PROLONGATION, EXPANDING VARIATION, AND PITCH HIERARCHY: A STUDY OF FRED LERDAHL’S WAVES AND COFFIN HOLLOW

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This thesis consists of two independent yet interrelated portions. The theory portion explores connections between Fred Lerdahl’s theoretical and compositional output by examining his work *Waves* in relation to his theoretical writings, primarily *A Generative Theory of Tonal Music* and “Tonal Pitch Space.” The theories together form a generative theory of tonal music that strives to create a musical grammar. “Tonal Pitch Space” defines a hierarchy among pitches and chords within and across tonal regions. Lerdahl uses these ideas in *Waves*, which is in the key of D minor. All other pitch classes, and likewise all other chords and tonal regions, are elaborations of the tonic D. The initial D tonic statement, called a flag motive because it heralds each variation, is the fundamental construct in *Waves*. Just as all other pitches elaborate D, all other motives in *Waves* are elaborations of the flag motive. Thus rich hierarchies are established.

Lerdahl also incorporates ideas from *GTTM* into his compositional process. *GTTM* focuses on four categories of event hierarchies: grouping and metrical structures and time-span and prolongational reductions. These four hierarchies and a set of stability conditions all interact with one another to form a comprehensive musical grammar. Grouping and metric structures in *Waves* are identified and analyzed in this thesis. These include the irregular grouping and metric structures elision, overlap, deletion, and compound grouping. Lerdahl, by fusing passing and neighbor diminutions, creates unstable harmonic cells that, due to their distance from the tonic, assume dominant and subdominant function in the context of *Waves*. These functional sonorities create both progressions and cadences. By using those same tonal diminutions to elaborate stable
tonic chords and pitch classes, Lerdahl also creates prolongation. Both Lerdahl’s progressions and prolongations can be analyzed through the tree diagrams of prolongational reduction.

*Waves* is shaped by a formal process called expanding variations. This is a procedure in which a single idea is expanded upon by interpolation in a series of variations. Each variation develops the previous one, creating a reduction in reverse. The expanding variations of *Waves* are governed by the Fibonacci series. Each number in the series corresponds to the number of tactus-level beats per variation.

The composition portion of this thesis borrows aspects of Lerdahl’s music, most notably the expanding variations based upon the Fibonacci series, and incorporates them into an original composition for chamber ensemble (alto flute, clarinet, percussion, piano, violin, and violoncello). The piece, *Coffin Hollow*, is based upon a ghost story of the same name. The story, set in northern West Virginia during the Civil War, has two main characters, a Union soldier and Confederate soldier. Each is assigned his own series of variations. While the Confederate soldier’s variations expand, the Union soldier’s variations contract, giving the sense of the former consuming the latter, much like the ghost of the Confederate soldier hunts down and kills the Union soldier. The Union soldier’s theme is based upon the Union folk song “Just Before the Battle, Mother,” while the Confederate soldier’s theme is based upon the folk song, “I’m a Good Old Rebel.”
This thesis is dedicated to my parents.
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CHAPTER 1. FRED LERDAHL’S THEORETICAL RESEARCH THROUGH 1988:
A SUMMARY OF *A GENERATIVE THEORY OF TONAL MUSIC* AND “TONAL PITCH SPACE”

Fred Lerdahl is well-known as both a theorist and a composer. Of his theoretical writings, *A Generative Theory of Tonal Music* (henceforth *GTTM*), cowritten with Ray Jackendoff, has had the greatest impact.1 *GTTM* is an extensive study of the grammar of tonal music: how tonal music is interpreted and organized in the mind of the listener. Lerdahl has also contributed to the field of cognitive music psychology in a recent study of the organization of pitches into tonal hierarchies. This study was first published in 1988,2 and Lerdahl has since expanded it into a book titled *Tonal Pitch Space* (2001), which was awarded both the Deems Taylor Award (ASCAP) in 2002 and the Wallace Berry Award (Society for Music Theory) in 2003.

As a composer, Lerdahl has received numerous commissions from groups including the Juilliard String Quartet, the Orpheus Chamber Orchestra, the Koussevitzky Music Foundation, and the Chamber Music Society of Lincoln Center. Lerdahl has won many awards, including the Koussevitzky Composition Prize and the Guggenheim Fellowship, and was a finalist for the Pulitzer Prize in 2001 for his work *Time After Time*.

Exhibiting a passion for both composition and theory, Lerdahl often blends the two fields, using theoretical groundwork to organize his compositions and compositional conundrums to direct his theoretical pursuits. This thesis shows how *Waves*, a work by Lerdahl for chamber orchestra written and published in 1988, incorporates the theoretical

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1 Ray Jackendoff is a concert clarinetist and professor of linguistics at Brandeis University.
2 Lerdahl, “Tonal Pitch Space.”
models of *GTTM* and the article “Tonal Pitch Space.” Waves was cocommissioned by the Orpheus, Saint Paul, and Los Angeles chamber orchestras with support from a Consortium Commissioning Grant from the National Endowment of the Arts. It was first performed by the Saint Paul Chamber Orchestra (April 1989) and was recorded by the Orpheus Chamber Orchestra in 1992.

This thesis presents an analytical study of Waves in relation to Lerdahl’s contemporaneous theoretical interests. It is not a complete analysis of Waves but will instead focus on ideas presented in both GTTM and “Tonal Pitch Space” as compositional and structural tools. This analysis will concern itself with motivic development, pitch organization, and structural boundaries. It will also include a detailed examination of Lerdahl’s alternative tonal language and his construction of unique hierarchical progressions. Because it is necessary for the reader to have a familiarity with Lerdahl’s theoretical ideas before such an analysis of Waves can be undertaken, GTTM and “Tonal Pitch Space” will be summarized below, stressing those concepts most essential to the analysis of Waves that follows.

The purpose of GTTM, according to its authors, is to “present a substantial fragment of a theory of classical Western tonal music … worked out with an eye toward an eventual theory of musical cognitive capacity.” Accordingly, Lerdahl and Jackendoff present a musical grammar consisting of generalizations that a listener is able to apply universally to any work in the tonal idiom. Lerdahl and Jackendoff model their theory along the lines of generative-linguistics theories, most notably that of Noam Chomsky.

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3 Because this thesis examines the impact of Lerdahl’s theories on Waves, special attention is given to his theoretical research written prior to or during the year 1988, the year Waves was finished. Therefore, the article “Tonal Pitch Space” is utilized rather than the later book Tonal Pitch Space.
4 Lerdahl, Waves, on Points of Departure.
5 Lerdahl and Jackendoff, GTTM, 4.
This is not to say that their theory proposes musical representations of grammatical ideas, such as participles and articles (it does not), but rather that it adheres to the basic generative ideas present in linguistic theory. For example, Lerdahl and Jackendoff base their ideas on hierarchical considerations, that is, the notion that a person subconsciously organizes groups and/or events into dominant and subordinate elements.

Lerdahl distinguishes two types of large-scale listening hierarchies present in the musical universe. An event hierarchy is that which a listener infers from a musical surface. Much of music theory, including Schenkerian analysis and GTTM, has dealt with the systematization of event hierarchies. A tonal hierarchy, in contrast, is a “nontemporal mental schema that listeners utilize in assigning event hierarchies to pitch sequences.” The circle-of-fifths chart is a very simple tonal hierarchy. Tonal hierarchy is discussed in GTTM under the topic stability conditions. “Tonal Pitch Space,” reviewed more fully later in this thesis, develops a pitch-space model to represent tonal hierarchy.

Hierarchy, as defined most generally in GTTM, is “an organization composed of discrete elements or regions related in such a way that one element or region subsumes or contains other elements or regions.” Although Lerdahl and Jackendoff are quick to explain that not all events on a musical surface are hierarchical, they identify four specific categories that do involve hierarchical properties: grouping structure, metrical structure, time-span reduction, and prolongational reduction. Each of these four categories displays a series of rules governing their establishment and musical

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6 Lerdahl, “Tonal Pitch Space,” 316. These listening hierarchies were first defined and explored by Deutsch, “Two Issues Concerning Tonal Hierarchies,” and Bharucha, “Event Hierarchies, Tonal Hierarchies, and Assimilation.”
7 Ibid.
8 Lerdahl and Jackendoff, GTTM, 13.
9 Ibid., 8.
interpretation. There are two types of rules, “well-formedness rules, which specify the possible structural descriptions, and preference rules, which designate out of the possible structural descriptions those that correspond to experienced listeners’ hearings of any particular piece.”

The first category of hierarchical musical structure discussed in GTTM is grouping structure, which “expresses a hierarchical segmentation of the piece into motives, phrases, and sections.” Grouping structure is governed by two sets of rules: “Grouping well-formedness rules (GWFRs) establish the formal structure of grouping patterns and their relationship to the string of pitch-events that form a piece…. Grouping preference rules (GPRs) establish which of the formally possible structures that can be assigned to a piece correspond to the listener’s actual intuitions.”

Grouping well-formedness rules formally define the term group and explain what in music constitutes a group. A group, as defined in GTTM, is an event or series of events that occur contiguously within a piece. Groups are hierarchical in nature, meaning, among other things, that they occur on multiple structural levels within a piece. A piece is, in and of itself, a group and comprises smaller groups on various hierarchical levels. Group boundaries are defined by slurs, rests, or attack points, as well as changes in register, dynamics, articulation, and/or length. Larger level group boundaries may be designated by intensification of those events, as well as by large-scale symmetries and parallelisms across the musical surface. Groups on the same hierarchical level must be disjunct, except for two highly specific occurrences: group overlap and elision.

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10 Ibid., 9.
11 Ibid., 8.
12 Ibid., 36-37.
13 Ibid., 55-62.
Group overlap and elision both force the strict rules of grouping to be loosened. *GTTM* accommodates this loosening through transformational rules, which “apply certain distortions to the otherwise strictly hierarchical structures provided by the well-formedness rules.” Transformational rules are highly specific within each hierarchy; otherwise they might undermine the hierarchical controls laid out by the well-formedness rules. To keep the grouping transformational rules as specific as possible, Lerdahl and Jackendoff distinguish two formal steps to grouping structure: underlying grouping structure, which is strictly bound by grouping well-formedness rules, and surface grouping structure, which contains the observed overlap and elision. Grouping overlap, according to *GTTM*, occurs when “the underlying grouping structure resolves the overlapped event into two occurrences of the same event, one in each group.” In other words, a musical event ends one group and at the same time begins another group. This most often happens at cadences. Grouping elision, on the other hand, occurs when a musical event beginning or ending a group at the same time obscures or elides the beginning (left elision) or ending (right elision) of an adjacent group. Thus, “the underlying structure contains the event understood as being elided.”

The second category of hierarchical musical structure is metrical structure or that which “expresses the intuition that the events of the piece are related to a regular alternation of strong and weak beats at a number of hierarchical levels.” Before a review of metrical hierarchy can be undertaken, the concept of accent must be clarified. *GTTM* recognizes three types of accent: phenomenal, structural, and metrical.

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14 Ibid., 11.
15 Ibid., 60.
16 Ibid.
17 Ibid.
18 Ibid., 8.
Phenomenal accents emphasize events on the musical surface by attacks, sudden dynamic changes, etc. Structural accents are harmonically stable events, such as cadences. Metrical accents fall on the strong points within a metrical context.\textsuperscript{19}

The basic element of metrical structure is the \textit{beat}, a singular point in time. \textit{GTTM} denotes a beat as a dot. Beats recur in equal measures of time. The duration between consecutive beats is called a \textit{time-span}. The strength of each beat in relation to other surrounding beats creates various structural levels in the metrical hierarchy (see fig. 1.1). Structural levels are determined by the duration of each time-span. The number of levels on which a beat occurs differentiates stronger beats from weaker beats. It is this interaction of alternating strong and weak beats that produces meter. Since a beat is technically a hypothetical construct, any duration can be assigned to the time-span between beats, so long as the duration maintains regularity. There is however, a level that is specifically designated as the “perceptually prominent level of metrical structure.”\textsuperscript{20} This level is the \textit{tactus}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{metrical_hierarchy.png}
\caption{metrical hierarchy in a simple meter.}
\end{figure}

\textsuperscript{19} Ibid., 17.
\textsuperscript{20} Ibid., 71.
Figure 1.1 displays a binary alternation of weak beats and strong beats. Notice that the first beat is strongest per measure, followed by the third beat. Tactus designation determines the actual meter. For example, if the quarter note is designated as tactus, then the meter is a simple binary, with four eighth notes per measure. In contrast, if the eighth note were designated tactus, then the meter would be simple quadruple. Ternary meters are similar in structure, but feature one strong beat followed by two weak beats.

As with grouping, the prevailing aspects of metrical structure are governed by two sets of rules, metrical well-formedness rules (MWFRs) and metrical preference rules (MPRs). “The former define the set of possible metrical structures, and the latter model the criteria by which the listener chooses the most stable metrical structure for a given musical surface.” 21 For a metrical hierarchy to be well-formed, an attack point must be associated with a beat at even the smallest durational levels at that particular point in time. Likewise, “every beat at a given level must also be a beat at all smaller levels present at that point in the piece.” 22 Beats within the tactus and on all metrical levels larger than the tactus must occur at evenly spaced intervals, while beats smaller than the tactus must occur regularly between strong and weak beats. In classical tonal music, strong beats must be spaced either two or three beats apart.

Preferred stability of a well-formed meter in classical tonal music is governed by a set of metrical preference rules. MPRs are used to map metrical structures defined by the MWFRs to the musical surface. As with patterns in grouping, metrical patterns often give rise to parallelism. Just as pitch events take precedence over silence, stressed events take precedence over unstressed. Strong beats are preferred early within grouping.

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21 Ibid., 68.
22 Ibid., 72.
structures. The inception of a metrical structure is preferred at the beginning of a long pitch-event, dynamic duration, slur, or articulation pattern, or at the beginning of a pitch or harmony at its respective level of reduction. A metrically stable bass is preferred, meaning that the bass is much less likely than the upper voices to take part in syncopation or other local metric instabilities. A metrically stable cadence is also preferred. Cadential stability resolves the tonal and metric instabilities leading up to the cadence. Suspension figures should occur on strong beats. Metrical structures in which every other beat is strong are preferred, giving rise to an ideal binary structure (although smaller metrical levels may contain triple-beat patterns). Lastly, grouping overlap and elision often create a phenomenon known as metrical deletion, in which either a strong beat or a weak beat is missing from the musical surface.

There are many inherent similarities between grouping and meter; however, they are fundamentally different in conception. “Grouping structure consists of units organized hierarchically; metrical structure consists of beats organized hierarchically.” However, the two structures can and often do interact with one another. If a group begins on a strong beat, then the grouping and metrical structures are in phase. If a group begins on a weak beat, the structures are out of phase.

Neither grouping nor meter specifically deals with pitch and pitch organization. Pitch structure, according to GTTM, “is a powerful organizing force at global levels of musical structure.” The two remaining categories of musical hierarchy, time-span and prolongational reductions, both specifically address pitch relations in a piece. Before

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23 Levels of reduction will be discussed more thoroughly below.
24 Ibid., 25.
25 Ibid., 30.
these two event hierarchies can be explained, it is necessary to discuss the concept of reduction in general.

Reduction is hypothesized by the authors as occurring when “the listener attempts to organize all the pitch-events of a piece into a single coherent structure, such that they are heard in a hierarchy of relative importance.”\(^{26}\) Reduction occurs at all levels of music, from the most global to localized pitch prolongations such as passing or neighbor notes. *GTTM* elaborates a *Strong Reduction Hypothesis*, which adds two conditions to the hypothesis given above. The first is that “pitch-events are heard in a strict hierarchy,”\(^{27}\) and the second is that “structurally less important events are not heard simply as insertions, but in a specified relationship to surrounding more important events.”\(^{28}\) Structurally important events are those that are heard on multiple levels of reduction. The larger the number of reductive levels on which an event occurs, the more important the event is structurally. Less important structural events do not float freely in time but always attach to a more important event to preserve hierarchy. Also, the structural importance of events may or may not correspond to their surface salience, as the hierarchies presented in *GTTM* are designed to capture other, more basic aspects of musical intuition.

The mind discerns which events are most structurally important through a process of *time-span reduction*. According to *GTTM*, “*time-span reduction* assigns to the pitches of the piece a hierarchy of ‘structural importance’ with respect to their position in

\(^{26}\) Ibid., 106.
\(^{27}\) Ibid.
\(^{28}\) Ibid.
This assignment is realized through a tree diagram, similar to a linguistic tree.

Lerdahl and Jackendoff employ tree notation not because of musical grammar’s similarity to linguistic grammar but as a matter of convenience. As was mentioned earlier, they assert no musical equivalents to linguistic syntactic ideas. Rather, tree diagrams are employed to reveal that “the fundamental hierarchical relationship among pitch-events is that of one pitch-event being an elaboration of another pitch event; the latter is the structurally more important event of the two.”

Tree diagrams are used in both time-span reduction and prolongational reduction, though each shows a different aspect of musical coherence.

Figure 1.2 shows an illustration of the strict branching called for in GTTM. As with grouping and meter, reductions, and thus reductive trees, must also meet the conditions of strict hierarchical structure. “Thus the trees must satisfy the requirements of nonoverlapping, adjacency, and recursion.” Branches may not cross, nor can they be assigned to more than one event, and all events must be assigned a branch.

In reading the tree shown in figure 1.2, event e₂ is subordinate to the prior event e₁. This is known as right-branching. Likewise, e₃ is subordinate to the event following it, e₄. This is known as left-branching. At a higher reductive level, events e₂ and e₃ are reduced out, and, as can be seen by the larger right-branching, e₄ is subordinate to e₁.

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29 Ibid., 8.
31 Ibid., 113.
32 Ibid., 113-14.
As with grouping and meter, the rules governing time-span reduction are divided into two sets, *time-span reduction well-formedness rules* (TSRWFRs) and *time-span reduction preference rules* (TSRPRs). The TSRWFRs convey that in every musical work, there is a hierarchy of time-spans progressing from single events to the entire composition. However, before assigning structural significance to any pitch or group of pitches through time-span reduction, *time-span segmentation* must be carried out. Time-span segmentation combines the metrical and grouping structures to “offer a principled way of segmenting a piece into domains of elaboration at every level—a hierarchy of *time-spans.*” The well-formedness rules also assert that “for each time-span … a single event is chosen as the most important event.” This event, which is known as a *head,* corresponds to the event that is most stable within the time-span. If a time-span contains only a single event, then that event is the head. If a cadence is immediately subordinate to the head, then the final of the cadence is subordinate to the head; the penult is subordinate to the final.

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33 Lerdahl, *Tonal Pitch Space,* 11.
34 Lerdahl and Jackendoff, *GTTM,* 119.
35 Ibid., 120.
The TSRWFRs acknowledge that all time-spans have a seminal event, the head, and the process of choosing that head is governed by the TSRPRs with respect to three categories of subrules: local rules, nonlocal rules, and structural-accent rules. Local details such as metrical position, harmonies, and registral extremes influence the choice of head in each time-span. Nonlocal events such as parallelism, metrical stability, and prolongational stability also influence the choice of a head, though, because of their interaction with local events and other nonlocal events, the authors do not consider a rigorous systemization of nonlocal rules to be feasible.\(^{36}\) Lastly, structural accents, that is, structural beginnings and cadences, strongly influence the choice of a head at larger and global levels. Structural accents are relevant at the reductive levels that the authors name \textit{cadenced groups}, or groups that reduce down to the two accent events just mentioned. The authors also emphasize that of those two structural accents, the motion to the cadence is structurally most important. Therefore, the final cadence of a tonal work is its structural goal.\(^{37}\)

As mentioned above, the time-span head is “a single event chosen from among the events in that time-span.”\(^{38}\) This process is known as \textit{ordinary reduction}. Three other situations exist in which atypical heads may appear. These atypical heads are the result of the processes of fusion, transformation, or cadential retention. The former two processes are heard only at very local levels. Fusion is the merging of a series of events (not to exceed a single group) into a single head. Transformation is a much rarer process in which actual events of a musical surface are subordinate to an understood but not realized head. Cadential retention states that the multiple events of a cadence (e.g., V→I) are of

\(^{36}\) Ibid., 163.  
\(^{37}\) Ibid., 174.  
\(^{38}\) Ibid., 153.
equal importance as a head. Therefore other subordinate events may be attached to the cadence as a whole.\textsuperscript{39}

Prolongational reduction is influenced by, but independent of, time-span reduction. Like time-span reduction, prolongational reduction is a strictly hierarchical form of segmentation, thus conforming to the Strong Reduction Hypothesis.

“\textit{Prolongational reduction} assigns to the pitches a hierarchy that expresses harmonic and melodic tension and relaxation, continuity and progression.”\textsuperscript{40} The idea of tension and relaxation, which the authors describe loosely as “the incessant breathing in and out of music in response to the juxtaposition of pitch and rhythmic factors,”\textsuperscript{41} is central to prolongational reduction. Prolongational reduction, therefore, weighs the stability of pitches in relation to a tonal center and maps the motion to and away from that tonic.

Before establishing a formal set of rules governing the process of prolongational reduction, the factors regulating the stability of prolongational events must be discussed. Rhythm is one of the most important determinants of prolongational stability.

“Specifically, rhythmically unimportant events are heard as prolongationally relatively unimportant, and structural accents are heard as prolongationally relatively important, regardless of absolute criteria of pitch stability.”\textsuperscript{42} To take this assertion one step further, because time-span reduction takes rhythmic factors and structural accent into consideration, it “thus becomes a governing factor in determining … prolongational importance.”\textsuperscript{43} That these reductions work so closely together is vital to a central claim of \textit{GTTM}, namely the idea that “the perceived patterns of tension and relaxation in pitch

\textsuperscript{39} Ibid., 153-59.
\textsuperscript{40} Ibid., 8-9.
\textsuperscript{41} Ibid., 179.
\textsuperscript{42} Ibid., 187.
\textsuperscript{43} Ibid.
structure depend crucially on the hierarchy of structurally important events within time-spans as defined by meter and grouping.  

Like time-span reduction, prolongational reduction is represented using tree diagrams, which are governed by the same rules of strict branching (no crossing and no free-floating branches or events) discussed above. Unlike time-span reduction, however, prolongational reduction involves three different types of branches, representing strong prolongation, weak prolongation, and progression (fig. 1.3). These three branch types are defined by the *prolongational reduction well-formedness rules* (PRWFRs). The right-branching trees in the figure (figs. 1.3 a-c) represent an overall tensing of the music. The left-branching trees in the bottom half of the figure (figs. 1.3 d-f) show a relaxing of the music. In a strong prolongation (a, d), event $e_2$ is an exact repetition of $e_1$. There is very little, if any, increase or decrease in tension in a strong prolongation. In a weak prolongation (b, e), $e_2$ contains the same root as $e_1$, but is either in a less-consonant position (right-branching) or more-consonant position (left-branching). Consonant position of a triad relates to inversion or a less-stable melodic note. Weak prolongation creates a noticeable increase or decrease in musical tension. In a progression (c, f), the harmonic root of event $e_2$ is different than that of $e_1$ ($I \rightarrow V$ would be right-branching, $V \rightarrow I$ would be left-branching). Progression gives the listener the strongest sense of increasing tension or resolution. While these six types of branches are not exhaustive, (for example, multiple progressive branches could be established) they are adequate in complexity for the purposes of diagramming prolongational reduction.

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44 Ibid., 188.
45 Ibid., 181-84.
Because the context of a local pitch event is dependent on large-scale pitch motion, prolongational reduction must be realized from global to local levels. Figure 1.4 gives what Lerdahl and Jackendoff call the *basic form* in both time-span reduction (fig. 1.4a) and prolongational reduction (fig. 1.4b). Though the two reductive trees seem very similar, they have very different interpretations. “[1.4a] expresses the arc of tonal motion from the piece’s structural beginning to its cadence; [1.4b] says first that the piece forms a relaxing prolongation of the tonic and second that the opening I tenses into the V, which in turn relaxes–more strongly than the previous tensing–into the final I.” Thus, while the two forms of reduction are realized through similar tree diagrams, they do not illustrate the same hierarchical concepts.

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46 Lerdahl and Jackendoff, *GTTM*, 182.
47 The basic form corresponds to the *Ursatz* of Schenkerian analysis.
48 Lerdahl and Jackendoff, *GTTM*, 189.
The prolongational basic form in figure 1.4b denotes a prolongational region. A prolongational region is demarcated by the selection of two events, a prolongational head and a prolongationally most important event. Lerdahl and Jackendoff link the prolongational head to the time-span-reduction head. They assert that “the point of maximal prolongational stability—the point of greatest relaxation—is that point in the piece that most strongly articulates the end of the largest group,” though as with time-span reduction, this may not necessarily be the very end of a piece (coda sections are less important than the final cadence that they follow) or even the final cadence (certain songs or slow movements may contain a nontonic cadence heralding the next movement).

With the selection of a prolongational head, a prolongationally most important event, secondary to only the head, is determined. All subordinate events within the region will in turn attach to either the head or the prolongationally most important event. This branching of subordinate events represents “an overall tensing or relaxing in the progression from its beginning to its end.” All subordinate branches to the

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49 Ibid.
50 Ibid., 216.
51 Ibid., 211.
prolongationally most important event are elaborations of it. There are two types of elaboration within a prolongational region: *direct elaboration*, in which an event’s branch is terminated by a structurally more prominent branch, and *recursive elaboration*, in which an event is attached to a branch through direct elaboration or through a series of elaborations. In other words, if event $e_1$ is the prolongationally most important event of a region and $e_2$ attaches to that event, then $e_2$ is a direct elaboration of $e_1$. If $e_3$ attaches to $e_2$, which in turn attaches to $e_1$, both $e_2$ and $e_3$ are recursive elaborations of $e_1$. Thus any event that elaborates the prolongationally most important event recursively elaborates the prolongational head as well.

The *prolongational reduction preference rules* systematize the selection of the prolongationally most important event and the attachment of subordinate events within a region. Time-span reduction plays an important role in the selection of event importance. A relatively important event or the head of a time-span is preferred as the most important event of a prolongational region. A prolongationally most important event should also be chosen “so as to form a maximally stable prolongational connection with one of the endpoints of the region.”

Also, the attachment of subordinate prolongational events to the head is preferably contained within a single time-span and, as in time-span reduction, parallel prolongational regions should receive parallel analytical treatment.

Specific patterns of tension and relaxation in cadenced groups result from the influence of time-span reduction on prolongational reduction. Normative prolongational structure, given in figure 1.5 as mapped onto the basic form, is the preferred reduction of those specific patterns and represents the minimum branching of most cadenced groups in tonal music. Notice that both figures include an opening tonic and a closing tonic related

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52 Ibid., 224.
by weak prolongation. A dominant attaches to the final tonic. A subdominant precedes
the closing cadence and is attached to the dominant. The only difference between the two
figures lies in the opening progression away from tonic. Figure 1.5a has a progression
away from tonic, while 1.5b, the basic progression of classical-era music, has both a
progression away from tonic and a strong prolongational return.

Figure 1.5. Normative prolongational structure combined with the basic form.\textsuperscript{53}

As has been heavily emphasized, the four musical hierarchies—grouping, meter,
time-span, and prolongational reductions—can and do interact with one another to convey
a complex and highly structured model of the organization of a piece. Figure 1.6
illustrates the generative theory as a whole.\textsuperscript{54} Notice that it only through the
understanding both of all sets of rules and of how the hierarchical types governed by
those rules interact with one another that a preferred analysis of a piece of music can be
achieved. Thus the theory “asserts that the perceived patterns of tension and relaxation in

\textsuperscript{53} Ibid., 199.
\textsuperscript{54} Ibid., 10. In this schematic, rectangles stand for sets of rules, while the ellipses stand for the inputs and
outputs governed by those rules.
Figure 1.6. The generative theory of tonal music.
pitch structure depend crucially on the hierarchy of structurally important events within time spans as determined by meter and grouping.\textsuperscript{55}

Underlying the four categories of musical hierarchies and the very idea of a generative grammar are what Lerdahl and Jackendoff call \textit{stability conditions}. Stability conditions are a series of idiom-specific constants from which a set of generative rules are developed. In \textit{GTTM}, Lerdahl and Jackendoff identify two important controls governing tonal music. The first is “the classical Western tonal pitch system—the major-minor scale system, the traditional classifications of consonance and dissonance, the triadic harmonic system with its roots and inversions, the circle-of-fifths system, and the principles of good voice-leading.”\textsuperscript{56} The second is “a scale of stability among pitch configurations, derived from the raw material of the given tonal system.”\textsuperscript{57} Specifically, stability conditions refer to the tension-relaxation principles of consonance and dissonance determining prolongational structure and the weights of pitches within the diatonic or other pitch system. Stability conditions are synonymous with the tonal hierarchy discussed earlier. Though they are fundamentally important to the discussion of tonal music, the authors of \textit{GTTM} largely forego their formalization, leaving that for future study.

Lerdahl’s article “Tonal Pitch Space” addresses the stability conditions left out of \textit{GTTM}, codifying those specific to classical Western tonal music. Lerdahl creates a model of tonal hierarchy in which multiple layers or spaces (or \textit{alphabets}, as Deutsch and Feroe

\textsuperscript{55} Ibid., 188.
\textsuperscript{56} Ibid., 117.
\textsuperscript{57} Ibid.
call them)\textsuperscript{58} are present (see fig. 1.7). These spaces of tonal hierarchy are those learned by the listener from previously heard musical surfaces.

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Figure 1.7. The basic space (oriented I/I).

The pitch-space model shown in figure 1.7 represents stability both horizontally and vertically. Pitch-class (pc) proximity, or the distance between pcs, is calculated horizontally. A horizontal step from 0 to 4 on level c would consist of a step distance of 1, while on level e the same interval would be considered a step distance of 4. There are five vertical levels of pitch space embedded within the basic space, though more levels may be added depending on the idiom of music being analyzed. “Level a is octave space, b ‘open-fifth’ space, c triadic space, d diatonic space, and e chromatic space.”\textsuperscript{59} “The vertical dimension gives the depth of embedding of a pc, counting the number of levels down that a pc first appears.”\textsuperscript{60} The higher the level (level a being the highest), the more stable the pitch. In figure 1.7, pc 0 occurs on all five vertical levels, making it the most stable pc.

The pitch space shown in figure 1.7 is labeled by its horizontal orientation on the chordal and regional spaces. Level c contains the pitches [047], or a C-major triad. Level d comprises a diatonic C-major scale [024579B]. Therefore, chordal space in figure 1.7 is

\textsuperscript{58} Deutsch and Feroe, “Internal Representation of Pitch Sequences,” 503-22.
\textsuperscript{59} Lerdahl, “Tonal Pitch Space,” 320.
\textsuperscript{60} Ibid., 321.
oriented on the tonic triad, while regional space is oriented on the tonic scale. Tonic
chordal space is represented as roman-numeral I, while regional space is represented by a
bold-faced I. Thus, the orientation of figure 1.7 would be I/I, or the tonic chord of the C-
major scale. Motion away from the tonic of either the chordal or regional spaces changes
the orientation of the pitch space and thus changes its roman-numeral label.

Chord proximity is also shown by the pitch-space model. “Chords are represented
at level c in the space, with level b outlining the fifth in the chord and level a supplying
the root.” Thus, if one wanted to project the beginning of a circle-of-fifths progression,
for example, V/I (here a G-major triad in the key of C major), then levels d and e would
remain the same (because the chromatic and diatonic spaces would remain unchanged),
while levels a, b, and c would shift four steps to the right with respect to level d to orient
themselves onto the dominant triad in the key, or 7B2 (fig. 1.8).

| level a: | 7 |
| level b: | 2 |
| level c: | 2 |
| level d: | 0 | 2 | 4 | 5 | 7 | 9 | B |
| level e: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B |

Figure 1.8. The basic space reoriented V/I.

If one continued to shift levels a-c four steps to the right on level d, then one
would reach ii/I [259], then vi/I [904], and eventually cycle through the entire diatonic
circle of fifths. As this shift would represent stepwise motion on level b, chordal motion
by fifth could be said to span a step distance of 1 at this level. Therefore chordal motion
from ii/I to vi/I would be considered a step, while motion from I/I to ii/I would be

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61 Ibid., 322.
considered a skip on level \( b \). This diatonic motion around the circle-of-fifths is coupled with diatonic motion by thirds (to represent maximum common tones between chords) to determine proximity between two chords within a region.\(^{62}\)

Chord proximity is most accurately represented by a chordal torus or chordal space (fig. 1.9). Chords that share two common tones will appear side-by-side horizontally; while two chords adjacent on the circle-of-fifths region (and sharing a single common tone) will appear vertically. Adjacency between chords on the torus represents distance between chords on some pitch-space level (with horizontal motion on the torus representing the smallest distance). Diagonal motion on the chordal torus represents diatonic stepwise motion between chordal roots. This motion is considered the most distant because of the lack of any common tones between those chords.

\[
\begin{array}{ccccccc}
\text{vii}^r & \text{ii} & \text{IV} & \text{vi} & \text{I} & \text{iii} & \text{V} \\
\text{iii} & \text{V} & \text{vii}^r & \text{ii} & \text{IV} & \text{vi} & \text{I} \\
\text{vi} & \text{I} & \text{iii} & \text{V} & \text{vii}^r & \text{ii} & \text{IV} \\
\text{ii} & \text{IV} & \text{vi} & \text{I} & \text{iii} & \text{V} & \text{vii}^r \\
\text{V} & \text{vii}^r & \text{ii} & \text{IV} & \text{vi} & \text{I} & \text{iii} \\
\text{I} & \text{iii} & \text{V} & \text{vii}^r & \text{ii} & \text{IV} & \text{vi} \\
\text{IV} & \text{vi} & \text{I} & \text{iii} & \text{V} & \text{vii}^r & \text{ii}
\end{array}
\]

Figure 1.9. The chordal torus.\(^{63}\)

Regional proximity is calculated through shifts on the pitch-space model in much the same way as chord proximity. The only difference is that levels \( a-d \) now move along level \( e \). For example, a shift from the C diatonic space to the G diatonic space would

\(^{62}\) Ibid.  
\(^{63}\) Ibid., 326.
move seven steps along level $e$. This would orient the tonic of the space on G major rather than C major (fig. 1.10).

| level $a$: | 2 | 7 |
| level $b$: | 2 | 7 |
| level $c$: | 2 | 7 | B |
| level $d$: | 0 | 2 | 4 | 6 | 7 | 9 | B |
| level $e$: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B |

Figure 1.10. G diatonic pitch space (I/V).

The theories presented above combine to form a generative grammar of tonal music. Here, the word *generative* refers not to a set of rules and guidelines used in the compositional process, but rather it is used in a mathematical sense, referring to the description of “a (usually infinite) set by finite formal means.” The authors also point out that the goal of generative analysis is not to discover what results may possibly be spawned by the presented rules but to give a structural description of any type of tonal work that may exist. However, the authors do not deny the possibility of a set of formal rules paralleling their own that might be used for the purpose of musical composition. “This is not to preclude the possibility that a sophisticated alternative approach of constructing computational rules to ‘compose’ pieces might not also be valuable. It is conceivable that such an enterprise could dovetail with our theoretical paradigm.” In the following chapters, this thesis will begin to show how the grammar established by these theoretical works becomes an important tool in Lerdahl’s own compositional process.

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64 Lerdahl and Jackendoff, *GTTM*, 6.
65 Ibid., 112.
CHAPTER 2. LERDAHL’S MUSICAL AESTHETIC: THE SYNTHESIS OF MUSICAL COMPOSITION AND THEORY

The first chapter of this thesis provided an overview of Fred Lerdahl’s theories of tonal music. The second chapter will begin to show how Lerdahl’s theories are reflected in his compositional process. This chapter will not deal specifically with the work *Waves*, yet it will show how both Lerdahl’s compositional ideology and his views on contemporary music gave rise to the formal and structural procedures that are key to an analysis of *Waves*.

The desire to link theory and composition is the driving force behind Lerdahl’s compositional process, as he himself has indicated: “Although the theoretical work [*GTTM*] took on a life of its own, I never lost my initial motivation of pursuing theory for the purposes of composition. The influence, in fact, went both ways. Not only did theoretical ideas find an adapted place in my music, but my musical imagination and creative needs also suggested theoretical ideas, sometimes well in advance of anything I was able to state systematically. This interaction between composition and theory has persisted to the present day.”¹ To Lerdahl, this marriage of composition and music theory is much different than using a mathematical process to order structure, rhythm, or pitch, such as in serialism or algorithmic composition. While Lerdahl himself has said, “I have always been attracted to systematic approaches to composition,” he has also indicated that “I wished to base my composing not on hidden codes”² and that “I compose

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¹ Lerdahl, “Composing Notes,” 244.
² Ibid., 243.
intuitively like everyone else.”\textsuperscript{3} The systematic approaches cited by Lerdahl are concerned with the synthesis of hierarchical processes by the cognitive mind, as codified in his theoretical research. The influence of this research on Lerdahl’s compositional output can be related to another important focus of his compositional ideology: the listening grammar. The listening grammar is the mental process of a listener’s mind as he or she breaks down music into the hierarchical groups of \textit{GTTM}.\textsuperscript{4} Lerdahl’s chief interest lies in how the music listener perceives classical tonal music versus contemporary music through use of the listening grammar. The eleventh chapter of \textit{GTTM} deals specifically with the listening grammar and its relationship to both music in general and contemporary music specifically.

Important to the understanding of how the listener breaks down both contemporary and classical music, as well as other idioms, is the concept of \textit{musical universal}. A musical universal is not necessarily a rule that applies to all musical idioms but rather a grammatical principle through which an experienced listener organizes the music he or she hears, regardless of idiom.\textsuperscript{5} Lerdahl and Jackendoff discuss which of the rules of their generative music theory could be universals. A rule may be considered universal “if it applies in the same way in every idiom that employs the distinctions to which the rule is sensitive.”\textsuperscript{6} However, a rule may not be applicable within a particular idiom because “the stylistic norms of the idiom simply do not give the rule opportunities to apply.”\textsuperscript{7} Thus, not all rules presented in \textit{GTTM} are musical universals, as some refer only to the idiom of classical Western tonal music. Furthermore, it is possible that there

\textsuperscript{3} Basart, “Expanding Variations,” 7.
\textsuperscript{5} Lerdahl and Jackendoff, \textit{GTTM}, 278.
\textsuperscript{6} Ibid.
\textsuperscript{7} Ibid., 278-79.
are idiom-specific rules not covered in *GTTM* that would incorporate those processes utilized when listening to other musical idioms. A number of hypotheses expressed by the rules of *GTTM*, those that the authors believe to be universal, are quoted in appendix A of this thesis (p. 85).

The codification of musical universals is important to understanding how the mind perceives music. Musical universals are “crucial to the question of the innateness of musical cognitive capacity.”

Musical innateness separates that which the listener learns from that which is “given by the inherent organization of the mind, itself determined by the human genetic inheritance.” This differentiation sheds light not only on how the listener understands and learns music but also on the cognitive similarities of all human beings, transcending cultural and historical conventions. Knowledge of learned conventions (i.e., idiom-specific rules) gives “an indication of the limitations of human musical cognition—the possibilities for structuring the musical surface available to someone learning an idiom.”

Lerdahl and Jackendoff attempt, largely unsuccessfully, to develop a theory of perception of twentieth-century art music in accordance with both the musical universals and the grammar system of *GTTM*. The authors begin by offering a generalization about contemporary music: “Even where there is a tonal center, much contemporary music does not offer a coherent measure of relative pitch stability; much of it denies a tonal center altogether. Moreover, a regular metrical hierarchy is often not conveyed, even if the music is notated in traditional terms. Through extreme motivic ‘transformations’ or even the avoidance of motivic content, much of this music withholds evidence for structural

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8 Ibid., 281.
9 Ibid.
10 Ibid., 282.
parallelism that would lead to any rich hierarchy of grouping structure. At bottom, all of these trends are manifestations of a tendency to avoid repetition.”¹¹ Contemporary music that is designed to avoid repetition lacks the organization necessary for those preference rules dealing with aspects such as symmetry, parallelism, tonal centricity, etc.¹² Without these preference rules, global structure in all hierarchies becomes indistinct, eliminating the possibility of strong reductions. Indistinct grouping organization in turn makes metric organization irregular, which weakens the time-span segmentation and, ultimately, the time-span and prolongational reductions. Rather than relying on pitch hierarchy for the purposes of tension and relaxation, contemporary music relies on salient events (local rhythmic, dynamic, and timbral emphases). Thus, in regards to the listening grammar, the authors state: “In sum, to the degree that the applicability of these various aspects of musical grammar is attenuated, the listener will infer less hierarchical structure from the musical surface.”¹³ Therefore, when exposed to contemporary music, the listener must rely on the innate musical universals, trying to fit the surface of the music into structures described by those principles.¹⁴

In his 1988 article, “Cognitive Constraints on Compositional Systems,” Lerdahl continues to investigate how a listener interprets contemporary music. Illustrating his discussion, a hypothetical listener has trouble discerning structure and pitch organization in a serial composition, Le marteau sans maître (1954), by Pierre Boulez. Lerdahl attributes this difficulty to many of the same reasons stated in GTTM (lack of repetition, lack of pitch centricity, etc.). Lerdahl refutes the claim that his listener is unaccustomed

¹¹ Ibid., 296-97.
¹² Ibid., 297.
¹³ Ibid., 298.
¹⁴ Ibid., 299.
to innovation—even after many hearings, the listener is still unable to grasp basic concepts about the work. In other words, the listener cannot comprehend the musical structure.

“Comprehension,” according to Lerdahl, “takes place when the perceiver is able to assign a precise mental representation to what is perceived.”\(^\text{15}\) Listeners do not necessarily find contemporary compositions such as *Le marteau* incomprehensible; however, they do not assign a detailed mental representation to it either.\(^\text{16}\)

![Figure 2.1. Two musical grammars.\(^\text{17}\)](image)

Lerdahl returns to the concept of a musical grammar, “a limited set of rules that can generate indefinitely large sets of musical events and/or their structural descriptions,”\(^\text{18}\) to better understand both the composer’s and listener’s place in Western musical society. The composer and the listener have different musical grammars, as shown in figure 2.1. In the compositional grammar (fig. 2.1a), one set of rules generates both the sequence of events and the compositional specifications within the music (input

\(^\text{15}\) Lerdahl, “Cognitive Constraints,” 232.
\(^\text{16}\) Ibid.
\(^\text{17}\) Ibid., 233.
\(^\text{18}\) Ibid.
organization). The listener’s grammar (2.1b) is a scaled-down version of that given in GTTM (fig. 1.6, p. 19). When the two grammars are combined, an overall musical grammar is created (fig. 2.2). The biggest problem with Le marteau and contemporary music in general, Lerdahl contends, is that composers do not attempt to link any components of the listening grammar back to compositional grammar (the dashed arrow of fig. 2.2). Without such a link, “the ‘input organization’ will bear no relation to the ‘heard structure.’ Here, then, lies the gap between compositional system and cognized result.”

Lerdahl distinguishes two types of compositional grammars, natural and artificial. “A natural grammar arises spontaneously in a musical culture. An artificial grammar is the conscious invention of an individual or group within a culture.”

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19 The input organization for Le marteau would be its serial procedures.
21 Ibid., 236.
22 Ibid., 235. Lerdahl cites Fux’s species-counterpoint rules as a prime example of an artificial grammar. This artificial grammar arose from the natural grammars expressed in the developments of composition at that time. Lerdahl also includes serialism as well as neoclassicism among artificial grammars: serialism is an example of a numerically based artificial grammar, while neoclassicism has a historical basis.
artificial grammars may arise from a variety of idiosyncratic sources. “The trouble starts only when the artificial grammar loses touch with the listening grammar.”

Lerdahl has noticed a trend among young composers to rid themselves of compositional grammars entirely, relying only on the intuitive ear or reverting to styles of the past. Both of these approaches are “motivated by the desire to avoid the gap between composing procedure and what is heard.” Lerdahl’s reaction, on the other hand, “has been less to avoid than confront this gap.” To address this disconnect between the listening and compositional grammars, Lerdahl has constrained his own composing with four basic assumptions: “(1) a compositional grammar is necessary; (2) it need not be nostalgic; (3) our musical culture is too fragmented and self-conscious for a natural grammar to emerge; but (4) an artificial grammar unresponsive to musical listening is unacceptable.” In order for a compositional grammar to reflect the listening grammar, the listening grammar first needed to be understood. Therefore, a theory of musical cognition had to be developed. GTTM was the result. “Such a theory, I reasoned, could provide the basis for artificial compositional grammars that could be intellectually complex yet spontaneously accessible to mental representation.” This theory, in essence, could be the arrow connecting listening grammar to compositional grammar.

To directly link the listening grammar to the compositional grammar (and thus fulfill his own four compositional assumptions above), Lerdahl presents and explains a set of cognitive constraints. A full list of the cognitive constraints is given as appendix B.

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23 Ibid. This is what Lerdahl has referred to as composing by hidden codes.
24 Ibid., 236.
25 Ibid.
26 Ibid.
27 Ibid.
28 Ibid., 236-37.
(pp. 86-7). The cognitive constraints group together in various ways, depending upon and reinforcing one another. Lerdahl proposes two main categories of constraints: 1-8 (constraints on event sequences) and 9-17 (constraints on underlying materials).

The first eight constraints regulate event hierarchies, or more specifically, the hierarchies discussed in *GTTM*. The first two constraints define the requirements for hierarchy and reduction. Constraint 1 calls for a musical surface to be broken down into a series of separate regions or events. Without such a parsing, the hierarchy necessary under constraint 2 would be impossible. Constraints 3-8 call for the establishment of event hierarchies in music through use of grouping, metrical, time-span, and prolongational hierarchies.

Constraints 9-17 can be thought of as constraints that form the foundation for tonal hierarchy or stability conditions in music. It is through these constraints that Lerdahl first developed the concepts later expanded in “Tonal Pitch Space.” For example, constraints 9, 10, and 11 call for a fixed collection of pitches that are organized into a scale that recurs at the octave. Specifications for the intervallic content of the scale are addressed in constraint 12. The remaining constraints, 13-17, may be accepted or rejected depending upon musical medium. These constraints address the concept of pitch space and put forth guidelines regulating pitch-space models.

These cognitive constraints reflect a deeply thought-out compositional aesthetic that has had a profound impact on all of Lerdahl’s music, including *Waves*. Lerdahl summarizes the results of his research on constraints into two aesthetic claims. While

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29 Lerdahl, “Tonal Pitch Space,” 251. These constraints are not any less important than the others; thus rejection of these last constraints will significantly decrease the cognitive coherence of the music.
inherently controversial, they provide valuable insight into Lerdahl’s compositional ideology.

**Aesthetic Claim 1:** The best music utilizes the full potential of our cognitive resources.\(^{30}\)

**Aesthetic Claim 2:** The best music arises from an alliance of a compositional grammar with the listening grammar.\(^{31}\)

The significance of these aesthetic claims to Lerdahl’s music, and the source of their inherent controversy, lies in the notion of musical complexity, which is contrasted with complicatedness. “A musical surface is complicated if it has numerous non-redundant events per unit time. Complexity refers not to musical surfaces but to the richness of the structures inferred from surfaces and to the richness of their (unconscious) derivation by the listener.”\(^{32}\) Music that follows all of the constraints listed by Lerdahl, including adherence to event hierarchies and a pitch-space model, achieves complexity and therefore is cognitively transparent. On avant-garde contemporary music, Lerdahl has this to say: “Much contemporary music pursues complicatedness as compensation for a lack of complexity.”\(^{33}\) Thus the music is opaque to most listeners.

Lerdahl’s views on contemporary music and his research into tonal music both directly shape his compositional process. As for specific aspects of Lerdahl’s theories incorporated into his compositions, the composer has stated: “GTTM’s theory of grouping and meter has been a constant resource, as has the theory of scales described in TPS. I have simulated timbral hierarchies (Lerdahl 1987) in orchestral settings and have often used TPS’s fundamental construct, the ‘basic space,’ in both its diatonic and various

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\(^{30}\) Ibid., 255.

\(^{31}\) Ibid., 256.

\(^{32}\) Ibid., 255.

\(^{33}\) Ibid., 256.
Lerdahl believes that these elements from his own theories form a "collection of related procedures that share a cognitive perspective," and that this perspective creates "an underlying unity and trajectory."

An important formal procedure derived from Lerdahl’s theoretical models is expanding variations. Expanding-variations procedure is Lerdahl’s answer to the cognitive gap created by contemporary music’s avoidance of both repetition and structural parallelism. This interest is conveyed specifically by constraint 4, which is as follows:

**Constraint 4:** Projection of groups, especially at larger levels, depends on symmetry and on the establishment of musical parallelisms.

Symmetry and parallelism are important to the projection of groups because “at global levels parallelism becomes the overriding grouping principle: listeners try to hear parallel passages in parallel places in the overall structure.” The expanding variations contain liberal amounts of both symmetry and parallelism, making the technique a “hearable process.”

Expanding-variations procedure involves a very short, basic idea, which is then developed through a series of increasingly longer variations. Lerdahl explains the technique as follows: “The idea was to begin with a single, stable event and elaborate it progressively into a few events, then more events, and eventually many events covering many minutes. As the events were elaborated, the complex would gradually become highly unstable. The materials would not be the standard tonal ones, but materials of my

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35 Ibid., 248.
36 Ibid.
38 Ibid.
Each variation draws upon the preceding variation for its material, and the successive variations grow larger and larger. Lerdahl’s first work utilizing expanding variations, First String Quartet (1978), expands each variation to “approximately three-halves the length of the previous one.” Thus, while the first variation of the First String Quartet is three half-notes long, the last (15th) variation is 307.5 half-notes long.

The idea for expanding variations developed out of the many analytical reductions used in GTTM. Lerdahl states: “While working with Jackendoff I did many reductive analyses of tonal pieces, some of which appeared in GTTM, in order to test and refine the rules that we were formulating. This activity led to the notion of composing by ‘expanding variations,’ which constituted a kind of reduction in reverse, spread over time.” The structure of the expanding variations is “analogous to that of a tree with branches and leaves, or of wedges going out on many levels.” This branching is similar in nature to the time-span and prolongational reductions in GTTM.

Expanding-variations procedure allows a large amount of freedom in its musical content; yet certain procedural consistencies do exist. Many of these consistencies were documented by Eileen Soskin in her 1986 dissertation, which looks specifically at the development of cadential structure of the First String Quartet. Soskin calls each motivic idea to be expanded a cell. Some of these cells are single homophonic sonorities; others are contrapuntal in nature. These cells are elaborated through interpolation or trope.

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40 Lerdahl, “Composing Notes,” 244.
41 Lerdahl, First String Quartet, score notes.
42 Lerdahl, “Composing Notes,” 244.
development, which is defined as “the expansion of a musical idea through the insertion of new material between portions of old material.”

The idea of a cell or short series of cells as the germinating seed of the expanding variations is vitally important to the technique. This gives the listener the ability to hear the compositional process of the work as it unfolds. However, to fully understand the technique, it is important to know how Lerdahl creates and organizes cells. Figure 2.3, shown in a prolongational reduction format, illustrates the expansion process of the first four variations of the First String Quartet. Each progressive relationship is represented by slur. Variation 1 presents a completely stable sonority. The first vertical pitch structure of the second variation also represents a stable sonority, though it is less stable than that of the first variation due to the D in the upper voice, creating a weak prolongation. In the third variation, a dissonant tetrachord is added, the fusion of the upper and lower chromatic neighbors of the sonority of variation 1. Lerdahl considers this a highly unstable sonority. As can be seen from the labeling of the fourth variation, this leading-tone sonority becomes a dominant construct in a progression. The fourth variation also adds another dissonant structure, this one further removed from the tonic, yet related to the leading-tone sonority by whole step. Lerdahl considers it a subdominant structure.

Each of these sonorities can also be thought of as a cell to be developed further in future variations and eventually expanded into various sections making up the larger variations. Each cell becomes the tonic of its own section, resulting in large-scale prolongations, which are in turn able to be interpreted through large-scale prolongational

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46 Ibid., 47, 59-60.
47 For a more in-depth exploration of the creation of these progressions, see chapter 4 of this thesis.
48 Lerdahl, “Composing Notes,” 245-47.
reductions. Soskin observes the function of these progressions, stating, “Lerdahl is trying to create cadential patterns by assigning tonic, subdominant and dominant functions to motives and interior sections.” The composer defines this process as the “idea of making a coherent harmonic syntax out of different chord types with varying degrees of dissonance.”

Figure 2.3. The first four expanding variations of the First String Quartet, notated by the composer in prolongational format.

The harmonic constructs in Lerdahl’s music are necessary for his adherence to the cognitive constraints. By organizing the pitch material to suggest specific tonal functions to his sonorities, he creates progressions analogous to standard tonal-functional progressions. These progressions create the tension and relaxation vital to prolongational reduction. By prolonging these progressive cells, Lerdahl thus creates hierarchical depth in his music. This progressive tension and relaxation is evident in both the First String Quartet and Waves and will be discussed in much greater detail later in this thesis.

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49 Ibid., 245.
51 Lerdahl, “Composing Notes,” 246.
52 Ibid., 247.
Lerdahl’s use of a complex progressive and prolongational scheme in his music is important to note, because it reinforces the idea that Lerdahl’s compositions and theories are interwoven. In fact, a case could be made that *Waves* is a compositional experiment on the very nature of prolongation. This compositional experiment dovetailed with a theoretical dialogue about prolongation in which Lerdahl was engaged. This dialogue was centered on the nature of prolongation and its realization in music.

At the heart of the dialogue was “The Problem of Prolongation in Post-Tonal Music,” by Joseph N. Straus. In the article, Straus discusses progression and prolongation in tonal contexts before moving on to atonal contexts. While the article’s main intent is to dispute the idea of prolongation in most posttonal music, it is the definition of prolongation in a tonal context that is most important to this thesis.

Straus defines prolongation as occurring when “some musical entity stays in control even when it is not explicitly present.” Straus gives four conditions necessary for prolongation. The first is “the consonance-dissonance condition,” which refers to the presence of relative weight and stability of tonal sonorities. The triad and its intervallic content are most consonant, while all other sonorities and intervals are more or less dissonant. The second condition is “the scale-degree condition,” which, as an extension of condition 1, determines the level of consonance and weight in a diatonic setting. The third condition, or “the embellishment condition,” refers to the consistent relationship between those sonorities of greater and lesser weight. Figure 2.4 gives the

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53 Straus, “Problem of Prolongation,” 2.
54 Ibid.
55 Ibid., 4.
56 Ibid.
three embellishment or prolongation types present in tonal music. These are the
arpeggiation progression (2.4a), the neighbor progression (2.4b), and the passing
progression (2.4c). The last of the four conditions is “the harmony/voice-leading
condition,” which creates a clear distinction between harmony and voice-leading for the
purposes of prolongation. Prolongation occurs when a vertical interval occurs
horizontally over time.

Figure 2.4. The three tonal prolongation types.

Straus’s article had an impact on Lerdahl, who later wrote his own article
discussing atonal prolongation using ideas from GTTM. In the article, Lerdahl agrees
with Straus that prolongation as represented by Schenkerian concepts relevant to classical
tonal music does not apply to posttonal contemporary music, but he argues that there is
indeed prolongation in atonal music. However, it is Straus’s discussion of tonal
prolongation that influenced Lerdahl’s compositional process in Waves. In fact, Lerdahl

57 Another appropriate label would be melodic diminutions, the Schenkerian term for the three
prolongational types. For more information, see Forte and Gilbert, Introduction to Schenkerian Analysis, 7-37.
58 Straus, “Problem of Prolongation,” 5.
59 Ibid., 3.
60 Lerdahl, “Atonal Prolongational Structure.”
61 Ibid., 67-68.
incorporated aspects of the discussion into his own tonal syntax. This influence can most clearly be seen in the motivic ideas utilized by Waves, as will be discussed further in chapter four of this thesis.

This chapter has explored Lerdahl’s compositional aesthetic, which values the incorporation of theoretical concepts and models as a source of coherence in his music. Lerdahl establishes coherence through the use of mandatory constraints on his own composition. These cognitive constraints require adherence to both the universal grammatical concepts found in GTTM as well as the use of a tonal pitch-space model. Because Lerdahl’s music incorporates such hearable processes, a listener is able to break down the musical surface into discrete events, thus establishing musical hierarchy. These constraints have also led to Lerdahl’s development of a hearable formal process known as expanding variations. This process, which is ultimately a reversal of musical reduction, begins with an opening musical cell that is subsequently expanded upon in a series of variations. By continually using material from the previous variations, musical symmetries and parallelisms are formed, both of which are key to establishing a listening grammar. The next two chapters contain an analysis of Waves, focusing upon the ways in which the composition draws upon the theoretical materials explored in these first two chapters.

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CHAPTER 3. GROUPING AND METRICAL STRUCTURES, STRICT EXPANDING VARIATIONS, AND OBSCURED VARIATION BOUNDARIES IN WAVES

The first two chapters of this thesis were devoted exclusively to Fred Lerdahl’s theoretical studies, compositional interests, and musical aesthetic. This background is fundamentally important to understanding Lerdahl’s music. This chapter will undertake a formal analysis of Waves, a work by Lerdahl for chamber orchestra. Grouping and meter will be examined in this chapter, and structural boundaries will be identified.

Lerdahl has briefly discussed Waves in many different interviews and writings, noting that it is “in expanding variation form, and a very strict piece from that point of view”\(^1\) and “a perpetual motion piece,”\(^2\) with “driving sixteenth-note motion from beginning to end.”\(^3\) Lerdahl has also specifically characterized it as a tonal work, describing it as being “like berserk Bach and … in a souped-up D minor with subordinate areas.”\(^4\) He has also stated that “the title refers less to the sea than to the quality of the energy. The motives, phrases, and sections surge at high speed in fluid, constantly varying patterns that break apart and merge.”\(^5\)

As Waves employs expanding variations, it is important to find the divisions between the variations, so that they can be compared and contrasted to reveal how material expands and grows from one variation to the next. In Waves, Lerdahl does not signal the end of each variation with fermatas or section numbers, as he did in the First String Quartet. Lerdahl says, “Although I have used this technique before, here [in

\(^1\) Lerdahl, “Fred Lerdahl,” 111.
\(^3\) Lerdahl, “Composing Notes,” 111.
\(^5\) Lerdahl, liner notes for Waves, on Points of Departure.
Waves] the impact is different because the boundaries are obscured by the perpetual motion and gradual changes in texture.

Therefore it is up to the listener (and analyst) to determine where each variation begins and ends.

A large amount of analytical information can be gleaned from the first four measures of Waves, which are given in figure 3.1. The piece begins with a unison tonic D stressed with a phenomenal accent. This accented D recurs at the ends of mm. 1, 2, and 4. Because the motive recurs frequently, the listener readily notes the parallelism occurring on the musical surface. This relates directly to Lerdahl’s adherence to constraint 4, which states:

Constraint 4: Projection of groups, especially at larger levels, depends on symmetry and on the establishment of musical parallelisms.

This constraint corresponds to GPR 6, which states that “where two or more segments of the music can be construed as parallel, they preferably form parallel parts of groups.”

Thus, the unison D motive is heard as the beginning of a new group, and it can be hypothesized that each variation in Waves will likewise begin with such a flag, meaning that a recurring motivic idea signals each new variation. Because the material following the motive is different each time, the flag for each variation consists of only the unison group of four sixteenth notes, as bracketed in figure 3.1.

With their inceptions indicated by the flag motive, the length of each variation can be measured through designation of a tactus, or the most perceptually prominent level of metrical structure. Determining the variations’ lengths is important in terms of

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6 Ibid.
8 Lerdahl and Jackendoff, GTTM, 51.
9 Ibid., 71.
identifying a pattern in the expansion process. According to GTTM, the tactus should be somewhere between 40 and 160 beats per minute. Lerdahl designates a metronome marking at the quarter-note level ($\mathbf{= 112}$, see fig. 3.1), though this is not necessarily indicative of the tactus. Along with the quarter note, the half note would also fall within the range of acceptable values ($\mathbf{= 56}$). However, GTTM states that the tactus “cannot be too far away from the smallest metrical level,” which in Waves is the sixteenth note. This would favor the quarter note as tactus.

The opening of Waves can be partitioned into individual variations defined by the flag motive and the number of tactus-level beats spanned. Each flag motive and the beats following it combine to form a group. Thus the opening variation is two beats in duration, while the second variation is three beats, and the third variation is five beats. Throughout Waves, there are thirteen incidents of the flag motive occurring as a large-scale grouping

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10 Ibid., 73.  
11 Ibid.
boundary, though it is not always as strongly emphasized as in the opening measures.

The division of Waves into thirteen variations, expressed in terms of the number of quarter-note values each comprises, is shown in figure 3.2. The page numbers in the score for each variation are also shown in the figure. Notice the lengths of the variations follow the Fibonacci series. Each number of this geometric series can be generated by adding the two previous numbers in the sequence. For example, to generate the thirteenth number as related to the variations above, one would add the twelfth number of the series to the eleventh (233+377=610).

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<td>13</td>
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Figure 3.2. The thirteen variations of Waves, their lengths in quarter-note beats, and the page numbers in the score that each covers. 

12 At the close of Waves, a fourteenth iteration of the flag creates a very short coda.

13 Figure 3.2 is a reduction of appendix C, which lists the number of beats on the tactus level per variation, the time signatures occurring during that variation, and the number of beats and measures occurring with respect to each of those time signatures.
With the designation of a tactus and the establishment of variation boundaries, interior grouping and metrical hierarchies begin to take shape. Figure 3.3 presents a grouping and metrical analysis of figure 3.1. The sixteenth note is the smallest level of the metrical hierarchy, here shown only to emphasize the constant sixteenth-note pulse. The tactus (quarter-note level) is the third level of the metrical hierarchy. Slurs in the voices establish local grouping boundaries (GPR 2a), especially in mm. 3-4. The quarter note is the smallest level of grouping in the example, making the flag motive a group. The flag motive is heard on all larger levels of grouping as the inception of that group. This is due to both the parallelism (GPR 6) mentioned above and the articulation change (GPR 3c). The convergence of all voices onto a unison D in these opening measures also creates a larger-level grouping boundary.

Figure 3.3. Grouping and meter of mm. 1-4 of *Waves*. 
Figure 3.3 displays a grouping structure that is out-of-phase with the metrical structure. The larger-level groups begin with the flag motive, while, metrically, the flag motive is an upbeat leading into a strong metrical accent. The flag motive is heard as an upbeat despite conflict within the metrical preference rules. MPR 4 would suggest that the flag motive, due to its local accent, would be a metrical downbeat; however, MPR 5, relevant especially to the half notes of the bottom two staves in figure 3.3 and the slurs mentioned above, overrides the local stress rule, creating a cross-accent that lends weight to the downbeat D that follows it.

The flag motive, understood as a weak upbeat preceding a strong downbeat, facilitates the organization of the remaining beats in the opening measures. As was suggested above, due to MPR 5a, m. 1 becomes a duple pattern, while the strong beat on the downbeat of m. 2 governs a triple-patterned meter. Measures 3 and 4 are broken into two metrical accents of two and three beats. MPRs 4 and 5c allow a strong beat placed on beat 3 of m. 3. A parenthetical strong beat is given on beat 1 of both mm. 1 and 3. This hypermetrical strong beat gives a symmetrical five-beat pattern to the opening section. This binary structure, however, does not continue past the opening measures shown in the figure.

The Fibonacci series contains many uneven numbers. This creates a naturally irregular metrical structure in the opening measures, with strong metrical accents of two, three, and five beats per variation. Because a five-beat meter (as shown by the parenthetical strong beats) is in clear violation to MWFRs 3 and 4, Lerdahl subdivides the five-beat variation 3 into two time-spans of two and three beats. While this satisfies MWFR 3, MWFR 4 is still clearly violated. In GTTM, the authors specifically discuss
violation of MWFRs 3 and 4, stating that unlike MWFRs 1 and 2, MWFRs 3 and 4 are not musical universals but specific to the idiom of classical tonal music. For example, “by keeping MWFR 3 but dropping MWFR 4 we describe a metrical idiom of considerable irregularity, in that strong beats at each level can be indiscriminately two or three beats apart.” 14 This specific variance of the MWFRs allows the asymmetrical meter seen in figure 3.3. Cognitive constraint 5 addresses Lerdahl’s treatment of meter, and he explains the constraint by saying, “Depending on the musical idiom, the criterion of equidistance may be loosened, but not to the extent of abandoning all sense of periodicity.” 15 Thus, this constraint calls for a general regularity among accents (conforming to MWFRs 1 and 2) but not necessarily a strict rigidity between them (MWFRs 3 and 4). Therefore, variance with respect to these MWFRs is not in violation of constraint 5 or the listening grammar.

Despite the irregular meter and grouping in the opening measures of Waves, as the variations continue to expand, both at times attain regularity. Figure 3.4, a grouping and metrical analysis of the fifth variation of Waves, is one such example. Local grouping is established through dynamic change (GPR 3b) and articulation (GPR 3c). Grouping boundaries are established through symmetry (GPR 5) and parallelism (GPR 6). The slurs and rests (GPR 2) in the bottom staff also strengthen grouping boundaries. The meter is simple quadruple and in-phase with the grouping, resulting in a variation that is perfectly symmetrical. 16

14 Lerdahl and Jackendoff, GTTM, 97.
15 Ibid., 240.
16 The first two slurs in the lower staff create a small out-of-phase conflict with the notated analysis, though not enough to influence perception of the passage.
Other local metric and grouping irregularities exist throughout *Waves*. Group overlap and elision are important constructs in *Waves*, playing a significant role in the organization of grouping. An example of group overlap in *Waves* is given in figure 3.5. Notice that the first violin descends in chromatic stepwise motion from F to D, while the D also begins a new phrase, an arpeggiation of a D-minor triad. Thus, the D has a dual function, cadencing the first group and initiating the second. Also notice that the grouping and meter are out-of-phase at the inception of the variation. The point of overlap reorients the grouping to conform to the metrical structure.
The contrapuntal nature of *Waves* leads to grouping irregularities not addressed in *GTTM*. This thesis calls one such situation *compound musical structure*. This takes place when multiple voices, occurring simultaneously, each contain separate descriptions of grouping and meter. Figure 3.6 gives an example of this from the ninth variation. The upper line, played by the flutes, oboes, and violins, features a subdivision of the quarter note. The bottom line, played by the clarinets for the first six beats, follows a dotted-quarter-note tactus. The metrical analysis of this example is even more complicated. The entrances are staggered, obscuring the meter even further. The upper staff also contains instances of both right elision and overlap, created in local detail through timbral change (not shown in the condensed score), register change (GPR 3a), and dynamic contrast (GPR 3b). Thematically, the left group of the elision both rises and descends chromatically in contrary motion by step, finally arriving on G♯ an augmented fourth from the initial D. The right group of the elision begins on the same G♯ and moves away chromatically by step. This instance of elision also causes a metrical deletion (a weak quarter-note beat is deleted between the first and second measures of the example). The overlap (beat three of the second measure) does not contain a metrical deletion, and, with the bottom staff’s return to the previously established meter (with a quarter-note tactus), emphasizes the cadential structure at the end of the phrase (MPR 7).

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17 Lerdahl and Jackendoff, *GTTM*, 116. The authors chose to avoid contrapuntal constructs in order to concentrate on more fundamental aspects of musical structure.
As the expanding variations in *Waves* grow longer, Lerdahl employs complex grouping and metrical constructs to obscure the flag motive and thus blur the structural accents denoting the beginnings of variations within *Waves*. Figure 3.7 shows the flag motive at the inception of variation 13. The motive (beat 4 of the example) no longer is articulated by phenomenal accent and is present only in the first violin. The lower strings maintain quarter-note groups leading into the flag motive, while the winds employ groups of irregular lengths, reinforced especially by registral and articulation changes (GPRs 3a and 3c). Because of the dynamic marking on beat 3 in the winds, a larger-level grouping boundary is placed between beats 2 and 3 (GPR 3b). The grouping boundary between beats 3 and 4 in the strings is due to a change in dynamics (GPR 3b) as well as a change in articulation (GPR 3c) and length (GPR 3d). The overlap by the winds of the grouping boundary in the strings obscures the presence of the flag motive and the entrance of the thirteenth variation.
Figure 3.7. Overlap between variations 12 and 13 (p. 62 [C score]).

Dissonant pitch structures further obscure the flag motive in this case. The winds are finishing a phrase group consisting entirely of the pitches F# and A. The strings meanwhile, are emphasizing the tonic key (D minor) and elaborating the flag motive that is to come. At the inception of variation 13, the strings move from the D-minor triad to an F#-C# perfect fifth, creating an F#-minor triad and a dissonant clash with the tonic D of the flag motive, especially between the D and C#.

Lerdahl also uses dissonant pitches beneath the flag motive to obscure its entrance in variation 11 (fig. 3.8). The pitches below that flag motive in the second and third violoncellos are the upper and lower neighbors of A. As at the beginning of variation 13 (fig. 3.7), Lerdahl removes the marcato stress and reduces the forces playing the flag
motive to a single stringed instrument. The flag motive beginning variation 12 is also obscured, by means similar to those already discussed. This means that the beginnings of the last three variations are all obscured.

![Figure 3.8. Flag motive to variation 11 (p. 25).](image)

The concealment of the flag motives gives a sense of continuity to the latter variations. The earlier variations do not directly obscure the flag motive, but use a large-scale pitch process to unify the smaller variations. In particular, Lerdahl uses the initial entrance of specific pcs to add tonal cohesion to the first seven variations of Waves. Figure 3.9 illustrates the order of pc entrances. By introducing pitches in this manner, Lerdahl creates the sense that the first seven variations are all part of a single larger process.

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Figure 3.9. Order of pc entrances through the first seven variations of Waves.
The specific order of pitch entrances through the opening variations is more meaningful than mere aggregate completion. Notice that variation 1 introduces the tonic perfect fifth, while variation 2 introduces the third of the tonic triad. Variations 3 and 4 begin to flesh out the diatonic scale of D minor. This closely resembles the basic space of D minor (fig. 3.10). Variation 5 introduces G♯, the first chromatic pc, as a lower neighbor to A. This pc is introduced first due to its importance in later variations and will be discussed more fully in the next chapter. Variations 6-7 introduce the remaining diatonic and chromatic pitches in no particular order, mostly as upper or lower neighbor tones to more stable pitch classes. The lack of a significant order is due in part to the variants of the minor scale, none of which are especially emphasized throughout the first seven variations.

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Figure 3.10. D-minor diatonic space (i/i).

This chapter has identified the formal boundaries of the thirteen variations in *Waves*. This was done through the identification of a flag motive and the designation of a tactus. Tactus designation revealed that each variation contains a unique number of beats, with the duration of each variation corresponding to a sequential element of the Fibonacci series. Rhythmic and grouping hierarchies, as well as more complex grouping and
rhythmic structures within some variations, were also examined. Many of the complexities of grouping and meter were due to the prominence of odd numbers in the Fibonacci series. By dropping GWFR 4, which is not a universal, Lerdahl was able to conform to both the Fibonacci series and constraint 5. The grouping irregularities of compound musical structure, group overlap, and elision were isolated and analyzed. These irregularities revealed complexities within the music beyond the basic hierarchies of GTTM, as though Lerdahl was experimenting with ideas not covered in his theories to create tension within his music.

Lerdahl also experiments with the unification of variations in Waves through large-scale processes and musical irregularities. Dissonant pitch structures used to obscure the boundaries of the variations were discussed, as was the use of a global regulation of pc entrances to create cohesion among the opening variations. Chapter 4 will continue the discussion of progression and cadence leading to a study of prolongational organization present in Waves and address more specific details of motivic content.
CHAPTER 4. EXPANSION OF MOTIVES, PROGRESSION, AND PROLONGATION IN WAVES

The first two chapters of this thesis are reviews of Lerdahl’s key theoretical and compositional writings. Chapter three of this thesis is concerned with the structure of Waves. Chapter four will continue the analysis of Waves by exploring the process of expansion in relation to motivic development as well as tonal motion within and between variations.

Motives play an important role with respect to both their grouping and development across the expanding variations. The opening three variations of Waves (figures 3.1 and 3.3) reveal this process. As was discussed in chapter three, an initial motive (flag) introduces each variation. In figure 4.1, the tonic/dominant arpeggiation in m. 1, beat 1 (itself an elaboration of the flag motive) doubles its size in m. 2 by including the third of the tonic triad. This creates two groups, each of which expands to create two more groups.

The development of motives in Waves is important to the process of expansion from variation to variation. Short motives develop into longer motives, then phrases, and eventually sections within the larger variations. There are four important motives in Waves (figure 4.2). These can be thought of as cells as defined by Soskin.¹ These four motivic cells are the fundamental building blocks for Waves; subsequent cells are elaborations or expansions of these four cells.² Elaboration from the first to the third variation can be seen in figure 4.1 (each bracketed group is essentially a cell). These first

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² This chapter will give many examples to support this statement; however, a comprehensive defense of this claim is beyond the scope of this paper.
four measures of *Waves* contain all four motives given in figure 4.2. Motives 4.2b, c, and d are all introduced as elaborations of the flag/tonic statement (4.2a) as well. This can be seen by comparing figure 4.2 to figure 4.1: the first two motives (fifths in m. 1, thirds in m. 2) are arpeggiation of the tonic, which the passing (m. 3, beats 1 and 2) and neighbor prolongational types (m. 3, beat 3) then elaborate. Thus, each cell is elaborating directly or indirectly upon the D tonic of the flag motive.

![Figure 4.1. Grouping and motivic expansion in the first three variations of Waves.](image)

The elaborative nature of the motives 4.2b, c, and d characterizes them as *prolongations*. This is to emphasize that each is also a standard tonal-contrapuntal gesture. These motives are identical to the prolongational types discussed by Straus (see pp. 38-40 of this thesis) and conform to the basic Schenkerian diminutions. By using these diminutions, Lerdahl prolongs single pitches or harmonic constructs such as triads. This in turn creates hierarchy, with the prolonged chord tones possessing more stability.
than their elaborations. Thus, reductions are possible, making Lerdahl’s music more cognitively complex (cognitive constraints 1, 2, 7, 8).

![Figure 4.2. Four motives of Waves.](image)

By emphasizing these three standard prolongational types so prominently in *Waves*, Lerdahl creates a hierarchically based prolongational system. Lerdahl also uses a unique hierarchical system to create harmonic progressions to and from a central tonic, which will be explained in more detail below. By creating a unique system of progression and using standard prolongational diminutions, Lerdahl seems to be experimenting with the nature of tonality and prolongation as an organizing factor for *Waves*.

The motives in figure 4.2 fall into two categories, those that contain pcs exclusively from the tonic triad (here [259] or D-F-A) and those that contain pcs related to the tonic triad by step. The tonic and arpeggiation motives (4.2 a, b) belong to the former category, while the passing and neighbor motives (4.2 c, d) belong to the latter. The passing and neighbor motives initially involve diatonic stepwise motion, but both
later contain chromatic pitches (fig. 4.3). When coupled with the other four (fig. 4.2), these six motives create the bulk of material in *Waves*.

![Chromatic neighbor](image1.png) ![Chromatic passing](image2.png)

**Figure 4.3. Chromatic stepwise motives.**

The diatonic and chromatic motives used by Lerdahl have roots in his own theories, particularly that of “Tonal Pitch Space.” The pitch-space model is one of tonal hierarchy in which multiple spaces are present. While specifically structured for Western classical tonal music, the pitch-space model (fig. 4.4) can shed much light on the pitch organization of *Waves*. Because *Waves* is set in the key of D minor, figure 4.4 orients the pitch-space model to D minor.

If one examines each of the motives already presented in relation to both the vertical and horizontal spaces of the pitch-space model given in figure 4.4, the nature of the motivic material as it relates to Lerdahl’s theories will be understood. For example, the arpeggiation motive consists of horizontal stepwise motion along level $c$. The diatonic passing and neighbor motives consist of horizontal stepwise motion along level $d$. The chromatic motives consist of horizontal stepwise motion along level $e$. The relationship of these motives to the pitch-space model also corresponds to the order of diatonic and chromatic pitch entrances in the work (see pp. 52-4 of this thesis). Thus, Lerdahl is using each of these motives to introduce pcs in the opening of *Waves* in a logical and coherent way.
The diatonic and chromatic motives presented above have two distinct functions. The first is to prolong more stable pcs and harmonies, such as the tonic D-minor triad. The second is to be elaborated themselves in various ways, such as through the addition of pitches, rhythmic variance (including augmentation and diminution), fragmentation, and sequential repetition. Figure 4.5 gives examples of motivic development as related to the passing motive. Some motives are fragmentations of other motives (e.g., 4.5f is a fragment of 4.5e transposed) or sequential expansions of motives (e.g., 4.5i is a sequential expansion of 4.5f).

Many of the motives in figure 4.5 are elaborations of other prolongations. For example, figures 4.5i and k both contain chromatic neighbor motion within larger diatonic passing motives. The passing motive itself is introduced as an elaboration of the arpeggiation motive (see fig. 4.1). Figure 4.5a can be understood as both an elaboration of the arpeggiation motive and the passing motive. Figure 4.5f could be heard as an incomplete neighbor motive, but in the context of 4.5i, becomes passing in function. Thus, all of the motives are fundamentally interrelated.
Lerdahl uses the motives given in figure 4.5 in different ways. He often transposes them to emphasize other pcs (for example, transposing a passing progression to arrive on A instead of D). He also often chains together transposed iterations of a motive to create longer, sequential phrases. Figure 4.6 is an example of a sequential chain consisting primarily of the tonic/dominant arpeggiation motive first heard in m. 1, beat 1. Here in variation 12, the motive (transposed to B-F♯ and inverted in the viola line) forms the basis of a duet between the second violins and the violas. Lerdahl sequences the arpeggiation, transposing by step to move from a B-F♯ arpeggiation to an F-C arpeggiation. The transposition occurs in contrary motion over the course of the four measures.
Fusion plays an important role in the comprehension of progression and prolongation in *Waves*. *GTTM* explores this process in Time-Span Reduction Well-Formedness Rule (TSRWFR) 3b. “Fusion … corresponds to the perceptual phenomenon of ‘auditory stream segmentation’ where one hears two voices instead of a single oscillating one.” In *Waves*, triadic and other harmonic motion is often arpeggiated. For example, in figure 4.6, use of the arpeggiation motive creates music that is linear and contrapuntal in nature; however, the process of fusion allows listeners to hear each arpeggiation as a single, vertical sonority. Transposition and sequencing of these arpeggiations can give a sense of progression and harmonic direction. Thus, the sequence expresses ultimately the motion B-F♯→F-C.

Other motives likewise fuse to create vertical sonorities. For example, figure 4.7a shows an early, chromatic-neighbor motive, occurring at m. 19 (var. 7) of *Waves*. Figure 4.7b shows the fusion of the upper and lower semitone neighbors into a vertical sonority.

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3 Lerdahl and Jackendoff, *GTTM*, 154. This process and its terminology were first defined by Bregman and Campbell, “Primary Auditory Stream Segregation.”
While figure 4.7a independently would not likely be heard as a fused sonority, Lerdahl realizes such a fusion as a development in later variations. The boxed area of figure 4.8 is one such example, occurring in the horns near the start of the ninth variation (mm. 41-42, pp. 10-11). Thus, linear neighbor motion creates a cell that connotes progression to and from a central pc.

Figure 4.7. Chromatic upper- and lower-neighbor motives.

The progression of fused sonorities expands beyond the half-step neighbor motion around a central pc shown in figure 4.7b. Figure 4.8 continues this motion with a dyad even further away from the tonic [B5]. This vertical sonority is a diminished fifth and can also be considered as two pcs a whole-tone step away from the [13] sonority presented in fig. 4.7b. This motion can also be seen as contrary passing motion by minor third arriving at the central pitch. By inverting the diminished fifth and collapsing the progression through a retrograde of the whole-tone and semitone motion, a secondary pc [8] is
reached. This motion away from a central pc and to a secondary pc is realized as a musical example in figure 4.9a and as a schematic in figure 4.9b, read top to bottom.

![Diagram of musical example and schematic](image)

Figure 4.9. Complete motion away from tonic (pc 2) to a secondary pc [8].

The relationship between D and G♯ has been mentioned in this thesis (pp. 49-50, 53) as being important to the design of *Waves*. In figure 4.9b the relationship between these two pcs resembles the hex-pole relationships of the hexatonic systems in neo-Riemannian theory, in which two chords are maximally distant, yet complementary. D and G♯ are chromatically as far away as possible (six semitones); yet in the context of figure 4.9 both share a tritone, giving them an inherent relationship. Examples of that relationship in *Waves* can be seen in figure 4.10. Figures 4.10a and 4.10b both display a direct linear relationship between the two pcs. Figure 4.10c, however, shows a harmonic relationship between the open fifth dyads generated by the two pcs. This harmonic relationship is created here solely through voice leading. D is the lower neighbor of D♯, while A acts as the upper neighbor of G♯. Larger progressive relationships between the

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4 In figure 4.9, D begins the example rather than closes it as in the previous figures. This is merely to emphasize that D is more important than the secondary G♯.

5 For more information on the hexatonic systems of neo-Riemannian theory, see Cohn, “Maximally Smooth Cycles.”
tonic areas D and G♯ are also present throughout *Waves* and will be explained in more
detail below (see fig. 4.15 and 4.26a).

Figure 4.10. Relationships between the pitches D and G♯ in *Waves*.

The addition of a perfect fifth A above the tonic D creates the basic tonic cell [D, A]. Just as the fusion of neighbor motion around the tonic resulted in a more distant dyad
[C♯, E♭], upper- and lower-neighbor motion around the A [G♯, B♭] is also fused into a less
stable dyad. This dyad is grouped with the [C♯, E♭] dyad to create a harmonic cell [C♯, E♭,
G♯, B♭] related to the tonic cell by half-step neighbor motion (fig. 4.11a). The resulting
cell is [8A13], (0257) in its prime form. As opposed to 4.11a, which is strictly a
paradigm, figure 4.11b is an occurrence of this progression in *Waves* (var. 9, mm. 44-45).
Whole-step neighbor motion away from the cell [8A13] (or minor-third stepwise motion
from the tonic dyad) is [B056], (0167) in its prime form. These three cells
[B056]→[8A13]→[92] make up a model progression in Lerdahl’s music (fig. 4.12).6
Figure 4.13a shows a paradigm with the complete motion from the tonic cell D to the
secondary cell G♯. Figure 4.13b is the corresponding schematic. Notice that in the

paradigm, the inversion of both tritones in the shared [B056] results in the correct linear motion to the polar tonic.

![Figure 4.11. Upper- and lower-neighbor motion around the perfect fifth creating an [8A13] tetrachord.](image)

![Figure 4.12. Whole-step motion from [8A13] creating a [B056] tetrachord.](image)

An important constraint in Lerdahl’s compositional process is the realization of music that is strongly hierarchical in nature and therefore cognitively complex. Lerdahl’s goal is “making a coherent harmonic syntax out of different chord types with varying degrees of dissonance.”

Lerdahl’s progressive construct satisfies these goals, creating various degrees of tension and relaxation through increasing and decreasing levels of dissonance. Figure 4.14a assigns progressive function to the cells, using the labels tonic (T), dominant (D), and subdominant (S).

The two perfect fifths have now been fleshed out into a tonic triad (as in 4.11b above). D minor (T1), as the tonic and anchor of the

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7 Ibid., 246.
8 Ibid., 245-46.
pitch-space model, is the most important cell in the hierarchy, followed by G♯ minor (T2), the secondary tonic (or polar tonic). The dominants attach to specific tones in accordance with their function; the subdominant is the same for both D and G♯ and can be used as a pivot between the polar tonics, as will be shown.

Figure 4.13. Lerdahl’s progressive construct realized through voice-leading.

Figure 4.14a is a purely hypothetical construct, used to assign function to the cells. In practice, Lerdahl rearranges the cells in various ways to create a sense of progression. Figures 4.14b and c are both paradigms of such restructurings, given in a prolongational-reductive format. In 4.14b, T1 is prolonged through a subdominant-to-dominant progression. Notice the similarity of the tree structure of figure 4.14a to the basic form given by GTTM (fig. 1.4b of this thesis, p. 16). The added subdominant in 4.14a is the only difference. Because of this likeness and the constant recurrence of this progression, 4.14a can be labeled the basic progression of Waves. Figure 4.14c also contains the left-branching subdominant as well as a weak prolongation of tonic (here an ambiguous neighbor prolongation by either the polar tonic or an incomplete [8A13]

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9 This progression is never used by Lerdahl in his music.
dominant). This progression is identical to the basic form/normative prolongational structure with reprise (see fig. 1.5b, p. 18).

![Diagram of voice-leading construct in Waves.](image)

**Figure 4.14. Hierarchical structuring of the voice-leading construct in Waves.**

With knowledge of Lerdahl’s functional progressions, one can begin to identify and analyze occurrences of these progressions within the music itself. Figure 4.15 contains a large phrase with three instances of the basic progression. This phrase (mm. 41-45) is an important part of Waves. Here for the first time a full phrase with the basic progression is revealed in its entirety. The first progression (4.15a) is an exact occurrence of the basic progression (fig. 4.14b). The tonic is prolonged by way of the subdominant and dominant. In the second progression (4.15b), Lerdahl uses the shared subdominant (0167) as a pivot to move from D to G# minor. The third progression (4.15c) is cadential
in nature and exhibits a return to the primary tonic of D minor. It also conforms to the basic progression.

![Figure 4.15. A progressive phrase in Waves (var. 9, p. 11).](image)

Analyzing each individual occurrence of the basic progression in figure 4.15 is important in understanding the nature of progression in *Waves*, but it does not reveal the true significance of the example, which has to do with the hierarchical organization of the phrase. All three together create a larger pattern of tonal tension and relaxation seen in the prolongational tree diagram above the example. The large-scale progression D minor→G♯ minor creates tension (4.15a and b), and the return to D minor (4.15c) releases it. Thus, the entire phrase is a weak prolongation of D minor. This larger phrase somewhat resembles figure 4.14c. The initial cadence in 4.15a corresponds to the strong prolongation seen at the beginning of 4.15c. Figure 4.15 expands 4.14c with a tensing move to G♯ minor. The material between 4.15b and c is ignored in the prolongational tree.
diagram. This section somewhat resembles a linear-intervallic pattern, building tension by destabilizing the harmony and rhythm established earlier and driving the phrase to the final cadence (see also discussion of fig. 3.6, pp. 49-50). This destabilization strengthens the metric and harmonic regularity at the final cadence.

Modulation may be realized through altered voice-leading resolution of pitches in the dominant or subdominant cells of the basic progression. By changing two of the pitches in the (0167)→D tetrachord (fig. 4.16a) or only one pitch in the (0257)→D cell (fig. 4.16b), Lerdahl is able to move to a new tonic a perfect fifth higher or lower (as well as their polar tonics). Thus, he is able to modulate to any of the twelve keys by progression on the circle of fifths. Figure 4.17 gives the complete cycle through the circle of fifths in schematic form. Though Waves does not ever complete the cycle, it is important for understanding the potential motion available to the composer within such a system. In figure 4.18, Lerdahl moves quickly from D minor to C major/minor using tetrachord cells containing common tones. The (0167) tetrachord is used as the pivot in both instances (D minor→G minor and G minor→C major/minor). This allows a full cadential progression to be realized in the new tonality. At the close of this phrase, Lerdahl keeps the third of the C triad purposefully vague by using a neighbor motive from E♭ to E. This modulating phrase is part of a larger prolongation of D as seen in the upper level of the prolongational tree diagram.

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10 The phrase presented here is sentential in nature. The larger structure contains a basic idea (4.15a), a repetition of the basic idea (4.15b), a continuation (the contrapuntal passing motive), and a cadence (4.15c). For more information on the sentence, see Caplin, Classical Form, 35-48 and Lerdahl, Tonal Pitch Space, 231-33.
Figure 4.16. Modulation to other cadential progressions.

Figure 4.17. The complete cycle through all twelve tonic areas, as implied by Waves.
A new tonic can be approached not only through modulation but also through an alternate resolution of a dominant (0257). Lerdahl utilizes this alternate resolution to lead away from a tonic triad and extend a progression. This resolution can be seen in figures 4.18, 4.19, and 4.20. In figure 4.18, the (0257)->C in the second measure resolves alternately to a G-minor triad.\textsuperscript{11} This (0257) ultimately acts as a neighbor between the two G-minor triads and creates a strong prolongation as seen in the prolongational tree diagram. Figure 4.19 gives the voice-leading of both the primary and alternate resolutions. Two of the four pcs [68] resolve as expected by the basic progression. The other two pcs [B1] resolve opposite to their expected resolution. Figure 4.20 shows an uncommon progression with an alternate resolution. This (0257) of E, which shares two

\textsuperscript{11} The alternate resolution of the (0257) of C has a second function within this larger progression from D minor to C. It also anticipates the cadential progression arriving on C that follows the G-minor triad.
common tones with the F-minor triad preceding it, resolves to B minor through an alternate resolution, creating motion from F minor to its polar tonic B minor.

Figure 4.19. Primary versus alternate resolution (expanded to show voice-leading).

Figure 4.20. Alternate resolution of a cadential formula (var. 9, p. 13).

As the variations become more complex, other cells are added to the basic progression through trope development, enriching the contrapuntal voice-leading.\textsuperscript{12} Figure 4.21 gives an example of a more complex string of cells creating a longer cadential progression. Notice in the second measure of the example, Lerdahl prepares a cadence in G minor with an (0167)$\rightarrow$(0257) subdominant-to-dominant motion; however, he then inserts an (0257) that would resolve to C minor instead. The (0257) of C minor in turn resolves to an (0358) cell, which finally heads to the G-minor triad.

\textsuperscript{12} Soskin, “Cadences and Formal Structure,” 59-60.
The voice leading of the (0358) tetrachord is realized through neighbor motion (fig. 4.22) similar to the other tetrachords discussed. The (0358) in figures 4.21 and 4.22 is almost identical to the (0257) of G minor, sharing three of its tones. As in the resolution of the (0257), those three tones in the (0358) resolve by half step to the tonic. The fourth pc is shared by the chord of resolution (A♯ = B♭) and remains static. The (0358) cell also has two common tones with the (0257) cell of C minor that precedes it.

With the interpolation of other tetrachords into the basic progression, larger, more complex sonorities result. The (0257)→(0257) juxtaposition in figure 4.21 is not a strong progression but a delay of resolution to the tonic. The two (0257) cells share three tones, making them nearly identical. Taken together they form the pentachord [B1368] (02479). When this pentachord is combined with the (0358) tetrachord, a diatonic hexachord

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13 Brackets in this figure refer to pitch combinations of cells and not to grouping.
[68AB13] (024579) results. The diatonic hexachord presents many attractive options heading into a cadence because of the large number of (0257) and (0358) tetrachords it contains. Figure 4.23 lists all of these specific subsets present in the hexachord from figure 4.21. From this hexachord, Lerdahl is able to cadence by primary resolution on D, G, or C. Lerdahl does not only utilize this hexachord linearly, but also uses a realized fusion of the diatonic hexachord to create complex sonorities. Figure 4.24 consists of two diatonic hexachords transposed by a diminished fifth, [3578A0] and [9B1246]. Notice, incidentally, that these two hexachords, all-combinatorial in nature, together create a twelve-tone aggregate.

![Figure 4.23. (0257) and (0358) subsets of the diatonic hexachord (024579).]

![Figure 4.24. Vertical use of the (024579) hexachord (var. 11, p. 32).]
By expanding both tetrachords, Lerdahl creates richer complex sonorities in the basic progression. Figure 4.25 begins with an (0167) tetrachord that has been combined with an (0146) to make an (01367) pentachord. As in figure 4.21, the (0257) and (0358) tetrachords combine into an (024579) hexachord. Therefore, the subdominant (0167) is enlarged to (01367), while the dominant (0257) now becomes (024579). Thus the expanded basic progression in figure 4.25 is (01367)→(024579)→G major.

![Figure 4.25. Trope development to lengthen the progression (var. 12, pp. 45-46; woodwinds [C score]).](image)

In the thirteenth variation, Lerdahl begins using extensive processes to manage the expansion of trope development. The first seven measures (265-71) of the thirteenth variation involve sequential motion from D to G♯, moving through the series of triads given in figure 4.26a. Though Lerdahl abandons this sequence after the arrival on G♯, figure 4.26b shows its continuation leading back to D minor. Governing the sequence is root motion based upon the whole-tone scale. The entire move from D to G♯ acts as a large-scale linear pattern with emphasis on the polar endpoints; however, in figure 4.27,

14 Brackets in this figure refer to pitch combinations of cells and not to grouping.
which shows the opening sequence of the process, embellishments, such as the (025) and
(0358) cells, add a richer layer of voice-leading. The perfect fourth in the bass of the
second-inversion D-minor triad leading into the B♭-minor triad anticipates the (025) cell
(with its perfect fourth in the bass as well). The (0358) acts as a neighbor between the
two C-minor triads and creates a weak prolongation between them. These embellishments
are all surface-level elaborations and are reduced out to create the diagram in figure
4.26a.

\[
\begin{align*}
&\text{a} \\
&\text{Dm} \rightarrow \text{B♭m} \rightarrow \text{Cm} \\
&\text{Cm} \rightarrow \text{G♯m} \rightarrow \text{B♭m} \\
&\text{B♭m} \rightarrow \text{F♯m} \rightarrow \text{G♯m} \\
\end{align*}
\]

\[
\begin{align*}
&\text{b} \\
&\text{G♯m} \rightarrow \text{Em} \rightarrow \text{F♯m} \\
&\text{F♯m} \rightarrow \text{Dm} \rightarrow \text{Em} \\
&\text{Em} \rightarrow \text{Cm} \rightarrow \text{Dm} \\
\end{align*}
\]

Figure 4.26. Process governing the opening seven measures of variation 13.

Throughout the thirteenth variation, Lerdahl develops the tritone relationship of
the polar tonics through use of the whole-tone scale as seen above in figures 4.26 and
4.27. Figure 4.28 displays descending triadic arpeggiation (highlighted in the figure)
transposed in accordance with the whole-tone scale. These triads are major in quality as
opposed to the minor triads in figures 4.26 and 4.27. The contrapuntal lines, upon
completion of the triadic arpeggiation, leap to the polar tonic of the root, similar to the
arpeggiated tritone relationship seen in figure 4.10 (p. 64).
This chapter has concerned itself with motivic development, prolongation, and progression in *Waves*. There are four basic motives in *Waves*. The most stable of these is the tonic statement, or flag motive. The other three motives are not only derived from the
tonic statement but also are used to prolong it. This prolongation is necessary for the creation of hierarchies in Lerdahl’s music, thus allowing the music to be cognitively complex. These prolongational motives correspond to the basic diminutions found in tonal music. The motives also conform to Lerdahl’s pitch-space model, creating distance from the tonic through motion across the basic space. In addition to melodic pitch distance, Lerdahl creates a quasi-functional system of chords, based on voice-leading distance. He fuses the upper and lower neighbors of the tonic dyad to form a dominant (D) tetrachordal cell. Further distance, represented by neighbors to the neighbors, creates a subdominant (S) cell that is related to the dominant and, recursively, the tonic.

Progression in Waves occurs through the interaction of those tetrachordal sonorities both with the tonic triad and with one another. When organized into specific patterns based upon proximity, these cells regulate the sensations of tension and relaxation. These patterns conform to the basic form and normative prolongational structure of tonal music, thus creating functional progressions that emulate tonal progressions and cadences. These progressions, like their tonal counterparts, create large-scale prolongation across each variation. Each tonic also shares a common (S) tetrachord with a polar tonic that is six semitones away. Lerdahl highlights the relationship between these polar tonics through linear patterns, neighbor relations, and substitutions. Modulations and alternate resolutions are used to extend the basic progression and move across tonal regions through the chromatic pitch space. These regional shifts, themselves tonicized by their own (S) and (D) cells, create large-scale hierarchy that ultimately is subordinate to both the initial and cadential D tonic areas.
CHAPTER 5. SUMMARY, FURTHER STUDY, AND CONCLUSIONS

This thesis has sought correlations between Lerdahl’s theoretical and compositional output by examining his work *Waves* in relation to his theoretical writings. These theories specifically explore the musical grammar employed by the mind of the listener. This grammar relies chiefly on hierarchical ordering, similar to the way the mind processes language. *Waves* exhibits many of the characteristics explored in Lerdahl’s research, including grouping and metrical structures, progression and prolongation, and the expanding-variations process.

Lerdahl hypothesizes a global musical grammar consisting of two distinct but interrelated grammars. The first is the listening grammar, or how the mind comprehends music. The second is the compositional grammar, or how the composer creates music. For music to be cognitively transparent, Lerdahl maintains that the compositional grammar must reflect the listening grammar. In order for this to happen, two global constraints must be followed. The first is that all compositional decisions are made with a hypothetical listener in mind. This listener has a basic grasp of musical structures such as melody, harmony, and form. The second constraint is that the music must be hierarchical, so that it is able to be broken down and processed by the hypothetical listener. In other words, in order for the compositional grammar to be comprehended, it must reflect the way the listener’s mind processes the music.

In order for Lerdahl to understand and then reflect the listening grammar in his composition, exhaustive study of the listening grammar had to be undertaken. The bulk of this study is laid out in *GTTM* and “Tonal Pitch Space.” Each study explores a certain
hierarchical aspect of the listening grammar. *GTTM* explores event hierarchies, which are the hierarchies present on the musical surface. *GTTM* formulates complex sets of rules through rigorous musical analysis. The rules explore four hierarchical categories (grouping, rhythm, time-span, and prolongational). Lerdahl then uses the rule systems of *GTTM* to formulate a foundation for his own compositional process. By constraining his music to adhere, for the most part, to these rules, Lerdahl is able to achieve complexity that the mind is able to easily synthesize. The rules include adherence to a regular metric and grouping hierarchy. This allows the listener to more easily comprehend the musical surface. Lerdahl also creates functional progressions and prolongational regions in his music, thus allowing his music to be reducible and therefore hierarchically complex.

Total conformity to the rules laid out in *GTTM* would create a musical paradigm that, while musically comprehensible, would also be excessively conservative. It is through the loosening of and experimentation with these rules that interest is created in Lerdahl’s music. In fact, *Waves* often seems to be an experiment exploring the murkier areas of the rule system and testing the limits laid out by the rules. In regards to grouping and meter, tension is created by way of complex structures that locally deviate from the regular patterns of Lerdahl’s theoretical constraints, including the ideas of group overlap and elision and also metrical deletion. In *GTTM*, Lerdahl and Jackendoff admit that linear aspects were overlooked in their study; however, *Waves* emphasizes use of linear motion and contrapuntal lines, while still operating under the rule-based listening grammar. Fusion to create harmony is explored, as are compound grouping and extended motion through uncommon linear-intervallic patterns.
Tension is also realized in *Waves* through a set of stability conditions that create tonal hierarchy. Tonal hierarchy is explored by Lerdahl in the article “Tonal Pitch Space.” Most important to the idea of tonal hierarchy is the model of pitch-space. Lerdahl’s model measures both tonal weight and distance in multiple pitch alphabets. Thus pc, chordal, and regional distances are all able to be calculated in the pitch-space model.

*Waves* explores many facets of the pitch-space model. Lerdahl employs the model’s vertical measurement of tonal stability (weight) to create a tonal hierarchy. Pitch classes are introduced throughout the first seven variations in order of their weight in relation to the tonic. Each of the nontonic pcs is introduced as a stepwise diminution within either the diatonic or chromatic spaces. These diminutions are the passing and neighbor prolongational types. They are used as motives in *Waves* specifically for their prolongational qualities. Because of the diminutions, each pc is introduced as an elaboration of the tonic.

Neighbor motion is the primary means for generating harmonic progression in *Waves*. The chromatic upper- and lower-neighbors of the tonic fifth form a harmonic cell through the process of fusion. A more distant cell is then created by the fusion of stepwise pcs a major second away from the neighbor cell, or a minor third away from the tonic dyad. Each of these two cells is weighed according to its distance from the tonic fifth. Thus, the less distant tetrachord becomes dominant in function (leading to the tonic), while the more distant cell becomes a subdominant (leading to the dominant, yet still related to the tonic dyad). These cells are organized into functional progressions to form phrases and cadenced groups. By resolving tones in various ways other than those
discussed above, Lerdahl is able to create modulations and alternate resolutions to other tonics.

All of the experiments and explorations of the listener’s comprehension in *Waves* discussed above occur within through a loose-knit process known as expanding variations. This is a procedure in which a single idea is expanded upon by interpolation in a series of variations. Each variation develops the previous one, creating a reduction in reverse. This process draws upon the rules of *GTTM* by using liberal amounts of symmetry and parallelism, thus creating a musical surface that is easily comprehended by the listener. *Waves* is divided into thirteen expanding variations marked by the repetition of the initial tonic statement, which creates a flag motive. The Fibonacci series governs the length of the variations. To enhance the sense of cohesion of the work, Lerdahl unites the short, early variations by introducing all twelve pcs in order of their stability as discussed above. In the later variations, Lerdahl obscures the variation boundaries by group overlap and the inclusion of dissonant pitch material underlying the flag motive. This effect diminishes the stability of the tonic statements at the inceptions of the last three variations and ultimately lends greater weight to the opening and closing tonic statements, thus creating a large-scale prolongation over the course of the entire work.

This thesis has specifically addressed how Lerdahl’s theoretical ideas during the time *Waves* was written are incorporated into his composition. It is not a systematic analysis of *Waves*, nor is it a generative analysis in which *Waves* is broken down hierarchically. A great deal of further study would be required to fully understand this work. The development of each of the three prolongational motives throughout *Waves* could be much more thoroughly researched. Such a study would lead to a better
understanding of the accompanying material largely ignored in this study. In conjunction with such a motivic analysis, aspects of grouping and meter could be much more exhaustively studied, as could both time-span and prolongational reduction, which were largely ignored here. Such an analysis would lend further weight to the notions of development presented in this thesis.

Another direction for further study would be to consider aspects of Lerdahl’s theories not examined in this thesis. This includes the ideas of both timbral hierarchy and tonal attraction. Timbral hierarchy, which Lerdahl discussed in the article “Timbral Hierarchies,” was published just prior to Waves in 1987. In this article, Lerdahl examines whether timbres can be arranged hierarchically (using ideas presented in generative music theory and other psychological studies). The idea of a timbral hierarchy may further the study of the accompanying material mentioned above, by supporting a parsing of the music into foreground, middleground, and background timbres. Another interesting direction for further study might be to explore whether the instrumentation of the progressions in Waves timbrally reinforces or conceals the progressions. Tonal attraction, elaborated in the book Tonal Pitch Space,¹ is tied to the proximity relations discussed in the article “Tonal Pitch Space.” Lerdahl’s theory of tonal attraction has been ignored in the main portion of this thesis, as it was not set forth in publications until well after Waves was composed (2001 as opposed to 1988).

Waves is a highly intricate work, in which Lerdahl, using a highly specific set of constraints and a complex formal process, has united the listening grammar with a compositional grammar. The expanding variations begin with a single germinating cell out of which an entire twenty-minute composition blossoms. It is made up of hierarchical

¹ Lerdahl, Tonal Pitch Space, 161-79.
prolongations and progressions. It contains modulations, alternate resolutions, and large-scale processes that govern both pitch entrance and tonal organization. All of these constructs have foundations in Lerdahl’s musical theories.

This thesis has shown how ideas from a composer’s theoretical studies have influenced his own compositional process. These theoretical studies have created systematic progressions, prolongations, and complex grouping and meter. By using tonal diminutions as motives and an invented functional tonal language, Lerdahl has created a unique sense of both prolongation and progression. These theoretical processes do not mimic a particular genre of music but develop a fresh, coherent language in Lerdahl’s own style: a new tonal language.
APPENDIX A. OVERALL HYPOTHESES CONCERNING MUSICAL UNIVERSALS
DERIVED FROM THE GENERATIVE THEORY OF TONAL MUSIC

1. Musical intuitions are organized along the four hierarchical dimensions treated here: grouping, metrical structure, time-span reduction, and prolongational reduction. Each of these (with specified exceptions such as overlap) is a strictly hierarchical structure that includes every pitch-event in a piece.

2. The structure of a piece in each component is determined by the interaction of well-formedness rules, preference rules, and transformational rules, applying in essentially the way [laid out by GTTM].

3. The four components interrelate basically in the ways developed here:
   a. Grouping and meter are independent (though different idioms constrain their interaction in varying degrees).
   b. Time-span segmentation depends on meter at small levels, grouping at large levels, and the combination of the two at intermediate levels.
   c. Time-span reduction depends on a combination of pitch stability and time-span segmentation.
   d. Prolongational regions and prolongational importance are determined largely in terms of time-span importance and stability of pitch connection.
   As a consequence of b-d, the listener’s understanding of global pitch structure is strongly influenced by his local segmentation of the musical surface.

4. In order for hierarchical decisions to be made within the two reductional components, there must be criteria for the relative stability of pitch-events. This means that a given idiom must supply both a tonal center for a piece (not necessarily a tonic as defined in classical Western tonality, but a center of pitch gravity) and a scale of distance of other pitch-events from the tonal center.

5. Structural beginnings and endings of groups form significant articulations of a piece’s structure; structural endings are marked by conventional formulas (cadences of some kind).

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1 Lerdahl and Jackendoff, GTTM, 280.
APPENDIX B. THE COGNITIVE CONSTRAINTS ON COMPOSITIONAL SYSTEMS

Constraints on event sequences

Constraint 1: The musical surface must be capable of being parsed into a sequence of discrete events.

Constraint 2: The musical surface must be available for hierarchical structuring by the listening grammar.

Constraint 3: The establishment of local grouping boundaries requires the presence of salient distinctive transitions at the musical surface.

Constraint 4: Projection of groups, especially at larger levels, depends on symmetry and on the establishment of musical parallelisms.

Constraint 5: The establishment of a metrical structure requires a degree of regularity in the placement of phenomenal accents.

Constraint 6: A complex time-span segmentation depends on the projection of complex grouping and metrical structures.

Constraint 7: The projection of a time-span tree depends on a complex time-span segmentation in conjunction with a set of stability conditions.

Constraint 8: The projection of a prolongational tree depends on a corresponding time-span tree in conjunction with a set of stability conditions.

Constraints on underlying materials

Constraint 9: Stability conditions must operate on a fixed collection of elements.

Constraint 10: Intervals between elements of a collection arranged along a scale should fall within a certain range of magnitude.

Constraint 11: A pitch collection should recur at the octave to produce pitch classes.

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2 Ibid., 243-50.
Constraint 12: There must be a strong psychoacoustical basis for stability conditions. For pitch collections, this entails intervals that proceed gradually from very small to comparatively large frequency ratios.

Constraint 13: Division of the octave into equal parts facilitates transposition and reduces memory load.

Constraint 14: Assume pitch sets of $n$-fold equal divisions of the octave. Then subsets that satisfy uniqueness, coherence, and simplicity will facilitate location within the overall pitch space.

Constraint 15: Any but the most primitive stability conditions must be susceptible to multidimensional representation, where spatial distance correlates with cognitive distance.

Constraint 16: Levels of pitch space must be sufficiently available from musical surfaces to be internalized.

Constraint 17: A reductionally organized pitch space is needed to express the steps and skips by which cognitive distance is measured and to express degrees of melodic completeness.

Aesthetic Claims

Aesthetic claim 1: The best music utilizes the full potential of our cognitive resources.

Aesthetic claim 2: The best music arises from an alliance of a compositional grammar with the listening grammar.

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3 Ibid., 255-56.
### APPENDIX C. WAVES DIVIDED INTO VARIATIONS BY TIME SIGNATURES AND BEATS

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BIBLIOGRAPHY


COFFIN HOLLOW

On a point of land just below my home is a very old cemetery. This cemetery contains the graves of some Civil War soldiers who died during the Jones’s raid. It is said that one of these soldiers was killed after being captured by the Yanks. This gallant Confederate soldier fought long and hard before being shot in the leg by some unidentified traitor. He was then taken prisoner, loaded on a wagon, and started on his way to prison.

Now a certain Yankee captain had seen his brother shot down by this soldier and hated him for it. He set out in pursuit of the wagon, caught up with it, and like the lowly Yankee dog that he was, placed a bullet through the rebel’s head, killing him instantly. The reb was buried in the cemetery previously mentioned and was forgotten.

Some years later, however, the Yankee captain moved to Monongah and began courting a girl from Watson. To get to this girl’s house, he had to ride past the cemetery where the soldier was buried. On the first night that he passed the grave, he heard a loud rumble and then that blood-curdling rebel yell. Looking up toward the cemetery, he saw the soldier he had killed, seated atop his coffin, riding it over the hill toward him.

The ex-captain gave a scream, wheeled his horse around, and ran for home. The ghost followed him only as far as the mouth of the hollow, there turning back to his grave. This went on for months on end, until one night some of the captain’s friends found him shot through the head with an apparently very old and previously used bullet.

Now these men had heard the captain’s story and also knew that the bullet had never been removed from the dead rebel’s head. They quickly went to the graveyard and opened the dead man’s grave. They found there, to their horror, that the bullet was gone from the reb’s head and in his hand was a still-smoking revolver.

From that time on, the wild rebel scream has never again echoed through the hollow, nor has the dead soldier ridden his coffin over the hill. However, to this day, the hollow where this took place is still called Coffin Hollow, and I can still show you the grave of the dead rebel.

- from Coffin Hollow and Other Ghost Tales, edited by Ruth Ann Musick.
COFFIN HOLLOW PERFORMANCE NOTES

Coffin Hollow is a study of expanding variations, a formal process developed by composer and theorist Fred Lerdahl. During performance, tempo markings are flexible in only the extent that the latter section of the work (designated: \( \frac{\dot{q}}{4} = 120 \)) must equal a tempo one-fourth faster than the first section (designated: \( \dot{q} = 90 \)). For example, the opening section of the work might begin with a metronome marking of \( \dot{q} = 84 \), which would place the latter section of the work at \( \dot{q} = 112 \). While this allows some freedom, chosen tempos should not be excessively faster or slower than those given.

STAGE LAYOUT

- \( \ominus \) = bass drum
- \( \Box \) = tenor drum
- \( \Box \) = very low tom-tom
- \( \ominus \) = log drum
- \( \Box \) = suspended cymbal
- \( \mathcal{P} \) = bamboo wind chimes
- \( \mathcal{O} \) = brass wind chimes
- \( \mathcal{O} \) = tam-tam
- \( \mathcal{O} \) = single D chime
- \( \mathcal{T} \) = claves, shaker, and spring
- \( \mid \) = music stand for score or mallets

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GUIDE TO NOTATION

The ensemble

1) Many techniques throughout the score occur over the length of many beats within the given meter (for example: a glissando). To aid the performer, the metric duration is given beneath the technique as a rest value in parentheses: (2)

2) Feathered beaming is used throughout the score. Feathered beaming does not indicate an accelerando or ritard, but rather a regular, but unmetered increase or decrease of the number of notes occurring within a given duration:

3) A boxed collection of notes means that those notes are to be played in no specific order as quickly as possible without regards to rhythm. The arrow indicates duration within the given meter:

Alto Flute

All flute multiphonics, harmonics, and extended techniques can be referenced in The Other Flute by Robert Dick. Contemporary notation used in this score is as follows:

1) Pitched key slap:

2) Pitchless key slap:

3) Tongue-pizzicato:

4) Tongue-stop:

5) Multiphonics are notated: These will always include a suggested fingering.

6) Harmonics are notated: The diamond notehead refers to the harmonic fundamental. The arrow indicates an intonation adjustment by the performer.

7) Resonance trills are notated: These will always include both the traditional fingering along with an alternate fingering. Resonance trills should occur steadily at an eighth note pulse.

8) Non vibrato notes are labeled n.v. This labeling impacts only the note above which the label occurs.
Clarinet

All clarinet multiphonics and other extended techniques can be referenced in *New Directions for Clarinet* by Phillip Rehfeldt. Contemporary notation used in this score is as follows:

1) Pitched slap tongue:

2) Multiphonics are notated: These will always include a suggested fingering.

3) Resonance trills are notated: These will always include both the traditional fingering along with an alternate fingering. Resonance trills should occur steadily at an eighth note pulse.

4) At times the clarinetist will be asked to breathe heavily in and out of the instrument. This technique is notated: The arrow refers to the duration of the breathing. The clarinetist may also be specified to breathe in or out specifically:

Percussion

The set-up given is merely a suggestion. The percussionist is welcome to set-up in his or her own fashion to better serve the performance.

1) The percussion score is notated as a one-line staff. It may briefly split into two staves to show multiple instruments struck simultaneously or to avoid clutter:

2) Unless otherwise noted, the percussionist is to use traditional mallets or sticks for all instruments. Soft mallets are used for any dynamic below *mf*, hard mallets for any dynamic above *mf*.

3) The percussionist is often asked to play inside of the piano. The percussionist is to softly roll his hand around the strings in a circular motion. This is meant to distort, but not entirely conceal what the pianist is playing:

4) At times the percussionist is asked to scrape two crash cymbals together. This is done by scraping the rim of one cymbal into the inner cup of the other. The rim of the cymbal may be coated with rosin or grease to induce the pitch more quickly. This technique is notated:
The pianist is asked to play many passages of this score on the strings inside of the piano. Preparatory markings should be made by the performer to designate specific strings. Those strings are: E\#1, G1, B1, C2, E\#2, F2, C3, E\#3, E3, B\#3, F3, C4, F4, F\#4, C\#5, and D5. The pianist is to resume playing at the keyboard at the *ordinario* or *ord.* indication.

1) When playing a pizzicato, the pianist is to pluck the string while holding down the damper pedal. It is notated:

2) The pianist is asked to run a fingernail along a string while holding down the damper pedal. This creates a metallic scraping sound. It is notated:

3) The pianist is at times asked to glissando across strings while holding down the damper pedal:

4) At times the performer is asked to dampen a string with his or her finger when striking the note at the keyboard. The finger should be placed where the maximum residual tones are produced

5) Tight clusters of notes may contain semi-tones residing on the same line of the staff. These are notated: and are to be played simultaneously with the other pitches in the chord.

6) Clusters are notated: When no specific pitches are introduced before the cluster, the pianist is asked to mash the notes of the keyboard with the palm of his or her hand beginning with the lowest pitch.

7) A diamond notehead indicates that keys are to be depressed silently:
Violin

The following non-standard and contemporary techniques are used in Coffin Hollow:

1) Nail pizzicato:  
2) Circle bow:  
3) Glissando:  

4) Scratch tone: This is achieved by placing heavy pressure on the strings with the bow. There are two types of scratch tones used in this score-pitched and pitchless.

5) A dashed arrow refers to bow pressure. The circle at the bass of the arrow refers to traditional bow pressure. The arrow points toward an increase in pressure. Often the arrow will indicate an increase in pressure from traditional pressure to a pitched or pitchless scratch tone.

6) Often a pitchless scratch tone and a glissando are to occur together. This is notated: At times a scratch tone glissando is notated as a quadruple stop. It may not be possible to play all four tones simultaneously. At these points, noise increasing in frequency is preferred over any pitch, so four strings are not necessary.

7) Natural harmonics are notated as the pitch that is to be sounded:

8) Artificial harmonics are notated: The played pitch is the bottom-most pitch. The diamond notehead is the touched pitch, and the small note in parentheses is the sounding pitch.

9) Multiple stops are played in one of two ways – the first is with an arrow indicating the arpeggiation direction: The second is with a bracket, meaning that the notes are to be played as close to simultaneously as possible.
The following non-standard and contemporary techniques are used in *Coffin Hollow*:

1) Nail pizzicato:  
2) Circle bow:  
3) Glissando:  

4) Scratch tone: This is achieved by placing heavy pressure on the strings with the bow. There are two types of scratch tones used in this score-pitched and pitchless.

5) The dashed arrow refers to bow pressure. The circle at the bass of the arrow refers to traditional bow pressure. The arrow points toward an increase in pressure. Often the arrow will indicate an increase in pressure from traditional pressure to a pitched or pitchless scratch tone:

6) Often a pitchless scratch tone and a glissando are to occur together. This is notated: At times a scratch tone glissando is notated as a quadruple stop. It may not be possible to play all four tones simultaneously. At these points, noise increasing in frequency is preferred over any pitch, so four strings are not necessary.

7) Natural harmonics are notated as the pitch that is to be sounded:

8) Artificial harmonics are notated: The played pitch is the bottom-most pitch. The diamond notehead is the touched note, and the small note in parentheses is the sounding note. At times, the performer will be asked to touch a node while another note is performed. This is notated as:

9) The direction of the arpeggiation for triple and quadruple stops is notated with an arrow:
Violoncello (cont’d)

10) The cellist is asked to play the strings below the bridge. Pitches below the bridge are indefinite. In this score they are notated with a cross notehead at the open pitch of the string:

11) A triangle with a durational arrow: \( \text{Bow tailgut} \) indicates that the performer is to bow the tailgut of the cello (the metal bar connecting the peg to the tailpiece).

12) The cellist is often asked to tap on the body of the cello in a percussion-like manner. This is notated on a separate staff below the cello line:

13) A quavered line without an arrowhead indicates to rapidly strum the strings of the cello with the hand:
Coffin Hollow

Distantly, as if emerging from the mists ($\frac{3}{4}$ = 90)

Alto Flute

Clarinet in Bb

Percussion

Piano

Violin

Violoncello

Bass drum tapped with fingers

Tap on cello body

Tap on cello body

Dry pizz.

At the tip
with increasing energy

\[ \text{pppp} \]

\[ \text{pp} \]

\[ \text{ppp} \]

\[ \text{mf} \]

\[ \text{mp} \]

\[ \text{p} \]

\[ \text{mp} \]

\[ \text{mf} \]

\[ \text{p} \]

\[ \text{mp} \]

\[ \text{mf} \]
With intense loneliness.

1. Fl.
2. Cl.
3. Perc.
4. Pno.
5. Vln.
6. Vc.
* The arrowhead direction indicates the amplification of intensity.
Bamboo wind chimes

Very dull, overly pitched

* Achieve scratch tone, but do not obscure pitch.
* The performer is to play the boxed notes at random as fast as possible.
With increasing malism

Very low tom-tom with timpani mallets

* The cellist is to apply as much bow pressure as possible to the strings, creating a pitchless scratch. The cellist will then raise the pitch through glissando as high as possible in the given duration. All pitches are approximate.
B With conflicted emotion

Tap fingers on v.c. body

Pizz.

3/4 Bamboo wind chimes

Field drum with snares off

Field drum with timpani mallets

sub. ff

mp

Dry pizz.

At the tip

Scratch trem. on random pitches arrived at after gliss.

* Scratch trem. on random pitches arrived at after gliss.
With a driving anxiety ($j = 120$)

Gently roll a hand in circular motion around piano strings

Roll on Tam-Tam with soft mallets

Scratch

Bow pressure

Bow pressure
A. Fl.

Cl.

Perc.

Pno.

Vln.

Vc.

Field drum with snares on

Suspended cymbal

Flutter pedal to dampen resonance

bow pressure

Scratch

gliss.
Pitchless key slaps*

(Leave index finger up)

* Pitch notations are for convenience only
Breathe slowly and heavily in and out of Clarinet

Roll hands in circular motion around piano strings

Inside pf. body (approximate pitches)

Scratch

Bow tam-tam

Tongue-stop

Brass windchimes

Bow tam-tam
Adjust intonation to match Vc.
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A. Fl.

Breathe into instrument heavily

Cl.

Breathe out

Perc.

ppp

Pno.

Dampen note with finger

Vln.

(no trem.)

Vc.

Widen trem.
D An ominous rumination

Breathe in harshly

Tam-tam with timpani mallets

Breathe out

Percussion

Piano

Violin

Viola

Vc
Breathy

Breathe in and out of instrument

D Chime

sul tasto

ord.