Music Perception
Fall 1999, Vol. 17, No. 1, 5–42

Musical Coherence, Motive, and Categorization

LAWRENCE M. ZBIKOWSKI
University of Chicago

Arnold Schoenberg's theory of musical coherence is used as a point of departure to explore how aspects of a musical motive can be explained by recent research into categorization. Categorization can account for the coherence produced by repeated statements of a motive, for the role of motive as a starting place for higher level cognitive processes, and for relationships among diverse motive forms. The first section of the essay reviews recent research into categorization, with applications to music. The second section presents an analysis of a principal motive from Mozart's String Quartet K. 465. This analysis demonstrates how the structure of a motivic category is realized over the course of an entire movement.

Received Sept. 23, 1997; revision received June 16, 1999; accepted for publication Aug. 15, 1999.

ALTHOUGH Arnold Schoenberg was occasionally given to mystical pronouncements on the origins and nature of musical ideas, much of his writing on music was of a practical cast: Schoenberg plainly believed musical composition was, at least in part, a craft subject to certain principles and laws. For Schoenberg, some of these laws had their origin in acoustic phenomena—for instance, in his *Harmonielehre*, he traced the origin of the major scale to the overtone series (Schoenberg, 1911/1978, pp. 23–25). However, Schoenberg believed the laws of acoustics were not the only ones a composer must observe.

> [T]here are other laws that music obeys, apart from these and the laws that result from the combination of time and sound: namely, those governing the working of our minds. This latter forces us to find a particular kind of layout for those elements that make for cohesion—and to make them come to the fore, often enough and with enough plasticity—so that in the small amount of time granted us by the flow of the

In memoriam James D. McCawley, 1938–1999.

Address correspondence to Lawrence Zbikowski, Department of Music, University of Chicago, 1010 E. 59th St., Chicago, IL 60637. (e-mail: larry@midway.uchicago.edu)

> events, we can recognize the [musical] figures, grasp the way they hang together, and comprehend their meaning. (Schoenberg, 1926/1975b, p. 259)

In Schoenberg's view, the laws governing the workings of our minds require the composer to write in such a way that listeners can quickly recognize musical figures and the way they cohere. The listener, upon grasping this coherence, will then be able to comprehend the work.

As developed in various published and unpublished writings, Schoenberg's theory of musical coherence involves specific ideas about the process of comprehension and the part motive plays in this process. According to Schoenberg, comprehension starts with recognition, and recognition starts with basic musical figures, which he came to call motives: "*Motive* is at any one time the smallest part of a piece or section of a piece that, despite change and variation, is recognizable as present throughout" (Schoenberg, 1934–1936/1995, p. 169). More specifically, motives consist of intervals and rhythmic patterns combined to produce a shape or contour that, once recognized, can be easily remembered (Schoenberg, 1967, p. 8). An illustration of Schoenberg's concept of motive is provided by his analysis of a subordinate theme from the first movement of Brahms's Sextet in B♭ major, op. 18 (1860) (Schoenberg, 1947/1975a, p. 417), shown in Figure 1.

As Patricia Carpenter and Severine Neff have noted, rhythm is central to Schoenberg's concept of motive (Carpenter & Neff, 1995, pp. 27–29). This centrality is clearly in evidence in his analysis of the Brahms. Each family of motives is distinguished by a specific rhythmic pattern: all of the **a** motives use a dotted-quarter/eighth/eighth/eighth pattern; and all of **b** motives use a dotted-quarter/eighth/quarter pattern. (Both patterns, of course, contribute to the marvelous waltzlike feel of the theme.) Contour also serves to distinguish the two families, although here some variation among the different motive forms can be noted. Motives $\mathbf{a}^1$, $\mathbf{a}^2$, and $\mathbf{a}^4$ all preserve the basic contour of motive **a**: the second note of the motive is lower than the first note, and the last note of the motive is higher than the first note. Motive $\mathbf{a}^3$ preserves only a portion of the contour of **a**: although the second

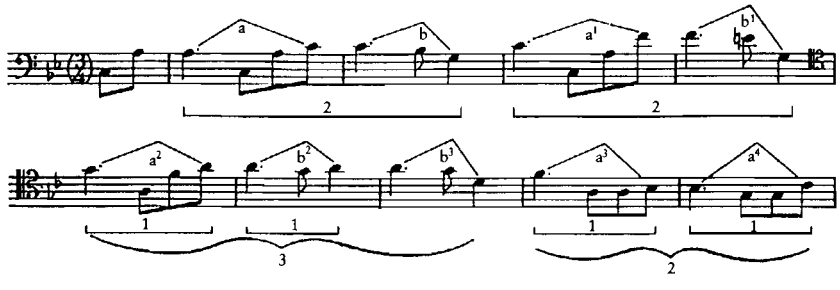

Fig. 1. Schoenberg's analysis of Brahms's Sextet op. 18/I, measures 84–93.

note of the motive is lower than the first, so is the last note. In a similar fashion, motives $\mathbf{b}^1$ and $\mathbf{b}^3$ preserve the basic contour of motive **b** (the second note is lower than the first note, and the third note is lower than the second), whereas $\mathbf{b}^2$ preserves only a portion of the contour of **b** (the second note is lower than the first note, but the third note is higher than the second).

As this example shows, Schoenberg's concept of motive is broad and dynamic: a family of motives can be distinguished simply by rhythmic figure or contour; motive forms can be various and need have only some of their features in common. This conception is rather different from, for example, Heinrich Schenker's or Rudolph Reti's concept of motive. Both Schenker (1906/1954, 1935/1979) and Reti (1951) regard specific intervallic relationships as constituent of motive; rhythm and contour are regarded as secondary aspects of motivic organization. The difference between Schenker's or Reti's conception of motive and that of Schoenberg lies with Schoenberg's notion of coherence and its role in making music comprehensible. *Coherence* comes about when the various parts that make up a musical entity are connected in such a way that those that are similar to other entities become prominent. The work is most *comprehensible* to the listener when the arrangement of these parts is such that their relationship to each other and to the whole is manifest (Schoenberg, 1917/1994, pp. 20–23). Thus there is no need to restrict the distinguishing features of a family of motives to specific intervallic relationships, nor is there a need to require that all motive forms share exactly the same features. All that is required of motive is recognizability and a potential for connection to other motive forms. This potential for connection contributes to coherence, which is in turn the basis for comprehensibility.

According to Schoenberg, then, the process of comprehension starts with recognizable bits (motives) that are easily remembered. Motives hang together not only because their constituent parts are connected to one another, but because these connections emphasize similarities to other motives. Coherence thus reflects properties shared by collections of motives; it is not, properly speaking, a property of any one individual motive. Motive forms are *of necessity* variable, for differences between forms reveal most clearly what is typical of the collection of motives as a whole. And, although attention to coherence is important to the composer who wishes to craft a convincing work, the apprehension of coherence is *essential* to the listener who would make sense of that work.

Although coherence is a relatively local and immediate phenomenon, its contribution to our sense of the unity of a musical work cannot be underestimated. As Edward Cone (1987, p. 238) has noted, the use of thematic transformation as a unifying device became increasingly important for composers of the later nineteenth century, whose lengthy movements often

embraced stylistic extremes of tempo, meter, texture, and mood. However, the prevalence of the device also poses problems for the listener, for it is oftentimes difficult to sort out relationships among various motivic entities. Consider the relationship of derivation, in which later motive forms are derived from earlier motive forms; thus motive **b**^{3} in Figure 1 is said to be derived from motive **b**. As straightforward as this might appear, tracing derivational relationships is rarely a simple task: motive **b** can itself be understood to be derived from one of the motives prevalent in the preliminary subordinate theme heard starting in m. 61 (shown in Figure 2), which has the same rhythmic pattern but the reverse contour. Could **b**^{3} then be regarded as derived directly from this earlier motive form, or is it still to be regarded as derivative of **b**?

Schubert's *Wanderer Fantasie* (op. 15) of 1822 presents an even more complicated situation. The work is based on a song Schubert composed in 1816, which is quoted in the work's second movement Adagio. If we have the song in mind, we can hear the motivic material of the first movement (labeled **c** on Figure 3a) as derived from the song, presented instrumentally in the subsequent Adagio (Figure 3b). The temporal order of the process of derivation is thus reversed: **c** is heard as derived from **c**^{1}. If we are coming to the work fresh, we will most likely hear the Adagio derived from the first movement: **c**^{1} is thus derived from **c**. Finally, if we know the song but have temporarily forgotten it, its reprise in the Adagio, anticipated by the "derived" motives of first movement, can be a moment of great rhetorical

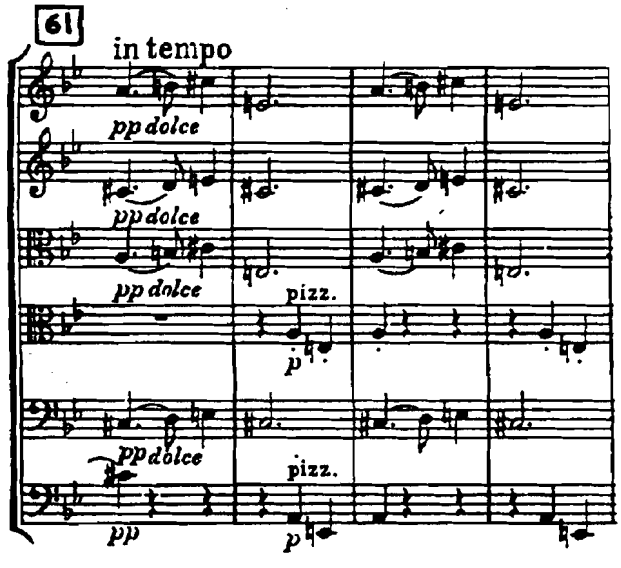

Fig. 2. Measures 61–64 from Brahms's Sextet op. 18/I.

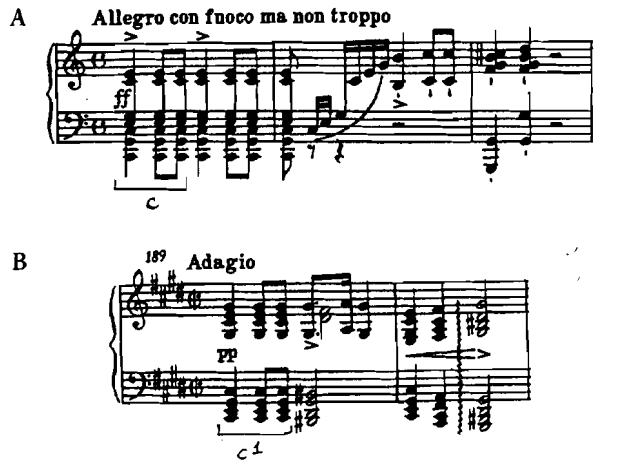

Fig. 3. Schubert's *Wanderer Fantasie.* (A) Measures 1–3. (B) Measures 189–190.

impact: the pianistic musings of the first movement have summoned forth the song that now stands before us.

It would appear that, as Cone has pointed out, hearing relationships among motive forms is an ineluctably subjective affair. Following Cone's argument still further, how we hear these relationships is important to how we respond to a work, for, as Schubert's fantasy suggests, it informs our understanding of musical rhetoric. The most dramatic case occurs in a work in which there are multiple derivations of motivic material. In the course of such a work we can lose our sense of how motive forms are connected, until the composer—often unexpectedly—reveals how the materials relate to one another by bringing them into rapprochement. The rhetorical aim of this sort of compositional strategy is what Cone calls "epiphany," and when successful it can compel the listener to realize a previously unsuspected—or at most unconfirmed—relationship among diverse motives (Cone, 1987, p. 246). Put another way, the strategy that leads to epiphany compels the listener to realize aspects of musical coherence that become evident only over the course of time.

Motives and motivic relationships are important for both the coherence and the rhetoric of music, but understanding the part they play in music cognition poses some unique challenges. If the recognition of motives is central to the process of comprehending music, it must be extremely rapid; indeed, David Temperley has argued that the speed of motivic perception points to the modular processing of motives (Temperley, 1995). However, coherence is an emergent property less well explained from a modular perspective, because it involves the comparison and evaluation of a number of motive forms.

One model that can rise to these challenges is offered by recent research into categorization, which has demonstrated that categorization is extremely rapid *and* evaluative. From the perspective provided by this research, the coherence of music reflects our ability to group musical events into categories: the **a** and **b** motives of Figure 1 each constitute a cognitive category, with five members in one category (**a**, $\mathbf{a}^1$, $\mathbf{a}^2$, $\mathbf{a}^3$, and $\mathbf{a}^4$) and four in the other (**b**, $\mathbf{b}^1$, $\mathbf{b}^2$, and $\mathbf{b}^3$). To describe the "laws of the mind" that force the composer to arrange musical elements so that they cohere is to describe the process of categorization.

In the next section, I shall review research on processes of categorization and show how categorization can be used to account for the role of motive as a starting place for higher-level cognitive processes and for relationships among diverse motive forms. In the second section, I shall present an analysis of the principal motive of the first movement of Mozart's String Quartet in C major (K. 465), which demonstrates how the structure of a motivic category is realized over the course of an entire movement, and which elaborates both the notion of musical coherence and the relationship between coherence and rhetoric.

Categorization and Musical Motive

My focus is on categorization at the level of concepts: that is, categories that are part of the substance of our thought processes. It is quite apparent that categorization also operates on preconceptual levels, and it seems likely that this sort of categorization is linked, either through shared processes or through recursion, to categories at the conceptual level; Gerald Edelman (1989, 1992), and George Lakoff and Mark Johnson (1999) have recently argued as much. However, in order to keep things manageable I shall concentrate on categories at the conceptual level, which I shall simply call "categories."[1]

Although, in the main, my overview simply draws together and summarizes research on categorization, certain aspects of the theory of categorization that emerges—in particular, the typology of categories I offer, and the use of conceptual models to account for certain aspects of category structure—are new. These innovations reflect my own work with cognitive cat-

1. It should be noted that for some writers and researchers there is a strong link between categories at the level of concepts and concepts themselves, which at times can erase any distinction between the two (Barsalou, 1993; Barsalou, Yeh, Luka, Olseth, Mix & Wu, 1993; Edelman, 1989; Hampton & Dubois, 1993; Murphy & Medin, 1985; Smith & Medin, 1981). Such a link is intriguing, in that it would make possible a characterization of musical concepts through accounts of categorization (something I attempt in Zbikowski, in press) and thereby offer a productive expansion of the concept of "concept" beyond the limits imposed by those who argue that music is nonconceptual (DeBellis, 1995; Jackendoff, 1987).

egories in recent years, which has involved bringing research on categorization to bear on problems of musical understanding.

BASIC-LEVEL CATEGORIZATION

The Basic Level

Roger Brown (1958, 1965) was perhaps the first to note that the categories we most frequently employ are not at the lowest level of a taxonomy (and concerned with individuals), nor are they at the highest level (and concerned with broad classes), but are instead in the middle of a taxonomy, at a level of maximum utility. For instance, we typically call the thing in our purse or pocket a *dime,* even though we might also call it *money* or a *metal object* (names at the superordinate level of the taxonomy), or *my favorite 1952 dime* (which would be at the subordinate level of the taxonomy).

Subsequent research into ethnobotanical systems of classification by Brent Berlin and his associates supported the importance of midlevel classification and gave empirical evidence that this level is psychologically basic: at this level, people name things more readily, languages have simpler names, categories have greater cultural significance, things are remembered more readily, and things are perceived holistically (Berlin, 1972, 1978; Berlin, Breedlove, & Raven, 1974). Research directed specifically at midlevel classification was carried out by Eleanor Rosch and her associates in the early 1970s. In their report, this level was named the *basic level,* a term that has been generally adopted in the literature on categorization (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Examples of sample taxonomies showing the basic level are given in Table 1.

TABLE 1
Sample Taxonomies Showing the Basic Level

Superordinate	Basic Level	Subordinates
Musical instrument	Guitar	Folk guitar Classical guitar
	Piano	Grand piano Upright piano
Fruit	Apple	Delicious apple Mackintosh apple
	Peach	Freestone peach Cling peach
Furniture	Table	Kitchen table Dining room table
	Lamp	Floor lamp Desk lamp

Adapted from Rosch et al. (1976, p. 388).

Rosch and her associates suggested that two contrasting principles influence the taxonomic level at which people prefer to categorize.[2] The first is the *efficiency principle*, according to which people prefer to minimize the number of categories they must consider in making a categorization. For instance, if you were concerned with *things in my house*, categorizing at the level of *musical instrument* would be the most efficient category, because the number of contrasting categories at this level (such as *furniture* and *fruit*) is significantly less than at the next level (*guitar*, *piano*, *apple*, *peach*, *table*, *lamp*). The second principle is the *informativeness principle*, according to which people tend to maximize the informativeness of their categorizations. Because the most information about any entity is found at the most specific level of a taxonomy, you would use *grand piano* to categorize the thing sitting in the living room. Rosch and her associates proposed that the intermediate level of a taxonomy (in this case, *piano*) optimizes both efficiency and informativeness and is thus the preferred level for basic categorizations.

A number of empirical operations converge at the basic level. The basic level is the highest level whose members have similar and recognizable shapes; it is also the most abstract level for which a single mental image can be formed for the category. The basic level is also the highest level at which a person uses similar motor actions for interacting with category members. The basic level is *psychologically* basic: it is the level at which subjects are fastest at identifying category members, the level with the most commonly used labels for category members, the first level named and understood by children, the first level to enter the lexicon of a language, and the level with the shortest primary lexemes (Rosch, 1977; Rosch et al., 1976; Tversky & Hemenway, 1984).

In her initial work Rosch assumed that the basic level depended on bundles of perceived-world attributes that formed natural discontinuities and that such attributes were inherent in the real world. She later came to doubt this assumption (Rosch, 1978), and subsequent research has shown that the basic level is variable, depending on cultural context and level of expertise (Barsalou, 1992a; Berlin, 1992; Tanaka & Taylor, 1991) and whether one is dealing with categories that occur naturally as humans interact with their environments or with categories created for experimental ends (Lassaline et al., 1992). Other research has indicated that the basic level is strongly determined by the ways humans interact with their environment (Lakoff, 1987; Tversky & Hemenway, 1983), and to be highly dependent on the way humans perceive the spatial configuration of physical parts (Barsalou, 1991; Biederman, 1987; Tversky & Hemenway, 1984). In all cases, how-

2. This interpretation of Rosch's work is drawn from Barsalou (1992a). See also Lassaline, Wisniewski, and Medin (1992), Rosch (1978), Rosch et al. (1976), and Mervis and Rosch (1981).

ever, Roger Brown's fundamental insight has held up: the preferred categorization for most of the things we encounter occupies a maximally useful level in the middle of a taxonomy.

The Basic Level And Musical Motives

In a close analogue to perhaps the most distinctive features of basic-level categories, Schoenberg's theory of musical coherence begins not with individual musical events or with four- or eight-measure phrases, but at a level somewhere in between. Although the motive is the smallest *recognizable* part of a musical work, it is in fact made up of still smaller parts, namely its constituent pitches, intervals, and durations. The cognitive salience of the motive thus mirrors that of the basic level: in both cases the focus is on the whole rather than on the parts. Each of Schoenberg's families of motives has a distinctive "shape" or contour that allows us to distinguish it from other motives. Similarly, the basic level is the highest taxonomic level at which category members have similarly perceived overall shapes and the highest level at which a single mental image can reflect the entire category. Finally, motive-recognition is not something given directly by perception and can change with expertise: what counts as a motive, just as what counts as the basic level, is not immutable.

To illustrate correspondences between a musical motive and a basic-level category, consider the over-familiar yet still serviceable example provided by the opening of Beethoven's Fifth Symphony, given in Figure 4. To the extent that we hear a "motive" in these opening gestures, we hear a figure that comprises four notes. The motive has a distinctive "shape" or contour that allows us to distinguish it from other motives (although such are in rather short supply in this particular example). Last, there is a certain minimal level of expertise involved in picking out measures 1–2 and their ilk as "the motive." One can easily imagine an alternative hearing that would take measures 1–2 and 3–4 as the main thematic material for this section; the ensuing music then represents a sort of fragmentation of this thematic material, rather than successive statements of various forms of the motive.

Summary

Research on basic-level categories provides support for Schoenberg's proposal that musical comprehension begins at the motivic level, for such a level maximizes both efficiency and informativeness. In addition, there appear to be a number of correlations between musical motives and basic-level categories. Both are concerned with wholes, rather than the parts of these wholes; shape (whether as visual property or auditory analogue) is

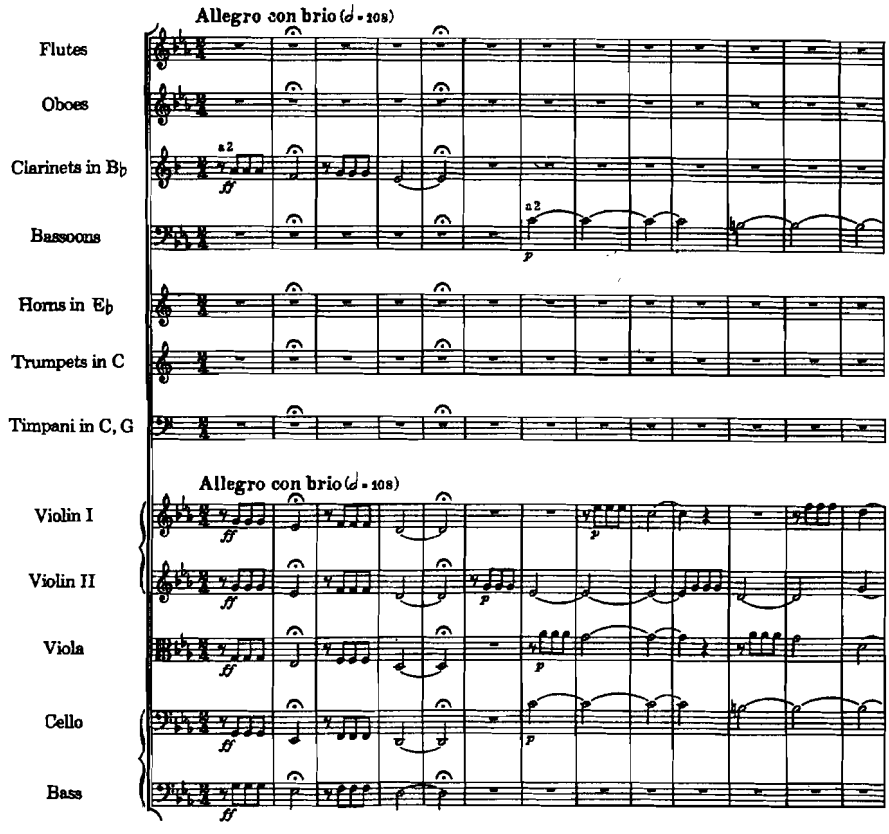

Fig. 4. Beethoven's Fifth Symphony, first movement, measures 1–37.

important to both; and both are subject to the influence of expertise. Finally, although entities such as "motives" may be basic to the process of comprehending music, they are actually relatively high level cognitive constructs (as are basic-level categories). Although such constructs are fundamental to reason (and may even represent an important starting point for conscious reasoning processes), they are the product of myriad other still more-basic processes that operate below the level of consciousness.

TYPICALITY EFFECTS

Graded Structure and a Typology of Categories

As noted earlier, the variability of motive forms was important to Schoenberg's notion of musical coherence, for this variability tended to emphasize how motive forms were similar to one another. Research on categorization has demonstrated an analogous structure for numerous categories. Membership in these categories is not fixed but is instead graded

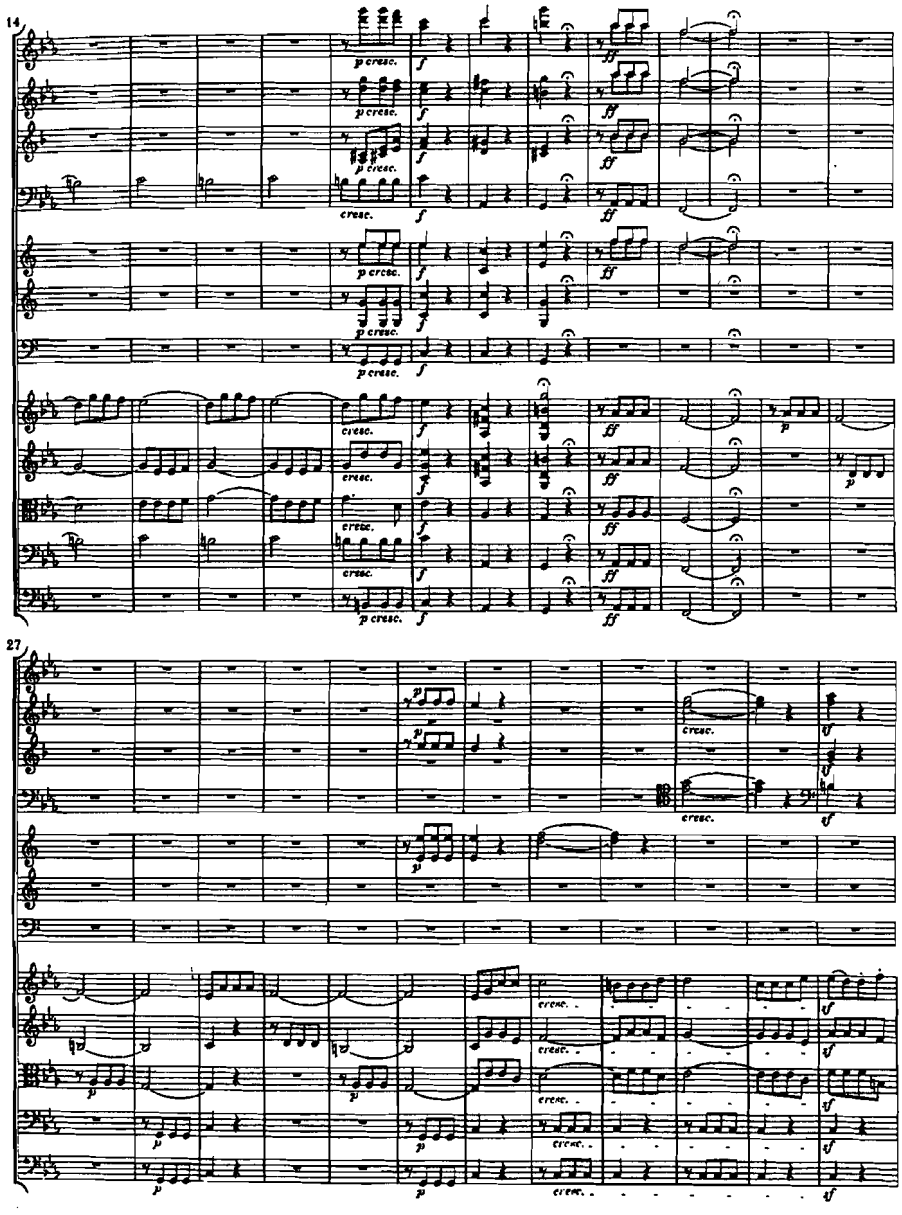

Fig. 4. Continued

through a dynamic process in which the attributes of potential category members are compared with the attributes most typically found within the category.

As an example of such a graded structure, consider the category *bird*. Experimental rankings show that subjects view robins and sparrows as the best examples of birds, with owls and eagles lower down in the rankings

and ostriches, emus, and penguins among the worst examples (Rosch, 1973, 1975). All are considered members of the category *bird*, but some better represent the category than others. Category structure is consequently graded according to typicality: category members range from the most typical to the least typical, with the former securely inside the bounds of the category (robins and sparrows) and the latter in danger of being excluded from the category (emus and penguins).

Graded membership has been shown to be pervasive among what are conventionally called *natural* categories (Barsalou, 1987), so named on the basis of their emergence from the interaction of humans with their natural environments (Barsalou, 1992a). For the sake of clarity, and to avoid certain of the associations summoned by the term "natural," I call this sort of category a Type 1 category.

Type 1 categories stand in contrast to categories in which membership is based on individually necessary and jointly sufficient conditions: the members of Category X must have features y and z; if things have features y and z they are members of Category X. Because the conception of categories of this latter sort is often traced backed to the work of Aristotle, such categories have been called *classical* categories; because the structure of these categories is not typically an analogue representation of the natural world, such categories have also been called *artificial* (Armstrong, Gleitman & Gleitman, 1983; Barsalou, 1992a; Gleitman, Armstrong & Gleitman, 1983; Lakoff, 1987; Mechelen, Hampton, Michalski, & Theuns, 1993; Smith & Medin, 1981). I call this sort of category a Type 2 category. Most evidence indicates that Type 2 categories simply represent a specialized form of Type 1 categories—take a Type 1 category, specify limits for the category through the imposition of necessary and sufficient conditions for category membership, and you create a Type 2 category.

Although this typology of categories places a burden on those familiar with the traditional labels, it has the advantage of classifying categories on the basis of their internal structure. This is especially useful when considering research on categorization, because "artificial" categories (such as *things to pack in a small suitcase* [Barsalou, 1991]) often have the same basic structure as do "natural" categories (such as *bird*).

Prototype Effects and Frame Structure

Eleanor Rosch and Carolyn Mervis, in their original work on Type 1 categories, suggested that such categories were organized around a stable cognitive construct called a *prototype* that encapsulated the statistically most-prevalent features of members of the category (Rosch & Mervis, 1975; see also Hampton, 1993). Type 1 categories were thus said to exhibit "prototype effects." However, it is clear that the prototype offers more structure than simply a record of the attributes correlated with a particular cat-

egory: although *wings* and *beak* are both highly correlated with *bird*, we know that *wings* are used for locomotion, and *beaks* are used for eating. Relationships between attributes, as well as the values assigned these attributes, are thus important to the function of the prototype.

As a way of capturing the relational structure inherent in most categories, Lawrence Barsalou has recently proposed using the notion of a *frame*, as developed in artificial intelligence research (cf. Lenat & Guha, 1989; Minsky, 1975, 1985), to represent category structure (Barsalou, 1992a, 1992b, 1993). As Barsalou has shown, the basic structure of a Type 1 category can be conceived of as a relational network made up of relatively abstract attributes to which concrete values are assigned by each individual. For the category *bird*, for example, attributes might include *size*, *color*, *sound*, and *locomotion*, as shown in Figure 5. For the attribute *size*, values might include *large*, *medium*, and *small*. Each member of the category exemplifies specific values for each of the attributes: a wren is *small*, *brown*, *chirps*, and *flies*; a chicken is *large*, *white*, *clucks*, and (for the most part) *runs*.

Individuals with none of the attributes of the category would, of course, be excluded from the category. Prototype effects arise from the comparison of the values represented by individuals with the values of the prototype for the category that are stored in memory (indicated with asterisks in Figure 5). If the values of the prototype for *bird* were *small*, *brown*, *chirps*,

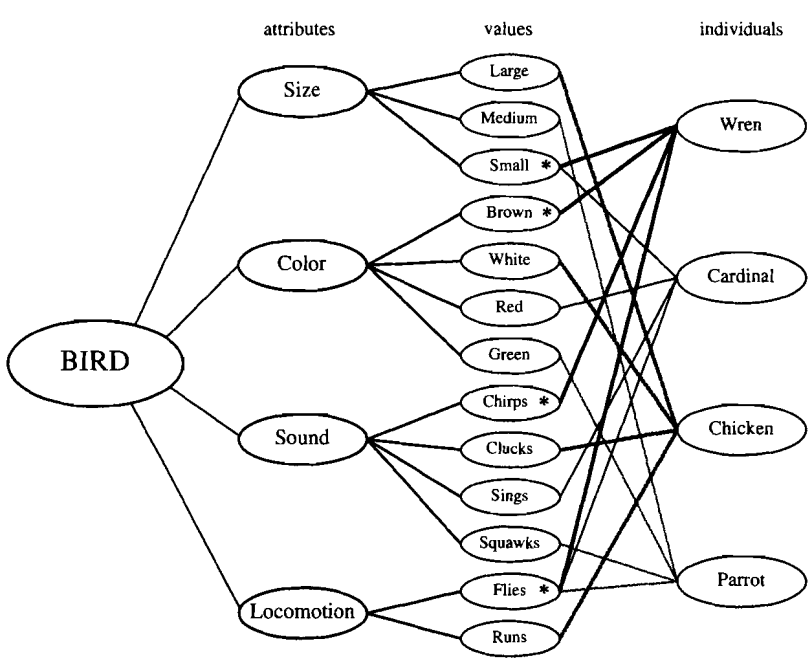

Fig. 5. A partial frame for the category *bird*.

flies, then a wren would be most typical of the category, a male cardinal (*small*, *red*, *sings*, *flies*) would be somewhat less typical, and a chicken (*large*, *white*, *clucks*, *runs*) would be least typical.

Applications to Music

Returning to the opening of the Fifth Symphony, we can see that, as suggested by Schoenberg's account of motive, there are a number of different forms that Beethoven's motive takes in the first 37 measures of the movement and that these vary with respect to contour, dynamics, and orchestration. Approached from the perspective of categorization, each motive form can be viewed as a member of the category *motive forms from the opening of Beethoven's Fifth Symphony*.[3] Attributes of this category might include things such as *orchestration*, *dynamic*, and *melodic profile*. In the following, I shall show how these three attributes could play a part in determining membership in the category *motive forms from the opening of Beethoven's Fifth Symphony*; however, I should emphasize that, for present purposes, what is of concern is less the specific attributes and more the model of categorization they illustrate.

In order to characterize melodic profile, it will be useful to account for intervallic relationships among motive forms in terms of diatonic intervals. That is, within the diatonic context of the movement, the descending third from G_4 to $E\flat_4$ can be reckoned to be equivalent to the descending third from D_4 to F_4, even though the former is major and the latter is minor. In the following, I shall represent a descending third with *-3*, an ascending third with *+3*, and a unison with a *u*. With this in mind, the attribute values for the first two statements of the motive would be *tutti*, *fortissimo*, and *u*, *u*, *-3*.

Although *rhythmic profile* is an equally important attribute of the category, it is not as useful for distinguishing among the various motive forms found in the opening measures shown in Figure 4. All the motive forms found there would assign the same value to this attribute: *short*, *short*, *short*, *long* (where *short* is equivalent to an eighth note, and *long* varies between a quarter note and three tied half notes). In consequence, the attribute *rhythmic profile* is relatively transparent in the opening of the symphony, as is the attribute *played by instruments*; both will be omitted from the following account of category structure.

3. What follows is by no means the first attempt to use research on categorization to model variation among musical elements; notable are the studies of Welker (1982) and Pollard-Gott (1983). The following extends this work by taking advantage of research done since the early 1980s and by endeavoring to give a more thorough account of the process of categorizing musical events.

Mention should also be made of Robert Gjerdingen's discussion of typicality (1988, especially pp. 93–94), which anticipates many of the points made here.

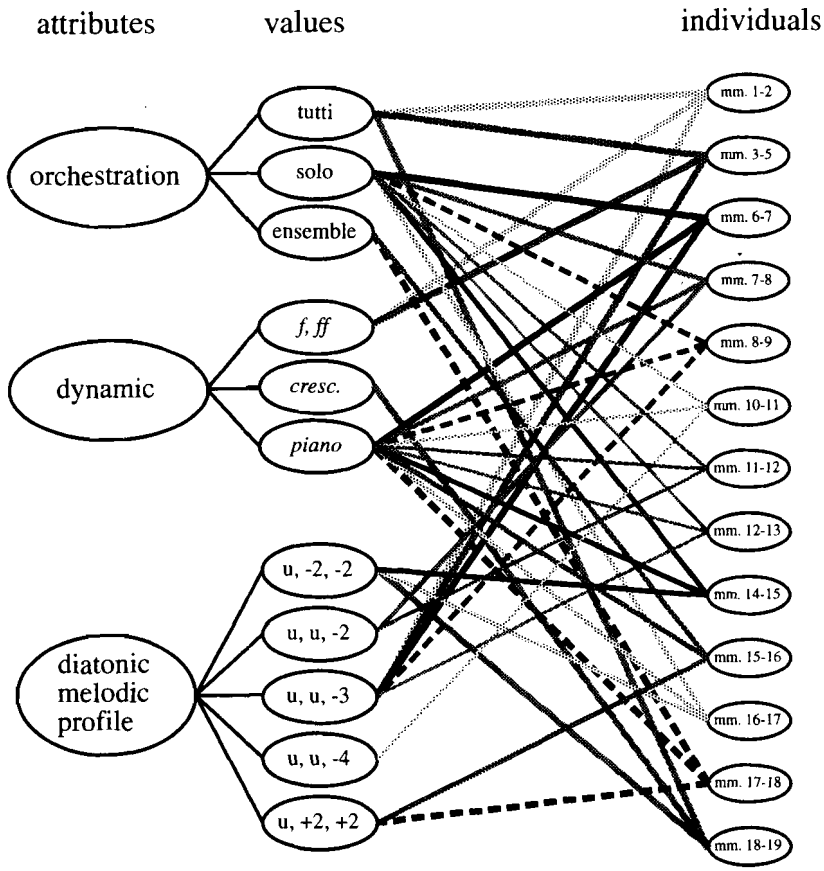

Fig. 6. Diagram of category structure for the category *motive forms from the opening of Beethoven's Fifth Symphony*, measures 1–21.

Figure 6 presents a frame diagram for the category *motive forms from the opening of Beethoven's Fifth Symphony* which shows the values 13 instances of the motive assign to the attributes *orchestration*, *dynamic*, and *diatonic melodic profile*. The result is a rather dense diagram (due in part to the number of individuals categorized) that gives an intriguing and rather counterintuitive picture of what is most typical of the various motive forms gathered there. Based on the evidence provided by these individuals, the most typical form of the motive would assign the values *solo*, *piano*, and *u, u,* –3 to the relevant attributes. Although the last value is what we might expect, the first two are not: it is difficult to think of Beethoven's theme as anything other than *tutti* and *fortissimo*.

Were we to take into account a further 15 instances of the motive (as shown in Figure 7; the frame diagram has been rearranged somewhat in

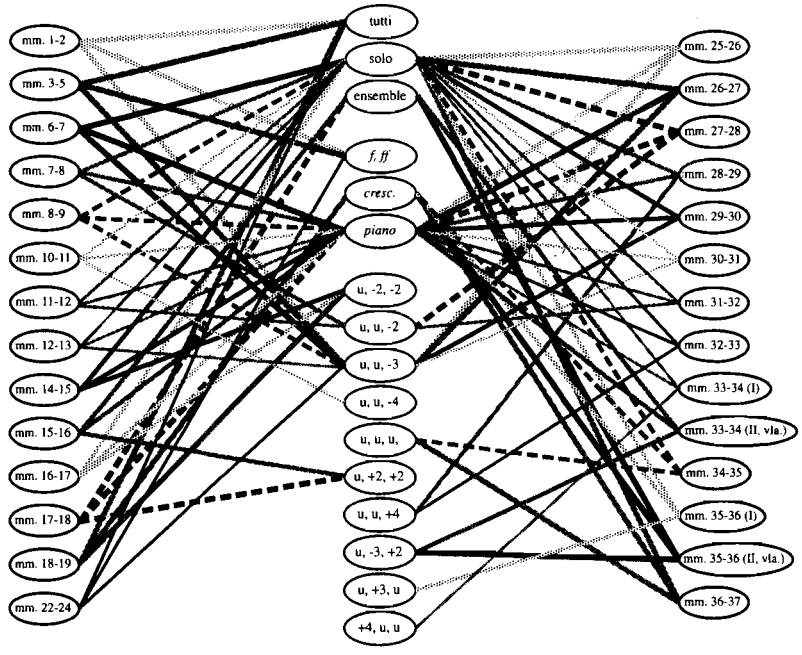

Fig. 7. Diagram of category structure for the category *motive forms from the opening of Beethoven's Fifth Symphony*, measures 1–37.

the interests of legibility) the profile of typicality is skewed even further away from what we might expect. The difference between the evidence provided by Figures 6 and 7 and our usual recollection of how Beethoven's theme sounds is due in part to a limitation of frame diagrams: they are essentially statistical representations of the most *common* values assigned attributes by individuals. However, they may not represent the most *important* attribute values for a given category.

Beyond the Prototype: Conceptual Models

Recent empirical work on categorization has shown that category structure is even more variable than had been assumed by the researchers who first proposed the prototype theory of category structure (Armstrong et al., 1983; Barsalou, 1987, 1989; Gleitman et al., 1983). In most Type 1 categories, some attributes are more important to category structure than others. As a result, some of the statistically most prevalent features of members of a category may be disregarded in formulating the prototype. For example, attributes such as *natural environment* and *means of locomotion* have a strong influence on how we categorize whales, leading us to disre-

gard such taxonomic attributes as *mode of respiration* and *means of reproduction*. In consequence, a whale seems closer to a prototypical fish than it is to a prototypical mammal, despite its proper Linnean categorization. Research has also shown that judgments of typicality change over time, even when no new individuals are categorized. Rather than constituting a stable cognitive entity, it appears that the prototype for a category is actually fluid and variable, and changes with the circumstances of categorization.

An alternative view of category structure suggests that categories are organized around *conceptual models*. In brief, conceptual models consist of concepts in specified relationships, pertaining to a specific domain of knowledge; such models are central to reasoning and inference.[4] With regard to categorization, the primary function of the conceptual model is to supply a guide for reasoning about accepted and potential members of the category. This is accomplished through a simplified representation of category structure that incorporates knowledge about what values are most typical for a select group of attributes for the given category. These attributes are selected according to the goals of categorization, which are themselves informed by more global conceptual models applicable to a broad range of categorization tasks (Barsalou, 1991; Barsalou et al., 1993; Sweetser, 1987). The conceptual model for a given category thus reflects information of the sort summarized in frame diagrams but conditioned by knowledge about the overall goals of categorization.

As a means of developing a preliminary understanding of the concepts and relationships constituent of a conceptual model for a category, let us return once more to the opening of Beethoven's symphony and consider a conceptual model for the category *motive forms from the opening of Beethoven's Fifth Symphony*. The model, which is diagrammed in Figure 8, consists of four correlated conceptual elements. Each element is either a concept or a cluster of concepts related to some

4. This sort of model has occupied researchers in cognitive science and artificial intelligence for more than 20 years. However, there is great diversity in just what is meant by a conceptual model and what such cognitive structures are called; for instance, the frame or framework can be considered to be a conceptual model. Other analogues for conceptual models include mental models (Barsalou, 1992a; Gentner & Stevens, 1983; Johnson-Laird, 1983); idealized cognitive models (Lakoff, 1987; McCauley, 1987); cultural models (D'Andrade, 1995; D'Andrade & Strauss, 1992; Quinn & Holland, 1987; Shore, 1996); cognitive domains (Langacker, 1987, 1992); and knowledge structures (Abelson & Black, 1986). More information on conceptual models can be found in Zbikowski (1997).

Although the terms for cognitive structures analogous to conceptual models vary widely, the approach to categorization I develop here is largely consonant with that presented in Murphy and Medin (1985), Lakoff (1987), and Barsalou et al. (1993).

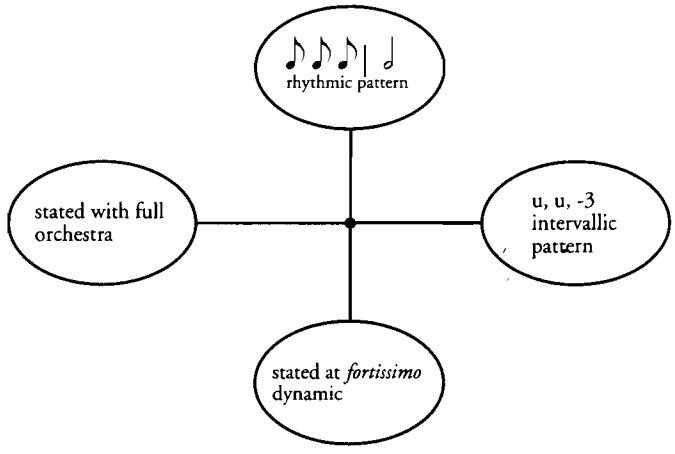

Fig. 8. Conceptual model for the category *motive forms from the opening of Beethoven's Fifth Symphony.*

aspect of the motive. The knowledge organized by the conceptual model includes the following:

- the rhythmic pattern of the motive (eighth/eighth/eighth/half [or more])
- the motive is stated with full orchestra
- the motive is stated at a *fortissimo* dynamic
- the intervallic pattern of the motive consists of three repeated notes followed by a descending diatonic third[5]

These elements give priority to select attributes of the motive and assign default values to these attributes—that is, they define what is a "typical" member of the category. This network of attributes and values then provides a guide for categorizing the various versions of the motive that occur in the opening measures. Accordingly, versions of the motive such as those of measures 1–2 and measures 22–24 (which instantiate all aspects of the conceptual model) would be judged most typical of the category; motive forms such as those of measures 6–7 and measures 29–30 (which instantiate only two aspects of the conceptual model) would be less typical; and motive forms such as those of measures 7–8 and measures 35–36 (which instantiate only the rhythmic aspect of the conceptual model) would be least typical of the category.

What, then, of the evidence provided by Figure 7? That is, what can one make of the lack of correlation between the conceptual model and the individual category members, since most of these would be reckoned to be less

5. I should emphasize that the conceptual models I describe here are by no means the simplest elements of conceptual structure. Each conceptual cluster of the present model, for instance, could be represented by a still-smaller conceptual model correlating the constituent concepts of the cluster.

typical members according to the conceptual model for the category? The answer to this question requires delving a bit deeper into the way conceptual models both reflect and shape our understanding of music.

The conceptual model shown in Figure 8 gives undeniable priority to the statements of the motive that open the movement. The preference given the first statements of musical materials we encounter is not absolute—there are, of course, works in which the principal materials emerge only gradually—but it does reflect the fact that we must process musical materials in time and that it is often the case that significance accrues to the first events in any psychological process. Note that Beethoven departs from his opening materials only gradually; in particular, divergences from the intervallic pattern of the motive (the aspect of the typicality shown by Figure 7 that best matches the proposed conceptual model) occur somewhat later in the opening measures and correlate with the compositional strategies of development and transition. The initial statements of the motive thus represent anchor points for the process of elaboration that Beethoven undertakes: the variations evident in Figure 7 are variations *on* the musical materials summarized in the conceptual model of Figure 8.

The conceptual model of Figure 8 is also informed by our ideas about musical themes: that is, such themes should be strongly and clearly stated at or near the outset of a movement, after which they may be modified or embellished in conformance with compositional strategies. Our local model for the motive of Beethoven's symphony is thus shaped by a global model of what constitutes an appropriate musical theme. Such global models are developed through abstraction from any number of local models, and, perhaps more importantly, taken from the broader base of knowledge constitutive of culture.[6] For instance, in the case of Beethoven's symphony, the relevant global model for a musical theme reflects the influence of nineteenth-century German and Austrian musical culture and in particular the efforts of the nineteenth-century critic and theorist Adolph Bernhard Marx and others to come to terms with Beethoven's compositional style.[7]

6. The idea that culture constitutes shared knowledge—in Naomi Quinn and Dorothy Holland's words, "not a people's customs and artifacts and oral traditions, but what they must know in order to act as they do, make the things they make, and interpret their experience in the distinctive way they do" (Quinn & Holland, 1987, p. 4)—is one of the bases of cognitive anthropology. For further discussion, see D'Andrade (1995).

7. Marx's is perhaps the most important voice within the tradition of analyzing the thematic aspects of Beethoven's music. Although Marx did not restrict himself to a definition of "theme" as such, preferring a broader and more organic account of musical organization, he did offer the notion of the *Satz*. Formed from motives, the *Satz* is a complete self-sufficient musical idea and represents the first coherent unit of musical organization (Marx, 1856/1997, p. 68); it is roughly comparable to Schoenberg's notion of a *grundgestalt* (Schoenberg, 1934–1936/1995, p. 169). It is, of course, no accident that Marx's formal theories reflect his efforts to make explicit Beethoven's compositional strategies—that is, to the extent that our notion of what constitutes a theme resonates with Marx's definition, that notion is informed by works such as the Fifth Symphony.

Our global model of what counts as a theme (which applies to any number of works by any number of composers) is thus in rapport with the local models through which we organize our understanding of specific musical works. Without a global model, it can be difficult to decide what aspects of a phenomenon are relevant for categorization. Without local models, there is no way to anchor global models to specific phenomena.[8]

It should be emphasized that the conceptual model sketched here and diagrammed in Figure 8 represents limited features of a network of interrelated propositions that might be used to guide reasoning about how motive forms in the opening of Beethoven's symphony relate to one another. The model does not represent, in a simple way, what someone "has in mind" when confronting this music. The simplicity of the model (which reflects in part the global models relative to which it is framed) contributes to its efficiency: it is specific enough to allow for clear distinctions between the motive of the opening measures and other thematic materials in the symphony (such as the second theme that enters in m. 63), but general enough to accommodate the wide range of different forms the opening motive takes. The model also reflects our intuition that there is just one main form of the opening motive, despite evidence to the contrary. Intuitions such as this contribute to the plausibility of Type 2 categories. Features of the conceptual model for a given category will often be transformed into the necessary and sufficient conditions characteristic of Type 2 categories; the result are "textbook" definitions of the sort that often lead to considerable debate among music theorists.

Summary: Typicality Effects and Musical Motive

Categories that show typicality effects offer a way to model both the coherence and variability of motive forms basic to Schoenberg's theory of motive. The property of coherence is analogous to the shared attributes of category members—that is, our sense that a collection of things coheres as a category reflects the attributes shared by those things. The variability Schoenberg noted is analogous to the variation among members of a Type 1 category. Just as certain motive forms are taken as the source for the derivation of further motive forms, so certain category members will be regarded as more typical of the category than others. Although typicality effects reflect, to a certain extent, statistical invariances among the attribute values demonstrated by category members, they are also a function of the goals of categorization. These goals shape the conceptual model for the

8. In their function, local models are analogous to what Eugene Narmour calls intraopus style, and global models are analogous to what Narmour calls extraopus style (Narmour, 1990, 1992). However, as I construe them, conceptual models are cognitive constructs that may be specified for music, whereas Narmour's style types are specific to musical structure.

category, which represents what is regarded as most typical of the category and which also provides a guide for reasoning and inference about potential category members.

An important difference between collections of musical motives and cognitive categories is that the former must be processed under the temporal constraints of musical performance. These constraints will, under most circumstances, inform the conceptual model for a category of motive forms, with priority given to those forms that occur early in a work. However, as the example of Schubert's *Wanderer Fantasie* suggests, other factors may cause our concept of what constitutes the central motive of a work to change as the piece unfolds.

Motive as Category in Mozart's String Quartet, K. 465

While the opening of the Fifth Symphony has the advantage of being immediately familiar, the sheer saturation of the first movement with various versions of the opening motive makes an account of motivic relationships somewhat unwieldy, as Figures 6 and 7 suggest. The first-movement Allegro of Mozart's String Quartet K. 465 (the "Dissonance" quartet, from 1785) proves rather more manageable for studying motive from the perspective of categorization, especially where the rhetorical effect of motivic transformations is concerned. The movement was one of Schoenberg's favorite examples when he discussed compositional technique, and, as Carpenter and Neff have noted, was treated to a number of analyses in Schoenberg's published and unpublished writings (Carpenter & Neff, 1995, p. 53). In these analyses, Schoenberg was not always consistent about what he regarded as the motive of the Allegro. To the extent that my analysis of the motive accords with that of Schoenberg, it follows the model set out in his discussion of the development section found in the *Fundamentals of Musical Composition* (Schoenberg, 1967, p. 208).

The motive is prominent in five sections of the Allegro: the opening and end of the Exposition (mm. 1–29 and 69–84, respectively); the Development section (mm. 85–132); and the opening and end of the Recapitulation (mm. 133–148 and 189–224). My discussion will focus on the first three of these sections, with briefer comments on the beginning of the Recapitulation and the conclusion of the movement.

MEASURES 1–29 OF THE ALLEGRO

Figure 9 gives the first 29 measures of the Allegro. The motive I shall focus on is presented in the first violin in measures 1–2 and then again in

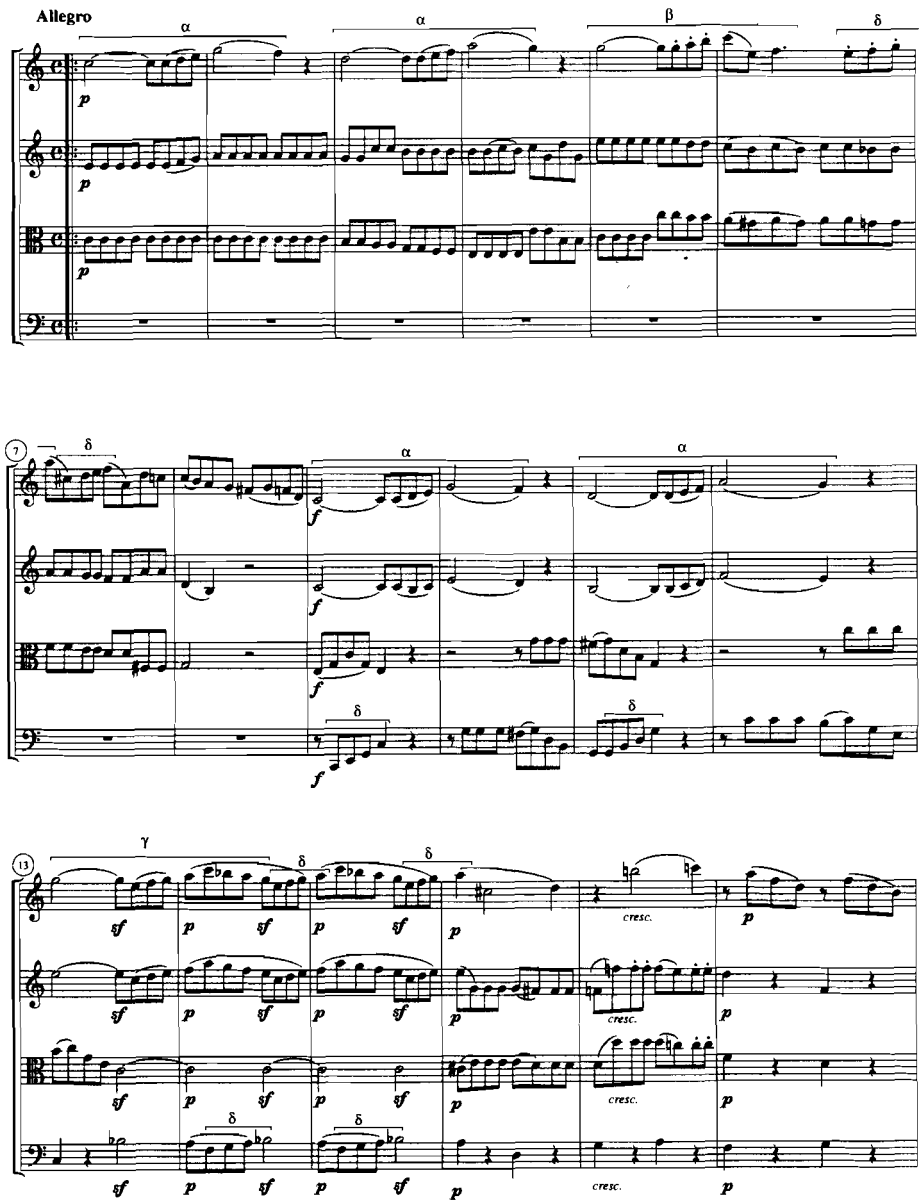

Fig. 9. Mozart, String Quartet K. 465, Allegro, measures 1–29.

measures 3–4 (symbolized with α on Figure 9). The principal features of the motive are as follows:

- a rhythmic pattern that spans two measures of common time:

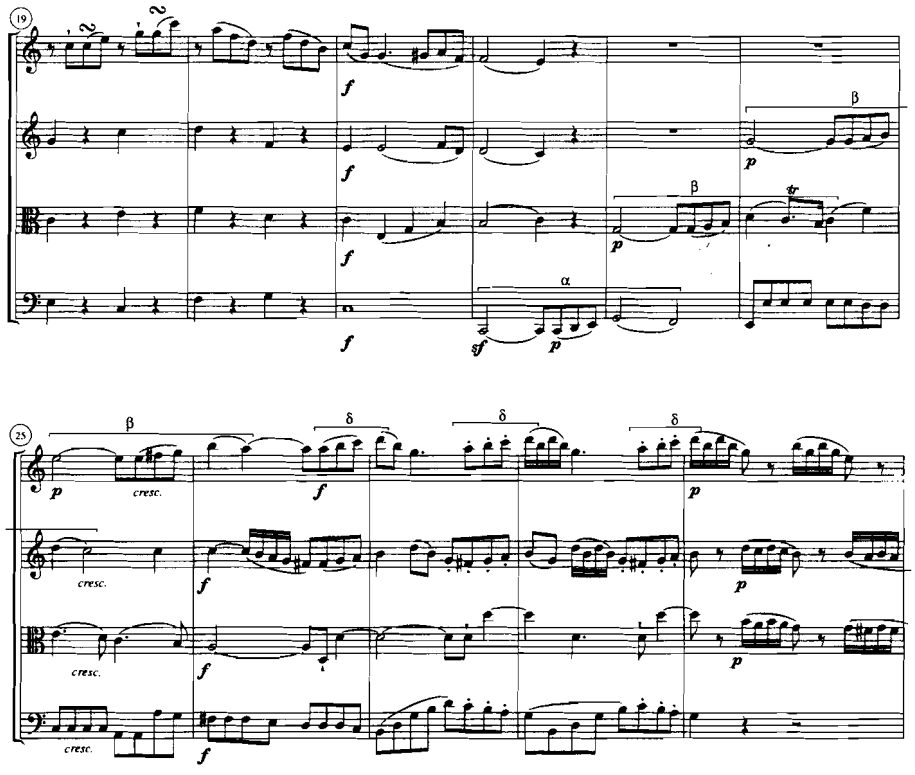

Fig. 9. Continued

- a rather specific diatonic contour, consisting of the four elements (each is shown in Figure 10); in order of succession, they are
  - i. a held first note
  - ii. an ascending stepwise motion through a third
  - iii. an upward skip of a third
  - iv. a downward step
- an implied harmonic change from the first to the second measure of the motive

The contour of the motive gives rise to two distinctive intervals: the fifth spanned by ii and iii; and the fourth between i and the last note of iv.[9] Although the implied change in harmony is masked in measures 1–2 (owing to the viola's pedal point), in most other cases it is quite apparent.

9. In an unpublished analysis, Schoenberg identified four motives within the central motive (which he called the *grundgestalt* of the Allegro): the fifth spanned by ii and iii; and the fourth between i and the last note of iv; the descending second of iv; and a descending third (marked between the first violin's m. 1 C_5 and the second violin's m. 2 A_4) (Carpenter & Neff, 1995, p. 56).

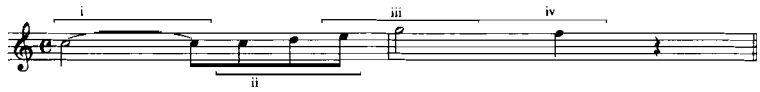

Fig. 10. Analysis of main motive from Mozart K. 465, Allegro.

The motive is restated in this form in measures 9–12 (accompanied by the second violin), and in the 'cello in mm. 22–23 (with the 'cello's concluding half note taking the place of the quarter-note/quarter-rest of the original). However, these are not the only versions of the motive evident in the opening measures. Other forms appear in the first violin in measures 5–6 and in the ascending cascade of measures 23–26 (ß in Figure 9). In each case, the very end of the motive has been modified: in measures 23–26, the most significant change is to the end of the rhythmic figure; in measures 5–6, both the end of the rhythmic figure and contour pattern have been changed. One additional version of the motive, heard in the first violin in measures 13–14 (γ in Figure 9), is still more distant, retaining most of the rhythmic pattern of the original but only element ii of the contour.

Although these are the only full statements of either the motive or a variant in measures 1–29, there is a subcomponent of the motive—the ascending gesture that ends on a strong beat—that is prominent throughout these measures. This element (shown with δ in Figure 9) contributes much to the sense that the main motive is a unifying force throughout the opening of the Allegro. However, without the context of the main motive, the gesture is not particularly distinctive: for instance, when a similar gesture occurs in measures 40–41 and 42–43, in the midst of the first subsidiary theme, it is decidedly subservient to the alternation of ascending and descending skips that dominates the musical scene.[10]

The various versions of the motive that appear in measures 1–29 can be thought of as constituting a cognitive category, with the principal motivic characteristics outlined above representing the conceptual model around which the category is organized.[11] Most typical of the category are the prominent statements of the motive that open the Allegro—

10. The transformation of the δ element from something that refers to the main motive of the Allegro to something that does not is an example of what Douglas Hofstadter calls "conceptual slippage": that is, the context-induced dislodging of one concept by another (Hofstadter & the Fluid Analogies Research Group, 1995, p. 198).

11. In the interests of concision, I have dispensed with a consideration of frame structure for the category *forms of the main motive from the Allegro of K. 465*. However, vestiges of this structure can be seen in that of the conceptual model, which describes the attribute values of the most typical form of the motive.

indeed, these provide the basis for the conceptual model for the category.[12] The motive forms that appear in measures 5–6 and 13–14 do not conform as completely to the conceptual model, but retain enough features that they are still suitable for inclusion as less-typical members of the category. In measures 15–21, the motive temporarily disappears (save for the δ fragments) but then reappears in its most typical form in measure 22, immediately followed by three slightly less typical versions. After this there are further δ fragments, followed by relatively generic cadential material that prepares for the entrance of the first subsidiary theme in measure 34.

Taken as a whole, the motive forms presented in measures 1–29 are a relatively normative Type 1 category, with the typicality effects characteristic of the type. What is striking, however, is the dynamic shape of the category as it is presented over the course of time. Although typical members dominate the musical texture in the first half of the section, they momentarily disappear from the texture in the second half, to be brought back at an important moment preceding the transition to the first subsidiary theme. The musical coherence provided by the main motive, then, is less a function of its constant presence and more a function of its memorability and cognitive utility. These make possible a musical syntax of both exposition and development: exposition as the motive is first established in its most typical form and development as less-typical variants are then introduced.

MEASURES 68–84 OF THE ALLEGRO

After its gradual departure in measures 22–29, the motive disappears completely for 40 measures, during which time two subsidiary themes are presented in the dominant. When the motive does return, it is at a moment of opportunity, following a final emphatic cadence of the sort that usually signals the conclusion of a section or that prepares the way for additional thematic material. By bringing back the main motive at this point, Mozart emphasizes the overall coherence of the Exposition. However, the coherence is of a contingent sort, for it is a variant of the main motive rather than the original that is introduced, and the compositional strategy applied to the statements that follow is closer to development than it is to exposition.

12. As noted earlier, it is also possible for the conceptual model for a category of motive forms to emerge over time, although the longer the process is delayed, the more the conceptual model comes into conflict with the global model for a musical theme. In addition, composers may challenge the putative typicality of a motive at some later point; just such a strategy is discussed later.

As shown in Figure 11, the motive enters in the second violin in measure 69, just as the first violin achieves its cadential G_5.[13] The first violin responds by taking up the motive as well, beginning a short game of motivic tag in which some form of the motive enters in each of the succeeding measures. The initial motive forms are of the ß variety, highly similar to the original form but with a slightly modified ending. Although harmonic change is still evident, the constant overlap of motives limits the harmonic possibilities to the tonic and dominant of G major. The sense of harmonic progress that accompanied the original statement of the motive is markedly attenuated: contributing factors are the constant alternation between tonic and dominant; the 'cello's pedal point in measures 69–73 and the halving of harmonic rhythm that follows in measure 74.

This reprise of the motive bears witness to new, and somewhat more extensive, variations. In measures 71–72 and 72–73, the second and first violins present embellished versions of the motive forms they've just stated (indicated with a γ in Figure 11); were it not for the temporal proximity of these to the preceding motive forms it might be difficult to make a case for their derivation from the original. More obvious is the inverted form of the motive that appears in the first violin in measures 74–77, and which is then used in the simultaneous presentation of motive forms in all four instruments in measures 82–83. Finally, the δ fragment that provided a measure of unity at the opening of the exposition reappears in measures 79–81 to serve as a link between the motive forms that precede and follow it.

Given the absence of the original form of the motive in these measures, a case could be made for modifying the conceptual model for the category such that variants of the sort shown with a ß in Figure 11 would be regarded as typical. However, retaining the sense that we have moved away from what is typical of the category is quite useful given what happens next. If the repeat sign of measure 84 is observed and the Exposition reprised, the typicality of the original version of the motive will be reaffirmed: we will have moved from the edges of the category (as represented by mm. 69–84) back to the center. If we instead proceed from measure 84 into the Development, we will move yet farther toward the fringes of the category.

MEASURES 85–113 OF THE ALLEGRO

As shown in Figure 12, Mozart begins the Development with a slightly modified version of the original motive, but with changes now made to the middle of the motive rather than to the end: he starts the ascending-third figure a step higher than the sustained note, instead of repeating the sus-

13. The sustained note at the beginning of the motive allows Mozart to introduce it under the cover of cadence, something he exploits at various developmental moments throughout the movement.

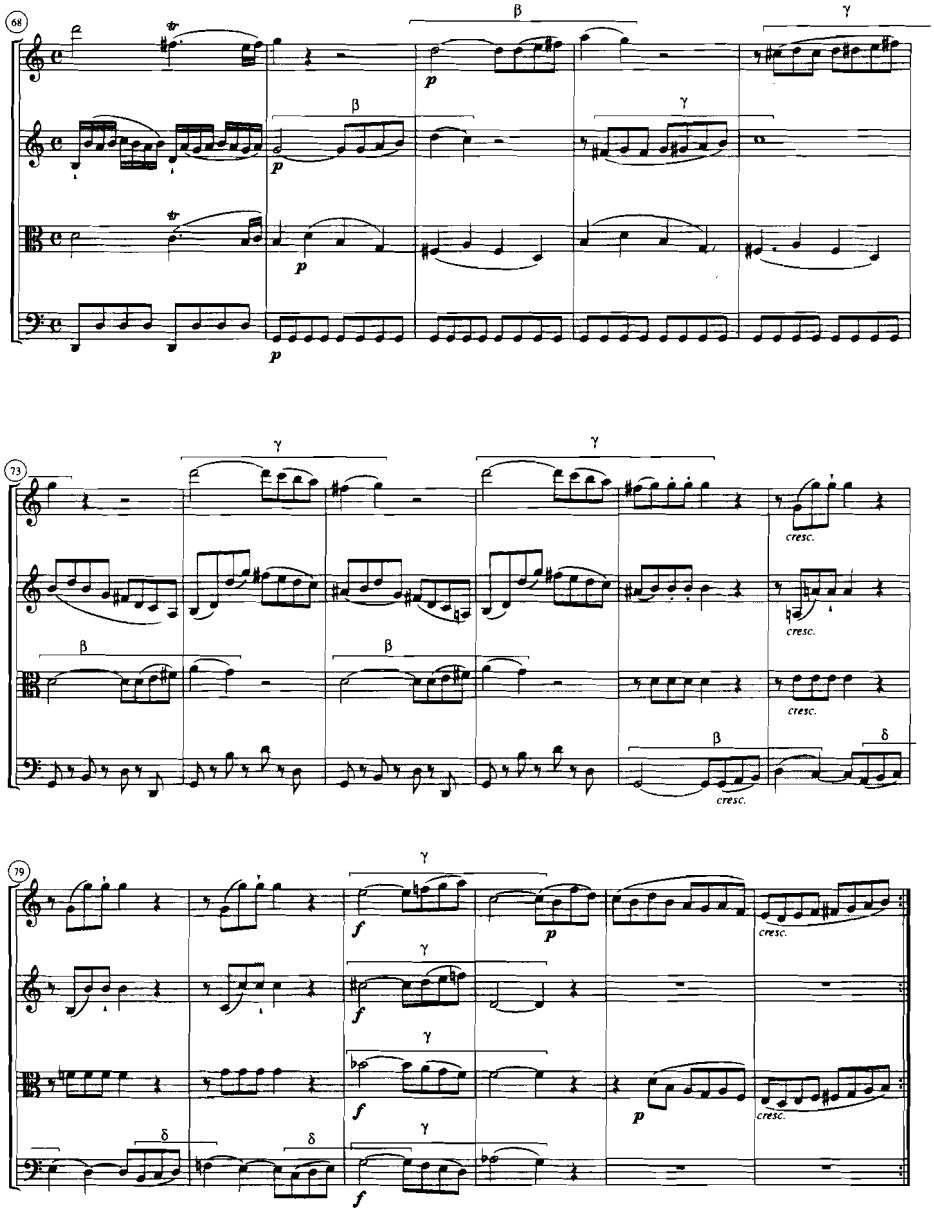

Fig. 11. Mozart, String Quartet K. 465, Allegro, measures 68–84.

tained note at the beginning of the figure. As a result, the motive as a whole now spans a fifth and implies no change of harmony. The chromatic alteration of the first note of the motive in measure 89 moves the motive a bit further away from its typical form, but it is the viola's version in measures 90–91 that accelerates the process of transformation. In this version (indi-

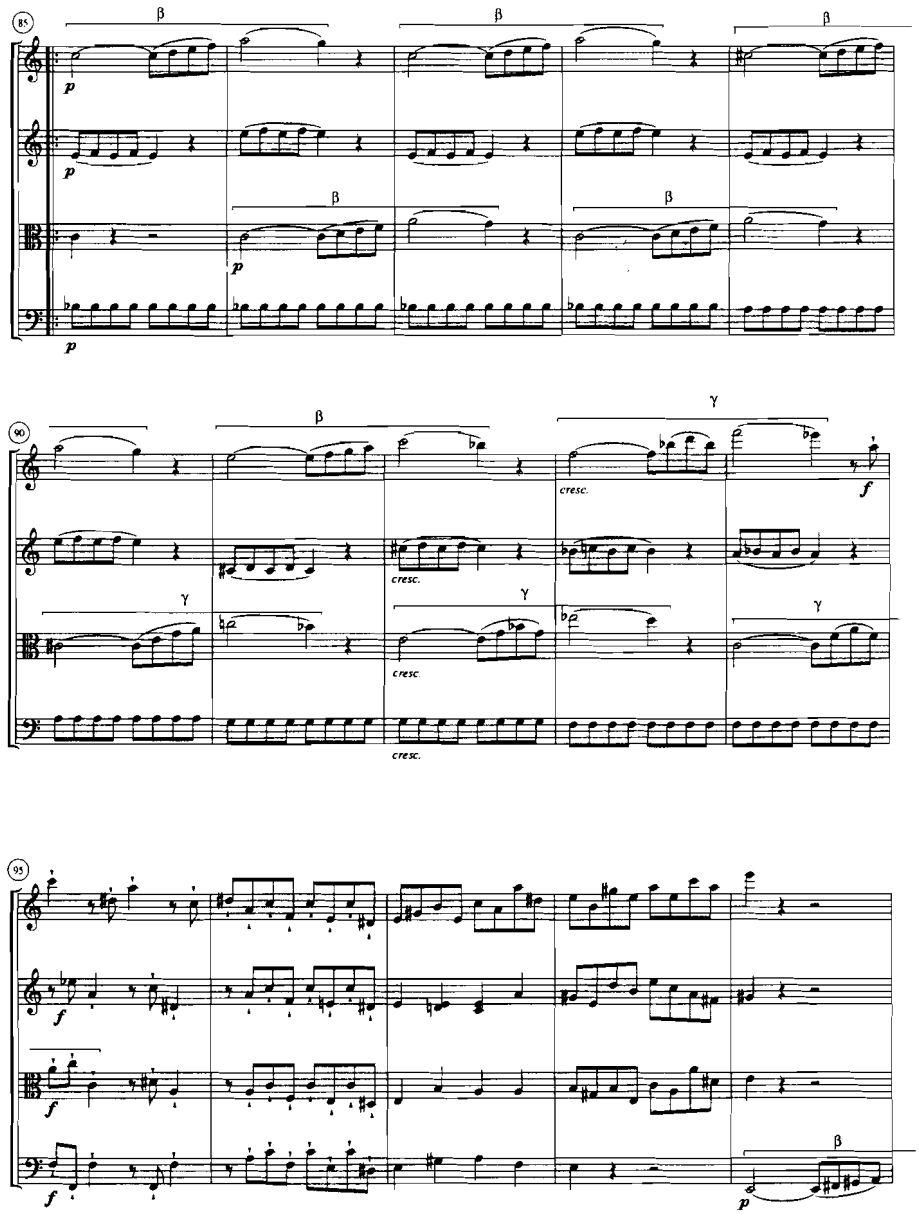

Fig. 12. Mozart, String Quartet K. 465, Allegro, measures 85–113.

cated with a δ in Figure 12) the ascending-third figure is replaced with an arpeggio, which becomes a feature of the following motive forms. At measure 95, the arpeggio figure takes over, and the subsequent dissolution of

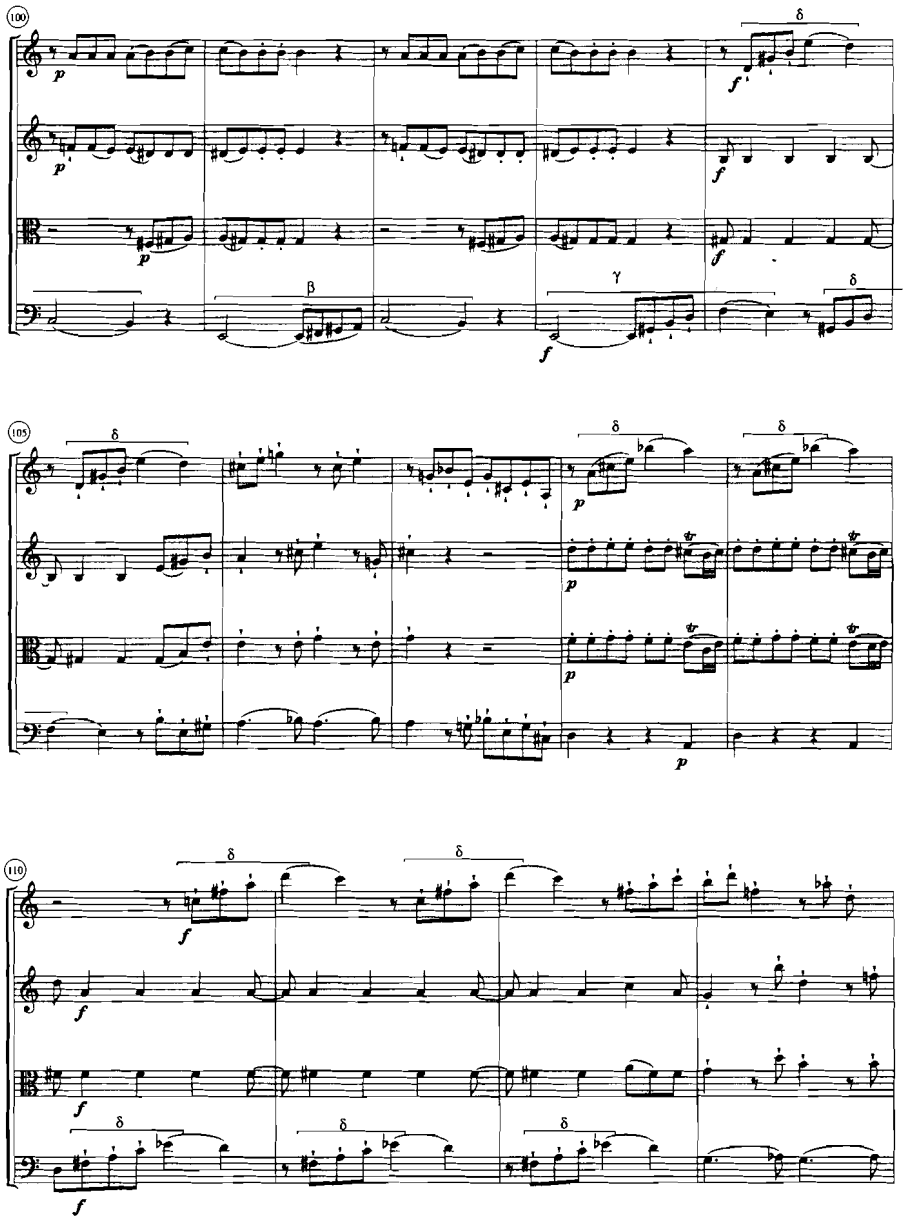

Fig. 12. Continued

the motive leads to a momentary cadence on the dominant of A minor in measure 99.[14]

14. Schoenberg called this sort of dissolution "liquidation" (Schoenberg, 1967, p. 208; Schoenberg, 1934–1936/1995, pp. 252–253).

At measure 99, the 'cello returns to the form of the motive used at the beginning of the Development (but now within the context of A minor). However, after two statements, the rising arpeggio figure once again replaces the ascending third within the motive, after which point it displaces the main motive (or its variants) altogether (as indicated by the preponderance of δ symbols in Figure 12). In measure 125, the form of the motive used at measures 85 and 99 makes a final appearance (beginning on the 'cello's G_2, but pointing toward C minor). Given the events that followed the previous two appearances of this form of the motive, this third appearance seems to suggest yet another episode of development. However, in measure 129, the motive yields to an ascending cascade of arpeggio figures (all outlining a G dominant seventh) which bring the Development to a close.

As was the case in the Exposition, in the Development, more typical forms of the motive are followed by less typical forms. What is distinctive is the close-order repetition of this strategy (which is used three times within the 40-odd measures of the Development), and the emergence of the ascending δ figure as the means for Mozart to advance his musical argument. Although the slightly varied form of the motive that marks the beginning of each pattern has prominence as a point of reference for this musical argument (and thus represents what is "typical" of thematic material), it lacks the sense of balanced harmonic progression summoned by the original form of the motive. However, given the variation of the motive that takes place over the course of measures 85–113, just what *is* typical of the original motive is something of an open question by the time we arrive on the dominant seventh of measures 129–132.

MEASURES 133–148 AND 189–224 OF THE ALLEGRO

The question of motivic identity posed by the Development is answered by the understated but nonetheless confident return of the original motive in measures 133–136, shown in Figure 13. Although the accompaniment is somewhat different than that used in measures 1–4, the motive itself is unchanged from its original form: this is the motive at its most typical. However, Mozart is not content to leave it at that. The accompaniment for the second statement of the paired motives, in measures 141–144, is not only fuller, but brings back the overlapped motive forms used at the end of the Exposition and in the opening of the Development. These slightly varied forms of the original (indicated with ß in Figure 13) recall the developmental cast of the earlier passages, as do the ascending δ figures in the 'cello. However, Mozart quickly turns away from any further dissolution of the main motive and instead moves with dispatch toward the first subsidiary theme, which commences in measure 154.

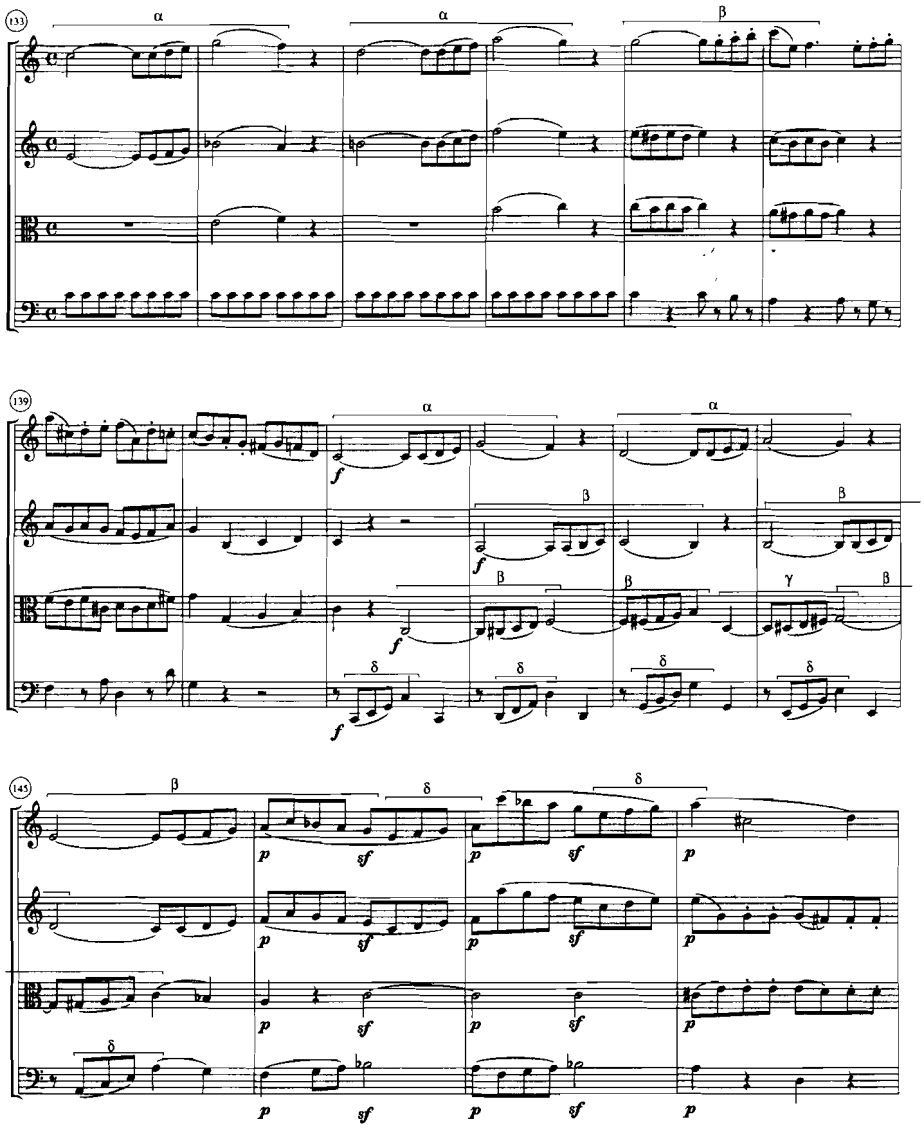

Fig. 13. Mozart, String Quartet K. 465, Allegro, measures 133–148.

The end of the Recapitulation restates the end of the Exposition almost exactly, measures 69–84 transposed into C major for measures 189–204. From this point, the music proceeds either back to the beginning of the Development (if the repeat is taken) or into a short concluding section (which occupies mm. 205–224). As shown in Figure 14a, the latter grows out of the opening of the Development, but uses yet another modification

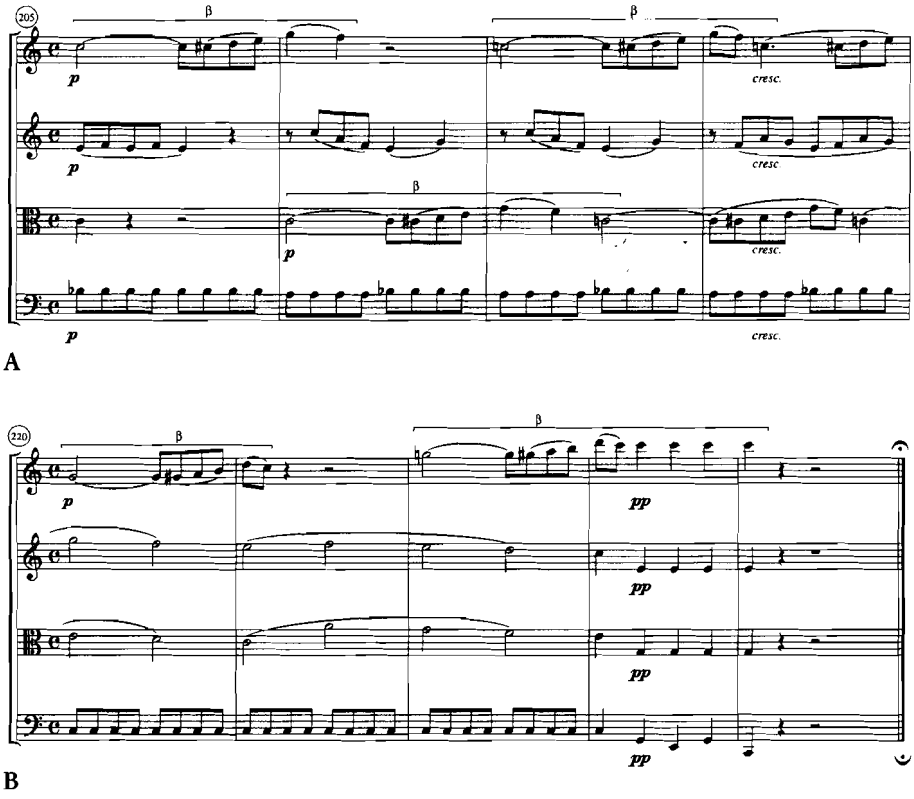

Fig. 14. Mozart, String Quartet K. 465, Allegro. (A) Measures 205–208. (B) Measures 220–224.

of the original motive. This version owes much to that used in measures 189–191 (the transposed quotation of mm. 69–71), but applies a chromatic inflection to the note at the beginning of the ascending-third figure. A further variant then concludes the movement, which is shown in Figure 14b: the end of the motive, shortened from the original half-note/quarter-note figure to the successive quarters of measures 205–207, is shortened yet again to two successive eighth notes. Although a similar figure occurs in measures 207–208, *that* variant refers back to measures 5–6, for the successive eighths lead immediately to additional material (in the case of mm. 207–208, a repetition of the ascending-third figure). In measures 220–223, the eighths simply represent a compression of the original motive, and it is with this abbreviated form of the motive that the movement ends.

Although the concluding section recalls the opening of the Development, Mozart allows the prospect of further divergence from the main motive to linger for only a moment before banishing it with a vigorous and trium-

phant cadence on C major in measures 212–213. Nonetheless, it cannot be said that the movement ends with an unequivocally typical form of the motive: if the original form of the motive represents the stable center of the cognitive category of motive forms, the conclusion does not return us to that center. Two factors, both related to global models that provide a context for conceptual model that defines what is typical of this motivic category, inform the ending. First, the ending is harmonically quite stable: the final version of the motive introduced in measures 220–223 reinforces this stability by outline scale degrees $\hat{5}$ and $\hat{1}$ and by placing the arrival on $\hat{1}$ as close as practicable to the first beat of the metric cycle while retaining the appoggiatura figure characteristic of the motive. Second, the most typical version of the motive, in accordance with the global model for music themes relative to which it is framed, represents musical material to be acted upon—it is a theme in the sense of a topic for discourse. At this point in the movement, however, discourse must be concluded: what is required is not a highly typical version of the main motive, but a reminiscence of the motive suited to the purposes of ending.

MUSICAL COHERENCE, MOTIVE, AND CATEGORIZATION IN THE ALLEGRO

As shown by the foregoing analysis, musical coherence in the Allegro from Mozart's string quartet is a sectional affair: although the motive plays a key role at prominent places within the Allegro, it cannot be used to account for all of the material of the movement. To offer such an account would require an analysis of the remaining thematic elements, as well as a consideration of the part played by stylistic formulas of the sort discussed by Robert Gjerdingen (1988, 1992, 1996). Nonetheless, within the sections I have discussed, the contribution of the category comprising various versions of the main motive is evident: to the extent that these sections cohere, they make use of musical material derived from the main motive. The coherence that is produced is by no means a steady state but changes in conformance with compositional strategy and reflects the typicality of the motivic materials in play at any given moment.

The view of musical coherence that emerges from this analysis is, in consequence, somewhat more involved than that laid out by Schoenberg. Schoenberg's intent was to show how musical materials were derived from a limited number of sources, a demonstration he felt to be of crucial importance to the student composer. In contrast, the unfolding of the category of motive forms that takes place in the Allegro suggests that musical coherence is contingent on local musical context, and that the dynamics of coherence play an important part in musical rhetoric. When Mozart wishes to suggest the dissolution of his motive (or at least confusion as to its identity), he gradually introduces forms that are less and less typical of the

category as a whole. When he wishes to reassert the vitality of the motive, he returns to more typical forms. The coherence of the category, reflected in the conformance of motive forms with the conceptual model for the category, thus waxes and wanes rather than remaining ever-constant. From the perspective of compositional technique, this is a somewhat less neat picture than that provided by the relatively straightforward organicist approach behind Schoenberg's theory of coherence. From the perspective of research on categorization, however, this is a view of music consonant with the way we structure our understanding of everyday experience.

Musical Coherence, Categorization, and Motive

Schoenberg's insight was that music was subject not only to the laws of acoustics and musical succession, but also to the laws that govern the working of our minds: the shapes music takes are constrained by human cognitive processes. As a composer, Schoenberg worried about how musical materials had to be organized so that, despite the inexorable flow of events and the complexity of musical thought, they would be coherent and comprehensible. Focusing on the challenges music presents to the listener, we could ask a correlate question: how can we account for the comprehension of music, given that our processing of musical events must be both rapid (because of the inexorable flow of events) and flexible (because of the complexity of musical thought)? Schoenberg's focus on and conception of motive in *his* account of musical comprehension suggest a partial answer to this question, for the similarities with recent research in categorization are striking. Motives, as the place where musical comprehension begins, share a number of features with basic-level categories: both concern wholes rather than the parts of wholes; overall shape plays an important part in both; and both are subject to the influence of expertise. The various statements of a given motive, considered as a collection, strongly resemble a Type 1 category: the coherence of the collection is analogous to the shared attributes of category members; the variability of motive forms is analogous to the range of values category members assign attributes; and the recognition that one form of the motive functions as the source for the derivation of further motive forms is analogous to the typicality effects characteristic of Type 1 categories. The analysis of the Allegro from Mozart's String Quartet K. 465 fleshes out this picture somewhat, suggesting that our sense of how well a category of musical events coheres will vary over the course of a musical work, and that this variation will inform musical rhetoric. What Edward Cone called "epiphany" can be interpreted as the moment when, coherence having been lost, it is unexpectedly regained.

During the past three decades, cognitive science has made great strides in discovering the "laws of the mind" that so intrigued Schoenberg. Important among these "laws" are processes of categorization, which have proven to be basic to human cognition. Applied to music, research on categorization offers a way to account for musical coherence, especially as it relates to the apprehension and evaluation of musical motives. This research also suggests ways to enrich the understanding of musical coherence beyond Schoenberg's original conception. Whether Schoenberg would embrace such extensions is an open question, for he was famously confident of the correctness of his opinions. Nonetheless, this very confidence also allowed him to relax his grasp on his intellectual progeny. At the end of the essay where he remarked on the importance of respecting the laws that govern the working of our minds, Schoenberg reflected on the future promise of the stylistic change he brought about with his atonal compositions. There he observed that both listeners and composers would need many years to come to terms with his innovations. He was not troubled about the value of atonality, but only urged others to hurry to fill the stylistic gap it had created: "The idea is timeless, so it can perfectly well wait; but the language must make haste!" (Schoenberg, 1926/1975b, p. 264). With respect to Schoenberg's theory of coherence, much the same could be said, even if the language provided by the theories and discoveries of cognitive science has only lately provided a theoretical model adequate to his insight.[15]

References

Abelson, R. P., & Black, J. B. (1986). Introduction. In J. A. Galambos, R. P. Abelson, & J. B. Black (Eds.), *Knowledge structures*. Hillsdale, NJ: Lawrence Erlbaum.

Armstrong, S. L., Gleitman, L. R., & Gleitman, H. (1983). What some concepts might not be. *Cognition, 13*, 263–308.

Barsalou, L. W. (1987). The instability of graded structure: Implications for the nature of concepts. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 101–140). Cambridge: Cambridge University Press.

Barsalou, L. W. (1989). Intraconcept similarity and its implications for interconcept similarity. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 76–121). New York: Cambridge University Press.

Barsalou, L. W. (1991). Deriving categories to achieve goals. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 27, pp. 1–64). San Diego: Academic Press, Inc.

Barsalou, L. W. (1992a). *Cognitive psychology: An overview for cognitive scientists*. Hillsdale, NJ: Lawrence Erlbaum Associates.

15. I thank the referees of *Music Perception* for providing valuable comments on how this essay could be improved. James D. McCawley was the Andrew McLeish Distinguished Service Professor of Linguistics and East Asian Languages at the University of Chicago. Jim had a deep and passionate interest in music and was a participant in my 1994 seminar on music and categorization, which led to this essay.

Barsalou, L. W. (1992b). Frames, concepts, and conceptual fields. In A. Lehrer & E. F. Kittay (Eds.), *Frames, fields, and contrasts: New essays in semantic and lexical organization* (pp. 21–74). Hillsdale, NJ: Lawrence Erlbaum Associates.

Barsalou, L. W. (1993). Flexibility, structure, and linguistic vagary in concepts: Manifestations of a compositional system of perceptual symbols. In A. F. Collins, S. E. Gathercole, M. A. Conway & P. E. Morris (Eds.), *Theories of memory* (pp. 29–101). Hillsdale, NJ: Lawrence Erlbaum Associates.

Barsalou, L. W., Yeh, W., Luka, B. J., Olseth, K. L., Mix, K. S., & Wu, L.-L. (1993). Concepts and meaning. In K. Beals, G. Cooke, D. Kathman, K. E. McCullough, S. Kita & D. Testen (Eds.), *Chicago Linguistics Society 29: Papers from the parasession on conceptual representations.* Chicago: University of Chicago, Chicago Linguistics Society.

Berlin, B. (1972). Speculations on the growth of ethnobotanical nomenclature. *Language in Society, 1,* 51–86.

Berlin, B. (1978). Ethnobotanical classification. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 9–26). Hillsdale, NJ: Lawrence Erlbaum Associates.

Berlin, B. (1992). *Ethnobiological classification: Principles of categorization of plants and animals in traditional societies.* Princeton, NJ: Princeton University Press.

Berlin, B., Breedlove, D. E., & Raven, P. H. (1974). *Principles of Tzeltal plant classification.* New York: Academic Press.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94,* 115–147.

Brown, R. (1958). How shall a thing be called? *Psychological Review, 65,* 14–21.

Brown, R. (1965). *Social psychology.* New York: Free Press.

Carpenter, P., & Neff, S. (1995). Commentary. In A. Schoenberg, *The musical idea and the logic, technique, and art of its presentation* (pp. 1–74). New York: Columbia University Press.

Cone, E. T. (1987). On derivation: Syntax and rhetoric. *Music Analysis,* 6(3), 237–255.

D'Andrade, R. G. (1995). *The development of cognitive anthropology.* Cambridge: Cambridge University Press.

D'Andrade, R. G., & Strauss, C. (Eds.). (1992). *Human motives and cultural models.* Publications of the Society for Psychological Anthropology. Cambridge: Cambridge University Press.

DeBellis, M. (1995). *Music and conceptualization.* Cambridge: Cambridge University Press.

Edelman, G. M. (1989). *The remembered present: A biological theory of consciousness.* New York: Basic Books.

Edelman, G. M. (1992). *Bright air, brilliant fire: On the matter of mind.* New York: Basic Books.

Gentner, D., & Stevens, A. L. (Eds.). (1983). *Mental models.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Gjerdingen, R. O. (1988). *A classic turn of phrase: Music and the psychology of convention.* Philadelphia: University of Pennsylvania Press.

Gjerdingen, R. O. (1992). Revisiting Meyer's "Grammatical simplicity and relational richness." In M. R. Jones & S. Holleran (Eds.), *Cognitive bases of musical communication* (pp. 225–243). Washington, DC: American Psychological Association.

Gjerdingen, R. O. (1996). Courtly behaviors. *Music Perception, 13,* 365–382.

Gleitman, L. R., Armstrong, S. L., & Gleitman, H. (1983). On doubting the concept 'concept.' In E. K. Scholnick (Ed.), *New trends in conceptual representation: Challenges to Piaget's theory?* (pp. 87–110). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hampton, J. (1993). Prototype models of concept representation. In I. v. Mechelen, J. Hampton, R. S. Michalski, & P. Theuns (Eds.), *Categories and concepts: Theoretical views and inductive analysis* (pp. 67–95). Cognitive Science Series. London: Academic Press.

Hampton, J., & Dubois, D. (1993). Psychological models of concepts. In I. v. Mechelen, J. Hampton, R. S. Michalski, & P. Theuns (Eds.), *Categories and concepts: Theoretical views and inductive analysis* (pp. 11–33). Cognitive Science Series. London: Academic Press.

Hofstadter, D. R., & the Fluid Analogies Research Group. (1995). *Fluid concepts and creative analogies: Computer models of the fundamental mechanisms of thought.* New York: Basic Books.

Jackendoff, R. (1987). *Consciousness and the computational mind.* Cambridge, MA: MIT Press.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness.* Cambridge, MA: Harvard University Press.

Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind.* Chicago: University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought.* New York: Basic Books.

Langacker, R. W. (1987). *Foundations of cognitive grammar: Theoretical prerequisites.* Stanford, CA: Stanford University Press.

Langacker, R. W. (1992). *Foundations of cognitive grammar: Descriptive application.* Stanford, CA: Stanford University Press.

Lassaline, M. E., Wisniewski, E. J., & Medin, D. L. (1992). Basic levels in artificial and natural categories: Are all basic levels created equal? In B. Burns (Ed.), *Percepts, concepts and categories: The representation and processing of information* (pp. 327–378). Advances in Psychology. Amsterdam: North-Holland.

Lenat, D. B., & Guha, R. V. (1989). *Building large knowledge-based systems: Representation and inference in the Cyc project.* Reading, MA: Addison Wesley.

Marx, A. B. (1997). *Musical form in the age of Beethoven: Selected writings on theory and method* (S. G. Burnham, Ed. and Trans.). Cambridge Studies in Music Theory and Analysis, vol. 12. Cambridge: Cambridge University Press. (Original work published 1856)

McCauley, R. N. (1987). The role of theories in a theory of concepts. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 288–309). Cambridge: Cambridge University Press.

Mechelen, I. v., Hampton, J., Michalski, R. S., & Theuns, P. (Eds.). (1993). *Categories and concepts: Theoretical views and inductive analysis.* London: Academic Press.

Mervis, C. B., & Rosch, E. (1981). Categorization of natural objects. *Annual Review of Psychology, 32,* 89–115.

Minsky, M. (1975). A framework for representing knowledge. In P. H. Winston (Ed.), *The psychology of computer vision* (pp. 211–277). New York: McGraw-Hill.

Minsky, M. (1985). *The society of mind.* New York: Simon and Schuster.

Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological Review, 92*(3), 289–316.

Narmour, E. (1990). *The analysis and cognition of basic melodic structures: The implication-realization model.* Chicago: University of Chicago Press.

Narmour, E. (1992). *The analysis and cognition of melodic complexity: The implication-realization model.* Chicago: University of Chicago Press.

Pollard-Gott, L. (1983). Emergence of thematic concepts in repeated listening to music. *Cognitive Psychology, 15,* 66–94.

Quinn, N., & Holland, D. (1987). Culture and cognition. In D. Holland & N. Quinn (Eds.), *Cultural models in language and thought* (pp. 3–40). Cambridge: Cambridge University Press.

Reti, R. (1951). *The thematic process in music.* New York: The Macmillan Company.

Rosch, E. (1973). On the internal structure of perceptual and semantic categories. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language* (pp. 111–144). New York: Academic Press.

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*(3), 192–233.

Rosch, E. (1977). Human categorization. In N. Warren (Ed.), *Studies in cross-cultural psychology* (Vol. 1, pp. 1–49). London: Academic Press.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 27–48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rosch, E., & Mervis, C. B. (1975). Family resemblances. *Cognitive Psychology, 7*, 573–605.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8*, 382–439.

Schenker, H. (1954). *Harmony* (O. Jonas, ed. and annotator; E. M. Borgese, Trans.). Chicago: University of Chicago Press. (Original work published 1906)

Schenker, H. (1979). *Free composition [Der freie Satz]* (E. Oster, Ed. and Trans.). New musical theories and fantasies, Vol. 3. New York: Schirmer Books. (Original work published 1935)

Schoenberg, A. (1978). *Theory of harmony.* (R. E. Carter, Trans.). Berkeley: University of California Press. (Original work published 1911)

Schoenberg, A. (1994). *Coherence, counterpoint, instrumentation, instruction in form* (S. Neff, Ed.; S. Neff, & C. M. Cross, Trans.). Lincoln: University of Nebraska Press. (Original work published 1917)

Schoenberg, A. (1975b). Opinion or insight?. In L. Stein (Ed.), L. Black (Trans.), *Style and idea: Selected writings of Arnold Schoenberg* (pp. 258–264). New York: St. Martins Press. (Original work published 1926)

Schoenberg, A. (1995). *The musical idea and the logic, technique, and art of its presentation* (P. Carpenter & S. Neff, Eds. and Trans.). New York: Columbia University Press. (Original work published 1934–1936)

Schoenberg, A. (1975a). Brahms the progressive. In L. Stein (Ed.), L. Black (Trans.), *Style and idea: Selected writings of Arnold Schoenberg* (pp. 398–441). New York: St. Martins Press. (Original work published 1947)

Schoenberg, A. (1967). *Fundamentals of musical composition* (G. Strang & L. Stein, Eds.). London: Faber and Faber Limited.

Shore, B. (1996). *Culture in mind: Cognition, culture, and the problem of meaning.* New York: Oxford University Press.

Smith, E. E., & Medin, D. L. (1981). *Categories and concepts.* Cambridge, MA: Harvard University Press.

Sweetser, E. E. (1987). The definition of lie: An examination of the folk models underlying a semantic prototype. In D. Holland & N. Quinn (Eds.), *Cultural models in language and thought* (pp. 43–66). Cambridge: Cambridge University Press.

Tanaka, J. W., & Taylor, M. (1991). Object categories and expertise: Is the basic level in the eye of the beholder? *Cognitive Psychology, 23*, 457–482.

Temperley, D. (1995). Motivic perception and modularity. *Music Perception, 13*, 141–169.

Tversky, B., & Hemenway, K. (1983). Categories of environmental scenes. *Cognitive Psychology, 15*, 121–149.

Tversky, B., & Hemenway, K. (1984). Objects, parts, and categories. *Journal of Experimental Psychology: General, 113*, 169–193.

Welker, R. L. (1982). Abstraction of themes from melodic variations. *Journal of Experimental Psychology: Human Perception and Performance, 8*, 435–447.

Zbikowski, L. (1997). Conceptual models and cross-domain mapping: New perspectives on theories of music and hierarchy. *Journal of Music Theory, 41*, 11–43.

Zbikowski, L. (1999). Seeger's unitary field reconsidered. In B. Yung & H. Rees (Eds.), *Understanding Charles Seeger, pioneer in American musicology* (pp. 130–149). Urbana: University of Illinois Press.