *sense of pattern change*. Rose also provides new, yet related, patterns by striking his tomtom. Chernoff has observed that the master drummer controls the density of patterning so as not to mask seed patterns. The drummers in the ensemble experience Rose's *sense of dramatic shape* and *pattern language* by responding to those patterns he provides, <u>when</u> he provides them.

However, exposure to Rose' sense of time and drama is not sufficient for acquiring it. When I observed Doudou H'Diaye Rose he had an apprentice, an already quite accomplished drummer, who functioned as the master drummer when Doudou H'Diaye Rose gestured to him. One might say that Rose controlled the behavior of the ensemble until he transferred control to this apprentice. There was an observable difference between Rose and his apprentice. The apprentice appeared so excited about his temporary role as master drummer that he would perform with great energy and variety, often at the expense of good timing and taste ("know when to change"). Soon he would return to his background role as a cue to Rose that he was done; occasionally, Rose would interrupt the apprentice's playing with a solo of his own.

Though the apprentice's mastery over the pattern language and techniques of changing between patterns was evident, this knowledge was insufficient for him to capture Rose's "aesthetics" even with daily exposure to Rose's methods. The acquisition of the pattern language was, perhaps, the easier problem; indeed, the pattern language and skills for switching between them were pre-requisites for the sense of time and drama. To acquire a sense of timing required practice of a different kind. The apprentice needed more time in the role of master drummer.

I'm fairly confident that Rose's method for imparting a musical sense was by gradually increasing the periods of time in which his apprentice could practice the role of master drummer. I imagine that Rose had a similar relationship with his own master.

I see the above anecdote as describing a learning paradigm which imparts three kinds of knowledge, each a pre-requisite for the next. Given the domain of Senegalese drumming, drummers need to acquire *pattern knowledge* before they can acquire the *pathway knowledge* necessary to move between patterns. Only after these kinds of knowledge are acquired can the drummer reflect on his role as master drummer. With *knowlede about role*, the master drummer can help other drummers develop a sense of when to apply what pathways so that they can become master drummers themselves.

### 3.7.1 The Knowledge Routes of Culture

The learning model provides a structure for musical style and how it might change. A change at either the level of pattern, pathway or role will cause the whole system to change, if only by a little. A new drumming pattern will enrich the pattern language and a new pathway will enhance the collection of those available. Similarly, a different sense of time will enhance the way pathways are applied to the selection of pattern. Most changes will not be destabilizing because the structure of the music ensemble is self-regulating: *knowledge flows where it can be used.*

If a master drummer invents a new pattern, the musicians in the ensemble can add it to their pattern language. But if the master drummer selects a change in pattern, the ensemble must respond to this change because of the position of the musicians in the control structure of the ensemble. Occasionally, patterns are passed upward to the master drummer; yet, he is free to improvise on them as if he had invented the patterns himself.

*Social structures (e.g. institutions) preserve traditional knowledge routes between individuals.* This increases the predictability of results. Drawing from a western example, we observe that wedding music has a particular mood. It is played on organs which are the typical instrument of the places in which weddings happen, and by organists familiar with organ literature. The circumstances which surround the wedding ritual are extremely predictable. We might say that social structure constrains what musical knowledge is relevant and which instrumentalists are engaged. The instrumentalists will use the musical knowledge appropriate for the role they serve.

Erlmann describes a variety of factors which can lead to cross-cultural change [17]. For example, with commerce comes the wandering minstrel, new musical instruments, systems of tuning and musical styles. An instrument may be introduced because of the melodies being played on it. Such melodies may be altered so that indigenous instruments can support them. At other times such instruments are retuned to support indigenous material. In each case, either melody or instrument can serve as vehicles by which new knowledge proliferates. At other times new melodies grow around an imported instrument and repertoire. This material can serve as a model for a new musical classification around which indigeneous melodies are born. The routes of knowledge cause these changes to be absorbed.

New institutions and knowledge routes can be constructed, connecting new groups of individuals. Patronage can inforce new musical classifications by isolating musicians from other local musicians, or it can result in new interactions among, say, court musicians whose networks span across different cultures.

## Notes on Chapter Three


1. Apel, Willi, Harvard Dictionary of Music. Belknap Press of Harvard University Press. Cambridge, Massachusetts. 1978.

2. Chernoff, John Miller. African Rhythm and African Sensibility: Aesthetics and Social Action in African Musical Idioms. University of Chicago Press. Pg. 46.

"..if rhythmic complexity is the African alternative to harmonic complexity, the repetition of responsive rhythms is the African alternative to the development of a melodic line" (pg. 55).

3. Papert, Seymour. "Turtle Geometry: A Mathematics Made for Learning". In Mindstorms. Basic Books. New York. 1980.

4. Rose, Doudou H'Diaye. Comment transcribed from a video documentary on Rose made by the National Television of Senegal, 1986.

5. Springer, Sally P. and Georg Deutsch. Left Brain, Right Brain. W.H. Freeman and Company. New York. Revised. 1985. Pgs. 58-59.

6. Logo is a computer language designed by Professor Seymour Papert and his colleagues at MIT. See Papert's book Mindstorms or Logo Memos (available through MIT) for details.

7. Gueye, Daouda. Senegalese ethnomusicologist with Senegal's Ministry of Culture. Personal interview. January 1987. Archives Culturelles Du Senegal. 77 Avenue Andre Peytavin. Dakar, Senegal, West Africa.

8. Chernoff's African Rhythm and African Sensibility. "...relating to the music depends particularly on resisting the tendency to fuse the parts" (pg. 96).

9. Body language, see chapter 2, note 27.

10. Merriam, Allan P. Chapter 7, "Social Behavior: The Musician", in The Anthropology of Music. Northwestern University Press. Illinois. 1964.

11. Coolen, Michael T. "The Wolof Xalam Tradition of the Senegambia". Ethnomusicology, Journal of the Society of Ethnomusicology. September, 1983.

12. Blacking, John. How Musical is Man? University of Washington Press. Seattle, Washington. 1973.

13. Nketia, J.H. Kwabena. "The Problem of Meaning in African Music." Ethnomusicology: Journal of the Society of Ethnomusicology. January, 1962. Also, the notion of *cross-rhythms*, commonly used in describing jazz rhythms, suggests the idea of pathways between rhythms.

14. Chernoff's African Rhythm and African Sensibility: Pg. 93

15-16. Rose, see note 4.

17. Erlmann, Veit. "Marginal Men, Strangers and Wayfarers: Professional Musicians and Change Among the Fulani or Diamare (North Cameroon)". Ethnomusicology, Journal of the Society for Ethnomusicology. May, 1983.

# Chapter 4:
# Examples of Musical Modelling

## 4.1 Contrasting Models:
**A Senegalese Kora Solo**

The following is an analysis of features characteristic of a Senegalese Kora solo played by Lassano Cissoko [1]. I use it to demonstrate a local theoretic formulation and how systemic and conceptual issues interact to make a listener model possible [2].

### 4.1.1 The Analysis

This analysis contrasts composer and listener models. The paragraphs which begin in underlined text are pieces of musical structure. In combination they represent the Kora solo. In contrast, the statements preceded by bullets (•) provide heuristics which I allege the listener uses to construct a musical model.

The solo has recognizable phrases which repeat. These phrases are organized sequences of notes and rhythms, each about 1/2 - 3 seconds in duration. There are 5 such phrases in the solo (four are shown in figure 1).

• There are a small number of recognizable musical objects, each short enough to be accessible.

Variations are constructed from phrase-prototypes to form groups.

• Those musical objects which are least different are organized as one of a kind. Classifications are constructed to reduce the number of musical objects to kinds of objects dictated by the prototypical phrases.

Repetitions of phrases are variable. While the content of each phrase does not change, the number of times a phrase repeats seems to be variable.

• Recurrence defines the notion of a musical object. As object-phrases become easier to recognize, part of the excitement of listening is to guess whether the repeating phrase will repeat the next time around. Guessing unmasks the organization of choices.

Figure 1: Kora Solo showing phrases, bridging melodies and rest points.

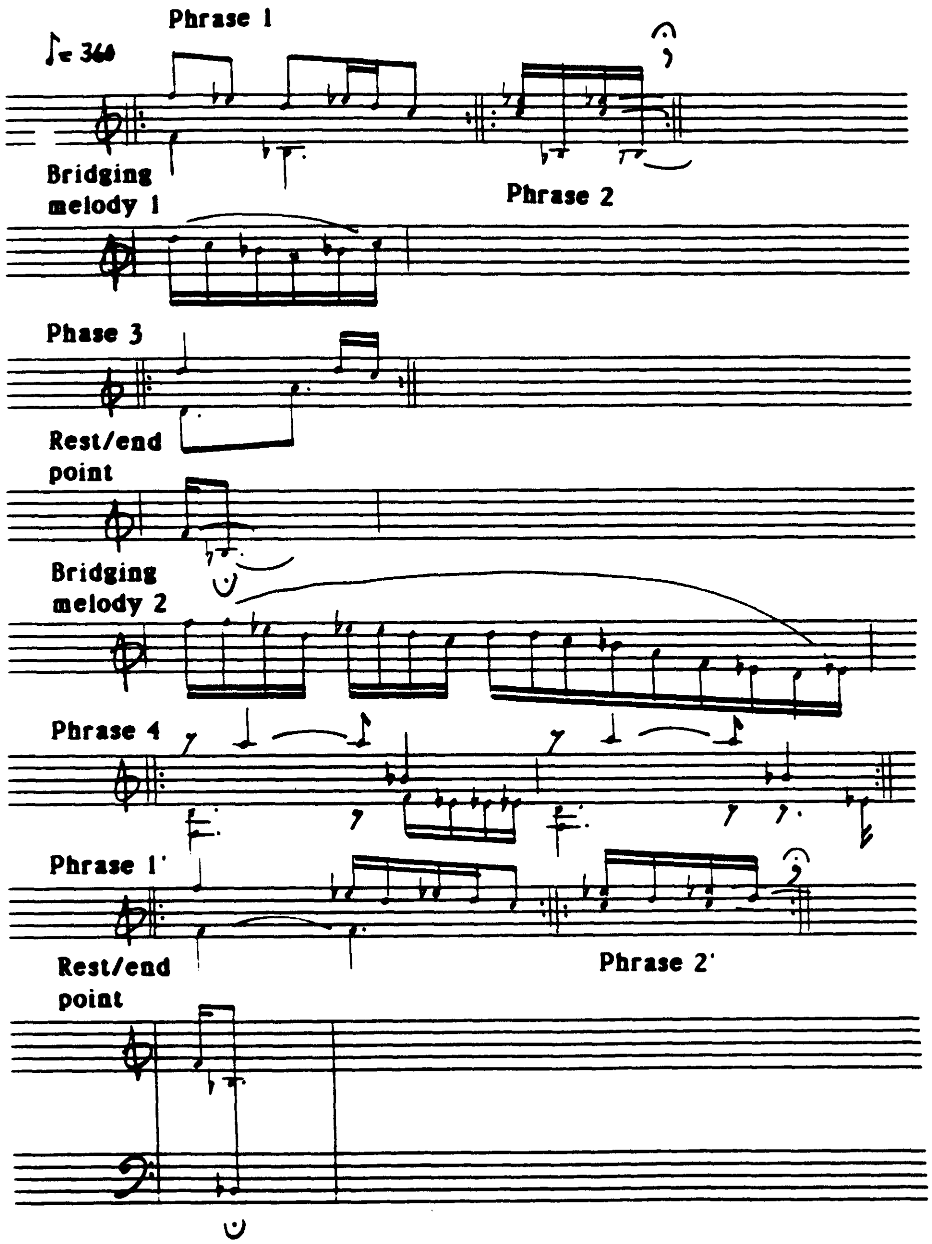
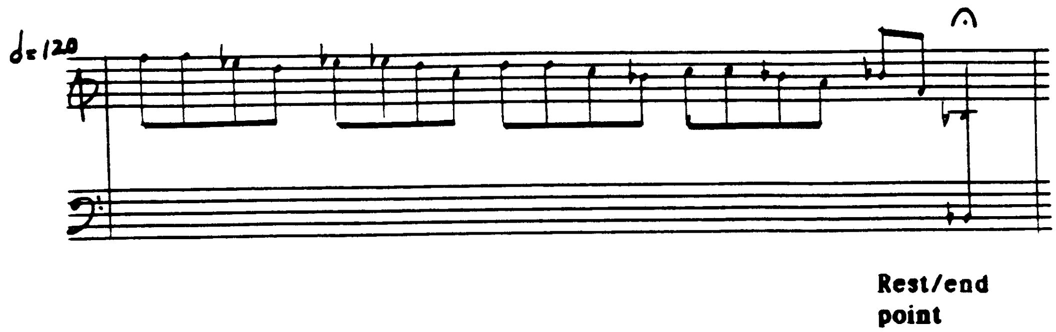


Figure 2: 2a and 2b are examples of variation groups.

Figure 3: 3a and 3b are examples of bridging melodies.

**Example 3a:**




**Example 3b:**

The techniques of masking are simple. A variation is made by either replacing or adding a small piece of the phrase with another, or by deleting a small piece. (Figure 2a and 2b show two variation groups. Phrase 1 in the Kora Solo is selected from 2a.)

• The difference between a phrase and its masked variations is the sub-part which is replaced, added or deleted. The masking operations (replace, add, delete) become increasingly recognizable through recurrence.

Choices are constrained. Phrases follow each other freely except for one constraint. Phrases can be played in any order provided that consecutive phrases are not from the same group.

• Part of the difficulty in listening is to select which phrase group will be used next. The task is made easier when the listener recognizes that the current phrase is disqualified in the next selection, especially when the group of choices is small. Constraints become increasingly recognizable through recurrence.

Phrases are interrupted by transient melodic walks and transient melodic walks are interupted by phrases.

Sometimes, phrases do not follow each other directly but are connected by transient melodic walks designed either to facilitate the performer's movement to a phrase physically far away (i.e. some number of plucked strings away ), or to decrease the predictability of when a new phrase will be selected. (See figure 3 and "Kora Solo".)

• Part of the excitement of listening is guessing when a transient melodic walk will land on a new phrase. The interrupts to and from walks and phrases construct higher-levels of structure.

There are points of rest during the patterning process. The F-Bb sequence (Bb doubled by the lowest string) serves as a rest point after a relatively long sequence of phrases or after a prolonged transient melodic walk.

• It's nice to have periods of time when very little is happening so that the one can recover from active listening. The end of the piece is such a rest point. Within the piece, the rest points are interrupts which allow still higher levels of structure.

### 4.1.2 How Music Means

The previous comments suggest how a listener might construct a musical model from the passage of musical events. He first has to recognize objects, classify them, and recognize differences. Later, he begins to appreciate the improviser's selection strategy among phrase types and makes predictions about how often phrases will repeat, and when they will be re-introduced. Through retro-prediction the listener continually modifies his theories about objects, their relations and order. The home question "what phrase type am I hearing?" is masked by replacement, addition and deletion operations. The interrupts serve as a means for constructing abstractions which, at the highest level, is experienced as the music's pace.

### 4.1.3 What Music Means

The above analysis allows us to make comments about how the music means without discussing culturally-specific issues. We often hesitate to address the question of musical meaning, especially in cross-cultural analyses. This is natural: who could pretend to know what is in someone else's mind? However, we can formulate the problem in a way which inspires more confidence; namely, there is always a view from which it is impossible to understand what a music means.

Given an understanding of the structure of the music and ways listeners might build a model of it, we can try to explain why the music cannot be understood by outsiders. This is a big "given". In order to understand the music's structure, the concept of a musical object, masking operations, organization, operations which mask organization, etc. contribute to the patterns of thought which are pre-requisite to musical understanding at a symbolic level.

Music doesn't operate in a "cultural vacuum". A piece of music is connected to the history of previous musical efforts and inherits meaning from them. As listeners, we are likely to apply previous listening to new listening situations. If we don't share the same histories we won't make the same comparisons.

The pace of the above Kora solo is reflective of "rhythms of life" of traditional Senegal. I haven't had many experiences in Senegalese culture so I won't be able to recognize how the pace of the music is connected to Senegalese life and values. Similarly, the phrases of this kora solo reflect a sense of phrase; and, perhaps, even refer to particular phrases found in other Senegalese kora music. I can't refer to these phrases because I don't know them. I know that Cissoko (the Kora player I recorded) uses similar phrases from piece to piece but I don't know how much these phrases are drawn from a shared tradition of Kora phrases or how much they are a product of his own invention. Yet, I conjecture that if I were to become a participating member of Senegalese society and a devoted listener of traditional Senegalese Kora music I would have musical experiences similar to those of a Senegalese listener. I also conjecture that the knowledge I already have about Senegalese music describes the reasoning which led to the music's production, though it doesn't capture extra-musical (symbolic) content.

## 4.2 Berio's Psychology in Points on the Curve to Find..

I use a piece by the Italian composer Luciano Berio (born 1925) to demonstrate Berio's invention of new home-structure [3]. Using the piece entitled Points on the curve to find.. for piano and 23 instruments, I show that the processes of listener modelling use the piano tremolos as a tracking system through which the ensemble sound is explored.

### 4.2.1 Pitch Networks of Interest

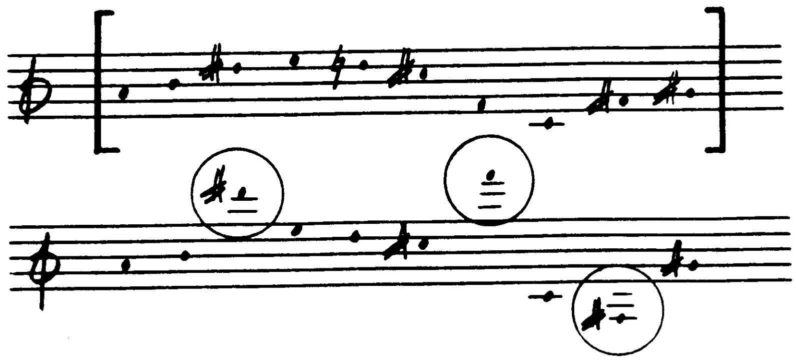
*Points on the curve to find...* is neither triadic nor strictly12-tone, nor is it "dissonant" in the traditional sense. Such language is inappropriate for discussing how it is organized and how it can be most beneficially heard. The melodic and chordal writing suggest a mixture of methods. When notes are placed in a temporally close sequence they are heard as chromatic, when they are placed in whole step sequences they sound impressionistic and when triads and smaller intervals are alternated they sound modal.

If one maps a triadic framework on the music one hears a variety of diminished and augmented chords. The idea of comparing the way pitches are organized in *Points on the curve to find....* with modal, wholetone or triadic organizations is both reasonable and misguided. It is reasonable to assume that most of Berio's listeners will bring such a musical background to his music. The fact that these chords are familiar increases the accessibility of the sounds one hears. One might even say that it was wise for Berio to use familiar organizations as transitional structures to the pitch organizations he has intended.

Figure 4: Five sequences of pitches, starting on F, which are from the pitch-set (first line of example). (pg. 76 of score)

Figure 5: 5a: Examples of octave displacement (pg. 4 of score)
5b: Examples of tremolos (pg. 46 of score)

5a



5b

Figure 6: Both 6a and 6b show the construction of new pitch sequences from an established pitch sequence (pg. 2 of score)

6a

line 1

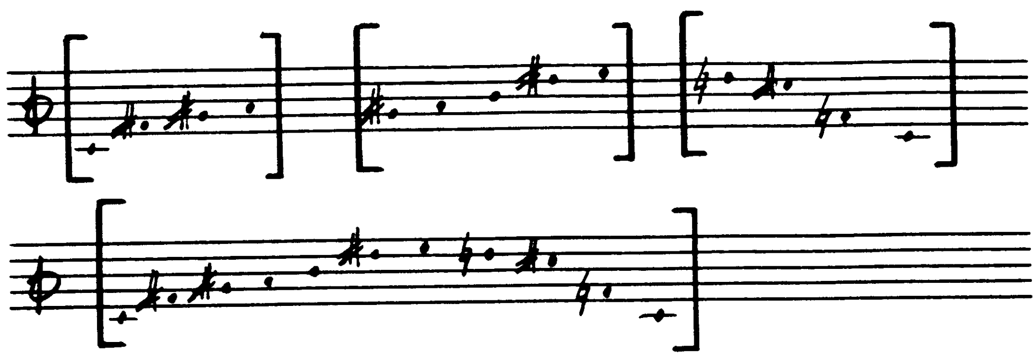
line 2

6b

Figure 7: The combination of octave displacements and tremolos (pg. 38 of score)

Figure 8: As in figure 6, both 8a and 8b show new patterns from old ones using combining and dividing procedures (pg. 3 of score)

8a



8b

On the otherhand, it would be foolish for the listener to ask when the chords are going to resolve! They never will because that's not the way the music is organized on a deeper level. The truth is that these patternings are not a "harmonic language" but a vocabulary of pitch-patterns which are regulated by different processes. The results of these operations produces "harmonic effects" without being caused by "harmonic thoughts".

### 4.2.2 Defining Musical Objects

As I see it, the instrumental writing is constructed from the piano part which reflects changes in the instrumental lines. This strategy seems valuable in both the construction and re-construction of the piece. The problem which faces both the composer and listener is: how can a musical object be defined during the process of its being heard? It is one thing for a composer to point to a piece of notation and say "this is a musical object"; and another for the listener to say so himself.

<u>Recurrence defines a musical object</u>. We can say that hearing something a number of times establishes the "it" we hear. After we record a short musical sequence in our minds, any sequence, we are able to compare that sequence with those we next hear and adjust predictions and results until the differences between them go away. These fine adjustments are facilitated by repeated hearings of pattern.

<u>Saving and classifying differences helps us to compare objects</u>. Musical objects are usually more complex than those we could account for by recurrence alone. The <u>differences</u> between musical objects are remembered and classified according to their frequency of appearance. Figure 4 shows five sequences of pitches each beginning on the note F. The bracketed sequence (above them) combines all the notes found in the five sequences into one larger sequence which is a compound structure made from other compound structures. The higher-level structure from figure 5b is used partially by line 1 and partially by line 2 in figure 6a. Figure 6b is partially masked by the tremolos found in both parts. Figure 7 shows an embellishment to a figure which is itself a transformation of that figure.

### 4.2.3 Un/Masking Musical Objects

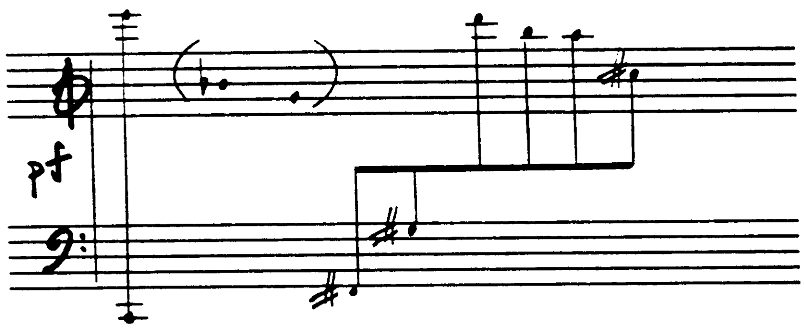
<u>Masking operations regulate our ability to recognize objects</u>. Composing is largely about making new patterns from older ones; i.e. in introducing differences and constructing objects with them. The more two patterns are different the more difficult it is for the listener to

Figure 9: An example of feature tracking. Each sequence is different except for the three notes which begin them. (pg. 70 of score)

Figure 10: Examples of the use of register to delimit spectral regions in which musical activity will take place. (Pages from score: 10a=pg. 30; 10b= pg. 32; 10c=pg. 73)

10a



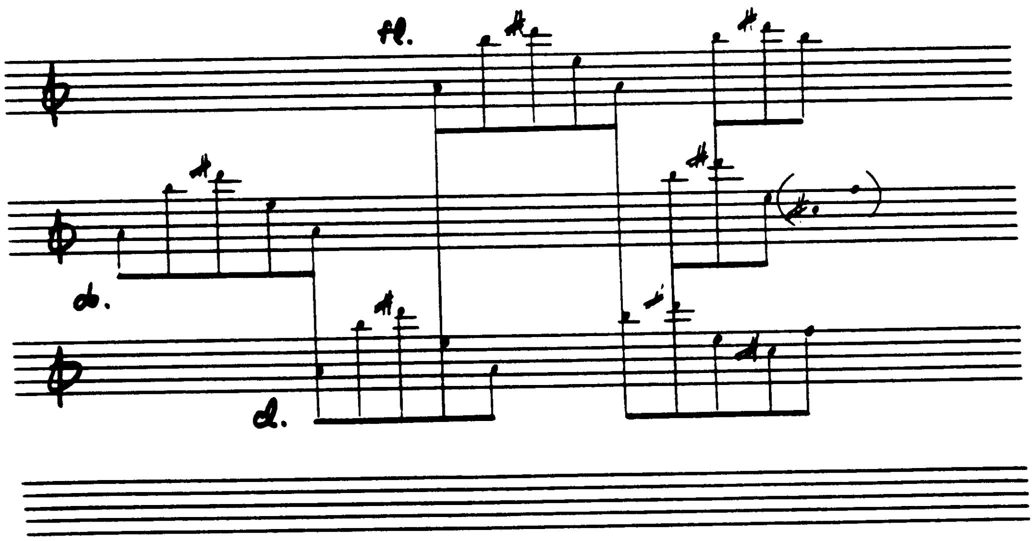
10b



10c


Figure 11: Examples of the use of pattern imitation and overlapping to produce rhythmic side-effects. (11a=pg. 3 of score; 11b= pg. 7 of score)

11a


11b



recognize them. We can think of these difference constructors as operations which reduce one's ability to predict recurrence. Berio frequently uses the following two:

- *octave displacement*. Any note in the sequence can be raised or lowered some number of octaves. (See figure 5a where the pattern of notes (in brackets) is shown below it with octave displacements (circled notes).

- *tremolos*. Any two consecutive notes in a sequence can be repeated several times before continuing in the sequence. Figure 5b shows two-note groups (in parens.) which are repeated in this way. Figure 7 shows the combined effect of octave displacement and tremolos.

### 4.2.4 Accumulating Causal-Models

Unmasking operations are either the result of deleting previous differences or a result of making a kind of difference recognizable.

We can recognize processes as well as objects through recurrence. We are able to adapt to masking operations. The accumulating memories of differences between objects become re-organized. "Difference", itself, becomes classified into *kinds* of differences which become the source of *causal models*.

This line of argument assumes that music instructs the listener about what is worth listening to. A composer will often introduce the simpler events before he introduces the more complex ones. This process allows the listener to accumulate a history of object-relations which he can use to investigate the remainder of the piece. Berio applies this advice by producing compound pitch-patterns from small patterns which have already become familiar. For example, figure 8b (pg. 54 in the score) is rooted in figure 5b (pg. 46 in the score) is rooted in figure 8a (pg. 3 in the score).

### 4.2.5 Dis/Orientation

Regulating the rate masking operations are applied controls listener orientation. The rate at which new patterns are produced will contribute to a listener's ability to orient himself to the events he is hearing. Noticing difference is only the first step in evaluating difference. Evaluation takes time. If the rate at which operations are applied (or differences are added) exceeds the listener's ability to recognize them, objects will become increasingly difficult to recognize.

Partial matches create ambiguity. Often Berio will keep part of a pattern invariant when other pieces are changing. This can facilitate the listener's ability to build new pattern memories. At the same time, partial matches may evoke too many other pattern memories to make recognitions complete (which is why they are called partial matches.) The building of new structure from old structure contributes to the pleasure (or the anxiety) associated with the process of recognition. Figure 9 shows a pitch sequence whose elements change slightly except for the first three notes in the repetition sequence (in brackets).

### 4.2.6 Side-Effects

At lower levels, it is improbable that composer and listener models match. Because of connectivity, different problem-solving chains can produce the same musical effect. At higher-levels of abstraction the relations among events convey patterns of thought which are shared by the composer and listener. For example, Berio seems to use piano tremolos to delimit local regions of pitch-space (See figure 10). This delimiting function is applied to both the piano line (10a and 10b) and instrumental lines (10c) to prepare listeners for the range in which the next musical activity will happen. Whether Berio worked backwards from the activity to the tremolos or forward from the tremolos to the activity is irrelevant to the patterns of thought he wishes to convey.

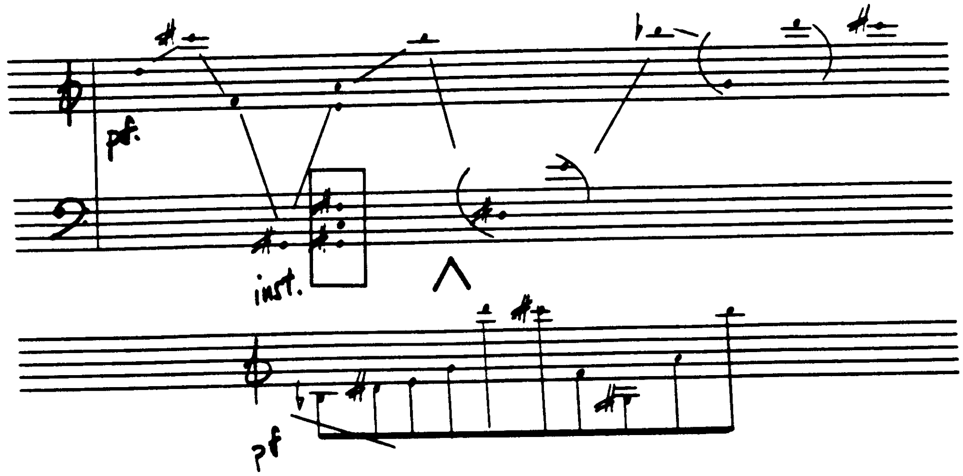
Berio uses pattern imitation as a way of making rhythm a side-effect of pitch-pattern. (This is similar to the rhythmic side-effect of harmony, described traditionally as *harmonic motion.*) Figures 11a and 11b provide two examples of this. Recurrence criteria are interactive and result in patterns of recurrence which are not found in the individual recurrences.

### 4.2.7 Local Abstractions

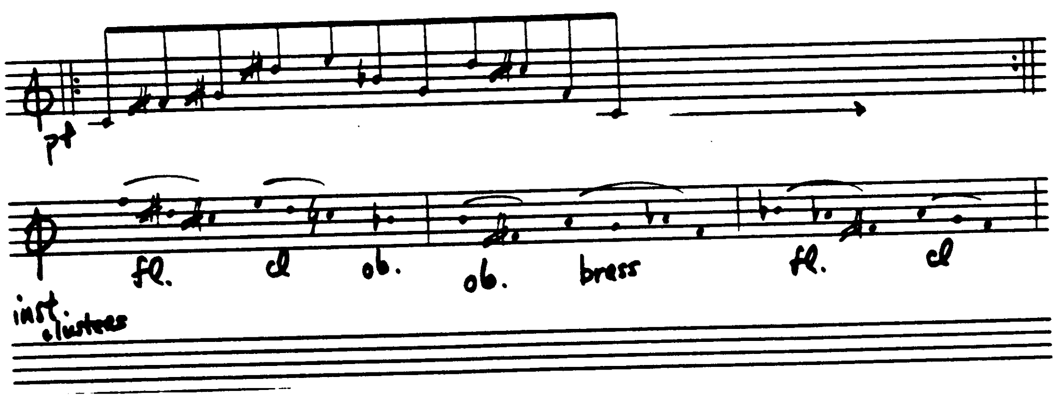
Patterns of objects or processes can also be defined through repetition. Occasionally, the instruments are playing only those notes which are not found in the piano line leading to *clusters* of sound which it would be inappropriate (or impossible) to consider as a pitch-pattern (see figure 12b). This results in a less precise interpretation of the pattern. The notion of "pitch-pattern" gives way to a textured sound made up of undifferentiated pitch elements. We can view this as a masking function regulated by tempo. Moderately fast clusters can be identified by the first and last notes of an, otherwise, amorphous group.

Figure 12: Examples of textured sounds. 12a: the recursive use of a pattern as an ornament to itself (pg. 40 of score). 12b: the use of pitches in clusters (pg. 50 of score).

12a




12b



Clusters which pass by at a faster rate can be identified by register (e.g. high, medium, low). The less time for processing the more general the classification system used by the listener.

Of course, the composer is privileged. He has ample time to process whatever he writes. He uses the listener's tendency to make models which depend on data rates to shape the listener's experience. He expects that the listener will callibrate his classification system in certain ways and relies on this to shift the attention towards processes he deems important [4].

### 4.2.8 Berio's Home-Structure: Interrupt Patterns

Remember that musical objects are *mental* entities. When I speak of them as being stable or unstable I am referring to how well recurrences have been established or masked. The same point applies to musical organization. "Objectness" and "structuredness" are always in question.

The tremolo serves an important organizational function in Points on the curve to find.. Tremolos which appear for only a short time (e.g. a fraction of a second) can be abstracted into embellishments which enhance more stable musical objects. When the tremolos are long (e.g. a few seconds long) they acquire their own stability. The durations of tremolos are functionally of two types: those which are short and unstable and those which are long and stable. Berio regulates our attention to the piano or to the ensemble by alternating between the stability of the piano sound and the stability of the ensemble sound.

A change in events will draw the attention of the listener to the piano or instruments whether the change is a stable or unstable one. Sloboda calls this the *orienting response* ; that is,

> "..the natural tendency to attend to a new event in a complex environment rather than the familiar ones."

I have used the term "interrupt" to describe gross change. In contrast, stability makes it possible for the listener to evoke mental mechanisms for use in further processing; thus, increasing stability further. Sloboda calls this *attentional conservatism* ; that is,

> "a listener will tend to remain with a particular line once drawn to it unless there are strong enticements to shift attention."

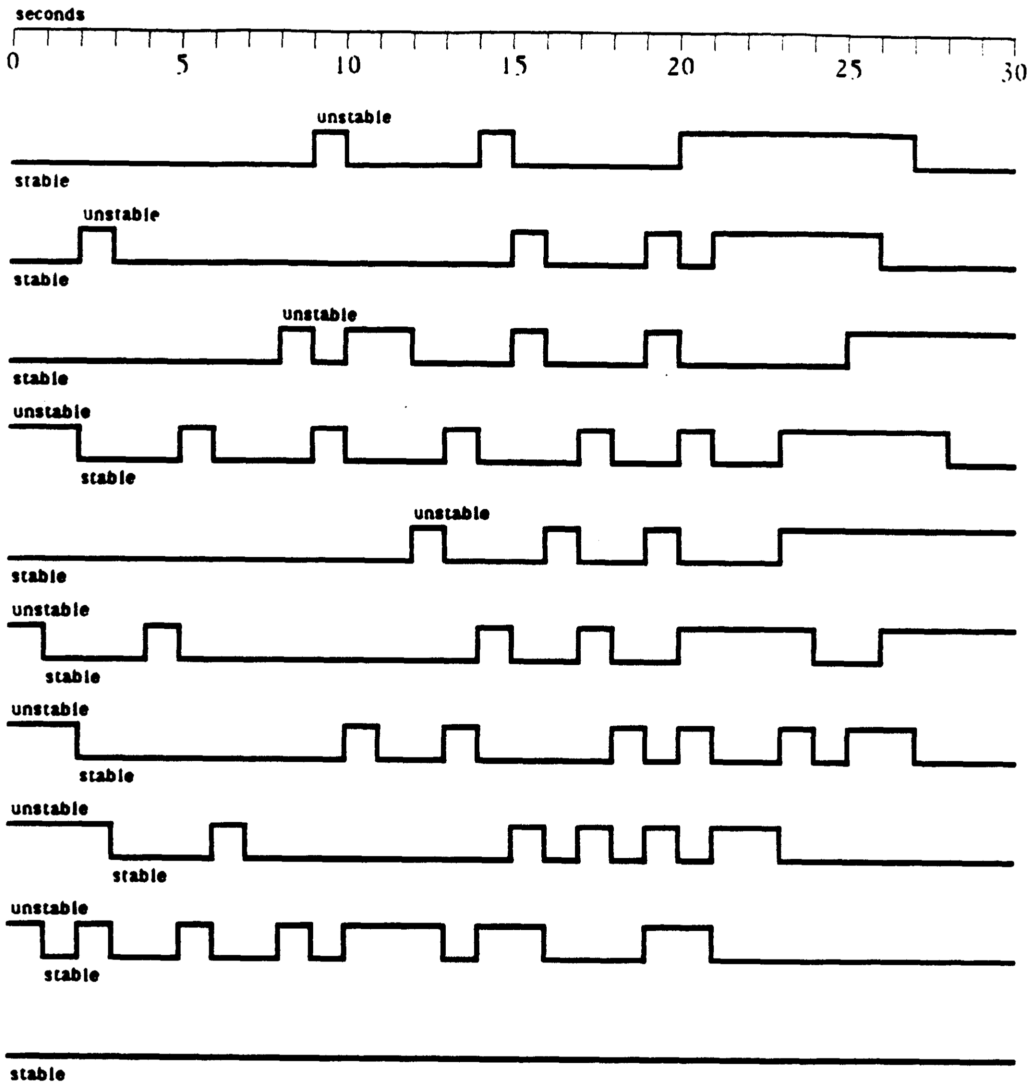
I have used the phrase "interrupt pattern" to describe the adaptive process of listening which results in the recognition of interrupts and their construction into higher-level patterns [5].

The attached three pages of graphic material (labelled "Rates of Tremolo Change") shows tremolo change and stability points which I produced by going through the score and measuring the durations for each. These two states are represented as a ***stable*** state for long and unchanging tremolos and ***unstable*** state for rapidly changing tremolos. Each line represents approximately 30 seconds of music and each zig or zag between states inforces an interrupt.

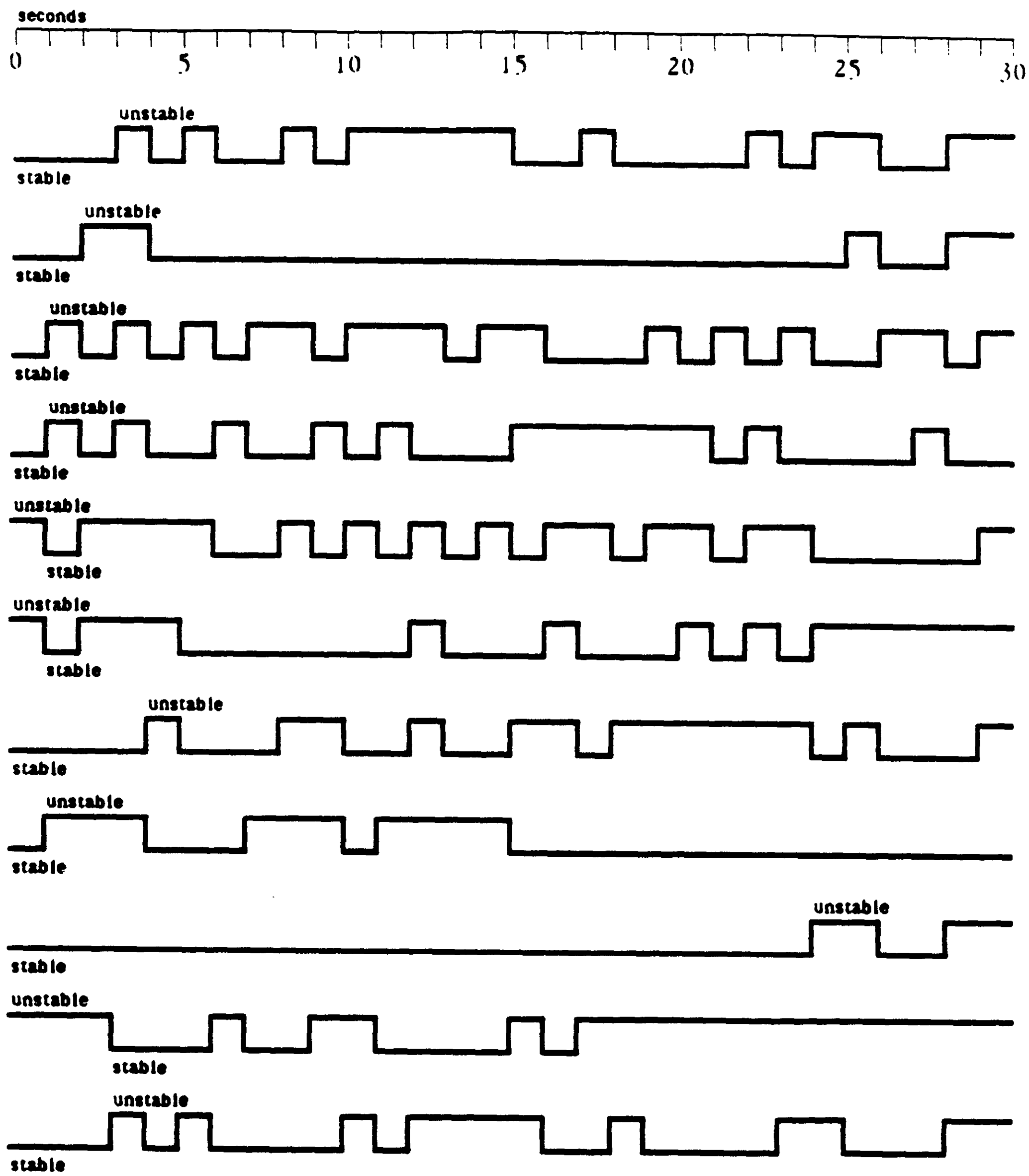
On the third page are two condensed versions of this analysis (under "Summary Graph"). The first shows the stable and unstable zones as the music proceeds from minute to minute. One finds that the graph gradually dips to points of greater and greater instability as the music progresses. Graph two shows a count of interrupts from either state to the other. This number increases as the music proceeds, peaking at about 6 minutes, dipping for another few minutes, and rising again to peak at 10 minutes. These peaks reflect the growing complexity of the music. The listener is able to model the music because of the previous minutes of experience he has had with it.

A larger pattern is visible when we compare the two summary graphs for coincident points. The two most stable points are at 5 minutes and 9 1/2 minutes. They preceed the most unstable points at 6 1/2 minutes and 10 minutes. Because these tremolo patterns start as moment by moment recognitions and grow into an arching structure which embraces the entire piece, this provides persuasive evidence of the homing function served by them. These points can be grouped into two stable-unstable patterns, the first about half-way and the second about three-quarters the way through the piece. At the abstract level, we can describe them as conflict-resolution patterns which demonstrate a relation between compositional structure and listener affectivity.

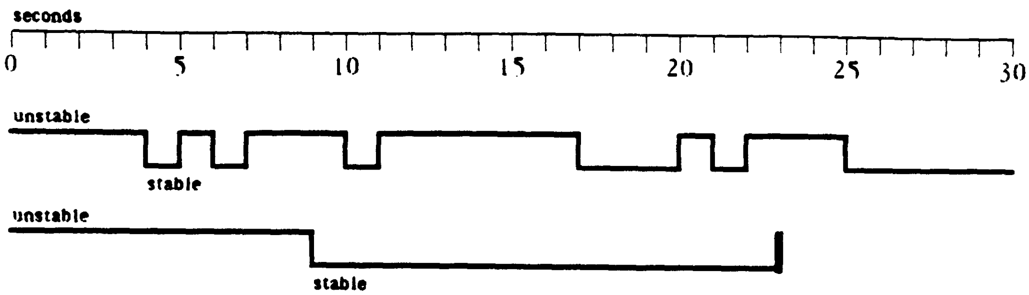
## Rates of Tremolo Change



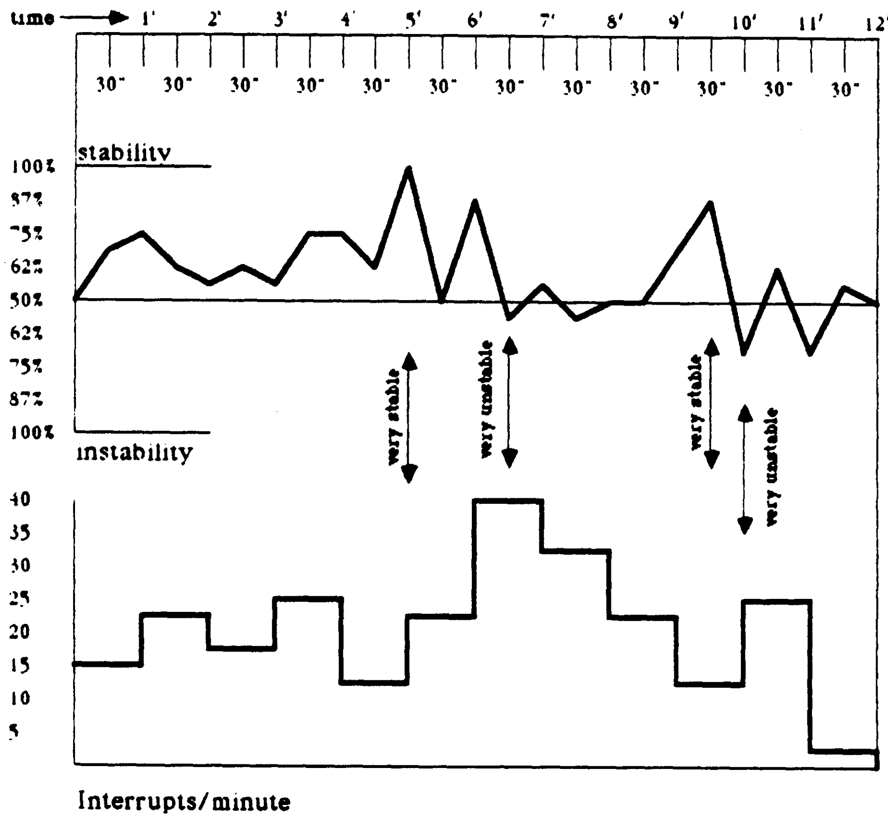
## Rates of Tremolo Change (page 2)



## Rates of Tremolo Change (page 3)




## Summary Graphs



## 4.3 Two Heuristics from Stravinsky's Rite of Spring

In the *Rite of Spring*, Stravinsky uses a compositional approach called *cellular writing* in a way which illustrates two heuristics for incorporating listener models in compositional method [6].

(1) Make musical objects recognizable, and
(2) Make musical organizations recognizable.

### 4.3.1 Music Cells

Music cells are elementary musical units which Stravinsky uses in the construction of his famous work, the *Rite of Spring*. Stravinsky uses a large number of cells organized in a hierarchy of more and more complex cell-units. For this reason, one will notice single cells which are short (say, .5 seconds), patterns of cells which are longer (say 5-10 seconds), and patterns of organizations longer still.

Stravinsky also changes cells dynamically within sections, and abruptly across sections. Changes are more or less surprising depending on the rate cells are constructed into larger hierarchies and depending on the sonic differences between cells. This brilliantly simple design made it possible for Stravinsky to provide a complex yet accessible alternative to traditional harmony.

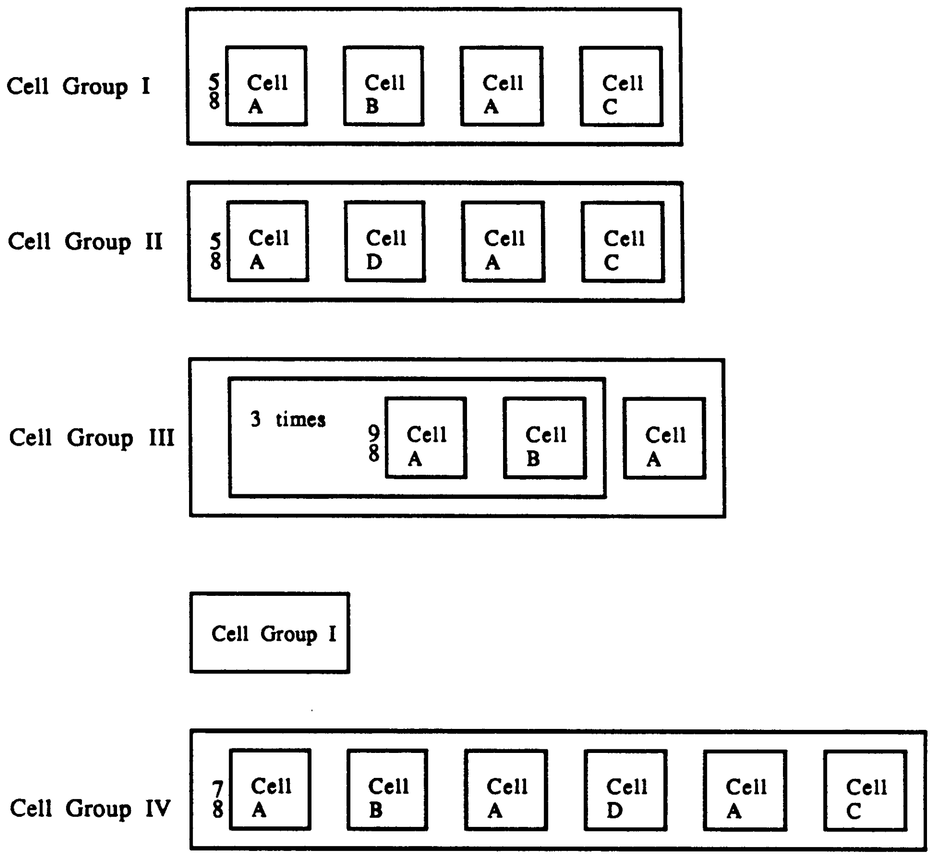
Figure 13 graphically illustrates some music cells and their construction into groups. Figure 13 starts from cue 104 in the score and continues for 5 measures. It then skips to the measure before cue 110. Each cell group represents a measure in the designated meter (e.g. 5/8, 7/8, etc.). There are a total of 8 musical cells (A, B, C, D, E, F, G, and H), and 5 cell groups (I, II, III, IV and V). It's interesting that cell group V, which has the greatest number of cells is, itself, a pattern which alternates between cell A and the others (E, F, G and H).

Figure 14 shows the cell groups as they are used starting from the measure after cue 117 and continuing for 13 measures. Figure 15a and 15b show the music cells using traditional music notation. It is striking how much the new material draws from the old material. What

**Figure 13:**

Stravinsky's
*Rite of Spring*

From cue 104, 5 measures
(time is left to right, top to bottom)




From measure before cue 110

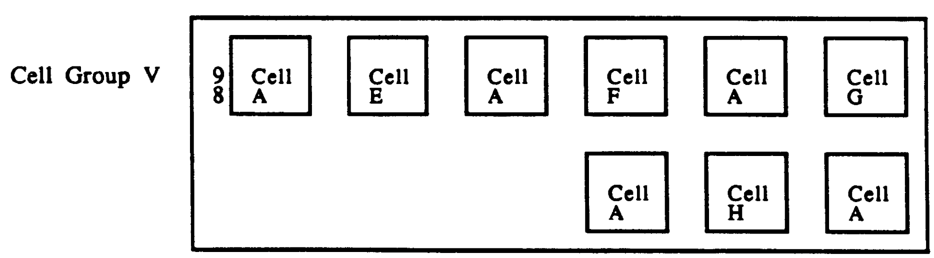
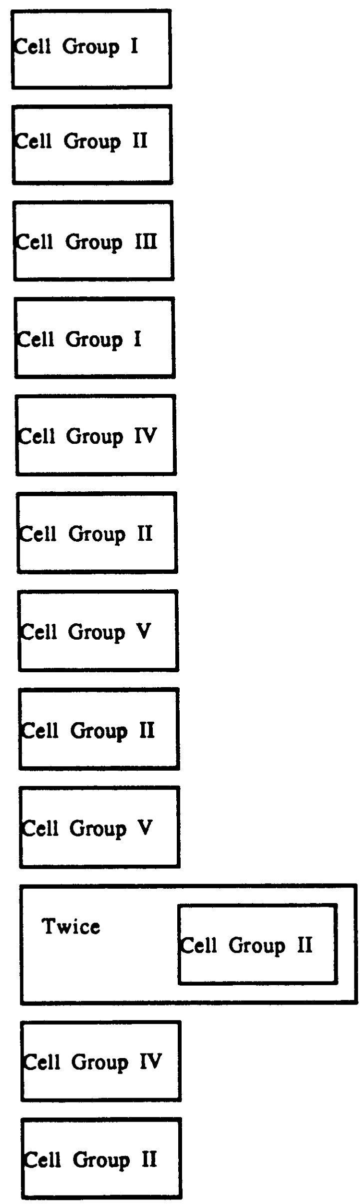


**Figure 14:**

*Rite of Spring*
From measure after cue 117, 13 measures
(time from top to bottom)



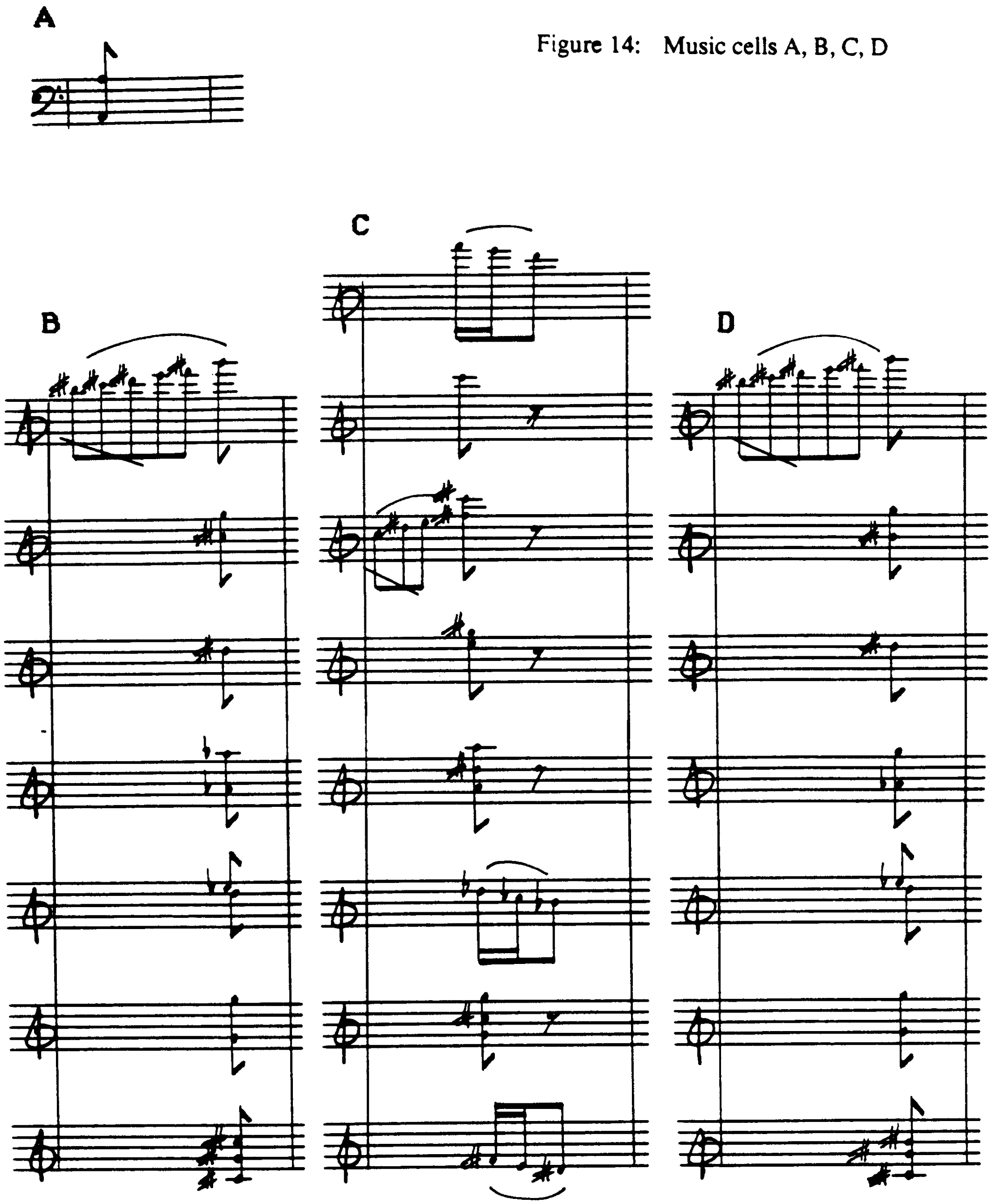
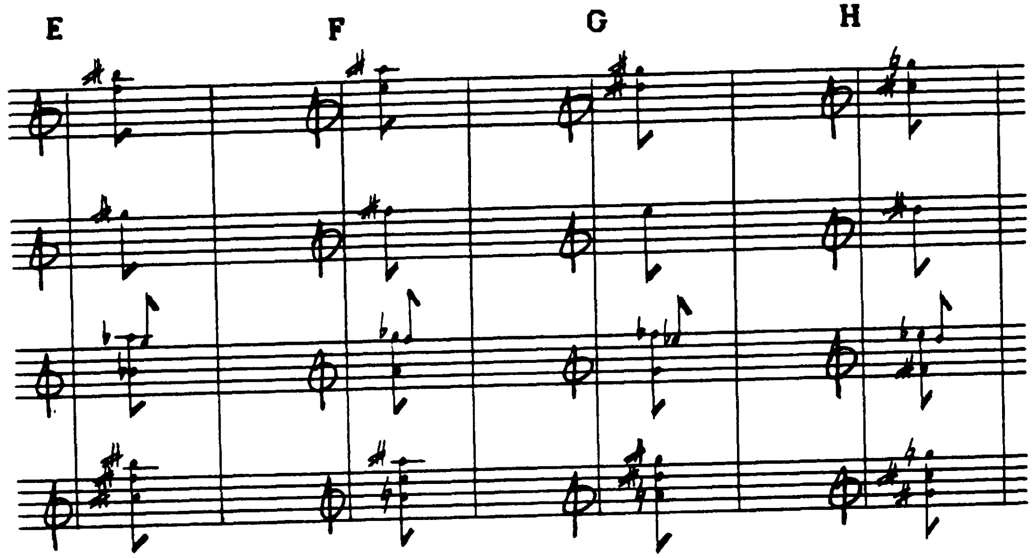
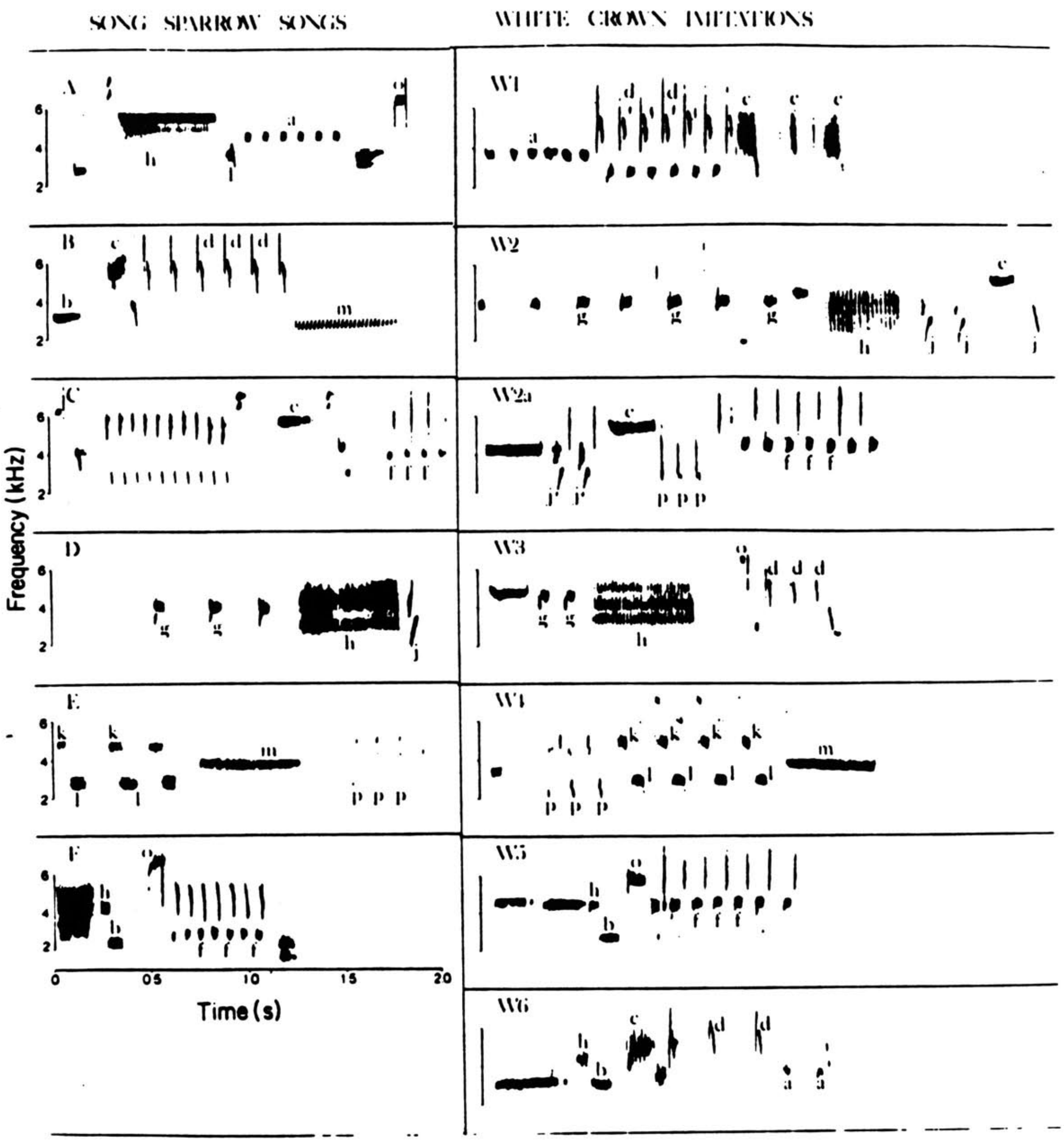



Figure 14: Music cells A, B, C, D

Figure 15: Music cells E, F, G, H






SONG SYLLABLES

Imitation of song sparrow songs. Songs A–F (left column) are from two song sparrow live tutors. Songs W1–W6 (right column) are songs from white-crowned sparrow students. Songs W2 and W2a are both from the same female. The other five songs are from five different white-crowned sparrow males.

is not shown is the material in between the examples which are, themselves, cell-like in character.

Stravinsky is able to construct musical expression by regulating the number of levels of organization, the number of cells he is using and the rate at which cells are replaced, modified or re-organized within levels. It might seem a little cold-blooded for music to be written this way, but the reverse is actually true: it is because Stravinsky is able to control musical detail with a simple system and because the match between composer and listener models is so clean that the Rite of Spring is such a powerful example of innovative expression.

### 4.3.2 Extra-Musical Influences

Composers have always been attracted to birds, nature's most instinctive singers. In our century Olivier Messiaen is the composer who has been most inspired by birdsongs carefully documenting and imitating them in pieces [7]. However, Stravinsky's *Rite of Spring* captures insights about birdsong which have musical utility. For example, birdsongs found in nature are constructed from simple sound syllables. Baby birds, taken away from their parents, tend to either reproduce sound syllables in a crude way, or even exclude sound syllables from bird "themes". The importance of the parent in establishing bird song syllables and organization is strikingly similar to the heuristics which make the *Rite of Spring* accessible (see attached illustration of bird-song patterns from Baptista and Petrinovich) [8].

One imagines that, in addition to other pieces of music, composers draw from nature and extra-musical culture for compositional models. A poetic formulation of this idea is described in Cage's book Silence where he states, drawing from Indian musical aesthetics, that music is "reflective of nature's manner of operation" [9]. These conjectures support an additional heurstic; namely,

(3) the structures of successful pattern recognition in nature
may serve as a source for new compositional structure.

## 4.4. Causality in Boulez's Répons

This section uses Boulez's *Répons* to demonstrate the building of causal listener models [10]. I hesitated to include this section in the thesis because, without a copy of the musical score, I felt uncomfortable making analytic statements about the piece. At the same time, I realized that I am in this position at least as often as not and that I do make analytic judgments about pieces without the use of scores. A formulation of musical understanding has to account for the way interpretation contributes to it without scores. Boulez himself says that "the real concern of composers today is the problem of transmission" [11]. In a sense, I am running Boulez's experiment about transmission.

For this reason, there are no musical examples with the exception of the brief example from Gerzso's article "Reflections on *Répons* " [12]. Instead, I give a textural analysis. While it is more rigorous than what I would be able to discuss over the phone with a composer friend, it captures more of this flavor than the analytic approach one normally finds in academic journals.

### 4.4.1 *Repons*

*Répons* is approximately 41 minutes long in the version I have heard (Paris, 1984). It is made up of an ensemble of 24 musicians surrounded by six soloists whose sounds are processed using IRCAM's 4X machine. The 4X is able to process sounds in real-time using programs written or selected by the composer to modify or generate sound material of any sort. The soloists answer the instrumental ensemble and the 4X "answers" them [13]. More details are provided in the sub-section entitled "Spectral Chord".

### 4.4.2 Networks of Interest

In my first hearing of *Repons* I found myself comparing it to the following pieces for some of the following reasons [14].

• Ornette Coleman's *Free Jazz* . The improvisations result in the construction of thick webs of melodic activity and the de-construction of them into simple melodies. I hear similar *melody-texture transformations* in both works.

• Boulez's *Le Marteau sans Maitre:* Boulez uses the fermata to construct activity-pause phrasing patterns. Boulez's collection of percussive melodic instruments -- for example, vibraphone, xylophone, and guitar -- defines an ensemble *sonority* and characteristic *articulation* quality. For me, *Le Marteau* and *Repons* have a similar *pace*

• Lucas Foss's *Time Cycle*, section IV. The slowly changing structures of Foss's work serve as *approximate descriptions* at the higher-level. I get to *Repons* lower-level changes through this description, as wrong as it may be!

• Luciano Berio's *Points on the Curve to Find*: The two pieces are similar in their organization as call-response groups which are mutually constraining. The use of pointilism (or *klangfarben* melodies), characteristic of the *Darmstadt sound*, is also shared.

These comparisons say more about my listening history than they do about Boulez's; however, to the extent that composers and listeners form a community, it is profitable for me to use other pieces of music and compositional ideas to identify what is significant in *Rêpons*. Because the recognized similarities were significant in the previous pieces they might also be significant in *Rêpons* and I begin to look for evidence to support these conjectures. Like a detective, I am able to increasingly narrow the possibilities. Even if my conjectures turn out to be untrue, discovering what isn't evidence is progress.

Preliminary comparisons inevitably become a hindrance to listening (a piece will remind you of other pieces, etc.) As real evidence emerges, I can build models based increasingly on data from *Rêpon's* acquired through the transitional theories of preliminary listening.

I also speculate about which musical concepts I should use in my modelling. For example, Schoenberg's definitions of "variation" or "liquidation" may be helpful [15]:

> variation: "changing some of the less-important features and preserving some of the more-important ones"
>
> liquidation: "gradually depriving the motive-forms of their characteristic features and dissolving them into uncharacteristic forms, such as scales, broken chords, etc."

as well as the notion of partitioning, encountered in chapter 2, and Boulez's own notion of proliferation which I describe later in this section.

### 4.4.3 Looking for Evidence, and Classification

As a listener I try to locate musical evidence which is interesting. However, I can miss interesting structure if I rely on traditional musical concepts alone. The following hierarchies compares a traditional notion of melody with a "Darmstadt" formulation; the latter draws from the music of the composers who attended the summer music festivals in Darmstad Germany during the late 1950s.

**Traditional Note**

more important

- harmony
- scale
- pitch

less important

**Darmstadt Note**

more important

- tone-row
- pitch-interval
  - register
  - instrumental color
  - envelope

less important

A traditional melody is comprised of notes in a scale and in a key; whereas, a "Darmstadt melody" is comprised of pitch intervals defined by pitch, register, instrumental color and envelope. We can see that new concepts must be formed from micro-structure not accounted for in the traditional concepts.

### 4.4.4 Spectral Chord and Proliferation

In *Répons*, the six instrumental soloists (piano/organ, harp, cymbalom, vibraphone, xylophone, glockenspiel) are surrounded by an ensemble of 24 musicians made up of woodwind, brass, and string players. While the ensemble sound is not electronically modified or amplified, the soloists are connected by contact microphones to the 4X which has programs for manipulating the sound material they produce. The 4X programs "answer" the soloists' sounds by:

(1) amplifying the sound
(2) ring modulating instruments
(3) frequency shifting the sound
(4) by echoing or delaying the "answer", and by
(5) changing the spatial location of the sound

My phrase *spectral chord* describes the mixture of sonic and musical properties which link Boulez's instrumental writing to his use of the 4X. This spectral chord is an intervalic pattern and not a particular collection of pitches. Its first appearance is in the vibraphone chord which is formed from the interval pattern (in descending order):

[M3 P4 M2 m3 P4 A4]

or the pitches (also in descending order):

[**B** F C A G D **Bb**]

All transpositions of pitch found in *Répons* appear to be selected from intervals found in this pattern which are applied to previous versions of the chord. The only constraint is that resulting pitches are required to be within a high B and a low B flat. Therefore, a transposition of a chord may require an additional octave transposition up or down of pitches which fall outside this range [16].

All relations between electronic and acoustic results (except the distribution of sound in space which I don't discuss) hinge on these interval relations which lead to a *proliferation* of effects from generation to generation. For example,

> Frequency shifting performs electronically the function of transposition. There are five frequency shifters which are used in *Répons*. They are set to transposition intervals found in the spectral chord.
>
> The manipulation of delay times and the number of delayed "answers" has the musical consequence of transforming chord (vertical space) into arpeggio (horizontal space) and vice versa. Similar transformations are exhibited in Boulez's instrumental writing.
>
> Given that the acoustic instruments remain constant, they define the spectral resources from which all the instrumental color is derived. These spectral resources depend on changes in interval relations for spectral re-definition.

*Répons* is built around one spectral chord defined by a primary intervalic set and all of its transpositional possibilities. Pitch-pattern is a side-effect of transposition and both pitch-pattern and rhythmic-pattern are side-effects of manipulations of delay. Therefore, a "Repons note", in contrast to those presented earlier, might look like this:

***Répons* Note**

more important
- tranposition-intervals (tone-row)
  - spectral chord (instrumental color)
  - echo-delay (vertical-horizontal transformations)
    - envelope
    - spatial distribution

less important

### 4.4.5 Causal Pairs

I use causal models to construct relations between musical events. If there are two consecutive musical objects, object 1 and object 2, and the second object is the same as the first in all respects <u>except</u> that the second is louder, we could say that object 2 is a result of the "louder operation" being applied to object 1. Similarly, if object 2 is the same in every respect as object 1 <u>except</u> that the pitches in object 2 are all up a pitch-interval from those in object 1, we could say that object 2 is a result of the "transposition operation" being applied to object 1. By identifying the operations which account for differences I am able to give operations the status of objects; i.e. I can use operations as evidence for other relations among objects.

Boulez's notion of proliferation is particularly suited to an operational analysis as the following demonstrates. Below are some operational abstractions which respect the hybridization of sonic and musical concepts found in my description of the "*Rĕpons'* note".

| **Operations** | **Definitions** |
|---|---|
| Chord | Make more than one note sound at once |
| Line | Make a note sequence (a melody) |
| Weight | Make a change in the amplitude of a spectrum |
| Arpeggiate | Make a chord a line |
| Unarpeggiate | Make a line a chord |
| Separate | Cut a line, chord, or spectrum in two parts |
| Combine | Paste two lines, chords, or spectra together |
| Pair | Attach two notes or chords together |
| Unpair | Detach two notes or chords |
| Delete | Erase note, line, chord, or spectrum |

What follows is a use of these concepts in a causal analysis of Repons which I produced after several listenings. It shows run-time ("clocked time"), causal models and the operations which explain them.

**(Rĕpons' Causal Pairs)**

| **Clocked Time** | **Object 1 --> Object 2** | **Operation** |
|---|---|---|
| 0" - 1' 22" | Chords--> Polyphony | Arpeggiate |
| | Polyphony --> Runs | Delete lines |
| 1' 22" - 6' 32" | Runs --> Melodic fragment | Separate lines |
| | Parallel chords --> Notes | Delete notes |
| | Notes --> Trills | Pair notes |
| | Trills --> Melodic fragment | Unpair notes |
| | | Combine lines |
| | Melodic fragment -> Chords | Unarpeggiate |
| | Chords --> Chord runs | Combine chords |
| | Chord runs --> chord trills | Pair chords |
| 6' 32" - 9' 31" | Spectral chords | Teach the use of timbre as a pathway to and from spectra, melodies and chords. |
| 9' 31" - 13' 48" | Melodic fragment -> Pointilism | Combine lines |

(continued)

| Clocked Time | Object 1 --> Object 2 | Operation |
|---|---|---|
| | Pointilism --> Chords | Unarpeggiate (fermata) |
| | Chords --> Chord runs | Combine chords |
| | Chord runs --> Chord trills | Pair chords |
| | Chord trills --> Polyphony | Unpair chords<br>Combine Lines |
| 13' 48" -19' 13" | Polyphony --> Melodies | Delete lines |
| | Melodies --> Trills | Pair notes |
| | Trills --> Stacato notes | Unpair notes<br>Delete notes |
| | Stacato notes --> Runs | Combine notes |
| | Runs --> Sustained chords | Combine chords |
| 19' 13" -28' 20" | Fermatas --> Spectral chords | Combine spectra |
| | Spectral chords -> Chords | Change spectrum weights |
| | Chords --> Polyphony | Arpeggiate spectra |
| 28' 20" - 34' 9" | Sustained chords -> Stacc chord | Separate chords |
| | Runs --> Melodic fragment | Separate lines |
| | Trills --> Chord fragments | Pair notes<br>Combine pairs<br>Unpair chords |
| | Trills --> Polyphonic fragments | Pair notes<br>Combine pairs<br>Unpair chords<br>Arpeggiate |
| 34' 9" -37' 36" | Instrument timbre --> Spectral bands | Arpeggiate spectra |
| | Spectral bands --> Chords | Change spectrum weights, Unarpeggiate spectra |
| 37' 36" -40' 48" | Melodic fragments | End |

### 4.4.6 Constructing Abstractions

One can see that the 10 operations are repeated frequently and have been used to construct 30 causal models in my analysis. As a listener, I string these causal pairs into more abstract entities. This process of abstraction is performed whenever the output of the first causal pair is the input to the next.

Thus,

Object 1 --> Object 2
Object 2 --> Object 3
Object 3 --> Object 4

becomes,
    Object 1 --> Object 4

The following illustrates this abstraction process drawing from the previous analysis.

| **Clocked Time** | **Abstraction of Causal Pairs** |
|---|---|
| 0" - 1' 22" | Chords--> Runs |
| | (pause) |
| 1' 22" - 6' 32" | Runs --> Melodic fragment |
| | Parallel chords --> Melodic fragment |
| | Notes --> Chord trills |
| 6' 32" - 9' 31" | Spectral chords |
| 9' 31"-13' 48" | Melodic fragment -> Polyphony |
| 13' 48"-19' 13" | Polyphony --> Sustained chords |
| 19' 13"-28' 20" | Fermatas --> Polyphony |
| 28' 20" - 34' 9" | Sustained chords -> Stacc chord |
| | Runs --> Melodic fragment |
| | Trills --> Chord fragments |
| | Trills --> Polyphonic fragments |
| 34' 9"-37' 36" | Inst timbre --> Chords |
| 37' 36"-40' 48" | Melodic fragments |

This leaves 14 abstract entities which are the product of 10 kinds of operators which "Boulez" applies to the spectral chord. Perhaps, this compact description reflects how my listening experience of *Répons* is structured.

### 4.4.7 Partitioning, and Proliferation Revisited

In the section entitled "Representing Musical Objects" I describe the role of partitioning in 12-tone music. The *separate* and *combine* operations serve that role here; for example, if a musical object is (say) separated by line and combined by chord a new object results.

Proliferation includes partitioning strategies but adds new ones like the pitch generating strategies described in the sub-section "Spectral Chord". These strategies make all musical details a consequence of the repeated application of operations which is why a causal approach to modelling *Répons* seems to work so well.

### 4.4.8 Local Theory Evaluation

Given the complexity of Répons, Boulez has made it remarkably accessible. Most of the above comments show how moments build up into more complex musical models. As a review:

- Boulez uses a handful of recurring operations,
- he trains the listener by using older patterns and operations to construct more complex ones. He introduces the "spectral chords" and establishes the new sonic-hybrid concepts with simple demonstrations before moving on to more complex ones, and
- he uses familiar musical concepts to get to new ones.

### 4.4.9 Modelling Intentions

The sub-section "Preliminary Listening" suggested that the use of familiar ideas to evaluate new ones is important. My comments about classification (e.g. the "Darmstadt note" and the "*Répons* note") were instances of such knowledge. A short history of contemporary musical thought is also useful. Without some exposure to this history, a listener is unaware of the compositional problems Boulez's is attempting to address. For example, in Boulez's book "On Music Today" he says:

> "It seems to me that one of the most urgent objectives of present-day musical thought is the conception and realisation of a *relativity* of the various musical spaces in use." [17]

Boulez's generation began the task of exploring mutually transformable relations between the parameters of music. This "relativity of musical space" is in contrast to the predominantly pitch-centered universe of tonal music. Jameux talks about Boulez's exposure to the electronic experiments of Pierre Schaeffer (the inventor of *musique concrete* ) and how this led Boulez to think about technology as a means for controlling this relativity. Quoting Boulez:

> "...with the increasing improvement of equipment built under the direction of Pierre Schaeffer, it seems that through the medium of tape in particular we can achieve an end result of extremely satisfying precision." [18]

It was the lack of precision of the early electro-acoustic media and the hope that such precision could be achieved with computers that partly explains why Boulez founded IRCAM. However, no one could know how these new compositional controls might change musical thought, as Boulez recognized [19].

> "We shall have to strive to think in new categories; to change not only the methods but the very aim of creation...Creative thought is in a position to examine its own way of working, its own mechanisms".

These comments suggest how much the subject of aesthetics is perpetually tied to questions about innovation, compositional method and the accessibility of musical results. Contemporary musical experiments are as much about what music might mean as they are about what it already means.

## Notes for Chapter Four

1. **Lassano's Background on Kora Music.** In addition to recording Doudou H'Diaye Rose, I was able to record an ensemble of Senegalese musicians: Lassano Cissoko (Kora player) student at the University of Dakar, Cheikou Diebate' (Balafon player), Diali Moussa Diebate' (male singer) with the National Band of Senegal, and Makale Diebate' (female singer) member of the family who is often hired to sing at ceremonies.

According to Lassano, there are three tuning systems for the Kora which originated in Mali: the Koyate' , Diebate' and Cissoko systems. These systems are associated with the 3 families who have, from generation to generation, been the carriers of the musics played in these tuning systems. Lassano also mentioned three of the great players in Senegal: Soundioulou Cissoko ("King of the Kora"), Lalo Keba Drame' (died in 1973), and Babou Diebate' who lives in the Casamance (the southern region of Senegal).
Finally, Lassano mentioned to great players in Mali: Batourou Se'kou Koyate' and Sidiki Diebate', who accompanies Diali Sori Kandia.

**The Kora.** The Kora, or *Kora bato* (in mandingo), is a 21 stringed instrument which is made using a gourd, wood and the hide of an animal. The strings were traditionally made of animal skin but have since been replaced by plastic. Even more recently the straps which hold the strings in tune have been replaced by pegs like those used on the guitar. A 22nd string has also been added, which is an octave lower than the lowest note (a Bb in my recording) on which a major scale is built. Lassano says that this low string gives body to the sound and is useful when the Kora is used to accompany dance. The gourd, which is used as the sounding board for the Kora, has a hole in it which helps in the transmission of the sound. Lassano jokingly said that "the hole makes it possible for the Kora player to collect money from the audience without having to stop playing".

2. This section uses a recording I made while in Senegal in January, 1987.

3. **Disc reference**. Luciano Berio's Points on the Curve to find.. For piano and 23 instruments RCA records ARL1-2291. New York. N.Y. 1977. **Score reference**. Luciano Berio's Points on the Curve to find.. For piano and 23 instruments. Universal Editions.1974.

4. Transition and contrast, see chapter 2, note 4.

5. Sloboda, John A. The Musical Mind: The Cognitive Psychology of Music. Clarendon Press. Oxford. 1985.

6. Stravinsky, Igor. The Rite of Spring. Boosey and Hawkes Music Publishers Limited. England.

7. Vinton, John. Dictionary of Contemporary Music. E.P. Dutton and Co. New York. 1974.

8. Baptista, Luis F. and Lewis Petrinovich. "Song development in the white-crowned sparrow: social factors and sex differences". In Animal Behavior. 34, 1359-1371, 1986.

9. Cage, John. Silence: Lectures and Writings. Wesleyan University Press. Middletown, Connecticut.

10. Boulez, Pierre. *Repons*. IRCAM tape. 1984

11. Boulez, Pierre. "The Bauhaus Model" (1971). Orientations: Collected Writings by Pierre Boulez. Harvard University Press. Cambridge, Massachusetts. 1986.

12. Gerzso, Andrew. "Reflections on Répons". Contemporary Music Review. Issue edited by Tod Machover. Volume 1, Part 1. G+B/harwood. New York. 1984.

13. Jameux, Dominique. "Boulez and the 'machine': Some thoughts on the composer's use of various electro-acoustic media". In Contemporary Music Review. Vol. 1. Harwood Academic Press. 1984.

14. Luciano Berio. *Points on the Curve to Find.* RCA Records. ARL1-2291;
Pierre Boulez. *Le Marteau sans Maitre.* For Alto and Six Instruments.
Turnabout, a Vox Production. TV 34081S; Ornette Coleman *Free Jazz.* Atlantic Records. 1364;
Lukas Foss. *Time Cycle.* Columbia Records ML 5680.

15. Schoenberg, Arnold. Fundamentals of Music Composition. Edited by Gerald Strang and Leonard Stein. Faber and Faber. London. 1967). On variation, pg. 8; On liquidation, pg. 152.

16. Gerzso, see note 12.

17. Boulez, Pierre. Boulez on Music Today. Translated by Susan Bradshaw and Richard Rodney Bennett. Faber Paperbacks. London. 1971. Pg. 83.

18. Jameux, see note 13.

19. Boulez, Pierre. "Technology and the Composer" (1977). Orientations: Collected Writings of Pierre Boulez. Harvard University Press. Cambridge, Ma. 1986).

# Conclusions: Future Work

### Composing

As a composer, I try to identify "new ideas" and ways of formulating them in a compositional language. For this approach to have been fully demonstrated in this thesis, it would have been useful to write a piece of music reflecting these discoveries. Time did not allow this to happen. However, the possibility is suggested in the following review.

- Drawing from chapter 1, I might evaluate my previous works by identifying recurrence or expressive criteria (e.g. the local theory constraint and distributed complexity criterion). I might also write new works with these kinds of evaluations in mind.

- Drawing from chapter 2, I might design a compositional method by converting psychoacoustic information into compositional heuristics; e.g. using streams or anchoring as compositional constraints.

- Drawing from chapter 3, I might use knowledge acquired from my trip to Senegal to influence my notions of metric structure, musical form (e.g. the "opposition aesthetic") and performance (e.g. execution strategies for metric modulation).

- Drawing from chapter 4, I might use the kinds of parts-whole relationship I found in Cissoko's Kora solo, Stravinsky's cellular writing, Berio's home-structure, or Boulez's operational writing.

There are enough differences between Cissoko's, Stravinsky's, Berio's and Boulez's approaches that a synthesis of these ideas into a new compositonal method will necessitate strategies like those proposed in chapters 1 and 2. This is one future direction my work will take.

### New Theory

The above section also illustrates how a compositional theoretic approach is different from conventional practices found in psychoacoustics, ethnomusicology or music analysis. Compositional theory emphasizes the construction of ideas and the representation of process-knowledge.

I use Senegalese and contemporary music in this thesis because they both provide counterexamples to the structure and structuring of music as we know it in the traditional west. I hope to find additional counterexamples to provoke representations I have not yet considered. This will involve looking at other musical traditions; for example,

• Japanese Music. My conjecture has been that the musical figures play as expressive a role in Japanese music as harmony plays in the west. I think of each Japanese musical figure as a "little composition" -- the auditory equivalent of a pictogram -- rather than an element in a musical phrase. If such a view is correct, new pieces of theory are necessary to represent the structure of ornamentation.

• East Indian Music. Traditional Indian music is strongly algorithmic with patterning rules for pitch and rhythm and control structures for regulating the construction of linear patterns of them. My conjecture is that these regulations are similar in form to what occurs in western polyphonic writing between melodic and harmonic motion. In the latter case, the more dense the polyphonic (horizontal) activity the less rapid the harmonic (vertical) change and vice versa.

Perhaps, in both the Indian and western cases, it is the *pattern of shifts between relatively high structures* (melody and rhythm, or melody and harmony, respectively) which are expressive at the abstract level. Since these are hierarchic shifts, they are *metamorphic* and require representations for changing representations themselves!

In a sense, this is ethnomusicology all over again with the significant difference that my account is not an "objective" documentation of a musical tradition but a cognitive model of ideas from a tradition -- how they appear to work in it; and a cognitive model of compositional method -- how ideas might work in my own writing.

### Cognitive Science

Perhaps, my approach is more suited to capturing salient features of a music than the allegedly "objective" approaches commonly used. Every approach is tied to a set of beliefs and a methodological framework. An "objective" approach is defined in terms of a framework.

Paradoxically, objectivity is relative, a problem we always encounter any time we are working across paradigms. It's difficult for thought to look at itself without everything becoming tangled which is why compositional theory separates the "composer" from the "listener", and why cognitive science uses computational metaphors to look at human thought. In each case, there is an attempt to callibrate paradigmatic bias by drawing a line between the instruments of inspection and the results of the inspection.

In spite of the fact that my thesis draws from books, articles and empirical data, it has been substantially speculative. (My own criticisms about thought looking at itself can be raised against the thesis.) My future work will attempt to increasingly root speculations in musical experiments and computer models. The following examples draw from those pieces of theory presented in the thesis which are most programmable.

- In the section entitled "A Local theoretic approach to rhythm" I described an execution strategy for metric modulation which is programmable. The idea of describing a structure in terms of how it can be executed may prove illuminating for a variety of programming projects.

- In the section entitled "Designing Intuition" I used a constraint-oriented approach to produce melodies. I hope to design a number of constraint-oriented examples like this one.

- In the section entitled "Micro-Composition" I designed collections of heuristics for producing vibrati. It should be possible to program them and others, as well as systems for regulating their use.

Ripe for future research are more difficult projects drawing from this thesis. In the section entitled "The Opposition Aesthetic" I described a musical form which controls the presence of two variation sub-forms. A programmed example would require categories of musical segments, one for each form, ways of modifying segments (combining and deleting operations), and higher-level administrators to control their order and how they are mixed.

A more complex version would be necessary to model the Kora solo. It would require the classification of material into a small number of types, administrators for selecting among types and an administrator for deciding <u>when</u> selections should occur (i.e. to model pace). This approach would capture some of the points discussed regarding Stravinsky's cellular writing and Berio's home-structure. It becomes clear that, as the number of musical segments increase it becomes necessary to develop more administrative processes for managing their use. Similarly, as the administrators become numerous it becomes necessary to develop administrators which decide which lower administrator should be used and <u>when</u>.

*When*-questions are about <u>musical causality</u> (which I illustrated using Boulez's *Repons.*). I didn't really give it the kind of attention it warrants from the compositional perspective. I might have said something like:

If recurrence criteria X, Y and Z are all active
Then transfer process control to administrator B.

Such an idea would have shown how junctions which describe points of completion result in interrupts which inforce new kinds of compositional processes.

I have described the emotional effect of music with the notion of pace which is tied to structural issues like the rates of pattern change. Future research will explore alternative representations which are more psychological. For example, patterns of *when*-states may be useful for modelling dramatic effect; i.e. how emotions grow and change.

Musical expressiveness requires levels of complexity which are built in stages. Masking-structure emphasizes the disorienting effect building new musical structure has on the listener and not necessarily the way the composer wants to think about the addition of new musical structure. Recall that in the *Repons* analysis, abstractions were represented as simplifications of causal chains into causal pairs at a higher level. Reciprocally, once the composer has constructed object 1, the construction of object 2 from it, object 3 from object 2, etc. relies on the fact that when recognition conditions are respected during each previously constructed stage, the resulting objects can serve as assumptions upon which new levels of complexity can be built.

It makes sense that the composer does not have to re-define objects and processes once they have already been defined (or that new definitions rest on older ones). Perhaps these older objects can be thought of as *prototypes* and older processes as *precedents* each influencing the kinds of objects and organizations a composer subsequently uses. This description fits with listener comparisions already discussed. Future research will explore such ideas.

### Concluding Remarks

To some of my readers, it may seem unnatural to describe music as a process of managing lots of details; indeed, some may doubt that this detail has anything to do with music at all. One of the reasons why a computational approach to music didn't appear before computers is that one needs the computer power to manage the detailed knowledge provoked by inspection. Before computers, our unconscious minds performed the management tasks we are now asking computers to do. In my view, unconcious thought centers conscious action by suppressing details which are contextually irrelevant. The advantages of a computational approach is that it could help us to inspect these details when desirable (or avoid them).

This requires software designers to focus on creating *design environments* rather than "easy to use" environments. In a design environment the composer can construct representations which will manage those pieces of musical detail he finds important. A composer's history with a system will reflect his cognitive model of music. In an "easy to use" environment a composer learns all the permutations of the software designer's assumptions about music.

Computational ideas are useful without computers. These ideas -- about process knowledge, representation, memory, etc. -- help us to make new conjectures about the relation between conscious and unconscious thought. I believe that, armed with computational ideas, experimental composers will establish musical conventions for the 21st century which are in line with other kinds of inquiry we have come to believe in.

## Bibliography


Abelson, Harold and Gerald Sussman. Structure and Interpretation of Computer Programs. MIT Press. 1985.

Ackerman, Edith. "How Does Sensori-motor Intelligence Develop from the Infant's Reflexes?" 1986. In Press.

Antoni, Giovanni Degli. "Music and Causality". Proceedings of the 1982 International Computer Music Conference. Venice, Italy.

Apel, Willi. Harvard Dictionary of Music. Harvard University Press. Cambridge, Massachusetts, 1978.

Ashby, W. Ross. Design for a Brain: The Origin of Adaptive Behaviour. Chapman and Hall. London. First published in 1952. Reprinted in 1978.

Baily, John. "Music Structure and Human Movement". In Music Structure and Cognition. Edited by Peter Howell, Ian Cross, and Robert West. Academic Press, New York. 1985.

Baptista, Luis F. and Lewis Petrinovich. "Song development in the white-crowned sparrow: social factors and sex differences". In Animal Behavior. 34, 1359-1371, 1986.

Barbour, J. Murray. Tuning and Temperament: A Historical Survey. Da Capo Press. New York. 1972.

Besmer, Fremont E. Horses, Musicians, and Gods: The Hausa Cult of Possession-Trance. Ahmadu Bello University Press. Zaria, Nigeria. 1983.

Bettelheim, Bruno. The Uses of Enchantment: The Meaning and Importance of Fairy Tales. Vintage books. A Division of Random House. New York. 1977.

Bharucha, J.J. "Anchoring Effects in Music: The Resolution of Dissonance". Cognitive Psychology. 16, 485-518. 1984.

Blacking, John. How Musical is Man? University of Washington Press. Seattle, Washington. 1973.

Boulez, Pierre. Orientations: Collected Writings of Pierre Boulez. Harvard University Press. Cambridge, Ma. 1986).

Boulez, Pierre. Boulez on Music Today. Translated by Susan Bradshaw and Richard Rodney Bennett. Faber Paperbacks. London. 1971

Bullock, Theodore H. "Comparative Audition: Where do We Go from Here?" In Comparative Studies of Hearing in Vertebrates. Edited by Arthur N. Popper and Richard R. Fay. Springer-Verlag. New York. 1980.

Cage, John. Silence: Lectures and Writings. Wesleyan University Press. Middletown, Connecticut.

Cage, John. Themes and Variations. Appendix A is Cage's 110 themes. Station Hill Press. Barrytown, New York. 1982.

Chernoff, John Miller. African Rhythm and African Sensibility: Aesthetics and Social Action in African Musical Idioms. University of Chicago Press. Chicago.

Cohen, Charles and Don Schaeffer. Complete Encyclopedia of Scales. Published by Charles Colin. New York. 1977

Coolen, Michael T. "The Wolof Xalam Tradition of the Senegambia". Ethnomusicology, Journal of the Society of Ethnomusicology. September, 1983.

Darwin, Charles. The Expression of the Emotions in Man and Animals. University of Chicago Press. Illinois. Reprinted in1965.

Ericsson, Andres K. and Herbert A. Simon. Protocol Analysis: Verbal Reports as Data. MIT Press. Cambridge, Ma. 1984.

Erlmann, Veit. "Marginal Men, Strangers and Wayfarers: Professional Musicians and Change Among the Fulani or Diamare (North Cameroon)". Ethnomusicology, Journal of the Society for Ethnomusicology. May, 1983.

Feyerabend, Paul. Against Method. Verso Edition, London, 1975.

Geertz, Clifford. The Interpretation of Cultures. Basic Books. New York. 1973.

Gerzso, Andrew. "Reflections on Repons". Contemporary Music Review. Issue edited by Tod Machover. Volume 1, Part 1. G+B/harwood. New York. 1984.

Ginsburg, Herbert and Sylvia Opper. Piaget's Theory of Intellectual Development. Prentice-Hall. New Jersey.

Gould, James L. "Auditory Design" and "Auditory Processing". In Ethology: The Mechanisms and Evolution of Behavior. W.W. Norton and Company. New York. 1982.

Griffin, Donald R. Animal Thinking. Harvard University Press. Cambridge, Massachusetts. 1984.

Harmon, Paul and David King. Expert Systems: Artificial Intelligence in Business. John Wiley and Sons. Inc. New York. 1985.

Hillis, W. Daniel. The Connection Machine. MIT Press. Cambridge, Massachusetts. 1985.

Holland, John H. Keith J. Holyoak, Richard E. Nisbett, and Paul Thagard. Induction: Processes of Inference, Learning and Discovery. MIT Press. Cambridge, Massachusetts. 1986.

Jackendoff, Ray. Semantics and Cognition. MIT Press. Cambridge, Massachusetts. 1985.

Jaynes, Julian. The Origin of Consciousness in the Breakdown of the Bicameral Mind. Houghton-Mifflin Company, Boston. 1976.

Jameux, Dominique. "Boulez and the 'machine': Some thoughts on the composer's use of various electro-acoustic media". In Contemporary Music Review. Vol. 1. Harwood Academic Press. 1984.

Kuhn, Thomas. The Structures of Scientific Revolutions. Chicago. 1962.

Kuffler, Stephen W. John G. Nicholis, A. Robert Martin. From Neuron to Brain. Sinauer Associates Inc. Suderland, Massachusetts. 1984.

Kyburg, Henry E. Epistemology and Inference. University of Minnesota Press. Minneapolis, Minn. 1983.

Lakatos, Imre and Alan Musgrave. Criticism and the Growth of Knowledge. Cambridge University Press. 1970.

Laszlo, Ervin. The Systems View of the World. George Braziller, Inc. New York. 1972.

Laudan, Larry. Progress and its Problems. University of California Press. Urbana, Illinois. 1983.

Lawson, E. Thomas. Religions of Africa. Harper and Row Publishers. San Francisco. 1984.

Lerdahl, Fred. "Cognitive Constraints on Compositional Systems". To appear in Generative Processes in Music. J. Sloboda Editor. Oxford University Press. 1987.

Lerdahl, Fred and Ray Jackendoff. A Generative Theory of Tonal Music. MIT Press. Cambridge Massachusetts. 1983.

Levi-Strauss, Claude. Myth and Meaning. Schoeken Books. New York. 1979.

Malm, William P. Six Hidden Views of Japanese Music. University of California Press. Los Angeles. 1986.

Mayakovsky, Vladimir. How to Make Verse. Curbstone Press. 321 Jackson St. Willimantic Ct. 06226. 1976.

McAdams, Stephen and Albert Breman. "Hearing Musical Streams". In Computer Music Journal. 3(4) 26-43, 60, 63. 1979.

McFarland, David. "Song". Editor of the Oxford Companion to Animal Behavior. Oxford University Press. New York. 1982.

Merriam, Alan P. The Anthropology of Music. Northwestern University Press. Illinois. 1964.

Meyer, Leonard. "Universalism and Relativism in the Study of Ethnic Music". Ethnomusicology: Journal of the Society of Ethnomusicology.

Meyer, Leonard. Emotion and Meaning. The University of Chicago Press. Chicago, Illinois. 1956.

Minsky, Marvin. "Music, Mind and Meaning". Computer Music Journal. Volume 5, Number 3. Fall, 1981. MIT Press. Cambridge, Massachusetts.

Minsky, Marvin. The Society of Mind. Simon and Schuster. New York. 1986.

Myrberg, Arthur A. Jr. "Sound Communication and Interception in Fishes". In Hearing and Sound Communication in Fishes. Edited by William N. Tavolga, Arthur N. Popper and Richard R. Fay. Springer-Verlag. New York. 1981.

Narmour, Eugene. Beyond Schenkerism: The Need for Alternatives in Music Analysis. The University of Chicago Press. Chicago. 1977.

Nettl, Bruno. The Study of Ethnomusicology: Twenty-nine Issues and Concepts. University of Illinois Press. Urbana, Illinois, 1983.

Nettl, Bruno. The Western Impact on World Music: Change, Adaptation, and Survival. Schirmer Books. New York. 1985.

Nketia, J.H. Kwabena. "The Problem of Meaning in African Music." Ethnomusicology: Journal of the Society of Ethnomusicology. January, 1962.

Norris, Margot. The Decentered Universe of Finnegan's Wake. Johns Hopkins University Press. Baltimore. 1976.

Papert, Seymour. Mindstorms: Children, Computers and Powerful Ideas. Basic Books. New York. 1980

Pfeifer R. and D.W. Nicholas. "Toward Computational Models of Emotion". In Progress in Artificial Intelligence. Editors Luc Steels and J.A. Campbell. John Wiley and Sons. New York. 1985.

Piaget, Jean. The Child's Conception of Time. Ballantine Books. New York, 1969.

Piaget, Jean. Genetic Epistemology. W.W. Norton and Company. New York. 1970.

Piaget, Jean. Intelligence and Affectivity: Their Relationship During Child Development. Annual Reviews, Inc. Palo Alto, California. 1981.

Pian, Rulan C.. Re: Chinese music. Lecture at Harvard University on "Topics in Ethnomusicology".

Piston, Walter. Harmony. W.W. Norton and Company. New York. 1948.

Polkinghorne, Donald. Methodology for the Human Sciences. Systems of Inquiry. State University of New York Press. Albany, N.Y.

Polya, G. How to Solve It: A New Aspect of Mathematical Method. Princeton University Press. Princeton, New Jersey. 1973.

Roederer, Juan G. "The Search for a Survival Value of Music". In Music Perception. Spring Vol. 1. No. 3. University of California Press. 1984.

Rose, Doudou H'Diaye. Comment transcribed from a video made by National Television of Senegal, 1986.

Rosen, Charles. The Classical Style: Haydn, Mozart, Beethoven. The Norton Library. New York, 1972.

Rowell, Lewis. Thinking About Music. The University of Massachusetts Press. 1983.

Schank, Roger C. Reading and Understanding: Teaching from the Perspective of Artificial Intelligence. Lawrence Erlbaum Associates, Hillsdale, New Jersey. 1982.

Schoenberg, Arnold. Fundamentals of Musical Composition. Edited by Gerald Strang and Leonard Stein. Faber and Faber. London. 1967.

Simon, Herbert A. Reason in Human Affairs. Stanford University Press. Stanford, California. 1983.

Slawson, Wayne. Sound Color. University of California Press. Berkeley, Ca. 1985.

Sloboda, John A. The Musical Mind: The Cognitive Psychology of Music. Clarendon Press. Oxford. 1985.

Springer, Sally P. and Georg Deutsch. Left Brain, Right Brain. W.H. Freeman and Company. New York. Revised. 1985.

Stebbins, William C. The Acoustic Sense of Animals. Harvard University Press. Cambridge, Massachusetts. 1983.

Stravinsky, Igor. Paraphrase of his comments made in a documentary film by Ricky Leacock.

Sudnow, David. Ways of the Hand: The Organization of Improvised Conduct. Harvard University Press. Cambridge, Massachusetts. 1978.

Turner, Frederick and Ernst Poppel. "The Neural Lyre: Poetic Meter, the Brain, and Time". In Poetry. Vol CXLII, Number 5. August. 1983.

Vinton, John. Dictionary of Contemporary Music. E.P. Dutton and Co. New York. 1974.

Wong. Mr. Wong is a professional Korean musician. Through personal communication.

Wuorinen, Charles. Simple Composition. Longman Press. New York. 1979.

Yost, William A. "Man as Mammal: Psychoacoustics". In Comparative Studies of hearing in Vertebrates. Edited by Arthur N. Popper and Richard R. Fay. Springer-Verlag. New York. 1980.

## Discography and Scores


Ames, David. "Wolof Music of Senegal and The Gambia". Recorded by David Ames. Ethnic Folkways Library FE 4462. Band 1.

Berio, Luciano. Points on the Curve to find.. For piano and 23 instruments. Universal Editions.1974.

Berio, Luciano. Points on the Curve to find.. For piano and 23 instruments. RCA records ARL1-2291. New York. N.Y. 1977.

Boulez, Pierre. *Repons*. IRCAM tape. 1984

Boulez, Pierre. *Le Marteau sans Maitre*. For Alto and Six Instruments. Turnabout, a Vox Production. TV 34081S.

Coleman, Ornette. *Free Jazz*. Atlantic Records. 1364.

Diatta, Keno and Sona Mane. "Songs from Senegal". Duets and songs. Recorded by Kimberly Safford. Lyrichord Stereo LLST 7381.

Foss, Lukas. *Time Cycle*. Columbia Records ML 5680.

Stockhausen, Karlheinz. *Hymnen*. Quote from record jacket. Deutsche Grammophon. SLPM 139 421/22

Stravinsky, Igor. The Rite of Spring. Boosey and Hawkes Music Publishers Limited. England.