Lerdahl and Jackendoff's Strong Reduction Hypothesis and the Limits of Analytical Description

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1.0 Introduction

Socrates is taller than Theatetus—true or false? This question is often used to illustrate one of the basic goals of philosophical inquiry, which is to come up with true descriptions of the world, as well as to introduce students to the conventions of philosophical argument. The exegesis of this question runs along the following lines: When Theatetus was just a boy, Socrates was indeed taller than Theatetus, and so the statement is true. But as the years went by, Theatetus grew into a tall man, whereas Socrates was always a rather short fellow, and so at this later point, the statement is false. This parable illustrates the fact that one cannot simply say "Socrates is taller than Theatetus," since this statement, in being both true and false, is incoherent. Now the reader may claim that all one needs to do is simply specify the domain over which the statement applies, and so one can say something like, "When Theatetus was a boy, one could say that 'Socrates is taller than Theatetus.'" This approach attempts to define the conditions under which the statement is true. But, as the saying goes, "True under certain conditions . . . that is to say, false." For one of the desiderata of analytical philosophy is free repeatability, that is, to be able to make tenseless statements that are simply true, such as "2 + 2 = 4." The grammatically astute will have noticed a tense agreement problem in the conditional version of the statement, for if

I am talking about "when Theatetus was a boy" then I also ought to say that at that time "Socrates *was* taller than Theatetus." But analytical philosophers don't want to make such tense-conditional statements.

Now the foregoing example might seem to illustrate very little (other than that analytical philosophers seem to have some very arcane concerns), but the point of the following pages is that music theorists very often have similar analytical urges. Marion Guck has pointed out that in theorists' discussions of tonal function, "we often talk as though such things as harmonic function are unequivocal aspects of a sound—e.g., a chord is or is not V. . . . [whereas] on the contrary, function can be weakly or strongly projected" (Guck 1993, 50, n. 7). Even if we admit that there are some aspects of musical description and analysis that are or may be equivocal, more often than not we still pursue these aspects as if they could be made unequivocal—that is, while under one set of conditions (perhaps when we first hear a particular chord) we are able to make some claim regarding its function, under another set of conditions (perhaps when we hear a few of the following chords) we can revise the initial claim, and then get it right. Thus, dominant sevenths are transformed into augmented sixths, and that is the end of it. Indeed, this is perhaps the chief theoretical assumption in any final-state analysis: at the end of the piece the structural function of each and every musical element becomes clear, and in this clarity one is able to reconcile any and all doubts or ambiguities regarding those portions of the piece that had posed a problem when they first occurred.

David Lewin presents a complex and subtle critique of this kind of final-state analysis in his well-known discussion of a single G^6 chord in m. 12 of Schubert's *Morgengruss* (Lewin 1986). For this one harmony Lewin provides a list of contexts in which this musical object may be considered, along with examples of the sorts of perceptions, relationships, and descriptive statements one could make about the G^6 in each context. Even though some perceptions and descriptions contradict others, they are not mutually exclusive:

> What-p_9-perceives includes the perception that p_2 does (did) in fact make sense, even though it was (is) "denied" by p_{3b} and "virtually annihilated" by p_5. . . . To put the matter more elegantly: p_2, p_{3b}, p_5, and p_9 are not all cohabiting the same phenomenological place at the same phenomenological time. They are different objects (or acts) in different parts of phenomenological space-time, exercising a variety of interrelationships. (Lewin 1986, 356; "p_x" is his notation for individuating the various perceptions that attach to this musical object.)

Lewin thus argues that for a single musical event there may be (and perhaps usually are) a number of separately true and valid analytical descriptions.[1] Moreover, he urges us not to assume that amongst these various analytical descriptions one can or should choose one as the single, best, "truest" account of the musical object. However, within each separate phenomenological continuum, Lewin suggests that one can make more or less determinate descriptions in some analytical language. This is because he believes that one has but a single perception of a musical object at any given time (1986, 368-70). So, for example, one cannot perceive a chord as being both a dominant and a tonic at the same time, though one might be able to regard the chord as a tonic in one continuum and as a dominant in another.

Yet there may be some contexts in which: (a) we can and do perceive a single event as two different things at the same time, as in the case of a phrase overlap where one event is heard simultaneously as the end of one rhythmic group and the beginning of another;[2] (b) there are events that are ambiguous, that is to say, indeterminately perceived as either X or Y in some context (but the listener is unable to make any more definite description of the event); and (c) there are contexts in which we are simply unable to perceive (and hence describe) any particular parametric structure (e.g., an extended modulatory passage in which one ceases to make any assignations of scale degree or functional category). This suggests that one can take Lewin's arguments a step further. For if listeners are able to inhabit the various phenomenological continua that Lewin lays out, then it seems plausible that they are also able to inhabit "meta-continua" in which they are aware of the tensions and antinomies between their lower-level perceptions and descriptions. In these latter perceptual contexts one may have many-to-one relationships, ambiguity, and, perhaps most interestingly, outright uncertainty.

In *A Generative Theory of Tonal Music* (1983; henceforth *GTTM*) Fred Lerdahl and Ray Jackendoff have crafted one of the most comprehensive and carefully thought-out theories of rhythmic and

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[1]See also Jackendoff (1991 & 1992) for discussions of a similar "parallel multiple analysis model."

[2]Indeed, it may be quite useful and interesting to sort out those parametric domains where such coextensive percepts and descriptions are possible versus those domains where only the singular sorts of perception and description described above occur. For example, while a single rhythmic event can be heard as both a beginning and an end, metric events cannot be heard in such an equivocal fashion (and hence the notion of a metric overlap or elision is problematic). A full discussion of this, alas, must be saved for another paper.

tonal structure. *GTTM* is the final-state model *par excellence* of the discipline. Through the interrelated processes of grouping analysis, metric analysis, timespan reduction, and prolongational reduction, Lerdahl and Jackendoff are able to provide not merely a comprehensive analysis of a musical structure, but have framed this analysis as an account of the listener's mental representation of his or her final-state knowledge of that musical structure. More precisely, *GTTM* produces a representation cast in terms of a structural description written under their cognitively based grammar (*GTTM*, 2; see also Jackendoff 1987 and 1991). Consider their analysis (*GTTM*, 35) of the grouping structure of the opening measures of Beethoven's *Hammerklavier* sonata (ex. 1).

Example 1. Analysis of Beethoven, Sonata No. 29, Op. 106, mvt. I, mm. 1-17 from Lerdahl and Jackendoff (1983, 35)
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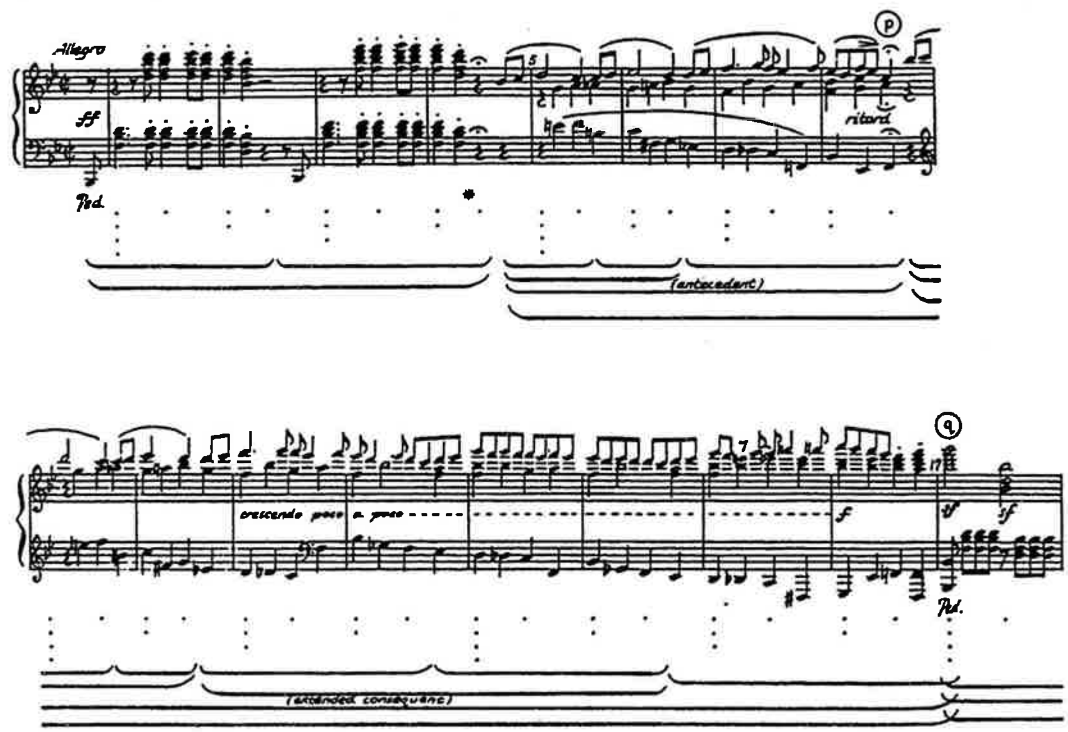

This analysis shows all parts neatly nested and with each structural level in a clear subordinate or superordinate relationship to the other parts of the rhythmic hierarchy. However, a reading more sensitive to ambiguities of grouping structure within these measures might look something like example 2.

Example 2. Alternative analysis of Beethoven, Sonata No. 29, Op. 106, mvt. I, mm. 1-17

This grouping structure contains overlaps, gaps, conflicts, and mismatches, though its broad hierarchic outlines remain intact. If in listening to this music we cannot sort it all out, then any analysis that overstates the confidence and precision with which group boundaries are marked is in some sense misleading. More problematic than individual analyses is a theoretical framework that engenders such analytical overconfidence. *GTTM*, as a result of its Strong Reduction Hypothesis (henceforth SRH), explicitly requires resolute analytical decisions, whether or not the music supports such decisions. The focus of this paper is a critique of the SRH through the exegesis of a number of problematic grouping structures.[3] In a more general sense this critique could be mounted against any number (if not most) analytical methods, to the extent to which they operate by assigning

[3]Though the focus is upon the analysis of rhythmic grouping structures, the more general points made herein can be applied to other analytical domains. Furthermore, grouping structure is often regarded as an unequivocal aspect of musical structure (or at least more unequivocal than, for instance, tonal relationships). One reason for focusing upon grouping structure is to show how even the most mundane aspects of analytical description may have both covert and overt difficulties.

a single analytical descriptor to each individual musical event. In other words, some version of the SRH is usually operative whenever we embark upon an analytical journey. Lerdahl's and Jackendoff's work is the focus here because: (a) they are forthright in overtly stating their SRH, why they hold to it, and, most notably, under what conditions they might be forced to abandon it; (b) in their discussion of grouping analysis in particular they make especially clear the way in which the presence of the SRH delimits the range of permissible grouping structures within their analytical system; and (c) as will be shown, even without the SRH, much (if not most) of the *GTTM* analytical system can still operate effectively.

In the second part of this article a number of problematic grouping structures will be discussed. First, a normative case (the opening measures of Mozart's Piano Sonata K. 283) will be presented, followed by an instance of a parenthetical group (in Haydn's String Quartet Op. 50, No. 3). Instances of ambiguous relationships among subgroups, including the opening measures of Mozart's G-minor Symphony, K. 550, as well as a case of grouping overlap (in Schubert's B-flat Piano Trio) will next be explored. Lastly an example of conflict between prospective versus retrospective locations for group boundaries (in the finale of Haydn's Symphony No. 92) will be considered. Along the way in presenting these examples various particulars of the *GTTM* grouping theory will be examined when appropriate. In the third part of the article, the SRH will be gone over in some detail and an alternative hypothesis, a weak reduction hypothesis, will then be proposed. In the closing section of the article a number of possible motivations for the SRH, both in the particular case of *GTTM* and in music theory in general, will be considered, concluding with a few remarks on music theory as a scientific endeavor.

2.0 Some Problematic Examples of Grouping Structure

2.1 A Normative Instance: Mozart's Piano Sonata K. 283

If a piece of music is a more-or-less contiguous stream of sound events, then in large part music analysis is concerned with the segmentation of this stream into parts, subparts, and so on. Musical analysis is also concerned with the ways in which these parts are internally and externally bound together. Furthermore, clarity and precision are what we value in analysis—we generally do not prefer an analysis that, after looking at the interplay of rhythm, meter, pitch processes, and harmony, concludes merely that the phrasing in a given passage is hopelessly murky. Therefore, it is most pleasing when the outcome of one's analytical efforts looks something like example 3.

Example 3. Analysis of Mozart, Sonata K. 283, mvt. I, mm. 1-4

An analysis of the grouping structure of the right-hand part of the first four measures of Mozart's Piano Sonata in G, K. 283 is given below the staff; it shows three levels of structure whose boundaries are recognized by the onset and offset of pitch/durational patterns. This sort of grouping structure, with clear boundaries for each unit and a clear sense of intralevel nesting, passes as a textbook example for grouping well-formedness according to *GTTM*. But the opening melody of K. 283 is, in fact, a rather exceptional passage: the boundaries of each group are marked by rests, melodic and rhythmic patterning, explicit articulation, harmonic change, register, and meter. Most group boundaries do not contain anything close to this degree of parametric redundancy.[4] So this example is given as a cautionary aside, even though the account of its grouping structure given above is perfectly right and proper. It will be useful to contrast this analysis with other analyses that, though similar in form, attach to rather different musical structures.

2.2 A Parenthetical Group

Leonard Meyer defines musical *parenthesis* as "internal prolongations which, while not affecting established implications, interrupt the musical structure, usually after arrival at some point of provisional stability. Because they do not really 'belong' to the preceding and following patternings, such internal interruptions have been called *parentheses*" (1973, 239). Example 4 shows Meyer's parenthetical illustration, using Haydn's String Quartet Op. 50, No. 3, mvt. IV.

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[4]All too often the opening measures and/or themes of classical movements are used as models for rhythmic, metric, and tonal structure. Yet opening measures have special functions: they must establish key, pulse, meter, principal motive, principal register and/or timbre, and so forth. In these passages, where durational patterns and groupings cue the metric organization, the overwhelming redundancy such as is found in K. 283 is both useful and necessary. It does not follow, however, that the rhythmic hierarchies one finds in the first eight measures will serve as archetypes for the rest of the piece (in particular) or for musical hierarchies (in general).

Example 4. Analysis of Haydn, Quartet Op. 50, No. 3. mvt. IV, mm. 1-12 from Meyer (241)

After an extensive analysis of the melodic structure of the passage, Meyer concludes that "we recognize at once that measures 5-8 are not part of the 'real' melody. . . . [T]he real melody is characterized by goal-directed motion, but the parenthesis is static. It is as though a person purposefully striding toward some objective should suddenly pause, perform a dancelike caper, and then continue to his objective" (1973, 241). The parenthetical nature of mm. 5-8 becomes readily apparent when one attempts to perform a grouping analysis and/or prolongational reduction following Lerdahl and Jackendoff's analytical method.

Example 5 lists a series of possible groupings for this passage. Example 5a presents the grouping structure of the passage through m. 8. At that moment we can hear mm. 5-8 as a prolongation of the initial tonic harmony, specifically a prolongation of $\hat{3}$, which functions as the goal of the melodic sequence in the first four measures. As the passage continues, however, mm. 5-8 may also be regarded as an antecedent to the articulation of $\hat{3}$ in m. 9. Thus one is tempted to revise the grouping analysis by bracketing mm. 5-8 with mm. 9-12, as indicated in example 5b. Yet example 5b is not really adequate either, as it ignores our initial understanding of the passage as given in example 5a. In order to include both our prospective and retrospective understanding of mm. 5-8, one might indicate some sort of grouping overlap, as given in example 5c.[5] Nor is this sufficient, for the overlap would seem to indicate that mm. 5-8 give rise to an interlocking and

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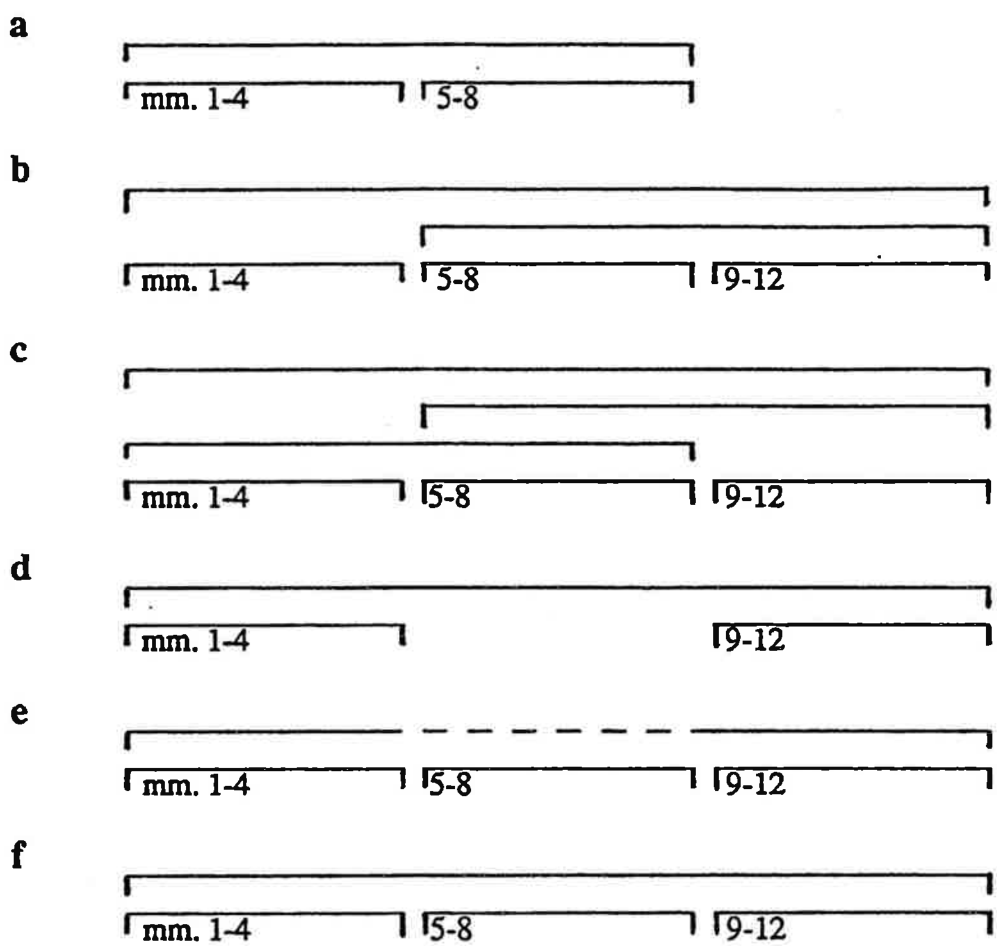
[5]Lerdahl and Jackendoff's grouping well-formedness rules are discussed in detail below (section 3.1). Here it will be sufficient to note that examples 5c, 5d, and 5e are not well-formed groups according to *GTTM* (though the grouping overlap in example 5c is permitted via a transformational rule).

hence tightly bound structure for the entire passage, which, at least according to Meyer, is precisely the opposite of their parenthetical function. Perhaps, then, we should analyze the grouping either as example 5d, where mm. 5-8 are simply a gap in the larger group, or as example 5e, where the three contiguous phrases do not form a continuous group on higher level. Of course, one could just ignore the problems created by the parenthesis and simply claim that there are three phrases that form one large group, as in example 5f; however, this would seem to be an oversimplification of the grouping relationships in the passage. Moreover, this oversimplification constitutes a misrepresentation of the grouping structure of the passage in that it ignores the discontinuity created by mm. 5-8.

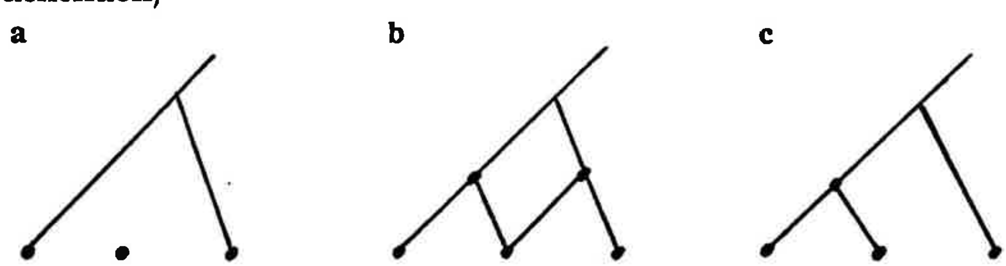
When we attempt to represent the prolongational structure of this passage, other problems arise. Example 6 contains a series of possible prolongational trees for this passage. The task here is to decide how to connect the node representing mm. 5-8 to the surrounding timespans—is it a left branch or right branch? If we want the timespan reduction to reflect the sense of parenthesis, we could just refuse to construct the branch and leave the node unattached (ex. 6a). Alternatively, as a neutral prolongation of $\hat{3}$ we could connect the node with two branches, one in each direction (ex. 6b). However, these two timespan reductions are forbidden by *GTTM*'s well-formedness constraints on tree-structures (113-14, as well as ch. 7 passim). A third choice (and one that follows the *GTTM* prolongational preference rules) would be to default to a right branch (ex. 6c). However, this forced choice does not accurately reflect the above understanding of these measures since it implies a rather cut-and-dried (though weak) sense of prolongation of the initial tonic.

The larger issue here is how to deal with discontinuous musical gestures and the noncontiguous grouping structures they create. If a measure or a phrase (or even a formal section) is understood as an interruption within the context of a larger gesture, then we are faced with a problem when such structures are to be described under a theory which demands that all groups exhaustively and recursively nest and that all events form a continuous left-to-right stream.

Example 5. Possible grouping structures for example 4



Example 6. Alternative branching structures (after Lerdahl and Jackendoff)



2.3 Ambiguous Relationships Among Subgroups

2.3.1 Grouping the Elements of an Extended Anacrusis

Mozart's G-minor Symphony, K. 550 begins with an often-discussed extended anacrusis (ex. 7). My commentary shall focus on the first two measures of the passage and on the groups that occur on the half-bar and full-bar levels. According to the analysis in *GTTM,* the first two instances of the two-eighth/quarter-note figure (E♭^{5}-D^5-D^5) each manifests itself as a group on the half-bar level and the remaining notes (up to and including the rest in the second measure of the example) form a single group. Lerdahl and Jackendoff also claim that the first two iterations of the E♭^{5}-D^5-D^5 figure form a group in their own right, a group that balances the duration of the following group, thus forming a symmetrical structure (see their discussion of GPR 5, *GTTM,* 49-50). One could also argue that a grouping pattern, once established, tends to perpetuate itself (if possible), and so one can describe the single group formed by the E♭^{5}-D^5-D^5-B♭^{5} as the product of a grouping overlap (ex. 8). (Overlaps are discussed in greater detail in the following section.)

Example 7. Analysis of Mozart, Symphony No. 40, K. 550, mvt. I, mm. 1-4 from Lerdahl and Jackendoff (1983, 48)
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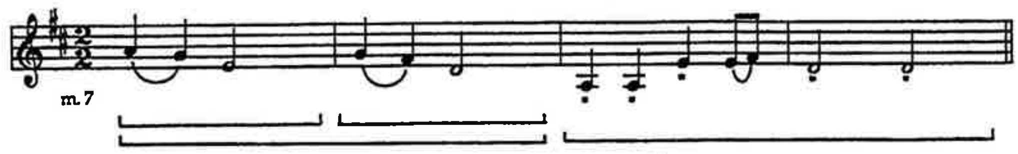
Example 8. Grouping overlap in Mozart, Symphony No. 40, K. 550, mvt. I, mm. 1-2

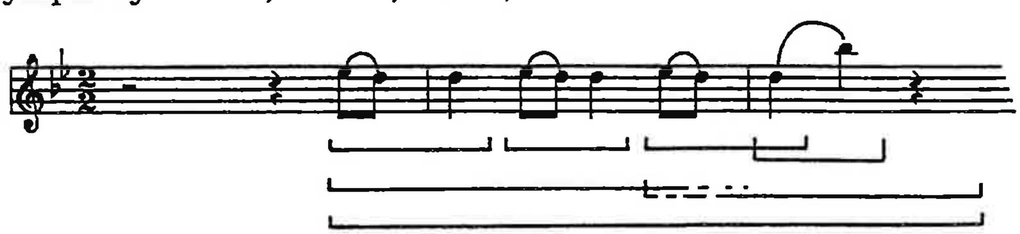
Nonetheless we may accept the lowest level of grouping posited by Lerdahl and Jackendoff as a given; my argument lies with their combination of the first two half-bar groups into a larger group on the basis of symmetry. Such (1+1)+2 grouping structures are, of course, quite possible (ex. 9).

Example 9. (1+1)+2 grouping in Haydn, Symphony No. 104, mvt. IV, mm. 7-10



In the finale of Haydn's *London* Symphony, mm. 7-8 (each a group in its own right) form a larger unit that balances mm. 9-10 (note, however, the substantial melodic contrast between mm. 1-2 and mm. 3-4). But the opening of K. 550 is quite different, as its groups collectively form an extended anacrusis, an unstable gesture that leads to the anchoring point of stability on the downbeat of m. 4. It seems counterintuitive to place the first two presentations of the half-bar E♭^{5}-D^5-D^5 motive into a separate group that supposedly balances the following one-bar timespan. I am especially uncertain how to relate the middle group to its surrounding groups, for while it is a continuation of the first group, it is also an anticipation of the third. Each presentation of the E♭^{5}-D^5-D^5 motive is an insistent reiteration of anacrustic function, a refusal to let the phrase begin. If pressed, I might suggest example 10, which shows a series of successively revised groups. At the top of the analysis are the half-bar groupings (including the overlap) as they are clearly manifest in the durational pattern of the music.

Example 10. Alternative grouping structure in Mozart, Symphony No. 40, K. 550, mvt. I, mm. 1-2

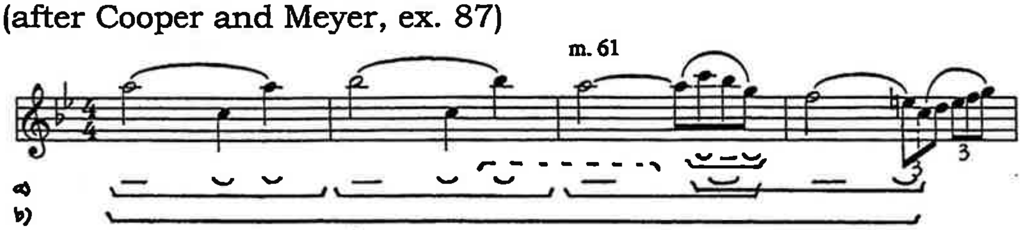


This passage is not balanced, at least not in terms of its kinetic qualities (and hence in terms of the articulative stability that is a precondition for group boundaries). Instead, it is a continuous sweep through the three iterations of the anacrustic figure to its point of arrival on the downbeat of m. 3.[6] The grouping analysis in example 10 is an attempt at acknowledging this rhythmic sweep and the problems it creates with respect to the grouping structure of the passage. Lerdahl and Jackendoff are aware of the kinetic qualities of this passage, and they argue that "the inner tension of this music is in part a product of the rhythmic conflict between the periodicity of the metrical structure (reinforced by the accompaniment) and the complexity of the time-spans resulting from such out-of-phase conditions" (*GTTM,* 127). On the contrary, the inner tension in this extended anacrusis comes not from the out-of-phase condition between meter and grouping, for of course these same out-of-phase conditions also obtain with respect to the opening measures of K. 283. Rather, it comes from the instability of the grouping structure itself.

2.3.2 Grouping Overlaps

Another problematic grouping structure occurs when a single musical event (which may itself be a group) is held in common by two adjacent groups. Example 11, mm. 59-62 from Schubert's Piano Trio in B♭, is taken from Cooper and Meyer (1960, 70).[7] The second half of m. 61 is common to two groups, and thus a grouping overlap is created.

Example 11. Schubert, Piano Trio D. 898, mvt. I, mm. 59-62 (after Cooper and Meyer, ex. 87)



Lerdahl and Jackendoff also discuss grouping overlaps in their more formalized theory, but they do so in an interesting fashion. On the face of it, an overlap such as that found in example 11 violates their Grouping Well-Formedness Rule #4: "If a group G_1 contains part of a group G_2, it must contain all of G_2" (*GTTM,* 38). They are quick to add, however, that:

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[6]Even though this downbeat is a likely location for the structural downbeat of the phrase, and hence of the transition from arsis to thesis within the passage, we are not certain of this fact until the B♭[5] is sounded on the second beat of the measure, forming the leap that convincingly and dramatically breaks the motivic repetition.

[7] I have included Cooper-and-Meyer-style analytical symbols, marking the strong and weak members of the group as befits their analysis.

> There are in fact cases in tonal music in which an experienced listener has intuitions that violate GWFR 4. Such *grouping overlaps* and *elisions* are inexpressible in the formal grammar given so far. However, since overlaps and elisions occur only under highly specific and limited conditions, it would be inappropriate simply to abandon GWFR 4 and permit unrestricted overlapping of groups. Instead overlaps and elisions receive special treatment within the formal grammar, involving *transformational rules* that alter structure. (*GTTM,* 38)

Thus an overlap is a surface structure that is formed when an underlying structure, which does not contain an overlap, is changed via a transformational rule. This transformational process can be shown as in example 12. Example 12a shows two groups with separate and distinct boundary elements. In example 12b this passage has been transformed into an overlap, as the G^5 is now common to both groups. Finally, in example 12c this G^5 is ornamented, creating the overlap found in example 11 (see the transformational rules for groups, *GTTM,* 55-62).

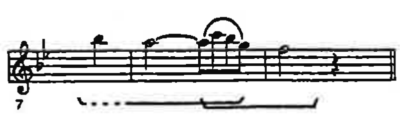
However, the use of transformational rules is not without problems. As Lerdahl has noted, "If the TRs [transformational rules] could apply arbitrarily, any absurd analysis would be admissible . . . A set of preference rules (PRs) is needed to model the requisite intuitions and constrain the application of the TRs" (Lerdahl 1991, 279). Accordingly, transformational rules play a fairly limited role in Lerdahl and Jackendoff's theory (*GTTM,* 11). While it is perhaps impossible to develop a generative theory that, while based on a manageable number of base structures, does not involve some transformational rules, why is it that overlaps cannot be included into the base structure of the grouping component of their theory? Constraints could then be added to delimit the contexts in which overlaps could occur (that is, only in cases of grouping juncture). The answer to this question is that the inclusion of overlaps would then create subsequent problems with the binary logic of the *GTTM* timespan and prolongational trees. That is, if the hierarchic structure is to be represented by binary trees (or more abstractly, by binary sub- and superordinate relations), then base structures that contain overlaps will generate unsatisfactory trees. What is intriguing about the original form of the *GTTM* theory is these constraints do not seem to be motivated by any empirical rationale, since overlaps are quite common.[8] Instead, the constraints on overlaps seem to stem from the SRH itself, as shall be shown in section 3.0 below.

Examples 12a, b, and c. Transformational process producing overlap in example11.

(a)

(b)

(c)



2.4 Retrospective Relocation of a Group Boundary

In the previous two examples the problem one confronts is one of how to relate the various components of the group to each other—while the boundaries of each lower-level group were clear, their higher-level relationships were unclear. In other instances it is the location of the group boundary itself that is in question (ex. 13). On the second beat of m. 4 there is a clear sense of arrival on tonic harmony following the inflection to the dominant. Had the following phrase been a varied repetition of the first, creating a parallel period, our sense of a group boundary between mm. 4 and 5 would have remained secure (ex. 14). Yet in Haydn's version the cadential arrival at m. 4 is undermined by the motivic repetition in mm. 5-6; when the melodic and harmonic

[8]See, for example, Cooper and Meyer (1960) for many examples of overlapping and interlocking groups.

Example 13. Haydn, Symphony No. 92, mvt. IV, mm. 1-8

arrival in m. 4 is heard within the context of a sequential passage, its sense of closure and phrase articulation is retrospectively weakened. How definite are the group and phrase boundaries between mm. 4-5 in the ear and mind of the listener once she has heard the entire passage? The structure of one group (mm. 5-6) directs one to retrospectively recast one's understanding of the grouping structure of that which preceded it. Indeed, are not most of our judgments of group boundaries subject to retrospective confirmation or revision? Even once we make our final-state analysis, these articulations are not yes-or-no propositions, but rather a matter of degree.[9]

Example 14. Author's recomposition of example 13

[9]If not all group boundaries on the same level mark closure to the same degree, it then behooves one to examine one's analytical symbology if it tends to represent all group boundaries in the same fashion (implying more-or-less equal degrees of articulation and closure). On the importance and influence of analytical symbology see Narmour (1984).

3.0 Reduction Hypotheses

3.1 The Strong Reduction Hypothesis of GTTM

The bedrock of the *GTTM* model is the Strong Reduction Hypothesis. Lerdahl and Jackendoff approach the SRH by first positing a general reduction hypothesis (GRH): "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" (*GTTM,* 106). Note that this general hypothesis does not say that the listeners *will* organize the pitch-events, but only that they will *attempt* to organize those events. With this telling hedge Lerdahl and Jackendoff recognize that the GRH involves an assumption that may not always be warranted, for there are times when the listener's attempts at organization are doomed to failure—and that, perhaps, is often the musical and aesthetic point. Lerdahl and Jackendoff themselves are quick to acknowledge the reductive price they have had to pay in the pursuit of formal rigor. They note that:

> It might be thought arbitrary to have to attach a subordinate event . . . either to the preceding . . . or . . . ensuing event. One might argue instead that subordinate events should appear simply in between structurally more important events at the next smaller reductional level, and therefore that a "network" notation . . . is more appropriate. In response, we observe that the sheer geometry of networks creates insuperable notational difficulties once even a moderate number of events are considered together; network notation is simply impracticable for the analysis of real pieces. . . . A more substantive reason for maintaining both left and right branching is that it enforces the generally pervasive intuition that subordinate events are elaborations of particular dominating events, not just elaborations within a certain context. (*GTTM,* 114-16)

Strict and strong hierarchic reduction, then, is the means by which structural coherence is obtained, as well as the means by which listeners can manage the cognitive complexities of musical structures. Their "pervasive intuition" is that one relates a given event to those that precede and follow it, either as a continuation (which marks a right-branching relationship) or an anticipation (which marks a left-branching relationship), but not both.

Lerdahl and Jackendoff then refine the General Reduction Hypothesis by adding the following conditions:

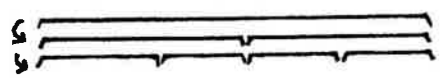
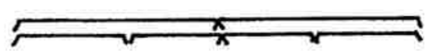
> a. Pitch-events are heard in a strict hierarchy.
> b. Structurally less important events are not heard simply as insertions, but in a specified relationship to surrounding more important events. (*GTTM,* 114-16)

The SRH gives their theory the necessary rigor for the formalized apparatus of their well-formedness rules and preference rules. The crux of the matter is the characterization of the hierarchy as "strict" in part (a) by means of the specified relationships in part (b). Thus the well-formedness rules for meter, grouping, and their tree structures all must obey requirements of nonoverlapping, adjacency, and recursion. When Lerdahl and Jackendoff later give the formalization of timespan reduction, these strictly specified hierarchic relationships are expressed in terms of subordination to the head of a given timespan. This subordination is both transitive and recursive: "That is, if pitch-event *x* is subordinate to pitch-event *y*, and *y* is subordinate to [pitch-event] *z*, then *x* is subordinate to *z*" (*GTTM,* 152).

In the case of grouping structure Lerdahl and Jackendoff specify that transitivity would require that "a time-span T_i *immediately contains* another time-span T_j if T_i contains T_j and if there is no time-span T_k such that T_i contains T_k and T_k contains T_j. Informally, T_i immediately contains T_j when T_j is exactly one level smaller than T_i" (*GTTM,* 152). When the Grouping Well-Formedness Rules are framed, the requirements for transitivity and recursion get cashed out as in example 15.

As grouping and metric structure are the inputs to formation of timespan and prolongational reductive trees, one can understand why such grouping strictures are necessary. As Lerdahl and Jackendoff note: "The tree notation is possible only if subordination is transitive. If the Strong Reduction Hypothesis turns out to be false, the notation for reduction will have to be modified accordingly. On the other hand, we find it difficult to envision a theory lacking the Strong Reduction Hypothesis that would be both *sufficiently rich and sufficiently constrained* to constitute a plausible account of musical cognition" (*GTTM,* 152; italics added). The principal problem with the SRH is that its high level of constraint too sharply limits the range of well-formed structures the grammar is supposed to cover. It simply is not flexible enough to account for all of the grouping structures one encounters in tonal music, though it is powerful enough (under such constraints) to recursively generate grouping, timespan, and prolongational structures at all structural levels. The SRH is strongly tied to *GTTM*'s stated goal of giving an account of musical cognition, a linkage that will be considered below. But more immediately, an alternative reduction hypothesis will be explored.

Example 15. Results of Lerdahl and Jackendoff's Grouping Well-Formedness Rules

Grouping Well-Formedness Rules	Result/Effect of Rule
1. Any contiguous sequence of pitch-events, drum-beats, or the like can constitute a group, and only contiguous sequences can constitute a group.	Prohibits: 
2. A piece constitutes a group. 3. A group may contain smaller groups.	Rules 2-3 establish the following top-down analytic procedure: 
5. If a group G1 contains a smaller group G2, then G1 must be exhaustively partitioned into smaller groups.	Prohibits: 
4. If a group G1 contains part of a group G2 it must contain all of G2.	Prohibits:  * But allows for: 

3.2 A Weak Reduction Hypothesis

Now we often *attempt* to organize the events of a piece into a single coherent whole (or at least at some times and for some pieces). So one would like music structures to follow the well-formedness rules outlined in *GTTM.* (In this sense, Lerdahl and Jackendoff's pervasive intuitions are correct.) But we cannot always do so, and to encompass the messy multiplicity that one finds in the kinds of grouping structures given above, I propose a loosening of the strictures of the SRH. My motivation for such loosening is based on the following observations:

1. Not all events admit structural descriptions of equal robustness, both on the same level as well as from level to level.
2. Some events admit more than one valid structural description (and let us assume that this set of structural descriptions is neither ambiguous nor contradictory).

3. Given (1) and (2), an analysis should not overstate the case for a particular structural description merely because one's chosen analytical method is biased toward a certain set of relationships.
4. We are able to cope with uncertainty. Not all musical objects one encounters can be given a precise structural description. We simply file certain structures as indeterminate or undecidable, and then move on.

In most cases our knowledge of the structure of a piece of music, even at some final state of understanding, is neither comprehensive nor complete. The problem with the SRH is that it tends to generate music analyses that *are* comprehensive and complete. Let us reconsider the two grouping analyses given at the outset of this paper (exx. 1-2, pp. 6-7). Most of the problem patches in the opening measures of the *Hammerklavier* can be accounted for in terms of unresolvable conflicts amongst and between *GTTM*'s well-formedness and preference rules. For example, at m. 6 we hear a conflict between symmetry (GPR 5) and motivic continuation (the contrary of GPR 3, which deals with changes in melodic direction, dynamics, articulation, and duration), hence the uncertainties on level (b) of the grouping analysis (ex. 2). In m. 12, there is a conflict between motivic parallelism (GPR 6) that leads us to construe the material on the downbeat as cadential (in a manner analogous to mm. 7-8), versus the contraries of GPRs 2 and 3, whereby the increased melodic motion and registral/melodic continuation (not to mention the G♭^{3} on the second beat) collectively subvert the sense of closure and articulation. As a result, what we might have initially thought to be a point of melodic arrival on the downbeat of m. 12 turns out to be only a fleeting instance of melodic similarity.[10]

The GWFRs and GPRs allow us to precisely describe those aspects of the musical surface that are giving us trouble—what exactly is giving rise to doubt in our mind's ear as to the precise location and/or nature of a group boundary or prolongational branching. The bulk of the *GTTM* apparatus provides the analyst with an elegant (in its separation of WFRs from PRs) and lucid means of untangling

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[10]Not all aspects of the grouping structure in these measures can be accounted for as unresolved clashes between *GTTM*'s current set of GWFRs and GPRs, most notably the parenthesis in mm. 9-12 (marked by the repeat that echoes mm. 5-8 in a higher register). However, it would be possible to account for these sorts of grouping structures through a parsimonious expansion of the GWFRs and GPRs, along with some protocols for the interaction between the GWFRs and the prolongational and timespan reduction rules. Thus a parenthetical grouping structure, for example, could be the product of a particular prolongational structure (e.g., a span of structural stasis coupled with motivic/thematic repetition) and its interaction with GWFRs that impinge on the location of group boundaries and on subgroup organization.

parametric conflicts and the problematic grouping structures such conflicts create.[11] With the SRH standing behind the WFRs and PRs, however, the analyst is forced to banish these conflicts from the final rendering of the musical structure. If one relaxes the strictures of the SRH, however, we will have a place for such conflicts and the sense of doubt they engender in one's analyses.

One cannot, however, simply dismiss the SRH from the *GTTM* model. For the SRH is what maintains the integrity of Lerdahl and Jackendoff's generative hierarchy; it keeps each level separate and distinct and makes the level-to-level relationships clear via transitive subordination. Therefore, in its stead I propose a Weak Reduction Hypothesis (WRH). Like Lerdahl and Jackendoff, I first establish a general reduction hypothesis:

> Alternative GRH: Listeners will structure the series of musical events that constitute a piece (including but not limited to pitch events) as hierarchically as possible, given the circumstances of a particular listening context.

Like Lerdahl and Jackendoff's GRH, this one recognizes that hierarchic structure is not simply an aspect of musical organization; it is also part of the way in which we tend to perceive and structure our musical experiences. We actively pursue hierarchic structures, "listening out" for motives, for phrases, for formal sections, and for large-scale shape and closure. We thus come to the listening experience with a highly developed set of hierarchic expectations. My GRH differs from the original in two important respects. First, it does not specify that reductions must comprise a "single coherent structure" but more

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[11] Indeed, Lerdahl and Jackendoff acknowledge that the GWFRs and GPRs may be used in this fashion: "First, intuitions about grouping are of variable strength, depending on the degree to which individual grouping principles apply. Second, different grouping principles can either reinforce each other (resulting in stronger judgments) or conflict (resulting in weak or ambiguous judgments)" (*GTTM*, 42). This is all to the good. But they go on to say "Third, one principle may override another when the intuitions they would individually produce are in conflict. . . . [O]ur hypothesis is that one hears a musical surface in terms of that analysis (or those analyses) that represent the highest degree of overall preference when all preference rules are taken into account. We will call such an analysis the 'most highly preferred' or 'most stable'" (*GTTM*, 42). Thus, here and elsewhere (e.g., pp. 22-25, 64-66, and especially 266-68) a conceptual tension is evident in Lerdahl and Jackendoff's treatment of ambiguous or indeterminate grouping structures. On the one hand, their analyses often show how particular WFRs and PRs are in conflict. On the other hand, when push comes to shove Lerdahl and Jackendoff seem to feel obligated to posit one particular grouping structure as the truest structural description of the passage in question, precipitating out much, if not all, of the ambiguity implicit in their analyses.

modestly claims that listeners will make the best hierarchic sense possible within a given listening context. Second, my GRH is mute with respect to the relative importance of various events. The reason for this lacuna is clarified by the weak reduction hypothesis proper:

> a. Musical events are heard as comprising hierarchically nested structures.
> b. Within a given musical style the approximate size and scope of musical structures on each hierarchic level is relatively constant and predictable.
> c. On different levels different parameters are relatively more or less salient and hence structurally determinate.

The WRH is viable because, as item (c) makes explicit, the musical hierarchy has important nonrecursive aspects. As Meyer has noted:

> The way in which a particular parameter acts in articulating structure may be different on different hierarchic levels. For example, on lower levels dynamics and orchestration tend to contribute to the articulation of rhythmic patterns, but on higher levels they generally serve in the structuring of large-scale formal relationships. Similarly durational relationships are crucial in the shaping of low-level events such as motives and phrases, while tonality and texture are especially important for the organization of high-level structures. Moreover, the role played by a particular parameter depends not only upon hierarchic level, but also upon style. Harmonic relationships play a central role in the structuring of tonal music, but none in the ordering of most serial compositions. Timbre plays a very significant role in defining relationships in Webern's music, but only a minor role in the music of Bach. (1973, 89)

It is due to the nonrecursive nature of the musical hierarchy that the revised GRH is silent with respect to the relative importance of hierarchic events. This is not to deny that the distinction between structural versus ornamental tones does not exist on a given level or across adjacent levels. But if different musical parameters play particular roles in organizing various levels of musical structure (and indeed, if the salience of a particular parameter is characteristic of a given structural level), then a number of corollaries follow. First, it is possible for musical hierarchies to emerge that are not dependent on transitively subordinate relationships within any single parametric domain. Second, in many cases the question of relative importance becomes moot—for what does it mean to speak of the "relative importance" of timbral contrast on one level versus cadential strength on another level? Nonrecursion also means that where there are unresolvable conflicts between structural descriptions on a given level, listeners will turn to other structures on adjacent levels, especially those structures that emphasize other musical parameters, to maintain a global sense of hierarchic integrity. Were this not the case, that is to say if the musical hierarchy were wholly or even primarily recursive, then the WRH would not be powerful enough to serve as an organizing framework for one's musical experience and understanding. Nonrecursion allows for robust structures on one level that are capable of coexisting with structures that are ambiguous or intermittent on other levels.

4.0 Conclusion: Why pursue the RH so Strongly?

As stated at the outset of this paper, Lerdahl and Jackendoff's SRH is a particularly clear articulation of a more general (though usually tacit) analytical assumption: for every musical event there is a single, best structural description, and the job of the music analyst is to produce that description. What is instructive about the SRH in the context of *GTTM* is that the motivations for holding to such a strong reductive hypothesis can be seen and understood with considerable clarity. Lerdahl and Jackendoff are quite overt about construing music theory as a subdiscipline of psychology. They begin their book with this sentence: "We take the goal of a theory of music to be a *formal description of the musical intuitions of a listener who is experienced in a musical idiom*" (*GTTM,* 1). But the questions and goals of cognitive science and the questions and goals of music theory (and in particular music analysis) are not the same. The different aims and claims of each discipline can be better understood if we consider a number of different questions or analytical contexts for Beethoven's *Hammerklavier*.

1. What kind of analysis is necessary in order to say that this piece is *tonal*—that is, what is involved in the recognition and comprehension of the basic elements of the tonal syntax of Western art music in general and Viennese classical (and perhaps early romantic) music in particular?
2. Given (1), what kind of analysis is required to identify this particular piece as (and perhaps even distinguish among particular performances of) the *Hammerklavier?*
3. Given (2), what additional analytical claims can be made about the structural relationships among and between its various elements, as well as the ways in which these elements and their relationships serve as vehicles for aesthetic expression?

It seems clear that cognitive psychology is primarily concerned with questions (1) and (2) while music theory and analysis is primarily concerned with (3), though of course there is considerable overlap between the disciplines in the area of question (2). In the first analytical context the structural description of the piece must be one that places it into a general class of musical phenomena. Thus one must identify a number of basic elements (e.g., particular scales and their temperaments, characteristic sonorities, characteristic rhythms and meters, etc.). In order to answer the second question one needs a structural description that individuates specific musical works (and, similarly, that allows one to recognize two separate performances of the same work as being just that—two instances of the same piece). This sort of structural description must identify the various structural elements of the piece more closely than in question (1), as well as attend to their particular combination. The third question/analytical context assumes that the second has been answered (or at least answered well enough to individuate a given piece). Thus, given that certain scale steps, durational patterns, harmonic complexes, and so forth, are present in a certain arrangement, how then do these elements cohere (or resist coherence) into a work of art?

In large part, the kinds of structural descriptions that *GTTM* is able to generate are those that serve primarily an identifying function; if two listeners both are able to construct the same structural description, with respect to *GTTM,* they are then able to say that they have both heard and in some sense now "know" the same piece. In this context having a SRH that disambiguates and simplifies is good, in that the kinds of structural descriptions it engenders readily and efficiently distinguish the opening measures of the *Hammerklavier,* for example, from other pieces of tonal music in general and from Beethoven's other piano sonatas in particular. While this is a useful kind of analysis, music theorists usually want to probe the structure of pieces more deeply, often to try to understand their more idiosyncratic aspects.

Psychology is a science (or at least endeavors to be a science); music theory is not a science, nor should it endeavor to become one. Narmour, who would like music theory to become a subbranch of cognitive science as much as Lerdahl and Jackendoff, observes that "It may be beneficial . . . to emphasize how different the goals are between the scientific approach to natural facts . . . and the humanistic approach to artifacts. Science seeks to discover commonality out of dissimilar instances, to reduce the disparate to the uniform, to account for the world in as few universal laws as possible" (1990, 58). This is all well and good, but he goes on to say that "Music theory has similar goals in attempting on all levels to discover what stylistically ties pieces, genres, cultures, etc. together and in trying to formulate parsimonious rules that will assimilate the dissimilar works of art into a unified field of research. In these things, a music theorist is no less a scientist than any physicist, chemist, or biologist" (1990, 58). Here I believe Narmour conflates the search for parsimonious rules—that is, the construction of any theory of music, art, literature, or cultural practice that wishes to make general claims—with the particular strictures of rules that operate under the scientific method. For what "stylistically ties pieces together" is not the broad application of natural laws, but rather the confluences of cultural contingencies. Musical works are contingent artifacts, each the product of a set of unique historical and compositional circumstances. They are not replicable in the manner of natural phenomena. A scientific theory of music would strive to parse a musical structure the same way each time it is encountered. We would not accept as valid a theory of molecular structure that tended to come up with different stoichiometric equations every time a chemical reaction was observed in the laboratory. Similarly, we may perhaps be uncomfortable with a method of music analysis (and its overarching theory of musical structure) that would produce one structural description for a piece on one occasion and then another structural description for the same piece on another occasion. Yet that is what listening to music is like. Clearly, this is not an anything-goes situation; we must, at the very least, come to the same sort of question (2) structural description each time we listen to a piece or else we are in serious trouble. Unlike science, however, music theory need not seek to find *the* structural description for any given piece of music. It is precisely the domain of music theory to adjudicate between the sorts of structural descriptions that might be valid for a piece of music versus those that would not or could not be valid. Music theorists are neither scientists nor philosophers, though of course their work is much enriched by a consideration of these other domains. Rather than searching for scientific certainty, we should be prepared to confront (with careful consistency and rigor) the uncertainty and contingency that is the hallmark of humanistic endeavor.

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