
Temporal Elements: A Cognitive System of Analysis for Electro-Acoustic Music

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I. INTRODUCTION

Composers of contemporary music make use of a wide variety of techniques in their music. Regardless of the harmonic vocabulary or medium used, one thing that great compositions of all styles and genres have in common is an effective and interesting use of the *temporal* elements of music. This is particularly evident in acoustic and electronic compositions which frequently use of a mixture of metered and free, non-metered elements. Although many articles, books and papers have presented methods of defining, discussing and understanding pitch materials, a proportionately insignificant number have dealt with the fundamental, temporal aspects of contemporary music, and virtually none deal with non-pitched based music. Since the temporal aspects of a composition are of fundamental importance, a method of defining, understanding and discussing the full gamut of the rhythmic and temporal relationships for pitched and non-pitched based music is essential.

Most existing rhythmic theories and analytical systems apply only to metered music, as do those of Maury Yeston, who at the end of *The Stratification of Musical Rhythm* adds the disclaimer that his theories are "... limited to a kind of tonal music in which the middleground rhythmic levels exhibit some regularity of motion." (Yeston, 1976: 148) Others, like Jonathan Kramer's *The Time of Music* (Kramer, 1988), thoroughly cover the philosophical unfolding of time within a work and the effects of tonality and pitch material on the perception of time in a work. Like Yeston, however, Kramer remains almost exclusively within the realm of metered music, providing only a passing mention of non-metered works (1988: 77).

The analytical concepts put forth in by Larry Austin and Thomas Clark (1989: 131-143) are more general and applicable to a much wider variety of types of music. Although these ideas are helpful in determining the rhythmic density and alignment at a detailed level, they require a great deal of time and computation. For this reason, these tools are most useful only after specific areas and strata of musical material have been isolated and identified. Moreover, the results of such analysis are in the form of raw data, and are not

indicative of the relationships and transformations that may be taking place in the music.

So, how would one begin understand or discuss the temporal characteristics of a work which moves freely from metered to non-metered sections? Yeston states:

"Extreme caution should be exercised in evaluating the universality of a theory. If it is too specific to a small domain of musical phenomena, a theory may mistake the unique aspects of very few compositions for general principles. On the other hand, if the theory is too general, the degree to which it may illuminate specific problems may be marginal when compared with the effort expended in arriving at general principles and solutions." (1976: 148)

This paper presents a cognitive-based system of identifying and labeling basic temporal elements. It is designed to be a first-level tool for theorists, composers, and teachers and is applicable to music regardless of the presence or absence of pitched-based materials, meter, or notation. Although general in nature, the application of this system is very easy and simple. Most importantly, in the case of sample-based computer music and many 20th Century acoustic works, temporal analysis can reveal underlying structures that might not be otherwise evident.

II. FACTORS WHICH DEFINE TEMPORAL ELEMENTS

When listening to music, regardless of pitch content, media, or style, the mind analyzes and organizes the sound it hears in order to comprehend it. Acoustically, when two or more sounds of differing amplitudes and/or timbres are sounded together, an effect called *masking* (Backus, 1969: 90) may cause the stronger sound to dominate, resulting in the perceived disappearance of the weaker sound. Similarly, when the listener is presented with a variety of sonic elements, the mind relegates some as being predominant, or *foreground* material, and some as less dominant, or

background material. The mind focuses on the primary elements while background material is mentally “masked” and perceived in a subordinate role or, in some cases, not consciously perceived at all. Studies have shown that the human mind reacts to the occurrence of a sonic event and then projects forward in time an expectation of what is to come (Dowling, 1986: 214-215). As long as an event continues according to what the mind expects, there is little mental attention required. When something unexpected occurs, such as a change in the pattern, there is a biological reaction within the brain signaling that something has unexpected has occurred. New events will also elicit this signal. Both reactions will bring about psychological conditions which shift the mind’s attention to the new or different event, while continuing events will elicit less and less of a reaction (Dowling, 1986: 214-215).

Consistent, unchanging elements are perceived as being more stable and can be more easily assigned a background role in favor of new material which demands more attention. Hence, material that is initially perceived as foreground material may later be perceived as background material when: a) it is repeated so many times that the mind is thoroughly familiar with it and no longer requires the same amount of attention or energy to process the information, or b) some new material upsets the order of priority in the mind of the listener. This interplay of consistency versus change results in the perception of, and transformations between, foreground and background material and is crucial to understanding the pacing and temporal unfolding of events in a composition. By defining the temporal elements used and their relationships, we not only create a tool for discussing specific aspects of a composition but also increase our awareness of these relationships, resulting in a greater understanding of the music.

Sustenance

The most stable, unchanging element is one that is said to sustain, or continue consistently without interruption after its initial attack. How long must a pitch/silence continue to be considered sustaining? In *Music Cognition*, W. Jay Dowling uses the term “psychological present” to refer to that temporal span of attention which we consider “now,” and during which the mind processes information as a whole (1986: 79). The term psychological present does not refer to the *actual* present which is occurring as you read this. Rather, it refers to a short interval of time, like a buffer, during which the mind determines if

events are to be perceived as a single unit or as separate events. Related materials are grouped together and processed as a single unit. This is the function that allows us to perceive speech as “words” rather than strings of phonemes. If the material continues beyond this time-span, the mind must find a new way to deal with it, since the “buffer is full” so to speak. Beyond this limit, the mind must categorize an event as either a continuation of the primary event or segment the material and perceive it as one or more new, separate events, thus effecting our basic perception. Research has set the psychological present at a normal maximum of about 2-4 seconds with some rare cases of up to 9 or 10 seconds (Dowling, 1986: 180). Events occurring entirely within this brief period are mentally grouped into, and perceived as, single units. Sounds or silence which exceed this limit in a consistent manner will generally be cataloged by the mind as a continuation of a previous event or, in this case, as sustaining.

Repetition

Similarly, shorter events which occur within the psychological present and then continue to consistently repeat beyond that time span will be psychologically grouped into a unit perceived as a continuation of the pattern. Pitch and timbre can play a determining role in the perception of repetition (Yeston, 1976: 50-51). However, a high degree of similarity may be sufficient cause for a pattern to be perceived as repeating, but to a lesser extent than an exact repetition. Therefore, in this paper *repeating elements* will be defined as patterns which repeat identically. Similar events which repeat will be considered a weaker sub-category of this element. Another weaker form of this type of element occurs when the length of the repeating element exceeds the psychological present. When this occurs, it may not be at first perceived as a repeating element but after a longer period of time, i.e. several repetitions, may be perceived as such. In this paper, these type of elements will be referred to as *long-repeating elements*.

A common application of this principle is found in the use of the “Alberti Bass” accompaniment, ostinato figures, tape loops, and other repeating patterns. With these figures, composers can sustain rhythmic interest and direction without distracting from the foreground material. Another application of this is in minimalism, where subtle changes introduced after the material has been shifted to a background-type perception elicit a stronger response than they normally would have if introduced within a changing, non-consistent environment.

Alignment to a Common Pulse

Another factor to be considered is alignment to a common pulse. When an event or a combination of events conform to a common, recurring interval of time, a pulse emerges. Extended to a higher level, regularly accented patterns of pulses form related groups, commonly referred to as *meter*. As there are a multitude of works on this subject, there is no need for a detailed discussion of this topic. However, we must note that alignment to a pulse has a great impact on our perception of music. In this paper, *aligned events* will refer to events that are coordinated to a common, recurring interval of time. Although metered events are a narrower interpretation of this factor, they will not be a requirement of the definition.

Fusion and Auditory Streaming

As summarized by Dodge and Jerse (1997: 44-45), when approximately 10-12 or more events occur per second, our mind does not react to each as a separate event, but groups them together into a single element through a process called *fusion*. Thus, a granulated sound is not perceived as a rapid series of repeated events, but rather as a single, sustained stream of sound. When a series of events that have the same timbre, or some other unifying aspect, occur in sequence, we also perceive them as a single *auditory stream* (Dodge and Jerse, 1997: 59). This is why a series of events of the same timbre, even if they do not repeat, are perceived as a single stream. Hence, a series of non-repeating events with the same timbre, register, or other unifying aspect, such as a phrase of spoken text, may be identified as a single, non-repeating element. Similarly, a group of elements that exhibit a high degree of consistency (such as an orchestral unison passage) may also be grouped into a single element for easier analysis.

III. DEFINITION OF THE FIVE BASIC TEMPORAL ELEMENTS

When a single sound, silence, or series of sounds occurs within the period of the psychological present, it will be referred to in this paper as an *event*. In the following discussion, let us define an *element* as an event or series of events continuing beyond the psychological present.

Sustaining elements by their very nature provide no opportunity for repetition or alignment beyond the initial attack and, as such, are unique. Within non-sustaining elements, however, the factors of repetition and alignment to a common pulse each have an effect on the perception of the resulting material. This means

that different combinations of these two factors will result in perceptually different elements. Hence, we may derive five basic temporal elements: *sustaining*, *aligned/repeating*, *aligned/non-repeating*, *non-aligned/repeating* and *non-aligned/non-repeating*.

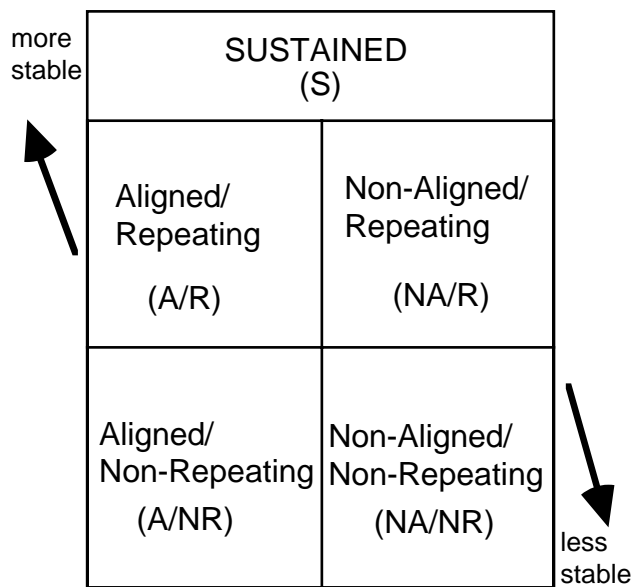


Figure 1: Basic Temporal Elements

1. Sustaining

A simple example of a sustaining element is a long fermata. The technique of “pedal point” is another example of this type of element.

2. Aligned /Repeating

In this type of element, events repeat to a coordinated regular pulse. It is often used in many types of music as an accompanimental figure.

3. Aligned /Non-Repeating

Unison passages, homogenous chorales, and metered music with distinctly independent lines with metrically congruent subdivisions of the beat are all examples of aligned/non-repeating elements. Although this type of element may contain recurring motifs and patterns, it does not contain consecutive repetitions like aligned/repeating elements.

4. Non-Aligned/Repeating

In this genre there is no coordinating temporal pulse. In polyphonic textures, each sub-element proceeds independently of the others but contains within itself repeating events.

5. Non-Aligned/Non-Repeating

This genre has no coordinating pulse, no continuously repeating figures, and individuality of sub-elements. Non-aligned/non-repeating elements are used in common practice cadenzas and many twentieth-century solo works.

The preceding categorization of basic temporal elements is intended to be general, not absolute or all-inclusive. There are an infinite number of “gray areas” between each genre and it is often these “gray areas” that are of the greatest interest in a work. Just as tonal theory can be used to help understand modulatory passages or passages of tonal ambiguity, these basic temporal elements may also be used to shed light on interesting musical passages of temporal ambiguity.

IV. COMBINATION OF TEMPORAL ELEMENTS

Temporal elements can, of course, exist singularly or simultaneously with other elements. In a singular relationship, different temporal elements are *juxtaposed* one after the other for temporal contrast. Composers frequently employ this technique to help define formal sections in a work.

When two or more elements begin in a *simultaneous* relationship, there may be a few moments of disorientation during which the mind is attempting to determine upon which element or elements to focus. As elements unfold past the psychological present, they may begin to be recognized as repeating or sustaining elements and be relegated to a background role, or as non-repeating elements or single events, and perceived as foreground material.

Another means of combination is achieved by the gradual *layering* of elements. Layered elements do not have to be of contrasting type in order to be effective. General observations seem to indicate that the normal active focus time for sustained elements is approximately three times the psychological present for sustained elements (once to perceive the event, once to recognize the continuity, and a third time to confirm the continuity), or approximately 6-9 seconds. The same principle applies to repeated elements, with a normal active focus time of approximately three repeats of the event. When new elements are brought in before this active focus time is complete, the passage may be perceived as building or possibly “rushed”, since the newly entering elements are drawing focus away from a active (foreground) element rather than a stable (background) element. Similarly, when new elements

enter beyond the normal focus time, the passage may be perceived as stabilizing, or possibly “lagging”, since there is time during which the mind has already processed the existing information, but no new events enter to retain the active focus.

In a *phased* relationship, two or more elements exist in related tempos or consistent subdivisions that result in points of coordination at a recurring interval of time. When this coordination point arrives within the active focus time, the relationship between the two phased elements may be perceived more strongly. When it occurs within the psychological present, the two elements may even be perceived as a single, fused element. This type of relationship is stronger in aligned elements, where it forms the basis for our perception of meter.

V. TRANSFORMATIONS BETWEEN TEMPORAL ELEMENTS

Just as transitional passages often provide the most interesting analysis in tonal theory, gradual transformations between different genres of temporal elements result in equally interesting material. These transformations fall into two basic categories: *hybrid elements*, and *gradual transformations*.

By combining traits of two different types of temporal elements, a hybrid element is formed. This may be used to form a transition from one type of element to another. One example of this is a trill, which is a aligned/repeating element whose repeating notes are joined through fusion to form an element similar to a sustaining element. Another example of a hybrid element is a sustained FM tone with an oscillator on the Modulation Index or amplitude. Although there is no new attack, a pulsing timbre can give the impression of a aligned/repeating element. Weaker sub-categories of elements may also be used as hybrid elements. A long non-aligned/repeating element may be perceived as repeating to some, but to others with a shorter psychological present, may be perceived as non-repeating for several repetitions.

Gradual transformations also provide interesting transitions between elements. For example, when a non-repeating element contains similar phrases that become more and more consistent, it may transform into a repeating element. Tempo and rate of unfolding of events can also create transitional phrases. In traditional music, a *rallentando* into a fermata is a familiar example of a transformation from a less stable non-sustaining element into a stable, sustaining element, hence it's effectiveness as a closing gesture.

VI. APPLICATIONS AND CONCLUSIONS

Analysis

The Electro-Acoustic literature is rich in interesting forms and structures. Unfortunately, most theorists are reluctant to discuss these works, as well as the works of many contemporary acoustic composers, because without the security of a time signature most analyses are reduced to generalized discussions of pitch sets. Once the factor of pitch is removed, traditional analysis comes to a virtual halt. However, within all these works, there exist temporal structures and relationships that significantly shape the form of the work. Recognizing, identifying and labeling temporal elements and their transformations provides a specific language for discussing and revealing interesting, underlying structures within these works.

With notated music, there is a fixed score in which various temporal elements and their use may be identified. In Electro-Acoustic works without a score, this may be more difficult in some ways. However, software that displays waveforms and time, such as SoundEdit16, is helpful in providing specific reference points in time and providing a visual graph of the work. Since this is a perceptual system, this may also be an advantage, since the aural characteristics are more important than a possibly deceptive notation. Also, since this is a cognitive-based system time is the unit of measure, not measure numbers, making this system ideally suited to electro-acoustic music.

Étude aux Chemin des Fer by Pierre Schaeffer is a classic and well known example of *musique concrète*. However, as such, it is rarely the subject of analysis. A temporal analysis of this pioneering work reveals several interesting structures and techniques:

The work consists of four sections: an introduction; a two-part, A-B style exposition, the first presenting A/R loops, the second presenting primarily NA/NR materials; a development using primarily hybrid elements that blur the difference between natural and artificial loops; and a coda that mirrors the introduction.

The introduction (Figure 2) opens with an A/NR element consisting of three whistle sounds. The closest to traditional, metered music, this element is used three times throughout the work, and in each case this signals the beginning of a new section. After this initial sound-set, he introduces a naturally occurring A/R hybrid element (the regular, accelerating clickty-clack of a train starting). This sound is an ideal choice, since it not only foreshadows the artificial A/R elements that he will create with his locked-loop recordings, but it also has a sustaining high-pitched whine as a part of

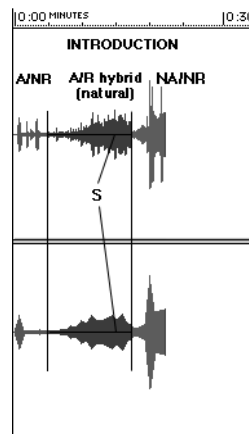


Figure 2: Introduction

the sound, thus adding additional stability to the beginning of the work. Following this stable sound, he selects a contrasting NA/NR element, as a transition into the main portion of the work.

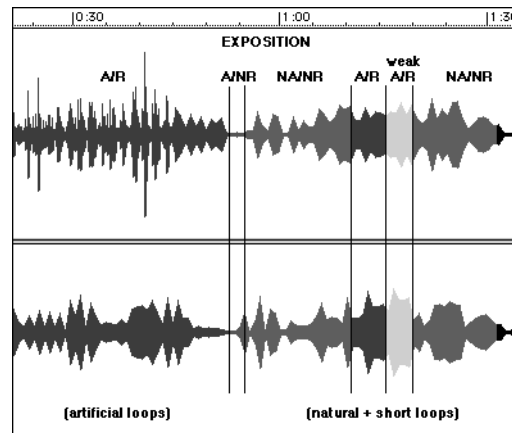


Figure 3: Exposition

The Exposition (Figure 3) presents the two basic ideas Schaeffer uses in this work: artificial, locked-loop recordings that create strong sense of meter, and naturally occurring, NA/NR sounds that invite the listener to attempt to find a pulse in the course of everyday life. The locked-loop sounds occur from :22 - :53. An A/NR whistle sound serves as a transition to the following NA/NR sample, which contains little if any naturally occurring repeating sounds. At 1:11, he inserts a 5 second A/R loop, and then a weaker (less strong metric subdivisions) 4 second loop that leads back into NA/NR material until 1:33, when the development begins.

Schaeffer develops his material by presenting less clearly defined elements, shifting between naturally similar (yet not identical) weak NA/NR elements verses weak A/R loops that never present more than two repetitions of an event. By shortening the length of

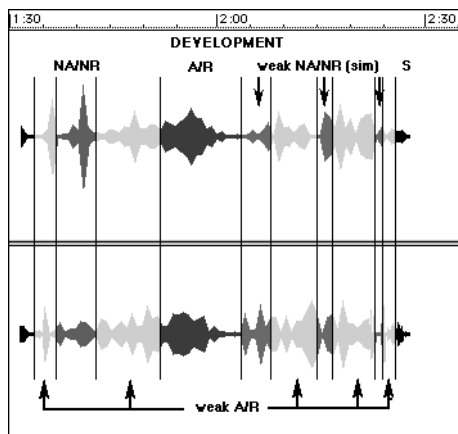


Figure 4: Development

each element and using closely related hybrid elements, the listener is constantly challenged to ascertain if a sound is repeating naturally or artificially, with less and less time to make this decision. Finally, he closes this section with three repetitions of a whistle tone. It is interesting to note that the third of these tones is allowed to sustain for several seconds, transforming this gesture into a stable, sustaining element.

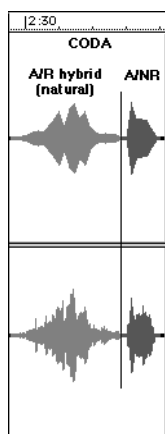


Figure 5: Coda

The coda mirrors the opening, with a naturally occurring A/R hybrid element (regular whistle pulses with Doppler shift) followed by an whistle sound A/NR element. A sustained tone with even pitched pulses, this sound combines traits of sustaining and A/R elements, yet does not make use of literal, artificial loops. The closing gesture, same type of element as the opening, rounds out the form.

Teaching

In theory and composition courses, different methods of handling pitch materials are presented, but there are rarely equally structured presentations of the many various methods of handling temporal aspects

of a composition. When various temporal systems are presented, they are often presented individually as separate “styles” such as “aleatoric”, “minimalism”, and “computer music.” This may be, in part, due to a lack of a common language and method of discussing these aspects. When these concepts are presented, it must be stressed that there are different methods of notating these various elements, and that sometimes the notation may be deceptive. By presenting all of the basic temporal elements together in one unified system, students may more easily approach new music with an open, unbiased perspective. Many contemporary techniques aren’t seen as totally foreign concepts but as extensions and developments of basic temporal and perceptual principles. As an additional benefit, understanding the underlying temporal principles behind the contemporary notation used in many works allows for the easier and faster identification of the pitch materials employed.

In teaching composition lessons, this system provides specific terms which allow for the direct discussion of the properties of a work. By identifying specific problems it also may suggest specific possible solutions. (i.e. - “You have only A/R elements continuing for 25 seconds in this section, but never elsewhere in the work. This creates an inconsistently static interval during which the listener’s attention will wander. Try layering a different type of element over it.”) It may also function as a compositional tool, allowing for the design of formal structures and new transformations.

Conclusions

While labeling temporal elements and identifying transformations between them may not provide the detailed, numeric data that would result from other forms of analysis, these processes do provide an overview of the structures and techniques used in temporally flexible works or passages. Used as a first-level analytical tool, this method may help isolate areas of particular temporal interest and aid in determining which other analytical tools might be appropriate for further in-depth study. It is hoped that this method might encourage and assist composers, theorists, students, and teachers in recognizing and appreciating the large-scale counterpoint of elements inherent in music of all styles and periods, including the often neglected and misunderstood music of our own time.

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