A Generative Theory of Tonal Music

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Preface

In the fall of 1973, Leonard Bernstein delivered the Charles Eliot Norton Lectures at Harvard University. Inspired by the insights of transformational-generative ("Chomskian") linguistics into the structure of language, he advocated a search for a "musical grammar" that would explicate human musical capacity. As a result of these lectures, many people in the Boston area took a fresh interest in the idea of an alliance between music theory and linguistics, and Irving Singer and David Epstein formed a faculty seminar on music, linguistics, and aesthetics at the Massachusetts Institute of Technology in the fall of 1974.

Our collaboration began as an outgrowth of that seminar. Consulting each other during the preparation of our individual talks, we soon found ourselves working together on an approach of some novelty. Our participation in the MIT seminar gave us frequent opportunities over the next three years to present and discuss our work in its formative stages. In addition, we had the good fortune to be invited in the spring of 1975 to a week-long seminar on music and language at the Institute de Recherche et Coordination Acoustique/Musique in Paris, organized by Nicolas Ruwet. We have also had the opportunity to present aspects of our work in talks at the Accademia Filarmonica in Rome, Brandeis University, Columbia University, the University of California at Irvine, and Yale University, and to the American Society of University Composers, the New York State Theory Society, a Sloan Foundation Conference on Cognitive Science, and the Third Workshop on Physical and Neuropsychological Foundations of Music in Ossiach, Austria.

In the course of preparing a written paper for the proceedings of the IRCAM conference (this paper eventually appeared as "Toward a Formal Theory of Tonal Music" in the *Journal of Music Theory*), we realized that the material we had worked out required book-length exposition. Hence this volume, written intermittently along with string quartets and books on linguistic theory.

We have tried to achieve a synthesis of the outlook and methodology of contemporary linguistics with the insights of recent music theory. There was a natural division of labor: Lerdahl, the composer, supplied musical insights, and Jackendoff, the linguist, constructed formal systems to express them. But of course it was hardly that cut and dried. Lerdahl had enough expertise in logic and linguistics to make substantial contributions on the formal side, and Jackendoff's experience as a performing musician enriched the purely musical aspect of the enterprise. Consequently, our individual contributions to the work are hopelessly intertwined, and neither of us could really have done any part of the work alone.

The result is a theory formulated in terms of rules of musical grammar. Like the rules of linguistic theory, these are not meant to be prescriptions telling the reader how one should hear pieces of music or how music may be organized according to some abstract mathematical schema. Rather, it is evident that a listener perceives music as more than a mere sequence of notes with different pitches and durations; one hears music in organized patterns. Each rule of musical grammar is intended to express a generalization about the organization that the listener attributes to the music he hears. The grammar is formulated in such a way as to permit the description of divergent intuitions about the organization of a piece.

We do not expect that these organizing principles will necessarily be accessible to introspection, any more than are the principles governing the ability to speak, walk, or see. The justification of the rules, therefore, lies not merely in whether they "look right" to ordinary intuition but in their ability to describe intuitions about a wide range of musical passages.

We conceive of a rule of musical grammar as an empirically verifiable or falsifiable description of some aspect of musical organization, potentially to be tested against all available evidence from contrived examples, from the existing literature of tonal music, or from laboratory experiments. Time and again in the course of developing the theory we discovered examples for which our musical intuitions did not conform to the predictions of our then-current set of rules. In such instances we were forced either to invent a new rule or, better, to come up with a more general formulation of the rules we had. Our exposition of the grammar here reflects some of this process of constant revision, but much more has been expunged in the interest of sparing the reader many of our blind alleys.

We consider this book a progress report in an ongoing program of research, rather than a pristine whole. We have taken care to leave the rough edges showing—to make clear where we have left problems unsolved or where our solutions seem to us inadequate. We present it at this stage partly because of limitations of time and patience and partly out of the realization that no theory ever reaches true completion. We feel,

however, that we have gone far enough to be able to present a coherent and convincing overall view.

The book can be read from several perspectives. From the viewpoint of music theory as traditionally conceived it offers many technical innovations, not only in notation but also in the substance of rhythmic and reductional theory and the relation between the two. We feel that our approach has succeeded in clarifying a number of issues that have concerned recent tonal theory.

We hope that this work will interest a wider circle of readers than the usual treatise on music theory. As we develop our rules of grammar, we often attempt to distinguish those aspects of the rules that are peculiar to classical Western tonal music from those aspects that are applicable to a wide range of musical idioms. Thus many parts of the theory can be tested in terms of musical idioms other than the one we are primarily concerned with here, providing a rich variety of questions for historical and ethnomusicological research.

Beyond purely musical issues, the theory is intended as an investigation of a domain of human cognitive capacity. Thus it should be useful to linguists and psychologists, if for no other purpose than as an example of the methodology of linguistics applied to a different domain. We believe that our generative theory of music can provide a model of how to construct a competence theory (in Chomsky's sense) without being crippled by a slavish adherence to standard linguistic formalisms. In some respects our theory has turned out more like certain contemporary work in the theory of vision than like linguistic theory.

Our approach has led to the discovery of substantive as well as methodological connections among music, language, and vision. Some of these connections appear in the course of the theory's exposition (especially in sections 3.2, 3.4, 4.2, and 7.2), but we have reserved for chapter 12 a discussion of those connections that strike us as most significant. The matters treated there suggest that our theory is of more than peripheral interest to the cognitive sciences.

The exposition of the book reflects the diversity of its audience. On occasion we elaborate fairly obvious musical points for the sake of nonspecialists; more often we go into technical issues more deeply than nonspecialists may care for. Readers should feel free to use the book as their interests dictate. Linguists and psychologists should probably read chapters 1, 3, 11, 12, and the beginning of chapter 5 first. Musicians may want to start with chapters 1, 2, 5, 6, 8, and 11. All readers should bear in mind that the heart of the theory resides in the chapters on formalization: 3, 4, 7, and 9.

In the course of working out our ideas we have benefited greatly from the writings of Noam Chomsky, Edward T. Cone, Grosvenor Cooper and Leonard B. Meyer, Andrew Imbrie, Arthur J. Komar, David Lewin, Charles Rosen, Carl Schachter, Heinrich Schenker, Peter Westergaard,

and Maury Yeston. We have also received valuable advice from many colleagues and students. Among the members of the MIT seminar, we must thank Jeanne Bamberger, Arthur Berger, David Epstein, John Harbison, David Lewin, and Irving Singer; among other musicians, Tim Aarset, Leonard Bernstein, Edward T. Cone, Gary Greenberg, Andrew Imbrie, Elise Jackendoff, Allan Keiler, Henry Martin, Gregory Proctor, Paul Salerni, Seymour Shifrin, James Snell, and James Webster; among linguists and psychologists, Morris Halle, Richard Held, Samuel Jay Keyser, Edward Klima, James Lackner, George Miller, Alan Prince, and Lisa Selkirk. Each of these people has contributed something essential to the content or form of this book. George Edwards and Louis Karchin read the entire manuscript and made many useful suggestions. The authors blame each other for any errors that remain.

We are also grateful to the School of Humanities at MIT for providing financial support to the Seminar on Music, Linguistics, and Aesthetics; to Brandeis University for support toward the preparation of the illustrations; to the John Simon Guggenheim Memorial Foundation for a fellowship to Lerdahl in 1974–75, ostensibly to compose; and to the National Endowment for the Humanities for a fellowship to Jackendoff in 1978, ostensibly to write on semantics. For the misuse of funds we can only apologize, and hope that this extracurricular activity has enriched our "real" work as much as we think it has.

We are deeply indebted to Allen Anderson for his splendid work in making our unusually difficult musical examples legible and attractive.

Earlier versions of portions of this book have appeared in the *Journal of Music Theory, The Musical Quarterly,* and the volume *Music, Mind, and Brain,* edited by Manfred Clynes.

Preface to the 1996 Reprint

This reprinting of *A Generative Theory of Tonal Music* incorporates a few minor corrections but otherwise leaves the text intact. Whatever its blemishes, *GTTM* is an integral whole whose main ideas appear to have stood up well since its publication thirteen years ago. We would not know how to revise it other than to start over and write a different book.

We often have been asked how a composer and a linguist came to collaborate on a music theory conceived as a branch of cognitive psychology. The answer is not far-fetched. A thinking composer in our confusing era has no choice but to be concerned with basic principles of musical organization. A linguist who is also a professional clarinetist finds it intriguing to extend his theory-building to the structurally rich domain of music. Intellectual currents in the 1970s encouraged the convergence of music, linguistics, and psychology within the emerging interdisciplinary field of cognitive science. And we were very lucky to find each other.

Each of us had in fact imagined doing such research independently before we met. But the ideas really took wing only in collaboration: neither of us could have done this work without the other. Our ability to collaborate depended on our geographical proximity in the Boston area during 1974–79. During that period we met weekly, hammering out ideas over kitchen tables, pianos, and typewriters. The give-and-take was unusually close; it would be pointless to try to disentangle who thought up this rule or wrote that paragraph. After 1979, when Lerdahl moved from Harvard to Columbia, our work was far enough along for us to complete it from a distance. Our close collaboration ended with the publication of *GTTM*, for it was not possible to develop new ideas together without the flow of weekly meetings.

One particular feature of *GTTM* bears mention in historical perspective. At the time that we were writing the book, a generative grammar was standardly conceived as a set of rewriting rules that generated "all

and only" the grammatical expressions of the domain in question. This conception was consonant with the algorithmic style in which theories of cognitive processing were couched, as well as with then-current fashions in artificial intelligence. We discovered early in our work that such a notion of generative grammar could not be applied to musical structure; any grammar we could write generated too many "grammatical" structures that did not make musical sense. We found that we needed instead a grammar that generated a large number of alternative structures and then selected from among them the ones that were "most stable." This process of selection involved the use of "preference rules," violable principles that interacted according to relative weight. Worried by this curious innovation, we were relieved to learn, thanks to George Miller's timely advice, that antecedents existed in the work of the Gestalt psychologists of the first half of the century.

Our innovation did not fare especially well with readers who were hoping for a more traditional generative grammar. However, within a few years cognitive science was swept by new conceptions of computation (including neural nets) that replaced serial algorithms with parallel constraint-based architectures. Default logic became pervasive in artificial intelligence. Even linguistics, through the Optimality Theory of Alan Prince and Paul Smolensky, has begun to explore rule interactions very much like those in *GTTM*. In retrospect, then, we feel vindicated in our choice of how to formulate musical grammar.

Since the publication of *GTTM*, we have each independently built on our collaborative work. Jackendoff has further explored the relation between the theories of rhythm in music and in language, a process begun in *GTTM;* and he has shown how the *GTTM* theory can be adapted to the real-time processing of music. More generally, he has used the preference-rule formalism extensively in his work on lexical semantics and has used the multi-modular organization of musical grammar as a model for the organization of other kinds of mental computation. Lerdahl has significantly extended the music theory itself to include the analysis of chromatic and atonal music, timbral organization, musical schemas, mappings between music and poetry, and the relationship between compositional system and heard result in contemporary music. The most important extension has been the development of a precise model of pitch space, which replaces the underdefined "stability conditions" of *GTTM*. The hearing of a piece as it unfolds can now be understood in terms of paths in pitch space at multiple prolongational levels. These paths in turn enable the quantification of prolongational tension and melodic attraction.

As the paucity of references in our text attests, we did not know much music psychology when we wrote *GTTM*. But then the field barely existed in the 1970s. Music theorists were preoccupied with Schenker and pitch-class set theory; only Leonard Meyer's work suggested an alterna-

tive path. A few psychologists such as Robert Francés, Diana Deutsch, and W. J. Dowling published empirical research on music perception, but their work was marginal within psychology as a whole, and it rarely reached the levels of musical structure that would interest a musician. All of this changed dramatically in the 1980s. The Ossiach conferences, organized by Juan Roederer, encouraged contacts among psychoacousticians, brain scientists, cognitive psychologists, and music theorists. The launching of the journal *Music Perception* paved the way for conferences and for American, European, and Japanese organizations devoted to the study of music cognition. Important books such as those by John Sloboda, Albert Bregman, Carol Krumhansl, and Euguene Narmour appeared. We are proud that our work has been a central reference point for this growing field, both as a source of ideas and as material for experimental investigation.

Selected Works of Relevance to *GTTM*

By Ray Jackendoff

Semantics and Cognition. Cambridge: MIT Press, 1983.

Consciousness and the Computational Mind. Cambridge: MIT Press, 1987.

A Comparison of Rhythmic Structures in Music and Language. In *Phonetics and Phonology,* edited by P. Kiparsky G. Youmans, vol. 1, 15–44. New York: Academic Press, 1989.

Musical Parsing and Musical Affect. *Music Perception* 9 (1991): 199–230.

By Fred Lerdahl

Timbral Hierarchies. *Contemporary Music Review* 2 (1987): 135–160.

Cognitive Constraints on Compositional Systems. In *Generative Processes in Music,* edited by J. Sloboda. New York: Oxford University Press, 1988.

Tonal Pitch Space. *Music Perception* 5 (1988): 315–350.

Atonal Prolongational Structure. *Contemporary Music Review* 3 (1989): 65–87.

Underlying Musical Schemata. In *Representing Musical Structure,* edited by I. Cross and P. Howell. New York: Academic, 1991.

Some Lines of Poetry Viewed as Music. (Co-authored with John Halle.) In *Music, Language, Speech, and Brain,* edited by J. Sundberg, L. Nord, and R. Carlson. Wenner-Gren International Symposium Series. London: Macmillan, 1991.

Pitch-space Journeys in Two Chopin Preludes. In *Cognitive Bases of Musical Communication,* edited by M. R. Jones and S. Holleran. Washington, DC: American Psychological Association, 1991.

Tonal and Narrative Paths in *Parsifal.* In *Musical Transformation and Musical Intuition: Essays in Honor of David Lewin,* edited by R. Atlas and M. Cherlin. Roxbury, MA: Ovenbird Press, 1994.

Octatonic and Hexatonic Pitch Spaces. *Proceedings of the International Conference for Music Perception and Cognition,* 1994.

Calculating Tonal Tension. *Music Perception* 13 (Spring 1996).

1
Theoretical Perspective

1.1 Music Theory as Psychology

We take the goal of a theory of music to be a *formal description of the musical intuitions of a listener who is experienced in a musical idiom.* To explicate this assertion, let us begin with some general remarks about music theory.

Music can be discussed in a number of ways. First, one can talk informally about individual pieces of music, seeking to illuminate their interesting facets. This sort of explanation often can capture musical insights of considerable subtlety, despite—or sometimes because of—its unrigorous nature. Alternatively, one can attempt to create a systematic mode of description within which to discuss individual pieces. Here one addresses a musical idiom by means of an analytic method, be it as straightforward as classifying pieces by their forms or putting Roman numerals under chords, or as elaborate as constructing linear graphs. An analytic method is of value insofar as it enables one to express insights into particular pieces. The many different analytic methods in the literature differ in large part because of the nature and scope of the insights they are intended to convey.

At a further level of generality, one can seek to define the principles underlying an analytic system; this, in our view, constitutes a theory of music. Such a theory can be viewed as a hypothesis about how music or a particular musical idiom is organized, couched in terms of some set of theoretical constructs; one can have a theory of Roman numerals, or musical forms, or linear graphs.

Given a theory of music, one can then inquire as to the status of its theoretical constructs. Medieval theorists justified their constructs partly on theological grounds. A number of theorists, such as Rameau and Hindemith, have based aspects of music theory on the physical principle of the overtone series. There have also been philosophical bases for music theory, for instance Hauptmann's use of Hegelian dialectic.

In the twentieth century these types of explanations have fallen into relative disfavor. Two general trends can be discerned. The first is to seek a mathematical foundation for the constructs and relationships of music theory. This in itself is not enough, however, because mathematics is capable of describing any conceivable type of organization. To establish the basis for a theory of music, one would want to explain why certain conceivable constructs are utilized and others not. The second trend is to fall back on artistic intuition in constructing a theory, essentially ignoring the source of such intuition. But this approach too is inadequate, because it severs questions of art from deeper rational inquiry; it treats music as though it had nothing to do with any other aspect of the world.

All of these approaches downplay the obvious fact that music is a product of human activity. It is worth asking at the outset what the nature of this product is. It is not a musical score, if only because many musical traditions are partially or completely unwritten.[1] It is not a performance, because any particular piece of music can receive a great variety of performances. Music theory is usually not concerned with the performers' activities, nor is it concerned centrally with the sound waves the performers produce. There is much more to music than the raw uninterpreted physical signal.

Where, then, do the constructs and relationships described by music theory reside? The present study will justify the view that a piece of music is a mentally constructed entity, of which scores and performances are partial representations by which the piece is transmitted. One commonly speaks of musical structure for which there is no direct correlate in the score or in the sound waves produced in performance. One speaks of music as segmented into units of all sizes, of patterns of strong and weak beats, of thematic relationships, of pitches as ornamental or structurally important, of tension and repose, and so forth. Insofar as one wishes to ascribe some sort of "reality" to these kinds of structure, one must ultimately treat them as mental products imposed on or inferred from the physical signal. In our view, the central task of music theory should be to explicate this mentally produced organization. Seen in this way, music theory takes a place among traditional areas of cognitive psychology such as theories of vision and language.

This perspective sheds a different light on the two recent theoretical trends mentioned above. On the one hand, in principle it offers an empirical criterion for limiting mathematical formulations of musical structure; not every conceivable organization of a musical signal can be perceived by a human listener. One can imagine some mathematical relationship to obtain between every tenth note of a piece, but such a relationship would in all likelihood be perceptually irrelevant and musically unenlightening. On the other hand, this approach takes artistic intuition out of isolation and relates it to mental life in general. It becomes possible to explain artistically interesting aspects of musical

structure in terms of principles that account for simpler musical phenomena. The insights of an "artistic" approach can thus be incorporated into a larger and more explanatory framework.[2]

We will now elaborate the notion of "the musical intuitions of the experienced listener." By this we mean not just his conscious grasp of musical structure; an acculturated listener need never have studied music. Rather we are referring to the largely unconscious knowledge (the "musical intuition") that the listener brings to his hearing—a knowledge that enables him to organize and make coherent the surface patterns of pitch, attack, duration, intensity, timbre, and so forth. Such a listener is able to identify a previously unknown piece as an example of the idiom, to recognize elements of a piece as typical or anomalous, to identify a performer's error as possibly producing an "ungrammatical" configuration, to recognize various kinds of structural repetitions and variations, and, generally, to comprehend a piece within the idiom.

A listener without sufficient exposure to an idiom will not be able to organize in any rich way the sounds he perceives. However, once he becomes familiar with the idiom, the kind of organization that he attributes to a given piece will not be arbitrary but will be highly constrained in specific ways. In our view a theory of a musical idiom should characterize such organization in terms of an explicit formal musical grammar that models the listener's connection between the presented musical surface of a piece and the structure he attributes to the piece. Such a grammar comprises a system of rules that assigns analyses to pieces. This contrasts with previous approaches, which have left it to the analyst's judgment to decide how to fit theoretical constructs to a particular piece.

The "experienced listener" is meant as an idealization. Rarely do two people hear a given piece in precisely the same way or with the same degree of richness. Nonetheless, there is normally considerable agreement on what are the most natural ways to hear a piece. A theory of a musical idiom should be concerned above all with those musical judgments for which there is substantial interpersonal agreement. But it also should characterize situations in which there are alternative interpretations, and it should have the scope to permit discussion of the relative merits of variant readings.

The concept of the "experienced listener," of course, is no more than a convenient delimitation. Occasionally we will refer to the intuitions of a less sophisticated listener, who uses the same principles as the experienced listener in organizing his hearing of music, but in a more limited way. In dealing with especially complex artistic issues, we will sometimes elevate the experienced listener to the status of a "perfect" listener—that privileged being whom the great composers and theorists presumably aspire to address.

It is useful to make a second idealization about the listener's intuition. Instead of describing the listener's real-time mental processes, we will be

concerned only with the final state of his understanding. In our view it would be fruitless to theorize about mental processing before understanding the organization to which the processing leads. This is only a methodological choice on our part. It is a hypothesis that certain aspects of the phenomena under investigation can be cleanly separated. Of course, its value depends in the end on the significance of the results it yields.[3]

The two idealizations we have adopted, that of the experienced listener and that of the final state of his understanding, are comparable to idealizations made elsewhere in cognitive psychology. Without some initial simplification, the phenomena addressed by scientific inquiry have almost always proved intractable to rational investigation.

Having outlined this goal for a theory of a musical idiom, we envision a further sort of inquiry. A musical idiom of any complexity demands considerable sophistication for its full appreciation, and listeners brought up in one musical culture do not automatically transfer their sophistication to other musical cultures. And because one's knowledge of a musical style is to a great extent unconscious, much of it cannot be transmitted by direct instruction. Thus one may rightfully be curious about the source of the experienced listener's knowledge. To what extent is it learned, and to what extent is it due to an innate musical capacity or general cognitive capacity? A formal theory of musical idioms will make possible substantive hypotheses about those aspects of musical understanding that are innate; the innate aspects will reveal themselves as "universal" principles of musical grammar.

The interaction between this level of inquiry and a theory of a musical idiom is of great importance. If a listener's knowledge of a particular idiom were relatively uncomplicated (say, simply memorization of the musical surface of many pieces), there would be little need for a special theory of musical cognitive capacity. But the more the study of the listener's knowledge reveals complexity and abstraction with respect to the musical surface, the more necessary a theory of musical cognitive capacity becomes; it is no longer obvious how the listener obtains evidence for his structures from the musical surface. Thus a theory of a sufficiently intricate musical idiom will be a rich source of hypotheses about psychological musical universals.

In this book we develop a music theory along the lines suggested by these general considerations. Specifically, we present a substantial fragment of a theory of classical Western tonal music (henceforth "tonal music"), worked out with an eye toward an eventual theory of musical cognitive capacity. Our general empirical criteria for success of the theory are how adequately it describes musical intuition, what it enables us to say of interest about particular pieces of music, what it enables us to say about the nature of tonal music and of music in general, and how well it dovetails with broader issues of cognitive theory. In addition, we impose

formal criteria common to any theoretical enterprise, requiring internal coherence and simplicity of the formal model relative to the complexity of the phenomena it accounts for. In short, we conceive of our theory as being in principle testable by usual scientific standards; that is, subject to verification or falsification on various sorts of empirical grounds.[4]

1.2 The Connection with Linguistics

In advocating these goals for inquiry about music, we are adopting a stance analogous to that taken in the study of language by the school of generative-transformational grammar, most widely known through the work of Noam Chomsky (see for example Chomsky 1965, 1968, 1975).[5] This approach has resulted in a depth of understanding about the nature of language unparalleled in previous approaches. Inasmuch as it has caused questions to be asked about language that could not even be imagined before, it has also revealed the extent of our ignorance; this too is progress.

Generative linguistic theory is an attempt to characterize what a human being knows when he knows how to speak a language, enabling him to understand and create an indefinitely large number of sentences, most of which he has never heard before. This knowledge is not on the whole available to conscious introspection and hence cannot have been acquired by direct instruction. Linguistic theory models this unconscious knowledge by a formal system of principles or rules called a *grammar*, which describes (or "generates") the possible sentences of the language.

Because many people have thought of using generative linguistics as a model for music theory, it is worth pointing out what we take to be the significant parallel: the combination of psychological concerns and the formal nature of the theory. Formalism alone is to us uninteresting except insofar as it serves to express musically or psychologically interesting generalizations and to make empirical issues more precise. We have designed our formalism with these goals in mind, avoiding unwarranted overformalization.[6]

Many previous applications of linguistic methodology to music have foundered because they attempt a literal translation of some aspect of linguistic theory into musical terms—for instance, by looking for musical "parts of speech," deep structures, transformations, or semantics. But pointing out superficial analogies between music and language, with or without the help of generative grammar, is an old and largely futile game. One should not approach music with any preconceptions that the substance of music theory will look at all like linguistic theory. For example, whatever music may "mean," it is in no sense comparable to linguistic meaning; there are no musical phenomena comparable to sense and reference in language, or to such semantic judgments as synonymy, analyticity, and entailment. Likewise there are no substantive parallels between elements of musical structure and such syntactic categories as noun, verb,

adjective, preposition, noun phrase, and verb phrase. Finally, one should not be misled by the fact that both music and language deal with sound structure. There are no musical counterparts of such phonological parameters as voicing, nasality, tongue height, and lip rounding. (See also section 11.4.)

The fundamental concepts of musical structure must instead involve such factors as rhythmic and pitch organization, dynamic and timbral differentiation, and motivic-thematic processes. These factors and their interactions form intricate structures quite different from, but no less complex than, those of linguistic structure. Any deep parallels that might exist can be discussed meaningfully only after a music theory, in the sense defined in the preceding section, has been developed independently. If we have adopted some of the theoretical framework and methodology of linguistics, it is because this approach has suggested a fruitful way of thinking about music itself. If substantive parallels between language and music emerge (as they do in sections 4.2 and 12.3), this is an unexpected bonus but not necessarily a desideratum.

To help clarify in what sense our theory is modeled after linguistic methodology, we must mention some common misconceptions about generative-transformational grammar. The early work in the field, such as Chomsky 1957 and Lees 1960, took as its goal the description of "all and only" the sentences of a language, and many were led to think of a generative grammar as an algorithm to manufacture grammatical sentences. Under this interpretation, a musical grammar should be an algorithm that composes pieces of music.[7]

There are three errors in this view. First, the sense of "generate" in the term "generative grammar" is not that of an electrical generator that produces electricity, but the mathematical sense, in which it means to describe a (usually infinite) set by finite formal means. Second, it was pointed out by Chomsky and Miller (1963), and it has been an unquestioned assumption of actual research in linguistics, that what is really of interest in a generative grammar is the structure it assigns to sentences, not which strings of words are or are not grammatical sentences. The same holds for our theory of music. It is not intended to enumerate what pieces are possible, but to specify a *structural description* for any tonal piece; that is, the structure that the experienced listener infers in his hearing of the piece. A third error in the conception of a generative grammar as a sentence-spewing device is not evident from passing acquaintance with the early works of the generative school, but emerges as a prominent theme of Chomsky 1965, Lenneberg 1967, and subsequent work. Linguistic theory is not simply concerned with the analysis of a set of sentences; rather it considers itself a branch of psychology, concerned with making empirically verifiable claims about one complex aspect of human life: language. Similarly, our ultimate goal is an understanding of musical cognition, a psychological phenomenon.

1.3 The Connection with Artistic Concerns

Some readers may object to our use of linguistic methodology in studying an art form. One might argue that everyone speaks a language, but not everyone composes or performs music. However, this argument misses the point. For one thing, we are focusing on the listener because listening is a much more widespread musical activity than composing or performing. Composers and performers must be active listeners as well. And even if not every member of a culture listens to music, those who do are exercising a cognitive capacity; it is this capacity that we are investigating. (The fact that not everyone swims is not a deterrent to a physiological study of swimming.)

A related objection is that, whereas music characteristically functions as art, language does not. The data for linguistic study are the sentences of the everyday world, for which there is no musical counterpart. At first blush, poetry or drama would seem to provide a closer analogy to music. However, we feel that traditional comparisons between poetry or drama and music, though perhaps valuable in particular instances, have necessarily been superficial as a general theoretical approach. Our attitude toward artistic questions is somewhat different. In order to appreciate the poetic or dramatic structure of a poem in French, one must first understand the French language. Similarly, to appreciate a Beethoven quartet as art, one must understand the idiom of tonal music (where "understand" is taken in the unconscious sense discussed above).

Music theory that is oriented toward explicating masterpieces tends to address primarily those aspects of musical structure that are complex, ambiguous, or controversial. But such discussion takes for granted a vast substrate of totally "obvious" organization that defines the terms in which artistic options or questions are stated. For example, it rarely seems worth special mention that a piece is in a certain meter, that such-and-such is a motive, that a certain pitch is ornamental, and so forth. Throughout this study we come to grips with such musically mundane matters as a basis for understanding the more complex phenomena that an "artistic" theory deems worthy of interest.

Uninteresting though such an enterprise may at first seem, it has proved to us to yield two important benefits in the understanding of music. First, one comes to realize how intricate even the "obvious" aspects of musical organization are—perhaps more complex than any extant mathematically based conceptions of musical structure. These aspects only seem simple because their complexity is unconscious and hence unnoticed. Second, one can begin to see how artistically interesting phenomena result from manipulation of the parameters responsible for "obvious" intuitions. Many interesting treatments of motivic-thematic processes, such as Meyer's (1973) "implicational" theory, Epstein's (1979) "*Grundgestalt*" organization, and aspects of Schenkerian analysis, rely on an account of what pitches in a piece are structurally important. In the present study we show how the notion of structural

importance depends on more elementary intuitions concerning the segmentation and rhythmic analysis of the musical surface; thus we offer a firmer foundation for the study of artistic questions. We consider our work to complement rather than compete with such study.

Our interest in the musically mundane does not deter us from taking masterpieces of tonal music as the analytic focus for our inquiry. As will be seen, it is often easiest to motivate principles of the theory with invented examples that are, roughly, "musical prose." But there are two reasons for then going on to grapple with existing works of art, one preferential and the other methodological. First, it is less rewarding to specify structural descriptions for normative but dull examples than for works of lasting interest. Second, if we were to restrict ourselves to contrived examples, there would always be the danger, through excessive limitation of the possibilities in the interest of conceptual manageability, of oversimplifying and thereby establishing shallow or incorrect principles with respect to music in general. Tonal masterpieces provide a rich data sample in which the possibilities of the idiom are revealed fully.[8]

An artistic concern that we do not address here is the problem of musical affect—the interplay between music and emotional responses. By treating music theory as primarily a psychological rather than a purely analytical enterprise, we at least place it in a territory where questions of affect may meaningfully be posed. But, like most contemporary music theorists, we have shied away from affect, for it is hard to say anything systematic beyond crude statements such as observing that loud and fast music tends to be exciting. To approach any of the subtleties of musical affect, we assume, requires a better understanding of musical structure.[9] In restricting ourselves to structural considerations, we do not mean to deny the importance of affect in one's experience of music. Rather we hope to provide a steppingstone toward a more interesting account of affect than can at present be envisioned.

1.4 The Overall Form of the Theory

A comprehensive theory of music would account for the totality of the listener's musical intuitions. Such a goal is obviously premature. In the present study we will for the most part restrict ourselves to those components of musical intuition that are hierarchical in nature. We propose four such components, all of which enter into the structural description of a piece. As an initial overview we may say that *grouping structure* expresses a hierarchical segmentation of the piece into motives, phrases, and sections. *Metrical structure* expresses the intuition that the events of the piece are related to a regular alternation of strong and weak beats at a number of hierarchical levels. *Time-span reduction* assigns to the pitches of the piece a hierarchy of "structural importance" with respect to their position in grouping and metrical structure. *Prolongational reduction*

assigns to the pitches a hierarchy that expresses harmonic and melodic tension and relaxation, continuity and progression.

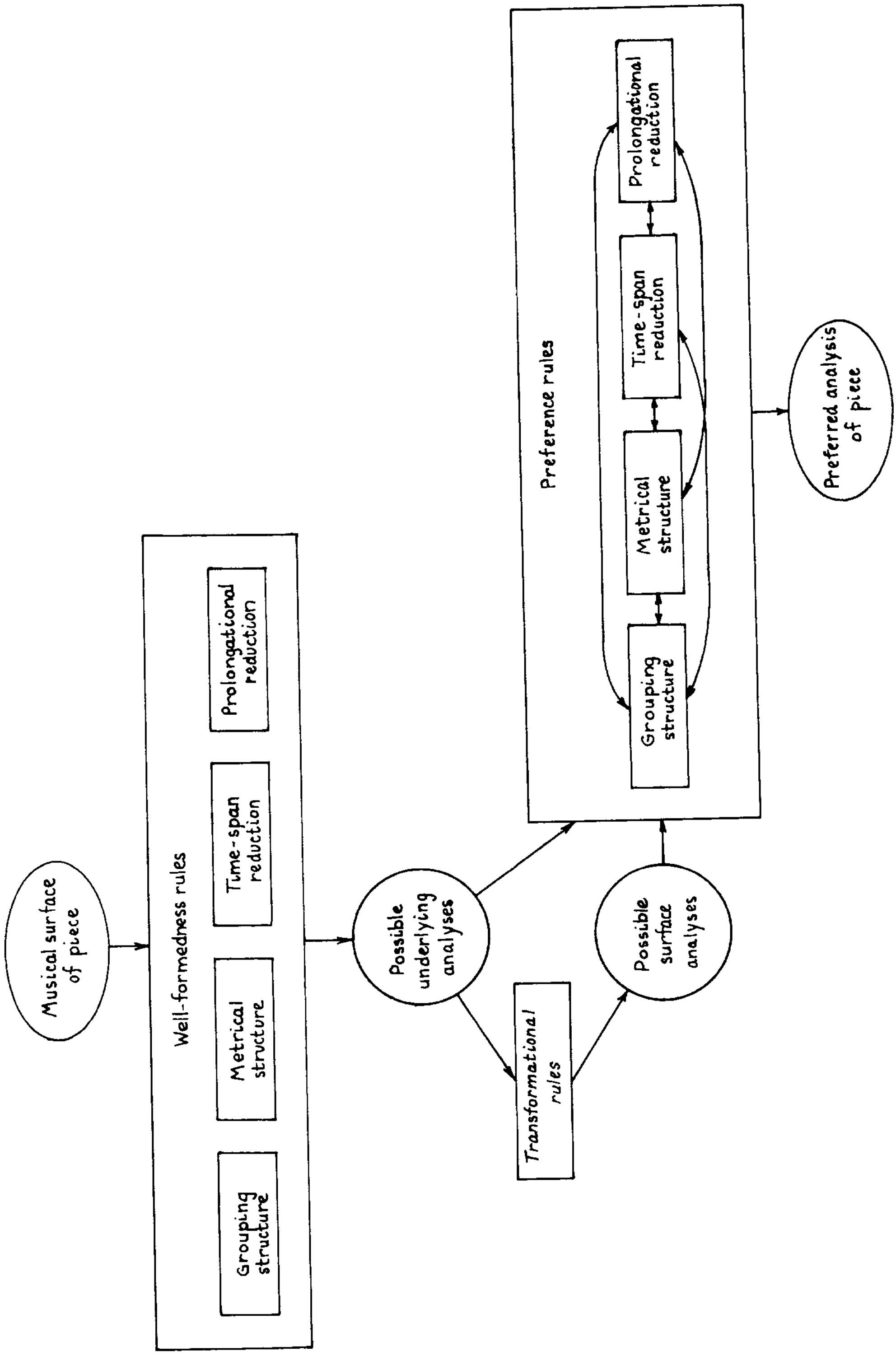
Other dimensions of musical structure—notably timbre, dynamics, and motivic-thematic processes—are not hierarchical in nature, and are not treated directly in the theory as it now stands. Yet these dimensions play an important role in the theory in that they make crucial contributions to the principles that establish the hierarchical structure for a piece. The theory thus takes into account the influence of nonhierarchical dimensions, even though it does not formalize them.

We have found that a generative music theory, unlike a generative linguistic theory, must not only assign structural descriptions to a piece, but must also differentiate them along a scale of coherence, weighting them as more or less "preferred" interpretations (that is, claiming that the experienced listener is more likely to attribute some structures to the music than others). Thus the rules of the theory are divided into two distinct types: *well-formedness rules,* which specify the possible structural descriptions, and *preference rules,* which designate out of the possible structural descriptions those that correspond to experienced listeners' hearings of any particular piece. The preference rules, which do the major portion of the work of developing analyses within our theory, have no counterpart in standard linguistic theory; their presence is a prominent difference between the forms of the two theories (see section 12.2 for further discussion).

The need for preference rules follows from the nature of intuitive judgments involved in motivating the theory. In a linguistic grammar, perhaps the most important distinction is grammaticality: whether or not a given string of words is a sentence in the language in question. A subsidiary distinction is ambiguity: whether a given string is assigned two or more structures with different meanings. In music, on the other hand, grammaticality per se plays a far less important role, since almost any passage of music is potentially vastly ambiguous—it is much easier to construe music in a multiplicity of ways. The reason for this is that music is not tied down to specific meanings and functions, as language is. In a sense, music is pure structure, to be "played with" within certain bounds. The interesting musical issues usually concern what is the most coherent or "preferred" way to hear a passage. Musical grammar must be able to express these preferences among interpretations, a function that is largely absent from generative linguistic theory. Generally, we expect the musical grammar to yield clear-cut results where there are clear-cut intuitive judgments and weaker or ambiguous results where intuitions are less clear. A "preferred" structural description will tend to relate otherwise disparate intuitions and reveal regular structural patterns.

Certain musical phenomena, such as elisions, require structures not expressible by the well-formedness rules. These structures are described

1.1



by adding a third rule type, *transformational rules,* to the musical grammar. The transformational rules apply certain distortions to the otherwise strictly hierarchical structures provided by the well-formedness rules. Although transformational rules have been central to linguistic theory, they play a relatively peripheral role in our theory of music at present.[10]

Figure 1.1 summarizes the form of the theory. The rectangles stand for sets of rules, the ellipses and circles stand for inputs and outputs of rules, and the arrows indicate the direction of formal derivation. Overall, the system can be thought of as taking a given musical surface as input and producing the structure that the listener hears as output. The meaning of the intermediate steps will become clear as our exposition of the theory proceeds.

In presenting the theory we discuss each component twice. First we present its *analytic system,* the conceptions and notations needed to express intuitions relevant to that component. At the same time we deal with the interaction of that component with the others and relate our formulations to contrasting theoretical approaches. Then we present each component's *formal grammar,* the system of rules that assigns that component's contribution to the structural description of a piece. These chapters are followed by further illustrations of the analytic system and by remarks on various musical, psychological, and linguistic implications of the theory.

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