Conceptualizing Music: Cognitive Structure, Theory, and Analysis

Lawrence M. Zbikowski

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CONCEPTUALIZING MUSIC

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dem andenken meiner Mutter:
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PREFACE

On picking up a book with the title *Conceptualizing Music: Cognitive Structure, Theory, and Analysis*, one might reasonably assume that it deals with music cognition and how our knowledge of that discipline can be applied to music theory and analysis. This book does not do that, or at least not in a simple way. To begin, it does not have much to say about the fairly large body of research usually placed under the rubric "music cognition." This work, having been developed out of music psychology and informed by recent research in the brain sciences and mind sciences, proceeds by carefully crafted experiments, which are subjected to closely argued statistical and logical analysis. As practiced by such eminent and able researchers as Carol Krumhansl, John Sloboda, and David Huron, the study of music cognition has told us much about how humans process sonic and musical information.

But this book proceeds in a somewhat different way. Drawing on the same body of research from the brain sciences and mind sciences that shaped studies in music cognition, it explores how basic cognitive capacities are specified for understanding music. The project takes inspiration from recent work in linguistics and rhetoric by researchers like Ronald Langacker, Gilles Fauconnier, Mark Turner, and George Lakoff, and it is based on the assumption that musical understanding relies not on specialized capacities unique to the processing of patterned sound but on the specialized use of general capacities that humans use to structure their understanding of the everyday world. The methodology, in consequence, relies not on experimental design and data analysis but on using a broad and quite extensive body of research to interpret recurrent tropes of musical understanding. These tropes involve such things as the importance to musical understanding of relatively small and compact musical phenomena like "motives," "themes," and "chords"; the use of terms grounded in nonmusical domains—terms like "space" and "depth"—to characterize musical events; and the reliance on patterns of logical inference to reason about music.

The result of this investigation is a theoretical perspective on musical organization, but one rather different from what usually counts as "music theory." To make sense of this claim requires a bit of explanation about the intellectual context of music theory, for music theory is, within the rolling seas of humanistic studies, a rather strange fish. Put bluntly, it is clear that much of what music theory does, as a discipline, does not count as any sort of theory in modern scholarship. This is exemplified by each of the two distinct but related and intertwined strands that make up contemporary music theory. One strand is occupied with pedagogy, the other with speculative and highly systematic approaches to musical organization.

Music theory, as it is presented in the classroom, is most often engaged with a careful and often relentless explication of what, for want of a better term, we can call musical grammar. Consider the following, from Edward Aldwell and Carl Schachter's *Harmony and Voice Leading*:

> Like VII^6, V^4_3 has $\hat{2}$ as its bass. V^4_3, in fact, resembles VII^6 so closely that they are almost interchangeable chords. The bass of V^4_3 is a more neutral tone than that of V^6_5 (or, as you will see, V^4_2) and can move convincingly either to $\hat{1}$ or to $\hat{3}$. Consequently, V^4_3, like VII^6, forms a natural connection between I and I^6 and appears very frequently as a passing chord within an extended tonic.[1]

The prose and terminology are impressively dense. But one should not be misled into thinking that the authors are concerned only with abstruse compositional techniques, for immediately after this excerpt Aldwell and Schachter refer to a passage from an impromptu by Franz Schubert that illustrates the niceties of voice leading with which they are concerned. Their assumption is that the reader is familiar with the music and counts it as typical, and it is this familiarity that provides a phenomenological anchor for what might appear to be rather thick jargon. If you know Schubert's impromptu, or (better yet) can summon it in your sonic imagination when reading the example in score, Aldwell and Schachter's point about the harmonization of the second scale-step in the bass is not just clear but even obvious.

At the heart of pedagogical music theory are familiar or typical examples of music, the mysteries of which are revealed by a music theorist (or theorists) eager to share the secrets and wonder of this music with others. As elegant and persuasive as this approach might seem, it is, within our current cultural climate, more than a little unrealistic: music by Schubert and his contemporaries is often unfamiliar to the students who read Aldwell and Schachter's text (or any of a number of similar texts) and is not typical of the music that resonates through these students' digitized and hypercommercialized environments. That this should be so is often regarded as symptomatic of an illness of the late twentieth century, an illness that leads to an insufficient engagement with the great traditions of Western culture. For Classical music (as it is so styled), the antidote is music theory. Music theory, with its careful explication of the musical grammar of Mozart and Beethoven and Schubert, thus becomes the last redoubt against the dissolution of Western culture represented by a dwindling interest in the music of eighteenth- and nineteenth-century Europe.

If, for a moment, we step back from Aldwell and Schachter's text and generalize its intent beyond the specific repertoire relative to which it is framed, we might be able to avoid this rather sanctimonious stance. We could argue that music is a highly complex and idiosyncratic mode of human communication and that having a knowl-

1. Edward Aldwell and Carl Schachter, *Harmony and Voice Leading*, 2nd ed. (San Diego: Harcourt Brace Jovanovich, 1989), 112.

edge of the grammar of this mode of communication is essential to its deeper appreciation, no matter what form music might take. The argument is a familiar one to me, not the least because I often find myself making it. And yet, something rings hollow. The grammar that music theory teaches is unavoidably tied to the repertoire to which it refers, and just how this is generalized to apply to other repertoires is not immediately apparent: I know of no theory text that explains how the grammar of Schubert's musical discourse is manifested in the music of, say, John Coltrane or Prince. Given its isolation from contemporary culture, the music theory of the classroom appears to be little more than a ghost that haunts the echoing halls of a crumbling cultural empire.

The second strand of music theory partakes of the systematic quality inherent in grammars but generalizes it away from natural language and toward a free-standing intellectual construct. As an example of this sort of theory, consider the following brief passage from David Lewin's analysis of a section of the opening of Claude Debussy's piano prelude *Reflets dans l'eau*. In this excerpt, X, Y, and Z represent specific collections of musical notes, RI refers to the compound operations retrograde and inversion, RICH is a function that effects serial transformations, and T refers to transposition:

> In measure 10 the music of measure 9 is repeated and extended. The crescendo recurs. In the melody the repetition gives rise to a rotated form of Z_1, marked "rot Z_1" on figure 10.10. Rot Z_1 is B♭–A♭–F–E♭; it embeds serially the original form of Y, A♭–F–E♭, and precedes this Y by its overlapping inverse-RI-chained form B♭–A♭–F. (B♭–A♭–F is RICH^{-1}(A♭–F–E♭).) This relationship is more or less inherent in the derivations of X, Y, T(X), their repetitions, and Z_1.[2]

It is, of course, something of a challenge to evaluate this passage in isolation. Not only is it just one part of a larger analysis, but also it comes late in a book occupied with various and sundry applications of formal algebra and mathematical mapping theory to music. Nonetheless, what should be clear is that more than familiarity with Debussy's prelude is required to make sense of Lewin's interpretation of the passage. The reader must also be familiar with a style of abstract thought that is bound to appear cabalistic to the uninitiated, one in which the transformation of musical entities is at least as important as the entities themselves. For some, the inaccessibility of this mode of thought is one of its charms. For others, it is proof of the hermeticism and irrelevance of music theory.

Before continuing, I should make clear that I have deep respect for the theorists whose work I have cited. I use this work in my teaching and continue to be intrigued and stimulated by it. I also want to emphasize that these excerpts by no means reflect all that there is to music theory. I take them as representative of two strands of thought that are replicated and woven together in all sorts of different ways to create the texture of contemporary theoretical practice. What is important for my purposes here is that the practice of contemporary music theory is not like that of contemporary cultural or social theory. Instead of probing the cultural or historical

2. David Lewin, *Generalized Musical Intervals and Transformations* (New Haven, Conn.: Yale University Press, 1987), 234.

context for musical utterances, or the complex networks of social interaction that give rise to musical behavior, music theory continues to focus on details of musical discourse with an obsessiveness that is both maddening and quixotic to cultural and social theorists.

Given the impressive traditions of music theory and their influence on my own thought, I cannot guarantee that what I offer here is a great improvement on this situation. One of the things I want to do in the chapters that follow, however, is to develop a somewhat different view of music theory—one that sees music theory as a response to a problem. The problem is that of musical understanding: how it is that we can make sense of sequences of nonlinguistic patterned sound, that we can do so with amazing rapidity, and that (often as not) we can return to these or similar sound sequences and find continued reward. I will argue that our understanding of music relies on a play of concepts and conceptual structures that emerges from training basic cognitive capacities on musical phenomena and that music theory and music analysis derive from this play.

This mode of inquiry is not one common in the discipline of music theory, despite its similarities to work done by Leonard B. Meyer, Eugene Narmour, and Robert Gjerdingen. It does, however, share features with the approach to music evident in Susan McClary's recent *Conventional Wisdom*. That this should be so reveals a debt on my part, for it was Professor McClary who first suggested that I read Mark Johnson's *The Body in the Mind* back in the late 1980s, and this had a profound effect on my research. In her book, McClary explores the cultural and historical forces that have shaped genres like opera and the blues and compositional practices like tonality. My focus is on a somewhat different set of forces: those that shape the way humans think. It seems inevitable that these forces are in some sort of grand, if ill-defined, dialogue with cultural and historical agencies: it is, after all, human cognitive processes and human culture and history about which we are talking. That cultural and social theory have turned a deaf ear to this dialogue is not surprising: cognitive theory has had little room for and less patience with culture, and the detail of its investigative method is no match for the epic sweep of high theoretical practice at its best. And yet it seems we must, at some point, come to terms with cognitive structure, for if we do not develop an understanding of how cognitive processes shape the basic materials of thought, we risk accepting these materials as things given by nature, just as culture and history—and music, for that matter—were once assumed to be given by nature.

A glimpse of the problem can be seen in McClary's compelling analysis of Robert Johnson's 1936 "Cross Road Blues." McClary contrasts Johnson's blues with those of Bessie Smith, noting that the influence of Johnson's music on white British blues players of the 1960s was due in part to a misconception: the British musicians believed that the idiosyncrasies of Johnson's blues style represented "authentic" blues practice. Describing the unique sound of Johnson's "Cross Road Blues," McClary writes,

> An affect of dread and entrapment pervades this tune—partly the result of his strangulated, falsetto vocals and his uncanny replication of that timbre on the guitar. Moreover, Johnson's percussive guitar pulse, which locks in at the eighth-note level, allows almost no sensual movement: even though Johnson's singing constantly strains

> against that beat, the listener's body is regulated by those short, aggressively articulated units. The guitar thus seems to represent simultaneously both oppressive outside forces and a desperate subjectivity fighting vainly for escape.[3]

I have no quarrel with McClary's analysis—indeed, in this short passage, she has captured a number of the essential features of Johnson's performance style. The difficulty comes with the ultimate justification for the affect produced by the song. Why do Johnson's vocals and guitar work yield dread and entrapment rather than joyful anticipation and a feeling of liberation? Clearly, the rhythmic framework is important, but why is it that the rigidity of Johnson's beat constrains us rather than providing a secure foundation from which we can coolly regard his plaint? These are not easy questions, all the more so because of the relatively unique character of Johnson's recording when compared with other blues recordings of the period, and because hearing "Cross Road Blues" as something other than a moving, haunting song is to misunderstand it rather thoroughly. Cultural, social, and historical context cannot, by themselves, explain the origin of our affective response to the song, for our broad agreement on the effect of Johnson's music transcends these implements of high theory (even if they have a profound influence on what we do with "Cross Road Blues" once we have heard it). I propose that exploring the way cognitive structure informs our understanding of music gives us a way to account for the source of our broad agreement on the affect that pervades Johnson's blues and can help us understand better the ways culture, society, and history reshape musical practice.

Again, the way I want to accomplish this is by reconceptualizing what it means to theorize about music. This can be done by approaching music theory from the perspective provided by recent work in cognitive science. My intellectual guideposts include not only the wealth of work done in the mind sciences and the brain sciences but also contemporary and historical ways of theorizing about music. These theories of music—now with "theory" understood in somewhat more traditional terms—capture important aspects of how it is we structure our understanding of music. At their best, they represent a technical and systematic articulation of an accord on what matters in music that is similar in kind, if not terminology, to our accord on how Robert Johnson's blues move us: we agree on how music is put together and we agree on what music means because both are structured by basic cognitive processes through which we organize our understanding of the world. And so music theory—this rather strange fish in the seas of humanistic scholarship—may yet tell us some quite interesting things about the cultural and social construction of music. Understanding the way music theory instantiates cognitive processes will also help explain its continuing value. It will offer such help whether that theory be prosaic—as within the classroom or within critical discourse (since even the most radical of cultural or sociological theorists inevitably makes recourse to basic music-theoretical constructs)—or poetic, as with the elusive and allusive constructs of abstract theory.

3. Susan McClary, *Conventional Wisdom: The Content of Musical Form* (Berkeley: University of California Press, 2000), 51.

As should be apparent from the preceding, my intent here is to address not only music theorists but also musicologists and ethnomusicologists who find the challenges of theorizing about music intriguing. What follows will also be of interest to those with either a professional or avocational interest in cognitive science, for music presents a number of interesting problems for cognitive processing, not the least of which are its embeddedness in culture and the demands it places on real-time processing. In entertaining the thought of such an audience, however, I should briefly clarify a distinction I draw between sound and music and the cognitive abilities related to each, which is based on three suppositions. First, not all sound is music. Second, an account of how humans process sound is not the same thing as how they understand music. Third, phenomena relevant to musical understanding exist at a conceptual level—that is, at a level of cognitive activity at least potentially accessible to conscious thought. I should emphasize that I regard the conceptual level as occupying only a small part of our total cognitive activity, and I am not at all opposed to efforts by music psychologists and others who try to explain how structures at the preconceptual level connect with and motivate structures on the conceptual level. For me, however, it is at the conceptual level that I find the most profoundly interesting questions, for concepts are the tools that allow us to construct the complex notions essential to musical understanding. From this perspective, conceptualizing music is fundamental to inquiries about music, whether those be from the perspective of music cognition, or ethnomusicology, or musicology, or theory.

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Deborah Gillaspie of the Chicago Jazz Archive and Regenstein Library patiently endured my requests for obscure recordings and was indispensable in helping me find materials that I needed. The musical examples were expertly prepared by Jürgen Selk of Music Graphics International. Philipp Goedicke and Heinrich Jaeger helped me with the translation of difficult passages in German, and my brother Gene Zbikowski assisted in deciphering some of the more recalcitrant clauses in Rameau's and Proust's French. José António Martins and Aron Topielski served as my research assistants, ably tracking things down, organizing my sprawling files, and getting to know the photocopier, perhaps better than they wanted to. Maribeth Payne, when she served as Executive Editor for Music at Oxford University Press, listened to my ideas for the book (at least once at the risk of missing her train) and then provided valuable encouragement and assistance in the process of turning a proposal into a final manuscript.

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Finally, production of this book was facilitated by subventions from two scholarly societies. The Society for Music Theory provided a subvention to defray the costs of producing the musical examples, and the result of this assistance can be seen in the number and appearance of the examples I was able to include. The Publications Committee of the American Musicological Society was equally enthusiastic about the book and agreed to include it in its series, AMS Studies in Music. This decision not only made the book more affordable but also gave me an excellent and endlessly patient editor in Lawrence Bernstein.

My family—Vicky Long, Anna Katia, and Andrei Nicolai—had to put up with sharing me with this project, and I am afraid they got the short end of the deal more than once. Without their support, understanding, and uncritical companionship, this book would have been much the poorer.

My musical examples generally adhere to the readings of the following editions: the new *Beethoven Werke*; the Johannes Brahms *Sämtliche Werke*; the *Neue Mozart Ausgabe*; Casimiri's edition of the works of Palestrina; the *Neue Schubert Ausgabe*; Clara Schumann's edition of the *Lieder* of Robert Schumann; the new *Richard Wagner: Sämtliche Werke* (in conjunction with the C. F. Peter's score of *Tristan*); and the Collected Works of Giaches Wert for *Corpus mensurabilis musicae*. Some indications of editorial intiative in those editions—generally with respect to dynamic markings added on the basis of parallel readings—have been realized tacitly in my examples for the sake of clarity of appearance. The setting of Bernhard Klein's "Trockne Blumen" was prepared from the 1822 edition by E. H. G. Christiani in Berlin.

When dealing with historical sources written in languages other than English, I have generally followed one of two practices. Where there is no translation of the work, or where I think existing translations are not wholly satisfactory, I provide my own translation, with the original in a footnote. Where satisfactory translations exist, I use these and do not include the original in the footnote. In a few cases, I have thought readers might like to make reference to both the original and a translation and consequently have included citations for both in the footnotes.

Some of the material that follows has been previously published elsewhere and is used here by kind permission of the journals in which it originally appeared. This material includes the following: "Conceptual Models and Cross-Domain Mapping: New Perspectives on Theories of Music and Hierarchy," *Journal of Music Theory* 41/2 (© 1997, *Journal of Music Theory*); "Musical Coherence, Motive, and Categorization," *Music Perception* 17/1 (© 1999 by The Regents of the University of California); and "The Blossoms of 'Trockne Blumen': Music and Text in the Early Nineteenth Century," *Music Analysis* 18/3 (© 1999, Blackwell Publishers, Ltd.).

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CONCEPTUALIZING MUSIC

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Early in the opening volume of *A la recherche du temps perdu*, Marcel Proust presents the first of a number of memorable accounts of listening to music. He describes Charles Swann's initial encounter with the andante of Vinteuil's sonata for violin and piano:

> Doubtless the notes which we hear at such moments tend, according to their pitch and volume, to spread out before our eyes over surfaces of varying dimensions, to trace arabesques, to give us the sensation of breadth or tenuity, stability or caprice. But the notes themselves have vanished before these sensations have developed sufficiently to escape submersion under those which the succeeding or even simultaneous notes have already begun to awaken in us. And this impression would continue to envelop in its liquidity, its ceaseless overlapping, the *motifs* which from time to time emerge, barely discernible, to plunge again and disappear and drown, recognized only by the particular kind of pleasure which they instill, impossible to describe, to recollect, to name, ineffable—did not our memory, like a laborer who toils at the laying down of firm foundations beneath the tumult of the waves, by fashioning for us facsimiles of those fugitive phrases, enable us to compare and to contrast them with those that follow. And so, scarcely had the exquisite sensation which Swann had experienced died away, before his memory had furnished him with an immediate transcript, sketchy, it is true, and provisional, which he had been able to glance at while the piece continued, so that, when the same impression suddenly returned, it was no longer impossible to grasp.[1]

What Proust summons in this lyrical, enchanted vignette is the awakening and initial consolidation of musical understanding. Swann's first impressions of Vinteuil's sonata are vague and unformed, his mind simultaneously struggling with and savoring the ineffability of the music. But then, with the aid of memory, patterns emerge. Although these are incomplete and subject to revision, they offer him a way to make sense of the music, even as it continues to play.

Conceptualizing Music provides an exploration of the process of musical under-

1. Marcel Proust, *Swann's Way* (vol. 1 of *Remembrance of Things Past*), trans. C. K. Scott Moncrieff and Terence Kilmartin (New York: Vintage Books, 1981), 227.

standing—that is, the process through which those liquid impressions spoken of by Proust are transformed into structures that make it possible to grasp music. In what follows, I argue that Swann's—or anyone's—understanding of music draws on the same cognitive processes that humans use to organize their understanding of the world as a whole. Confronted with musical sound, these processes create musical concepts, the things that enabled Swann to gain a grasp of the music. The act of conceptualizing music is the beginning of a whole chain of cognitive events that allow us to theorize about music and to analyze the things that populate our aural past, present, and future.

The notion that Swann's musings might give rise to musical concepts demands some further consideration. Concepts are often thought of as highly stable cognitive structures of considerable complexity, a view hardly commensurate with the ephemera attended to or produced by Swann. Recent work in the brain sciences and the mind sciences, however, has changed how we view concepts. There are now persuasive arguments that concepts are quite fluid, that they are not irrevocably wedded to words or to concrete representations, and that they are not even unique to our species.[2] In consequence, the provisional replicas of musical phrases that make it possible for Swann to secure a foothold in the unfamiliar terrain of Vinteuil's sonata need not automatically be excluded from the conceptual domain. In fact, they are very much like the concepts we use to structure our understanding of the everyday world.

This same work in the brain sciences and the mind sciences suggests a way to account for the apparent simplicity and immediacy of musical understanding, which seems incommensurate with the complexity of musical structure. For instance, the sonata by the fictional Vinteuil is intended to be a relatively complex contemporary work that has captured the fancy of the musical elite of the Paris salons. Nonetheless, Swann, whose connoisseurship does not extend to music, is able to gain a grasp of the work almost immediately. That he is able to do so is not simply novelistic license but is, in fact, thoroughly plausible: almost everyone has had the experience of listening to an unusual composition or exotic repertoire and being able to make *something* of it. This possibility has suggested to some a latent musicality in humans comparable to the sort of competence for language proposed by Noam Chomsky.[3] Competencies of this sort raise as many questions as they answer, however, particularly where cultural entities such as music are concerned. It seems more promising to follow the path of researchers who have rejected linguistic competence as a given

2. See, for instance, Douglas R. Hofstadter and the Fluid Analogies Research Group, *Fluid Concepts and Creative Analogies: Computer Models of the Fundamental Mechanisms of Thought* (New York: Basic Books, 1995), chaps. 5–6, 8–10; Gerald M. Edelman, *The Remembered Present: A Biological Theory of Consciousness* (New York: Basic Books, 1989), chap. 8; and Donald R. Griffin, *Animal Minds* (Chicago: University of Chicago Press, 1992), chap. 6.

3. The notion of musical competence has generated a range of commentary and scholarship. See John Blacking, "Music, Culture, and Experience," in *Music, Culture, and Experience: Selected Papers of John Blacking*, ed. Reginald Byron, with a foreword by Bruno Nettl (Chicago: University of Chicago Press, 1995), 228–31, on musical competence and culture; Steven Pinker, *How the Mind Works* (New York: W.W. Norton, 1997), 528–38, on musical competence and its relation to other competencies; and Allan Keiler, "The Origins of Schenker's Thought: How Man Is Musical," *Journal of Music Theory* 33 (1989): 273–98, on a nineteenth-century conception of musical faculties akin to musical competence.

and who have set about exploring the cognitive foundations of language.[4] Their task has been to discover what processes are basic to human cognition and then to determine how they are specified for language. For my part, I would like to explore how some of these same general cognitive processes are specified for music. By this means I hope to account for the apparent ease and real rapidity with which we can conceptualize a highly complex, completely unfamiliar music on our first encounter, without having to postulate the faculty of musical competence.

At a bit more of a remove, but no less important for a complete account of cognitive processing, is the way concepts come to be organized into the more extended cognitive structures with which our thought is usually occupied. This is where theories come into play, for theories are the cognitive tools that guide the way we reason about the things we experience. At first, this might seem to be a rather specialized use of the notion of "theory," for the theory with which much current literature is occupied—within and without music scholarship—is hardly the stuff of everyday experience. Recent research has countered this view of theory by demonstrating that the elegant and abstract theories of science have much in common with the tools for reasoning used by very young children.[5] Theories are the basic means by which we make our experience coherent and guide further action. The rough-and-ready transcript that guides Swann's listening thus has something in common with the more fully articulated and systematic structures we usually associate with the idea of "music theory."

That music theory might have alliances with everyday thought processes is a provocative claim. On the one hand, music theory often manifests itself as a relentlessly practical discipline: a codification of the scales, chords, and grammatical rules proper to a highly circumscribed portion of musical discourse, assembled with the intent of rendering music comprehensible to those who would become musically literate. On the other hand, music theory can reach into the far corners of abstraction to embrace complicated mathematical concepts or the arcane symbologies of voice-leading graphs, as any reader of the *Journal of Music Theory, Music Theory Spectrum*, or *Music Analysis* will quickly discover. Nonetheless, I want to argue that music theory, in all its diverse forms, reflects the same basic processes that guide our understanding of the everyday world. Theorizing about music is an activity specialized only in its domain, not in the cognitive processes it involves.

What might these cognitive processes be, and how would they manifest themselves? To answer these questions, let us begin at a beginning, with two theories of

4. For general introductions to some of the working assumptions of cognitive linguists, see George Lakoff, "The Invariance Hypothesis: Is Abstract Reason Based on Image-Schemas?" *Cognitive Linguistics* 1 (1990): 39–74; and Michael Tomasello, "Introduction: A Cognitive-Functional Perspective on Language Structure," in *The New Psychology of Language: Cognitive and Functional Approaches to Language Structure*, ed. Michael Tomasello (Mahwah, N.J.: Erlbaum Associates, 1998), vii–xxiii. In the field of cognitive linguistics, Ron Langacker's work is particularly notable for its thoroughness and its systematic approach. See Langacker, *Theoretical Prerequisites,* and *Descriptive Application*, vols. 1 and 2, respectively, of *Foundations of Cognitive Grammar* (Stanford, Calif.: Stanford University Press, 1987, 1992); idem, *Grammar and Conceptualization* (Berlin: Mouton de Gruyter, 2000).

5. See Alison Gopnik and Andrew N. Meltzoff, *Words, Thoughts, and Theories* (Cambridge, Mass.: MIT Press, 1997); and Alison Gopnik, Andrew N. Meltzoff, and Patricia K. Kuhl, *The Scientist in the Crib: Minds, Brains, and How Children Learn* (New York: William Morrow, 1999).

music from Greek antiquity. These theories, and the music to which they refer, are so unfamiliar that even many who make music theory the focus of their research have only passing knowledge of what they involve. But there is an advantage in this unfamiliarity, for the disorienting effect it can have also serves to loosen our notions about what a theory of music, or a theoretical construct, should be. Despite connections with music theory as it was practiced in Europe and (to a lesser extent) in the Arabic world, Greek music theory of antiquity is the theory of an alien society. Nonetheless, this theory was a beginning—one of the starting points for accounts of musical organization in the Western tradition. We can discern within it, therefore, the theorists of antiquity grappling with basic constructs equivalent to, if still different from, the sort of constructs taught in beginning music theory classes today. Both aspects will allow us to see the role basic cognitive structures play in our understanding of music.

ANCIENT MUSIC THEORY AND MODERN COGNITIVE SCIENCE

Those who wrote on Greek musical practice in antiquity concerned themselves with a wide variety of topics, including the place of music in society, musical aesthetics, the construction and nature of musical instruments, and the organization of pitch materials. Specific discussions of pitch materials—the usual topic of disquisitions more directly oriented to music theory—centered around the set of pitch relationships that has come to be called the Greater Perfect System.[6] As shown in figure I.1, this consisted of a set of four tetrachords (*hypaton, meson, diezeugmenon,* and *hyperbolaion*), which, together with one additional note (called *Proslambanomenos*), provided the framework for a two-octave system of pitches basic to Greek music. The end points of the tetrachords (the notes *Hypate hypaton, Hypate meson, Mese*, and so on), together with *Proslambanomenos*, were regarded as stable, unmovable pitches. There was, however, no fixed standard for tuning—the note-names given in figure I.1 are simply for the purposes of illustration. Within the boundaries marked by each tetrachord were two other pitches, whose placement varied according to which of three different genera was understood to be in play. (In the tetrachord *hypaton*, for instance, the variable notes above *Hypate hypaton* were *Parhypate hypaton* and *Lichanos hypaton*.) The diatonic genus located the movable pitches in a manner analogous to modern diatonic scales (for instance, given the reference pitches on fig. I.1, *Parhypate hypaton* in the diatonic genus would be equivalent to F3, and *Lichanos hypaton* would be equivalent to G3), but the chromatic and enharmonic genera situated the pitches in ways that have no comfortable analogue in modern scale construction. The result was a system in which the placement of movable pitches could vary widely and in which intervals between successive pitches could be smaller than a half step and larger than a whole step.

6. For a more detailed discussion of the Greater Perfect System and its place in Greek theory of antiquity, see Andrew Barker, ed. and trans., introduction to *Harmonic and Acoustic Theory* (vol. 2 of *Greek Musical Writings*), Cambridge Readings in the Literature of Music (Cambridge: Cambridge University Press, 1989), 12–13. For a more general overview of Greek music theory and a thorough discussion of the sources, see Thomas J. Mathiesen, *Apollo's Lyre: Greek Music and Music Theory in Antiquity and the Middle Ages* (Lincoln: University of Nebraska Press, 2000), part 4.

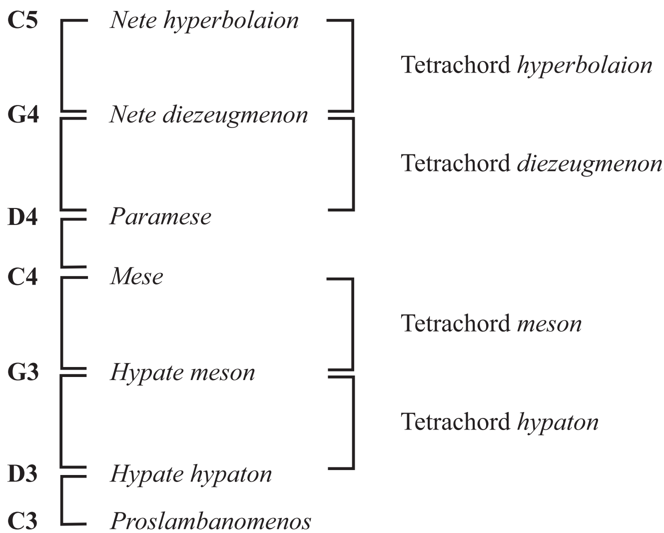

FIGURE I.1 Diagram of the Greater Perfect System of Greek music theory

There were two main theoretical approaches to presenting the elements of the Greater Perfect System. The Pythagorean approach derives from a metaphysics associated with Pythagoras of Samos, who lived during the sixth century B.C. Its hallmarks are a persistent interest in number and the deployment of numerical conceptions in cosmological contexts. In contrast to this, the Aristoxenian approach, associated with the Peripatetic school of the fourth century B.C., places little reliance on number, trusting instead in observation and reason as the means to knowledge about music.

Pythagoras and the Blacksmiths

Nicomachus of Gerasa, a mathematician and harmonist writing around the beginning of the second century A.D., described Pythagoras's discovery of the basic principles of music theory as follows:

> He [Pythagoras] was plunged one day in thought and intense reasoning, to see if he could devise some instrumental aid for the hearing which would be consistent and not prone to error, in the way that sight is assisted by the compasses, the measuring rod and the *dioptra*, and touch by the balance and by the devising of measures; and happening by some heaven-sent chance to walk by a blacksmith's workshop, he heard the hammers beating iron on the anvil and giving out sounds fully concordant in combination with one another, with the exception of one pairing; and he recognized among them the consonance of the octave and those of the fifth and the fourth. He noticed that what lay between the fourth and the fifth was itself discordant, but was essential in filling out the greater of these intervals. Overjoyed at the way his project had come, with god's help, to fulfillment, he ran into the smithy, and through a great variety of experiments he discovered that what stood in direct relation to the difference in the

> sound was the weight of the hammers, not the force of the strikers or the shapes of the hammer-heads or the alteration of the iron which was being beaten. He weighed them accurately, and took away for his own use pieces of metal exactly equal in weight to the hammers.[7]

Nicomachus continues the story by describing how Pythagoras used the weights to conduct further experiments. After suspending the weights from identical strings, Pythagoras plucked pairs of strings and discovered the same concords as he had heard produced by the blacksmiths. He further discovered that the interval of an octave was produced by weights in a 2:1 ratio, that of the fifth by weights in a 3:2 ratio, and that of the fourth by weights in a 4:3 ratio, as shown in figure I.2a. The one discordant interval—that of a second sounded by the middle two weights—was the product of a 9:8 ratio. Additional experimentation showed that the smallest weight sounded a fourth, with the next to smallest weight (8:6 ≡ 4:3) and a fifth with the next to largest (9:6 ≡ 3:2; see fig. I.2b). The octave could thus be viewed as the product of either a fourth plus a fifth (12:9:6; fig. I.2c) or of a fifth plus a fourth (12:8:6; fig. I.2d). According to Nicomachus, Pythagoras also discovered that these ratios held constant throughout the musical domain. It made no difference whether the constituent notes of the intervals were produced through string tension, string division, beating on pots, or blowing on tubes—the relationships between these notes always reduced to the self-same ratios.[8]

The Pythagorean view of music outlined by Nicomachus assumes that music has its origins in the natural world and that the natural world has a basic (if often unseen) order that can be expressed through number. It is thus important to Nicomachus's story that the ringing of the hammers is accidental and not contrived: their harmony has everything to do with the inherent order of the world and almost nothing to do with the blacksmiths. It is also significant that the concordant intervals are immediately apparent to Pythagoras and that he can discern them even amid the discordant clang of the major second. Not only is the basis of musical order natural, but also it is manifest to all who have ears to hear. The association of these intervals with the pounding hammers provides the computational tool for

7. Nicomachus, *Enchiridion*, in Barker, *Greek Musical Writings*, 2: 256–57. The *dioptra* was a rod that was used for the indirect measurement of the height of tall objects.

8. Nicomachus, *Enchiridion*, 258. It should be noted that Nicomachus's story is a complete fiction. There is no evidence whatsoever that Pythagoras ever conducted any empirical research on the acoustic origins of harmonic relationships, with or without blacksmiths. Perhaps more important, the ratios described by Nicomachus simply do not work. To sound the intervals described in the story, the values of the weights must be squared—that is, the weights must be in the ratio 4:1 to produce the octave, 9:4 to produce the fifth, and 16:9 to produce the fourth. The ratios given by Nicomachus only work when used to segment a string into different sounding lengths. One-half the length of a string will sound an octave with the entire length of the string; two-thirds the length of the string will sound a fifth with the entire length of the string; and three-fourths the length of a string will sound a fourth with the entire length of the string. The importance of Nicomachus's story lies in its influence: in the form Boethius gave it in the sixth century, it became the standard account of basic Pythagorean principles for the Middle Ages and Renaissance; see Ancius Manlius Severinus Boethius, *Fundamentals of Music*, ed. Claude V. Palisca, trans. Calvin Bower, Music Theory Translation Series (New Haven, Conn.: Yale University Press, 1989), 17–19. A somewhat different perspective on Nichomachus's story can be found in Mathiesen, *Apollo's Lyre*, 399.

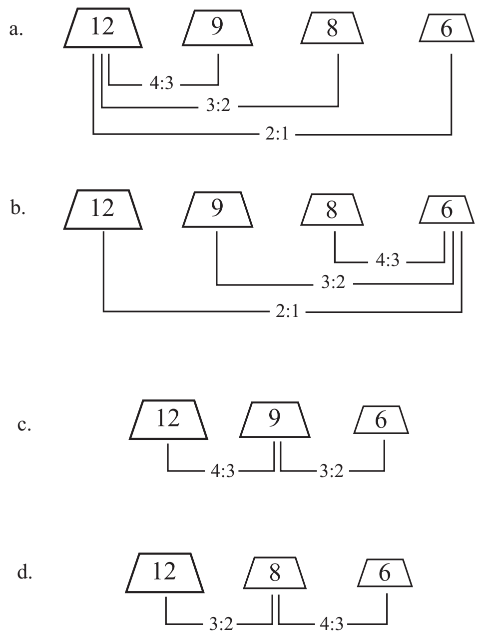

FIGURE I.2 Ratios of the octave, fifth, and fourth from Pythagorean legend

which Pythagoras had searched, for it allowed him to translate the constituent notes of the harmonic intervals into magnitudes—that is, into number.[9] These numbers then provide further proof of the order of nature, for the ratios of the concordant intervals (the octave, fifth, and fourth) are all simple (1:2, 2:3, and 3:4), while the ratio of the discordant second is relatively complex (8:9). Finally, the numbers involved in the ratios of the concords—1, 2, 3, and 4—were also those of the *tetraktys* of the decad, which Pythagoreans regarded as the "fount and root of ever-flowing nature."[10]

The account of musical organization presented by the story of Pythagoras and the blacksmiths is a model of concision. At its core are but three intervals: the octave, fourth, and fifth. The notes that make up these intervals are assigned magnitudes, the correspondence of which yields numerical ratios. These ratios come to stand for the intervals—the ratio 1:2 is the octave—and can also be used to describe relationships between them, leading to a precise account of the composi-

9. The notion of a computational tool I employ here derives from the work of Edwin Hutchins, especially that presented in the second chapter of his *Cognition in the Wild* (Cambridge, Mass.: MIT Press, 1995). Hutchins proposes that various of the navigational tools used by seafarers are in fact computational tools in that they facilitate computation by transforming analog information into digital information. This is exactly what the hammers did for Pythagoras: they transformed the analog information of sound into the digital information of hammer weights (with an intermediary stage occupied by the computational tool of a scale for measuring the weights).

10. Barker, *Greek Musical Writings*, 2: 30. A *tetraktys* is any coordinated group of four items; those of the *tetraktys* of the decad sum to 10, which is the basis of the base-10 number series used by the Greeks.

tion of intervals. The interval between the *Mese* and *Proslambanomenos* of figure I.1 is an octave, a 1:2 ratio. This octave is made up of a fourth (from *Mese* to *Hypate meson*, a 3:4 ratio) and a fifth (from *Hypate meson* to *Proslambanomenos*, a 2:3 ratio). The fifth is in turn made up of a fourth (from *Hypate meson* to *Hypate hypaton*, another 3:4 ratio) and a tone (from *Hypate hypaton* to *Proslambanomenos*, an 8:9 ratio). With these components in place, a Pythagorean theorist could describe, through number, relationships between any of the fixed notes of the Greater Perfect System and eventually characterize the relationships that obtained among the movable notes of the various genera. The order of the cosmos, which was for Pythagoreans the order of number, thus found sounding expression in the domain of music.

Aristoxenus and Aristotelianism

Although the Pythagorean perspective on musical order was an influential one—for instance, it informed Plato's and Aristotle's writings on music—it was not the only one available to antiquity. The alternative offered by Aristoxenus in his *Elementa harmonica* (most likely written toward the end of the fourth century B.C.) starts with a definition of the science of harmonics:

> It is to be understood as the science which deals with all melody, and inquires how the voice naturally places intervals as it is tensed and relaxed. For we assert that the voice has a natural way of moving, and does not place intervals haphazardly. We try to give these matters demonstrations which conform to the appearances, not in the manner of our predecessors, some of whom used arguments quite extraneous to the subject, dismissing perception as inaccurate and inventing theoretical explanations, and saying that it is in ratios of numbers and relative speeds that the high and the low come about. Their accounts are altogether extraneous, and totally in conflict with the appearances. Others delivered oracular utterances on individual topics, without giving explanations of demonstrations, and without even properly enumerating the perceptual data. We, on the other hand, try to adopt initial principles which are all evident to anyone experienced in music, and to demonstrate what follows from them.[11]

This account of harmonics reveals Aristoxenus to be in conflict not only with the Pythagoreans (the unnamed antagonists who dismiss perception and explain pitch relations through ratios) but also with earlier harmonic theorists whose empirical work he found deficient because they did not explain their methods of proof or properly describe their observations.

Aristoxenus's alternative was to apply Aristotle's intellectual method to music more rigorously than did Aristotle himself.[12] This entailed restricting the account of music to terms and concepts that could properly be said to belong to the domain of music. It excluded descriptions that made recourse to ratios (which are in the domain of number) or to theories about the propagation of physical sound (which

11. Aristoxenus, *Elementa harmonica*, in *Harmonic and Acoustic Theory* (vol. 2 of *Greek Musical Writings*), ed. and trans. Andrew Barker, Cambridge Readings in the Literature of Music (Cambridge: Cambridge University Press, 1989), 149–50.

12. For commentary on Aristoxenus's approach, see Barker, *Greek Musical Writings*, 2: 66–69, 119.

are in the domain of physics). Once the definition of these basic musical concepts was accomplished, an explanation of the entire domain of music could then follow.

Aristoxenus's demonstration proceeds in three steps. First, he identifies two forms of vocal motion, the continuous and the intervallic. In the continuous form, which is associated with speech, the voice appears to traverse space without stopping, until the point of silence. In the intervallic form, which is associated with singing, the voice appears to stand still at specific points, and then pass over some interval of space before coming to rest at another point.[13] The various pitches upon which the voice pauses when singing constitute musical notes; the spaces between these notes are musical intervals.

Aristoxenus's second step is to draw distinctions among the various musical intervals. The first distinction is made with regard to magnitude, which reflects the amount of space between the two notes of the interval. That such a space exists is inferred from the difference between the two pitches that adjoin the interval; the size of the space can be reckoned in terms of how many other notes could be put inside it.[14] The second distinction is made with regard to concord and discord. Aristoxenus identifies the concordant intervals as the fourth, fifth, and octave (and their octave duplications). These are the only concordant intervals he accepts as determined by the intrinsic nature of melody—all other intervals are by definition discordant.[15]

The final step toward assembling the basic definitions and principles of harmonics is the derivation and division of the tone. Aristoxenus defines the tone as the difference between the first two concords (the fourth and the fifth) and explains that it can be divided in half (yielding the semitone), in thirds (yielding the least chromatic diesis), or in fourths (yielding the least enharmonic diesis, which is the smallest interval recognized as melodic).[16] These distinctions allow him to locate various notes within the tetrachords of the different genera and thereby to specify the scalar structure of each.

With these steps, Aristoxenus lays out the basic materials for his account of musical organization. Singing involves a specific way of using the voice that creates musical notes and musical intervals. Intervals can be distinguished according to size and whether they are concordant or discordant. Concordant intervals—the fourth, fifth, and octave—are accepted as axiomatic to melody and thus representative of the basic materials from which the various intervals of the Greater Perfect System can be developed.

13. Aristoxenus, *Elementa harmonica*, 133.

14. Aristoxenus, *Elementa harmonica*, 136.

15. Aristoxenus, *Elementa harmonica*, 139. Aristoxenus further distinguishes between composite and incomposite intervals (p. 137); however, this distinction is not necessary for a basic understanding of his theory.

16. Aristoxenus, *Elementa harmonica*, 140. The different *dieses* apply to the three genera mentioned above: the half-tone is used in the diatonic genus; the third-tone is used in the chromatic genus; and the fourth-tone is used in the enharmonic genus. For further discussion of Aristoxenus's *Elementa harmonica*, see Mathiesen, *Apollo's Lyre*, 319–34.

Greek Theory and Cognitive Structure

As mentioned, the music theories of Pythagoras and Aristoxenus belong to a world remote from our own. Not only did these theorists have to grapple with the most basic of principles, but also the music they would describe is a microtonal one that is primarily concerned with the successive notes of melody rather than the simultaneous notes of harmony. Despite this—or perhaps because of it—Pythagorean and Aristoxenian accounts of musical organization give us a glimpse into how theories are formed and, more important, the cognitive processes that are basic to these theories. In particular, three cognitive processes can be seen at work: categorization, cross-domain mapping, and the use of conceptual models.

CATEGORIZATION Our ability to categorize things is a cognitive process so basic and so pervasive that it can easily escape our notice. Were you to lift your eyes from this book and survey your surroundings, you might well see chairs, lamps, tables, and other books; were you outside, you might see trees, birds, clouds, cars, and bicycles. If you considered the other things that populate your day, you might think of friends and family members, facial expressions and gestures, actions and activities. Your recognition of these things reflects the categories through which we structure our thought: to recognize a book is to identify it as a member of the category *book*; to recognize a tree is to identify it as a member of the category *tree*. Categorization occurs in all sensory modalities and throughout the range of mental activities: we categorize smells and sounds, thoughts and emotions, skin sensations and physical movement.

Categories are not just basic to thought; they also give insight into our thought processes. At one time it was thought that categories reflected the structure of the real world, but recent research has shown that the categories humans use are shaped by their interactions with their environments. Our reasons for developing and employing a given category are part and parcel of the category itself: categories are not only *not* given by nature, but also they are subject to change and modification as our thought unfolds.

Two categories basic to Pythagorean and Aristoxenian music theory are those for consonant or dissonant intervals. Consonant intervals (such as the octave, fifth, and fourth) are fundamental to the conceptualization of Greek music: they mark the stable pitches of the Greater Perfect System and are the source of derivation for all further intervals, both consonant and dissonant. The process of categorization is also exhaustive: any interval that can be conceived belongs to one of these two categories.

This is not to say, however, that consonant and dissonant intervals are given by nature in any simple way, Pythagoras and the blacksmiths notwithstanding.[17] As one

17. I should note here that psychoacousticians distinguish between musical consonance, which is a cultural construct framed relative to a particular set of musical practices, and sensory consonance, which is a consequence of how sound waves are processed by the hearing mechanism (which involves the cochlea and the auditory cortex). Sensory consonance is thus a fairly straightforward product of nature. Although musical consonance has its basis in sensory consonance, there is some freedom in how the sensory data are interpreted.

example, consider the way Aristoxenians and Pythagoreans classified the interval of an octave plus a fourth. Aristoxenians considered the interval a consonance, since it was simply the combination of two smaller consonances. Pythagoreans, in contrast, classified intervals according to the numerical ratio formed by their constituent pitches. As explained by the anonymous (and thoroughly Pythagorean) author of the *Sectio canonis* (fourth century B.C.), consonant intervals are those whose ratios are either multiple (of the form $[mn]:n$) or epimoric (of the form $[n + 1]:n$). Dissonant intervals are those whose ratios are epimeric (of the form $[n + m]:n$, where m is greater than 1 and neither equal to nor a multiple of n).[18] Because the octave plus a fourth had the epimeric ratio 8:3, it was regarded as a dissonance.

Another example of how categories shape our understanding of phenomena is provided by Greek theorists' treatment of thirds and sixths. Although thirds and sixths sound fairly consonant, they were nonetheless categorized as discords. Two factors bear on this classification. First, forming thirds and sixths *requires* using the movable pitches of the Greater Perfect System—at best, a third or a sixth will involve only one of the stable pitches bounding the constituent tetrachords of the system. Thirds and sixths were intervals that necessarily varied in size, and so they were placed among the dissonances. Second, in the classification of intervals Greek theory followed a tradition of dichotomous categories: there was concord, discord, and nothing else. By contrast, neither of these factors played a part in the music theory of early India. Indian music theorists were consequently free to focus on the qualitative aspect of intervals rather than on their correspondence with the fixed notes of a tuning system and to construe intervallic relationships as concordant, discordant, or neutral.[19]

These two examples show that while the categories for consonant and dissonant intervals may be basic to Pythagorean and Aristoxenian theory, just how they are defined reflects the context and goals of categorization: consonance and dissonance are not naturally occurring properties, but ways of constructing an understanding of musical organization.

Of course, there are numerous other categories important for Pythagorean and Aristoxenian music theory, including those for pitches, intervals, and numerical ratios. These categories and others are basic to the sort of systematic account of musical phenomena provided by these theories—indeed, it is simply not possible to have a theory of music, or of anything else, without first having categories.

CROSS-DOMAIN MAPPING Cross-domain mapping is a process through which we structure our understanding of one domain (which is typically unfamiliar or abstract) in terms of another (which is most often familiar and concrete). For example, one way to think about the elusive concepts of electrical conductance is in terms of a hydraulic model: flipping the light switch turns on the *juice*, and elec-

18. *Sectio canonis*, in *Harmonic and Acoustic Theory* (vol. 2 of *Greek Musical Writings*), ed. Andrew Barker, Cambridge Readings in the Literature of Music (Cambridge: Cambridge University Press, 1989), 193.

19. Lewis Rowell, *Music and Musical Thought in Early India*, Chicago Studies in Ethnomusicology (Chicago: University of Chicago Press, 1992), 157–60.

trical current *flows* to the light bulb to light the room. By this means we take what we know about a fairly concrete and familiar source domain—the flow of water and other liquids—and map it onto a rather abstract and unfamiliar target domain: that of electricity. As a wealth of research on analogy and metaphor has shown, the process of mapping structure from one domain to another is basic to human understanding.

One place cross-domain mapping is evident is in the Pythagorean and Aristoxenian construal of interval. Because musical pitches are ephemeral and virtually intangible, relationships between pitches—musical intervals—represent something of a challenge to understanding. One way to meet this challenge is to map structure from the physical world onto music, a process evident in Nicomachus's story of Pythagoras and the blacksmiths. Pythagoras hears harmonious sounds, traces their origins to the blacksmiths' hammers, and then proceeds to conduct various experiments using weights equivalent to those of the hammers. These experiments lead, among other things, to a highly pragmatic objectification of musical pitch, as pitches are translated into physical objects that can be weighed, studied, and preserved. By performing a mapping from the concrete physical domain proper to the blacksmiths' hammers onto the domain of musical sound, Nicomachus's story allows us to structure the latter domain in terms of the former. Of course, musical notes are not physical objects that can be weighed, studied, and preserved—they remain ephemeral and virtually intangible. Nonetheless, we are so accustomed to the mapping between concrete physical objects and musical sound that we sometimes have to be reminded that notes are not enduring physical objects.

Aristoxenus's construal of musical interval involves a slightly different mapping. As we have seen, according to Aristoxenus, when the voice moves intervallically, it appears to stand still at a given place (a musical pitch) and then pass over an interval of space (a musical interval) before coming to rest at another place (another musical pitch). Underlying this account is a mapping from the familiar domain of two-dimensional space onto that of music. This mapping allows us to apply the methodology of measuring space to music. The difference between two linear measures yields a third measure; similarly, the difference between the intervals of a fifth and a fourth yields the interval of a tone. Since linear measures can be easily divided into equal halves or thirds or fourths, the musical tone can be similarly divided, something impossible from the Pythagorean perspective.

On closer inspection, the Pythagorean and Aristoxenian construals of interval are indeed incommensurate. From the Pythagorean perspective, pitches are physical objects, and an interval describes the relationship between these objects. From the Aristoxenian perspective, pitches are breadthless points that simply mark out an expanse of two-dimensional space, and an interval is the expanse itself. Each mapping gives an account of interval, but each leads to a different conceptualization of musical structure. This point can be generalized for music theory as a whole: mapping structure from a nonmusical domain onto music is a way of *creating* musical structure, and different mappings will lead to different accounts of musical structure.

CONCEPTUAL MODELS Both categorization and cross-domain mapping provide the basis for fundamental ontological assertions about musical materials: this interval *is* a consonance; the pitches of an octave *are* physical objects. They can also lead to conditional statements: *if* the interval is an octave, *then* it is a consonance; *if* a pitch is an object, *then* its properties are measurable. Propositions like this are basic to conceptual models, which act as guides to reasoning and inference. In their simplest form, conceptual models consist of concepts in specified relationships, which pertain to a specific domain of knowledge.

For an example of a conceptual model, let us return to the classification of consonant and dissonant intervals presented in the *Sectio canonis*, according to which all consonant intervals have either multiple or epimoric ratios, and all dissonant intervals have epimeric ratios. This classificatory system relies on a conceptual model that organizes concepts related to interval, concord, discord, and the three classes of ratios. The simple pattern of inference that follows from this model is that if an interval has a multiple or an epimoric ratio, it is a concord; if it has an epimeric ratio, it is a discord.

Integral to this model are the products of categorization and cross-domain mapping. Two types of categories are involved in the model: those pertaining to music (the categories of concord and discord) and those pertaining to number (the multiple, epimoric, and epimeric ratios). Cross-domain mapping correlates the two types of categories by construing musical interval as a relationship between two objects (namely, musical pitches) to which magnitudes (in the form of numbers) can be assigned. Specific classes of ratios can then be used to distinguish between the musical categories.

The robustness of this particular conceptual model is reflected in the debate over the status of the octave plus a fourth that continued into the Middle Ages. In the second century A.D., Ptolemy showed the speciousness of the correlation of concord with multiple or epimoric ratios and argued for a classification of intervals based on empirical evaluation and the postulate that a concord added to a concord produces a concord.[20] Although Ptolemy still used ratios to describe various intervals, they were no longer part of the conceptual model through which intervals were classified into concords and discords. In the sixth century, Boethius presented both the Pythagorean and Ptolemaic models but took no position on which he preferred.[21] After Boethius, when an author wished to invoke the authority of the Pythagorean approach, the Pythagorean model of intervallic classification was cited; when an author wished for a more empirically satisfying classification, the Ptolemaic model was used.[22]

Conceptual models provide the first level of organization for concepts. They are too limited and localized, however, to provide the comprehensiveness we expect from theories of music. Theories achieve this comprehensiveness by integrating

20. Ptolemy, *Harmonics*, in *Harmonic and Acoustic Theory* (vol. 2 of *Greek Musical Writings*), ed. Andrew Barker, Cambridge Readings in the Literature of Music (Cambridge: Cambridge University Press, 1989), 286–90.

21. Boethius, *Fundamentals of Music*, 81–82, 169.

22. For a discussion of these modes of reasoning, see C. André Barbera, "The Consonant Eleventh and the Expansion of the Musical Tetractys: A Study of Ancient Pythagoreanism," *Journal of Music Theory* 28 (1984): 191–223. Barbera's treatment of Aurelian's *Musica disciplina* on p. 210 is especially illuminating.

clusters of conceptual models. And as we shall see in the following chapters, conceptual models also play a role in categorization and cross-domain mapping. There, as in theories, they provide guides for reasoning and inference about specific and circumscribed domains of knowledge.

COGNITIVE PROCESSES AND MUSIC THEORY Much has been left out of this discussion of theories of music from Greek antiquity, with respect to both the theories themselves and the cognitive processes behind them. To be sure, these theories are of a different order than Swann's musings on Vinteuil's sonata. Nonetheless, the cognitive processes we have seen at work in Pythagorean and Aristoxenian theory are the same processes through which we organize our understanding of the world as a whole. Just how this occurs—how categorization, cross-domain mapping, and the use of conceptual models shape our theories of music and guide our analyses of musical works—is the subject of the remainder of this book.

OVERVIEW

I have divided the chapters that follow into two parts. In the first, I present a detailed overview of research on the three cognitive processes highlighted in this introduction. This overview is itself framed around specific musical topics, such as motivic transformation, text painting, and the ways in which we structure our understanding of a specific musical domain. The research that has been done in cognitive science over the past three decades has been extensive and far ranging, and one of the jobs of this portion of the book is to bring this work to bear on basic issues of musical understanding. Another objective is to show in some detail how these processes relate to one another and how they form the bedrock for our thought about music. The second part of the book moves from this foundation to analytical studies of specific musical issues. These issues include relationships between categorization and musical syntax, the problem of musical ontology, text-music relations, and conceptions of musical form and musical hierarchy.

Chapter 1 begins the overview of research in cognitive science with a close look at processes of categorization. For centuries, writers in the West regarded categories as fixed and immutable, and any variation in categorization was taken as evidence of the failure of the human intellect to deal with the structure of the real world. It took the pioneering work of Eleanor Rosch and others in the 1970s to show that category structure was not as simple as first believed. In particular, some levels of categorization are preferred over others, and some members of a category are regarded as better representing the category than others (a phenomenon known as *graded membership*).

The key to how this research can be applied to music is provided by the musical motive (or, as Proust would have it, the *motif*). Motives are generally reckoned to be one of the basic building blocks of musical works, but they are also a bit slippery: the "same" motive typically assumes a number of diverse shapes over the course of a work. Thinking of a motive as a cognitive category makes it possible to account for its identity, as well as its diversity, and reveals how aspects of categorization are embodied by musical materials. These preliminary applications of categorization to music also show ways musical materials can be organized over the course of a work and offer an explanation of how it is possible to have musical concepts that are independent of language.

If categorization can be said to be the source of musical concepts, cross-domain mapping is the means by which these concepts are placed in correlation with others. Chapter 2 examines the process of cross-domain mapping in some detail, beginning with the work of cognitive linguists who, in the 1980s, proposed that metaphor was a basic structure of understanding. This proposal gained added weight when it was shown that metaphorical projection (which is one way to accomplish cross-domain mappings) was a general process not restricted to linguistic expressions but grounded in embodied experience.

One example of cross-domain mapping that involves music in a rather immediate way is the technique of text painting, a compositional device that aims to represent in music specific images summoned by the text of a vocal work. Text painting provides a point of departure for the exploration of how cross-domain mapping is manifested in our understanding of music, as it leads to an extension of cross-domain mapping called conceptual blending. In a conceptual blend, elements from two correlated domains are projected into a third, giving rise to a rich set of possibilities for the imagination. As I show in the latter part of chapter 2, text painting can lead to such blends, as can program music.

Chapter 3, which focuses on conceptual models and theories, gets to the heart of the perspective on cognition developed in part I. My point of departure is research by Jeanne Bamberger on children's representations of musical structure. In my analysis of Bamberger's study of one specific eight-year-old boy, I show the part played by categorization and cross-domain mapping in the conceptual models used by this boy to come to terms with a musical environment. I also show how these models are combined to form a theory of music and how this theory changes in response to changes in the task at hand. This close-up glimpse of the structure and role of conceptual models and theories leads, in the middle of the chapter, to a more generalized characterization of these knowledge structures, which I connect with work on similar structures in artificial intelligence, cognitive anthropology, ethnomusicology, and developmental psychology. In the latter part of the chapter, I return to music theory and explore the role of conceptual models and theories (that is, theories framed relative to a cognitive perspective) in analyses by Jean-Philippe Rameau and Heinrich Schenker, two of the best-known music theorists of the last three hundred years.

Although the features of cognitive structure discussed in part I might seem to be relatively detailed, in truth all are associated with relatively high-level cognitive processes. My reason for focusing on this level is quite simple: it allows me to engage in issues of immediate and occasionally central importance to music scholarship and to do so in a way that connects with extensive research in cognitive psychology and cognitive linguistics. Part II explores this possibility in greater depth by considering various problems of musical understanding from the perspective on cognitive structure and music theory developed in part I.

In chapter 4, I turn to the matter of how musical materials are organized within a work—more properly, the problem of musical syntax and, by extension, musical semiotics. Although semioticians are usually quick to grant that music has a syntax, they are more doubtful about whether its semantic level has any depth. By taking a close look at how composers make use of categories of musical events—in this case, the way Mozart and Beethoven use motives in the opening movements of three string quartets—I am able to provide insight into how musical materials are organized in the service of musical discourse, as well as how features of this organization contribute to meaning construction as a whole.

In chapter 5, I confront a somewhat larger problem—one that may seem irredeemably abstract: the problem of what counts as a work of music. I view this problem, usually called the problem of musical ontology, as one of cultural knowledge and try to show that, as opposed to being hopelessly recondite, the problem is of immediate importance for understanding music. By approaching the entire work of music as a category—a category that includes all the scores, performances, representations, and such that are said to be "of" the piece—I develop a model for the cultural knowledge upon which judgments about musical ontology are made. Determinations of what counts as an instance of a particular musical work are thus one of the ways members of a musical community construct and negotiate their identity. My examples for this chapter are two songs taken from the traditions of popular music and jazz: "I Got Rhythm" and "Bye Bye Blackbird." The latter offers an intriguing case of how the cultural knowledge relative to which determinations of musical ontology are made can become complicated when implicated in the layered discourse structures Mikhail Bakhtin called "double-voiced discourse," and which were extended to African American culture through Henry Louis Gates Jr.'s notion of "Signifyin(g)."

Chapter 6 returns to the analysis of individual musical works by pursuing one of the entailments of text painting noted in chapter 2: under certain circumstances, combinations of words and music, through the process of conceptual blending, create worlds for the imagination well beyond those that spring from words or music alone. Where only a few fairly circumscribed instances of text-music relations were considered in chapter 2, here research on conceptual blending is applied to the whole of five Lieder from the nineteenth century. These analyses offer a way to flesh out the theory of conceptual blending as it applies to music and provide a further perspective on musical syntax. In these songs, we see words and music combining to create rich domains in which the imagination can play, as well as discover how musical syntax shapes our understandings of the words themselves.

The final analytical chapter (chap. 7) turns to music theory itself, specifically to the theories of musical form and hierarchy that go back to the eighteenth and early nineteenth centuries. Accounts of the form a musical work takes, or of how its elements relate to one another, are basic to theorizing about music—indeed, we can see these emerging in the course of M. Swann's ruminations on Vinteuil's sonata—but at times it seems that theorists are talking about quite different things. For instance, there are two common ways to talk about musical form: the first approaches form as deriving from the assembly of relatively static building blocks that are combined to create the finished work; the second approaches form as an emergent property of the work, which becomes manifest only as the music unfolds over time. The first approach yields a view of musical form that is quite static, the second a view rather more dynamic. Using the analytical framework provided by cross-domain mapping, I discuss the source of these two models for musical form, as well as two models for musical hierarchy, and explore some of the ways these models interacted over the course of the history of music theory.

In the conclusion I return to M. Swann and to his final encounter with Vinteuil's sonata after a year in which it became thoroughly intertwined with his love affair with Odette, the courtesan with whom he had become acquainted around the same time he first encountered the andante. This will provide a frame for a review of the points made in the preceding chapters and an instrumentality for drawing conclusions from the whole.

COGNITIVE STRUCTURE, THEORY, AND ANALYSIS

A central claim of this book is that through developing an appreciation of how aspects of cognitive structure shape our understanding of music we can better appreciate the active role of theories of music in that understanding. A further claim is that our analyses of musical phenomena—from the most mundane and localized of accounts to the most abstract and comprehensive—similarly reflect cognitive structure, in that every analysis is based on some sort of theory of music. Musical analyses are in truth dialogues, and not just dialogues between the analyst and an imagined audience: musical analyses are also dialogues between the analyst and some body of theoretical knowledge. Analysis rarely, if ever, simply corroborates a theory: analysis pulls theory and pushes it, extending and changing theory just as it also extends and changes our understanding of musical phenomena.

The analyses I present throughout this book are no different, except that they engage cognitive theory as well as music theory. The intent of the analyses is to show how our understanding of particular musical phenomena can be characterized in terms of specific cognitive processes and structures and thereby connect that understanding to research in cognitive science as a whole. The analyses are not intended as definitive statements about how we can account for such understanding; they are intended to be the initiation of a dialogue with cognitive theory, a dialogue whose purpose is to expand our knowledge of both music and cognition. Analysis is thus a central concern of what follows, but, unlike cognitive structure or theory, I have not treated it as a central topic for investigation. Instead, analysis will be a fundamental tool to explore both and to provide new insight into the conceptual worlds wrought by musical sound.

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PART I

ASPECTS OF COGNITIVE STRUCTURE