Rhythmic structure in music: a study of the perception of metrical and phrase structure, from a mechanistic viewpoint

Fraser, George Robert Mackie

RHYTHMIC STRUCTURE IN MUSIC: A STUDY OF THE PERCEPTION OF METRICAL AND PHRASE STRUCTURE, FROM A MECHANISTIC VIEWPOINT

by

George Robert Mackie Fraser

Thesis submitted to the Faculty of Music
in the University of Durham
for the Degree of Doctor of Philosophy

1982

In Two Volumes

V O L U M E   O N E

ACKNOWLEDGMENTS

My grateful thanks are due to the Faculty of Music in the University of Durham for giving me the opportunity to research and write this work. I am especially indebted to my supervisor, Mr. David Lumsdaine, for his patient guidance and depth of understanding. I should like to thank Miss Winifred Wallis for her kindness and encouragement and Mrs. Margaret Buglass for typing the thesis. Finally, I wish to thank my Mother and Father for their unreserved help and support without which this thesis would not have been written.

ABSTRACT

The thesis investigates the perception of musical metre and phrasing, which together form a hierarchical rhythmic structure, represented in tree-diagram form. Rather than study human perceptual processes, a mechanistic approach is adopted. It is shown that the most likely rhythmic structure of a passage can be generated largely from the pitch and durational information in scores, through the perception of certain features, termed <u>structural characteristics</u>, supported by some general perceptual preferences. Each characteristic is itself a perceptual preference, capable of selecting certain groupings of notes or chords as <u>phrase groupings</u> or highlighting particular temporally disjunct notes or chords as <u>structural accents</u>, each of which is a potential metrical accent. Mental connections between relatively long notes, a preference for regular metre, and the grouping of relatively close attacks establish a basic (if sometimes ambiguous) rhythmic structure, which may be modified or developed by repetition, a longer-note accompaniment, harmonic rhythm, dissonance and resolution, pitch patterning, and notated dynamics and articulation. Phrase structure influences the perception of tonality, in conjunction with the Harmonic Series, for whose contribution a tonal map is put forward. The characteristics may be temporally congruent or incongruent (cross-rhythmic) and are of unequal strength, thus giving rise, in their many different configurations, to further perceptual preferences, which are illustrated by several hundred musical examples. The differences in relative strength permit metre and phrase grouping to be read qualitatively, as a product of the characteristics which generate it.

C O N T E N T S

VOLUME ONE: TEXT

Contents | Page

VOLUME TWO: EXAMPLES

INTRODUCTION

It has been said that 'to study rhythm is to study all of music'.[1] Although rather exaggerated, this assertion expresses the far-reaching importance of the temporal dimension in pervading virtually every aspect of a subject which must, after all, exist in time. To ignore or fail to take proper account of rhythmic structure in the study of music is to weaken the relevance of one's findings and possibly to misrepresent and distort musical meaning.

The object of the present work is to present a theory of the perception of metre and phrasing, the two constituents of rhythmic structure on the small scale. Although metre is affected by dynamics and phrasing by articulation, neither of these aspects of performance is essential to the communication of rhythmic structure in most music, as can be appreciated by playing in strict time and as <u>legato</u> as possible on an instrument such as the electric organ, on which there need be no variations in dynamics and timbre. Such an exercise would not be designed to undermine the value of playing musically, but to suggest that there are characteristics in durational and pitch sequences which can give rise to the perception of metre and phrasing by highlighting some notes or chords to produce metrical accentuation or by grouping them to produce phrases. The identification and description of these characteristics and the examination of the principal relationships among them will be the subject of this study. There is, of course, no suggestion that dynamics, articulation, and tempo cannot help to determine rhythmic structure and their contribution will also be taken into account.

1. Grosvenor W. Cooper and Leonard B. Meyer, <u>The Rhythmic Structure of Music</u> (Chicago, 1960), p.1.

Differences in the perceived rhythmic structure affect the conception of music at its most fundamental levels. Example 1a shows in simple form the most likely metrical and phrase structure for the given passage, together with a tonal interpretation; Example 1b shows one that is rather less likely. The first is produced by characteristics which are present in the sequence of notes; the second is not, which is why it is difficult, though possible, to imagine. The phrasing of Example 1b could be produced only by deliberate articulation, aided, perhaps, by timbral distinction. By contrast, if metrical structure alone is altered, the passage has the phrase structure of Example 1c, which is similar, but not identical, to that of Example 1a. The fact that it is not identical is evidence of the effect that metre can have on the grouping of notes. Even where phrase grouping is independent of metre, there is no doubt that the position of the metrical accent has a profound effect on the character of the phrase, as is illustrated by comparison of the phrase groupings in Example 2 with each other and with a 5/8 metre (see also Example 4/14).

The conception of music is also affected by the fact that the qualitative nature of rhythmic structure is a product of the characteristics which generate it, as is seen in the following features of Example 1a. There is a minim metrical pulse in the example, but it is of considerably weaker effect in bar 1 than in bar 3, which has a change of implied harmony. The metrical weakness at the minim level in bar 1 cannot suddenly become strength in the durationally similar opening of Example 1/7 (Beethoven, Op.10, No.3, I, second subject); thus the barline does not necessarily indicate the most important metrical level in a passage. The answering phrase following Example 1a and identical to it except for the last three pitches (E♭-D-C) is distinguished from it by the dominant to tonic relationship which, in turn, unites the two phrases as antecedent and consequent to form the next level of grouping. Because of repetition, the two minim-length phrases ending in bar 3 are brought into prominence relative to any grouping that might have united them; if the second phrase of the example is altered to copy the first, starting one degree of the scale lower (A♮-B♮-C-C-C), a similar weakening of their joint grouping is observed.

Musical theory has remained surprisingly aloof from an examination of rhythmic structure as cause rather than effect, and Cooper and Meyer, who have made an important contribution to an understanding of the latter, go so far as to claim that the former is impossible:

> This division of function among the several elements of music in which some produce unity and others separation is one of the things which at times makes it difficult to know what the dominant grouping is . . . Again, it is partly the fact that no hard and fast rules can be established to solve this problem of the precedence of variables that makes analysis an art rather than a science.[2]

Although the lack of a rational basis for rhythmic structure is a gap in musical knowledge which remains to be filled in its own right, both the incentive to account for what are normally intuitive perceptual preferences and the conceptual framework within which such an investigation can take place arise from the possibility, now increasingly exploited, of using the digital computer as an aid to musical research. Since a computer program is a sequence of explicit instructions, the observation of musical structures by computer must be the result of specific analytical operations on the input data. These operations may incorporate predetermined assumptions about the nature of either the data or the structure to be

2. _ibid_,p.10.

observed and may draw on stored procedures or information, which can be the result of previous analyses by the machine.

Such a mechanistic approach permits any explicit analytical process or perceptual theory to be modelled on the computer and tested against human intuition,[3] however naive its musical assumptions, but it also presents a challenge to theorists to find explicit means of identifying and describing every kind of valid musical structure. The theoretical task is a general one of which the present study forms only a part, and not an isolated part, for rhythmic structure cannot be divorced from tonal and thematic structure (where these are present in a piece). Thus the perception of rhythmic structure is part of the wider question of how to account, mechanistically, for the cognitive interpretation of music as a hierarchical structure. This question will be considered in Chapter 1, in order to set terms of reference for the present study.

The present work will be argued from a mechanistic viewpoint, in three senses. Firstly, its aim is to find explicit reasons why some notes are perceived as grouped together in preference to others, and why some bear metrical accents while others do not. Secondly, it will not investigate human perceptual processes as such, but rather view the perception of rhythmic structure in terms of analytical operations which give rise to the structure (or structures) most likely to be perceived, but which may or may not mirror human perceptual processes. Thirdly, the mechanistic environment that is envisaged for the future implementation of the present theory is that of the computer. Its normally sequential

3. Examples are the early experiments in automatic composition by Hiller and Isaacson (1959), the study of thematic process by Smoliar (1974), the musical dictation program of Longuet-Hoggins (1976), the modelling of Schenkerian transformations (Frankel, Rosenschein and Smoliar, 1976), and Morehen's comparison of Renaissance theory and practice in text underlay (see Bent and Morehen, 1978). Publication details in bibliography.

mode of operation, its capacity to make many examinations of a passage in search of different aspects, the storage of information for future use and its use of such stored information are all assumptions that underlie the viewpoint to be adopted.

However, while one intention is to discuss the principal musical questions that it would seem essential for a successful algorithm for rhythmic perception to take into account, a consideration of programming method is beyond the scope of this study. There are two reasons for this. Firstly, in the desire to write a workable algorithm or program, practical limitations might have to be made which contradicted known musical practice as considered in the theoretical discussion. Secondly, even if an algorithm or program is a successful implementation of a musical theory, it is no proof of the correctness of the theory; this has to be determined by the theory's consistency with intuitive musical understanding. The theory to be put forward will therefore be argued by means of illustrative musical examples, rather than by the presentation of computable procedures. The degree to which the discussion approaches the minute detail of such procedures will vary according to the needs of the argument and the state of current knowledge.

Chapter 1 examines the background to the present approach in greater depth than above and discusses the assumptions and practical limitations that have been adopted. Chapter 2 presents a tree-diagram notation for rhythmic structure. Chapters 3 and 4 put forward durational and pitch characteristics that generate metre and phrasing, while Chapter 5 considers the relationship between these characteristics and other information in the score that is relevant to the perception of rhythmic structure.

CHAPTER ONE

BACKGROUND AND ASSUMPTIONS

A. MECHANISTIC APPROACHES TO HIERARCHICAL STRUCTURE IN MUSIC

The present work is concerned with the perception of rhythmic structure from a mechanistic viewpoint. Such a viewpoint permits rhythmic perception to be presented as a set of abstract perceptual preferences, without the need to study human perceptual processes. Secondly, since a mechanistic viewpoint is necessary for the use of the computer in musical research, the perception of rhythmic structure may be discussed in terms that are relevant to the modelling of such perception on the computer, yet are limited to an examination of musical features, as opposed to possible programming methods. Some different approaches to the question of how to deal with musical structure mechanistically will be considered below, in order to elucidate the particular approach to be taken in this study.

The increasing use of the digital computer in musical research has brought about a fundamentally new attitude to the nature of musical analysis, by highlighting the distinction between intuitive and explicit observation. Traditionally, the analyst, in drawing attention to a structure, has seldom needed to explain how he selects certain notes as the constituents of that structure, in preference to others, since the ability to perceive musical structure is as much the common currency of the musical mind familiar with the type of music under observation as is the ability of everyone to recognize everyday objects. The computer presents a new challenge, however, in demanding that every musical structure to be observed by the machine be specified explicitly. All musical cognition thus becomes an act of analysis by the programmer, whether expressed as a series of computable operations or incorporated into the program or data as _a priori_ assumptions (or both). Since music is largely hierarchical in structure, the necessity of explicitness poses questions of the extent to which the hierarchical nature of music is understood, of which notes are more closely associated and in what ways, and which are more important than others and why.

Certainly, music is not necessarily hierarchical. For example, at the lowest levels of organization, those relevant to phrase structure, structural ambiguity may be so great as to preclude the emergence of any predominant grouping of the smallest phrase units. This seems especially likely in music employing chance techniques. Equally, at higher levels of structure, development may take place without generating any further levels, as, for example, in a Theme and Variations or in a jazz or blues improvization. However, unless it is known in advance that a passage lacks a particular type of hierarchical structure, it is necessary to search the passage for the features that would have generated that structure, in order to confirm their non-existence. Thus the mechanistic analysis of any passage can be expected either to have such advance knowledge at its disposal or to treat the passage as potentially hierarchical and make the appropriate search.

Just as music need not be hierarchical, so it is possible for some or all of music's hierarchical aspects to be disregarded, in a mechanistic approach to musical analysis. Music may be treated as an array of notes whose pitch, duration, dynamic or other values are seen as content to which to apply the chosen analytical procedures rather than as aspects which might directly condition the form of such procedures. The statistical techniques of the 1950's and 1960's that were brought together and extended by Gabura typify this approach.[1] While such non-hierarchical analysis is not invalid, its premises and results must be interpreted carefully to avoid any contradictions of musical commonsense. Particularly important in this respect is the fact that music is not the same if played backwards; indeed, the order of events in all serially ordered behaviour is considered to condition the memory and conception of the sequence concerned, as is demonstrated by trying to recite the alphabet backwards.[2] It has been shown experimentally that hierarchical groupings likewise condition conception and memory: a sequence of digits or musical notes, presented as partitioned at various points to form internal groups, is poorly recognized on a subsequent presentation if the serial order is maintained but the grouping changed.[3]

It would seem advisable, then, for mechanistic methods of analysis to pay close attention to the hierarchies into which the mind most commonly structures musical data and which thereby become understood as intrinsic to the music in which they are found. Further evidence for this opinion may be seen in one of the earliest applications of the computer in musical research, that of Hiller and Isaacson, whose attempts to generate music as the output of given rules of composition produced examples which those with traditional Western expectations might describe as music which wanders, goes nowhere, establishes no

1. A. James Gabura, 'Musical Style Analysis by Computer', in The Computer and Music, edited by Harry B. Lincoln (Ithaca and London, 1970), pp.223-275.
2. Natasha Spender, 'Psychology of Music' in The New Grove Dictionary of Music and Musicians, 20 vols (London, 1980), XV,388-421 (pp.405,416).
3. Gordon H. Bower and David Winzenz, 'Group Structure, Coding and Memory for Digit Series', Journal of Experimental Psychology,80 (1969); W. Dowling, 'Rhythmic Groups and Subjective Chunks in Memory for Melodies', Perception and Psychophysics, 14 (1973),37.

goals.[4] This is not mere value-judgement, but a reflection of the authors' rules, and it may be noted as a positive achievement of their work that it shows that hierarchical structure in music must come from aspects other than those covered by their rules.

In essence, there are three ways, not necessarily mutually exclusive, in which mechanistic methods may take account of hierarchical structure in music. One is to study psychological processes and then incorporate the results into the assumptions or operations of an algorithm. To date, experimental musical psychology has been more concerned with the lowest, psychoacoustic levels of perception than with higher levels of organization such as phrase structure and tonal structure,[5] although the experiments of Deutsch and others have investigated aspects of the grouping of notes into musical lines.[6] While a mechanistic analogue of perception may take the results of psychological research into account, there are several problems with trying to simulate perceptual processes directly. Knowledge of human methods of organization may not be necessary to find a mechanistic solution to a problem or may not provide the simplest or most effective mechanistic method. It is more likely, however, that such knowledge will simply not be available and that the computer simulation of a perceptual task will throw light on human procedures by showing the function of component operations in carrying out the task. For example, Longuet-Higgins has devised an algorithm capable of rationalizing the actual durations played on an

4. L.A. Hiller and L.M. Isaacson, Experimental Music (New York, 1959).
5. See Spender, op.cit.
6. Diana Deutsch, 'Music Perception', The Musical Quarterly, 66 (1980), 165-179 (pp.170-4).

electronic keyboard into their normal notated equivalents, by incorporating into the algorithm metrical assumptions and degrees of tolerance to accommodate deviations of tempo from the anticipated beat.[7] Components of pitch perception are illuminated in a computer program by Piszczalski and Galler, which first produces a three-dimensional graph of a monophonic signal, plotting amplitude and pitch against time, and then analyzes the strongest peaks to find harmonic ratios that identify the perceived fundamental.[8]

For certain perceptual problems, then, it seems that the machine simulation of human processes is more likely to aid our understanding of these processes than _vice versa_. Moreover, it is doubtful at present whether any experimental research into human cognition at a higher level than the perception of notes would reveal insights of much value to the mechanistic modelling of such cognition. The problem lies in the variety of knowledge and musical ability of different listeners, a topic which will be pursued in greater detail at the end of this section (pp.20-22).

Piszczalski and Galler's work is an example of the second mechanistic approach to musical structure: the recognition and analysis of features. The present work will be argued from this second viewpoint, which regards musical data as initially unstructured, but likely to contain certain features, the recognition of some or all of which will give rise to hierarchical structure, either directly or indirectly. In the case of the perception of rhythmic structure, this second mechanistic approach involves applying to the unstructured data analytical operations that are analogous to human perceptual preferences.

Each of the features, or, as they will be termed, _structural_

7. H.C. Longeut-Higgins, 'Perception of Melodies', _Nature_, 263 (1976), 646-653.
8. Martin Piszczalski and Bernard A. Galler, 'Computer Analysis and Transcription of Performed Music: A Project Report', _Computers and the Humanities_, 13 (1979), 195-206.

characteristics, is informally understood as defining one way in which the listener gives importance to certain notes over others. While each may thus be seen as a perceptual preference, this latter term will mostly be employed to describe the choice that prevails among different combinations of characteristics and the different structures they suggest. The intention is to consider how otherwise unstructured data becomes structured as progressively more information is acquired through the observation of the various characteristics. Such as abstract view of musical cognition is not inconsistent with the possibility that certain types of structure may be derived only from learnt preferences, since the latter may be seen as secondary characteristics derived from primary observations which on their own might produce only a partial understanding of a given passage.

In the search for a consistent set of structural characteristics, our heritage of theory, having little need for a conscious understanding of musical perception, provides only a meagre knowledge. Paradoxically, our very familiarity with common musical structures as effect makes it hard to appreciate the extent of current ignorance about their cause. Traditional theory tends to lend itself more readily to the formulation of explicit definitions and the attempt to formalize such theory and define aspects of musical structure as effect rather than cause may be distinguished as the third mechanistic approach to musical structure. While this is not necessarily in conflict with the present method, the differences between the two approaches are worth pursuing in greater detail in order to clarify certain assumptions underlying the present work.

In the present method, the recognition of certain structural characteristics in a given piece might lead to the selection of information that would normally be described by a traditional term such as 'phrase'. This would not imply, however, that the selection procedure constituted a definition of the term 'phrase', since there might be further characteristics, observable in other music, including music as yet unwritten, which would also give rise to the perception of a phrase. Thus musical terms other than those which, like the term 'C major chord', demonstrably refer to a finite and identifiable set of features should be considered as generic terms, capable of explicit definition only within an explicitly defined corpus of music.

This qualification about definition becomes inverted in its effect, however, when it is realized that the act of defining a generic term or, more generally, the formalized description of any musical feature, whether it has a customary generic term or not, itself defines a certain corpus of music, by defining stylistic boundaries which may have no reason to be considered significant other than as the product of such a formal description. It is this notion of absolute and possibly artificial stylistic boundaries that distinguishes the third, or 'generative', approach from the present 'analytical' one, not the potential inadequacy of either method for certain types of music.

The distinction between the 'generative' and analytical' approaches to musical cognition is due to Laske,[9] but a similar distinction is to be found in linguistic theory. Thus Lyons contrasts what he calls the 'inductive' view of linguistics, based on 'inductive generalisation from the events that have first been observed and systematically described', with the 'deductive' view, in which the selection of the events observed are presumed to follow certain assumptions, however inexplicit, which may be used in the construction of a formal theory that can itself be verified by observation.[10] The parallel with

9. Otto E. Laske, 'In Search of a Generative Grammar for Music', Perspectives of New Music, 12 (1973-4), 351-371 (p.360).
10. John Lyons, ed., New Horizons in Linguistics (Middlesex, 1970), pp.7-8.

linguistics is not unimportant, since Lyons identifies the generative grammar of Chomsky as belonging to the deductive view and it is from Chomsky that Laske takes his cue in pursuit of a generative grammar for music. There is, however, one fundamental difference between natural language and music. Although a natural language tends to change gradually over the years, it is considered reasonable by linguists to treat it as static and attempt to represent it as a formalized language whose expressions follow certain explicit grammatical rules against which linguistic competence may be judged. Compositional practice, on the other hand, is in a continuous state of change and any attempt to define rigorously and finally the generic terms which are given to intuitively perceived musical structures will be frustrated by this change, if not by the sheer variety of musical style, both of which constantly call into question the fixed ideas that definitions are made of, whether they are stated explicitly or held implicitly in the expectations of the listener.

For Laske to regard musical competence as similar to linguistic competence is to presume the existence, which he does, of a prescribed set of rules that define musical activity, from which 'grammatical' musical structures may be generated and against which they may be comprehended as acceptable.[11] Not only is such a view anathema to the spirit of iconoclasm which seems to be the driving force behind much of twentieth-century music, but it presupposes that definitions could be laid down now that would cover all possible forms of musical expression, both of the past and the future. This hardly seems likely, to say the least.

11. Otto E. Laske, 'On Musical Strategies with a View to a Generative Theory of Music', Interface, 1 (1972), 111-125 (pp.113-4).

The ideas of definable rules and closed musical systems that characterize the generative approach have been summarised by Winograd:

> As the great body of scholarship on musical theory shows, there is a set of quite specific structural (syntactic) rules governing most types of music, and a generative grammar would provide a neat and useful way of expressing them. It is possible to separate various aspects of music into partially independent areas, and the number and complexity of the rules operating in any such subset are quite small compared to those which must be used in any reasonable theory of a natural language.[12]

Such ideas are inconsistent with the view that will be taken in the present work, namely that compositional practice is a continuum: there is no rule for which an exception cannot be found or made, no musical structure that cannot be related to any other by a series of transformations, however remote the connection. The difference between the present view and the generative approach is especially relevant to harmonic analysis, the subject of Winograd's paper. In contrast to Winograd's definitions of certain aspects of tonal harmony, following the traditional ideas of the diatonic key system, the present view is in accordance with Messaien's declaration that 'the terms "tonal", "modal", "serial" and other words of this kind are illusory...[they] make an improper, though perhaps useful means of dividing phenomena which are basically linked'.[13]

The view of compositional practice as a continuum does not suggest that change has taken place at a uniform rate throughout musical history, that music is not established into recognizable styles. The ideas of common practice and constant change are not in opposition, but simply different ways of looking at the same

12. Terry Winograd, 'Linguistics and the Computer Analysis of Tonal Harmony', Journal of Music Theory, 12 (1968), 2-49 (p.4).
13. Claude Samuel, Conversations with Olivier Messiaen, translated by Felix Aprahamian (London, 1976), pp.23-25.

continuum of actual or possible practice. On the one hand, the composer must assert some individuality if he is not merely to copy, and in Western art-music the conscious desire to express an individual style has a long tradition that extends back well before the period of so-called 'common practice' in harmony. On the other hand, if the composer is too original for his audience, he may not be understood. Clearly he is limited, too, by virtue of his time and place: it would be absurd, for example, to pretend that electronic music was a choice available to Monteverdi, as a musical conception, quite apart from technical limitations.

Furthermore, there are certain predetermined factors which affect the choices made by the composer. These include, where appropriate, his own prescribed material, thematic or formal. Secondly, music is plainly the direct product of performance and only indirectly the composer's creation. Through the development of notation and its dominance over improvization, the Western composer has been able to exercise considerable control over the final sound, but, even in electronic music, he has never yet been able to ignore the limitations of instruments and their performers. Thirdly, far-reaching cultural assumptions may be involved in the production of music; it may be conditioned by social function, as in religious or dance music, or by stylistic or formal norms, especially in improvized music and non-notated music in general. Thus, even if the composer works intuitively, he does so to a greater or lesser extent within a consciously accepted framework.

However, compositional practice may still be regarded as a matter of preference, with the likelihood of certain practices being so small and the certainty of others so great as to be equivalent to the conscious following of rules. This view is in accordance with the notion that expectation and originality in music might be expressed by the mathematical concepts of probability and Information Theory, respectively, a view that is explored in greater depth by Meyer[14] and Youngblood.[15] The idea of style as preference is even wide enough to include indeterminacy, which may be seen as an uncertain choice between two or more possible states, in contrast to the traditional Western composer's apparently certain preference for a single outcome, a certainty which never actually extends to the final sound because of the indeterminacies of performance. Since the fine gradations of musical style are ideal material for cataloguing by computer, the resulting catalogue could control the setting of any stylistic boundaries needed for assessing the significance of the choices made in any piece, in such a way that the idea of considering the present-day composer's range of choices as available to the composer of the past would never arise.

The rejection of prescribed rules by no means implies a rejection of the entire generative approach. Traditional definitions of generic terms, theories that are generalisations of actual practice (for example, Sonata Form) and abstract constructions such as the key system may well turn out to model the expectations of the listener of a particular time and place in the most efficient way. If such theories were known to the composer and consciously followed or rejected by him in a given piece, it is clear that they have a special importance to the understanding of that piece. For example, it is essential to have a knowledge of the diatonic system in order to appreciate the full significance of its undermining in Wagner's

14. Leonard B. Meyer, Music, The Arts and Ideas (Chicago and London, 1967), pp.5-21.
15. Joseph E. Youngblood, 'Style as Information', Journal of Music Theory, 2(1958), 24-35.

Tristan 'by continual avoidance of the positive cadence which would have clinched a key',[16] although it is just as important to have a wider theory of tonality to explain in its own terms the opera's opening progression of the 'Tristan chord' and its resolution, which 'by the end of the opera we have come to accept...as a satisfying entity in itself'.[17]

Furthermore, it is valid to construct a formal theory by deduction from intuitive understanding and to verify by observation its adequacy for some passages and its inadequacy for others. For example, in harmonic analysis, it would be reasonable to identify major and minor common chords under the assumption that they had particular importance in the structure of tonal harmony. In jazz harmony, however, with its emphasis on added-note chords, this analysis would appear inadequate unless it were widened to include the observation of major and minor triads contained within other chords. The original assumption, however inadequate, would not be invalidated by the existence of jazz harmony; only if the assumption were that tonality is a product purely of major and minor triads, would this be shown to be an inaccuracy.

The formalization of an intuitive theory under the generative approach does, however, presume that the rules concerned define stylistic boundaries of particular significance. How many unique systems would be required to account for the whole gamut of musical practice can only be conjectured; it would either be a needlessly large number, with considerable redundancy in the repetition of rules, or, if a smaller number, there would be many complicated variations and exceptions, each of which would have to be specified by the

16. Anthony Payne, Schoenberg (London, 1968), p.1.
17. ibid.

programmer. While such systems may be used to compare theory with practice, both the specification of the theory and the observation of its inadequacy in certain instances can be made only by a human analyst. But with the alternative and more broadly based ability to analyse musical structures that might be derived from the structural characteristics of the present work, the two approaches could be used in conjunction, formal rules being matched against preferential practice by the computer itself. Although the generative approach is undoubtedly of value and is not incompatible with the present view, the reason for choosing the present approach as a means of identifying musical structure has already been given: if musical structure is a product of perception, it will be defined most effectively by the perceptual preferences that give rise to it.

The relationship between the two approaches does not end here, however, since certain limitations and assumptions which rely on defined structures will be made in the present work, for the sake of practicality. Most of these are embodied in the representation for musical notation upon which the work is based. It seems reasonable to consider the data of this representation as 'unstructured' for present purposes, provided that its limitations and assumptions are understood; they will therefore be examined in Section C of this chapter.

Within the defined stylistic boundaries of any notation which might be chosen, it is desirable for the search for structural characteristics to range as widely as possible. If the idea of electronic music was beyond the scope of Monteverdi, his stylistic preferences are still available to the composer of electronic music and will be related to some degree to whatever the composer of today might choose, however tenuously. Wherever such relationships cannot be explained by musical theory, the latter must be widened to account for them. While this emphasises the similarities among musical styles, it may be seen from the foregoing that it need not do so at the expense of their differences. It presumes, however, that if, for example, a certain musical entity exists in two pieces of distinctly different styles, it retains the same identity in both. Clearly it must also be seen in context, since its function in different contexts may not be comparable, but an emphasis on context alone would make it impossible to identify the constituents of musical style, with every piece establishing its own unique context.

But the relevance of similarity to the present work extends beyond simply the correlation of content if, as Meyer believes, 'what remain constant from style to style are not scales, modes, harmonies, or manners of performance, but the psychology of human mental processes - the ways in which the mind, operating within the context of culturally established norms, selects and organises the stimuli that are presented to it'.[18] This notion of a wide diversity of musical practices unified by a smaller number of perceptual principles will be mirrored in the present work in the assumption that once a structural characteristic has been established, it may be taken, by inductive inference, to be a generator of structure in any piece in which it appears, though it may not be the predominant one. Thus it will be seen that a relatively small set of characteristics appears to account for those aspects of structure under consideration, throughout a large range of superficially very different music.

In contrasting the human perception of music with the mechanistic viewpoint required by the use of the computer, it was noted earlier that the

18. Meyer, op. cit., p.7.

listener familiar with the style of a piece is in a position to see musical structure as an intrinsic part of the music itself, allowing for the possibility of structural ambiguities. This familiarity is crucial and cannot be taken for granted. As any teacher of music knows, the automatic response of everyone to the nuances of structure, especially phrasing, is by no means guaranteed. This is consistent with Meyer's argument that perception is 'an act of learned discrimination'.[19] Yet learnt information must be derived from somewhere and thus there must be certain innate perceptual principles from which to start the learning process. However, the structural characteristics which will be put forward may or may not be synonymous with these innate principles. It is the discrimination among notes, the ways in which certain notes are more important than others for the purposes of perceiving rhythmic structure in music, that are the concern here, not how the human being comes to learn them.

The question must be raised, however, whether there is really any such thing as musical structure or whether it is simply something that is imposed by the culturally conditioned listener in accordance with his individual interpretation. Meyer sees perception and communication as depending on 'our having learned a musical style'[20] and Lerdahl and Jackendoff describe the 'educated listener' as 'not necessarily a trained musician but a listener who is aurally familiar with the musical idiom in question' and is thereby 'able to identify a previously unknown piece as an example of the idiom'.[21] But such statements do not necessarily imply that different musical styles require mutually exclusive sets of perceptual preferences to

19. ibid., p.271.
20. ibid., p.274.
21. Fred Lerdahl and Ray Jackendoff, 'Toward a Formal Theory of Tonal Music', Journal of Music Theory, 21(1977), 111-171 (p.111).

interpret them. If such sets do overlap, it is correct to infer that a structural characteristic is relevant wherever it appears, for the perceptual preferences learnt in one style will help the listener to understand the music of an apparently quite different idiom.

If, on the other hand, even a single structural characteristic could be shown to have no effect on the musical structure of a certain style as heard by the native educated listener, though found in the music concerned, the relevance of the structural characteristics, individually and collectively, to the music from which they are derived in the present work would nevertheless remain unaffected; the implications for a theory of musical cognition and hence musical structure would, however, be far-reaching, establishing that the educated listeners of two fundamentally different cultures might interpret each other's music in irreconcilably different ways.

But while it is obvious that no two listeners focus their attention on exactly the same structures in a piece at exactly the same time or approach the music with the same set of expectations, such differences are not examples of irreconcilable interpretations. It is in the nature of hierarchical structure to present different levels of information such that the listener may alter his focus of attention at will, as, for example, a reader of prose may observe a sequence of syllables, a sequence of words, or whole clauses and sentences. Hierarchical groupings may be interpreted either in their own right or in the light of the organisation on the next or subsequent levels. They may be perceptible without the information provided by expectation; thus the listener's expectations afford a further way of observing the data. These varieties of interpretation should be distinguished from differences in the perceptible structure itself: even with all of the relevant characteristics brought to bear on a passage, the discrimination of perception may not always produce a single 'correct' structure at every level; as Bernstein has shown, structural ambiguities play an important part in making music interesting.[22]

With a variety of 'viewpoints' available to the listener, it is important not to confuse these individual interpretations with the overall hierarchical structure, ambiguous or otherwise, that they constitute collectively. The present work is concerned with how to derive the overall rhythmic structure that the educated listener is most likely to be able to perceive in a passage of music, rather than what might be observed in a single listening. To this end a structural notation will be put forward, from which the various possible individual interpretations may be read.

While it is possible that the theories to be presented might form the basis of hypotheses that could be tested by experimentation, the range of possible individual interpretations of music seems to indicate that, without a conception of overall structure from which to frame suitable hypotheses, any experimental evidence on the perception of musical structure would be either inchoate or misleading. Such an outcome seems likely even if the subjects tested were all 'educated listeners', assuming that such a group of people could be identified; if they were selected at random, the difficulties of interpreting the results would be multiplied. For these reasons, it does not seem appropriate at the present stage to seek any experimental evidence for the structural characteristics put forward. The present work is derived from an intuitive understanding of musical structure and accordingly must be judged, like traditional theory, by musical commonsense and by its consistency with musical practice.

22. Leonard Bernstein, The Unanswered Question (Cambridge, Massachusetts, 1976), pp.93-107.

B. THREE MUSICAL HIERARCHIES

The previous section has used the terms 'hierarchical structure' and 'musical structure' without any attempt to define them. The idea of musical structure as a hierarchy appears in musical theory under three principal headings: motivic analysis, reductional analysis, and rhythmic structure. A brief general description of the first two of these is now appropriate, to help to establish why the third, rhythmic structure, has been judged here to be the perceptual basis of the listener's overall hierarchical organization of music. In a sense, the reasons for choosing rhythmic structure are more appropriate as conclusions of the present work than as premises, since only a detailed examination of what is meant by 'rhythmic structure' can do justice to the argument. On the other hand, in order that the bulk of the present theory should not be seen in isolation from the wider view in which it is set, it seems better that an outline of the relationship between rhythm and motivic and linear analysis be given at the outset.

Motivic analysis embraces much of the nineteenth-century idea of Form in identifying material which is repeated directly in whole or in part or related by transformation. The usual distinction between formal and motivic analysis is that Form is concerned with labelling whole sections of a work and need not involve repetition, whereas motivic analysis tends to involve a polyphonic partitioning, not necessarily of the whole of a passage, but sufficient to identify the material that the analyst considers most important thematically. The analysis of Form is thus suited to the largest-scale subdivisions of a piece and motivic analysis to the smallest thematic cells which may be repeated, developed, extended or otherwise transformed in building and, at the same time, unifying a larger structure. It is customary for formal subdivisions to be labelled with capital letters and motives with lower-case letters.

Motivic analysis, including Form, is hierarchical in the sense that material may be divisible into more basic motives or a passage may be subdivided into sections determined by similarity or deliberate contrast.[23] This places it outside the scope of the present work for three not unrelated reasons. Firstly, the ability to judge contrast, although intuitively obvious to the human observer, is hard to account for objectively without perhaps having a set of quantifiable features and some means of assessing the significance of changes in their values. It is not the purpose of the present work to investigate what such features might be, although it seems doubtful that they could reasonably be divorced from the rest of musical structure.

Secondly, motivic analysis requires an ability to judge the significance of a proposed motive, both in relation to the passage or work and in its intrinsic originality, and in this regard it presupposes a vocabulary of transformational procedures ranked, perhaps, according to such principles as the probability of transformation and the ease of the listener to hear the relationship concerned. Without such knowledge, it is too easy to assume that all material can be related equally easily and to argue on the basis of circumstantial evidence, for example to 'prove' that some commonplace interval is the germ of an entire work. In these circumstances, the line between genius of insight and a fertile imagination is hard to draw; the writings of Réti, for example, seem to tend towards the latter category.[24]

23. A diagrammatic form of thematic hierarchy is given in Thomas Fay, 'Perceived Hierarchic Structure in Language and Music', Journal of Music Theory, 15(1971), 112-137 (pp.124-127).
24. Rudolph Réti, The Thematic Process in Music (London, 1961).

Thirdly, motivic analysis presupposes some other form of musical structure within which the motives are set. Thematic development and repetition may contribute significantly to this form of structure, but they are not the totality of it. Lerdahl and Jackendoff put the matter thus:

> If...[motivic] ideas were developed compositionally without respect to context, the result would largely be chaotic; in the work of sophisticated composers, they often seem to be inextricably bound up with context. It would be pointless to discuss them without first evolving a theory of the structures in which they are embedded.[25]

It is not surprising, then, that Smoliar, after isolating the thematic process in Bach's Two-part Invention in D minor and substituting new themes, generates a successful new piece only because in his own words, 'these [themes] do not deviate from the originals very radically.'[26] Motivic development is not a proven necessity in musical structure, although its long-standing and obvious presence in Western music suggests something of greater importance than a mere stylistic tendency. Nevertheless, the structure of motivic development may be regarded as extrinsic to the musical structure that it presupposes, though not independent of it.

It should be noted that the computer can perform a type of motivic analysis that mostly disregards hierarchical structure. Searching for the repetition of any sequence of symbols is a simple and common application of its capacity to compare information, which has been made particularly easy in such high-level programming languages as COBOL and SNOBOL. Similarity of a kind can be examined if one considers strings with one or more elements different or omitted. The possible combinations of similarity or difference may

25. Lerdahl and Jackendoff, op. cit., p.162.
26. S.W. Smoliar, 'Process Structuring and Music Theory', Journal of Music Theory, 18(1974), 308-336 (pp.319-332, p.324).

be governed by the set of binary numbers with, say, 1 representing an element that is the same and 0 standing for one that is different or missed out. There is no doubt that a method such as this can reveal many similarities of style to the analyst, provided that he examines his output with musical commonsense. But its notion of similarity is not based on recognized musical relationships, that is, on explicit or intuitively understood transformations. Thus the sequence of Example 1/1a would be found in Example 1/1b either by chance or systematic examination of all combinations, rather than by deliberate selection, and would be of no greater significance to the computer than the sequence of Example 1/1c.

Transformation is one of the key constituents of the second type of hierarchy, reduction, which is inevitably associated with the technique of linear analysis first put forward by Schenker.[27] Schenker conceived of tonal music as a hierarchy of structural levels (*Schichten*), the most fundamental, or *background*, of which (the *Ursatz*) is the simple cadential progression $\left\{\begin{matrix}\hat{3} & \hat{2} & \hat{1} \\ \mathrm{I} & \mathrm{V} & \mathrm{I}\end{matrix}\right\}$. (The Arabic numerals represent scale steps.) Each subsequent level is an elaboration of the previous one, resulting in a 'composing out' (*Auskomponierung*) from the most background levels, through those of the *middleground*, to the *foreground* structure, which is the composition itself. The technique deals exclusively with pitch, duration values being included only in the foreground diagrams. Seen in reverse, the analysis is reductional, a progressive filtering out of pitches in reverse order of their importance to the overall tonal structure. Conversely, pitches are seen as *prolongued* from the background to the foreground. In Schenker's notation, the various hierarchical levels are, for convenience, usually condensed

27. See especially Heinrich Schenker, *Neue musikalischen Theorien und Phantasien*, III, *Der Freie Satz* (Vienna, 1935), translated and edited by Ernst Oster as *Free Composition* (New York and London, 1979); see also David Beach, 'A Schenker Bibliography', *Journal of Music Theory*, 13 (1967), 2-37.

into three diagrams, or graphs, representing the background, middleground, and foreground levels. In this amalgamation of levels, pitches are distinguished in rank by the use of duration symbols adapted from musical notation, including unstemmed black notes for the lowest level, and by employing beams and slurs to denote structurally important remote connections.[28]

Although the ideas of linear analysis are well known and have been widely followed, they have not yet gained universal acceptance. The musical relevance of elaboration is, however, undeniable and is clearly demonstrated in an example which Schenker himself analyzes (Example 1/2).[29] It is also related to the technique of variation, as Forte has pointed out: 'By means of variation techniques a basic structure becomes more elaborate, in terms of increasing number and variety of melodic-rhythmic events. Reduction accomplishes the reverse.'[30] In a Theme and Variations, the elaboration is not necessarily of the theme (and Forte does not suggest that it is). The theme is certainly transformed in the variations and elaboration is also usual, but the important principle is that in all examples of the form, it should be possible to find by reduction the basic material from which the theme and the variations are all descended by elaboration or other transformations. In this regard, Schenker's analysis of the theme from Mozart's Sonata in A major, K.331, first movement, is also found to be a reduction of each variation except the third, for which only the transformation from major to minor mode is required.[31] Whether or not it is the most appropriate reduction is, of course, a separate matter.

28. A detailed description of the notation of linear analysis is given in 'A Glossary of the Elements of Graphic Analysis', The Music Forum, 1 (1967), 260-268.
29. Schenker, Der Freie Satz, op. cit., Anhang, p.71.
30. Allen Forte, 'Schenker's Conception of Musical Structure', Journal of Music Theory, 3 (1959), 1-30(p.14).
31. Schenker, ibid, p.119.

Any concept of elaboration or reduction presupposes not only a set of transformational procedures and the ability to select the appropriate transformations at each stage of analysis, but also some criteria by which the products of such transformations may be judged. It is usual for those who practise or write about linear analysis to assume that these presuppositions, which have only been satisfied intuitively to date, conform to the principles of tonality, but this phrase requires some qualification. Leaving aside the question of how appropriate it is for linear analysis to be applied to atonal music and restricting the notion of tonality to music that appears to fit the diatonic key system, there are three senses in which such 'principles of tonality' might be understood: they might be the products of characteristics directly visible in the score, of learnt preferences, or of some predetermined system.

The principles of harmony which Rameau and others derived from the Harmonic Series belong to the third category. While these theorists produced much of the accepted model of the key system, their largely vertical treatment of harmony failed to secure the criteria for absolute consonance and dissonance which they sought. It has always been understood that any concept of triadic tonality must be able to account for the ability to identify passing notes and the resolution of dissonance and, to the extent that it is capable of this, traditional harmonic theory is successful. Rameau's model of the key system also implies the hierarchical ranking of triads and keys with respect to a given tonic, which is an extension of the distinction between consonance and dissonance.

One of Schenker's major contributions to tonal theory was to appreciate the significance of linearly as well as vertically asserted tonics to the recognition of relative consonance and dissonance and to the relative importance of the various triads in a piece. The necessity of linear relationships to a concept of tonality has led Komar to reconsider in Schenkerian terms the recognition of relative consonance and dissonance as it applies to suspensions.[32] The importance of establishing the overall tonal context is seen in his example of a 'consonant suspension' (Example 1/3),[33] in which, if the final were the overall tonic, the following E♭(6) would be the elaboration or 'dissonance'; but since E♭ is the tonic, it resolves the leading-note D, even though the latter is harmonized as a consonance.

Thus Schenker's system is linear in the sense that the hierarchical reduction of pitches is made initially in relation to any local, or secondary, tonic which may be embedded in the overall tonal structure, and ultimately to the tonic of the overall key, which is determined by the final cadence. It is also linear in aiming to follow the voice-leading principles of strict counterpoint to preserve a melodically intelligible succession of pitches at each level. In accordance with this aim, the basic melodic line (Urlinie) of the fundamental structure (Ursatz) invariably descends by step from scale-steps $\hat{3}$, $\hat{5}$, or $\hat{8}$ to the tonic, $\hat{1}$.

But while the hierarchical nesting of keys and its derivative, the notion of secondary dominants, have become accepted aspects of tonal analysis, the inevitable linear descent of the Urlinie is far from uncontroversial. All too often it seems to be a predetermined notion, a structure towards which the reduction proceeds by design,

32. Arthur J. Komar, Theory of Suspensions (Princeton, New Jersey, 1971).
33. ibid., p.84.

rather than the final product of a series of explicit transformations each seen to be the most appropriate in context. The descent from $\hat{2}$ to $\hat{1}$ is by no means the only way to terminate a melodic line in tonal music and one of the stock cadential formulae of the Renaissance (Example 1/4) is sufficient to deny the suggestion that it ever was and to reaffirm the importance of the ascending semitone as a potential leading-note, that is, as a means of defining a tonic linearly. If it should be argued that Renaissance music is outside the scope of Schenkerian theory, it is not hard to find an example from the period of 'common practice' in harmony, in which the leading-note to tonic progression unequivocally announces the final cadence (Example 1/5).

An extended attack on the wisdom of reduction by tonal harmonic and linear voice-leading preferences alone has been made by Narmour,[34] who puts forward an 'implication-realization model' for reduction, based on Meyer's concept that certain pitches imply certain subsequent pitches and that these implications may or may not be fulfilled.[35] Essential to this approach is the role of expectation, which is beyond the scope of the present enquiry, as it presupposes not only the perception of metre and phrasing, but also a prior knowledge of the musical style in question. While Meyer and Narmour are right to counter the notion that pitch functions only in relation to its tonal interpretation, the hierarchical ranking of pitches by this criterion, which Schenkerian reduction involves, can nevertheless reveal important 'deep structures' (to borrow the linguistic term) that are embedded within tonal music.

While the correctness of the Ursatz is not beyond question, to take sides on this matter would not be appropriate here: it would demand a critical appraisal of every aspect of Schenker's theory such as would not be satisfactory without attempting to construct a method of reductional analysis

34. Eugene Narmour, Beyond Schenkerism: The Need for Alternatives in Music Analysis (Chicago and London, 1977).
35. Leonard B. Meyer, Explaining Music (Berkeley, California, 1973),pp.131-241.

based on explicit rather than intuitive transformations. It should be stressed that this would be a method of reduction, not prolongation: the latter only follows from a predetermined Ursatz which must itself be seen to follow from accepted principles of reduction if it is not to seem a fabrication of Schenker's imagination. Schenker's own analyses would provide an acceptable basis for deriving explicit reduction procedures if the correctness of the choices at each level were intuitively obvious to anyone familiar with tonal music and the theory could satisfactorily counter any serious criticism. But one crucial criticism persists, namely that Schenker failed to accord rhythm its rightful place in musical structure. For example, Rosen questions the idea that a 'composition [is] conceived only in linear terms, mostly, indeed, as a pure arrangement of pitches without regard to rhythm, intensity and texture...Our hearing is not exclusively linear - nor is it desirable that it should be'.[36] But Rosen also laments the dearth of a suitable vocabulary for rhythm, a factor that presently curtails and confuses any reasoned attempts at an examination of the relationship between rhythm and linear analysis.[37]

The synonymity in popular parlance of 'rhythm' with 'duration' is responsible for much of the confusion. For example, Schachter challenges a further comment of Rosen's that tonal elements should not be separated from rhythmic contour, by citing two related themes from Bach's 'Musical Offering', which, although tonally equivalent, are seen by him as having altogether different rhythmic countours (Example 1/6).[38] However, according to the theory that will be put forward in the present work, the themes have much the same rhythmic structure at a higher level of organisation, though hardly any identical duration values at the foreground level. Whether 'rhythmic structure' or 'duration' are synonymous with either Rosen or Schachter's

36. Charles Rosen, The Classical Style (London, 1971), p.46.
37. ibid., p.36.
38. Carl Schachter, 'Rhythm and Linear Analysis', The Music Forum, 4 (1976), 281-334 (pp.283-4).

idea of 'rhythmic countour', one cannot be sure: this itself is indicative of the confusion in rhythmic terminology. Likewise, one cannot interpret with any certainty Schenker's own statement that 'in the fundamental structure rhythm exists no more than it does in a cantus firmus exercise',[39] though it presumably refers to durational values rather than to any wider concept of temporal design.

Whether Schenker should have paid more attention to rhythm or not, he chose to develop our understanding of the tonal ranking of pitches and harmonies without pursuing the fact that the foreground was itself already hierarchically structured in the form summarized by Cooper and Meyer as follows: 'Just as letters are combined into words, words into sentences, sentences into paragraphs, and so on, so in music individual tones become grouped into motives, motives into phrases, phrases into periods, etc.'[40] Despite any ambiguities of vocabulary, it is this third form of hierarchy that is appropriately understood by the term <u>rhythmic structure</u>, because it describes the flow of musical ideas as directly perceived by the listener, dependent though it may often be on tonal interpretation, linear and vertical.

Rhythmic structure is hierarchical in two senses: through metre and phrasing. Although, in theory, music need not be phrased, phrasing arises of necessity in song from the need to breathe and, perhaps because of this, it is undoubtedly a universal feature of music. On the other hand, music need not be organised metrically, either in regular or irregular metre. Thus, several authors, for example Zuckerkandl,[41] Piston,[42] and Cooper and Meyer,[43] write of the independence of rhythm and metre by referring to rhythmically free and flexible music like Gregorian chant or recitative. Their view is not necessarily inconsistent with the present one, which is

39. Schenker, <u>Der Freie Satz</u>, <u>op. cit</u>., p.45; see also Forte, <u>op. cit</u>., p.20.
40. Cooper and Meyer, <u>op. cit</u>., p.2.
41. Victor Zuckerkandl, <u>Sound and Symbol</u>, translated by Willard R. Task (London, 1956), pp.158,170.
42. Walter Piston, <u>Harmony</u>, revised by Mark DeVoto (London, 1978), p.199.
43. Cooper and Meyer, <u>op. cit</u>., p.6.

that in metrical music, metre and phrasing produce a combined rhythmic structure. On the one hand, phrasing is independent of metre in that a phrase need neither begin on the first note nor end on the last note of a metrical unit. On the other hand, a sequence of phrases does not indicate any higher level of grouping (except that of the whole sequence) without some positive reason to make such a grouping. By providing a hierarchy of connected time-points, metre joins phrases to form new phrases on a larger scale, or higher level. Thus, in Example 1/7, there are not simply four two-bar phrases (level b), but a metrical mental connection between the beginning of bar 1 and the beginning of bar 5, caused by repetition, groups these into two four-bar phrases (level c) and joins them into one eight-bar phrase (level d).

That a unified notion of phrasing and metre is commonplace can also be seen in the description of a phrase as being of so many beats or bars in length. In Example 1/8, the bracketed phrase grouping not only delineates a pattern of higher-level timelengths measured in dotted-crotchet beats, but these timelengths are metrical timelengths, each beginning on the point of metrical accentuation nearest to the start of the phrase, rather than on the first note of the phrase itself, as the alignment in Example 1/8 shows. Phrases, then, are heard in relation to any metrical scheme in which they may be set.

The present approach stems largely from the fact that rhythm is not a single parameter that can be seen in isolation from the rest of music. Certainly, duration, in the sense of discrete units of time between attacks, can exist on its own without specific pitch, on so-called 'unpitched' instruments, whereas pitch cannot exist outside time, and it may be because of this distinction that duration has traditionally been regarded as the basis of rhythm. But however important duration (in the above sense) can be to rhythm, it is not an indispensable parameter of music, for example in electronic music, where attack can be as gradual as decay.

By contrast, rhythm, in its broadest definition as the articulation of pitch through time, is as essential to music as time itself. Pitch content is rhythmically articulated by duration, dynamics, and timbre, but these come to be articulated in their own right. Hence the nature of rhythmic articulation is such that differentiation in the four parameters of pitch, duration, dynamics, and timbre, plus the configuration of musical lines in a passage, with its harmonic and durational properties, result in a foreground rhythmic mixture which in most music is perceived, at least to some extent, as hierarchically structured in the form of metre and phrasing.

There are already two links here between rhythm and perception. Firstly, the recognition of distinct musical lines is a matter of perceptual grouping resulting mainly from the proximity or otherwise of pitch, duration, and timbre. Secondly, the various means of differentiation, in causing certain notes to be grouped together or highlighted relative to others, may be seen as an act of discrimination, or perceptual preference, on the part of the listener. It is these means of differentiation that will be termed 'structural characteristics', while the term 'structural accent' will refer to the relative importance that a certain characteristic confers on a note or chord.

The term 'structural accent' is similar in meaning to the general sense of accent mentioned by Cooper and Meyer, who define 'accent' as 'a stimulus...which is marked for consciousness in some way' and warn against its confusion with dynamic intensification, or stress, which is only one kind of accent.[44] A concept of accentuation wider than dynamics can be traced back at least to Riemann, who introduced the term 'agogics' and 'agogic accent' to refer to the slight lengthening of notes and fluctuations of tempo that are essential to avoid an unmusical, machine-like performance. He reasoned that organists must use agogics, in the absence of dynamics, to communicate a metrical and phrase structure.[45] Several writers have included under 'agogics' the emphasis of a relatively long <u>notated</u> duration[46] and used the term 'tonic accent' to describe the accentual quality of the peak of a melodic curve.[47] Cooper and Meyer note that 'such factors as duration, intensity, melodic countour, [and] regularity' contribute to the overall impression of accent, but they do not attempt to distinguish further types of accent, believing instead that the causes of accentuation are beyond the scope of present knowledge.[48]

The present view is that a finite set of structural characteristics must exist, can be identified and, within certain limitations, can be shown to be responsible for the generation of metre and phrasing in data that can otherwise be regarded as unstructured, or uninterpreted.[49] These characteristics may be either temporally congruent

44. ibid., p.8.
45. Hugo Riemann, <u>Musikalische Dynamik und Agogik</u> (Hamburg, 1884), pp.9,11,31.
46. Six are mentioned in Howard E. Smither, 'The Rhythmic Analysis of 20th-Century Music', <u>Journal of Music Theory</u>, 8 (1964), 55-88 (p.86).
47. See, for example, Grosvenor Cooper, 'Accent' and 'Tonic Accent', in Willi Apel <u>et al</u>, <u>Harvard Dictionary of Music</u>, revised second edition (London, 1970), pp.24,857.
48. Cooper and Meyer, <u>op. cit</u>., p.7.
49. 'Uninterpreted' refers to cognitive interpretation; see Maury Yeston, <u>The Stratification of Musical Rhythm</u> (New Haven, Connecticut, 1976), pp.35-36. In the present work, the term 'unstructured' similarly means 'structurally uninterpreted', but avoids confusion with the 'interpretation' of musical performance.

or incongruent, that is, they may select either the same or different notes or chords as marking the beginnings of metrical units and the ends of phrases. If incongruent, further perceptual preference is required between the various characteristics or sets of characteristics and for this to be possible it seems reasonable to assume that the characteristics themselves, independently of context, are not of equal importance and may be ranked accordingly. Thus, in Example 1/8, there are tonal characteristics which might have produced the metre of Example 1/9, were they not weaker than, and surpassed by, those of duration. If two or more incongruent structures are equally likely, a structural ambiguity results.

If music is to be regarded as necessarily rhythmic, then there must be a sense in which harmonic and linear analysis are also rhythmically structured. This conclusion is reached by Boretz[50] and Schachter,[51] the latter of whom puts forward the idea of what he calls 'tonal rhythm', acknowledging Zuckerkandl as an earlier exponent of the idea.[52] Schachter sees the hierarchical ranking of tonal elements as providing a difference in emphasis which is as rightly called rhythmic as any other form of differentiation. Thus, Schenker's Urzatz may be characterized as 'strong-weak-strong'[53] and, in Example 1/10, 'the members of the tonic chord function as stable elements in contrast to the other "dissonant" tones'.[54] A similar idea is put forward by Fay, whose self-explanatory hierarchical representation (Example 1/11) demonstrates that the basis of tonal rhythm is the sounded or implied harmonic interpretation of a melodic line.[55]

50. Benjamin Boretz, 'In Quest of the Rhythmic Genius', Perspectives of New Music, 9 (1971), 149-155 (pp.153-154).
51. Schachter, op. cit., pp.313-315.
52. Zuckerkandl, op. cit., pp.100-104.
53. Schachter, op. cit., p.317.
54. ibid., p.315.
55. Fay, op. cit., pp.128-9.

While the concept of tonal differentiation is not at all new, being of the essence of tonal reductional technique, of the evaluation of key structure, and of the distinction between consonance and dissonance, its inclusion as part of 'rhythm' has important implications for the latter, in suggesting a transformation of rhythmic structures between the foreground structure and the reductions of a tonal composition. In the background structures tonal rhythm will predominate; in the foreground rhythmic structure, however, it must take its place alongside all other rhythmic forces and it is clear that it does not always determine the prevailing metre, for example in the 'feminine ending'. The main purpose of the present work, however, is to consider what structural characteristics and perceptual preferences will give rise to the foreground rhythmic structure. If it can be shown that it is this structure which is the product of all the rhythmic influences that the composer presents and if our analytical standpoint is that of the listener, then any reductional transformations must ordinarily be seen as inferred from the foreground rhythmic structure, not the reverse. Yet, bearing in mind that tonal rhythm will largely determine the pitch content of more background structures, this view requires some qualification, as follows.

Certain tonal preferences seem to have no other basis than familiarity and may be taken to have been learned through the continual assertion of various associations in the foreground rhythm. For example, familiarity with certain pitch sets as harmony permits their recognition in a melodic context as the harmonic basis of the melody (Example 1/10). Once such preferences are learnt, however, they operate much like any other structural characteristic in helping to determine the prevailing foreground hierarchy. If the tonal preferences are temporally congruent with other structural characteristics that could determine the prevailing foreground rhythmic structure in their own right, it makes little difference whether the tonal preferences are known or not. They will be highlighted by the prevailing foreground rhythm and, if already known, the knowledge will be reinforced; if not, each such instance will contribute towards their being learnt as preferences in their own right.

In any other circumstances, however, the tonal preferences can hardly be said to be inferred from the foreground rhythm. There are two sets of such circumstances: (a) The tonal preferences, whether known or unknown, are temporally incongruent with the characteristics that determine the prevailing metre and phrasing. Thus the foreground rhythm will highlight alternative pitches which, if constantly favoured, might form learnt preferences in their own right. (b) The tonal preferences determine the prevailing metre and phrasing, but, if they were unknown, another characteristic or set of characteristics (with which the tonal preferences will be temporally incongruent) would do so. In this case, it would be a circular argument to say that the importance of certain pitches both determined and was determined by the foreground rhythm, as Yeston has pointed out.[56]

Although tonal preferences will largely match the pitch content of any middleground and background structures in circumstances (a) and (b) above, it is still valid to speak of such structures as reductional transformations of the foreground since, if they are to be regarded as more than mere successions of pitches and chords, they

56. Yeston, <u>op. cit</u>., p.76.

will only be determinable as rhythmic structures once the relevant influences from the foreground, principally metre and phrasing, have been established. Furthermore, it is not circular reasoning to confer a certain equivalence on notes or chords placed in rhythmically similar positions in the foreground, however those places have been determined. If this sometimes causes tonal preferences in effect to highlight themselves, nothing is gained or lost.

The fact that tonality does not seem to be wholly derived from context-free sources is a prime reason for considering rhythm as the basis of musical structure. If there is only a limited sense of tonality in the first instance, learnt tonal preferences can hardly be derived from the same background that depends on them for its content unless it is otherwise inferable from the foreground. Thus, unless such preferences are generated independently of context, they may be taken to be derived from foreground rhythmic structure. This throws some doubt on the idea of analyzing the foreground of a tonal composition as a transformation of more background structures. For example, Komar treats suspensions and accented dissonances as rhythmic displacements of more basic structures existing on 'prior' levels.[57] Yet, while a composer might choose to think of some basic structure before considering how to elaborate it, from the listener's standpoint it first has to be inferred by learnt preference, or otherwise, from the foreground.

More doubtful still is the notion that rhythm itself is dependent on tonality.[58] However important an understanding of diatonic harmony

57. Komar, op. cit., pp.12,22.
58. Schachter, op. cit., p.289.

may be to the most probable rhythmic interpretation of many tonal compositions, such an idea must be invalidated by the dissipation and disappearance of tonal preference in twentieth-century music. The reverse is much more likely: that an analysis of atonal rhythmic structures will reveal ways in which the twelve tones are not as equal as they might at first appear.

The question of tonality will be approached from three different angles in the present work. Firstly, it will be necessary to treat certain learnt tonal preferences in the same manner as other structural characteristics, even though the learning process that gives rise to them remains unknown. The aim is to show the contribution of these preferences to the generation of metre and phrasing and to consider their relationship to other structural characteristics in this respect. Secondly, some attention will be given to how pitches may be related tonally, independently of context. Here the generator of tonality is the Harmonic Series. Thirdly, consideration will be given to how the foreground rhythmic structure, as understood without the effect of learnt tonal preferences, might contribute to a sense of tonality. Particularly important here, and already a well-known idea, is the tonal effect of cadence. The possibility that partially understood rhythmic structures might not be consistent with the tonal structure as we instinctively understand it does not invalidate this approach: it is quite normal for different structural characteristics to be incongruent and a similar incongruence between learnt tonal preferences and any tonal structures suggested by the other structural characteristics is to be expected in certain cases.

A fundamental tenet of the present approach is that those structural characteristics which do not predominate in the formation of the prevailing metre and phrasing are not lost, but are retained in a subsidiary role. The notion of cross-rhythms, which are often produced by such incongruence between characteristics, is possibly as old as music itself, since only the most regular march-like music is likely to avoid the interplay of rhythmic influences that makes music interesting. The importance of incongruence between durational and tonal rhythm has been recognized by Schachter,[59] and the relevance of subsidiary characteristics in general is not only enshrined in the very name 'cross-rhythm', but is especially evident when the incongruence is produced by the counterpoint of two musical lines whose distinctiveness is beyond dispute.

Except where there is structural ambiguity, there can be no doubt that off-beat structural accents are heard in relation to whâtever metrical structure is established and that the question of which characteristics predominate and which are subordinate is crucial to the character of music, as Examples 1/8 and 1/9 show. A major feature of the analytical technique of Yeston is to represent the connections between the structural accents of a characteristic (the characteristics usually being selected intuitively) as durations on a higher level,[60] a reductional interpretation which is intended to produce an intelligible succession of pitches. The reductional transformation from the higher-level timelengths of metre to single durations is a fairly obvious possibility and Yeston has simply extended this notion to include the higher-level timelengths between the structural accents of subsidiary characteristics (Example 1/12). In his belief that this procedure reveals the middleground

59. ibid., pp.324-332.
60. Yeston, op. cit., pp.68-118.

strata from which the foreground rhythmic structure is compounded, Yeston fails to distinguish sufficiently in importance between those connections which are and those which are not responsible for the higher-level timelengths of the prevailing metre.

If Yeston's approach undervalues the importance of the perceptual preferences between structural characteristics by making his strata seem equally important, the extension of his ideas by Smith bypasses altogether the preferential basis of the structural characteristics themselves, by considering as potential higher-level durations connections which are purely arbitrary, thereby treating notes which are highlighted in no way at all as rhythmically equivalent to those which receive relative emphasis.[61]

Such a viewpoint is not only the antithesis of the present approach, but seems to be fundamentally inconsistent with the nature of perception in general. Smith's structures are certainly not a matter of structural ambiguity or of individual interpretation, for which hierarchical structure by its nature gives plenty of scope, but seem, rather, to be an expression of the observer's right to look at something in any way he can imagine, as in the following two examples. In natural language, the sentence 'this drew attention to him' could be misconstrued by ignoring semantic conventions and trying to reconstruct its meaning as if the word 'drew' had an artistic connotation. In visual interpretation, one could imagine that a picture on a wall was nothing more than a variation in the wallpaper design.

61. Charles J. Smith, 'Rhythm Restratified', Perspectives of New Music, 16(1977), 144-176 (pp.158-9).

Such exotic interpretations, however possible, are not very helpful to comprehension. In those fields where the sense of meaning depends on perceptual organization, the distinction between what one can and what one is most likely to perceive is crucial to making sense of the subject matter, of establishing any common ground and hence communication between observers. Indeed, two examples of visual perception indicate that perceptual norms can be powerful enough to lead to interpretations which are physically impossible. One is the 'distorted room', in which the image of an apparently rectangular room is used to suggest that a midget is standing in one corner of the room and a giant in another.[62] The second example is the phenomenon of subjective contours, in which certain incomplete geometrical figures have their outline completed by the mind, even if this leads to the figure being seen against a background of identical colour and appearing, for example, whiter than white.[63] According to Meyer-Eppler, for communication to occur in music 'the composer's inventory of forms and structures must coincide with that of the listener to a certain degree'.[64] If this is so, the relevance to musical understanding of establishing the perceptual preferences which will account for small-scale form and structure can hardly be in doubt; if it is rhythmic structure that such preferences generate, then the perception of rhythmic structure must lie at the heart of musical cognition.

62. See, for example, Paul J. Barber and David Legge, Perception and Information (London, 1976), p.120 and cover photograph.
63. Gaetano Kanizsa, 'Subjective Contours', Scientific American, 234 (1976), 48-52.
64. Werner Meyer-Eppler, 'Musical Communication as a Problem of Information Theory', Die Reihe, 8(1968), 7-10(p.10).

C. ASSUMPTIONS, LIMITATIONS, AND DEFINITIONS

In order to keep the present investigation of rhythmic structure within the bounds of practicality, certain limitations and assumptions are required. Most of these are concerned with the types of data under consideration, which impose defined limits on the range of music to which the present theory can be applied. While the present analytical standpoint is nominally that of the listener, an attempt to explain every aspect of the musical cognition of an auditory signal would detract from the purpose of the present work. Key experiments in the perception of pitch and duration are still being undertaken, and our present understanding of pattern recognition is not sufficiently advanced even to extract individual parts from the recorded signal of a compound instrumental texture. Musical analysis is traditionally based on the score, but the score does not simply bypass questions of psychoacoustics; rather, it presents a variety of information from the acoustically interpreted to the structurally interpreted, with a bias towards providing a set of practical instructions for the performer rather than a definitive set of data for the analyst. Thus it is necessary to decide which aspects of the score are suitable as initial data for present purposes.

The present work is restricted to music composed of notes, where 'note' is defined as a discrete unit of duration and pitch, with optional designations of instrumentation, dynamic accentuation, and articulation (slur, *staccato*, or *tenuto*). *Portamento*, *vibrato*, and sounds which do not begin with a definite attack are beyond the scope of this study.

The perceptual organization of music into separate melodic lines, where relevant, is largely presupposed in the present work, as is the distinction of the principal melody line (or lines) from the accompaniment. Timbre is the basis for much of linear organization, but where there is insufficient timbral distinction, notes are connected melodically according to proximity of attack and pitch: the next available attack often determines the next note in a line, but proximity of pitch prevails over this factor if voices would otherwise overlap or if the melodic interval to the next attack is too great compared with a later note of closer pitch. But the phrase grouping of durations by proximity of attack also exercises a powerful influence on linear perception and since such grouping is one aspect of the present study, a complete account of the perception of melodic lines cannot precede the study.

The melody line is variously the highest or loudest line or that with the fastest rate of melodic change, but it may stand out because of thematic distinctiveness, a factor which cannot be programmed for computer without considerable knowledge about the human evaluation of musical content and structure. Thus it seems that the perception of individual lines and of the melody line, on the one hand, and the perception of rhythmic structure, on the other, are not entirely independent processes; nevertheless they will be treated as such, and the trained musician's ability to make linear judgements (in the hearing, reading, and encoding of scores) taken for granted, in order to aid the investigation of the characteristics to be presented.

Since the point of final decay of a single note's 'sound envelope' is seldom as easily identifiable as that of its attack, the length of a duration is normally determined by the onset of the next attack in the same line. The timelength between two attacks will be termed an <u>attack interval</u>, following Hiller and Fuller.[65] The concept of an attack interval as a duration confers equivalence on such diversely notated entities as 𝅗𝅥, 𝅗𝅥̣, ♩𝄽, and ♫𝄽, by subsuming under a single timelength both the <u>sounded notelength</u>, which may be ill-defined,

65. Lejaren A. Hiller and Ramon Fuller, 'Structure and Information in Webern's Symphonie, Op.21', <u>Journal of Music Theory</u>, 11(1967), 60-115(p.94).

and any silence following it. Differences in sounded notelength will be taken to be an aspect of articulation. The attack interval becomes an unsuitable determinant of duration when its own relevance is in doubt, that is, when a mental connection between the two attacks concerned is not as likely as one between an alternative pair of attacks. This matter is an aspect of perceptual grouping into musical lines. Under certain circumstances, rests are not subsumed within the timelength of the sounded notelength which precedes them, but are perceived as durations with no pitch. These will be termed structural rests.

Clearly, the final duration of a line cannot be determined by an attack interval. If two similarly damped notes are sounded in moderately close succession (within the metronome's range of values), the second note is heard to have a duration at least as long as that of the first. This is because our perception of duration as proportional (see below) requires that the first attack interval be used as an initial unit of measurement. Hence, a third attack is predicted after a second attack interval equal in length to the first (Example 1/13). Yet whether the second duration will be heard as equal to or longer than the first seems to depend on tempo. Between about MM40 to 80, the two notes seem to have equal length, but at a faster rate of succession our subconscious measurement of time appears to register more than one unit of the initial attack interval beyond the second attack, thus making the second note appear longer, as in Example 1/14.

Despite the above, it would not be true to say simply that the final duration in a passage is always about the same length as the preceding one, since such durations may also have to be seen within a metrical context. Nevertheless, the reverse is also the case: the expected repetition of an attack interval has important implications for metre, as will be considered later.

While the word 'duration', in non-musical usage, simply refers to a length of time, its meaning here will be restricted to the timelength of a note as heard proportionally. The terms real time and real timelength will refer to the sense of absolute time, as measured in minutes, seconds, and so forth. The term timelength, without the prefix 'real', will thus refer to the proportional sense of time in music. Since we do not operate stopwatches when listening, proportion is our only means of relating real timelengths to one another. Thus the real timelength between the first and second attacks of a piece constitutes by definition an initial unitary timelength against which the second duration is measured. Although the human listener may perceive duration as the subdivision of a regular beat, if one is available, the timelength of a duration will here be expressed as the smallest possible whole number such that all durations in a given sequence of durations, or duration string, are valued in proportion to each other. The unitary timelength 1 will normally be that of the smallest duration in a passage, but it may be smaller, as in Example 1/15.

The idea of duration as proportional, which is embodied in standard musical notation, assumes a certain degree of aural rationalization for the purposes of understanding the intended structure. Not only would it be virtually impossible for a performer to execute the written proportions with mathematical exactitude, but such a performance would probably sound dull, leaving no room for the variations of real timelength and tempo that are commonly understood to enhance musical expression. Conversely, such agogic variations can be expected to produce real timelengths that it would be extremely hard for the listener to quantify as exact proportions.

It will be assumed here that the score represents durations in the proportions that the mind is most likely to rationalize them, although it has to be acknowledged that it is possible to notate durations which would be difficult to perceive as written. For example, 𝅝· ♪ ♩· ♩ represents the proportion 13:5 (♪=1), yet, rather than subconsciously count 13 and 5 units, it seems more likely that the listener would hear the much simpler proportion 12:6 in its reduced form 2:1. On the other hand, the proportion 13:5 is quite easily heard if accompanied by durations of the unitary timelength, as in Example 1/16. In certain cases, then, it might be unwise to use notated durations as data without first having an experimentally tested theory of the process of rationalization. It is not anticipated, however, that such cases will arise very often in Western music before 1950 and, in music since that date, it could be argued that the ambiguities are intentional.

In the present work, it will be sufficient for most purposes to assume that the pitch notation in the score represents what is perceived. At the same time, however, the twelve-tone chromatic scale will be regarded as the universal pitch set of Western music, the superset of all scales, modes, and harmonies, and as an initial means of unifying modality, the key system, twentieth-century tonality, and twelve-tone atonality under a common theory. The numerical representation of the twelve-tone scale will follow convention in numbering pitch-classes from C to B as 00 to 11, while octaves will be numbered such that Middle C begins the fourth octave and the lowest sounding C (32.7 Hz.) begins the first. In this system, pitch is represented as an octave/pitch-class number-pair; for example, Middle C is 400.

To talk of perceived pitch or pitch-class as an absolute quality is to exclude the majority of educated and uneducated listeners alike, and even among those who possess so-called 'perfect pitch' there are presumably very few who can hear with the accuracy of a frequency counter. Yet the average awareness of absolute pitch is not so impoverished that to study melody and harmony from a purely intervallic point of view would be a satisfactory alternative. For example, despite the importance of octave equivalence (and hence interval-class), not all transpositions of a chord are musically equivalent, probably because subdivisions of the octave have a progressively lesser density of frequency from the lower to the upper end of the pitch spectrum. Furthermore, to reduce all pre-twentieth century pieces to the same key would be to ignore the key relationships between pieces and that intangible quality of a key that some have tried to describe in terms of colour. Thus the identification of specific pitches and pitch-classes is not irrelevant to melodic and harmonic analysis, even though it does not necessarily refer to absolute frequency.

While it is unlikely that tonal music is, or ever was, perceived in twelve-tone terms, the musical letter-names for pitch carry a certain amount of tonal information which the twelve-tone scale lacks and which must be deduced by the listener, whether aided by past experience or not. For this reason, the pitch input to the cognitive process will be regarded as being composed of members of the twelve-tone scale, whether the music is performed with strict equal temperament or not. The tonal interpretation of a twelve-tone input will be considered in Chapter 4, Section E. The use of the twelve-tone scale as a theoretical construction does not presuppose equal-tempered performance, because of the same human tolerance of pitch and intervallic approximation that is attested by the practical success of equal temperament. The twelve-tone scale may represent just intonation and equal temperament alike, just as equal temperament may be used to perform both twelve-tone and tonal music.

The assumption that musical letter-names such as B♯, C, and D♭♭ are different tonal interpretations of the pitch-class 00 is also related to the question of equal temperament. The compromise of tuning that produced equal temperament could not have taken place without there first being a concept of twelve pitch-classes to the octave, despite the differences in tonal interpretation. This concept is illustrated by the Spiral of Fifths (Example 1/17), produced by successive Perfect Fifths (3:2) from the Harmonic Series. In the Spiral, elements such as B♯, C, and D♭♭ retain their tonal identity and their independence of frequency from each other, standing a Pythagorean comma (81:80) apart within any given octave. In placing such elements at points on the same radius, however, the Spiral represents their equivalence as members of a twelve-tone pitch-class. In the Spiral's more famous equal-tempered counterpart, the Circle of Fifths (Example 1/18), these tonally distinct members of each twelve-tone pitch-class are amalgamated into a single frequency (within any given octave) and, tonally, become enharmonically equivalent. The Spiral of Fifths is only irrelevant if it can be shown that elements such as B♯, C, and D♭♭ were ever considered as separate pitch-classes, as distinct as, for example, B and C. But the fact that the Pythagorean comma is so close to the Unison as to have invited comparison with it seems to belie this possibility. Such a distinction might have been likely if, say, B♯ and C had often occurred in adjacent positions and the comma between them had habitually been heard, but this would depend on a fineness of tuning that is extremely hard to maintain.

Since the principal aim of this study is to present the structural characteristics of duration and pitch, the variables of performance - dynamics, articulation, tempo, and timbre - will be given minimal attention, except where their specifications in the score are essential to the discussion. The musical examples have mostly been chosen to illustrate particular rhythmic properties, rather than to comment on the original pieces as such, and their titles are given simply for identification. Any notated aspect of performance not included in an example's accompanying tree-diagram is considered not to alter the structure shown. A similar distinction between written and sounded data is found in linguistics: linguists often examine the phrase structure of written sentences, even though it is evident that a significant degree of structure is usually communicated by the way language is spoken. The present approach is almost the opposite concept to that of Riemann (but not necessarily inconsistent with it), who put forward the 'dynamic and agogic shading' he considered appropriate to different rhythmic structures and sufficient to communicate them.[66]

Dynamics and articulation are structural characteristics in their own right and are considered briefly at the beginning of Chapter 5, as well as in those examples in which the presence of either has an effect on structure which cannot be discounted. Articulated phrasing will be known by that name and not simply as 'phrasing', while the term <u>phrase grouping</u> (defined in Chapter 2) will refer to a grouping of notes produced by one or more of the present characteristics and preferences. 'Phrase grouping' should not be confused with 'phrase group', which has been used to mean a group of phrases.[67]

Tempo is not a structural characteristic in the normal sense (although fundamental changes of tempo may produce structural accents or cause phrase grouping), but it does have an effect on the perception of upbeats as well as determining the hierarchical levels on which the mind is most likely to focus. Apart from these very important aspects, the tree-diagrams which will be derived to represent metrical and phrase structure are neutral with respect to tempo. The use of timbre as a means

66. Riemann, <u>op. cit</u> .
67. Wallace Berry, <u>Form in Music</u> (Englewood Cliffs, New Jersey, 1966), pp.26-27.

of rhythmic differentiation has been studied by Cooper and Meyer[68] and Yeston[69] and falls outside the present study. Continuous change in any of the variables of performance is also beyond the scope of this work, which deals only with discrete forms of differentiation.

The present theory will devote relatively little attention to the processes of expectation, since these usually require some knowledge of the style of a piece, which presupposes the ability to perceive rhythmic structure. However important prediction and implication may be, the intention is to present structural characteristics and perceptual preferences which will account for metre and phrase grouping, not to examine the human perception and cognition of music as such. For this reason, no conscious attempt is made to relate the present theory to the perceptual principles of Gestalt psychology,[70] although several of the structural characteristics reflect the influence of these principles, especially the principle of proximity. The principles of 'good continuation' and similarity are relevant to the perception of musical lines, while figure-ground perception has been related to the musical concept of reduction.[71] Fundamental to the present theory is the Gestalt notion that the simplest structure is the one most likely to be perceived, although most potential structural ambiguities will be regarded as solved by differences in the relative 'strength', or importance, of the temporally incongruent characteristics and preferences concerned.

Apart from the limitations already mentioned, the present work requires no restrictions of scale or defined historical and cultural boundaries: both are determined by the extent to which the characteristics

68. Cooper and Meyer, <u>op. cit.</u>, p.16.
69. Yeston, <u>op. cit.</u>, pp.41-44.
70. Barber and Legge, <u>op. cit.</u>, pp.26-28.
71. Ian D. Bent, 'Analysis', in <u>The New Grove Dictionary of Music and Musicians</u>, ed. Stanley Sadie, 20 vols (London,1980), I, 340-388(p.354).

and preferences are applicable. Rhythmic structures will generally be seen as built from the lowest level upwards and thus deal mainly with small-scale structure. The thesis is concerned principally with Western art-music and some of the perceptual preferences may not have universal validity, but it is anticipated that much of the theory will be relevant to music of other cultures. The examples are drawn mostly from familiar tonal music of the 'common-practice' period, but not as a deliberate stylistic restriction. On the other hand, there are aspects of harmony and rhythmic structure found in twentieth-century music which will not be considered and whose inclusion would seem to require a considerable expansion of the present theory.

Three terms from the terminology of computers require brief mention. The American spelling of 'programme' - 'program' - will be used when referring to a computer program. The word 'string' refers to a finite sequence of symbols drawn from an alphabet of characters. Lastly, the term 'nesting' is used in the same sense as a nest of tables or a collection of Russian dolls, to refer to a hierarchical arrangement of non-overlapping square brackets. Nested sets have as their Venn diagram a series of concentric circles.

CHAPTER TWO

A STRUCTURAL NOTATION FOR RHYTHM

In order that the generation of metre and phrasing may be examined as unambiguously as possible, it is desirable to have a suitable notation for rhythmic structure. The main requirement of such a representation is not simply that it should be hierarchical, but also that it should be capable of showing both the independence and interdependence of metre and phrasing. While at least three representations of the independence of phrasing from metre already exist - those used by Riemann,[1] Cooper and Meyer,[2] and Lerdahl and Jackendoff[3] - none of these authors have considered their interdependence in sufficient depth to derive a successful combined representation for them both. Although any special notational requirements of individual characteristics will require separate discussion, the principal features of the present notation may now be put forward in relation to the general concepts of metre and phrasing that will be adopted in the present work.

Firstly, however, it may be noted that a unified notation for metre and phrasing does not imply the use of a single diagram for a given structure, for the following reasons: (1) A representation for foreground rhythm is related to any more background structures that are inferable from it. (2) There may be structural ambiguities in a passage, suggesting two or more equally likely structures. (3) There may be cross-rhythms and overlapping phrases between two or more musical lines. In general, the rhythmic structure of each line has

1. Hugo Riemann, Musikalische Dynamik und Agogik (Hamburg, 1884).
2. Grosvenor Cooper and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago, 1960).
3. Fred Lerdahl and Ray Jackendoff, 'Toward a Formal Theory of Tonal Music', Journal of Music Theory, 21, No. 1 (1977), 111-171.

a relevance in its own right in addition to being part of the whole. (4) It may be necessary to represent, independently of the overall context, the structures put forward by an individual characteristic or by other subsets of the total set of characteristics present at a particular time. (5) There may be notational changes as further hierarchical levels are established: a single, highest-level view of a passage could be misleading unless the lower-level structures were also implied. If such aspects are relevant, there seems no reason to suppose that rhythmic structure can best be represented by a single form of diagram in the two dimensions of a sheet of paper.

A. METRE

The poverty of rhythmic theory to date is probably largely due to the failure to derive a coherent theory of metre. As a result of the overwhelming predominance in post-Renaissance European music of regular-lengthed beats and their grouping in twos and threes - the so-called 'tyranny of the barline' - it is perhaps understandable that the misconception could arise that metre was simply a means of marking time. Zuckerkandl's graphic description of the 'metrical wave' which, once established, will carry on its regular cycle unimpeded,[4] is not without foundation in accounting for the perception of syncopation in certain cases, but it does not explain why the alternative possibility of irregular metre is felt in others. Piston's remark that 'metre is simply measure' reflects an engrained expectation of regular metre, yet is paradoxically set in a context that argues against this very concept.[5] Cooper and Meyer build their theory of rhythmic structure

4. Victor Zuckerkandl, Sound and Symbol, translated by Willard R. Task (London, 1956), pp.168-73.
5. Walter Piston, Harmony, revised by Mark DeVoto (London, 1978), p.199.

around the idea of metre as regular pulse: 'Meter is the measurement of the number of pulses between more or less regularly recurring accents'.[6]

All of these authors, writing well into the twentieth century, must have been aware of the possibility of irregular metre and their remarks are not wrong as such, but simply require placing in a wider theory. A single theory for regular and irregular metre does not need to pretend that both are equally likely, but it cannot presume the certainty of a regular beat. The only regular timelength that can be sure of being maintained is that of the unitary duration, but neither the listener nor the practised performer consciously counts in such units.

With no certainty of a regular beat, it becomes apparent that the single idea of the grouping of notes into higher-level units is sufficient to account for both regular and irregular metre. The term <u>metrical timelength</u> will be used here to signify the duration of such a <u>metrical unit</u> as distinct from that of a single note. An emphasis on metre as grouping rather than as subdivision need not devalue the importance of the beat in regular metre, where it may be assigned to the metrical level on which the mind is most likely to focus at a given tempo, with the bar signifying a higher (and usually the next) level of the hierarchy. But regular metre is more than a series of beats: in fact, a sequence of undifferentiated notes, having the same duration, pitch, intensity, and timbre, is simply a sequence of pulses with no certain metrical structure, as Yeston and Cooper and Meyer have noted.[7,8]

6. Cooper and Meyer, <u>op. cit</u>., p.4
7. Maury Yeston, <u>The Stratification of Musical Rhythm</u> (New Haven and London, 1976), p.35.
8. Cooper and Meyer, <u>op. cit</u>., p.9.

However much theories of metre may differ, there tends to be general agreement that a metrical unit should function as a higher-level timelength, that is, as the analogue of a duration. There are three principal ways in which such timelengths come into being. They may be directly perceptible as timelengths on a higher level in relation to shorter, accompanying metrical units or durations, by possessing some intrinsic unifying quality such as the pitch unity of a single note or the harmonic unity of so-called harmonic rhythm. An instance of the former is Example 2/1, in which the semiquavers have little choice but to be grouped into minim-lengthed metrical units by the accompanying Middle Cs. In Example 2/2, the metrical grouping is generated by harmonic rhythm: a regular metrical timelength of a crotchet is established by the first common attack of the two voices and maintained by the recognition of arpeggiated chords.

Alternatively, higher-level timelengths may be perceived as the result of a metrical connection between two non-adjacent notes or chords. The time-points so connected normally require special emphasis to command attention; consequently, the notes or chords concerned tend to be structurally accented, the products of structural characteristics. In such cases, the higher-level timelengths will be called <u>structural timelengths</u>. Each is theoretically capable of being perceived as a metrical timelength, although in any given configuration of structural characteristics it is a matter of perceptual preference which structural timelengths, if any, will form the prevailing metrical hierarchy.

A simple instance of this second way of generating metre is that of a mental connection between dynamic accents, as shown in Example 2/3. It is clear from this example that such mental connections establish what Yeston calls a second level of rhythmic motion[9] and that an awareness of a structural or metrical timelength can only come about once the connection has been made. Example 2/3 is taken from Cooper and Meyer, who represent accents and non-accents, respectively, by means of the diacritical signs macron (–) and breve (◡).[10] Cooper and Meyer show the higher-level timelength not as the result of a structural connection between the accents, but as a grouping in its own right, thereby mixing accented and unaccented notes on one hierarchical level (Example 2/4), when in fact their hierarchical rank is distributed between two levels. This amalgamation of levels is one of the principal flaws in Cooper and Meyer's notation, as will be seen.

In conjunction with the idea of metre as requiring two levels of rhythmic motion, Yeston argues that since motion must proceed from one event to another, it is dependent on recurrence, which itself requires 'some criterion that establishes a logical class of events of which the occurrence and its recurrence are both members'.[11] The equivalent statement in the present terminology would be that there must be two structural accents (normally generated by the one structural characteristic, or 'logical class') for every structural timelength. This is indeed largely the case, but, with certain characteristics, a single accent may suggest the possibility of a further level, even if the structural timelength concerned is in doubt until the appropriate second structural accent is encountered.

A more serious objection to the requirement of two structural accents might be the fact that the final metrical timelength on a particular level cannot be followed by a structural accent that might

9. Yeston, op. cit., p.66.
10. Cooper and Meyer, op. cit., p.10.
11. Yeston, op. cit., p.38.

determine its length. The solution to this problem is provided by the similarity between the perception of duration and that of metre. Attacks and structural accents both establish points of relative emphasis whose connection focuses attention on the timelength between them. Just as one attack interval can suggest another, so the perception of one metrical timelength between two time-points establishes a potential second metrical unit of the same length, extending from the second time-point. The fact that such a second metrical timelength might be interrupted before its completion or last longer than expected does not invalidate this principle any more than the possibility of irregularly lengthed durations invalidates it in the perception of duration.

This anticipated repetition of a metrical timelength is Zuckerkandl's 'metrical wave',[12] the third way of generating metre, and a default structure if one is needed, but it is not a method that will always automatically assert itself in opposition to the positive rhythmic force of a structural characteristic. As a form of 'self-generating' metre, it may be seen in Example 2/5, where the initial duration becomes a metrical timelength on a progressively higher level in relation to an increasing number of metrical subdivisions, as the unitary timelength is redefined. A regular metrical timelength also emerges on a higher level with the repetition of the fugue subject in each of the four voices after a timelength of three semibreves (Example 2/6), but this 3/1 metre cannot be maintained automatically at bar 8 in contradiction to the harmonic and durational unity of the bass (Example 2/7) and its failure at this point illustrates the weakness of automatically generated metre.[13]

12. Zuckerkandl, <u>ibid</u>.
13. Although an initial 3/1 metre runs counter to Bach's barlines, it is assumed that these do not necessarily indicate the dynamic accentuation that would be needed in performance to assert the given time-signature (¢) as a regular metrical timelength in opposition to the repetition mentioned.

In other circumstances, however, it is possible for an established regular metrical timelength, or multiple, to be continued automatically in opposition to a structural characteristic. In Example 2/8, relatively long durations, the crotchets (X), act as structural accents in establishing a minim multiple between them, yet the succeeding relatively long durations (Y) do not alter this metrical scheme, but are subordinated to it in syncopation. The differences between Examples 2/7 and 2/8 cannot be pursued at present, since the automatic continuance of a multiple is not a characteristic in its own right and its success or otherwise must therefore depend on the properties of individual characteristics and on the particular configuration of characteristics and preferences present at a given time.

The parallel between duration and metre suggests that, like the length of a final duration, a final metrical timelength may be determinable from its predecessors. Example 2/9 illustrates the consequences of this theory for the perception of both metrical timelengths and duration. At its onset, the length of the final duration is indeterminate, but, both in and out of context, it lasts sufficiently long to function as a relatively long duration which, mentally connected with the previous such duration (as bracketed), establishes an unopposed structural, and hence metrical, timelength between the durations, together with its presumed repetition.

The assignation of a dotted crotchet as the length of the final duration, even out of context, is compatible with such a metrical scheme and with the standard musical notation of an upbeat phrase. The latter appears to truncate such a phrase's final metrical unit by a timelength equal to that of the initial upbeat. While the metrical unit itself may indeed be shorter, its associated metrical timelength is not, being the sum of the durations in the final metrical unit and those of the upbeat to the phrase. What is involved here may be envisaged as a metrical displacement of at least the initial downbeat from a position at the start of the phrase (for instance Example 2/9 is a displacement of Example 2/10), which is where any metrical scheme would begin by default in the absence of any reason to perceive an upbeat. Since phrase lengths are not structural timelengths, an incongruence between phrase and metre is not comparable with incongruence between structural characteristics, with their customary cross-rhythms and off-beat accents. Thus the notion of metrical displacement is compatible with the earlier-noted capacity of metre to measure phrase lengths (Example 1/8).

Balance between incongruent metre and phrasing does not depend on binary metre, regular metre, symmetry or other such assumptions; if the metrical timelength of Example 2/9 were shorter or longer in some context, the final duration of the example would have to be altered accordingly (Examples 2/11 and 2/12), but the resultant phrase in each case would still be balanced in regard to metre. Thus the final duration of a passage will be perceived as being of sufficient length to complete the highest prevailing metrical timelength, a requirement which is similar to the rule given by Schachter for tonal music in regular metre: 'The closing chord of a cadence will normally occupy at least a full metrical pulse (reckoning in rests, etc.)'.[14]

The proposed notation for rhythmic structure is in the form of a tree-diagram, based on the square-bracket type often used in family trees. Its basic component will be termed a <u>structural grouping</u> and is defined as two or more branches connected by a common horizontal beam (Example 2/13). Since every note is attached to a branch, a

14. Carl Schachter, 'Rhythm and Linear Analysis', <u>The Music Forum</u>, 4 (1976), 281-334 (p.294).

string of equal durations, which displays no certain hierarchical organization, would be represented as in Example 2/14. If a higher-level branch is vertically aligned with a lower-level one, it signifies that the note specified by the composite branch is metrically accented, that is, it falls at the beginning of a metrical unit, whose associated metrical timelength may be inserted within the higher-level branch and placed in brackets to distinguish it from a duration (Example 2/15). The mental connection between such a metrically accented note and the note which begins any following metrical unit will be represented by a horizontal beam, thereby forming a structural grouping on the next level. Thus, whichever of the three methods described above gives rise to metre, the latter will be represented by means of the connection between metrically accented notes.

With the establishment of a structural grouping on the next level, the former horizontal beam between the two notes or chords that are now metrically accented becomes somewhat redundant in its present state, since its function is largely duplicated by the higher-level beam (Example 2/16). Leaving aside the notational requirements of phrasing, a purely metrical notation might have the general form of Example 2/17, in which all notes belonging to a particular metrical unit are contained within the sub-tree emanating from the branch that signifies the metrical accent. In this notation, the rightmost portion of the former beam has been lost, since the connection that it signified has been subsumed by the new higher-level connection, a flow of thought which may be represented by the diagram of Example 2/18. Such a notation is also intended to be read as a combination of individual structural groupings as circled in

Example 2/19. In this way, a lower-level structural grouping may be shown as having an identity in its own right within the context of the higher-level grouping which has produced it.

The notion of metrical accentuation, indicated by the vertical alignment of a branch with one on the next level, is to be understood as a product of the formation or anticipated formation of the next-level structural grouping, not as a kind of structural accent in its own right. There is an inevitable association of the first note or chord of a metrical unit with the metrical timelength denoted by the higher-level branch, either by virtue of their simultaneity or because structural accentuation of the note or chord has aided the perception of the higher-level structural grouping. This relationship between duration and metrical timelength results in an apparent enhancement, or metrical accentuation, of the former if it is less than the latter. Whether this enhancement is real or not is difficult to determine: the metrical timelength could be seen as the substance rather than the cause of the enhancement, a quality ascribed to the metrically accented note or chord rather than an independent, though related, entity. Whichever viewpoint is adopted, the effect of a metrical accent as the product of such a relationship is confirmed by varying the metrical timelength but not the initial duration of the metrical unit, as in the two metrically interpreted structures of Example 2/20. If the metrical unit is filled by a single duration (for example, the last duration of Example 2/20), there can be no enhancement and hence no metrical accent. Technically, such a duration is not a metrical timelength either; thus in the metrically interpreted Example 2/21, while convention refers to four beats in each bar, the word 'beat' can be understood only as regular pulse and not in a metrical sense, there being no metrical grouping until the next level.

Misunderstanding of the nature of metrical accentuation has led in the past to much confusion about metre and rhythm. The pattern of differentation between strong and weak beats, which is clearly represented in the present notation as a difference in hierarchical level, so strongly characterizes each type of metrical grouping at a moderate tempo that it is said that, for example, the pattern 'strong-weak' is duple metre, 'strong-weak-weak' is triple metre, and so on. Confusion arises firstly in the mistaken textbook description of metre as the product of dynamic accents, a view which presumably comes from the general tendency in performance to translate the metrical accent-patterns into dynamic accentuation. Certainly, dynamic accents will generate a metrical structure if no other means of differentiation are available and may contribute to one otherwise. Later in the present work, it will be necessary to consider examples in which it appears that the intended metre can only be justified if dynamic accents are inferred from the barlines, but dynamic accents alone are not sufficient to dictate a metrical structure: if they were, they would never occur in an off-beat position. Thus, any desired metrical structure cannot be guaranteed simply by drawing barlines at will and it is seldom that composers have made such a mistake.

Although a general sense of accent,such as that of Cooper and Meyer,[15] will account for metrical accent-patterns at lower metrical levels without reference to the cause of such accentuation, it does not avoid an apparent paradox which often arises in metrical units larger than the bar. In these, the accentual pattern can appear inverted, so that a binary metrical unit may seem to be subdivided as 'weak-strong' and a ternary one as 'weak-weak-strong' or

15. Cooper and Meyer, op. cit., pp.7-8.

'weak-strong-weak'. Such inversion is argued by Matthay on the grounds that rhythm, as musical movement, must progress somewhere and thus seems to move towards points of climax more often than away from them. Matthay uses arrows to depict such rhythmic progression in 'God Save the Queen' (Example 2/22).[16] Many examples of groupings which are beginning-accented on one level but middle-accented or end-accented on the next are also given by Cooper and Meyer, for instance Example 2/23.[17] The apparent paradox of accentual patterns has sometimes led to the assumption that the accented note or chord necessarily marks a metrical downbeat. Thus Matthay is led to the conclusion that many composers, notably Schumann and Brahms, have misplaced their barlines, suggesting an accentual scheme that is the wrong way round: 'strong-weak' instead of 'weak-strong'. He considers that, for example, in Chopin's C minor Prelude, Op.28, No.20, 'the true bar-line occurs two pulses later than the written bar-line' (Example 2/24).[18] Matthay was perhaps influenced by Riemann, who pursued this distortion to its logical conclusion: that all binary metre must be accented 'weak-strong'.[19]

Since metre must involve two hierarchical levels, it is quite possible for a structural accent which has been superseded metrically to create a middle-accented or end-accented structural grouping on the level below that which defines the metrical accent. Part of the Cooper and Meyer example quoted above (Example 2/23) can be rewritten in the present notation with the addition of diacritical signs to

16. Tobias Matthay, Musical Interpretation (London, 1913), p.37.
17. Cooper and Meyer, op. cit., p.38, Ex.47.
18. Matthay, op. cit., pp.38-39.
19. See, for example, Riemann, op. cit., pp.186-188, 249-50, 262.

show the conflict of accents that gives rise to the paradox (Example 2/25). The anapestic duration pattern of the accompaniment becomes an iamb on the second level (conforming to Cooper and Meyer's own 'Principle of Metric Equivalence'[20] and their third-level analysis), but will be subject to metrical accentuation on the next level (♫ equals —◡, where — is a metrical accent). Since the effect of metrical accentuation is dependent on awareness of the metrical timelength represented by the higher-level branch, rather than the presence of any structural accent or mental connection it may involve, it follows that a weakening of this awareness will allow the lower-level structural accent to predominate in any overall impression of accent, as in Cooper and Meyer's notation, but not to alter where the metrical unit begins, as in the distortion of Riemann and Matthay.

The awareness of a metrical timelength is itself dependent on the extent of the separation in real time of the notes or chords specified by the branches of a structural grouping and, in general, is weaker at higher levels or a slow tempo, while the structural importance of any mental connection will, paradoxically, be all the greater. While large-scale structural connections like that of recapitulation in Sonata Form might seem too remote to be identified with the concept of metre, the existence of some form of metre on a larger scale than the bar is well recognised, although at these levels metrical units are sometimes loosely referred to as phrases because they so often coincide with phrase groupings. Yet a distinction must be made: the three-bar units that Beethoven has pointed out in the scherzo of his Ninth Symphony with the instruction 'Ritmo di tre battute' (Example 2/26) are not phrases, but the special emphasis at the

20. Cooper and Meyer, op. cit., p.22.

beginning of each, caused by the relative length of its first duration and, more noticeably, by repetition, undoubtedly marks syntactically important time-points between which metrical units may be perceived.

The present concept of metre as a hierarchy of structurally connected points in time has also been put forward by Komar[21] and Lerdahl and Jackendoff,[22] partly in response to Cooper and Meyer's assignation of accentual values to whole groupings and even to the largest subdivisions of a piece,[23] an approach which has also been criticized by Schachter.[24] Lerdahl and Jackendoff employ columns of dots to show the metrical level of a note or chord, but their view of metre as necessarily regular and as synonymous with counting in multiples of the smallest duration mars the effectiveness of their notation (Example 2/27).[25]

Komar's theory of metre is more concerned with adding a metrical element to a Schenkerian type of analysis than with identifying the timelengths that actually exist as a result of large-scale structural connections. His concept of metre is unquestioningly one of equal metrical timelengths seen not as aggregates but as subdivisions of the whole piece and subject to expansions and contractions as the lower, foreground levels are approached. While the elimination of irregular metrical timelengths may indeed be a suitable transformation of the foreground, such an approach is not directly comparable with the present view of metre and Komar's application of his own theory is coloured by curious idiosyncracies such as the addition of a silent 'bar 0' to the slow movement of Beethoven's 'Pathétique' Sonata,[26]

21. Arthur J. Komar, Theory of Suspensions (Princeton, New Jersey, 1971).
22. Lerdahl and Jackendoff, op. cit., p.123.
23. Cooper and Meyer, op. cit., pp.188-203.
24. Schachter, op. cit., pp.306-7.
25. Lerdahl and Jackendoff, op. cit., p.121, Ex.3.
26. Komar, op. cit., p.156.

a metrical analysis of the same piece which does not conform to his own reading of the movement's form,[27] and his idea that 'the third beat of three is stronger than the second beat, just like the third beat of four'.[28] Although Komar sees the distinction between metrically strong and weak time-points as a matter of differentiating between higher and lower metrical levels, as does the proposed notation, his assumption that such a distinction can be made at the highest levels, even across pages of music, has been rightly criticised by Schachter[29] and would be wrongly inferred from the present concept of metre.

Arguing in favour of metrically accented time-points rather than whole time-spans, Komar reasons that in 'Frère Jacques', 'with _frè_ on the first beat and _re_ on the second, while it is proper to say that _frè_ occurs on a stronger beat than _re_, it does not follow that the entire time-span of _frè_ is stronger than the time-span of _re_'.[30] Against this, Schachter reasonably points out that 'every musical event must occupy time'.[31] The issue involved in this argument is relevant to a correct reading of the present notation. A branch will be taken to refer to the attack point of the duration which it specifies. Such a time-point is not only identified with the length of the duration but with any associated metrical timelengths that begin simultaneously with it. Thus the branch may represent durations and metrical timelengths alike without being restricted in function to an infinitely small time-point, as in Komar's theory, and without the suggestion that whole metrical timelengths are accented, as in Cooper and Meyer's notation. Komar's views are not as far apart from those

27. _ibid._, p.151
28. _ibid._, p.54.
29. Schachter, _op. cit._, p.308.
30. Komar, _op. cit._, p.6
31. Schachter, _op. cit._, p.294.

of Cooper and Meyer as might be thought: any accentual value associated with a whole section in Cooper and Meyer's representation would, in practice, be ascribed to the attack point identified with the relevant metrical timelength, thus producing a metrical hierarchy of strong and weak time-points, though not necessarily with the same accentual values as in Komar's theory. The realignment of Cooper and Meyer's diacritical signs that this suggests not only gives a clearer reading of metre in their notation (Example 2/28),[32] but must surely be implied in it, since it is inconceivable that an unaccented upbeat on one level could be heard as accented on the next, as a casual reading could imply.[33]

Another possible misreading of the proposed notation concerns Yeston's concept of a second level of rhythmic motion. While the parellel with Yeston's view was appropriate earlier, to establish that a flow of thought between non-adjacent notes can form a structural connection between them, some qualification is required, since a true higher level of motion would refer to an implied musical line. Yeston's theory of rhythm is principally concerned with the identification of such implied lines and their relationship to Schenkerian theory. In the tree-diagram notation, however, it cannot be guaranteed that the branches of a structural grouping on any level but the lowest specify pitches or chords that would necessarily form an intelligible sequence in their own right.

32. Cooper and Meyer, op. cit., p.70, Ex.87.
33. See also ibid., p.65, Ex.81; p.81, Ex.96; p.97, Ex.110.

B. PHRASE GROUPING

Since the metrical notation joins all notes in a metrical unit to the left branch of the next-level grouping, it cannot show phrasing in a metrical context, unless the phrase happens to coincide with the beginning and end of a metrical unit. Although a metrically derived structural grouping is an important entity relative to the many arbitrary mental connections that could be made, it is well accepted that it is phrasing and not metre that delineates the strings of which musical structure is composed. The incompleteness of metrically grouped strings as opposed to phrase groupings has been succinctly described by Macpherson:

> ...certain sounds within any metrical bar bear definite relationships to certain other sounds, not always - indeed, rarely - confined to that bar itself, and to dissever those logical relationships would be to destroy the sense of the music just as inevitably and surely as to dissever certain words from others in a sentence of poetry or prose would ruin its meaning.[34]

Schoenberg's description of this function of phrasing is also relevant here:

> The smallest structural unit is the phrase, a kind of musical molecule consisting of a number of integrated musical events, possessing a certain completeness, and well adapted to combination with other similar units. The term phrase means, structurally, a unit approximating to what one could sing in a single breath. Its ending suggests a form of punctuation such as a comma.[35]

The senses of completeness and punctuation that Schoenberg mentions stem from the fact that phrasing in the widest sense is

34. Stewart Macpherson, Form in Music, revised edition (London, 1930), p.9.
35. Arnold Schoenberg, Fundamentals of Musical Composition, revised by Gerald Strang and Leonard Stein (London, 1967), p.3.

the product of proximity or, conversely, of separation, in five main categories: duration, harmony (especially tonal harmony), pitch, articulation, and repetition, principally that beginning on an upbeat. The term phrase grouping will be preferred here to 'phrase', since the criteria of proximity and separation cause smaller groupings, more often called 'motives' or 'figures', to be included in the same category as the phrases articulated in, and associated with, performance. The words 'group' or 'grouping' have previously been used by Riemann, Cooper and Meyer, and Lerdahl and Jackendoff to denote this joint category,[36] although the present concept of a phrase grouping differs in certain respects from that of any of these writers. The parallel of phrase grouping with grouping in visual interpretation should also be noted: the first three categories in particular are a musical equivalent of the 'proximity principle' of the Gestalt psychologists.[37]

The separation of phrase groupings involves a separation of structural groupings that is established either at a pre-metrical stage or at a particular metrical level, but which will normally retain its identity however any higher-level groupings are placed. Thus, phrase groupings, however small, must be separated from each other within a metrical context. This is achieved by distinguishing between two types of upbeat within a metrical unit: a structural upbeat, which shows the start of a phrase grouping and whose branch is joined only to a right-hand beam (Example 2/29a), and the ordinary afterbeat of the metrical notation, whose branch is joined only to a left-hand beam (Example 2/29b) and which denotes the absence of a structural upbeat. Where necessary, the end of a phrase grouping may be marked by an

36. Riemann, op. cit.; Cooper and Meyer, op. cit.; Lerdahl and Jackendoff, op. cit.
37. See, for example, Paul J. Barber and David Legge, Perception and Information (London, 1976), pp.26-27.

asterisk (as in Example 2/30), to cover those circumstances in which it falls on a note or chord belonging to an afterbeat structure. It should be noted that an asterisk cancels the function of any beam which it replaces and that the presence of an asterisk on a particular level will be taken to imply its presence on all lower levels at the same point.

The afterbeat and upbeat structures are not mutually exclusive, as they might at first appear, but achieve equivalence on the level of the lowest structural grouping which covers them both. At such a level, the flow of thought is not simply between the members of the structural grouping which confers equivalence (Example 2/31) but may also be seen as follows: the whole content of the metrical unit contained by the structural grouping, plus any preceding structural upbeat, is related through the structural grouping's first branch to the note or chord of its second branch. For an afterbeat structure, this flow of thought has already been shown diagramatically (Example 2/18); for an upbeat structure, it is as in Example 2/32. Such a relationship depends on the extent to which the metrical unit can be seen as a whole, that is, on the separation in real time between the branches of the structural grouping containing it.

At the level of their equivalence, a structural upbeat functions as an afterbeat and an afterbeat as an upbeat. An afterbeat can never function as a structural upbeat, however, since the latter is associated with separation on the lower level, whereas the afterbeat structure is established as a result of the higher-level connection. Thus an afterbeat structure subsequently seen as a structural upbeat would be reinterpreted on the lower level, but would still function as an afterbeat in relation to the higher-level structural grouping.

With structural upbeats and afterbeats so distinguished, it should not be possible to misread the structure of Example 2/33 as a conjunction of two phrase groupings as bracketed beneath, which would require the placing of an asterisk after the final duration 3, in line with the beam on the second (lowest) level; the correct reading is as a superimposition of the structures of Example 2/34.

In both upbeat and afterbeat types, the loss of a beam need not lead to a loss of metrical information, provided that structural groupings on the same level are horizontally aligned and the metrical timelength is inserted in its usual place within the branch. Since any missing beam is still implied as part of a former lower-level structure (unless it has been replaced by an asterisk or implied asterisk), it may be indicated by a dotted line where this gives greater clarity. Similarly, dotted lines may indicate implied branches and structural groupings. If the values of metrical timelengths become unwieldy at higher levels, they may be replaced by values reduced in proportion (for example, 48:24:24:96 becomes 2:1:1:4). Within individual branches, proportional values will be inserted in square brackets (for example: [2:] [1:] [1:] [:4]). Any remaining difficulty in reading metrical structure seems amply compensated by the advantages of separating phrase groupings and by the ability to show successive layers of upbeats. These and the above-mentioned features are illustrated by Example 2/35.

Certain properties of the present notation may require further clarification, as follows. Firstly, the boundaries of phrase groupings are not to be misunderstood as necessarily implying divisions that would be articulated in performance. Since the intention is to show the various groupings and associations of notes that are relevant to rhythmic structure, it is inevitable that certain phrase groupings will be revealed which the performer could not execute without presuming articulation either not present in, or expressly denied by, the score. In Example 2/36a, for instance, the separate articulation of the final two lowest-level phrase groupings (Example 2/36b) would contradict the articulation Mendelssohn has indicated by rests and slurs, which creates a clear pattern of phrase lengths, or <u>phrase contour</u>: 1:1:2.

Secondly, by notating phrase grouping as an amalgamation of square-bracketed structural groupings and articulation by slurs and <u>staccato</u> marks, the present notation avoids the confusion that can exist in standard musical notation between an ordinary phrase mark and an articulated slur. The distinction between phrasing which is conditioned by articulation and phrasing which is not is of paramount importance to an understanding of the latter, since it is all too easy to think of a structural upbeat solely in terms of the articulated type.

The duration string of Example 2/37b will serve to illustrate the distinction. According to Keller,[38] this may be interpreted with equal likelihood either as a series of anapests, as bracketed beneath, or as a series of dactyls, as bracketed above. Such a view is echoed in the present notation (Example 2/37a): the separation of attacks leads to a series of anapestic phrase groupings on the lowest level and each structural upbeat, when functioning as an afterbeat on the next level, may be seen as the unaccented part of a dactyl. Since, however, the dactyl could not stand very well on its own as a phrase grouping and its perception as such would preclude that of the

38. Hermann Keller, <u>Phrasing and Articulation</u>, translated by Leigh Gerdine (London, 1966), p.54.

anapest (being on the same level), its strength as a pattern is heavily dependent on its repetition (marked 'R') and on the ease of the connection between its first and second notes. By shortening the sounded timelength of the dactyl's first note, articulation binds any preceding structural upbeat to it by relative legato and weakens the connection between the dactyl's first and second notes in favour of the anapest (Example 2/38). The metrical connection on the third level between the relatively long durations of the string is still apparent in the articulated example; the separation on that level is one of silence, not of structure. Thus the bias that articulation gives to the anapest over the dactyl simply has to be inferred from the separate notation of articulation as qualifying information.

A third aspect of the present notation concerns the correct reading of phrase groupings which are followed by a structural upbeat. In such cases, the metrical timelength associated with the final branch on the highest level of the phrase grouping will be greater (by the value of the following structural upbeat) than the sum of the durations in the subtree of that branch (Example 2/39). If the first phrase grouping of Example 2/40 were to stand on its own, it would be as in Example 2/41, with the final duration of the phrase expanded to balance the final metrical timelength. If, however, Example 2/40 were given an initial upbeat (Example 2/42), the final duration of the first phrase grouping on its own would be the same as in its original context. These two types of phrase groupings, in their contexts, may be called unbalanced and balanced, respectively.

A structural upbeat following an unbalanced phrase grouping cannot be quite as separate from the phrase grouping as that following a balanced one. In Example 2/40, the domain of the metrical timelength 6 (♩.) on the crotchet E extends to the end of the bar, overlapping the following quaver upbeat; in Example 2/42, it does not. Thus, in Example 2/40, there is one sense in which the phrase grouping ends on the crotchet E, on the grounds of the duration pattern up to that point (see Chapter 3, Section B), and another in which it lasts a full two bars, overlapping, but not incorporating, the quaver E. In Example 2/40, the quaver E functions as an afterbeat in relation to the metrical timelength 6. In Example 2/42, it does so in relation to the metrical timelength 12; although it is nominally in the same metrical unit that covers the second half of bar 1, it is associated more closely with the metrical timelength 6 at the beginning of bar 2.

In the present notation, the only way in which an unbalanced phrase grouping can be understood in the above two senses is by noting the discrepancy between duration and metrical timelength at the end of the phrase grouping. It would be incorrect to regard the following upbeat as part of an afterbeat <u>structure</u> (Example 2/43), notwithstanding its function as an afterbeat. It happens that, in Example 2/40, the association of the quaver E with the preceding phrase is stronger than it might otherwise have been (Example 2/44), because of the pitch unity of the two Es. In addition, repetition favours the perception of a second phrase starting at the beginning of bar 2, rather than on the last quaver of bar 1. Thus the second phrase is also understandable in two senses: with and without its upbeat. This aspect of repetition is a very common feature in music, which will be discussed further in Chapter 3 (Section C). But these features are further qualifications of the structure and do not necessarily make the quaver E part of the first phrase, to be separated from the beginning of bar 2 by articulation, as Meyer has suggested in his extensive analysis of the theme.[39]

In other examples, the notes following an unbalanced phrase grouping are clearly an upbeat, even with repetition (Examples 2/45 and 2/46). In Example 2/45, the effect of repetition in weakening the upbeat is itself weakened because the repetition is intervallic, rather than of exact pitches. In Example 2/46, it is weakened by the extent of the repetition's separation in real time.

Provision must be made in the present notation for those circumstances in which one phrase grouping does not follow another on consecutive notes. Keller outlines four special types of phrase conjunction.[40] In the first, <u>phrase-end concealment</u>, two phrases are joined by an articulated slur, so that the boundary between them is blurred. Such blurring could be inferred from slurs added to a tree-diagram. In the second type, <u>phrase-linkage</u>, 'the first phrase ends with the beginning note of the next'.[41] In the first of Keller's three examples of this type, from the opening Allegro of Beethoven's First Symphony, the linkage concerns a two-bar bridge passage between the tonic cadence on bar 5 and the repetition of the theme in bar 7 (Example 2/46). 'Linkage' is indeed the appropriate word for this structure, but it does not fit Keller's description of the term. The bridge passage does not begin the second phrase; nor does the first phrase end on the A^7 chord of bar 6, although it would be heard as six bars long without the bridge passage.

The tree-diagram notation for phrase linkage is as in Example 2/46, where two tied branches refer to the same note or

39. Leonard B. Meyer, <u>Explaining Music</u> (Berkeley, California, 1973), pp.30-43.
40. Keller, <u>op. cit</u>., pp.21-27.
41. <u>ibid</u>., p.23.

chord. The same notation will be used for what will here be known as phrase elision, and for which Keller's description of phrase linkage is appropriate. Keller's other two examples under the heading 'phrase linkage' do match his description, but the phrases between which he finds elision ('linkage' in his terminology) would not be revealed by any of the characteristics considered in the present work. Keller reserves the term 'phrase elision' for a structure that would have involved phrase elision (in the present terminology) if the second phrase did not begin with an abrupt change, particularly of dynamics or widely separated pitches. A dual branch does, in fact, seem appropriate to such a structure, even though the elision has been weakened.

Phrase overlapping 'almost always requires the presence of two or more voices'[42] and, as such, requires two separate structures in the present notation, thus being more suitable for internal representation in the computer than for display on paper. Overlapping is one of the key principles of phrase construction in vocal music, especially of the Renaissance; such music can only be understood as a single structure if the latter is an amalgamation of individual, overlapping structures. Keller points out the overlapping in a single voice which arises in the first C minor fugue of the Well-Tempered Clavier from dual repetition, one local, the other of the fugue subject.[43] Overlapping tree-diagrams (sharing the same notes) are also required for this type of structure (Example 2/47).

The only addition to the form of individual tree-diagrams required by these four types of phrase conjunction is the use of the dual branch. This structure is particularly necessary to cope with

42. ibid., p.25. 43. ibid.

a certain type of tonal cadence. The harmonic progressions most commonly associated with cadences do not necessarily define a phrase ending by themselves. It is overwhelmingly the case that the sense of closure in tonal music is durational, firstly, and that such points of closure can then be evaluated harmonically. Example 2/48 consists of the second four bars of an eight-bar metrical unit and the first four bars of the following eight-bar metrical unit. The semiquavers in bars 7 and 8 clearly run on to the minim in bar 9 as a point of duration closure which is also a point of harmonic cadence (V - I). Yet the minim, as a phrase ending, cannot be followed by an upbeat to a new higher-level metrical unit beginning on bar 10; this is precluded by the repetition starting at bar 11. Thus the structure is an example of phrase elision, requiring a dual branch. If bar 9 had begun with an appoggiatura, a dual branch would still be appropriate, but would be positioned on a higher level (Example 2/49). Such a structure indicates that the sub-tree common to the two branches is appropriate to them both.

C. PREVIOUS NOTATIONS

The form of the present notation may now be compared with that of its antecedents. Perhaps the first systematic study of the independence of phrasing from metre was that of Riemann.[44] In encyclopaedic style, Riemann catalogues permutations of durational motives in different positions with respect to the bar lines, in the manner of Example 2/50, these motives being separated by a small division mark, or Lesezeichen (literally 'reading sign', but

44. Riemann, op. cit.

but translated by Riemann as 'guide'),[45] with higher levels of phrase grouping indicated by a double or triple stroke. Keller notes that this sign was first introduced by Türk in 1789, and traces an earlier tradition of equivalent signs for showing phrase divisions.[46]

Riemann's aim was to show the relationship between metre and phrase grouping, on the one hand, and 'dynamic and agogic shading', on the other, the term Agogik being coined by him to refer to the slight fluctuations from strict tempo and duration that a performer might use to enhance metrical accentuation and phrase boundaries.[47] To Riemann, this relationship is indivisible; his analyses may be viewed either as what Yeston calls 'interpreted structures',[48] that is, as given configurations of metre and phrasing irrespective of cause, to which belong the patterns of dynamics and agogics that might be most appropriate to a 'musical' performance, or as structures which are themselves the products of such dynamic and agogic shading.

As interpreted structures, Riemann's three dynamic forms (Example 2/51)[49] may be seen as perceived rhythmic emphasis in a general sense that is analogous to Cooper and Meyer's notion of accent. His metre and phrase grouping can often be generated by the structural characteristic which will be known here as duration contour (see Chapter 3) and his phrase divisions mostly depict repetition, although it is doubtful that repetition is always strong enough to counter the effect of duration on phrase grouping (Example 2/52a and b). In many cases, such interpreted structures must be judged either as forms which can be generated by dynamics

45. ibid.,p.9.
46. Keller, op. cit., pp.16-20, citing Daniel Gottlob Türk, Klavierschule (1789, 1802), pp.20,23.
47. Riemann, op. cit., pp.9-10.
48. Yeston, op. cit., pp.35-37.
49. Riemann, op. cit., p.15.

(Example 2/53) or as forms which it might be possible to generate, but in various unspecified ways (Example 2/54).

If, however, Riemann's metre and phrasing are seen as generated by dynamics and agogics, respectively, this point of view is not only challenged by cases such as those of the last example, but confuses the ideas of musical and structural interpretation. A performance that is devoid of dynamic and agogic expression may be dull but it still has musical meaning; most of its rhythmic structure will be transmitted as intended. To say that the structure was itself generated by its means of expression would be similar to defining clauses and sentences in natural language as groupings separated by pauses for breath.

From the point of view of notation, Riemann's Lesezeichen has little more to offer than the use of slurs or separated notes (where these would normally be joined together), both of which devices Riemann also employed in his writings and editorial work. Through his use of dynamic signs, Riemann attempts to show the effect of a combined notion of metre and phrasing and even introduces conceptual graphs of the dynamic curves involved at different levels of phrase grouping.[50] But here Riemann is hoist by his own petard: by using dynamic signs to unite smaller phrase groupings under a higher level of organization, and having used the same signs as his justification of metrical accentuation, he effectively puts forward the rather suspect idea that his dynamic peaks mark the start of metrical units. Many of these peaks are correctly placed metrically, but it is through this idea that the earlier-mentioned paradox of accents, expressed in dynamic signs, leads to a distortion of metre.[51] Equally suspect is the corollary of this: that larger metrical units are inevitably associated with greater dynamic accentuation.

50. Riemann, op. cit., pp.143-4,148.
51. ibid., pp.186-7, 249-50, 256, 262 (musical examples).

The use of slurs or square brackets to show phrase grouping (Example 2/55) suffers from the same drawback as that of division marks, namely, that a separate metrical interpretation is required. The possible confusion of phrasing slurs with articulated slurs has already been mentioned, although this can be avoided by the careful definition of signs and symbols. Layered slurs have been used by Lerdahl and Jackendoff[52] and layered brackets by Cooper and Meyer;[53] the latter do not employ brackets solely for the use of phrase grouping, however. Lerdahl and Jackendoff are aware of the independence and interaction of metre with 'grouping structure'[54] and a combined reading of their metrical and grouping structures would effectively amount to a unified concept of metre and phrasing. The elimination of unnecessary dots from their metrical analysis and the interspersion of phrase grouping with metrical structure suggests the notation of Example 2/56, which is similar in form to that of the present work and also follows from a notation Lerdahl and Jackendoff themselves employ.[55] The tree-diagram notation is more suited to the present purpose, however, in showing metre and phrasing as an amalgamation of structural connections.

The notation of Cooper and Meyer attempts to unify the concepts of metre and phrasing through the use of several of the traditional accentual patterns (or 'feet') of prosody. Their five 'rhythmic groupings' may be seen as an expansion of Riemann's beginning-accented, middle-accented and end-accented forms; the iamb is linked to the

52. Lerdahl and Jackendoff, op. cit.
53. Cooper and Meyer, op. cit.
54. Lerdahl and Jackendoff, op. cit., p.120.
55. ibid., p.126, Ex.7.

anapest, and the trochee to the dactyl, by 'Metric Equivalence':[56]

1. trochee	— ∪	beginning-accented
2. dactyl	— ∪∪	
3. amphibrach	∪—∪	middle-accented
4. iamb	∪ —	end-accented
5. anapest	∪∪—	

With the macron (—) representing a general sense of accent, a rhythmic grouping on a given level is identified by the enclosure within a square bracket of the most appropriate accentual pattern. The whole grouping is then assigned a 'strong' or 'weak' value on the next level, such that a new rhythmic grouping is formed on that level. Despite criticism of the idea that a whole rhythmic grouping can be labelled either 'strong' or 'weak', especially up to the level of a whole composition, and although Cooper and Meyer rely on intuition rather than a formal theory for their selection of the appropriate accent pattern, the principal objection to the use of their notation in the present work stems from the fact that accentual patterns appropriate to two distinct levels are displayed on a single level.

The notational inconsistency caused by Cooper and Meyer's fusion of levels may be observed first. If their notation is taken as a representation of metre and phrasing, it is apparent that neither the accent-sign (—) nor the square bracket has a single, consistent function within such a representation. An end-accented or middle-accented grouping always denotes a phrase grouping. An end-accent may denote durational or harmonic closure where attached to a specific note, but may also be expected to function as a metrical accent, which is a beginning-accent.[57] A beginning-accented grouping usually denotes

56. Cooper and Meyer, op. cit., p.22.
57. ibid., p.51, Ex.68.

a metrical grouping, but it may also be a phrase grouping.[58] An accent attached to a whole grouping may qualify a metrical accent on a lower level, for example when two equal accents on the lower level are distinguished as strong and weak on the next (Example 2/57);[59] it also appears to distinguish between end-accents[60] or between the non-accents which end a trochaic or dactylic phrase grouping.[61]

Despite the apparent contradictions in the above, metrical structure can, in fact, be read correctly in Cooper and Meyer's notation, with the aid of the barlines. Up to the level of a bar, the macron almost invariably denotes the start of a metrical unit, even if it functions as an end-accent or middle-accent as well.[62] Beyond this point, a bracket groups lower-level groupings into groupings which are higher-level metrical units plus any initial upbeats and minus any following afterbeats. It also differentiates between their initial accentual values, as the vertical alignment of these values shows (Example 2/28). If such differentation were inappropriate, this could be indicated by introducing an 'equal-value' sign (=) into the notation.

The present objection to Cooper and Meyer's notation is due less to its form than to the distortion of hierarchical levels which it entails. The authors' fusion of levels is revealed by Meyer in the following statement and in the example to which it refers (Example 2/58): 'A series of notes of equal duration in duple meter tend to be heard

58. ibid., p.103, Ex.117, level 3.
59. ibid., p.42, Ex.53a.
60. ibid., p.115, Ex.125. The iambs on level 1 are so distinguished on level 2.
61. ibid., p.103, Ex.117. The trochees on level 3 are so distinguished on level 4.
62. An exception is: ibid., p.92, Ex.106a, level 1.

as trochaic. This effect will be particularly clear if a slight accent is placed upon each main beat.'[63] Yet such an example must have two hierarchical levels, not one, in order to be consistent with its nearest equivalent, Example 2/59, in which the two levels are distinguished as separate duration strings. On each level of Example 2/59, the durations are undifferentiated; the pattern of dynamic accents which they generate is thus a product of the two levels seen in conjunction. In Example 2/58 the dynamic accents may nevertheless be seen as appropriate to the first level; to perceive duple metre, however, there must be a mental connection between these accents, which will form a second level.

Thus Cooper and Meyer's notation, at least up to the level of the bar, shows each level as seen from the one above. Although the authors argue, correctly, that rhythm depends on differentation, it is still necessary to be able to show a lack of differentation on a single level. Alternatively, it is possible for material to be differentiated on one level and to be further differentiated by another characteristic which gives rise to the next level. One effect of Cooper and Meyer's fusion of levels, then, is that certain rhythmic patterns that exist on one level in their own right cannot be shown as such.[64] For example, where accentual patterns arise from relative duration, the duration strings of Examples 2/60a and 2/61a are appropriately an (end-accented) iamb and (middle-accented) amphibrach, respectively. Placed at the beginning of a metrical unit, however, they are given a beginning-accented pattern (Examples 2/60b and 2/61b).[65] Cooper and Meyer preserve the lower-level accent with a stress mark (/),

63. Meyer, <u>op. cit</u>., p.32.
64. In one case (p.127, Ex.134), Cooper and Meyer do show the lower-level pattern, by splitting a level into two parts.
65. Cooper and Meyer, <u>op. cit</u>., p.41, Ex.61c.

which they have initially defined as denoting dynamic intensification.[66] This is an unfortunate inversion of reality, since, in many cases, it is dynamic intensification on the lower-level 'weak' note (often from an accompaniment) that generates the metrical accent and prevents that note from becoming a structural upbeat; a stressed non-accent might therefore be more appropriate (Example 2/62).[67]

The difficulties of notation that Cooper and Meyer experience with the opening of Brahms' Symphony No. 3, third movement,[68] are easily resolved by a separation of their fused levels. Accentual values have been added to the present notation in Example 2/63 to show iambic grouping from duration on level 2 and from a crescendo and consequent dynamic accent on level 3. In relation to level 3 the decrescendo figure is trochaic ( ), the trochee's accent coming from metrical and dynamic accentuation ( ). Finally, the trochaic pattern of the durations on level 3 prevails over the dynamically accented iamb in forming the grouping on the next level.

At levels higher than the bar, when the effect of metrical accentuation is beginning to weaken, accentual patterns on a single level tend to predominate over those as seen from the next level and appear in Cooper and Meyer's analyses in preference to the latter. This is, of course, the apparent paradox of accents to which reference has been made and under which a beginning-accented metrical accent pattern may give way to an end-accented one. The fact that it does not lead to a confusion of levels in Cooper and Meyer's notation seems partly due to the similarity in timelength between phrase grouping on one level (in the present notation) and metrical grouping on the next.

66. ibid., p.8.
67. Further examples of this inversion are: ibid., p.32, Exs.40a and 40b; p.44, Ex.57.
68. ibid., pp.168-171.

For instance, two four-bar phrases may be asserted on one level and connected on the next, the connection confirming the four-bar phrase length as a metrical timelength and relating the two phrases to each other to form an eight-bar phrase (Example 2/64). Since Cooper and Meyer's groupings higher than the bar usually denote phrase grouping, they may substitute for metrical units that in the present notation would require to be asserted on the next level.

In removing the inconsistencies in Cooper and Meyer's notation for present purposes, it would be necessary first to eliminate the use of brackets for both metrical and phrase groupings. An overlap between beginning and end-accented groupings is a common feature of Cooper and Meyer's notation, suggesting structural ambiguity not always to be found in the music. Inevitably, the square brackets would have to show only phrase grouping and the notes which identified the beginnings of metrical units would then have to be indicated, perhaps using the accent marks. It may be seen from Example 2/65 that this specifies a form of notation that is virtually identical to that of Example 2/56, suggested as an improvement to the notation of Lerdahl and Jackendoff and possessing the principal features of the present notation, but without the connection of structural groupings.

Since the form of the tree-diagram notation has largely been dictated by the desire to show the interdependence of metre and phrase grouping, it is not claimed to be ideal for every aspect of musical structure, but reflects the limitations of style and scale that were discussed in Chapter 1. Although each diagram deals only with a single musical line, in polyphony, far from forming a haphazard collection of independent structures, the individual diagrams are linked by a common metrical structure, although it is possible for any line to put forward a subsidiary metrical structure of its own, producing a cross-rhythm in the overall context. Individual lines are also linked by a common harmonic structure and through their relationship to the attack string (or 'rhythmic resultant'),[69] which is the composite string of all durations regardless of their line of origin and to which can be ascribed any overall metrical structure.

The notation's dependence on metre for the connection of phrase groupings seems to render it ineffective when metrical connections can no longer be made. In fact, there is no musical reason why new branches should not be formed and connected as before, to show the grouping of phrases into what are normally called 'sections' or 'paragraphs'. To treat such sections as if they were metrical units (and even to name them as such) would reflect what they have in common with lower-level metrical units and would imply no distortion of the latter concept. The one notable difference would be that new structural groupings would normally be formed to connect one established phrase or section with the presumed start of another, rather than to show a connection between structurally accented notes or chords, as on the lowest levels.

The principal objection to the formation of structural groupings up to, say, the level of an entire composition would be visual, if such diagrams were to be written, as opposed to being stored in computer memory. Large gaps between the branches of structural groupings would make it difficult to grasp the significance of the connections. Although the purpose of the tree-diagram notation is as a conceptual model, not a teaching one, it may be that the hierarchical structuring of sections is in any case better represented by some other

69. Yeston, op. cit., p.26.

means, such as nested square brackets. The general form of the relationship between a nested-bracket notation and the present tree-diagram notation is shown in Example 2/66, each number referring to the number of bars in a hypothetical phrase. In the tree-diagram notation, the structural grouping in which the sixteen-bar phrase is asserted depicts the phraselength as 8+8, whereas the nested-bracket notation, on the same level, refers to it directly as 16.

CHAPTER THREE

STRUCTURAL CHARACTERISTICS: DURATION

Of the two main parameters in music - duration and pitch - the structural characteristics arising from duration patterns will be considered first. This is not because pitch is less important than duration; it is probably more important. Nevertheless, while only a single pitch or chord can be sounded without creating even the simplest rhythmic pattern, sequences of durations can be considered independently of pitch, as if played on unpitched instruments, however impoverished a view of music this might be on its own. In many of the following examples, however, pitches will be included, not only to help to identify the source, but also to show the effect of the metrical and phrase-grouping aspects of duration on the passage. Where this duration structure is inadequate, inaccurate, or ambiguous, it serves to highlight the fact that 'rhythm', even in the present limited sense, means more than simply 'duration' and must take pitch and harmonic factors into account.

A second reason for considering duration structure first is that it is less well understood than pitch and harmony. Perhaps because of this, the analytical technique of Schenker and his followers tends to give the impression that pitch and harmonic structure is the essence of Western tonal music and that duration is merely their servant. In Schenkerian theory, a composition is an *Auskomponierung* ('composing-out') of a basic pitch structure in which durational values do not appear, being added only at the foreground levels as if lacking in any structure of their own. Some redress of the balance in favour of duration has long been overdue and the Schenker system will be devalued not one bit by continued research into duration structure and rhythm in general, for no theory based on a limited view of music (including the present one) can claim to answer all questions of musical structure and meaning. The opening of the last movement of Mendelssohn's 'Italian' Symphony (Example 3/1) is just one of the many instances in which the character of the music is chiefly determined by a distinctive duration pattern. In such a piece, a pitch and harmonic analysis may be useful, but will not grasp the essence of the musical message.

A. DURATION COUNTOUR AND METRE

If the notes of a single written musical line are considered without regard to pitch, tempo, articulation, dynamics, and timbre, the remaining duration string has only one feature that could generate musical shape or structure: the proportional values of its durations. If these values are displayed graphically as a series of vertical lines (Example 3/2), a potential structural characteristic becomes clearly visible in the contour described by the varying height of the lines. This characteristic will thus be termed duration contour.

The principal feature of duration contour is that of a sense of movement from shorter to longer durations in which the latter may act as points of cadence, or closure, capable of absorbing the momentum from preceding shorter notes. Conversely, a duration which is followed by shorter notes usually seems unresolved until matched by a duration of equal or greater length. That this rhythmic motion is as described seems due to our response to the rate of change per unit of time. If such a unit, irrespective of its size, is filled by a single note, it is associated with less change, or less activity, than if it is filled by, for example, several separately articulated notes of the same pitch or several legato notes of different pitches, and still less activity in comparison with several separately articulated notes of different pitches. Such a notion of activity accounts for the sense of acceleration and deceleration that may be felt in a passage like Example 3/3, provided that the increasing or decreasing frequency of attacks is not simply perceived as so many more or less subdivisions of a given metrical multiple.

Compared with the activity of preceding, relatively shorter durations, then, a long duration is sensed as a period of rest, or stability. Although the opposite motion - an increasing frequency of attacks - also gives rise to a steady state in the form of a continuous pitch,[1] this is not a phenomenon that it has been possible to exploit until the advent of electronic music.[2] The motion from subordinate shorter durations to longer ones may be loosely equated with the terms 'upbeat' and downbeat', respectively, but it can be misleading to use these terms in a non-metrical context and it is perhaps better to say that duration contour grades duration values as relatively 'weak' or 'strong'.

Duration contour is in some respects analogous to physical contour and a sense of varying gradient. The greater the proportion between a duration and a shorter note immediately preceding it, the greater the 'gradient', that is, the greater the emphasis on the longer note, not in its own right as an absolute quality, but in relation to the preceding note. Meyer has observed that in a sequence

1. Karlheinz Stockhausen, 'How Time Passes', Die Reihe, 3 'Musical Craftsmanship' (Bryn Mawr, Pennsylvania, 1960).
2. The electronic sounds in Stockhausen's 'Kontakte' (1960), for example, were produced by accelerating periodic sequences of impulses provided by a pulse generator. See Karl H. Wörner, Stockhausen: Life and Work, translated by Bill Hopkins (London, 1973), pp.136-7.

of alternately long and short notes (Example 3/4a), increasing the proportion between the long and short durations binds the shorter note more closely to the longer one (Examples 3/4b and c).[3] Ultimately, the shorter duration is reduced to an acciaccatura, at which point musical notation confirms our perception of it as a rhythmic inflexion of the longer note (Example 3/4d).[4] Here there is no doubt that the longer duration appears accented by the preceding shorter one. Such an accent is not a dynamic accent (although it is quite likely that it will be emphasized by dynamic accentuation in performance), but a structural accent of duration contour, created by the sharp increase in relative notelength. If the longer note is followed by others of the same length (Example 3/5), it is apparent that only the first of the equal durations is perceived as structurally accented.

While an intuitive understanding of the sense of duration contour is commonplace, neither its effect in generating metre and phrasing nor its place as a constituent of rhythmic structure within a metrical context seem to have been adequately investigated. Many of Riemann's analyses could be seen as an attempt to consider duration contour within different metrical contexts, but Riemann does not investigate how duration itself might have given rise to the metre and phrasing indicated.[5] Schachter, reviewing rhythmic theory nearly a century later, describes what he calls 'durational rhythm' in similar terms to the above, but is unable to make more than general comments on its place within metrical structure.[6] Likewise, LaRue simply notes that

3. Leonard B. Meyer, Explaining Music (Berkeley, California, 1973), p.32.
4. The acciaccatura has been represented numerically as O. An approximate proportion is used in the graph.
5. Hugo Riemann, Musikalische Dynamik und Agogik (Hamburg, 1884).
6. Carl Schachter, 'Rhythm and Linear Analysis', The Music Forum, 4 (1976), 281-334 (pp.315-6).

'rhythmic contours' can create a satisfying phrase and provides two illustrative examples.[7]

Smither sees a relatively long duration as restraining rhythmic flow and classifies its accentual effect by its notated length, its length relative to its immediate neighbours, and whether, in reverse order of effectiveness, the following note alone is shorter, the preceding note alone is shorter, or both neighbours are shorter.[7.1] He notes that durational accents may occur in regular or irregular patterns, but does not develop a theory to explain the generation of metrical structure within the different configurations of structural accents. In the account which follows, duration will be considered first from a non-metrical point of view in order that its effect on metrical and phrase structure may be examined without the bias of a given metre generated by other characteristics.

1. Pre-metrical phrase grouping

To begin with, the display of duration contour may be changed to save space. The strict proportions of the duration values' vertical lines are not always necessary and in the following examples will be replaced by columns of crosses, which rank the duration values in ascending order of magnitude: one cross for the shortest duration, two for the second smallest and so on. The time base will be measured in units of the duration 1, thereby maintaining the proportions of the attack intervals. Such a display allows the eye, in most cases, to form groups of durations intuitively, largely by proximity of attack. The Brahms theme of Example 3/2 has been rewritten in the new display as Example 3/6, with an intuitive grouping underneath. Being based on proximity, such groups suggest a pre-metrical form of phrase grouping which follows duration contour in the sense that the last duration of each group tends to be the longest, since it is its

7. Jan LaRue, Guidelines for Style Analysis (New York, 1970), p.105.
7.1. Howard E. Smither, 'The Rhythmic Analysis of 20th-Century Music', Journal of Music Theory, 8 (1964), 54-88 (p.62).

relative length that normally defines the group's identity, separating it from adjacent groups. The inherently hierarchical nature of duration contour and durational phrase grouping is also self-evident in Example 3/6, relatively long durations being subordinate to those of even greater length.

Mere intuition is not satisfactory, however, and a more systematic derivation of such grouping must be sought. What is required is a form of Cluster Analysis.[8] If proximity of attack were the only criterion for grouping and the relative 'strength' ascribed to the duration values did not have to be taken into account, the simplest form of clustering, the single-linkage (or 'nearest-neighbour') method, would be sufficient.[9] For the Brahms theme (Examples 3/2 and 3/6), this method would produce a dendrogram (tree-diagram) with the general form of Example 3/7 , in which the closest attacks, separated by the duration 1, are grouped together first; then those separated by the durations 2, 3, 4, and 6, respectively. By this means, the single-linkage method will faithfully generate successive groupings of durations by proximity of attack, with each group ending on its longest duration, thereby following the principle of progression from shorter to longer durations.

Yet the single-linkage method often produces groups which seem musically wrong as phrase groupings or which are acceptable, but for the wrong reasons. In the Brahms theme (Example 3/7), it assumes that the group 3 1 6 is formed by joining the duration 3 to the duration 1, the latter already grouped with the following duration 6, whereas to a musician the mental connection, or transfer of 'rhythmic weight' is between the two longer durations, the 3 and the 6. In conjunction with this connection the existing grouping 1 6 forms a higher-level grouping 3 1 6, yet the attack interval 4 which connects

8. The term 'Cluster Analysis' refers to any of the several mathematical techniques for clustering, or grouping, multivariate data according to their proximity in multidimensional space. See Brian Everitt, <u>Cluster Analysis</u> (London, 1974).
9. Everitt, <u>op. cit</u>., pp.9-10.

the 3 and the 6 is the same as the previous duration; thus, at the level at which durations separated by this attack interval are clustered together, the grouping formed should be the string 4 3 1 6 (Example 3/8). A similar connection should group the last four durations of Example 3/9, rather than the single-linkage method's curious grouping at the stage at which groups are linked by the attack interval of a dotted crotchet (6). In a further example, the Bach fugue subject of Example 3/10, the single-linkage method finds the string 1 1 2 2 8 as a grouping in preference to 1 1 2 2 8 8 and includes this last duration only after it has grouped together all of the preceding notes.

Restoring the vertical dimension to the duration values suggests the possibility of clustering on successive rows of crosses, working from the bottom up. By this means, groups are formed not only by joining adjacent notes, but by making connections between structural accents of duration contour, that is, between non-adjacent relatively long durations. Example 3/11 is a cluster analysis of the Brahms theme by this method, successive stages, or levels, of clustering being shown by the rows of connecting brackets below the graph, reading from the top down. The pre-metrical phrase groupings that have been formed up to and including a given level are read, as in Example 3/8, by amalgamating those strings, as specified by the connecting brackets, which have at least one duration in common. Each size of attack interval represents one level of clustering only, the attack intervals being arranged in ascending order of magnitude and placed in brackets on the left of the diagram. In Example 3/11 the levels of connecting brackets correspond to the smallest attack interval available for clustering on rows 1,2,3,4, and 5, respectively, of the graph.

The full procedure for the pre-metrical clustering of durations is as follows:

On each row, proceeding from the lowest to the highest:

(1) Connect those durations that are separated by the smallest attack-interval. (There may be duplication of previously made connections, but this does not matter.)

If (2) The smallest duration value has been connected - to a larger duration unless none is available - designate the next larger duration value as the 'smallest' and proceed to the next row. Go to Step (1). (The connection to a larger duration may be indirect, provided it is not by way of a smaller duration value. In Example 3/12, the first '2' is considered connected indirectly to the '3'.)

Else (3) Connect by means of the next larger attack-interval of the row. To be valid, each connection here must involve the current 'smallest' duration value and must enable an unconnected duration to be connected. Go to Step (2).

Note: (A) A bracketed string terminates with a 'shorter' duration if (and only if) that duration is closer to the preceding member of the grouping than to the succeeding duration of equal or greater length.

(B) Step (3) may establish a new level of clustering, but a subsequent Step (1) may make connections at that level or on a lower or higher one, as appropriate.

In this method of clustering, then, when each duration value, starting with the smallest, has been grouped, the analysis proceeds to the next higher row of the graph. In some examples, more than one stage of clustering is required to group a particular value. In Example 3/13, for instance, the first crotchet (4) is separated on row 3 by an attack interval of 8 and its clustering must succeed that of the subsequent crotchets, separated by the smallest attack interval of 6, even though the latter forms a grouping that includes a longer duration (5). Similarly, in the method's analysis of the Chopin example considered above (Example 3/14), the second dotted crotchet (6), separated by an attack interval of 8, is grouped before the first one, whose relevant attack interval is 16.

Unlike the single-linkage method, the proposed method of clustering does not always produce groupings which end on their longest duration. The absurdity of grouping each duration with the first succeeding longer one, however distant, is seen in Example 3/15. In the proposed method, if a duration has not already been connected and is separated from the preceding duration of equal or greater length by a shorter attack interval than from the succeeding such duration, it is grouped with the preceding one. Examples 3/16 to 3/19 show instances of this type of grouping, the durations so grouped being marked 'X'. In fact, in the Schumann and Berlioz examples (Examples 3/18 and 3/19), these durations are grouped, in the full context, not with the preceding longer duration, but with the following one, matching duration contour (Examples 3/20 and 3/21). However, it must be assumed that at a pre-metrical stage of analysis the information which would generate the full metrical and phrase-grouping structure is not yet available. While there is bound to be a certain artificiality in considering one structural characteristic on its own, its effect on metre and phrasing in general need not be invalidated simply because it is superseded or surpassed in certain contexts by other more powerful characteristics or preferences.

Apart from producing the essentials of small-scale phrase grouping in most cases, the pre-metrical analysis of duration contour has two important functions. One is to provide a hierarchical structure for duration strings where there is no certain metre, as in Examples 3/22 to 3/24. The other is that, in being derived from the possible connections between the structural accents of duration contour (the relatively longer notes), the pre-metrical structures put forward potential metrical connections. Although in many examples some or all of these connections are contradicted by the eventual metre, in others they are clearly capable of generating it (Examples 3/14, 3/25 to 3/29).

It is interesting that such an elaborate and richly varied duration string as Example 3/28 nevertheless generates a metrical multiple, but the other Mozart example (Example 3/29) is even more noteworthy in generating a hierarchical structure which, if placed above instead of below the duration string (Example 3/30a), is virtually identical to its equivalent in the tree-diagram notation described in Chapter 2 (Example 3/30b). Subdivision of a given metrical multiple is the only amendment required to generate the latter from the former. This is not mere coincidence, but reflects the close correspondence between the tree-diagram notation and its origins in duration structure; indeed, the grouping structures of the remainder of these 'metrical' duration strings also require few transformations to be turned into their full tree-diagrams.

The assumption that mental connections are made between relatively longer durations separated by one or more shorter notes stems from the longer durations' greater prominence or 'rhythmic weight'. But if it is to be claimed that these connections generate metre in the examples just cited, rather than merely being coincidental with it, it is necessary to investigate why they do not always do so.

2. Preference for regular metre

Apart from structural characteristics which are external to durational structure, one reason is that there appears to be a general perceptual preference, at least to the Western listener, for regular metre which may be incongruent with duration contour, as opposed to the irregular metre following duration contour that is often put forward by the above grouping procedure. If connections between the structural accents of duration contour are potentially metrical, then the addition of a preference for regular metre should cause the first such connection to be asserted as a potential metrical multiple, unless other structural characteristics or perceptual preferences predominate. This would also be in accordance with the earlier-noted parallel between metre and duration, namely that, in functioning as the analogue of a duration and as a means of measuring time proportionally, one metrical timelength predicts another of the same length, whether the expectation is subsequently fulfilled or not (see Chapter 2, Section A).

Examples 3/31 to 3/34 are instances of themes in which the timelength established between the first two structural accents of duration contour is maintained as a metrical multiple by the preference for regular metre, despite being incongruent with the characteristic's subsequent structural accents. For easy reference, this feature will be known as the multiple from duration contour. The mental connections belonging to the multiple are marked 'M' beneath the graphs. Where the multiple does not coincide with an attack, broken lines have been used to indicate the subconscious counting, rather than overt syncopation, that is involved in maintaining the multiple.[10] Such subconscious counting can result in the amalgamation into a higher-level timelength of the metrical

10. The distinction between overt syncopation and subconscious counting is considered in subsection 4 below.

timelengths preceding and following the missed attack. In the Mozart, Handel, and Wagner examples (Examples 3/32 to 3/34), the metrical multiple forms a pattern of metrical timelengths in the proportions 1:1:2 (c.f.♩♩𝅗𝅥), and in the Mozart example (Example 3/32) the immediate repetition of the amalgamated timelength establishes a higher-level multiple ('M′') to which the preceding lower-level metrical timelengths become upbeats. A similar higher-level multiple operates from the beginning of the Handel example (Example 3/33), but is generated not by duration but by the pattern of harmonic changes generally known as harmonic rhythm. In the Wagner example (Example 3/34), there are two levels of metrical multiples from duration contour (marked 'M' and 'M′'), generated by the attack intervals on rows 3 and 4, respectively, of the graph.

Returning to the earlier duration graphs, the multiple from duration contour may be seen to generate the commonly understood metre in Examples 3/11, 3/16, 3/17, and 3/18. The Bach fugue examples (Examples 3/22 to 3/24) must be excepted since their metrical ambiguity involves too many factors to be explained at this stage. In the theme from Beethoven's 'Emperor' Concerto (Example 3/13), the initial incongruence of metre and duration contour is produced by the accompaniment, particularly by harmonic rhythm, which is also directly responsible for the 6/8 multiple in Example 3/19 (Berlioz: Romeo and Juliet), although this multiple could be determined by subsequent binary subdivision of the structural timelength of 24 from duration contour (row 6). Whether the attack interval of 24 is maintained as a multiple beyond two counts, however, is in some doubt.

Notwithstanding the importance of the initial structural time-length of duration contour as a potential metrical multiple and the large number of themes whose notated time-signature it will match, the feature itself is of less importance to the present discussion than the questions and assumptions it leaves in its wake. Firstly, it is apparent that it will not generate a multiple in every instance, even where melodic and harmonic factors are expressly discounted. The timelength of 24 discussed in the Berlioz example above (Example 3/19) is a case in point; more unlikely still is the multiple 10 in the Bach fugue subject of Example 3/24. Thus, there is the question of which timelengths are acceptable as metrical multiples and why. Secondly, there is the matter of incongruence with subsequent duration contour: whether there are limits to the number of attacks that can be missed or to the number and size of incongruent structurally accented durations that can be tolerated. Thirdly, in many cases the first structural timelength of duration contour follows what will become an upbeat if the timelength is perceived metrically. Since more than one layer of upbeats is possible and the first structural timelength might be followed later by a larger one, it must be asked whether there are limits to the number of such layers and their separation in time, or whether music is essentially anacrustic, as Riemann appeared to believe. In each of these matters, the deciding factor is undoubtedly ease of perception: the simplest structure is the one most likely to be perceived.

3. Choice of Multiple

The weakness of a metrical multiple maintained automatically (by expected repetition) was illustrated in Chapter 2 by an example (Examples 2/6 and 2/7) in which a multiple which had ceased to be asserted by a structural characteristic failed as soon as another characteristic put forward an alternative structure. While it seems from many of the above examples that duple and triple metre can often be maintained automatically in opposition to duration contour, the failure of the metrical multiple 10 in Example 3/24 raises doubts about whether the same is true of regular metre based on a multiple of 5 or, for that matter, any higher prime number.[11]

Example 3/35 is constructed so that it can be partitioned by the metrical multiples 5, 7, and 11, whereas the multiples 2 or 3 would require subconscious counting or syncopation (marked); yet it seems that 2 is the most likely multiple. Even in a string like Example 3/36, although it is easy to perceive the multiple 5 throughout by deliberate choice, it is not certain whether such a multiple would otherwise be maintained beyond the third or fourth count or whether it would be supplanted by, perhaps, binary metrical grouping. As a working hypothesis, then, it may be assumed that duple metre is most easily maintained against incongruent duration contour, triple probably less so, with quintuple, septuple and others hardly worth considering in this respect, since they would have to challenge not only incongruent duration contour but also the Western listener's traditional expectations of structures in duple or triple metre: witness the ease of perceiving the pattern  in Example 3/35.

Clearly, the larger an automatic multiple is, the more vulnerable it will be to being displaced by incongruent smaller-scale structures which will literally be perceived first. Metrical timelengths in duple or triple metre will be perceived before those of higher prime

11. In the present work, 'the multiple x' refers to a metrical multiple; 'a multiple of x' refers to the number series x,2x,3x,....., as in conventional usage.

numbers and in this regard it is significant that, since metre is additive, any metrical timelength greater than three is an aggregate of twos or threes and is highly likely to be seen as so compounded if it may be perceived at all;[12] conversely, unless these duple-metre or triple-metre timelengths are unambiguously grouped into higher-level metrical timelengths based on a prime number greater than three, alternative metrical groupings may assert themselves. Thus, it is not surprising that the use of irregular metre and multiples based on prime numbers greater than three relies heavily on being produced by the dominant structural characteristic (or group of characteristics) in a given rhythmic texture, and in particular by repetition.

The preference for duple and triple metre to metrical multiples based on higher prime numbers suggests that there might be a similar preference between duple and triple metre themselves. If there is, it is certainly less marked; on the small scale it is hard to find any evidence for it at all, since there are relatively few duration strings which present a genuine ambiguity between the two metrical multiples. The duration string of Example 3/37 does not do so, for instance. The anticipated repetition of the crotchet as a metrical timelength causes the following quavers to be grouped in twos; another structural characteristic would have to group them in threes to create a 6/8 metre. The well-known <u>hemiola</u> does not qualify as an example either, since it is a cross-rhythm, presenting simultaneous duple and triple subdivisions of the multiple 6, one of which may predominate metrically with the other heard as a syncopated subsidiary structure.

12. If it may not, it is likely that the string involves durations of complex proportions, posing further difficulties of perception considered in Chapter 1, Section C.

The subdivision of the first metrical timelength 6 in Example 3/38 (marked 'A') differs from the hemiola, however, in that whichever of the two lower-level multiples is chosen, the other contender will tend to be forgotten. Thus, while there is a metrical ambiguity in this example up to the second dotted crotchet, it is resolved retroactively in the second metrical timelength 6 in favour of a 3/4 subdivision in Example 3/38a and a 6/8 one in Example 3/38b. Example 3/40 is rhythmically interesting because, with melodic patterns also to be taken into account, this process of retroactive interpretation leaves a metrical ambiguity in its wake, rather than solving one: the ambiguity is between a cross-rhythmic interpretation (Example 3/40b) and irregular metre (Example 3/40a).

In Example 3/41, a ternary multiple is upset by a binary pitch pattern, even though pitch patterns tend to be the weakest, metrically, of all structural characteristics; yet the ternary pitch pattern in Example 3/42 is subordinate to a pre-established binary multiple (from the preceding scherzo). This might be indicative of a general perceptual preference for duple to triple metre but for a more fundamental principle: a well-established multiple is more likely to be continued automatically in opposition to an alternative structure than a newly-established one. Thus in Example 3/43 the binary pitch pattern does not upset the established triple metre, but is subordinate to it.

There is at least one set of circumstances in which a preference for duple to triple metre might be a useful default procedure to build into a computer program, however. In cases like Example 3/44, where the first structural accent of duration contour is the duration 3 (or a multiple of 3) but is not incorporated into a metrical unit for some time ahead, it seems more likely that the Western listener, through cultural conditioning, will perceive a binary multiple (in this case 4) than a ternary one (in this case 3). Such a preference could only be considered to operate in anticipation of further information and its binary multiple would be rejected by any structural characteristic with which it were incongruent. The procedure could also be extended to durations that are prime numbers greater than 3 or multiples of these numbers.

The fact that smaller metrical timelengths are perceived before larger ones has some effect in giving preference to binary rather than ternary groupings, but this process appears to take place not at the levels of the initial metrical connections, but at higher levels where the distinction between metrical and phrase grouping can become blurred because each is contributing to the perception of the other. At such levels, Western music has a clear preference for binary grouping in default of any other. While this does not amount explicitly to a preference against ternary grouping, anyone may test for himself the practical difficulties of composing in groupings that are successive powers of 3. For example, the main theme of the first movement of Elgar's 'Cello Concerto, already in 9/8, might be altered to make the melodic repetition occur after three bars instead of two; but it is highly likely that a following three-bar unit constructed in similar manner would give rise to the binary 'antecedent-consequent' form before the third such unit had been heard.

4. Syncopation

The automatic continuance of a metrical multiple in opposition to duration contour is clearly dependent on the complexity of syncopation that can be tolerated. The size of each incongruent duration, its position within the proposed metrical timelength, the size of that timelength, the number of missed attacks, and tempo are all factors which would seem to have a bearing on whether the structure put forward is too complicated relative to some alternative structure. With so many variables to handle, the tolerance of syncopation might appear to be qualitative and only roughly determinable; yet, in practice, the influence of other characteristics tends to decide most of the potential ambiguities before they arise. For example, the number of missed attacks does not seem to threaten our ease of perception if the syncopations are contained within a higher-level timelength whose perception is ensured, as is the semibreve multiple (8) in Example 3/45, which is generated by pitch unity.

The matter of duration contour being in syncopation with a given multiple and thus metrically subordinate to it can be simplified by removing from the discussion what is perhaps the most common category: overt syncopation. This term will refer to those circumstances in which the prevailing metrical accent is sounded, that is, it is carried by a note in some line other than the syncopated one. Moreover, if the metrical accent does not simply occur by default (as when it is the product of an automatically continued multiple), it will, by definition, fall on the note or chord which generates it, the one highlighted by the predominant structural characteristic at that point. When the syncopated duration is perceived as part of such a metrically interpreted context rather than as a member of a single musical line with its own identity, it is heard as split: into a note which precedes a sounded metrical accent, followed by one or more tied notes, each falling on a sounded metrical accent (as in Example 3/46).[13]

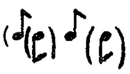
By making incongruent durations subordinate to the prevailing metre, overt syncopation essentially avoids any conflict between duration contour and a previous multiple; yet the syncopated line's identity in its own right cannot be denied altogether. Thus it can hardly be by accident that when melodic lines involve complex syncopations and, without the accompaniment, would present metrical irregularity or ambiguity, as, for example, in jazz and twentieth-century popular music, they tend to be accompanied by a forceful and steady beat, a framework around which the incongruent durations may be woven and within whose order they may, paradoxically, be all the more free.

Within a single line, when a metrical accent does not fall on an attack, at least one of three things can happen. Either (a) the metrical accent is perceived consciously and produces a tied note; (b) there is subconscious counting: the metrical accent is perceived subconsciously and the measurement of anticipated metrical timelengths proceeds without affecting the perception of the incongruent duration; or (c) structures incongruent with the multiple prove stronger than it and it fails. It might seem that there should be a straight choice between these alternatives, but, unfortunately, the matter is not as simple as that.

In relation to the first alternative, it will be assumed that deliberately conscious counting is mostly confined to players of music to whom what is known simply as 'counting' may be the only safeguard against performing durations incorrectly. The learner who cannot

13. In the present work, the term 'tied note' will refer only to a note that has no attack because it is tied to the preceding note. It will be represented in the tree-diagram notation by a tie and a broken-line branch.

instinctively grasp the rhythm of Example 3/45, bar 1, may well play it slowly, counting aloud (viz.: 'One and two and .....'), and thus be consciously aware of metrical subdivisions which in standard notation and the present tree-diagram notation are not considered significant (Example 3/47). By contrast, those who do not consciously partition a (single) musical line by counting, tapping or otherwise 'beating time' will normally be only subconsciously aware of those points where a multiple does not coincide with an attack; yet such subconscious counting is crucial to our perception of duration. Thus in the song 'Auld Lang Syne', we must be counting subconsciously to know that the second duration is 1½ times as long as the first, but we do not tend to hear the tune as in Example 3/48, although, like the learner, we could choose to do so.

On the other hand, it may be that at a slow tempo the subconscious counting that measures duration becomes more conscious. It has been argued by Fay that 'when the tempo falls below ♩ = 60, a tendency to group each pulse with a silent afterbeat is very strong' ().[14] For any given duration string, as tempo is reduced, so is the frequency of attacks; thus the mind must store the information from progressively longer real timelengths in order to recognize patterns (<u>Gestalten</u>). Since this will reduce the pre-eminence of higher levels of organization, lower-level ones such as the measurement of duration could come into greater prominence. However, to concede this point simply raises another issue: at what tempo does conscious counting, with its awareness of metrical subdivision, provide the predominant structure and when does this awareness fade and become subconscious?

14. Thomas Fay, 'Context Analysis of Musical Gestures', <u>Journal of Music Theory</u>, 18, No. 1 (1974), 124-151, p.129.

When is there equal ambiguity between the two? It should be noted that in this context 'tempo' does not simply mean 'metronome mark', but also involves the frequency of attacks, which varies with each individual duration string. If, for any given example, it is not possible to measure the likelihood of subconscious counting becoming conscious, it is perhaps better to assume that in a single musical line anticipated metrical accents and implied metrical subdivisions can always be perceived subconsciously, but that in certain circumstances they may also be consciously perceptible (deliberate counting excluded). To assume that they were always perceived consciously would permit such absurd structures as Example 3/49. Criticism of the notion that all metrical subdivisions are perceived consciously has already been made in respect of Lerdahl and Jackendoff's notation of metre (Chapter 2, Section A).

The notation of subconscious counting in tree-diagram form must cater for the notion that a melodic line may be perceived within a metrical context, without the incongruent durations being split. An incongruent duration whose branch may be joined directly or indirectly to that of a higher-level structural grouping presents no problem (see Example 3/45). Where it is necessary to show subconsciously perceived branches and beams in order to establish the metrical context, these will be marked with broken lines, the branch of the unsounded metrical accent extending only as far down as is absolutely necessary. Examples 3/50 and 3/51 illustrate this latter notation; Example 3/51 depicts a structure that is unlikely to be perceived on a first hearing, because of metrical ambiguity. In this notation, the syncopated duration is seen as essentially belonging to the metrical unit in which its attack falls, even though it extends into the next metrical unit. It will be seen that this concept is consistent with the pre-metrical grouping of duration, but on harmonic and other grounds it can sometimes be more meaningful to view a syncopated duration as anticipating the beginning of the next metrical unit and to notate it accordingly (Example 3/52).

In attempting to draw the line between those unsounded metrical accents that are likely to be perceived consciously and those that are not, a distinction should be made between two familiar types of structure, depicted in Examples 3/53a and 3/53b. In Example 3/53a, a note coincides with one metrical accent, but overlaps its unsounded successor; the unsounded accent will be taken to be relevant only to subconscious counting. Example 3/53b depicts the standard form of syncopation: the metrical accent falls between two attacks. Here it will be assumed that the unsounded accent may be perceived consciously, but that the resulting structure is subsidiary to that of its subconscious perception. The distinction between these two types of structure covers both anticipated metrical accents and those implied by regular subdivision of a given metrical timelength. In the latter case, however, the conscious binary subdivision of a metrical timelength that is a multiple of 2 (Example 3/54a) is almost as strong as the irregular version (Example 3/54b), but successive implied binary subdivisions are progressively less likely to be perceived consciously (Examples 3/45 and 3/47).

The degree of consciousness of an unsounded metrical accent may be affected by the size of the metrical timelength concerned. Because a higher-level multiple is unaffected by irregular subdivisions, unsounded metrical accents on the lower level are less important to the ability to make a metrical interpretation than any occurring on the higher level itself; in order to maintain the higher-level multiple and, with it, a conception of musical structure, there is more incentive to perceive the unsounded metrical accent consciously on the higher than on the lower level. Further incentive comes from the fact that the greater the real timelength of a multiple, the longer will be the period of metrical uncertainty before the multiple is restored by coinciding with an attack. If the real timelength is indeed significant in this respect, this would be in accordance with the greater awareness of unsounded metrical accents at slow tempi. Example 3/55, with unsounded metrical accents on three levels, seems to bear out the above observations. In its later syncopations, however, a conjunction of the phrase groupings shown above and below Example 3/56 (the top set created by melodically varied repetition of the preceding dominant arpeggio, the bottom set by duration contour) could also be seen as producing the conscious perception of a tie.

The conscious perception of an unsounded metrical accent is also dependent on the extent to which a multiple has become established. There is certainly a strong tendency in Western music to maintain the beat in one part or another and in certain cases our expectancy of this must be understood as providing an awareness of the beat, consciously or subconsciously, if our perception is to match the composer's intentions. In Example 3/57, the quaver rest is undoubtedly a structural rest, a hiatus, and its perception does not conflict with any alternative structure. In two celebrated examples, however (Examples 3/58 and 3/59), there is a temporary metrical ambiguity between the notated structure that presumes the anticipated beat (Examples 3/58a and 3/59a) and an alternative one which does not (Examples 3/58b and 3/60). In the case of the Brahms example, it is particularly common for the alternative structure to be heard in preference to the syncopated one, especially since the quaver rests that precede and end the passage can be heard as breathing pauses and the theme that follows has previously been heard beginning on a downbeat (Example 3/60). In these two examples, the alternative structures by no means invalidate the notated ones since the latter result from multiples that are very well established. By contrast, it was noted in the previous subsection that if a newly established multiple is challenged by a simpler structure soon after it has been asserted, it is highly likely to fail. This process is not unrelated to the size of the multiple concerned. It has been stated above that a relatively large multiple can accommodate smaller durations which are incongruent with its regular subdivisions. On the other hand, a relatively small multiple is hard put to partition a succession of longer durations, except by conscious awareness of the metrical accents, for which the multiple would normally require support from other characteristics (resulting in overt syncopation). The opening voice of the D minor fugue from Book 1 of <u>The Well-Tempered Clavier</u> serves as an example in which duration contour suggests a multiple (6) which would immediately be at odds with the subconscious counting that measures the subsequent three durations (Example 3/61). The choice is straightforward: either the crotchets are subordinate to the given multiple or the metre must fit round them. The evidence from this and many other examples is that the latter course is chosen: durations that are longer than, and incongruent with, a preceding newly established multiple (or potential multiple) tend to establish points around which the previous metre conforms. This tendency is particularly relevant to the perception of initial upbeats, as will be considered below.

5. Upbeats

The tendency for metre to follow duration contour does not necessarily mean that each time a duration is encountered which is longer than the previous longest one, it must be seen as the start of a new metrical timelength on the next level. Even where there is no conflict between duration contour and the preference for regular metre, such a view could, in many cases, lead to several layers of upbeats, as in Example 3/62. The structure of Example 3/62 is as misleading as it is intuitively wrong. It is misleading because it assumes that the flow of rhythmic momentum towards relatively long durations as points of closure can only be expressed in the metrical terms of upbeat and downbeat. This is not so: it has been shown above that such durations tend to create natural phrase groupings because of their relatively greater separation from other durations; since music flows in time, the momentum toward these relatively long durations is assured before metrical connections are included in the analysis.

Example 3/62 is intuitively wrong because it is too complicated: in order to balance the upbeats to the breve multiple (32) it is necessary to remember an upbeat structure of 1+4+16 (the 16 being metrically subdivided into 8+8). If a metrical timelength were to begin on the final duration, the breve itself would be added to this list (1+4+16+32). The balancing of upbeats is not a theoretical nicety but is simply the means by which the final metrical unit of an upbeat phrase is perceived as having a metrical timelength greater (by the length of the upbeat structure) than the sum of its own durations. In Chapter 2, the creation of an upbeat structure was seen as a displacement of the higher-level structural grouping from the position it would occupy at the start of the phrase if there were no clear reason for an upbeat. Although the perception of two non-adjacent relatively long durations is often sufficient reason for a metrical connection between them, it was also observed in Chapter 2 that the perception of a metrical timelength depended on the size of the real timelength involved, itself affected by tempo, and it seems likely that tempo similarly affects the creation or otherwise of upbeat structures.

As an example, the simple duration string of Example 3/63, as perceived at 𝅗𝅥 = ca.40 (1.5"), has two phrase groupings on one level which are joined by a structural grouping on the next level only by default: there is apparently not enough momentum to produce a metrical connection between the longer durations. At four or more times the speed, on the other hand, this connection is assured (Example 3/64). Since the first bar of the 'Marseillaise' is four times the length of the second-level upbeat, one is easily persuaded, with a little imagination, that it, too, could function as an upbeat at four times the speed; whether the result would still be heard as the 'Marseillaise', however, is open to doubt. Moreover, at such a tempo, in order to accommodate the largest timelength (16) as an upbeat, the smallest timelength (1) would hardly be articulated at all. Thus the combination of tempo and a wide range of upbeat timelengths may be responsible for the tendency for no more than two layers of upbeats to precede an initial main downbeat.

While tempo is a significant factor in the perception of initial upbeats, it cannot be isolated from other considerations, even within a duration string alone, quite apart from the effect of other structtural characteristics. The tendency for metre to follow duration contour is paralleled by a resistance on the part of relatively long durations against being incorporated in metrical units in which, though structural accents, they are nevertheless incongruent with the prevailing metre, as in Example 3/65. More specifically, if the establishment of a certain higher-level structural grouping would result in the structural grouping on the next-lower level having unequal timelengths such that the first timelength was less than any of the subsequent ones in the grouping, then the proposed higher-level grouping will not be established unless it is congruent with at least one more powerful structural characteristic or perceptual preference. Without the aid of any other characteristics or preferences, the higher-level grouping will begin on the longer or longest of the lower-level timelengths. The word 'timelength' in this context refers to the metrical timelength of a lower-level branch, failing which, the duration specified by that branch. Thus the simple duration string of Example 3/65 will have the structure of Example 3/66 unless some more powerful characteristic (for example, dynamic accentuation or a longer-note accompaniment) suggests a higher-level grouping on the initial crotchet (Example 3/67). In accordance with the structural type of Example 3/53, the initial crotchet timelength of Example 3/65 does not partition the following minim to produce a consciously perceived metrical accent: the minim groups the crotchet pulses into a sounded attack plus an unsounded consciously perceived one (Example 3/68).

If the lower-level timelengths are equal, however, tempo can influence the placing of the higher-level structural grouping, as seen in Example 3/63 and the 'Marseillaise' (Example 3/69). While the effect of other characteristics and preferences means that there is little to be gained from trying to assess the precise critical tempo above or below which our perception of metre in a duration string will change, for equal lower-level timelengths, as a rule of thumb, the range MM 66 to 80 (.91" to .75") seems to be the 'borderline area' within which it is uncertain whether a metrical timelength will be heard as an initial upbeat structure, following duration contour, or as a default downbeat structure positioned on the potential upbeat because of insufficient tempo.

By comparison, when the lower-level timelengths are unequal, the critical tempo below which a default downbeat may be perceived is much lower. While Example 3/70, with equal lower-level timelengths and at 𝅗𝅥.=ca.76 (.79"), does not establish an upbeat, Example 3/71, at ♩=ca.60 (1") and with an opening duration string like Example 3/66, does do so. Similarly, the opening crotchet of Example 3/72 is an upbeat, though at ♩=ca.54(1.11"), because it is succeeded by a timelength five times its length, generated by the conjunction of harmonic rhythm with durational phrase grouping. On the next level, however, the timelengths generated by harmonic rhythm, though in the proportions 1:2, do not form an upbeat structure in the manner of Example 3/66. At this level, the real timelength of the multiple is 6.66" or 𝅝.=ca.9. Only if the theme is imagined at about three or more times this speed, say 𝅝.=30(2"), does a sense of upbeat begin to emerge.

It should not be inferred that the failure to establish an upbeat structure at a slow tempo means that any metrical connection established by default on the potential upbeat will necessarily have a powerful metrical accent. There is not simply 'metre': rather, the quality of a metrical connection is determined by the strength of the structural characteristics and perceptual preferences that have generated it. Like the automatic continuance of a multiple and the implied subdivision of a metrical timelength, both also established by default, structural groupings created by the failure to establish an upbeat are relatively weak, that is, they may not give the impression of a strong downbeat. This weakness is consistent with Cooper and Meyer's observation of predominant end-accented groupings in such cases[15] and goes some way towards explaining Riemann's obsession with upbeat structures, since the next step is to put a metrical interpretation on the end-accents. In his consideration of harmony and melody in Dynamik und Agogik, Riemann finds many dynamic contours which parallel end-accented iambs (Example 3/73) and which, if seen in the same way as his dynamic contours for duration strings alone, would define a spurious upbeat-downbeat structure.[16]

With some examples, usually within the 'borderline' range of tempi around MM 66 to 80, there may indeed be a genuine metrical ambiguity between an upbeat interpretation following duration contour (Example 3/74a) and the default structure with its weak downbeat (Example 3/74b). At slower tempi, it can be tempting to take the Riemannesque view that one is hearing a true upbeat-downbeat structure, as shown in Example 3/75a. In such cases, it must be asked whether the music is really heard in the same way as some overtly upbeat variant (Example 3/75b); if not, it is likely that it should have a default downbeat structure (Example 3/75c). A clear example of the distinction between default downbeat and true upbeat structures is given by Beethoven in the two versions of the main theme in the finale of his Third Piano Concerto, the first of these (Example 3/76) being

15. Cooper and Meyer, The Rhythmic Structure of Music, op. cit., p.92, Ex.105.
16. Riemann, op. cit., pp.186-7.

about half the speed (𝅗𝅥=ca.58 or 1.03") of the second (Example 3/77), whose specified tempo is ♩.=112(.54").

The tendency for duration contour to create initial upbeats raises the question of the metrical organisation of the upbeat structures themselves. Any metrical timelength established at the start of the first relatively long duration, or any equivalent timelength,[17] has a reprospective effect on what precedes it. Thus in Example 3/78a, the 3/8 metrical timelength from duration contour partitions the preceding quavers retroactively and in a retrograde fashion. The two groups of three quavers then suggest the multiple 6, which is confirmed by the subsequent phrase grouping and metre (Example 3/78b). If the upbeat or potential upbeat is not long enough to be partitioned by a subsequent multiple, it is interpreted in accordance with any metrical subdivisions of that multiple. Thus the upbeat of Example 3/79a is interpreted as a triplet and that of Example 3/79b is not.

It is, however, possible for a metrical structure to be fitted round a relatively long duration as soon as the latter is encountered, before the multiple from duration contour or any equivalent timelength has been established. Thus the structure of Example 3/80a is perceived before a combination of repetition, a connection between two structural accents of duration contour, and tempo assign a higher-level branch to the dotted crotchet (3) (Example 3/80b). That the metrical organization of the initial quavers in Example 3/80 is independent of the length of the subsequent longer duration is easily demonstrated by varying the latter (Examples 3/81a and 3/81b). It seems, then, that it must be perceptual preference among the various

17. Such a timelength might be produced by, for example, harmonic rhythm, a longer-note accompaniment, repetition, or pitch patterning.

possible multiples which suggests a metrical organization for such initial equal durations.

Example 3/82 shows, in their probable order of preference, the likely metrical schemes for upbeats or potential upbeats of up to eleven equal durations. In most cases it is felt that there is a preference for binary to ternary metre, in addition to the preference for either of these to the multiples 5 or 7. A computer program could safely regard the first choice in each case as the definitive suggested metre, since it is only a default structure capable of being overturned either by the subsequent metrical organization or by other structural characteristics operating on the upbeat itself, the most likely of these being pitch patterns or implied tonal characteristics. The latter possibility becomes progressively more likely as the number of upbeat durations increases, and the validity of the first choice correspondingly decreases.

6. The metrical algorithm of Longuet-Higgins and Steedman

Several of the ideas that have been put forward in the foregoing subsections echo the parsing rules used by Longuet-Higgins and Steedman in their metrical algorithm.[18] This algorithm operates on durational information alone and appears to be the only computer program to date which has attempted to mimic the human perception of metre.[19] Despite the apparently *ad hoc* nature of Longuet-Higgins and Steedman's rules and the admission that they 'have not been informed by any methodological principles',[20] their similarity to

18. H.C. Longuet-Higgins and M.J. Steedman, 'On Interpreting Bach', in *Machine Intelligence 6*, edited by Donald Michie (Edinburgh, 1971), pp.221-239.
19. It has since been developed to analyze input from live performance on an electronic keyboard. See H.C. Longuet-Higgins, 'Perception of melodies', *Nature*, 263 (1976), 646-653.
20. Longuet-Higgins and Steedman, *op. cit.*, p.223.

the above ideas allows them to be set against at least one theory of rhythmic structure and affords a critical appraisal of their strengths and shortcomings.

The purpose of the authors' program is to deduce the time-signature and key-signature from the durational and pitch values of a single musical line,specifically in Bach's fugue subjects from The Well-Tempered Clavier. Although the metrical and harmonic analyses are treated as two quite separate operations, the stylistic limitation of the diatonic key-system permits the assumption of regular duple or triple metre at every level considered. Thus the principal question that the algorithm faces is when to increase the existing multiple by a factor of two, three, or a multiple of either of these, since an established multiple is never abandoned in favour of a shorter one or one with which it is incongruent.[21]

Having excluded the possibility of metrical timelengths that are not multiples of two or three, Longuet-Higgins and Steedman then attach particular significance to the dactyl as the generator of a multiple, a dactyl being defined as 'the first three notes in a group of four, such that the second and third are equal in length and shorter than the first or the fourth'.[22] In seeing the dactyl as bounded by two longer durations, rather than simply as a long note followed by two shorter ones, Longuet-Higgins and Steedman go some way towards the present view in which a metrical connection between the two 'longs' establishes the dactyl as a potential metrical timelength generated by duration contour. The authors consider treating in similar fashion the trochee's pattern of a single shorter

21. ibid., p.226. For the present term 'multiple' the authors use the term 'metrical unit'.
22. ibid., p.227.

note bounded by two longer ones, but draw back from doing so, citing the D♯ minor fugue subject of Book 1 as a problematic example in this respect. The consequence of treating the trochee like the dactyl might have been the present view that the former is a potential generator of metre, although its effect may be surpassed in certain examples by other structural characteristics. In the D♯ minor fugue, duration contour might in fact establish a metrical timelength at the beginning of the dotted-note figure, but for the combination of a tonic on the opening note and a moderate tempo. The position of entry of the second voice is also against such a structure.

In their avoidance of a solution that would have posed questions about the possibility of further characteristics, Longuet-Higgins and Steedman adopt the following rule:

> When a note falling at the beginning of a metrical unit is followed by a single shorter note (which is followed by a longer note), the metrical unit is to be doubled, trebled, etc., only if the length of the first note minus that of the second is a reasonable number of current metric units.[23]

A 'reasonable number' is defined as an integer whose only prime factors are two or three. Similarly, they rule:

> When a dactyl occupies an 'unreasonable' number of current metrical units, then the metrical unit is to be doubled, trebled, etc., only if the length of the first note minus the combined length of the two short notes is a reasonable number of current metric units.[24]

This curious subtraction of the smaller note or notes is given no musical justification. It leads to the correct multiple 6 in Fugue 14 of Book 1, as the authors show, but only by accident; if Fugue 5 of Book 1, which the authors also cite in connection with this rule, were played in double-dotted fashion (Example 3/83a), the

23. ibid., p.228.

24. ibid.

'subtraction rule' would again lead to the multiple 6, but this time incorrectly (Example 3/83b).

Except where the subtraction rule or the dactyl rule is applicable at the beginning of a piece, Longuet-Higgins and Steedman consider that the first duration always defines a multiple at some level of the hierarchy. This is generally true, but does not provide for the situation envisaged in Example 3/44, in which an initial dotted note is perceived in duple metre and does not define a multiple. In Longuet-Higgins and Steedman's concept, the dotted note would have to be followed by a shorter note or notes, then by another relatively long duration, before it could be seen as belonging to a metrical unit longer than itself.

A further rule is that an existing multiple may be increased by a factor of two or three if it falls at the beginning of (a) a sequence of notes to which the subtraction rule or dactyl rule applies, or (b) a note which is two or more times its length, in which case the current multiple is multiplied by the largest 'reasonable number' of times that it may be divided into the longer note or timelength. This rule envisages circumstances similar to those considered in the subsection on syncopation, namely those in which a multiple encounters a greater duration or timelength; but the rule assumes that if the existing multiple does not fall at the beginning of the duration or timelength, it will be continued, as is the dactyl in Example 3/84a. The present view is that unless the multiple is well established or supported by other characteristics, it is liable to fail (Example 3/84b).

Longuet-Higgins and Steedman believe that a duration or dactyl that is as long as the current multiple has special prominence: is 'marked for accent'. Thus they put forward what they call the 'isolated accent rule':

> If, in the current metre, a unit which is marked for accent is followed by a number of unmarked units, and then by another marked unit, which in turn is followed by an unmarked unit, then the two marked units are taken to establish a higher metre, in which they occur on successive accents.[25]

The higher metrical timelength must, of course, be a 'reasonable number' of lower-level units. The perception of a metrical timelength between two relatively long durations is directly comparable with the present theory and it is surprising that Longuet-Higgins and Steedman have not been prepared to generalize the concept, particularly in regard to the trochaic patterns to which they apply the subtraction rule. Indeed, it appears that the 3/4 multiple in Example 3/85 could only be found indirectly through the isolated accent rule, since the subtraction rule and the initial duration would both establish the incorrect multiple 2. Presumably, when the crotchet is encountered, the initial minim is revalued as a multiple twice the length of a crotchet; the minim will then be marked for accent and related to the following minim, similarly marked. If the metrical algorithm in its original or modified form does not contain some such procedure for trochees, it must be seriously flawed; yet, if it does apply the isolated accent rule in such circumstances, the subtraction rule seems to be rendered superfluous for all trochees that are followed by a longer note.

The inclusion of the dactyl under the isolated accent rule may produce correct results in certain circumstances, but is musically unsound. In Example 3/86, the metrical connection from duration contour should be between the first crotchet and the crotchet that

25. ibid., p.229.

follows the dactyl; it seems, however, that Longuet-Higgins and Steedman's isolated accent rule would mark the dactyls for accent and produce a metrical timelength between them. It is certainly true that the application of the isolated accent rule to dactyls is vindicated in the example the authors consider - Fugue 2 of Book 1 (Example 3/87) - but the minim multiple falls where it does (as opposed to beginning on the first quaver), not because of any metrical connection between dactyls, but because of the descending pitch sequence A♭-G-F-E♭ in conjunction with repetition, a structural characteristic of pitch patterning that will be called a 'moving voice' (see Chapter 4, Section A).

Despite the comparative success of Longuet-Higgins and Steedman's metrical algorithm with the material for which it was devised, its over-riding limitation is the assumption that duration alone is responsible for metre. From the different aspects considered in the foregoing sections, it should be apparent that, as a generator of metre, duration suffers from potential structural ambiguities between several interdependent processes: (1) the initial duration is important to the process of counting duration lengths and may function as a multiple, but it may be overshadowed by longer groupings in both respects, generated by (2) perceptual preferences for certain multiples and by (3) the structural timelengths from duration contour. Such timelengths may establish a multiple in opposition to future relatively long durations, but the success of this depends on (4) preferences among multiples and (5) the desire to avoid syncopation if the incongruent durations are too long and appear too soon. Yet (6) the conformity of metre with duration contour does not necessarily extend to multiple layers of upbeats: insufficient tempo and the equality of lower-level timelengths help to stop that. Finally, (7) the metrical structure of a duration string is open to the powerful influence of repetition, which will be considered below (see Section C) but which is not mentioned by Longuet-Higgins and Steedman. None of these seven factors has any absolute sway over metre; it is necessary to consider the influence of more powerful characteristics, especially those of tonal harmony. Their effect is illustrated in just a single theme by Bach (Example 3/88) which, on durational information alone, would be given a coherent, but erroneous, interpretation by Longuet-Higgins and Steedman's algorithm (Example 3/89).

B. DURATION CONTOUR AND PHRASE GROUPING

It has been shown above that duration contour can give rise to a pre-metrical form of phrase grouping, but it still remains to place the concept of durational phrase grouping in a metrical context and to consider its effects, if any, on the perception of metre. To meet the notational requirements that this involves, some Separation Rules will be put forward, which aim to separate phrase groupings from each other within the present tree-diagram notation, in particular by distinguishing between upbeat and afterbeat structures. A phrase grouping generated by duration contour will be termed a duration phrase. The Separation Rules attempt to treat durational phrase grouping as an individual and independent entity within musical structure and, in so doing, serve to highlight its ambiguities and weaknesses as such. For while certain duration strings seem to present clear and unambiguous grouping, in others the grouping is not so clear and is therefore more prone to influence from other characteristics. Although ambiguous grouping is a perfectly natural and predictable aspect of perception, it can sometimes make the formulation and application of Separation Rules seem arbitrary or tentative. Yet the alternative of devising enough rules to cover individual ambiguous structures seems quite impracticable at present and it is better to consider ways in which the strength or weakness of a duration phrase may be judged from the pattern of durations that gives rise to it.

The possibility of showing ambiguous duration phrases as separated groupings within metre comes from the separation of afterbeat as well as upbeat structures, which was mentioned in Chapter 2. This separation is illustrated by Example 3/90 and may be formalized by the following rule:

> Where (1) a structural grouping formed on the higher of two adjacent levels makes a metrical connection between notes specified by two non-adjacent branches on the lower level, (2) the beam of the lower-level grouping is joined to both of these branches, and (3) the formation of the higher-level grouping does not cause another Separation Rule to delete a portion of the lower-level beam, then the rightmost portion of the lower-level beam is deleted. (Separation Rule 1)

As outlined in the last chapter, a phrase grouping whose identity is established on the level of a particular structural grouping is the tree consisting of that structural grouping and all subtended structural groupings. This tree specifies a unique string of notes in the musical line. Although not all tree structures separated by Separation Rule 1 are phrase groupings, provision has been made for denoting a phrase grouping by placing an asterisk after its highest-level structural grouping. Yet, because of the ambiguity of some groupings as duration phrases, there is an advantage in not having to decide whether a certain separated grouping is or is not a valid duration phrase in order to place an asterisk; it should be possible instead to read most duration phrases within metre from the duration values themselves, without the need for asterisks. Thus, before considering further the relationship between the present tree-diagram notation and the pre-metrical analysis, it will be useful to specify how unambiguous duration phrases may be read within the tree-diagram notation.

The essence of durational phrase grouping within metre, as within its pre-metrical analysis, is the capacity of relatively long notes to act as points of cadence, or <u>duration closure</u>. <u>Strict duration closure</u> may be defined as occurring on a note which is longer than all preceding durations in the string concerned or which is the last in a sequence of equal durations the first of which satisfies this condition. However, as is illustrated by several of the following examples, it seems that the last note of a duration phrase need not always be a point of strict closure and that a duration may often be balanced by a subsequent duration of the same length and sometimes by one of a shorter length, if such equal or shorter durations are themselves points of duration closure, preceded by shorter durations. To decide whether a separated structural grouping indicates the separation of a duration phrase, the duration string specified by the entire tree subtended from the structural grouping should be read first, just as if the tree structure were a phrase grouping:

> Subject to the provisions of Closure Rules 2 to 4, if the last duration of the string specified by a separate tree structure has the greatest value and at least one member has a lesser value, the string identifies the tree as a duration phrase. (Closure Rule 1)

Example 3/91 illustrates this rule, duration phrases which are defined correctly by the rule being marked with asterisks. Other strings, such as 1 1 2 2 in Example 3/91c, which identify duration phrases according to the provisions of the rule, but which are invalidated as such by Closure Rules 2 to 4, are not marked. As outlined in Chapter 2, the asterisks are placed at the end of the duration phrase concerned and at the level on which its tree structure forms a separate entity, the effect of an asterisk covering all points vertically below it so that, for example, the string 1 1 2 2 in Example 3/91b identifies a duration phrase. This phrase grouping also shows that if a duration is immediately followed in the same structural grouping by one of equal or greater length, its capacity for closure passes to the latter duration.

The exceptions and qualifications to Closure Rule 1 are mainly concerned with structures which result from Separation Rule 1 and which would not have been classed as duration phrases on the former highest level, before the formation of the structural grouping which brings Separation Rule 1 into operation. The first of these exceptions is as follows:

> A duration cannot mark the end of a duration phrase if the next duration is equal to or greater than it, unless it falls at the end of a metrical unit whose duration string identifies a duration phrase. (Closure Rule 2)

The main purpose of this rule is to eliminate as identifiers of duration phrases strings such as 1 1 2 2 in Example 3/91c, which would have had the structure of Example 3/92 before the perception of the next-level structural grouping. The qualification to the rule has been added to deal with progressive closure of the type illustrated in Example 3/93. A succession of duration phrases is perceived in this example because each is congruent with the content of a metrical unit which, as a structural unit in the general sense, is perceived as an entity in its own right, following the mental connection between the two structural accents that bound it. The beginning of any metrical unit may be seen as the start of a potential duration phrase, irrespective of any preceding upbeat, although, if there is an upbeat, it is normal for the phrase grouping that includes it to be predominant, unless the duration phrase which begins on the following downbeat is highlighted in some way, for example by repetition.

In Example 3/93, each point of closure is immediately superseded in its effect by a longer duration; hence the use of brackets round the asterisks. There can be no suggestion that the single notes sandwiched between two points of closure are phrase groupings and a computer would have to take this into account. On the other hand, the temporary nature of the closure does not invalidate it altogether. In Example 3/94, where repetition highlights three identical duration structures, it could hardly be said that all were duration phrases except the last. Furthermore, if temporary closure were a means of invalidating a duration phrase, there would have to be a hidden rule of composition that no new phrase could start on a duration longer than that which ended the preceding phrase. This is plainly ridiculous, as is illustrated by Example 3/95, in which both the independence and linkage of the bracketed phrase grouping can be perceived.

A similar rule to Closure Rule 2 is as follows:

> Subject to the provisions of Closure Rule 2, a duration cannot mark the end of a duration phrase if the next duration on the same level, though separated from it, is equal to or greater than it, unless it is a point of strict duration closure. (Closure Rule 3)

The qualification to this rule covers the temporary closure of duration phrases which are followed by an upbeat, such as those of Example 3/96. The rule itself is designed to invalidate as duration phrases structures such as those bracketed in Example 3/97a, which would formerly have been as in Example 3/97b. These structures also involve repetition and are invalidated on that count by Closure Rule 4:

> If the duration string specified by a separated tree structure, or such a structure plus any succeeding upbeat duration, can be subdivided into a succession of (non-overlapping) identical duration strings, the separated structure is not valid as a duration phrase. For the purposes of this rule, a tree structure may be considered without any preceding upbeat, unless it is followed by an upbeat of equivalent length; if the resulting structure is invalidated by the rule, the structure including the upbeat is also invalid. (Closure Rule 4)

This rule considers duration strings such as those bracketed beneath Example 3/98. Where two brackets are shown, the shorter bracket is that which identifies the invalid duration phrase. 'Succeeding upbeat durations' are to be understood as those immediately following the duration string specified by the separated structure and are appended to that string in turn. Hence in Example 3/98d it is necessary to examine only the first two durations of the upbeat. The second clause, concerning upbeats, invalidates structures such as that identified by the string bracketed beneath Example 3/98e; the qualification about a succeeding upbeat is designed to avoid eliminating structures that involve upbeat repetition, as in Example 3/98f, whose bracketed strings do identify duration phrases. Both upbeat repetition and the reasoning behind Closure Rule 4 are discussed in Section C of this chapter.

Having considered how unambiguous duration phrases may be read within the present tree-diagram notation, attention may now be given to the separation of such phrase groupings within metre. The greater part of this process is carried out by the lower levels of the pre-metrical analysis. If connecting brackets representing metrical connections (marked 'M') are added to such analyses, they supersede any higher-level or incongruent pre-metrical brackets. Yet this does not mean that the larger-scale phrase groupings of the pre-metrical analysis are entirely irrelevant, since there is a general tendency for duration closure to be independent of metre.

Example 3/99, taken from the opening of Ravel's Piano Trio in A Minor, shows three possible metrical interpretations of the repeated pre-metrical phrase grouping represented by the string 2 3 1 3 1 2 4. The first of these is generated by the multiple from duration contour; the second by the effect of a longer-note accompaniment; the third is how Ravel wishes the theme to be heard and would follow from the slight dynamic accentuation of the first chord. Although the duration phrase of each interpretation is different in character, the pre-metrical grouping is common to them all. A particular metrical scheme or the influence of other characteristics may cause our perception of the pre-metrical grouping of duration to be altered; nevertheless, such grouping forms the basis of a common denominator of phrase grouping within many different actual or potential metrical schemes at higher levels.

One question which arises from the addition of metrical connecting brackets to the pre-metrical analysis is illustrated in Example 3/100. In this example, the middle-level connecting bracket (marked 'M') has been added in between the two brackets generated by the pre-metrical procedure and corresponds to the (crotchet) multiple 2 produced as much by automatic repetition of the metrical timelength put forward by the initial duration as by subdivision of the higher-level multiple 4 from duration contour. Example 3/100 differs from the present tree-diagram notation (Example 3/101) in showing the separation of each duration phrase whose string is 1 1 2 as existing on the quaver level only, as opposed to the crotchet level in the latter diagram. This duration phrase does indeed exist at the quaver level, but at that level the perception of the '2', both as a duration and as a point of duration closure, must wait until the following missed quaver pulse (shown by a dot in the graph) has been counted, consciously (Example 3/102a) or subconsciously (Example 3/102b). It is evident from Example 3/102 that the added unsounded quaver pulse is only another means of understanding a crotchet and that duration closure and the separation of phrase groupings are both implied on the crotchet level and should be indicated on that level.

In general, the notational choice is between indicating the separation of phrase groupings on the lowest or highest level only, since it would be hard to specify any more suitable level in between these two extremes, with the number of possible levels varying from one example to another. The present tree-diagram notation adopts the latter choice, separating phrase groupings on the highest possible level, which is normally one level below that on which the whole phrase grouping is, or could be, subtended by a single branch (Example 3/103a). However, separation of a phrase grouping on the highest level does not deny that the same phrase grouping may have been recognizable on a lower level when less metrical information had been deduced, whereas separation on the lowest level alone does deny the existence of the grouping on any higher level, as seen in Example 3/103b whose structure mirrors that of the connecting brackets underneath. Example 3/103 also illustrates a further problem that can arise from separating phrase groupings on the lowest level only: the phrase grouping indicated by the bracket beneath Example 3/103a appears as a separate structure in that example's tree-diagram but not in that of Example 3/103b.

In the pre-metrical bracketing and the tree-diagram notation, a broken line will indicate that a beam is marked for separation (Example 3/104). In the tree-diagram notation this separation will normally be realized on the establishment of the next-level structural grouping. The broken line preserves on the same level both the continuity of grouping and the likelihood of separation, the former being important in cases such as those of Example 3/105. Here, repetition (marked 'R') strongly suggests the possible ending of a phrase grouping before the first note of repetition, though in contradiction to the pre-metrical grouping. Since the suggested structure is found to be a viable duration phrase, it tends to predominate, although the alternative separated grouping is still latent and can be brought to the fore by other characteristics, for example pitch patterning (as in Example 3/106). With confirmation of the repeated structure as a phrase grouping, the broken line may be replaced by separation or a full line (Example 3/107).

The separation in Examples 3/105c and 3/107c of the duration phrase whose specified string is 1 1 2 2 may seem to contradict the continuity of grouping of the earlier-beginning duration phrase whose point of closure it shares, yet the denial of the smaller phrase grouping would convey less information (Example 3/108). In fact, such shared closure is not unlike progressive closure in that, in both, a duration phrase that is a subset of another duration phrase may have a set-complement that is not itself a phrase grouping (see the Venn diagrams in Examples 3/109 and 3/110). In both shared and progressive closure, the status of the subset phrase grouping as an independent entity is severely weakened, unless, in the case of shared closure only, it is a duration phrase that begins at the start of a metrical unit. Thus in Example 3/111, where three duration phrases share the same point of closure, the middle-sized one is especially weak and the smallest one less so, though less prominent than the largest. The similarity between shared closure and progressive closure in respect of weakened duration phrases is illustrated by Examples 3/112a and 3/112b respectively. There is very little difference between the phrase grouping of the string 1 1 2 8 in either example, since in both cases the independence of the subset grouping is diminished relative to the overall structure (which is virtually identical in both versions). Only if such weakened or diminished independence is understood in its context can the larger phrase grouping be seen as predominant.

With the use of broken lines to mark phrase groupings for separation and with the allowance for the effect of repetition in suggesting possible phrase grouping, the separation of duration phrases begins to be visible within the pre-metrical form of analysis altered by the addition of metrical connecting brackets. Example 3/113 is a simple case of a repeated pre-metrical grouping (the repetition being marked 'R') with a higher-level metrical bracket added and marked for separation accordingly. The added application of Separation Rule 1 is all that is needed to turn the structure of connecting brackets into the equivalent of the present notation.

The Separation Rule that governs the assignment of broken lines is as follows:

> A pre-metrical grouping or its equivalent, which has been passed as a phrase grouping, establishes an imaginary vertical boundary line at the attack point of its first duration (or structural rest or equivalent) and at the attack point of the first duration (or structural rest or equivalent) which follows the grouping. Any beam which this line crosses, up to but not including the level at which the grouping would be subtended from a single branch, is replaced by a broken line to mark it for separation. (Separation Rule 2)

Examples 3/115a to 3/115e illustrate the application of this rule to mark phrase groupings for separation. The principal pre-metrical groupings and metrical connecting brackets are shown underneath, the latter being accompanied by the reasons for their generation. In assigning broken-line beams within the pre-metrical style of notation (including metrical brackets) it should be remembered that where the last duration of one pre-metrical grouping is shared by the first duration of another, the two form a joint grouping (Example 3/114).

Separation Rule 2 refers to the perception of phrase groupings and their equivalents (including pre-metrical groupings), rather than simply duration phrases; the pre-metrical analysis of duration is seen only as an initial perceptual operation whose groupings may be superseded or added to by the effect of other structural characteristics or combinations of characteristics, including certain aspects of duration itself (the so-called 'ambiguous' duration phrases discussed below). The rule is envisaged as following the perception of phrase groupings (or equivalents) and preceding the perception of metre and the application of Separation Rule 1. These three operations form a cyclical procedure which, in a computer program, might be applied several times throughout the process of transformation from pre-metrical structure to full metrical tree-diagram, since metrical groupings can follow from the perception of phrase groupings and _vice versa_. Thus, an alternative version of the cycle is: metrical connection, Separation Rule 1, perception of phrase grouping, Separation Rule 2.

As an initial conception for such a computer program, it may be imagined that the perception of metrical connections would proceed from the lowest to the highest levels, with tests being made at each stage for the status of phrase groupings already perceived and for the perception of new ones. In practice, however, considerable ambiguity could be avoided if new metrical connections were not constructed in this way and it is highly likely that our own perceptual processes are much more flexible; the amount of information embraced within our perceptual 'now' at the normal range of tempi is often sufficient to cover more than one or two metrical levels and subdivision of a given metrical timelength or phraselength is thus a common feature of metre and an adequate explanation for the generation of many structural groupings. Harmonic rhythm and a longer-note accompaniment (Chapter 4, Section D and Chapter 3, Section D, respectively) are each especially important as generators of subdivisible metrical units.

The perception of metre aside, Separation Rule 2 is designed to follow the perception of phrase groupings in a pre-metrical or metrical context. As far as duration is concerned, with one exception, separated pre-metrical groupings conform to the definition of strict duration closure, rather than to Closure Rule 1. That exception concerns what may be termed 'unclosed' pre-metrical groupings, in which a duration is grouped with the preceding longer duration instead of with the succeeding longer one. Such groupings are not counted as duration phrases by any of the Closure Rules; neither are duration strings such as that marked 'X' beneath Example 3/116, although, in context the separation of either type is akin to that of a phrase grouping if it is not simply the product of Separation Rule 1. The purpose of forming unclosed pre-metrical groupings is, in any case, not so much to create such groupings as entities in their own right, as to avoid the alternative of inevitably grouping the shorter duration with the succeeding longer one, however distant. Unclosed groupings are subject to the provisions of Separation Rules 3 and 5 below and can be superseded accordingly.

The variance between strict duration closure and Closure Rule 1 poses a problem for the analysis of durational phrase grouping at the lowest levels. In some cases, the continuity of grouping, which is one interpretation of the broken-line beams, in conjunction with Closure Rule 1, would permit the recognition of strings which seem to have little relevance as identifiers of phrase groupings, such as 2 1 1 2 2 2 in Example 3/105c. In other examples, however, the denial of such strings would not match musical commonsense, missing the string 4 2 1 1 2 2 4 in Example 3/117, for instance. The importance of recognizing this latter string as a phrase grouping four beats long is that it results in, rather than from, the metrical subdivision which is shown in Example 3/117 in anticipated form as a broken-line grouping on the next level. In other words, metre cannot be relied on as the sole means of joining phrase groupings into larger groupings; they may be concatenated on the one level.

Examples 3/118a to c and 3/115a display a succession of separated duration phrases in which the closure is cumulative, the first point of closure being hierarchically subordinate to, though independent of, the second, while in Example 3/118b the second gives way to the third as well. Logically, it seems that there must be some perceptual preference governing phraselengths, so that some concatenations are more suitable than others; otherwise there would be no true hierarchy of phrases resulting from successive closure, merely continual additive growth. In practice, metre and the characteristics which generate it both confound and help to solve this question. In particular, most additive phrase groupings that are not binary or ternary are contained within points of repetition, as in Example 3/119. So is the ternary grouping in Example 3/118a; despite the repetition that extends a two-bar phrase into a three-bar one, the latter would have no independent existence if it appeared as in Example 3/120. Yet that is not to say that binary grouping cannot give way to ternary grouping without the latter being bounded by repetition: it does so in Example 3/121. Likewise, a ternary grouping can (despite Example 3/120) be a subset of a four-bar grouping (Example 3/122). Either seems preferable to a grouping based on a higher prime number, however, as will be seen in the comparison of Example 3/134 with Example 3/119.

Although binary and ternary duration phrases can be subordinate to each other, binary phrase grouping is particularly prominent in (at least) Western music and special significance can be attached to this, whether its origin is a perceptual or cultural preference. It is possible to find many instances like Example 3/117 in which the perception of four or eight equal metrical units gives rise to a higher-level binary subdivision, the latter having little or nothing else to generate it. Four is, of course, the smallest possible phraselength that can produce such subdivision, and is the most common type. The groupings concerned will thus be called <u>four-groupings</u> (for want of a better term) and those of a different length may be named after their own number of highest-level branches.

Some examples of four-groupings and eight-groupings are shown in Example 3/123. To these may be added Examples 3/118b and c, 3/117, 3/116, and 3/115a. A case can be put for some direct perception of a binary structure in Example 3/123c, with its changes of harmony, and in Example 3/123b, with its return to the tonic. In general, however, the implied subdivision is weak. This is attested by both Examples 3/123a and 3/123b, which have very little sense of the duration of closure falling on an afterbeat and, in the latter, very little sense of a structural rest. But to say that the implied subdivision of four-groupings was unnecessary would be inconsistent with the structural rests that it produces in Examples 3/118b and c, both of these examples being considered without their accompaniments which produce overt syncopation on the unsounded metrical accents concerned. There is some evidence that certain four-groupings which are not duration phrases according to the Closure Rules may nevertheless be perceived, at least to some extent, as independent entities and these structures will be considered below.

Two other principles affecting the separation of phrase groupings will be put forward first, however. The first is that unequal metrical timelengths may establish a pattern akin to duration contour, which may be termed <u>metrical contour</u>. The similarity between phrase grouping by metrical contour and that by duration contour is illustrated in Examples 3/124a and 3/124b. In comparing the unsounded metrical accents of these examples, it is impossible to say where the counting of duration ends and that of metre begins, since the unsounded pulses have the same function in the two cases. So close is the parallel that the grouping function of metrical contour is usually covered adequately by that of duration contour.

However, the pre-metrical analysis groups on the basis of durations alone and can take no account of the eventual metrical structure within which these durations will be framed. Within a given triple metre, the grouping of the upbeat with the following downbeat in Example 3/124 seems justified solely on the grounds of metrical contour (the 2:1

proportions of the metrical subdivisions), whatever the duration values in the following bar. Thus it is possible to find or construct examples in which the pre-metrical analysis groups with the preceding longer duration notes which in the eventual metrical context should be regarded as upbeats. A clear case is Example 3/125, in which the upbeat at the end of bar 1 is repeated in bar 2 and is shown as such in the tree-diagram, while in the pre-metrical structure the first eventual upbeat is grouped with the succeeding longer duration and the second with the preceding one. A third Separation Rule is required to correct such discrepancies:

> Subject to Separation Rule 4, if a given metrical unit is subdivided on the level immediately below it into two unequal timelengths (which may be metrical timelengths or durations), the second of which is less than the first and whose branches are joined together, then the beam joining the branches should be marked for separation and the right-hand branch joined as an upbeat to the first branch of the metrical unit following the given one. (Separation Rule 3)

This rule would, however, be inappropriate if it separated a point of duration closure from the rest of the duration phrase. Thus:

> Separation Rules 3 and 5 do not apply if any duration subtended by the right-hand branch under consideration is equal to or greater than the longest duration subtended by the left-hand branch or is otherwise regarded as an essential point of closure. (Separation Rule 4)

Separation Rule 5 is considered below. Example 3/126 illustrates the need for this exception to Separation Rule 3, revealing from bar 9 a structural ambiguity between a duration phrase that lasts throughout the bar and an upbeat structure suggested by the accompaniment. 'Essential closure' is hard to define, but is linked to the uncertainty of the conditions for separating upbeat structures and to the ambiguity of certain strings as duration phrases; the three will be considered together below.

The need for another principle of separation is illustrated by Example 3/127a which may be regarded as a variation of the string 4 2 2 4 2 2 4 . . . , but in which the pre-metrical analysis brackets together the durations 4, 2, and 4, missing the phrase grouping represented by the string 2 1 1 4. Separation Rule 1 would then confirm the separation of the duration 2 from the following duration 4 instead of from the preceding duration 4. The pre-metrical procedure could, of course, be altered to avoid a connection being made between two durations when the second was less than the first. But the procedure would then fail to highlight important metrical connections, such as that bracketed above Example 3/128. The criterion for separating an upbeat structure in Example 3/127 is roughly the reverse of that which governs Separation Rule 3. In examples to which Separation Rule 3 applies, a lesser metrical subdivision gives rise to an upbeat, but not if one of its durations is sufficiently long. In a case like Example 3/127, the metrical time-lengths are equal, but an upbeat is perceived if the duration specified by the second branch is sufficiently short. How short it should be is a matter for discussion, but the proportion of 1:2 between the second and first durations of Example 3/127 is enough to produce an upbeat structure (Example 3/127b).

As vital a question as the separation of upbeats, however, is the need to limit their separation. This matter arises from the action of Separation Rule 2 in a case like Example 3/129, in which the separation in the first bar is carried to the highest metrical level, as the pre-metrical bracketing shows. The separation of adjacent branches whose specified durations are in the proportions 1:2, as in Example 3/127, would confirm such an analysis. The notion that the first duration in Example 3/129 is followed by a gigantic upbeat is either profound or profoundly misleading and is almost certainly the latter, since there is no guarantee that the semiquavers will ever be followed by a longer note to terminate a duration phrase, except perhaps at the end of the piece. The moto perpetuo style of much Baroque music decisively rules out any idea of such prolongued upbeats, if only because an upbeat structure must be perceived as a whole, not simply as a connection between its highest-level duration and the following downbeat.

The relationship between the duration values specified by adjacent branches is not only a matter of their proportions, but also of how far apart they are. In terms of the graphical analogy of Example 3/2, the separation proposed in Example 3/127 may be seen as a product of the rapid drop in height from the first duration to the second; the same durations separated by a greater length of (proportional) time may be seen as connected by a more gentle decrease in height and subject to a decreased tendency towards separation. For the sake of finding a suitable measure to help determine when separation is appropriate, there may be assumed to be a constant rate of decay (inverse exponential growth) from the top of the first duration's vertical line to that of the second.

The proposed measure, i_A, which will be termed the decay value, expresses, as a real number in the range $0 \leqslant i_A \leqslant 1$, the ratio of the supposedly decreased height at the end of the first duration to that duration's original value. Thus, if the second duration follows immediately after the first, the decay value will be the ratio of the two durations. As the 'distance' between the durations is increased, so the decay value increases.

The formula required for measuring the decay value is a variant of the standard Compound Interest formula $FV=PV(i)^n$, where FV is the future value, PV the present value, i the rate of increase or decrease in each period, and n the number of periods. Similarly, where B is the second duration; A is the first duration; i_A (the decay value) is the rate of decrease within the timelength of A; and d/A - the 'distance' divided by the timelength of the first duration - is the number of periods:

$$B = A(i_A)^{d/A}$$

$$\therefore\ i_A = (B/A)^{A/d}$$

A table showing the decay values for a selection of durations and 'distances' between them is given as Example 3/130. The separation of upbeats appears to be justified if the decay value is about 0.75 or less and on this basis the following Separation Rule may be formulated:

> Subject to Separation Rule 4, if two adjacent branches, representing metrical timelengths or durations, are joined together and the decay value between the durations specified by the two branches is less than or equal to 0.75, the two branches should be marked for separation. (Separation Rule 5)

Unlike Separation Rule 3, Separation Rule 5 does not require the prior existence of a metrical unit containing both branches. Separation Rule 4 is invoked because the very perception of a point of closure within the potential upbeat structure must preclude its separation from the rest of its duration phrase.

While the use of the decay value avoids the possibility of an endless upbeat, it is by no means the perfect solution to all problems concerning upbeats. The critical value of 0.75 is not an absolute threshold, but a point of ambiguity between upbeat and afterbeat structures. Two strings which are particularly notable for their ambiguity of separation are 3 1 2 and 4 3 (and their proportional equivalents), with decay values of 0.73 and 0.75 respectively.

The tendency to separate the durations 4 and 3 is weak and is thus strongly open to influence from other characteristics, especially pitch patterning. In Example 3/131, it seems that without this influence to produce the structure of Example 3/131a, the pitch characteristic concerned being one called 'directional grouping' (see Chapter 4, Section A), the duration 3 would be too far apart from the following downbeat to be grouped with it (Example 3/131b), as the graph of Example 3/132 translates into visual terms. Even in Example 3/133a, with a decay value of 0.93 between the first two durations, the notated upbeat structure is quite clearly perceptible and relevant because of pitch grouping; Example 3/133b is a less extreme example from an actual piece. By contrast, Example 3/134 illustrates a positive tendency not to perceive separation between the durations 4 and 3. This example is adapted from the 'St. Anthony Chorale' melody of Example 3/119 for the purpose of comparison with it. In the present example, the grouping of six beats is preferable to five, while in Example 3/119 eight beats are preferable to seven: the separation or otherwise of the durations 4 and 3, being a weaker preference, merely follows suit.

In the string 3 1 2 , the decay value between the durations 3 and 2 is not the only relevant factor; also important is the closure of the sub-grouping 1 2 . Meyer calls this figure a 'closed trochee'[26]

26. Meyer, op. cit., p.34.

which sounds like a contradiction in terms, but sums up the figure's own contradictions rather well. The classic exposition of these contradictions is the first movement of Beethoven's Seventh Symphony, in which pitch patterning sometimes decisively favours an afterbeat structure (Example 3/135a) and at other times an upbeat (Example 3/135b), but as often as not leaves the figure to its own ambiguity (Example 3/135c).

On balance, the duration string 3 1 2 does not favour separation of the durations 3 and 2, despite the decay value being less than that of the string 4 3. The closure of the string 1 2 seems to inhibit an already weak tendency towards such separation. This is illustrated by Examples 3/136a and b, as well as by Examples 3/123c, d, and e, and Example 3/119. The figure is an example of an ambiguous duration phrase and Closure Rule 1 may be assumed to be amended to include it specifically, together with its variants such as those listed in Example 3/130. Because each of these listed figures ends on a relatively short duration, its sense of closure cannot be as strong as that of a duration phrase which fits the previous definition and this weakened closure leaves it more open to the influence of pitch patterning; hence the word 'ambiguous'. Yet each of the figures is an entity in its own right, as is seen in Example 3/136b at the point where an asterisk has been marked: the phrase would not end on the following longer duration even if the latter's phrase grouping were pitched an octave lower. Certainly, this duration phrase is enhanced by harmonic rhythm and also by being a four-grouping, but these characteristics could not create a phrase grouping if the potential for one were not present.

It should also be noted from Example 3/136b that the string 3 1 1 2 is not a duration phrase in this context, despite Closure Rule 3, because its last duration is followed by one of the same length. The same is true of any figure that may be described as a closed trochee and Closure Rule 3 may be taken to be amended accordingly. The reason for the amendment is that a drop or an increase in duration value following such a figure is sufficient change to give the figure identity; an equal duration merely extends it. However, pitch separation or a point of repetition also count as 'sufficient change'; Example 3/137 illustrates the effect of the two together.

For present purposes, the term 'closed trochee' may be defined, in the first instance, as an amalgamation of two structures, one on a lower level than the other and following it: the lower-level structure is a duration phrase according to the original definition of Closure Rule 1; the higher-level one is a structural grouping whose last specified duration is less than the grouping's longest duration and is also a member of the lower-level duration phrase. This definition covers a variety of structures, as is illustrated by Example 3/138 in which the lower-level duration phrase is marked with a square bracket and the higher-level structural grouping with a trochee. (These structures should each be seen as the content of a metrical unit.) The definition could be widened so that the string 3 1 2 or any of its variants would be permissible as the lower-level duration phrase. However, since these figures are themselves closed trochees, the degree of closure would be seriously weakened. In Example 3/139, such closure does not seem sufficient to avoid the separation of the higher-level branches by Separation Rule 5. Similarly, two of the structures in Example 3/138 have been placed in parantheses because it is likely that their higher-level branches would not avoid separation.

Example 3/139 leads to the central question in evaluating structures of the closed trochee type as ambiguous duration phrases. If the higher-level structural grouping ought to be separated by Separation Rule 5 because of the decay value associated with it, to what extent is this separation affected by the second branch being connected to a subsequent lower-level point of closure? While Separation Rule 5 has a provision for 'essential closure', it is not possible, at present, to measure the degree of closure in closed trochee structures. The decay value can, of course, be measured between the two critical durations: the higher-level structural grouping's longest duration and the lower-level duration phrase's duration of closure. But such a measure on its own takes no account of metrical contour, of the latter duration's proximity to the following metrical accent (on the level of the branches to be separated or otherwise), or of the size of the duration specified by this metrical accent. The second of these factors, though not necessarily the same as metrical contour, is akin to it. For the third factor, the degree of closure is stronger if the following metrical accent's specified duration is less than the second critical duration than if it is greater. All of these factors are clearly visible in graphical form in Example 3/140, of which only 3/140a seems to give rise to a closed trochee. In the absence of a measurable criterion for deciding between closed trochee and upbeat, perhaps the best solution for a computer program is for the machine to consult a table of the commonest structures of this type, with each given an individual decision.

Beyond the point where any ambiguity over upbeats is likely to arise, the strings concerned being too long, it is still possible to have duration phrases that do not end on their longest duration value. Two such phrase groupings, identified by square brackets underneath, are given as Example 3/141. Both are amalgamations of lower-level phrase groupings and it is possible that their perception is aided by their being four-groupings. In Example 3/141b, repetition certainly groups the lower-level phrases together, though a point of repetition does not by itself create a phrase grouping. In Example 3/141a the lower-level phrases are probably grouped together because the time-lengths from harmonic rhythm (see below the example) favour a metrical unit of four beats' length. But, having been grouped, and without being able to shed any of their members as upbeats (although pitch patterning claims a crotchet upbeat in the second example), there need be no specific rationale behind their identity as phrase groupings. They may be more 'open-ended' than if their last note were a point of overall duration closure, but this is a qualitative judgment about their content which is outside the scope of the present study. The largest category of such unclosed phrase groupings, without considering the structural characteristics of pitch and harmony, is of those created by upbeat repetition, which will be discussed in the following section.

Mention must be made of a category of duration phrases which appear to be unclosed, on the basis of their duration strings alone, but which are in fact ordinary duration phrases if metre is taken into account. Three examples of what may be called 'closure by counting' are given as Example 3/142. In each case, the closure depends on the metrical timelength of an unsounded pulse, which is perceived and associated with the appropriate duration before that duration's value is found to be less than expected, because of the following upbeat.

The effect of durational phrase grouping on the perception of metre is deceptively simple. In a case like Example 3/115a, the separation of four binary groupings clearly suggests the multiple 8 to connect them on the next level. Yet one cannot say with equal confidence that in Example 3/142a, counting on the crotchet level, the pattern of metrical timelengths should be 2 3 7. The creation of discernible phraselengths through the separation of phrase groupings does indeed put forward a potential metrical structure, but it is one which comes into effect only in default of any stronger characteristic or preference being able to place the metrical accent on a note other than the first of the phrase. It is normal for the structural accent of such a characteristic to be perceived before the lower-level phrase grouping has run its course, although the resulting metrical connection may not be confirmed until after the end of the phrase. Clearly, the idea of the perception of successive levels of phrasing and metre is a simplification that may suit analysis by computer but does not match the actual chronology of events.

In Example 3/115a, then, the first branch on the next level may be placed provisionally above the third note, before the structural grouping on that level can be formed. In this particular example, the placing of this branch is affected not a little by the fact that the music can be recognized as a gavotte, the rhythm of the dance taking over where equal metrical timelengths on the lower level and a moderate tempo do not favour an upbeat following duration contour. In Example 3/142a, the branches of the dotted-minim multiple 12 from duration contour are placed before the lower-level phraselengths have any opportunity to be heard as metrical timelengths.

The blurring between metre and phrase grouping begins when any structural grouping that joins two phrase groupings falls on the first of the phrase groupings' highest-level branches and is, by definition, confirmed after the end of the first phrase grouping. In these circumstances, the only function of such a structural grouping is to join the phrases and to express the awareness of a metrical timelength. But such phrases are concatenated by default; further hierarchical structure depends on finding ways of separating them, including evaluating the kinds of qualitative change that a computer would find very hard to perceive and humans find very easy: thematic changes and changes in harmonic, rhythmic, and instrumental texture. As for the perception of metrical timelengths: as phrase groupings increase in size, this fades to a rough notion of the relative lengths of sections or to something that is understood as a conjunction of lower-level metrical timelengths. It may be possible to form structural groupings on very high levels, to connect, say, the beginning of a sonata exposition with the recapitulation, but the extent to which such connections could be called 'metrical' is clearly questionable.

In the final analysis, there is a potential discrepancy between the metrical and phrase-grouping functions of duration contour. The desire for closure on a relatively long note is at least as strong as the tendency for a metrical accent to fall on such a duration. Much depends on whether one is considering the first or a subsequent branch of a structural grouping: a first branch generated by a relatively long duration is likely to arise provisionally; the bias is then towards perceiving the end of a phrase grouping, a function which, as seen above, can be fulfilled by a relatively long duration however it is placed metrically. Nevertheless, the discrepancy is there to be exploited by other characteristics. In Example 3/143, duration contour could generate an initial metrical timelength of 6 or 9; harmonic rhythm decides in favour of the former. In Example 3/144a, the text requires that articulation separate the durations 2 and 3 and, perhaps with slight dynamic accentuation, bring out the metrical potential of the latter duration in the form of an off-beat structural accent, rather than allow passive closure on an afterbeat, as in Example 3/144b.

C. REPETITION

Mention has already been made of the effect of repetition in suggesting possible phrase grouping and its effect on the perception of metre is even more marked. The extensive use of thematic analysis in musical literature is ample evidence of the importance of repetition in Western music, even though the systematic study of the transformations on which such analysis depends is still in its infancy. Yet while the importance of thematic unity and development as structural devices cannot be overestimated, the thematic process is sufficiently distinct from rhythmic structure to be treated as a different dimension of musical structure as a whole. Thus the present discussion will be limited to the function of repetition in the perception of metre and phrase grouping, although the same repetitions are also part of thematic structure.

More important to the perception of both metre and phrasing than the repetition of complete passages is the establishment of a point of repetition. The very perception of such a point means that a mental connection, similar to that required for the perception of metre, has been made between it and the start of the original statement. In the tree-diagram notation, both the start of the initial statement and its point of repetition will be marked with the letter 'R'. If further marking is necessary to avoid ambiguity, subscripted numbers may be used to identify different statements of the same material and subscripted letters to distinguish different repeated material. Two related letters 'R' will always be found on the same hierarchical level as each other, irrespective of differences in the higher-level structures above the two notes or chords at the point of repetition.

The foremost concern of the present section is durational repetition, but this is usually congruent with some form of pitch repetition and any remarks about the former apply equally to the two together. The different forms of pitch repetition (including intervallic repetition) are considered in Chapter 4, Section A; also considered in that section is the effect of pitch repetition that is incongruent with the underlying duration string.

Pitch repetition is relevant to the present argument for another reason. For any repetition to be perceived, it must be sufficiently distinctive; the problem in designing a suitable computer program is to decide what repetition is significant and what is not, since, if duration is considered alone and no constraints are employed, the computer will judge every repeated duration to be a point of repetition. Yet as few as two durations can establish such a point: in Example 3/145 the first repetition of the duration string 2 3 seems perceptible irrespective of pitch. On the other hand, its congruence with an approximate form of intervallic repetition undoubtedly contributes to the distinctiveness of the point of repetition as a whole. It is virtually impossible to determine the minimum requirements for establishing a point of durational repetition, since the distinctiveness of a duration string depends on the other duration values which surround it and these can only be evaluated intuitively at present. Thus it can only be an advantage to consider all aspects of repetition together whenever possible, including pitch repetition.

One way of doing this would be to award a number of points for the perception of each type of repetition, the number awarded for each type increasing with the length of the repetition. If these points summed to more than a given threshold value, a point of repetition would be considered to have been recognized. For duration, the minimum requirement would be two durations that were either different from each other or different from the duration that immediately preceded them. Inexact durational repetition is easily handled by the computer: in the repetition, either a single note is replaced by several shorter ones or *vice versa*; the computer could simply pass over these non-repeated durations. Pitch repetition ranges from the exact repetition of pitch through several forms of intervallic repetition to the repetition of an unordered pitch set (see Chapter 4, Section A). The different forms of pitch repetition could be arranged in an intuitive hierarchy of perceptibility, according to the number of points to be awarded on the perception of each. Apart from duration and pitch, points could be awarded for the repetition of harmony, rhythmic texture, and instrumentation.

Before this technique could be successful, the most suitable number of points and the size of the threshold would have to be found by trial and error. The basis of the technique - that there are relative degrees of repetition - does seem to be borne out in musical examples, however. In Example 3/145, for instance, the repetition marked 'RB2' is distinguished not only by being the entry of the second voice, but also by being a closer repetition to the original subject than the lower-level point of repetition 'RA2'. Conversely, where two or more successive repetitions have equal status, no higher-level point of repetition can be established without some further distinction. Thus the structure of Example 3/146a is transformed into that of Example 3/146b only by pitch patterning and, on the next level, by pitch repetition.

Although repetition may be treated as a structural characteristic because of its effect on metre and phrase grouping, it differs from the other characteristics in not establishing structural accents directly on the notes and chords prefixed by the letter 'R' and, correspondingly, structural timelengths between these points. Instead, repetition fits round and reinforces whatever metrical structure is established by other characteristics; it is a matter of structure and a set of characteristics being repeated rather than repetition directly creating structures as a characteristic in its own right. Thus in Example 3/147, where duration contour establishes an initial upbeat, the repetition at the end of bar 4 does not cause this upbeat to be superseded, by creating an alternative downbeat, but merely duplicates the previous structure and causes a metrical connection (indicated by a broken-line structural grouping) to be established as a consequence of this duplication. By such means, phrase groupings may be separated by upbeat repetition in addition to metrical connections being established on the following downbeat. In Example 3/147, as in Examples 3/146b and 3/145, the letter 'R' is placed on the highest possible level, one below that of the new structural grouping established by the repetition; horizontally, it is still placed to the left of the first note of repetition.

It should not be imagined that repetition will merely duplicate all structural groupings associated with a previous structure, if one of the characteristics crucial to the original is not present in the repetition. In Example 3/115b, while the opening duration string 1 2 is repeated immediately, the first duration bears the metrical accent in opposition to duration contour, through a combination of pitch unity, a pre-established metrical multiple, and, possibly, a dynamic accent as well. If the second duration 1 were dynamically accented, it might be perceived as metrically accented; as it is, the combination of duration contour and a dominant to tonic harmonic progression prove stronger.

Because repetition appears so frequently in music, its occurrence is, not surprisingly, not always essential to the generation of a particular metrical and phrase structure, but can be incidental to it.

This is the case in Example 3/148, in which the end of one phrase gives rise to the beginning of the next. Repetition does indeed reinforce the structural grouping connecting the beginnings of bars 1 and 3, but it is of a kind that would not be the easiest for the computer to recognize: the pitch repetition is obvious, but its not being matched by durational repetition does not lead to a structural incongruence with duration contour in this instance, whereas in another example it might. While it can only be an advantageous short-cut for the computer to take account, as early as possible, of higher-level groupings generated by unambiguous points of repetition, the same procedure could be needlessly inefficient if the validity of a point of repetition proved difficult to determine.

The metrical connections put forward by repetition are undeniable, unless the repetition is confined to one structural characteristic or set of characteristics that is challenged by incongruence with another. Repetition is thus ideally suited to creating regular metrical schemes and metrical units that are based on prime numbers greater than three. The multiple 7 is inevitable in Example 3/149, for instance, as is the multiple 5 in Example 3/150. (The subdivisions of these multiples will be discussed in the following section.) In Example 3/151, repetition creates an irregular metrical scheme that is indicated at the level of the barlines. Examples 3/152 and 3/153 show that metre must fit round the start of an original statement subsequently related to a point of repetition. In Example 3/152, the point marked 'RB1' interrupts the potential multiple 18 that might be expected to follow from the repetition at 'RA2'. In Example 3/153, the metrical timelength that might have followed from the repetition at bar 5 is interrupted by the original statement in bars 7 and 8 that is repeated in bars 9 and 10.

Unlike metre, phrase grouping cannot be expected to fit round repetition. Example 2/48 showed the necessity of a dual branch when a point of duration closure is also the start of an original statement. By contrast, in Example 3/154 the first letter 'R' follows the point of closure and is heard as a repeated upbeat.

The opening of Schubert's Ninth Symphony shows, in its third bar, that repetition can provide an extension to an existing structural grouping (Example 3/118a). Since the repetition is connected metrically on the same level as the first bar, there can be no suggestion that the latter should be an upbeat, to fit round the repetition. An original statement and its repetition <u>can</u> form a joint structural timelength and thereby condition the perception of upbeats, but the tempo is too slow for that in this example. The opening five-bar metrical unit in Example 3/119 (St. Anthony Chorale) was previously explained as generated by the repetition that follows it, but it is also the result of a repetitive extension, the extra bar (3) consisting of an equivalent harmonic progression to that of bar 2. In both this example and Example 3/118a, the repetition extends the previous duration closure.

The fourth and fifth bars of Example 3/155 are simultaneously a pitch repetition of bars 2 and 3 and a durational repetition of bars 1 and 2. A metrical connection following from the durational repetition seems preferable to a repetitive extension from the pitch repetition. Similarly, a repetitive extension gives way to the metrical sub-division of a four-grouping in the musical equivalent of chiasmus (Examples 3/139, 4/51, and 3/120), although the reverse is also possible: that such subdivision can be superseded by a repetitive extension of the fourth metrical unit (Example 3/156).

The highest degree of irregularity in repetition is probably to be found in Stravinsky's technique of incremental repetition, introduced in The Rite of Spring and an important element in most of his subsequent works. In this technique, a set of small thematic cells appear in a constantly varying order. Example 3/158 shows at 'RB2' that repetition can separate phrase groupings without necessarily producing structural groupings between the points of repetition. The function of structural groupings in connecting phrase groupings accounts for the grouping placed between point 'RA4' and point 'RB2'. On the second-highest level indicated, the various repetitions duplicate their previous structures wherever possible, again without the need for structural connections to their previous statements; by so doing they help to create a regular metre on that level.

The extent to which the principle of incremental repetition is consciously or recognizably hierarchical is uncertain. Two potential structural groupings from repetition clearly cannot conflict with each other; it is normal, then, for the first to have priority. In Example 3/159, however, assuming that the figure at 'RA1' is the key one for making structural connections, the melodic descent at Number 109 in the score nevertheless marks a significant thematic change and justifies a connection to its repetition, even though this precludes any connections to the original figure in the intervening bar. This is a likely pitfall for a computer program, since the significance of thematic change can only be judged intuitively at present.

On the other hand, it may be that the conflict between these potential connections in Example 3/159 is the product of a structural ambiguity which undermines the relevance of either. It is mistaken to assume that music is necessarily organised hierarchically and no clearer example of this can be found than the passage beginning at Number 149 in The Rite (Example 3/160), in which an irregular metre is established by the intermittent quaver rests. Any higher-level organization would have to come from repetition, but it would be misguided to assume that the pattern in the first bar is any more distinctive for this purpose than any subsequent one. This being so, the various possible connections from repetition cancel each other out.

One of the most important aspects of repetition concerns the perception of repeated upbeats and their effect on phrase grouping. Several tree-diagrams have already shown the influence of upbeat repetition, for instance those of Examples 2/63, 3/62, and 3/153. In each case, the upbeat begins at the point of repetition rather than immediately following the potential point of closure put forward by duration contour (as in Examples 3/161 a to c, respectively). In general, a point of repetition marks for separation the beam which precedes it on the same level, unless the first duration of the repetition or a subsequent duration to which it is connected is an essential point of duration closure. This separation marks the beginning of a phrase grouping and thus causes the separation of any higher-level beams at the same point, up to the level of the highest structural grouping which defines the phrase grouping. Since the repeated upbeat duplicates the tree structure of its previous occurrence, it must override any conflicting provisions put forward by one of the Separation Rules. Thus, if a branch preceding the point of repetition is separated both to its left, through a Separation Rule, and to its right, through repetition, the left separation is invalidated and replaced by a full beam.

This provision can be seen in Examples 2/63, 3/62, and 3/153 and is further illustrated by Examples 3/162 to 3/166. In each of this latter group of examples, the point of repetition separates two equal durations which duration contour would otherwise group together and it is questionable whether, in any of them, durational repetition alone would be sufficiently distinctive. In Examples 3/163, 3/165, and 3/166, where the initial downbeat and its repetition are created by duration contour, a structural grouping has been placed on the next level, between the two downbeats. In the other two examples, the downbeats are connected by a broken-line grouping, since the characteristics which produce them (dynamic accentuation in Example 3/162 and a longer-note accompaniment or harmonic rhythm in Example 3/164) have not been represented. Comparison of Example 3/163 with Example 3/164, both of which have the same repeated duration string, shows that the separation of phrase groupings at the point of repetition is largely unaffected by the position of higher-level branches.

Not only can a point of repetition occur on an upbeat, but an upbeat itself appears to suggest its own recurrence. This seems to be the case in bar 2 of Example 3/167, which may be compared with the pre-metrical grouping in Example 3/28, and with the end of bar 2 in Example 3/163. The tendency for one upbeat to aid the perception of another would, at least within regular metre, be in accordance with the notion of balance between metrical timelengths and the lengths of phrase groupings, considered in Chapter 2. However, it is difficult, in a computer program, to draw the distinction between a tendency and an automatic procedure. The suggestion of recurrent upbeats should not be allowed to produce the structure of Example 3/168a in preference to Example 3/168b, for instance. The computer may usefully be programmed to expect or seek the recurrence of an upbeat if one has occurred, but it is likely that the actual generation of every upbeat can be accounted for by a structural characteristic or set of characteristics. In Example 3/167, the upbeat on the third beat is the product of harmonic rhythm and duration contour, while its initial quaver is set apart from the preceding structure by the pitch unity in the latter (marked 'p-p'). In Example 3/163, the upbeat follows the full repetition of a phrase grouping.

The examples of upbeat repetition given above have shown repetition to be stronger than duration contour in respect of phrase grouping. When the repeated upbeat contains the duration of closure for the preceding notes, however, as in Example 3/169a, the perception of such closure is not denied by repetition and only a dual branch can represent the two structures. Such a situation is not fundamentally different from that in many structures which involve both an upbeat from duration contour and repetition on the following downbeat. The closest counterpart to Example 3/169a is also by Brahms (Example 3/169b). The main structural difference between these examples, apart from the position of the downbeat, is that separation as a result of repetition is necessary in Example 3/169a to reveal the upbeat, but is not necessary in Example 3/169b to reveal the downbeat. Thus a dual branch has not been used in the latter and, indeed, would be inappropriate in examples where the closure was not on the downbeat but on a subsequent note (Example 3/170).

A dual branch on a repeated downbeat preceded by an upbeat would also be wrong musically. The upbeat belongs not simply to the nearest duration of closure but to the whole phrase grouping to which it is joined. As was noted in Section B, the start of a metrical unit may always be regarded as the beginning of a potential phrase grouping because it is the start of a structural unit in the general sense. A point of repetition (or, retrospectively, the start of the original statement) enhances the prominence of any structural accent or metrical accent on which it falls and any structural units or metrical units associated with these accents. Thus repetition on a downbeat strengthens any phrase grouping beginning on the downbeat at the expense of the larger phrase grouping that includes a preceding upbeat. As was noted in Chapter 2 in respect of the opening theme of Mozart's Sonata in A, K.331, such a structure need not deny the upbeat to the point of repetition altogether.

Just as there is repetition on and preceding a downbeat, so a point of repetition may follow one. This usually happens after a structural rest or a harmonic cadence, otherwise it is likely that the downbeat would mark the start of the original statement, even though this might involve some variation at the point of repetition. There is a tendency to perceive an upbeat in this type of repetition, as is illustrated by Example 3/171. In this example the repeated phrase grouping is treated as a separate structure on which a higher-level metrical scheme has been imposed. The general form of Example 3/171 may be schematized as in Example 3/172, with the numbers representing beats of the bar. The different parts of Example 3/172 show how an upbeat arises as new metrical levels are established and the original repeated phrase grouping is preserved. An alternative view is that the initial downbeat should be seen as part of the structure to be repeated. This results in a dual branch, as shown in Example 3/173. An upbeat structure would be quite inappropriate in bars 3 and 4 of Example 3/173 or in a case such as Example 3/174; furthermore, this type of repetition may involve a phrase grouping of several bars' length (Example 3/175), in which an upbeat is not likely to be heard, since it would be perceived retrospectively.

The structure of Example 3/171 is, in any case, a special kind of upbeat, encapsulated within a given (downbeat) metrical structure on the next level. Such a structure can arise in an unaccompanied voice if there are grounds for not placing a higher-level metrical accent at the first available point, and if the required upbeat would take up too high a proportion of the new metrical timelength, usually three-quarters or more. In Example 3/176a, for instance, duration contour and the implied harmonic progression suggest the further metrical structure indicated by broken lines. Yet because of the slow tempo, an initial upbeat is impossible. Bach's score thus shows an initial rest (Example 3/176b), which can be heard, though retrospectively, unless the performer places too much dynamic emphasis on the initial note. A similar situation prevails in Example 3/177; indeed, an initial rest seems to be a mannerism of many of Bach's fugue subjects.

The opening of the second movement of Brahms' Second Piano Concerto (Example 3/178) is notable for not having such an initial rest in what appear at first to be similar circumstances to those of the above examples. While the opening motive is not subject to repetition in the short term, although it is in the restatement from bar 16, there are grounds for perceiving a metrical accent at the beginning of bar 4 on the same level as the one which would fall on the initial structural rest, if there were one. By the above argument, the upbeat to this metrical accent, being four bars long less a crotchet, should give rise to an initial structural rest to complete the four-bar unit. If this is done, a perfectly regular sixteen-bar metrical unit emerges, followed by a tonic cadence on the seventeenth bar (bar 16) and the repetition of the opening motive (Example 3/179). However, the above-mentioned metrical accent at the beginning of bar 4 falls there, rather than in bar 2 as duration contour would suggest, because of the long B♭ pedal which begins at that point and which harmonically unifies bars 4 to 11 into an eight-bar structural unit. Thus the first three and two-thirds bars can be seen as an upbeat to a main downbeat on bar 4, generated by harmonic rhythm and a longer-note accompaniment, without the need for an initial crotchet rest. This structure is repeated satisfactorily at bar 16 (Example 3/180).

Some discussion of the reason for Closure Rules 3 and 4 (see Chapter 3, Section B) is now appropriate. When the repetition is of the entire sequence falling between the letters 'R', or some recognized variant of this sequence, the structural timelengths and structural units associated with the first statement are themselves replicated. In the case of downbeat repetition, the structural unit is the repeated sequence itself, which, in the first statement, coincides with the metrical unit created by the point of repetition. (See the square brackets in Example 3/181.) With upbeat repetition, the structural timelength also falls on the main downbeat, since it is a product of the characteristics which give rise to that metrical accent. The corresponding structural unit, likewise a product of these characteristics, also begins on the downbeat and thus cannot be repeated in its entirety unless there are three statements of the material. The present concern is with entire repeated structural units and is therefore mostly confined to downbeat repetition.

The need for Closure Rule 3 arises when a repeated structural unit is incongruent with the phrase grouping from duration contour, as in Example 3/182a. While a repeated metrical unit can clearly be seen in the tree-diagram notation, on the next level (Example 3/182b), a spurious phrase grouping arises on the following level, after the application of Separation Rule 1 (Example 3/182c). It is this type of duration phrase that is invalidated by Closure Rule 3 in the context of the more strongly perceived repetition. A repeated structural unit that is not a duration phrase cannot be treated as one. On the other hand, any portion of the repeated structure that duration contour would group as an upbeat cannot be regarded completely as such. This incongruence cannot be shown in the tree-diagram notation alone and may be represented by the overlap between an upbeat tree structure and a square bracket added underneath to indicate a repeated structural unit that the computer would have to take into account (Example 3/181).

If a succession of repeated structural units are followed within a metrical unit by some other material, their combined structural timelengths form a higher structural timelength (Examples 3/183 and 4/59). On the other hand, the reasoning behind Closure Rule 4 is that the mere repetition of a structure does not guarantee the perception of a single larger phrase grouping: some further distinction is required to create this, as was seen in Example 3/146. The bracketing underneath Example 3/184 shows how such conjunction of repeated phrase groupings could undermine a clear pattern of phraselengths, or phrase contour. In this example, as in Example 3/185, the conjunction indicated would create a similarly artificial subdivision of the larger duration phrase into two halves. In addition to Example 3/146, Examples 3/186 and 3/187 illustrate how a succession of repeated patterns may be separated into higher-level phrase groupings, both examples employing further repetition and, on a higher level, a distinction between harmonic cadences.

As yet, no mention has been made of repetition between two separate voices, although its perception has been taken for granted in at least four cases (Examples 2/5, 3/176, 3/177, and 3/179). For its effect on the overall metrical structure, such repetition may be treated as if it occurred in a single voice, that is, it is capable of establishing a metrical connection, unless the structural characteristic or combination of characteristics at the point of repetition is against this, harmonic rhythm and a longer-note accompaniment being two characteristics that are particularly immune to incongruent repetition. With the possibility of imitative entries occurring at irregular intervals, however, it could be confusing and misleading if all points of repetition were connected on the same level. In the first D minor fugue from The Well-Tempered Clavier, for instance, the entries of the subject (or its inversion) occur in the pattern of Example 3/188 which is perhaps more immediately reminiscent of Stravinsky (see Example 3/160) than Bach. Quite apart from the difficulties of organizing irregular metrical timelengths into hierarchical levels, the timelengths in this example are only one possible form of hierarchical organisation and must be considered subordinate to harmonic rhythm and tonal structure in particular.

For phrase grouping, two voices with adjacent points of repetition may also be treated together, but, since parts frequently overlap, this should only be done on the understanding that a point of closure established as a result of the repetition is subordinate to that of each individual voice, if different from it. The distortion that could otherwise result is illustrated by Example 3/189: any duration phrase created in the bass voice by the entry of the tenor voice and extending from R1 to point R2 would be purely temporary in the light of the following bass note, on durational, tonal, and textual grounds.

D. LONGER-NOTE ACCOMPANIMENT

Several writers, including Riemann, Sachs, Cooper and Meyer, and Yeston,[27] have commented on the metrical questions arising from the relationship between two or more duration strings. Sach's terms 'metric consonance' and 'metric dissonance' are good descriptions of what Yeston has schematized as Examples 3/190a and 3/190b, respectively. The relevant structural characteristic will here be called a longer-note accompaniment, however, because the present concern is with the effect of longer accompanying notes on phrase grouping as well as metre.

Metrical consonance and dissonance can often seem to involve two or more musical lines whose metrical interpretations, determined by structural characteristics present in each individual line, simply happen to coincide or otherwise. But while such characteristics contribute both to the metrical interpretation of each line and to any overall metrical scheme, the relationship between two duration strings may establish a further type of structural accent, as follows. In the metrical consonance of Example 3/190a, if the triplet-semiquaver string, having no higher level of organization of its own, is heard in conjunction with the longer-note quaver string, it acquires a quaver multiple. Similarly, both the quaver string and the triplet-semiquaver string have a crotchet multiple if heard in conjunction with the crotchet string; and all three heard with the minim string have a minim multiple.

Each line, then, has a structure in its own right which has no metrical organization, and all but the minim string have structural

27. Riemann, op. cit., p.191ff; Curt Sachs, Rhythm and Tempo (New York, 1953), p.41; Cooper and Meyer, op. cit., p.108; Maury Yeston, The Stratification of Musical Rhythm (New Haven and London, 1976), pp.77-9.

accents attributed to them, derived from the various longer-note strings, when interpreted in the light of one or more of these strings. Such structural accents could be seen as the product of dynamic accentuation arising on points of common attack, and to some extent this theory has validity. But the characteristic would remain even if the parts were played so that the overall dynamic level was constant for every point of attack. Furthermore, the analysis of such common attack points can have no validity within a passage of metrical dissonance in which there are none, but in which one line may still be interpreted relative to another.

As part of the overall metrical structure, the multiples in Example 3/190a are implicit in Yeston's musical notation and in his description of the example. But while Yeston observes that 'the existence of [structural] accents necessarily implies the existence of another level of motion corresponding to the succession of the accents'[28] and while he sees the lines in Example 3/190a as individual levels of motion, he does not appear to view the relationship between two lines as potentially giving rise to a succession of structural accents in one of the lines, but mentions only the accentual effect on the attack string.

In the metrical consonance of Example 3/190a, the attack string between any pair of lines is always one of the lines; in Example 3/190b, it never is. In metrical dissonance, there can be a subtle, but important, difference between the structure of an individual line, its structure perceived in relation to another line that puts forward a higher-level metrical organization, and the structure of the attack string. The concern of both metrical consonance and dissonance, then,

28. Yeston, op. cit., p.77.

is not simply the generation of an overall metre, but the extent to which the structure of one line is affected by being perceived in relation to another.

In the term 'longer-note accompaniment', the word 'accompaniment' does not refer exclusively to the bass line, although the bass has a special importance of its own and often contains the longest notes in a particular rhythmic texture. Metrically, there is a tripartite relationship between a longer-note accompaniment, the bass, and harmonic rhythm, which will be considered below and in the section on harmonic rhythm (See Chapter 4, Section D). The structural accents and timelengths acquired from the accompaniment are those most appropriate to the accompanying line. In Example 3/191, the top line acquires a minim multiple from the duration contour of the bottom line as well as a less important pattern of timelengths corresponding to the durations of the bottom line.

The metrical strength of a longer-note accompaniment is seriously challenged only by incongruence with harmonic rhythm (the pattern of chord changes), certain duration patterns, the preference for regular metre, and a pre-established multiple. This strength is shown in its ability to establish irregular metre, especially in conjunction with repetition, as is illustrated throughout Bartok's Six Dances in Bulgarian Rhythm (Mikrokosmos, Nos. 148-153), two of which were quoted in the last section (Examples 3/149 and 3/150). In each of these two examples, the accompaniment metrically accents the right-hand part in a straightforward subdivision of the multiple from repetition. In two of the Dances, the longer-note accompaniment produces an irregular subdivision of the multiple 8: 5+3 or 3+2+3 in Number 151 (Example 3/192) and 3+3+2 in Number 153 (Example 3/193). Without careful dynamic shading of the melody, there is a tendency in these pieces for an implied regular subdivision of 4+4 to supersede the irregular schemes and create syncopation in the middle of the bar. Presumably this tendency is culturally conditioned and seems more marked to those whose familiarity with jazz and popular music is stronger than their affinity with the folk music of Eastern Europe. A similar tendency is avoided in Example 3/194 (Number 148) because of harmonic rhythm: the E major chord gives prominence to the first, third, and fifth quavers in the bar; conversely, if the right-hand scale had begun on an E, the same triadic associations would have favoured a 9/8 metre.

Example 3/195 illustrates the metrical inferiority of the longer-note characteristic to harmonic rhythm, and a similar rhythmic texture will be found in Examples 4/128 and 4/109. The duration contour of the accompaniment in Example 3/195 also seems to be surpassed metrically by the bass A♭s; the structural characteristic concerned will be termed <u>bass accentuation</u> (See Chapter 4, Section A). The semiquavers accompanied by the A♭ minor triad (and their counterparts in Examples 4/128 and 4/109) may be seen as acquiring a structural, though not metrical, accent and timelength from their accompanying duration.

The generation of an upbeat by a longer-note accompaniment is partly caused by overall dynamic intensification on the entry of the longer note; similarly, Yeston refers to changes in 'the density of simultaneous attacks or the density of simultaneous sub-patterns' as a rhythm-producing criterion.[29] On its own, however, the concept of an increase in the number of voices as giving rise to a structural

29. Yeston, <u>op. cit</u>., p.47.

accent is probably of little use, since there are relatively few examples in which its metrical function is not duplicated by some other characteristic, which, when not a longer-note accompaniment, is usually harmonic rhythm, as in the opening of Mozart's G minor Quintet (K516). Harmonic rhythm is also liable to generate metre in such a way that the second entry does not begin at the beginning of the bar (Examples 3/196 and 3/197). Furthermore, there is no guarantee that the entry of a second voice generates an upbeat: in Example 3/196, an upbeat to the beginning of the second bar may be appropriate, but a similar upbeat seems less suitable in the opening of Wagner's Tristan, though the tempo is equivalent.

The metrical interpretation of polyphonic duration strings involves not simply the duration contour of each line and the grouping of durations by longer accompanying notes, but also a partitioning of the attack string. It is possible for this string to have a duration contour that conditions the overall metre. For example, in the two-against-three relationship, there seems to be a marked preference for a ternary interpretation (Example 3/198a) to a binary one (Example 3/198b), even in duple time: the duration contour of the attack string gives rise to a ternary metre but resists a binary one (as in Example 3/198b), because the latter's metrically accented iamb is unsubstantiated. A similar preference towards a ternary interpretation of the attack string may be observed in the four-against-three relationship, but this does not seem to have overall predominance, perhaps because of the strength of binary subdivision in the 'four' line.

The resistance against a metrically accented iamb (as in Example 3/198b) is generally overcome by the longer-note characteristic, as is illustrated by Example 3/194 (bar 4 ff.). However, dynamic emphasis is useful in such a case to support the accompanying longer note; conversely, if such emphasis is given instead to the longer duration of the iamb, the longer-note accompaniment tends to become syncopated (Example 3/199).

Such considerations of duration contour affect metrical interpretation when two durations overlap, both of which might be seen as the longer accompanying note. Thus, Example 3/200a is more likely than Example 3/200b, and Example 3/201a is more likely than Example 3/201b. These examples illustrate that the durational relationship between overlapping durations is stronger metrically than bass accentuation, a characteristic which is closely akin to a longer-note accompaniment, because it involves the structural connection of relatively low notes (see Chapter 4, Section A). Similarly, in Example 3/202, the structural connection of the arpeggios' bottom pitches would not lead to their being metrically accented.

In Example 3/203, although the attack string has equal durations, structural connections between the left hand's dotted minims or the right's minims will determine the metre; in creating metrically accented iambs, the latter is the less likely structure. Like Examples 3/200 and 3/201, the structural choice is neutral with respect to harmonic rhythm, otherwise the latter characteristic would almost certainly determine the metre (see Chapter 4, Section D). When the overlapping durations or structural timelengths are genuinely equal, the metrical accents normally fall on the first to be sounded and its successors; this provision is also subordinate to harmonic rhythm if incongruent with it.

It is possible for a longer-note accompaniment to be shared between several voices or for parts to overlap, such that in each duration string the structural timelengths between the relatively long durations would generate irregular metre; yet the overall metre is perfectly regular. Where such metrical regularity is not created by the attack string, it may usually be produced by the opposite concept - the longest-note string - each member of which is the longest available duration at any given time, irrespective of its voice of origin. Example 3/205 illustrates the derivation of this string in a case of overlapping durations, none of which forms a metrical timelength in the overall context. The first member of the string, the duration 5, is superseded when its remaining timelength of a semiquaver (the value 1) is no longer the longest timelength available in comparison with the new duration 7, which therefore replaces it in the string. Such a procedure does not at first sight appear to match our own perceptual processes, since we do not know the length of a duration until it has run its course. However, the general form of Example 3/206 does appear to be a valid type of grouping by a longer accompanying note; in other words, if the second of two overlapping durations sounds into the timelength of the duration following (in the same voice) the first of the overlapping durations, it functions as a longer accompanying note, beginning from its own point of attack. Such grouping is retroactive, independent of the length of the first overlapping duration, and consistent with the above procedure.

The influence of regular metre may be added to the longest-note string when an expected metrical accent is not sounded in the string but is present in the attack string; this is required in Example 3/205. Conversely, any regular metre generated by the attack string is metrically superior to any incongruent irregular timelengths put forward by the longest-note string, as in Example 3/207, and affects the perception of the longest-note string. 'Attack string' in this context need not be interpreted strictly as a combination of all of the voices, if the result is an undifferentiated duration string.

The overlapping of voices influences the perception of structural rests, as is reflected in musical notation and illustrated by Example 3/208. The sounded metrical accent in Example 3/208a generates a tied note in the upper voice, but the crotchet duration still exists when the upper voice is interpretated on its own or with a subconscious perception of the metrical accent. In Example 3/208b, the metrical accent generates a structural rest, because the upper voice is silent when it is sounded, and the crotchet duration is relevant only to the upper voice in its own right. Duration closure is, however, governed by the proximity and separation of attacks in each line and remains unaffected by the perception of a structural rest. Off-beat notes separated by structural rests tend to be associated more closely with their metrically accented accompaniment than with each other, although their linear connection is not obliterated and is aided by fast tempo, as is reflected in Bartok's notation in Example 3/149 (bar 4 ff.).

The effect of the longer-note characteristic on phrase grouping does not come from longer accompanying notes as such, but from the capacity of the phrase grouping in one part potentially to affect that of another, when the two are interpreted together. Thus, it is at least as likely that a longer-note accompaniment will acquire the phrase grouping of the part to which it gives a metrical structure as _vice versa_. It should be stressed, however, that in polyphony a phrase boundary is not necessarily shared by all of the voices. In this respect, a distinction may be made between artificial phrase groupings, extracted for the purposes of comparison with other music, and those that are genuinely perceived in a voice, either on its own or in the partial or full rhythmic texture of the piece.

A typical instance of the transfer of phrase grouping is Example 3/209. Duration closure in the longer-note top part generates phrase boundaries in the durationally undifferentiated bass part at the end of bars 2 and 4 and, to a lesser extent, at the end of bar 8. In bars 2 and 4, the separation of phrase groupings is encouraged by the subsequent points of repetition. Separation at the end of bar 8 is justified by similarity with previous phrases, but, without a point of repetition, the final two Gs are equally likely to be an upbeat linked by pitch unity to the subsequent note. Examples 3/210a and 3/210b complement Example 3/209 as two of the many instances in which duration closure in one voice transfers phrase separation to its accompaniment.

The transfer of phrase grouping cannot reasonably be explained on durational grounds alone, since pitch and harmonic patterns affect the transfer of duration closure. For example, the phrase grouping marked in Example 3/211, which contradicts the duration contour of the upper voice, is possible because the F♯ is harmonically linked to the accompanying longer-note chord. If it were, say, a C♯ leading upwards (as opposed to being a neighbour note), the phrase grouping would end on the minim B, although, out of context, this would have the duration value of a dotted minim to match the accompaniment and balance the upbeat.

Despite pitch and harmonic aspects, distinctions can be made between different types of duration patterns in their capacity to transfer phrase grouping. In Example 3/212a, the closure in the top part is likely to be transferred to the lower part, even though the latter in its own right has phrase separation, at the minim level, between the minim and the subsequent crotchet. Pitch or harmonic criteria might suggest phrase separation at the end of the third crotchet beat in the top part, which would still produce a valid phrase grouping that could be shared by the bottom line. By contrast, in Example 3/212b, the pitch or harmonic grouping of the first three beats would not be strong enough to contradict the duration closure on the fourth beat, and this phrase grouping could be expected to be transferred to the bottom line. In Example 3/212c, the overall phrase grouping is again determined by the duration closure in the top line, although a contradictory phrase grouping of the harmonic sequence would supersede it.

Example 3/213 differs from Example 3/212 in having a greater degree of separation of attacks in the bottom part and thus a lower decay value between the first and fourth beats in that part, resulting in the greater likelihood of a crotchet upbeat. The overall tendency in Example 3/213a, then, is for phrase separation after the third beat in the top part; in Example 3/213b, the top part maintains its duration closure and the bottom its upbeat, unless harmonic grouping (for example V - I) permits an overall phrase separation at the end of the fourth crotchet.

Not unlike Example 3/213b in content is Example 3/214, except that here the accompaniment shares the duration closure of the melody as well as having the sense of an upbeat in its own right. Yet if the duration values of Example 3/213b are assigned the pitch or harmonic content of Example 3/214, the bottom line of the former example still does not share the top line's phrase grouping. Thus it seems that durations in the proportions 2:1 are sufficiently weakly separated to be capable of being grouped together with a little help, whereas those in the proportions 3:1 are decisively separate and may normally only be grouped by a strong unifying force (such as dissonance and resolution). However, the notion of separation is dependent on a corresponding following phrase grouping and is weakened if the smaller duration in the proportions 3:1 is, like its predecessor, followed by a shorter duration from which it may be separated. In this case, transfer of duration closure is possible (Example 3/215).

The above examples have shown that certain duration structures normally separated in their own right may be joined in the overall context to produce phrase grouping that matches duration closure in another part. In the examples involving undifferentiated duration strings, the transferred separation preceded a point of repetition. If this qualification is removed, it permits a host of unlikely transfers from phrase groupings that are normally perceived as subsidiary to the predominant phrasing at a given tempo. For instance, the 'Cello part in Example 3/216 is not heard as partitioned by every point of separation in the First Violin part, let alone those of the inner voices, although it could be artificially segmented if the phrase groupings of the melody were required to be isolated from their context, together with their accompaniments. Example 3/216 illustrates a further aspect of transferred phrase grouping. Familiarity with cadential chord progressions permits recognition of a phrase ending in bar 24 in accordance with the duration contour of the melody, instead of in bar 23 in accordance with the duration contour of the bass line, but a general rule giving predominance to the melody in this type of incongruence would have the same effect.

Two final examples (Examples 3/217 and 3/218) illustrate both the metrical and phrase-grouping aspects of a longer-note accompaniment. In Example 3/217, the 3/4 multiple is determined by the sequence of dotted minims, and by automatic continuance when the dotted minims are replaced by a hemiola, unless the performer's dynamic accentuation of the hemiola produces a temporary overall binary metre. The phrase grouping in the top part is either transferred to the other parts or matched by them, although the four-bar phrase between bars 10 and 13 is generated by the bass. In the following phrase, the bass's duration closure in bar 15 could justify an artificial segmentation of the top part, but in terms of overall phrase grouping the lack of suitable closure in the top part produces a continuation of the phrase. The same situation occurs in bar 29. The structure of Example 3/217 is that produced by the characteristics presented so far, principally by duration, and the phrase groupings are asserted without any knowledge of tonal cadence. It is evident, however, that the recognition of the $\left\{\begin{matrix}\hat{7}-\hat{1}\\ V-I\end{matrix}\right\}$ progression defines cadences that can lead to a higher level of phrase grouping than that shown.

In the opening of Example 3/218, the attack relationships among the various parts produce a crotchet multiple, itself grouped metrically by the longer-note minims of the top part. The main duration phrases are perceptible at this minim level, but on the same level there is metrical ambiguity at the beginning of bars 5 and 7: at the slow tempo, structural rests seem less likely than the alternative structures shown beneath the main diagrams, although the recognition of repetition in bar 6 (in relation to bar 2) would produce the first structural rest retroactively. The semibreve multiple is generated by tonic accentuation (see Chapter 4, Section A) in bars 2 and 6, as well as by subdivision of the two-bar duration phrases. Transfer of phrase groupings between the bass and treble in bar 2 is not appropriate, because the lower-level phrase grouping of the quavers would be contradicted without being replaced by duration phrases. Thus the treble and bass phrase groupings overlap.

CHAPTER FOUR

STRUCTURAL CHARACTERISTICS: PITCH

Theorists from the time of Ancient Greece to the present day have mainly been preoccupied with the structure of pitch systems 'outside time' (to use Xenakis' term)[1]: scales, modes, hexachords, temperament, consonance and dissonance, diatonic harmony, and, more recently, the classification of pitch sets in twelve-tone and atonal music.[2] In the writings of Schenker and those who have followed and extended his system, and in the theories of Cooper and Meyer, Komar, and Yeston, an attempt has been made to consider the relative importance of pitches and harmonies inside actual compositions as they affect, or are affected by, the flow of musical ideas 'inside time'.[3] But while the pitch structure of a composition, which is one of the principal concerns of this second group of theorists, is a fundamental aspect of rhythmic structure, relatively little can be found in their writings to elucidate the structural characteristics of pitch and harmony that affect the perception of metre and phrasing on the small scale.

The present chapter puts forward these characteristics, as follows: Section A considers the characteristics that generate pitch patterns without any understanding of tonal harmony; Sections B to D deal with the structural characteristics from tonal harmony; while

1. Iannis Xenakis, Formalized Music (Bloomington, Indiana, 1972), p.185.
2. See, for example, George Perle, Twelve-Tone Tonality (Berkeley, California, 1977); Allen Forte, The Structure of Atonal Music (New Haven and London, 1973).
3. See, for example, Schenker, Der Freie Satz; Salzer, Structural Hearing; Cooper and Meyer, The Rhythmic Structure of Music; Meyer, Explaining Music; Komar, Theory of Suspensions; and Yeston, The Stratification of Musical Rhythm. Full details in bibliography.

Section E discusses some aspects of the relationship between rhythmic structure and tonal harmony.

A. PITCH PATTERNS

This section considers the structural characteristics which determine phrase grouping and structural accentuation in strings of pitches, largely through proximity or separation in the pitch spectrum. The patterns concerned are non-tonal: they do not depend for their existence on the presence of tonality or the ability to recognize it, although they often complement tonal procedures. While these patterns arise from pitch contour, this term is not to be confused with melodic contour. Melody, in its widest sense, is concerned with the overall contour of a musical line, shaped by duration as well as pitch, by metre and phrasing, harmony and tonality, timbre, articulation, and dynamics. Except where it produces pitch patterning, pitch contour itself does not tend to function as a structural characteristic, that is, it does not necessarily generate metre or phrasing. Rather, the tension and relaxation represented by the rise and fall of pitch often exists as part of melodic contour within a given metrical and phrase structure, which pitch patterns may nevertheless have helped to create (Example 4/1).

The structural characteristics of pitch patterning tend to be the weakest of all characteristics, in respect of both metre and phrase grouping. However, if other means of differentiation, especially duration contour, are absent from a musical line or are not too prominent, pitch patterning is perceived clearly and its effect on rhythmic structure can be quite powerful. For instance, in Example 4/2, it creates a phrase grouping which is unaffected by the higher-level structural grouping imposed by the longer-note accompaniment, though metrically subsidiary to it (Example 4/2b). Repetition of the pitch pattern determines the next metrical level and a phrase grouping is created on this level by further pitch differentiation: the change in register in both treble and bass voices. This in turn will produce the metre of Bach's barlines (see the dotted line bracket in Example 4/2c) if we accept the opening bass Ds as the start of a metrical unit and assume a preference for a metrical timelength that is a multiple of 4 to one that is a multiple of 5.

In Examples 4/3 and 4/4, the raised pitch of the Ds and Gs, respectively, creates what have been termed <u>tonic accents</u>, which function as structural accents of pitch contour.[4] Example 4/3 demonstrates their ability to create metre in the absence of durational differentiation: the first tonic accent produces a metrical subdivision of the first duration phrase. In Example 4/4, the tonic accents create a pattern of structural timelengths, analagous to the durations below the example. Structural timelengths are produced by the phrase groupings of pitch patterns in general, whether on or off the beat (Examples 4/5 and 4/6 respectively).

<u>Pitch separation</u> is the analogue of the separation of attacks in duration contour. Only the simplest clustering procedure for pitch will be presumed here. This procedure would examine musical lines individually and consider the melodic interval between adjacent members of the pitch string, successive layers of grouping being formed by increasing the size of the interval (measured in semitones).

4. Willi Apel, <u>Harvard Dictionary of Music</u>, second edition (London, 1970), p.857.

Clustering up to and including a given interval size can then be read by amalgamating layers of groups, as in the pre-metrical grouping of duration contour. The distinction between layers need not and should not always be uniform: seconds can be classed together, as can thirds, sixths, and sevenths; fourths can be classed with fifths. To class the unison with the octave would create problems in such a purely intervallic assessment; these two are in any case linked by octave equivalence as an aspect of pitch unity (see below).

A procedure based on the above lines should produce the grouping bracketed above Examples 4/7 and 4/8. A more comprehensive clustering technique would attempt to group pitches that were not adjacent in order of attack, but were relatively close in the pitch spectrum. Such grouping would be concerned with the identification of musical lines, which has largely been omitted from the present study. It would not only separate the pitch patterns of Example 4/9a, but suggest the possibility of grouping these into two voices (Example 4/9b). The opposite procedure, that of amalgamating separated lines, is within the scope of the present procedure, however. Tovey has remarked that the arpeggiated opening of the B♭ Prelude from Book 1 of _The Well-Tempered Clavier_ (Example 4/10a) should be regarded as a complete voice in conjunction with the bass (Example 4/10b);[5] such a reading is produced by the attack string (the upper voice of Example 4/10b) and is justified as a single musical line because it shows no significant pitch clustering, due to the relative uniformity of interval size. Its pitches are in any case related to each other by harmonic rhythm, according to which the string would be analyzed as a series of arpeggiated triads.

5. J.S. Bach, _Forty-Eight Preludes and Fugues_; edited by Donald Francis Tovey, 2 vols (London, 1924), I, p.158.

The principal difficulty with the more comprehensive form of pitch clustering suggested above is that it would essentially be a clustering by both melodic interval and attack interval, a simultaneous clustering of pitch contour and duration contour, in which the unit intervals of these two parameters would not have equal status, duration contour being the stronger characteristic. In Example 4/11a, in which duration contour is incongruent with pitch proximity, phrase grouping is by duration contour, not by the interval of a semitone, which the metrical grouping of musical notation highlights. Duration contour predominates even if the difference in duration values is severely curtailed (Examples 4/11b and 4/11c); the semitone grouping requires the aid of articulation to have any structural significance (Example 4/11d) and duration contour still produces a subsidiary structure. The structural preferences in Example 4/11 are further complicated by the fact that duration contour highlights a meaningful, though arpeggiated, harmonic progression; it will be seen that harmonic rhythm is the most powerful of all structural characteristics and, even within a single musical line, it is difficult to avoid its presence or its effect on phrase grouping. In Example 4/12, the dactylic groupings predominate over the incongruent anapestic phrase groupings from duration contour and this appears to be due to the increasing separation of the former; but in this example, too, other factors are present (principally repetition), as will be considered below. By contrast, in Example 4/13, the increasing pitch separation has little effect on the phrase grouping from duration, except, perhaps, to suggest linear grouping.

A third aspect of pitch patterning is <u>directional grouping</u>, by which is meant the perceptual preference for phrase groupings which proceed only up or down in pitch (Examples 4/14a and 4/15a) as opposed to those which involve a change of direction (Examples 4/14b and 4/15b). In Example 4/16a, this type of patterning produces separated groupings and subsequent metrical connections on the levels on which duration contour gives no further differentiation. In this and many other cases, pitch separation would produce the same grouping, but directional grouping is not dependent on a relatively large interval (Example 4/16b).

In Example 4/17, directional grouping creates an anacrustic phrase grouping which would not be revealed by duration contour or harmonic rhythm. In Examples 4/2, 4/14, 4/18, and 4/19, it gives rise to off-beat timelengths that are enhanced by the tonic accents which it also reveals. In Examples 4/14 and 4/19 directional grouping establishes a cross-rhythm of 4 against 3 which is more intriguing in Example 4/19, where repetition creates a second-level cross-rhythm in relation to the metrical timelength of 18 (6x3).

Despite its clarity in these examples, directional grouping often suffers from an inherent ambiguity of direction which relies on other characteristics for its solution. In Examples 4/20 and 4/21 the directional grouping could be 4 + 2 or 3 + 3; it is 4 + 2 in Example 4/20 because of the longer-note accompaniment and 3 + 3 in Example 4/21 because, in the perception of harmonic rhythm, it is recognized as an expansion of a sequence of thirds.

Directional grouping is certainly weaker than pitch separation (Examples 4/22 and 4/23). It fails at 'X' in Example 4/23 despite the fact that the expectation of it is reinforced by the preceding repetition. It is weaker than dissonance resolution (marked 'd-r') in Example 4/24. It can be weaker than repetition of a pitch pattern, as in Example 4/25, where its theoretically possible subdivision of 1 + 3 is meaningless unless produced by articulation, for example by playing the first of every four notes staccato (although there is no musical justification for doing so). On the other hand, repetition of a proposed directional grouping, as in Examples 4/26a and 4/27, often strengthens its case: it is doubtful that the first four pitches of Example 4/26a alone would produce directional grouping (Example 4/26b).

Directional grouping is weaker than duration contour, if incongruent with it (Examples 4/28 and 4/29), and weaker than other phrase grouping derived from it (Example 4/30). Directional grouping is also weaker than any phrase grouping generated by a longer-note accompaniment (Example 4/31) or by harmonic rhythm (Example 4/32). In these last five examples, the relative weakness of directional grouping effectively invalidates its influence on the prevailing phrase grouping.

Pitch unity is concerned with the perception of two or more notes as having the same pitch. Such notes will be labelled with the letter 'p'. Pitch-class unity, which is of slightly lesser structural importance, may similarly be labelled 'pc'. Pitch unity and pitch-class unity are most easily recognized between adjacent notes, but may also be perceived between non-adjacent notes, depending on other grouping and on how far apart the notes are.

As a structural characteristic, pitch unity binds the repeated pitches together into a single phrase grouping, thereby establishing a structural timelength which may become metrical if it is not incongruent with any other characteristic. Pitch unity is responsible for the grouping and off-beat structural timelengths in Example 4/6, the metre being determined by a pre-established multiple. In Example 4/33, it generates metrical timelengths of 2. For all its simplicity, this example illustrates precisely the difference between a note of a certain duration (the minim G) and two pitch-unified notes of an equivalent timelength: despite the pitch unity, the duration string has an independent structural identity. The generation of metre by pitch-class unity is illustrated by Example 4/34, although either the longer-note accompaniment or directional grouping would produce the same structure.

Pitch unity includes the concept of the 'neighbour-note', in which the repeated pitches are separated by one other pitch that is a diatonic or chromatic step above or below (Example 4/28).[6] There is a difference, however, in that the neighbour-note tends to be seen as an elaboration of a harmony note, whereas in the present view, no concept of triadic harmony is required. Furthermore, the size of the interval involved is of no significance to the perception of a repeated pitch or pitch-class; indeed, the larger it is, the more closely the repeated pitches are associated by linear grouping. In Example 4/35, the regularly repeated C♯s affirm the multiple 2 (which, in context, has been established already), while separation on this level is caused by the congruence of pitch unity with pitch proximity. Pitch unity also has the capacity to define the beginning and end of a phrase grouping. In Example 4/36, this leads to a metrical ambiguity between a multiple of 3/8 produced by the connected Gs and one of 3/16 (or 6/16) from the triplet groupings defined by the alternative pitch unity indicated. The notated metre presumably suggests the addition of sufficient dynamic accentuation to solve this ambiguity, but the triplet grouping survives as a cross-rhythm. (A similar ambiguity occurs in the third movement of Grieg's Sonata for Violin

6. See, for example, Walter Piston, Harmony, revised by Mark DeVoto (London, 1978), p.114.

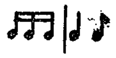
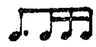
and Piano, Op.45, where the notated metre favours the triplet.)

The 'double neighbour-note' - two pitches separating the repeated pitch, one above and one below - is also recognized in harmonic theory,[7] but the concept may be extended here to include repeated pitches separated by any reasonable number of notes, subject to the influence of stronger characteristics. Pitch unity defines separate phrase groupings and the multiple 4 in Example 4/37, though reinforced by repetition; it may be noted from this example that such phrase groupings are stronger than those that might be produced by directional grouping. In Example 4/38, there is no real conflict between the alternative pitch repetitions: the middle pair form a structural timelength on one level (a); the outer two form one on the next (b). It would take only a little dynamic accentuation on the first note of the middle pair, however, for their pitch unity to predominate and produce the metrical multiple 4 with a quaver upbeat. In Example 4/39, similarly, repetition of the first pitch predominates in generating the metrical connection, but slight emphasis on the second pitch would cause it to do likewise.

While the repetition of a pitch cannot alone dictate a metrical structure in opposition to stronger characteristics, in particular duration contour, it is not so certain that its capacity for phrase grouping is annulled by incongruence with other characteristics. In Example 4/40a, the first quaver E is still an elaboration of the D♯, despite the latter's harmonic inferiority; successive reductions would favour the pitch unity of the D♯s (Example 4/40b) before removing the dissonance (Example 4/40c). Another instance of the

7. Piston, <u>op. cit.</u>, p.115.

apparent superiority of pitch unity over dissonance resolution is Example 4/41, in which the first of each pair of repeated pitches is primarily an anticipation of the second on the main beat, and only secondarily the resolution of a dissonance, where marked as such. By contrast, in Example 4/42, the addition of articulated grouping favours afterbeat structures in preference to pitch unity and imparts the sense of an appoggiatura to every slurred pair, whether a dissonance and resolution or not.

An upbeat strongly asserted by duration contour is not turned into an afterbeat structure by pitch unity, although the latter tempers the degree of separation of the phrase groupings. Thus, in Example 4/43, we are aware that the pitch unity in the dotted-note figures forms a subsidiary structure in respect of phrase grouping, which seems adequately notated in a single tree-diagram by the use of the letter 'p'. In Example 4/44, likewise, the elaboration of the A is understood by the pitch unity marked, whereas the figure  shown in the tree is important in its own right. Such incongruence between pitch and durational structures simply has to be understood in two senses simultaneously. The phrase grouping of the melody line in Example 4/44 by duration contour (and dissonance resolution) does not permit the pitch structure to be understood properly, but the melodic segment represented by the above duration string is at least viable as a phrase grouping, whereas that denoted by the figure  seems considerably less so. Since the grounds for viability are durational in both cases, it may be concluded that duration contour is the superior characteristic and the grouping from pitch unity is subsidiary. By contrast, in Example 4/45b, thematically developed from Example 4/45a (which is similar to Example 4/44 in duration structure and pitch unity), the grouping from pitch unity is congruent with that from pitch separation and repetition, and predominates over durational phrase grouping.

Example 4/46 has been constructed to illustrate the confusion that might arise if all possible pitch unity were given equal status in respect of phrase grouping. The first two repeated Ds (1) help to form a minim metrical timelength; the third D, however, sandwiched between the first two repeated Es (2), is subordinate to them, just as the alternative pitch repetition in Example 4/39 is subordinate to that which occurs first. Likewise, the repeated Fs (3) form a subsidiary grouping in relation to which the third E has little significance. The repeated Es (4) have latent structural importance: if repetition did not link structures (2) and (3) or if some dynamic accentuation were added to the first E, the pitch unity of the two Es and the notes in between them would form a phrase grouping with a minim structural timelength. The two As (5) are not a valid case of pitch unity; they illustrate that the characteristic is too weak to contradict duration closure. An articulated slur connecting the two As could, of course, bring out their pitch unity, thereby giving the first A a dual structural function (it would still be a point of duration closure). The two adjacent Gs (6) have an easily recognizable pitch unity, but, as in (4) above, this seems to have no effect on phrase grouping when incongruent with a repeated pitch pattern (the two halves of bar 3). Had the first note of the last bar been a E, however, the further pitch unity would have created an alternative repeated pitch pattern and a corresponding structural ambiguity between the two repetitions. The pitch unity of the two Fs (7) is also incongruent with the repeated pitch pattern in bar 3, but its congruence with the phrase grouping from duration contour gives it validity.

Pitch pattern repetition will be taken to include patterns related by intervallic repetition. Alternative but less immediately perceptible forms of repetition are retrograde (of both pitch and interval strings), inversion (intervals only), and repetition of an unordered pitch set. Furthermore, any of these six types may occur independently of (be incongruent with) durational repetition.

The specification of exact intervallic repetition would be of little relevance in most tonal music, which is more concerned with diatonic intervals (that is, with the equivalence of seconds, thirds, etc.). Yet the perception of intervallic repetition in tonal music does not require the recognition of diatonic intervals, which a computer could only deduce from their twelve-tone equivalents through a knowledge of scales or a conception of tonal space. For instance in Example 4/47 it is not essential, though not irrelevant, to recognize a repeated interval of three scale steps between the latter two members of each group of three. The notions of approximate interval and interval direction ('up' or 'down') seem to be sufficient criteria for perceiving a repeated pattern. Thus in Example 4/48a we are aware of a repeated quaver figure in one sense, through the similarity of interval movement, while the dissimilarities of pitch command our attention in linear and harmonic senses (Example 4/48b). Three further examples containing repeated interval patterns with significant pitch changes are the B♭ major (Example 4/10a), the C major, and the C minor Preludes from Book 1 of The Well-Tempered Clavier. Interval direction may not seem a sufficiently distinctive criterion for identifying a pitch pattern; yet a dictionary of musical themes has been compiled on this basis alone.[8]

Octave equivalence has been omitted from pitch pattern repetition, since pitch-class repetition is covered by interval repetition and octave-equivalent intervals are covered by repetition of interval direction. The retrograde repetition of a pitch pattern (Example 4/49a) is covered by repetition of an unordered pitch set and sometimes by directional grouping (Example 4/49b), but the concept is useful, nevertheless; the retrograde repetition of an interval pattern (Example 4/50) is not covered by any other characteristic. Retrograde repetition also includes the 'antecedent-consequent' form, the musical equivalent of chiasmus, in which the reversal of elements does not necessarily take place on the lowest level, but may involve the repetition of whole sub-trees or parts thereof (Example 4/51). The inversion of an interval pattern is a clearly recognizable form of repetition (Example 4/52) if it is the interval direction that is inverted; the octave complementation of individual intervals in a pattern seems too contrived to be perceived as a 'natural' transformation. Equally contrived would be the repetition of an unordered set of intervals (Example 4/53a); but the repetition of an unordered pitch set is a different matter (Example 4/53b).

While it may be generally desirable to consider pitch patterning as a set of structural characteristics in its own right, in the case of pitch pattern repetition the influence of other characteristics is too strongly pervasive to be left out of the argument. The tendency of repetition to reinforce the metre and phrase grouping of other characteristics, including those of pitch patterning, helps to make it dependent on these characteristics, rather than assert its own identity. Example 4/54 illustrates the need to consider all

8. Denys Parsons, The Directory of Tunes and Musical Themes (Cambridge, 1975).

characteristics together to decide which structural interpretation is reinforced by repetition. Bars 90 and 91 each have a repeated pattern of diatonic intervals in the treble line, whose congruence with metrical grouping suggests a possible phrase grouping (Example 4/55a). However, incongruence with duration contour makes this highly unlikely; duration contour itself puts forward the phrase grouping of Example 4/55b. Against the structure of Example 4/55a, too, is the tonic accentuation of the dotted crotchets; Mozart's sforzando markings strongly emphasize a repeated grouping beginning on these tonic accents (Example 4/55c). If an understanding of tonal harmony is included, the recognition of a perfect cadence at the beginning of bar 90 suggests a following upbeat whose reinforcement by subsequent repetition makes the structure of Example 4/55c the most likely phrase grouping.

Repetition of a pitch pattern alone is not stronger than duration contour in respect of phrase grouping, when incongruent with it. If Example 4/55c were rewritten as in Example 4/56, that is, with an added appoggiatura and without the sforzandi, the repetition would probably only be apparent if emphasized by articulation in the form of a short break after the A; otherwise, duration closure would tend to predominate, as shown in the tree-diagram. It does not do so in Example 4/55c because the repeated pattern is the duration string 3 1 2 , noted previously as a potentially separable duration phrase (see Chapter 3, Section B).

However, the phrase grouping from duration contour can be subsidiary to a repeated pitch pattern if the latter is reinforced by directional grouping or by pitch separation and pitch unity. In Examples 4/57a and 4/57b, it is clearly pitch pattern repetition and directional grouping that determine the phrase grouping of the melody line, in 4/57b predominating over durational repetition; in both cases, however, the groupings are acceptable as duration phrases. In Examples 4/58 to 4/60, on the other hand, the congruence of the same two characteristics predominates over duration contour, although in each example the latter provides an important subsidiary structure; in Example 4/58, the upbeat from duration contour, with its progression from dominant to tonic, is significant enough to be included in the tree-diagram. In Example 4/59a, the phrase grouping creates the impression of added-note chords; the pitches on the crotchets are not passing notes in any melodic sense. In this example, also, pitch pattern repetition produces a pattern of structural timelengths in the proportions 3:1, which a linear reduction would properly take into account (Example 4/59b). In Example 4/60, the durational upbeats (the crotchets) are clearly part of the prevailing triadic chord, but congruence with harmonic rhythm is not a prerequisite of directional grouping (Example 4/61). In Example 4/62, proximity of attack would probably favour the phrase grouping put forward by duration contour, but for the pitch separation which offsets the first directional grouping. The repetition of this pattern then continues to favour directional grouping as the predominant phrase grouping. Examples 4/12 and 4/45b show that the congruence of pitch separation and pitch unity is stronger than duration contour; in both examples, repetition reinforces the grouping that other characteristics have established.

In the foregoing examples, the incongruence of pitch pattern repetition with duration contour concerns only the phrase grouping put forward by the latter; the duration values themselves do not change when the pitch pattern is repeated. The familiar <u>augmentation</u>

and diminution consist of a repeated pitch pattern whose corresponding durations are in the same proportions as those of the original statement, but are respectively longer and shorter. Where the duration values of the repeated pitch pattern are not related to those of the original, the effect of the repetition on metre and phrase grouping is minimal, although clearly vital to an overall structural explanation of the passage. The repetition in Example 4/63a is a form of inexact diminution which does not contradict the phrase grouping from duration contour and thus complements it; duration contour itself establishes the metre and the four-bar phrase, although the thematic unity of the latter is undoubtedly strengthened by the repetition. In Example 4/63b, the D♭s which begin the repeated pitch pattern establish an initial metrical timelength of 12 (3/4), but they do so because of tonic accentuation, while the repetition is incidental. In Example 4/64, one is aware of the pitch and pitch-class repetition, but the phrase grouping is derived from duration contour nevertheless.

Two further aspects of pitch patterning must be mentioned, both of which are related to linear grouping. The first is illustrated by Example 4/65: one pitch remains static while the other moves downwards. Similarly, in Examples 4/27 and 4/66, there is one 'moving voice' among static configurations of two and three other notes, respectively. The structurally important feature of such examples is that the moving voice is a generator of metre, the moving notes being seen as occurring at the start of metrical units. Example 4/65 demonstrates that this characteristic is stronger than the capacity of the tonic to determine metrical accentuation (see Section C); on the other hand, a longer-note accompaniment could easily suppress the metrical tendency of such a moving voice.

The last aspect of pitch patterning to be considered here will be termed bass accentuation. It concerns the structural accentuation of the lowest pitches in a line and their frequent metrical and linear connection, particularly in the bass line. This characteristic is the opposite of tonic accentuation and is normally associated with pitch pattern repetition, but its perception may also arise from pitch separation (Example 4/67), pitch unity (Example 4/68, in which the repeated pitch is technically not the lowest), or directional grouping (Example 4/69). Conversely, bass accentuation may be seen as reinforcing the perception of other pitch patterns, since it tends to suggest the beginning of such a pattern and is perceptible in its own right. A computer could easily be programmed to pick out the lowest pitches in a string and ascribe special significance to repeated pitches and to those lowest pitches recurring at regular intervals.

The concept of bass accentuation includes the Alberti bass and other groupings made from broken chords which start on the bass note of the chord. Pitch patterns which begin on a relatively low pitch need not necessarily be arpeggiations of functional chords, however, and it is important to stress that such patterns as those in the treble line of Example 4/70 are perceptible as simple pitch patterns without any knowledge of triadic harmony. Although they can also be seen as the expansion of a triadic progression, it is much simpler if this analysis follows the perception of the patterns rather than precedes it.

The metrical capacity of bass accentuation stems from the fact that relatively low pitches are structurally accented: their linear connection effectively makes them equivalent to a bass longer-note accompaniment; for instance, Examples 4/67 and 4/71 differ only in that they are two possible ways of partitioning the same material into musical lines. The structural accentuation is seen in Example 4/63, in which the grouping is off the beat, being incongruent with an established metrical multiple; in this example, however, attention is also drawn to the lower note of each pair because it is a moving voice against a static one, of the type described above. But the same structural accentuation may be observed in Example 4/70, whether the multiple is perceived as beginning on the first note of the treble line, following the repeated pitch pattern and harmonic rhythm, or on the first A in the bass line (perhaps aided by dynamic accentuation), following the longer-note accompaniment.

Metrically, bass accentuation is as important a characteristic as a longer-note accompaniment. In the light of this, Ravel's scoring of the second movement of his Piano Concerto in G major (Example 4/72) in 3/4 seems wishful thinking in relation to a distinctively 3/8 (or 6/8) accompaniment; separate time signatures might convey the 3/4 of the treble line in its own right, but the transfer of this metre to the bass line in opposition to the grouping from bass accentuation would require articulation or dynamics out of character with the quiet legato nature of the movement. An instance of metrical ambiguity involving bass accentuation is given as Example 4/73. According to the notated score, the established metre enables the chords marked 'X' to prevail metrically over the lower notes in between them. But even when performed with carefully graded dynamics, the metrical tendency of bass accentuation causes these lower notes to suggest an alternative structure too strongly to be ignored. This structure is further emphasized by the dynamic accents on the second and fourth beats in the treble line and especially by the structural timelength between the first and second of these accents. It is doubtful that many listeners, hearing only a passage beginning on the second beat of bar 208, would perceive the metrical accents as notated, in preference to bass accented ones, which also feature the 'moving voice' characteristic.

The incongruence of bass accentuation with tonic accentuation in respect of metre is common, but to say that one was simply stronger than the other would be naive, since much depends on which comes first. In phrase grouping, tonic accentuation is unaffected by bass accentuation; in Example 4/2, for instance, the repeated As can be classed as tonic accents, but the phrase grouping is directional and would not be altered if there were a metrical connection between the bass accented Ds. Metrically, tonic accentuation depends on a rise and fall of pitch. Bass accentuation also depends on a rise and fall of pitch, but is unaffected by a fall of pitch preceding the initial lowest pitch. Thus, in Example 4/74a, the metrical connections are determined by tonic accentuation; in Example 4/74b, by bass accentuation.

A final example (Example 4/75) illustrates not only the effect of bass accentuation on metre, but sums up pitch patterning as a whole by showing the cross-rhythms which can emerge between its different aspects. If there were not a pre-established metrical multiple, the treble line , on its own, would be governed metrically by the tonic accents that Chopin has highlighted to be emphasized in performance as the predominant melodic line. These accents would partition the accompanying notes (the '2's) into groups of four, a grouping reinforced by a repeated pattern of interval direction. However, the broken-chord figuration of the bass line produces a bass-accented metrical timelength of 18 which is imposed on the treble line. The common attack points of the two-against-three pattern now establish a metrical subdivision of length 6, which metrically breaks up the grouping of what are now triplet semiquavers and places the tonic accents in a cycle of length 8 against the bass line's one of 18, a cross-rhythm which, as the brackets reveal, runs its full length of 72 (the lowest common multiple of 8 and 18), a pattern of nine against four.

B. DISSONANCE AND RESOLUTION

The nature of consonance and dissonance must surely be the oldest controversy in musical theory. The gradual emancipation of the dissonance, which came radically to fruition at the turn of this century, has involved changes in our evaluation of certain chords as much as changes in harmonic practice itself. But these changes of attitude do not seem to have altered our capacity to recognize the resolution of dissonance when it occurs. For example, while nobody in the late twentieth century, hearing a single $^6_4$ chord in isolation, is likely to hear it as dissonant in an absolute sense, as he might have in the sixteenth century, most people would still readily sense its resolution in a following $^5_3$ chord. Many listeners, perhaps drawing on past experience, might appreciate the capacity for resolution in the $^6_4$ chord, but such expectation is a dimension of musical experience which is not essential to the present study.

The perception of metre and phrase grouping is less concerned with dissonance _per se_ than with the association of the dissonance with its resolution, which will be marked 'd-r'. In Example 4/76 this association, aided by articulation, results in an afterbeat structure, in opposition to duration contour which would otherwise have included the note of resolution in a repeated upbeat. Apart from articulation, the qualifying factor in this structural preference is the recognition of resolution in relation to a preceding dissonance, not of any quality of dissonance in itself. If resolution does not occur, the potentially dissonant chord must stand on its own merits, being heard as dissonant, consonant, or otherwise, according to one's historical or cultural standpoint. In Example 4/77, the resolution is so long-delayed as to be of limited structural value, especially since the dissonance is an acceptable entity in itself for the year of composition (1913).

Dissonance resolution is normally associated with metrically accented dissonances (including both suspensions and appoggiaturas) not so much because of cultural preference in placing the characteristic in such a metrical position, but rather because of the characteristic's own properties which favour that position. The first of these is the strong tendency to have at least one duration or one repeated pitch which is common to both the dissonance and its resolution. The common pitch is often highlighted by being the bass note or the tonic of the chord of resolution or both. The metrical effect is of a longer-note accompaniment, which is unlikely to fall naturally across a barline, despite the tonal superiority of the chord of resolution, as can be appreciated by comparing Example 4/78a with Example 4/78b.

The second property is that the dissonance and its resolution form a single grouping and structural timelength for the purposes of determining harmonic rhythm, the representative chord for this purpose being the tonally superior chord of resolution. Since harmonic rhythm has the strongest influence on metre of all structural characteristics, especially in conjunction with a longer-note accompaniment, dissonance resolution becomes virtually synonymous with metrical accentuation on the dissonance, unless such a structure would be incongruent with a pre-established metre (Example 4/79) or a strong dynamic accent on the resolution. Thus, in Example 4/80, the recognition of dissonance resolution alone is sufficient to generate a 3/4 metre.

A passing-note dissonance need not be confused with dissonance resolution, since, in the former, the above features normally occur in reverse order. The representative chord for harmonic rhythmic purposes precedes the passing note or notes, and the harmony notes and passing notes are likely to be linked by a longer-note accompaniment. An exception is the suspension, which could be interpreted either as a passing-note chord or as an accented dissonance (Example 4/81a and b). The progression of Example 4/81 is derived from the first Prelude in Book 1 of Bach's *Well-Tempered Clavier*, in which a sequence of such suspensions appears in broken-chord form at the rate of change of 𝅝=13 to 26, this range of tempi being far too slow for the perception of an upbeat to a metrically accented dissonance as in Example 4/81b. Slow tempo apart, however, there seems to be a culturally conditioned bias towards metrically accented suspensions, from which arises a preference that is essential to the perception of initial upbeats in cases like Example 4/82.

In Example 4/82, the use of a dual branch results from the after-beat structure of the resolution and from the repeated upbeat. In the following examples, dissonance and resolution will always be joined by a structural grouping, but the appropriateness of this should not always be taken as read. Firstly, examples will be given below in which, through the degree of separation of attacks, duration contour seems a stronger characteristic than the grouping of the dissonance with its resolution. Secondly, it is hard to find instances in which the incorporation of both dissonance and resolution in a single structural grouping is not justified or at least aided by some other characteristic. Thus there are grounds for considering that the characteristic should simply be marked 'd-r', with the understanding that it tempers the effect of any separation with which it is incongruent, without dissonance and resolution necessarily belonging to the same structural grouping. This attitude has been adopted with pitch unity and will be taken with harmonic rhythm below. By comparison with these two characteristics, however, the association of the dissonance with its resolution generally seems too strong for such marking to be a satisfactory representation, as Example 4/82 amply illustrates: upbeat repetition produces one phrase grouping and dissonance resolution another, but both are heard together.

The relationship between dissonance resolution and duration contour in respect of phrase grouping is the most important aspect of the characteristic for present purposes. Where aided by other characteristics, the effect of dissonance resolution on phrase grouping is most pronounced, with the resolution robbing duration contour of potential upbeats. In Example 4/76, as already seen, articulation combines with dissonance resolution to avoid the upbeat repetition shown in the alternative structure of Example 4/83, whose two elided interpretations are further linked by pitch unity. In Examples 4/84 and 4/85, as in many other cases, the incorporation of the resolution into an afterbeat structure is aided by repetition; in Example 4/86, where the eight-bar phrase is not followed by a point of repetition, it is aided by pitch separation. Without such aid, the following of the point of resolution by an upbeat structure is not assured, as is seen in Example 4/87a, where Mozart's slur over the final three quavers in bar 4 seems a deliberate separation by articulation, in comparison with the phrase elision that would otherwise occur (Example 4/87b).

If what follows the resolution in a metrical unit is an elaboration of the chord of resolution, it is unlikely, because of harmonic unity, to be an upbeat in the full sense or even an upbeat at all. Examples 4/76, 4/87a and 4/88 fall into the first of these categories because of the articulated separation of the resolution from what follows. Without such articulation, these examples would still have upbeats, joined to the resolution by phrase elision, but only because an afterbeat structure alone would be inappropriate to the voice leading. By contrast, in bar 8 of Example 4/89, with a melodic contour that falls to the root of the accompanying chord, an afterbeat structure is essential. Similar cases of such extended resolution are given as Examples 4/90 to 4/93. In such examples, any upbeat succeeding the note of resolution would be quite inappropriate on harmonic and melodic grounds.

If the grouping of attacks by duration contour produces a relatively large separation between the dissonance and its resolution, the latter's appearance in a single structural grouping begins to be called into question. Examples 4/84 and 4/85 show that a structural grouping between dissonance and resolution is still appropriate where the durations concerned are in the proportions 2:1. In the accompaniment of these examples, however, duration contour does not favour an upbeat on the chord of resolution and the treble line follows suit. In Example 4/94, where both melody and accompaniment could be an upbeat on the chord of resolution, the phrase grouping by duration contour also has structural significance, but the afterbeat structure of dissonance and resolution is not in doubt.

When dissonance resolution occurs on a dotted-note figure, that is, when the durations concerned are in the proportions 3:1 or more, the upbeat grouping from duration contour seems distinctly stronger melodically than the afterbeat grouping of the dissonance and resolution; yet the latter is still essential harmonically. That the incongruence is between melodic and harmonic understanding is illustrated by Example 4/95, in whose first bar the setting of a new word favours the melodic upbeat, while in the second bar it favours the harmonic afterbeat and gives rise to a following upbeat. In some of the following examples, the comparative weakness of the structural grouping uniting dissonance and resolution will be shown by notating the grouping with a broken line.

Examples 4/96 to 4/98 show varying degrees of harmonic independence of the dissonance. A diminished seventh is normally heard as a dissonance when it resolves on to a dominant seventh, first inversion; but when the progression occurs in a dotted-note figure (Example 4/96, bar 6), the independence of the two chords is more prominent. The slur that joins dissonance to resolution in this example may be taken to indicate legato string playing, rather than a hiatus at the end of the bar. The same is no doubt true of the slurs in Example 4/97, but here it is likely that articulation aids the perception of an afterbeat structural grouping connecting dissonance and resolution, since none of the four dissonances involved are suitably interpreted as independent functional chords, if heard in their historical context.

That a historical point of view is required to assess whether a chord is likely to be understood as a harmonic entity in its own right was noted in the commentary on Example 4/77. While a notion of harmonic independence may affect the grouping of dissonance and resolution in a dotted-note figure, it is still the case that durational separation in such structures itself contributes towards that independence. It is by such a means that a chord is made to stand on its own and, having done so sufficiently often, it becomes familiar and meaningful in its own right. This process of changing attitude to harmony nevertheless poses a problem for the analysis of the present dotted-note figures by computer: the computer would, at first, have to draw on an imperfect human assessment of the independence of a chord, until it had made its own survey.

If the grouping of the ninths in Example 4/97 with their resolution is aided by articulation, the ninth in Example 4/98a is made to stand on its own not only because it is repeated in the upbeat following the dotted note, but because its resolution is of the extended type mentioned above and its precise note of resolution is thereby obscured. The passage is clearly an elaboration of Example 4/98b, although a computer might recognize the B♭ in bar 28 as forming the first available chord of resolution. This example demonstrates that in a dotted-note figure (or equivalent), the harmonic unity of an extended resolution is not strong enough to contradict the upbeat from duration contour. In Example 4/99, the afterbeat grouping of the extended resolution is aided by pitch separation, but the durational upbeats nevertheless add impetus to the upwards thrust of the melodic sequence. In Example 4/100, the congruence of the durational upbeat with directional grouping makes this structure equal in importance to the connection between dissonance and resolution. In Example 4/98, bar 29, and in Examples 4/99 and 4/100, the resolution has been marked at the level which covers the whole of the extended resolution, in an attempt to show the influence of a more basic structure within its elaboration. The pitch of resolution to which this marking refers is given at the bottom of the appropriate branch.

By contrast with the last three examples, the resolutions in Example 4/101 are stronger than the following durational upbeat because the independence of the latter is weakened by shared duration closure; afterbeat structures alone seem appropriate here. Consistent with this observation is the fact that repeated dotted-note figures can present the clearest incongruence between melodic upbeats and dissonance resolution. Such cases are almost invariably oddities of common-practice harmony and doubtless contributed to its downfall by giving prominence to the dissonance. A full structural grouping between dissonance and resolution is not appropriate to these structures, unless aided by some other characteristic such as pitch separation (Example 4/99) or articulation (Example 4/103). Otherwise, a broken-line grouping seems the best compromise, as in Example 4/104. A predominant phrase grouping ending on the dissonance in accordance with duration contour is hard to deny in Examples 4/105, 4/106, and 4/107, and even harder to deny in Example 4/108.

A broken-line grouping between dissonance and resolution must be considered essential when the resolution is not only separated by relative duration, but is also of the 'displaced' type, in which the pitch of resolution is not directly harmonized by its chord of resolution. An example of such indirect resolution is the D in Example 4/93. An example involving durational separation is the B in Example 4/109, which resolves the preceding C♯, but whose chord of resolution - I - has been replaced by chord VI.

The degree of association between dissonance and resolution is not only affected by the proportional separation of attacks, but also by tempo. It is clear that if the resolution does not last sufficiently long in real time, its effect will hardly be registered. It is not certain what the minimum real timelength of a resolution can be, but two examples from Chopin (Examples 4/110 and 4/111) rank among the most extreme cases of dissonance and resolution on repeated dotted-note figures, because of their fast tempo. Although in both examples the appoggiatura involved is the progression from major seventh to octave, Example 4/110 is the less extreme of the two because the chord of resolution is constant throughout the sequence in the right hand. Example 4/111 is a sequence of diminished sevenths in both hands and sounds far more like the sequence marked with a broken line, with 'wrong notes' added, than a sequence of appoggiaturas.

It is one thing to describe the effect of dissonance resolution on a rhythmic structure; quite another to identify the characteristic in the first place. Not only is it impossible at present to supply an exhaustive list of its various forms, but scholarship still seems to be divided on its basic approach to the subject. On the one hand, there is Schoenberg's idea that dissonance is distinguished from consonance by a 'greater or lesser degree of comprehensibility ... The term emancipation of the dissonance refers to its comprehensibility, which is considered equivalent to the consonance's comprehensibility'.[9] Rufer notes that this process of emancipation

> can be traced from the early days when the third still counted as not a perfect consonant, to the "emancipated" appearance of the diminished seventh in classical music

9. Arnold Schoenberg, 'Composition with twelve tones', in Style and Idea (New York, 1951), quoted in Josef Rufer, Composition with twelve notes, translated by Humphrey Searle (London, 1965), p.47.

> ...and, further, to the free use of augmented triads and even more acutely dissonant intervals and chords in the second half of the nineteenth century.[10]

On the other hand, Komar, in his recent study of the suspension, refers to relative dissonance in tonal music, but only by way of defining certain intervals as 'absolutely consonant' and others as 'absolutely dissonant'.[11] In his list of absolute dissonances are intervals which belong to functional chords that may stand on their own in common-practice harmony, for example, sevenths in sequences of dominant or non-dominant sevenths.[12] The following account is based on theoretical assumptions that are nowadays well accepted, in particular the idea of the steady growth of harmonic vocabulary throughout the common-practice period. The purpose is not to present a definitive exposition of this growth of vocabulary, but merely to illustrate the main types of chord progression that the computer would have to be capable of recognizing to be able to perceive dissonance resolution.

The description of dissonance resolution as a structural characteristic has rested on the assumption that it is not normally necessary to recognize any quality of 'dissonance' *per se*, but only the relationship between a dissonance and its resolution. Nearly all dissonance and resolution has the quality described earlier: two adjacent chords (simultaneities) are linked by at least one common pitch in the same voice. A clearer connection between the chords is evident if the common pitch is also a common duration creating a longer-note accompaniment or is the tonic of the second chord. In a computer program by Patrick and Strickler, the feature of a common pitch between a dissonant chord and its associated consonance is used to recognize which line bears the dissonant pitch: at the point of dissonance between any two lines, the

10. Rufer, *op. cit.*, p.47.
11. Arthur J. Komar, *Theory of Suspensions* (Princeton, 1971), p.28.
12. See, for example, Piston, *op. cit.*, p.357.

consonant line has a pitch in common with the immediately preceding and succeeding consonances, or with the latter alone, provided that it is not on a higher metrical level, or, failing both of these conditions, with the former alone.[13] These criteria are applied to both accented and unaccented dissonances in the music of Josquin des Prez. However, Patrick and Strickler's concern is not with the recognition of consonance and dissonance as such, but with the identification of the appropriate type of voice-leading surrounding the harmonic interval of the second, fourth, or seventh, and with processes of reduction which eliminate these intervals.

Within the class of chord progressions containing a common pitch in the same voice, much of the dissonance and resolution to be found in tonal harmony can be perceived by reference to a hierarchy of chord categories, in which a higher-ranking chord functions as the resolution of a preceding lower-ranking one that is metrically accented. The hierarchy is as follows: (1) root position and first-inversion triads; (2) second-inversion triads; (3) dominant sevenths; (4) diminished triads, diminished sevenths and their enharmonic equivalents; (5) non-dominant ('diatonic') sevenths and augmented triads; (6) non-triads of three or more pitch classes. Example 4/112 illustrates the various combinations of chord categories that may be found. The hierarchy follows approximately the order in which the chords concerned were emancipated from dissonant status. It is key-independent and enharmonic equivalence is assumed; this is an advantage where the key is uncertain, but a limitation when the perception of a particular resolution requires a given tonal context.

Although the $^6_4$ chord has been made the second category, lower-ranking chords, with the exception of non-triads, do not seem to resolve

13. P. Howard Patrick and Karen Strickler, 'A Computer-Assisted Study of Dissonance in the Masses of Josquin Desprez', Computers and the Humanities, 12(1978), 341-364 (p.346).

on to it, usually because it itself is so often an accented dissonance. Yet in Example 4/113, where it stands on its own and shares a common pitch with the preceding diminished chord, there is still no marked sense of dissonance and resolution. The resolution from diminished seventh to root triad in Example 4/113 is an exception to the stipulation about a common pitch, but is clearly appropriate to the hierarchy. However, the independence of the diminished seventh must still be recognized for harmonic rhythmic purposes (Example 4/114a). Similar in function are metrically accented dominant sevenths and chords of the augmented sixth which resolve on a weak beat, as does the dominant seventh in Example 4/114b.

Among the progressions not recognized by the hierarchy as dissonances and resolutions are the suspensions and their succeeding chords in the sequence of sevenths of Example 4/115a. The recognition of suspended pitches in this example is not a problem; the case for perceiving their resolutions as dissonances seems to rest not on harmonic grounds, but on their sharing the same features as suspensions which do resolve. The suspension itself is one of these features; others are a longer-note accompaniment and the strong tendency for dissonances to resolve down. Regarding the last of these features, it has already been noted that in pitch patterning a drop in pitch following the metrically accented note is more readily recognized and associated with dissonance resolution than a strictly harmonic interpretation would suggest (Example 4/42). Similarly, while one could regard Example 4/115a as employing indirect resolution through its relationship to some supposed prototype such as Example 4/115b, it is perhaps better to regard the first two suspensions in the sequence as suspensions which do not resolve as dissonances in any harmonic sense.

While a hierarchy of categories seems similar to Komar's approach, mentioned above, no attempt has been made in the present hierarchy of chords to follow the traditional path, as Komar does, of labelling certain harmonic intervals as 'dissonant' with respect to certain 'consonant' ones so that these intervals may be identified within chords of more than two voices. Yet a table of such interval progressions can easily be constructed (Example 4/116) which, with its transpositions, will cover most of the dissonance resolution to be found in two-part writing. Such a table could be used by the computer in conjunction with the hierarchy of chords, both to see if the chord progression contained at least one component interval progression that complied with the table, since it might be suspect as a dissonance and resolution if it did not, and to enable the computer to build up its own knowledge of which of the table's interval progressions correspond to which chord progressions.

However, the simple labelling of certain intervals as 'dissonant' is naive, since the same chromatic or diatonic interval can vary in function as a dissonance or otherwise, according to the tonal context. For this reason it is always helpful and sometimes essential to have such a context. Example 4/117 shows several chords which appear to be able to resolve on to each other, assuming enharmonic equivalence where necessary. Without the given key, the second chord could be taken to be the resolution, yet, for each progression, the tonal context assigned to the opposite member of the pair is always a possible solution. The case of the major third as a 'dissonance' might seem particularly unlikely had Brahms not furnished us with an example of its sublime effect (Example 4/118). Indeed, this single example endorses much of the present attitude to dissonance resolution: the major third can hardly be described as 'dissonant' in itself; without the subsequent D minor chord, the passage would simply be interpreted as a move to the tonic major, which, briefly, it is; only in the light of the D minor chord is the D major's F♯ seen as a chromatic note resolving on to a scale note and hence as an appoggiatura.

It is clear from Example 4/117 that the fullest range of dissonance resolution and the least ambiguity in its perception depends on having a definite key or other tonal context as a reference and some aspects of the perception of tonality will therefore be considered in Section E of this chapter.

C. STRUCTURALLY ACCENTED TONICS

This section concerns the capacity of certain melodic intervals to define a tonic and considers the effect of such structurally accented tonics on metre. Unfortunately, the existing use of the term 'tonic accentuation' (see Section A above) precludes the assignation of this term to the structural accentuation of tonics and it might be better if the former characteristic were renamed to avoid possible confusion.

Example 4/119 is scored correctly, in 12/8, a metrical multiple which comes from repetition. But this does not explain why there is an initial quaver upbeat. If there were no structural accentuation of the second note, there might be no such upbeat and the pitch unity of the repeated As might establish an initial multiple of 3/8, beginning on the first note. Although bass accentuation generates the given metre, there is clearly structural significance in the fact that the second note is the tonic (marked 'T') and that it is defined as such by the downward melodic interval of a fifth (seven semitones). The repetition of this tonic establishes a multiple of 3/8. Similarly, in Example 4/120, the upward melodic movement of a fourth defines the second note as a tonic which forms a metrical connection with the subsequent minim to produce a 3/4 multiple.

In the absence of duration contour or a longer-note accompaniment, examples such as these suggest the structural accentuation of the tonic as the likely explanation of the notated metre. Yet while it is common knowledge that a dominant to tonic progression can be characterized as 'weak' to 'strong', the strength of the structural accent on the tonic is considerably less than its tonal importance would suggest. There is an obvious advantage to the communication of tonal structure in placing the tonic on the initial downbeat. But while the structural accentuation of the tonic will reinforce such a downbeat, it may not be strictly necessary to the perception of the latter; Examples 4/121 to 4/123 would assert their first downbeats through duration contour alone.

A closer look at the structural accentuation of the tonic reveals that it is weaker than the three main generators of metre - duration contour, a longer-note accompaniment, and harmonic rhythm - and that it usually owes its position on a downbeat to being congruent with whichever of these characteristics predominates metrically. Thus in Example 4/124, while the upward interval of the fourth defines the tonic, the metrical scheme is nevertheless determined by duration contour. A longer-note accompaniment is stronger than the progression to the tonic in Example 4/125; harmonic rhythm is stronger than it in Examples 4/126 and 4/127. In Example 4/128, the opening is metrically ambiguous; but a downbeat on the tonic, although congruent with duration contour, is superseded retrospectively by harmonic rhythm and the preference for a metrical timelength of eight quavers instead of seven. (The latent tonic downbeat is, however, realized in a later variant of the theme in the relative major.) Example 4/65 illustrates that the structural accentuation of the tonic is weaker than the 'moving voice' characteristic, while Example 4/129 shows that it is weaker than pitch unity.

With such incongruence defeating the metrical potential of the tonic, it is not surprising to find that the downbeat tonics in Examples 4/119 and 4/120 are congruent with the implied and actual harmonic rhythm, respectively, of these examples. Similarly, in Examples 4/130 and 4/131, the downbeat tonics are congruent with a longer-note accompaniment. It might seem, then, that there is no such thing as the structural accentuation of the tonic; but Examples 4/132 and 4/133 clearly show that the tonic asserts a downbeat before it is confirmed by harmonic rhythm. In Examples 4/134 and 4/135, the upward movement of a fourth seems the main justification for a downbeat on the tonic, where the tempo would normally be insufficient to generate the upbeat shown.

While the above examples have concentrated on the capacity of the downward movement of a fifth or the upward movement of a fourth to define a tonic, the upward movement of a semitone has the same property, though to a much lesser extent. The interval is too common as a chromatic inflexion to permit a single tonal interpretation; none of its four appearances in the few notes of Example 4/136, for instance, define the tonic of the passage. To argue that the interval always defined a tonic would not be inconsistent with tonal practice or theory, but all such tonics involving chromatic notes would be secondary to the root of the prevailing chord or the tonic of the scale. Thus the value of perceiving upward moving semitones would be diminished by the need for tonal interpretation by other means and it certainly could not be argued that each such semitone produced a structural accent. Yet the interval seems the only justification for the opening downbeat in Example 4/137, despite the highly chromatic nature of the passage.

The fourth, fifth, and semitone emerge as tonic-defining intervals through a tonal interpretation of the Harmonic Series up to the sixteenth harmonic, with the fundamental as the tonic. Such an interpretation is essential to Rameau's long-accepted theory of harmonic inversion and to assume that the intervals of the Series can be tonally interpreted melodically as well as harmonically implies no extension of the accepted view, the only practical drawback being tonal ambiguity.

An obvious melodic interval to consider as tonic-defining is the major third, but its principal value in this respect is still harmonic: in the analysis of harmonic rhythm, rather than as the generator of structural accentuation.

D. HARMONIC RHYTHM

Harmonic rhythm, the pattern of chord changes, is the strongest structural characteristic in the generation of metre and has an important effect on phrase grouping. The present use of the term differs slightly from the standard description given by Piston[14] and others. In the standard view, harmonic change gives rise to a pattern of durations which, as Piston notes, may be 'unlike any one of the melodic rhythm patterns'. LaRue splits harmonic rhythm into 'chord rhythm', 'key rhythm', 'progression rhythm' (of sequences), and 'modulatory rhythm' (of swift modulations), each capable of generating its distinctive duration string.[15] Harmonic rhythm is indeed compounded of structural timelengths which are analagous to durations; yet they are clearly not durations, although their proportions often permit them to function in a manner akin to duration contour.

For present purposes, it is more important to stress the unifying function of harmonic rhythm in grouping within each of its structural timelengths pitches that might otherwise be regarded as unconnected or simply as a sequence of chords (simultaneities) changing with each new attack, unless linked by pitch unity. Such a concept can be termed 'harmonic unity', although it is in fact included in the standard view of harmonic rhythm, since the latter must presume such grouping to

14. Walter Piston, 'Harmonic Rhythm', in Willi Apel _et al_, _Harvard Dictionary of Music_, second edition (London, 1970), pp.369-370; _Harmony_, revised Mark DeVoto (London, 1978), pp.199-211.
15. Jan LaRue, _Guidelines for Style Analysis_ (New York, 1970), pp.48-49.

account for the pattern of timelengths it reveals. Yet Piston refers to the static harmony of the Prelude to Das Rheingold as having a 'complete absence of harmonic rhythm',[16] which suggests that the term 'harmonic unity' may be useful after all.

The unity of harmonic rhythm can be an extension of pitch unity (Example 4/6). It can arise from tonal harmony: pitches are associated with each other though not simultaneous (Example 4/138a and b) or certain chords have precedence over others (Example 4/139[17]). Thirdly, it can be the result of a pedal (Example 4/140), in which case it often matches a longer-note accompaniment.

Harmonic rhythm has the strongest influence of all characteristics on the generation of metre, although its timelengths are not necessarily metrical timelengths. In Example 4/141 a metre is determined by duration contour and phrase grouping by upbeat repetition; yet in Example 4/141b the metre is determined by harmonic rhythm. Although the relative influence on metre of harmonic rhythm and duration contour seems inconsistent in these examples, the first metrical level in each is established by duration contour in its capacity as a pattern of timelengths, whereas its influence on the second level is only in providing a distinction between equal (metrical) timelengths, an influence which is weaker than an actual pattern of timelengths created by harmonic rhythm as in Example 4/141b.

Example 4/142a confirms that, like pitch unity in Example 4/142b, harmonic rhythm is weaker metrically than a pattern of timelengths from duration, while Example 4/142c shows this weakness to be a flexibility that allows the characteristic to underscore any metre so created: once the start of the first bar is established, harmonic rhythm alone could continue the metre at this level, its potential metrical grouping

16. Piston, Harmony, op. cit., p.205.
17. Quoted in Piston, Harmony, op. cit., p.200.

of pairs of bars, beginning at bar 2, being precluded by insufficient tempo. Conversely, Example 4/143 confirms that the timelengths of harmonic rhythm are stronger metrically than a distinction between the first duration values of equal metrical timelengths.

The subordination of harmonic rhythm to duration may be qualified further: in Example 4/144, the metrical accent falls on the first of the two G major chords not simply because of their harmonic unity, but because it follows a harmonic change; with the D major chords removed, the downbeat would fall on the root G major chord. In Example 4/145, the dotted-minim C♯ in bar 1 might first be heard as bearing a metrical accent as shown in the tree-diagram, but this accent would be repositioned following the third beat of bar 2, when harmonic unity and regular metre proved stronger than duration contour. The relevance of the initial prospective downbeat is seen by condensing bars 2 and 3 into 6/8. Further examples which involve regularity of metre and incongruence between duration contour and harmonic rhythm are Example 4/146, in which duration contour is metrically weaker than the other two aspects, and Example 4/147, in which the irregularity of harmonic rhythm's structural timelengths is weaker than a regular interpretation favouring duration contour.

Although it is clear that harmonic rhythm provides the simplest explanation of metre in the absence of durational differentiation, for example in the first and second preludes from Book 1 of The Well-Tempered Clavier and in creating a 3+4 subdivision in Example 4/148, the real strength of the characteristic as a generator of metre comes through its relationship with a longer-note accompaniment, especially one in the bass. Included with the longer-note characteristic as part of this relationship are adjacent notes linked by pitch unity and similarly linked notes occurring on adjacent metrical accents on the same level, as in trills and *tremolo*. Trills starting on the upper note are also relevant, so the above provision may be widened to include pitch unified resolutions and exclude their corresponding metrically accented dissonances. These provisions not only include pedals, but might also apply to Alberti basses and arpeggios, although those are better seen as expansions of familiar chords. Yet the distinction between trills, *tremolo*, Alberti basses, arpeggios, and other configurations of pitches as pitch sequences and as chordal variants is slender and varies with historical standpoint and tempo: the opening of Brahms' Intermezzo Op. 119, No. 1 (Example 3/202) invites interpretation as a series of arpeggios, though novel ones for their time; the cascading chromatic passage over the tonic chord at the end of Chopin's B minor sonata must surely be perceptible as harmony, foreshadowing a practice common in post-war twentieth century music and amenable, perhaps, only to a probabilistic form of analysis.

The relationship between harmonic rhythm, a longer-note accompaniment and the bass is as follows. If the longer-note accompaniment is in the bass,it is in an almost unassailable position metrically, unless subject to implied regular subdivision (Example 3/54) or a pre-established multiple (Example 4/149). It is either congruent with harmonic rhythm, as in Example 4/150a, or provides a higher-level harmonic rhythm in the form of a pedal (Example 4/150b). It is stronger than incongruent duration contour (Example 4/150c) although some dynamic accentuation on the incongruent duration can favour a metrical accent on it (Example 4/150d with accent and ties). However, as already seen, if the bass accompaniment consists of separate durations unified only by pitch, an incongruent duration contour is stronger metrically (Example 4/150d without accent and ties), except when dissonance resolution is involved (Example 4/151).

If a longer-note accompaniment is not in the bass, it loses its harmonic unity and is metrically weaker than harmonic rhythm when incongruent with it, as in Example 4/152. A more common structure is for these two characteristics to be stronger than an incongruent bass, as in Example 4/153. The rests in this example are structural, the first through the position of the metrical accent, the others through repetition. If the separate pitch-unified bass notes in Example 4/153 are merged into single notes, however, the metrical interpretation is affected by the duration contour of the attack string and the notes of the treble line are heard as harmonic anticipations (Example 4/154). But for considerations of regularity and duration, it is normal for the first of two overlapping durations to bear the metrical accent (as in Examples 4/150e and 4/153), unless incongruent with harmonic rhythm (Examples 4/155 and 4/156).

In phrase grouping, a timelength from harmonic rhythm may substitute for the single duration of a longer-note accompaniment in providing closure (see the end of Example 4/149). Apart from this, the effect of harmonic rhythm on phrase grouping is largely a matter of the extent to which harmonic unity can counteract the separation of groupings put forward by duration contour, when the two characteristics are incongruent. This question is in the same category as that already considered in respect of pitch unity, repeated pitch patterns, and dissonance resolution: in a pitch or harmonic sense, the phrase grouping put forward by durational grouping may be less coherent than that suggested by the other characteristic or, at the other extreme and in a durational sense, the latter may so violate the sense of duration closure that it is unlikely to predominate against the incongruent duration phrase.

As with pitch unity in Examples 4/43 and 4/44, it is normal for the pitch associations of harmonic unity to be heard, even where duration contour provides the predominant phrase grouping, and to temper the relative degree of separation of the latter. The two senses of pitch grouping, by harmonic unity and duration contour, are illustrated by the square brackets and phrase groupings, respectively, in Example 4/157. In this example, the two interpretations are relevant even without durational differentiation, because the grouping by duration contour is congruent with grouping by pitch proximity.

Since the timelengths of harmonic rhythm tend to be congruent with metrical timelengths, such an example does not so much demonstrate a discrepancy between harmonic rhythm and durational phrase grouping as illustrate the distinction between a structural (or metrical) unit and a phrase grouping. Although harmonic rhythm reinforces our awareness of the former at the expense of the latter, the two coexist on different levels. A metrical connection does not simply create an association between two metrically accented pitches, but, in defining a metrical unit, focuses attention on it as a potential pitch or harmonic entity. Whether the metrical unit is in fact a harmonic unit or is subdivided by an internal harmonic rhythm or, more fundamentally, by phrase separation on the level of the metrical connection, is a separate matter. If it is a harmonic unit, however, it is not normal for it to turn duration upbeats into afterbeats.

Bar 2 of Example 4/158a is a case in which harmonic rhythm does alter the predominant phrase grouping as put forward by duration contour. Although there is harmonic unity in the repeated chord of the accompaniment, the upbeat belongs, by implication, to the dominant chord. This would not be sufficient to affect the phrase grouping if the bar were the first in some hypothetical context (Example 4/158b). But the second half of bar 2 is the last branch of a four-grouping, already anticipated on the next level by the metrical timelength from duration contour. A phrase grouping, or at least a structural timelength, of three minim beats would have been acceptable if the fourth beat had been the dominant chord. As it is, however, the fact that the metrically accented note on the fourth beat is harmonically associated with the third allows it to become detached from the durational upbeat and would do so even if it were a quaver or semiquaver. (In Rossini's scoring, this phrasing is aided by the entry of the clarinet.)

By contrast, in the second bar of Example 4/159, harmonic rhythm creates an upbeat in the melody, where duration closure alone would not do so. Although the phrase grouping of the accompaniment produces the same phrase grouping in the melody, the melodic upbeat in bar 2 would still exist if the accompaniment's upbeat were replaced by a rest. The effect of harmonic rhythm on the melody's duration string is similar to that of upbeat repetition: what remains after the loss of the upbeat is viable as a duration phrase. If it were not, it would be necessary to indicate harmonic closure with an asterisk on the crotchet's level alone, in the manner of Example 4/160 below.

Example 4/159 leads to the question of harmonic elaboration. The duration strings in the fourth bars of Examples 4/120, 4/160, and 4/161 share to some extent in the duration closure of their longer-note accompaniments; as melodies they do not have overall upbeat status because of their triadic associations with these accompaniments.

A single foreground tree-diagram may not easily show the effect of such associations on phrase grouping; the placing of an asterisk on the appropriate level, but without lower-level separation, is a compromise to indicate simultaneous phrase ending and continuation.

The congruence of harmonic rhythm with downbeat repetition weakens the phrase separation put forward by duration contour if it is of the type covered by Separation Rule 5, in which a distinction is made between the duration values specified by the branches of equal metrical timelengths. Both downbeat repetition and harmonic rhythm strengthen our awareness of metrical units and, in the case of the former, there is a tendency to favour the congruence of metre with phrase grouping, if possible. Thus, the phrase grouping from duration contour may be weakened to the point of structural ambiguity, as in Examples 4/162 and 4/163.

In such circumstances, even relatively weak characteristics can decide the predominant phrase grouping. In Example 4/161, pitch proximity would tilt the balance towards an upbeat if the quavers formed an ascending scale from the tonic instead of a descending one to it. Similarly in Example 4/85, there is more pitch separation and consequently more awareness of pitch grouping after the second bar than after the first. By contrast, the harmonic link between the dominant and the tonic chords in Examples 4/164 and 4/165 is stronger than the potential upbeat from duration contour. The pitch unity in Example 4/165 and the arpeggiation in Example 4/164 ensure that, as harmonic elaborations, the melodies of the potential upbeats cannot be dissociated from the phrase grouping of their accompaniments.

Where the durational grouping is produced by the separation of attacks, however, harmonic rhythm alone does not create afterbeats, even before a point of downbeat repetition. The upbeats in the second bars of Example 4/118 and Example 4/166 are weakened both by the following repetition and by their harmonic relationship with the preceding note; yet they are upbeats nevertheless. But if harmonic rhythm weakens such an upbeat, it does at least give the pitches of the upbeat some identity as part of a harmonic elaboration and a strengthened structural unit. Upbeats similarly weakened by a point of downbeat repetition but which are not connected harmonically to the previous phrase grouping are almost lost both to phrase grouping and harmonic analysis, yet as passing notes they may be far from inessential (Example 4/167).

Examples 4/168a and 4/168b show that upbeats produced by the separation of attacks can be overturned: in both examples, harmonic rhythm is in conjunction with pitch repetition and pitch unity and strengthens the afterbeat interpretation that they could be considered to put forward on their own. The interpretation generated by duration contour is a subsidiary one in both examples, but more so in Example 4/168b, since its repetition is less exact, being by inversion.

Another aspect of harmonic rhythm and phrase grouping concerns the perception of structural rests and ties. These are more likely to be perceived if a musical line is heard from the harmonic than the melodic point of view. Where an attack interval extends from one harmonic unit into the next, the sounded notelength may or may not also do so. Where it does not, the change of harmony, from the harmonic viewpoint, normally produces a structural rest. Where it does, also from the harmonic viewpoint, if it is a syncopation, then it will be split into two notes joined by a tie. For the purposes of durational phrase grouping, it will be treated as two notes, unless it is a harmonic anticipation.

It is also possible, however, for a line to be heard from the melodic point of view, but in relation to the underlying harmony rather than purely independently. From this viewpoint, structural rests are less common, unless aided by repetition (Example 4/169) or pitch separation (Example 4/170), in which case their effect on the phrase grouping is stronger than that of duration contour. A structural rest does not seem appropriate when a line displays dissonance and resolution, even if the dissonance is technically not sounded, as in Example 4/171a which may be compared with the harmonic viewpoint of Example 4/171b.

The present concept of harmonic rhythm is not necessarily based solely on tonal harmony, especially since it is closely related to a longer-note accompaniment and particularly one in the bass. But while the unity of tonal harmony should present relatively few problems in computer analysis, since its basis in the triad and related chords is well known, an equivalent basis for harmonic unity in extended tonality and atonality is not so self-evident. One likely parallel between the analysis of tonal harmony and twentieth-century harmony stems from the fact that the perception of harmonic rhythm is largely an act of reductional analysis: there seems no reason why reduction should apply to tonal music alone. On the other hand, a systematic study of the reductional techniques suitable to derive a harmonic rhythm for atonal harmony would be beyond the scope of the present work.

Piston has shown that, even in tonal harmony, the perception of the triad is not the sole criterion for determining harmonic rhythm: an extended form of harmonic rhythm can come from the distinction between triads themselves.[18] In his two examples, the oscillation

18. Piston, Harmony, op. cit., pp.208-209.

between chords I and V gives rise to a harmonic unity based on whichever of the chords is consistently metrically accented on the higher level. It is thus dependent on a rhythmic characteristic, rather than a distinction in importance between triads. Similarly, in Example 4/172, the pitch unity of the neighbour-note figures predominates over the normal supremacy of the triad to the non-triad. Again, in Example 4/173, there is separate harmonic unity in bar 95 and in bar 96 on the level below that which connects them as dissonance and resolution.

In most Western music, however, it is clear that the unity of harmonic rhythm is mainly derived from the recognition of thirds, triads, and other functional chords within a harmonically elaborated texture. For the computer, such recognition should follow the rhythmic structure as closely as possible, to the extent that that structure can be determined by other characteristics. This is not a case of begging the question, of assuming the prior existence of a rhythmic structure which, it is then argued, is generated by harmonic rhythm, but of utilizing some aspects of that structure to aid the perception of others and thereby to generate the whole. The fact that we ourselves tend to perceive whole objects instantaneously is not an argument against the existence of separate perceptual preferences, since these will simply be in operation simultaneously, whereas computer processing is traditionally sequential.

The close correspondence between the perception of harmonic rhythm and the harmonic reduction of the foreground was mentioned above and may be illustrated by deriving a simple procedure for the latter. The essential difference between the two is that, in harmonic reduction, a single duration is substituted for each structural timelength of harmonic rhythm and the different harmonies of the structural unit are replaced by the representative harmonic-rhythmic chord. The tree-diagram of a harmonic reduction is derived by pruning the original tree: the branches which bear the structural timelengths of harmonic rhythm are preserved, while the branches subtended from them are discarded. Since such a diagram largely consists of all but the lowest levels of the original foreground structure, it may be regarded as an aspect of that structure and therefore relevant to the present study. A full-scale investigation of reduction would, however, involve issues that are both highly controversial and fall outside the present terms of reference: the relevance and relationship of extensive reduction to the foreground structure; how to differentiate among triads and to what extent it is valid to do so; and problems of melodic reduction, particularly the differing claims of voice-leading and the original pitch register and function.

The derivation of a single harmonically reduced tree-diagram for two or more passages equivalent in harmonic rhythm reveals at least the minimal extent of the similarity between their foreground rhythmic structures. An instance of two such passages is the example quoted by Schachter from Bach's Musical Offering, to which reference was made in Chapter 1 (p.31 and Example 1/6). The harmonic reduction of these passages is given as Example 4/173.1. At each stage of reduction, (a) pitches belonging to the prevailing harmony of their immediate metrical unit are contracted into a single chord and placed at the head of the unit, which bears only one branch, passing notes being eliminated; (b) dissonances are shifted into the structural unit of the preceding harmony and appear as notional passing notes, notated as unstemmed black notes. Operation (a) can be split into two stages, the deletion of passing notes preceding harmonic contraction. In Example 4/173.1, this has been done twice in the first-stage reduction of the Variation, to highlight its similarity to the Theme. Since there is no harmonization of the Theme, its reduction is in accordance with the harmonic unity contained within it. Differentiation between functional chords has been kept to a minimum: those with pitches chromatic to the scale are treated as quasi-dissonances (c.f. Example 4/118); other chords are ranked as in the table of Example 4/112, with the additional proviso that a first inversion has a lesser status than a root triad.

Example 4/173.1 shows that Schachter's observation that the two melodies have different rhythmic contours (see p.31) refers to duration rather than rhythmic structure in the present sense. The similarity between the melodies and structures is made clearer by the Variation's first-stage reduction. Bar 6 of the original is treated as an upbeat before reduction, because of the preceding duration closure; with the alteration of duration values in the reductions, it defaults to an ordinary afterbeat. In the second-stage reduction of the Variation and the reduction of the Theme, the two sets of material become virtually identical. Their metrical structure appears, at first sight, to be different from that of the original Variation, if not of the Theme, if one assumes that each phrase grouping of the original is, by default, perceived with a weak metrical accent on its first branch. In fact, the higher-level harmonic rhythm highlighted by reduction provides a strong enough reason for a new two-bar metrical level in the original (level a), which supersedes the default metre and is compatible with the original phrase grouping.

It would be mistaken, however, to imagine that the above form of harmonic reduction necessarily highlights a higher-level harmonic rhythm in the foreground rhythmic structure. In selecting pitches and chords considered tonally superior, it may involve shifting them from weak rhythmic positions they have held in the foreground structure. Yet pitches also gain prominence from rhythmic strength. While the perception of harmonic rhythm maintains and strengthens the relative importance of its representative chord, even though another chord in the same metrical unit may occupy a greater proportion of the unit or be in a metrically stronger position, Examples 4/110 and 4/111 have shown that an accented dissonance may be rhythmically prominent enough to weaken the perception of the following chord as a resolution and, consequently, as the representative harmonic-rhythmic chord. Likewise, when chords are in a weak rhythmic position in the foreground structure and their tonal superiority is less marked than that between relative consonances and dissonances (see Example 4/112) - occurring, for example, from a tonal distinction between triads - any harmonic rhythm generated by such chords is relatively weak. At remote stages of reduction, such a harmonic rhythm may become highlighted to such a point that it is a distortion of its prominence in the original music and its relevance is in doubt.

E. RHYTHMIC STRUCTURE AND TONALITY

Ideally, this section should consider the influence of tonality on rhythmic structure, especially that on the large scale, on which it can have a strong influence. But this presupposes that the nature of tonality is itself understood with sufficient explicitness to be modelled on the computer. While several computer programs have analyzed diatonic harmony,[18.1] the concept of tonality clearly extends beyond the textbook definition of the diatonic key system, however useful the latter may be. A single theory is required that will unify what are intuitively classified under such terms as modality, diatonicism, bitonality, and polytonality; probably even atonality as well. For the present work to pursue such a theory in detail would take it well outside its brief in scope and scale. However, some aspects of the identification of tonics, that are relevant to the perception of rhythmic structure, will be put forward in this section.

The reliance on intuition in traditional theory is well illustrated by the description of harmonic cadence as a matter of various types of chord progressions: perfect, imperfect, plagal, and interrupted. Not only is the identification of the tonic within whose scale these progressions may be numbered left to intuition, but, more seriously for present purposes, so is identification of the rhythmic contexts within which each of these progressions forms a cadence. It is an elementary observation that not every I-V or V-I, for instance, is cadential.

The various means of separating phrase groupings, in particular the criteria for duration closure, establish many different rhythmic contexts in which harmonic progressions may subsequently be described and through which they may form a higher level of differentiation, as

18.1 See, for example, Jackson (1967), Longuet-Higgins and Steedman (1971), Longuet-Higgins (1976), Holtzman (1977); publication details in bibliography.

was noted in the case of repetition. The phrase ending on a dissonance in Example 4/174 illustrates that such contexts may exist quite independently of harmonic content and it is but a small step from this observation to the contention that they may shape the perception of tonal structure.

But without the clear punctuation of phrase groupings by the structural characteristics described in the present work, the perception of a cadence depends on the recognition of certain harmonic progressions as well as on an evaluation of the need for a cadence at the point concerned. The second criterion is hard to define, although it presumably increases with the length of a phrase. Yet this alone does not explain why, for example, in the C♯ minor fugue from Book 1 of The Well-Tempered Clavier, the E major cadence at bar 35 is more important than the G♯ minor cadence at bar 22. It is not a point of duration closure, whereas the latter is; significance must instead be attached to its being in the relative major, being predicted by the preceding dominant pedal, and being followed by new thematic material.

Observations of this type will be crucial to the modelling of tonal structure on the computer. The grading of triads in relative importance within a particular piece is of the essence of the Schenker technique of reduction; such a tonal hierarchy is increasingly important as the predominance of phrase grouping diminishes. In the above-mentioned fugue, for instance, the return of the subject in the tonic at bar 73 establishes a high point of the structure towards which the preceding modulations can be related, but it does not mark a particularly prominent phrase ending.

Within the key system, in which any triad can stand in a tonal relationship to any other, especially indirectly through secondary tonics, few triadic progressions are bound together as strongly as that from the dominant to the tonic and its equivalent progressions with the same root movement. Whether the strength of this association derives purely from the Harmonic Series or whether it comes from continual assertion in tonal practice is not clear, but it is certainly strong enough to act like a dissonance and resolution in phrase grouping, in contradiction to duration contour (Example 4/175), and to influence the elision of phrases (Example 4/176).

Before a point of downbeat repetition, many triadic progressions can counteract an upbeat put forward by duration contour, in the manner of Example 4/175 (see also the F♯ major triad in Example 2/44). Those triads that cannot do so are associated with each other significantly less than the second of them is associated with the chord of the following downbeat. Like the association between dominant and tonic, such associations are context free; unlike the dominant and tonic, they are mostly learnt associations derived from past harmonic practice and are the product of an intuitive probability analysis on the part of the listener. In Example 4/177a, the B major triad is less likely to be grouped with the D major first inversion chord than the latter is to be grouped with the following E major dominant seventh. Example 4/177b confirms that the same associations affect phrase grouping in opposition to the principles of duration closure.

To catalogue every possible pair of triadic progressions, so that individual intuitive decisions on phrase grouping could be made, would be a laborious exercise of limited value, since the strength of the associations would have been excluded and it is a knowledge of this strength that is required to assess the effect of harmonic association on phrase grouping in the many different rhythmic contexts put forward by other characteristics. An alternative is to calculate the probabilities of association by a study of harmonic practice, using the computer. Such a study cannot be limited simply to sequences of harmonies irrespective of their metrical position and phrase grouping. It is evident that the increased separation of attacks lowers the degree of association between triads, just as it does between dissonance and resolution. The phrase grouping in Example 4/175 would be markedly less appropriate if the durations concerned were in the proportions 3:1 or more. Tempo is not insignificant, either: a raising of tempo increases the dissociation of two chords when the second of these has a lesser duration value than the first; this was also noted in respect of dissonance resolution (Examples 4/110 and 4/111).

The proposed calculation of harmonic associations, though affected by rhythmic structure created by other characteristics, would have to be subject to subsequent adjustment. For example, each time duration contour grouped together two chords that with hindsight were understood to be associated only weakly, because of the harmonic association between other chords, the contribution of the original observation to the statistics and probabilities would have to be adjusted according to hindsight. On a large scale, this might affect the strength of the harmonic associations and further adjustments might be required until equilibrium was obtained.

If such a learning process, originating in a partial understanding of rhythmic structure, can affect the association of triads, it is not unreasonable to suppose that partial rhythmic structure can similarly affect the perception of tonality. In tonal music, the chords of a harmonic progression normally form a sequence of roots (each a tonic), culminating in the final chord of each phrase grouping. Since it is this final chord that is customarily identified with each type of cadence, the phrase structure may be seen as defining that chord's root as the overall tonic of the phrase, in one sense. Such cadential tonics are necessary to the interpretation of passages which cannot be described within the scale system, such as Examples 4/178 and 4/179. In these examples, a twelve-tone description has been used, with zero representing the tonic. This practice avoids the often clumsy attempts to label chords as members of a scale to which they do not really belong.

The notion of a cadential tonic misses two important aspects of the tonal interpretation of a harmonic progression. One is that the tonal interpretation of the fifth and the fourth is as primordial (because of the Harmonic Series) as any tonal interpretation deriving from rhythmic structure. The other is that while one focal point of any progression is the point of arrival, the other is the point of departure. In most music of the common practice period, a tonic asserted at the beginning of the piece is as important a point of reference as that of the final chord, which it will usually match. The tonic of departure guides our expectations through the remotest modulations in anticipation of its final return. Furthermore, we do not need to wait until the last chord to make a tonal interpretation of the whole piece.

Example 4/90 illustrates the value of the initial tonic in unifying the diversity of tonal structures that a cadential interpretation alone would generate. In the case of an imperfect cadence such as this (bar 8), a 'modal' interpretation based on a cadential tonic can seem particularly superfluous in comparison with that determined by the initial tonic; yet the cadential interpretation is a subsidiary structure that cannot be dismissed so lightly. The opening of Barber's <u>Adagio for Strings</u> consists of an overall progression from an E♭ minor to an F major triad (Example 4/180) and a cadential tonal interpretation is in accordance with the final triad of the piece. Aside from any argument about the true key of the piece, if the first chord were a B♭ minor triad, diatonic theory would interpret this opening as being in B♭ minor, ending on an imperfect cadence. The cadential interpretation, though clearly subsidiary in the B♭ minor variant, does at least establish the common ground between the variant and the original; whereas in traditional nomenclature, not a single chord of the variant would be tonally interpreted as in the original, whether the latter were placed in E♭ minor, G♭ major, or F major.

Two further examples illustrate the function of cadential tonics. In the first (Example 4/181), there need be no dispute over the notated key of A major and the function of G♯ in identifying the correct scale. Because of its opening phrase groupings, however, the passage has a distinct feel of D major with a chromatic G♯; if this note is replaced with a G♮, the passage is correctly in D major ending on an imperfect cadence of the dominant key, A. From the viewpoint of a subsidiary cadential tonic on this E major chord, the original and variant are tonally identical, but for the distinction between G♯ and G♮; from the traditional viewpoints of A major and D major they are entirely different.

The second example (Example 4/182) is a pun on Western habits of perceiving keys, designed to give an 'oriental' feel. The B♮ suggests the subsequent A minor in the same way that the G♯ in the Brahms example suggests A major, but the subsequent cadence is on the dominant seventh of F. It is futile to argue whether the passage up to the repeat is really in F or in A minor: the final cadence is unequivocally in F. Although the dominant seventh has an identifiable root, its value as a cadential tonic is considerably less than that of a triad, unless it is not heard to resolve. When a phrase ends on a dissonance or a tonally ambiguous chord such as the diminished seventh, the bias of tonal interpretation is clearly in favour of the phrase's tonic of departure (see Example 4/174). This is consistent with the case of the imperfect cadence, since the dominant's relationship with the tonic is one of a quasi-dissonance, as was noted in Example 4/175.

The tonic of departure can be defined in the first instance as the root of the chord specified by the first branch on the highest level of a phrase grouping. It seems likely that this downbeat tonic will only be superseded by a tonic from the preceding upbeat if that tonic (a) is a fifth below it, or (b) is the tonic of a key unambiguously identified by its scale, or (c) matches a cadential tonic. Conditions (a) and (b) may also cause the downbeat tonic to be superseded by the root of a following chord on the same or a lower level. Neither the tonic of departure nor the cadential tonic can lay indisputable claim to being the overall tonic of a phrase grouping. The tonic of departure is weaker than a cadential tonic and its tonal interpretation predominates only when it is the more familiar of the two. Yet with neither tonic can one disregard the associations of scale and key and the capacity of the fourth and fifth to generate a tonic at some level of the tonal hierarchy.

The ultimate method of tonal analysis may well be comparative: interpretations could be based on each of the most likely tonics and that with the most familiar set of tonal relationships would predominate, unless incongruent with the tonic of departure or the cadential tonic, whose claims would have to be given probability values in their own right. Though not based on computed probabilities, the probabilistic approach to harmonic analysis has been incorporated in a computer program by Winograd, who assigns 'plausibility values' to the various tonal interpretations of chord progressions.[19] For an overall tonic,

19. Terry Winograd, 'Linguistics and the Computer Analysis of Tonal Harmony', Journal of Music Theory, 12(1968), 2-49 (p.25).

the program uses that of the final cadence and parses backwards from there.

The statistical analysis of the familiarity of tonal relationships would be co-ordinated with that of harmonic association, proposed above, since a tonal relationship is merely a particular kind of association and one with an identified tonic. As with harmonic association, the original analysis would have to be adjusted with hindsight, which in this case would affect passages whose 'correct' tonal interpretation was not derived from the cadential tonic, the tonic of departure, or the Harmonic Series.

The above argument has been put forward from a viewpoint that differs significantly in one respect from traditional tonal analysis. While such analysis is often hierarchical, acknowledging local secondary tonics for modulatory passages or chromatic notes, the general aim is to provide a tonal interpretation at the highest possible level. The present viewpoint is more closely related to rhythmic structure: a phrase grouping is an entity in its own right as well as being part of the whole and it is necessary to be able to express its tonal relationships independently of the whole before the structure can be compared with similar passages in other pieces. This is all the more important since the grounds for similarity are often harmonic. However many individual tonal relationships may be embedded within a passage and whether they are expressed in diatonic or chromatic scale steps, it is desirable to have a common setting for them all. The lack of such a setting is the principal fault in the differences of harmonic description between Examples 4/180 and 4/181 and their hypothetical variants.

The solution to this problem may lie in some form of tonal 'map', based on the Harmonic Series and showing different areas of flatness and sharpness. The origin of such a map lies in Schoenberg's concept of harmonic regions,[20] but more important for present purposes is the two-dimensional table put forward by Longuet-Higgins (Example 4/183).[21] This shows a succession of Perfect Fifths on the horizontal axis and major thirds on the vertical axis. These two intervals are the first to be generated by the Harmonic Series, other than by inversion, that produce new pitch-classes after that of the Fundamental. They are placed on different axes because they are acoustically distinct, the major third produced by Pythagorean tuning in Perfect Fifths being different by a comma (81:80) from the pure third (5:4).

Acoustically, then, Longuet-Higgins' table is an expression of just intonation and can be extended indefinitely in either dimension, although Fokker, who derives the same two-dimensional relationship between fifths and thirds, closes it within a 31-note scale, which he considers sufficient to represent just intonation in performance.[22] Tonal relationships do not depend on accuracy of tuning, however, but on the perception of tonics. If this were not so, the compromise of equal temperament would fail to communicate tonal structure.

The importance of a tonal map is that it enables configurations of pitches to have a tonal identity, through their proximity in the tonal 'space' that is common to all scales and modes, without necessarily being identified with one overall tonic. Such an identity finds expression in the assignment of accidentals and Longuet-Higgins has employed his map in a computer program that performs this task

20. Arnold Schoenberg, Structural Functions of Harmony (London, 1954), Chapter 3.
21. H.C. Longuet-Higgins, 'Letter to a musical friend' and 'Second letter to a musical friend', The Music Review, 23(1962), 244-8, 271-80.
22. Adrian D. Fokker, New Music with 31 Notes, translated by Leigh Gerdine (Düsseldorf, 1974), pp.35-39.

with a high rate of success, working with a twelve-tone melodic input from an electronic keyboard.[23] The link between this input and the tonal map is the map's twelve-tone equivalent (Example 4/184). To identify the tonic of the initial key, Longuet-Higgins requires a further criterion: 'the tonic may be determined from the first two notes and . . . will be either the first note itself or the note a fifth below it'.[24] The index to Barlow and Morgenstern's thematic dictionary,[25] in which all entries are transposed into C major or minor, affords a statistical evaluation of how effective this rule might be.

An alternative, though not fundamentally different, view of tonal space may be derived from the interlocking of major and minor triads, as in Example 4/185. Such a diagram was implicit in Rameau's description of the key system as founded on a succession of major triads a fifth apart, the dominant and subdominant triads being closest to the central tonic triad (Example 4/186).[26] The major triad, generally held to be the basis of Western tonal harmony, though not of all tonality, is represented in the Harmonic Series by the ratios 4:5:6. Interpreting the Fundamental as a tonic, both the major third and the fifth point to a tonic on the multiple of the Fundamental (Example 4/187). In Example 4/185, the interpretation of the minor triad as the product of two major ones, each having the ratios 4:5:6, is acoustically correct: its major third points to a subsidiary tonic on its middle note, while the fifth between its lowest and highest notes is Perfect and points to

23. H.C. Longuet-Higgins, 'Perception of melodies', Nature, 263(1976), 646-653. See also H.C. Longuet-Higgins and M.J. Steedman, 'On Interpreting Bach', Machine Intelligence, 6(1971), 221-239.
24. H.C. Longuet-Higgins, 'Perception', op. cit., p.650.
25. Harold Barlow and Sam Morgenstern, A Dictionary of Musical Themes (London, 1949), pp.527-644.
26. Jean-Philippe Rameau, Génération Harmonique (Paris, 1737), Chapter 3, quoted in Matthew Shirlaw, The Theory of Harmony (London, 1917), p.200.

its bass note as the overall root of the chord (Example 4/187). It is possible that this latent bitonality is the cause of the supposed imperfection of the minor triad relative to the major and the reason why music in the minor mode tends to seek the relative major, whereas the reverse tendency is less common. These tonal interpretations of the major and minor triads may be considered as an integral aspect of the sequence of interlocking triads.

In Example 4/185, there are two letters for each pitch-class, one capital and one lower-case. The distinction between them corresponds to that between, for example, the two Ds in Longuet-Higgins' table. Although they are treated as enharmonically equivalent in music, they represent different parts of the tonal spectrum, as the sequence of triads shows. Our tonal conception of the D in a B♭ major triad is different to that in a D major triad because that conception is linked to the triad in each case. The well-known diagram of the cycle of fifths sometimes also employs two letters for each pitch-class, when shown in conjunction with an equivalent cycle of keys in the relative minor.[27] But neither the single-dimension sequence of triads nor a cyclic diagram shows pitch as distinct from pitch-class. If the members of the triadic sequence are numbered in positive and negative integers, with C as the arbitrary centre of the tonal system and numbered zero, and if the upper-case and lower-case pitch letters are placed in a two-dimensional diagram, of which this number sequence of 'tonal values' forms one axis and the twelve-tone scale another, the result is the tonal and pitch map of Example 4/188. In this example, the enharmonically equivalent pitches are linked by vertical lines, since they are, in effect, the same pitches.

27. See, for example, Piston, Harmony, op. cit., p.9.

The proposed tonal map clearly shows the relationship between the scale system and its triadic origins. The major scale is a zig-zag pattern embracing those pitches whose tonal values lie closest to the tonic of the key and the natural scale of the relative minor follows the same pattern. Although visual prominence has been given to the enharmonic connections in Example 4/188, a computer representation of the map would incorporate not only these links but also those of the original sequence of triads, which form the left-to-right diagonals. The tonal links of the fifth, fourth, and major third could also be incorporated, unless included in a subroutine for the tonal interpretation of pitches that had already been placed on the map.

While each pitch of the twelve-tone scale has four or more possible tonal values, its most likely value is identified by the narrowest possible clustering of tonal values in a given pitch set, harmonic intervals having priority over melodic ones. Thus, in the scale of B minor, B-A♯-B would not be interpreted as B-B♭-B, because the latter involves a shift in tonal value of -7, whereas in the former the shift is only +3. It is common in traditional harmony for a note to change tonal function with a change in harmony, as in Example 4/189, but this merely reflects the enharmonic equivalence between the 'major' (upper-case) and 'minor' (lower-case) versions of the same musical letter-name, just as a change in letter-name (between, say, G♯ and A♭) may signal a change in tonal function within the second generation of enharmonic equivalence embodied in the twelve-tone scale.

The tonal values themselves are not of equivalent status, since they are the product of both major and minor thirds. There is no suggestion that a progression from C major to E minor is half-way towards G major. The values are better seen as separate sets of even and odd numbers, representing the tonics of major and minor keys, respectively. The relationship between tonal value and key signature is easily deduced.

It is anticipated that the tonal map will aid the perception of dissonance resolution and harmonic rhythm. Just as our learnt associations are stimulated by musical input and aid its interpretation, so the tonal values generated by a particular pitch set may excite pre-established tonal links in the map, somewhat in the manner of the game noughts and crosses. For instance, the map predicts the resolution of the chord C-F-G on one of the triads C-e-G, C-F-a, c-E♭-g, or c-f-A♭. Whichever resolution occurs causes a retroactive interpretation of the original chord: if it is a major triad, the minor tonal values tend to be forgotten; if a minor triad, the major values recede in importance. The 'dissonant' chord alone is not devoid of tonal interpretation: it is seen to be associated with tonics on C and F, and if the influence of the bass is included, the chord's tonic can be identified as C.

In the perception of harmonic rhythm, triadic associations function in the same way as above. In Example 4/138b, for instance, even without metrical analysis, the D minor triad is the first to emerge in the first six pitches; in the second six, A major is suggested before D minor. In the same example, the recognition of thirds suggests an intermediate stage of reduction (Example 4/190), preceding that of the predominant triad alone.

As stated earlier, one of the chief functions of a tonal map is to provide tonal identity when there is ambiguity over the predominant overall tonic. It is possible, then, that the proposed map may have some relevance for the analysis of extended tonality and atonality, but it is evident that the relationships highlighted in the map are progressively undermined in music from at least the mid-nineteenth century onwards. Firstly, the ends of the tonal spectrum are joined by enharmonic equivalence and there is a greater willingness to cross the boundary between the flat and sharp sides. Secondly, the rate of transition between radically different tonal values is radically increased. Thirdly, more and more tonally ambiguous harmonies are employed. Such changes reflect the demise of triadic tonality and do not mean that the map should not be used with the music concerned.

CHAPTER FIVE

OTHER ASPECTS OF THE SCORE AND THEIR EFFECT ON RHYTHMIC STRUCTURE

Being derived from the score, the structural characteristics of duration and pitch that have been put forward in Chapters 3 and 4 cannot reasonably be divorced from the other aspects of the score which can affect the cognition of rhythmic structure. These are timbre, the notated aspects of performance - dynamics, articulation, and tempo - and the notated metre and phrasing. Phrasing slurs either are editorial, in which case they are better avoided, or match the phrase structure that can be communicated without them, or indicate articulation. Timbral distinction has been judged to lie outside the scope of the present enquiry (see p.52). This final chapter will therefore consider the notated aspects of performance and the relationship between the predicted and the notated metre.

A. NOTATED ASPECTS OF PERFORMANCE

This section will examine the effect of notated dynamics, articulation, and tempo on rhythmic structure. That is not to say that the way the performer interprets the score in these three domains, in addition to what is notated, does not affect the listener's understanding of the musical message. For example, it can be inappropriate for a passage to be played legato, even though staccato marks or rests are not notated; dynamic accentuation of a cross-rhythm (see Example 1/5) may be suitable if the metre is assured by an accompaniment, and less so if not; agogic accents (tenuto) may aid pitch separation and important melody notes that might otherwise be obscured; a decrease in tempo often precedes the shared note of two elided phrases and the last note of a piece. Means of interpretation such as these, though part of the rhythmic structure communicated to the listener, must nevertheless remain outside the scope of the present enquiry, because they are subjective inferences from the score. Riemann's idea (in Dynamik und Agogik) that musical notation implies a single dynamic and agogic interpretation is as misleading as it is well-intentioned. The variability of interpretation makes performance an art and ensures a continuing debate among performers, an involvement in which would detract from the present purpose. The analysis of music as performed is, in any case, not yet sufficiently far advanced to foster objective discussion.[1]

The prominence of dynamic accentuation (or 'stress') is self-evident, but its existence and strength often must be inferred from the metrical structure given in the score. In Example 5/1a, as the durational proportions increase, so the minimum dynamic accentuation necessary to produce the given metre must be progressively stronger. The notated metre in Example 5/1b implies that duration contour is predominant and that the relative dynamic accentuation (between each pair of short and long notes) falls short of this minimum. There is also a class of examples in which the correct metre depends on inferring dynamic accentuation from the position of the barlines: Examples 5/2 to 5/4 are shown with the structures that would otherwise result; in each case these alternative structures are determined by duration contour, supported by tonic accentuation and harmonic rhythm in Example 5/2, the structural accentuation of the tonic in Example 5/3, and pitch unity in Example 5/4.

The existence of such examples would seem to make the barlines essential input to a computer program for the perception of rhythmic structure; they are, in any case, useful in aiding the correct encoding

1. See, for example, Martin Piszczalski and Bernard A. Galler, 'Computer Analysis and Transcription of Performed Music: A Project Report', Computers and the Humanities, 13(1979), 195-206.

of the data and the ease of access to it. But the barlines cannot simply be assumed to imply a dynamic accent whenever the predominant structural characteristic or set of characteristics does not generate the notated metre. In modern editions of early music, the barlines will be editorial, but even in music of the 'common-practice' period they may reflect the fact that regular barlines are the norm, rather than indicate the predominant metre of a passage. One instance of this was Example 2/6; a second example is Example 5/5, whose dynamic accents, emphasized by the longer-note accompaniment, strongly suggest the repeated pattern of three bars of 2/4 followed by two of 3/4. The notated metre would require strong dynamic accentuation at the beginning of bar 2 and the omission of the second accent in bar 1. Similarly, in Example 5/6, the dynamic accents in bars 4, 9, 14, and 19 suggest a pattern of two bars of 2/4 followed by two of 3/4, the metrical scheme taught by Schnabel.[2]

Clearly, the composer's metrical structure of beats and bars cannot always be taken at face value. To assume that it necessarily implied dynamic accentuation would be to make all metrical accents on the one level dynamically equal in performance, a uniformity that would override the subtle differences in their relative strength that have been examined in the last two chapters. The inference of dynamic accentuation in Examples 5/2 to 5/4 comes, first, from noting a discrepancy between the notated metre and the predicted one, then from deciding that the composer's choice is the correct one and that it can prevail only through dynamics. While a computer could usefully refer such discrepancies to the researcher, the decision to infer dynamic

2. Konrad Wolff, Schnabel's Interpretation of Piano Music, second edition (London, 1979), p.94.

accentuation is too problematic to be left to a machine. It is not always certain that the composer's intentions can be communicated by dynamics or that it is appropriate to attempt to do so. This wider question of the relationship between the notated and the predicted metre is the subject of Chapter 5, Section B, and will involve examining further examples of such discrepancies.

The prominence of dynamic accentuation is such that, even in an off-beat position, its structural timelengths and corresponding structural units may be important subsidiary structures. Both Cooper and Meyer[3] and Yeston[4] have drawn attention to such structural timelengths at the beginning of the Danses des Adolescentes in The Rite of Spring (Example 5/7), although Cooper and Meyer erroneously believe them to undermine the duple metre pre-established by pitch pattern repetition. In the tree-diagram notation, such structural timelengths are best illustrated by a second diagram. Since dynamic accentuation is not a form of separation, its effect on phrase grouping is less marked than its effect as a structural accent. Cooper and Meyer have shown that a repeated off-beat dynamic accent can be perceived as an upbeat;[5] such an upbeat must not be an essential point of duration closure, as was discussed in relation to Examples 4/54 to 4/56.

Crescendo and diminuendo are clearly important aspects of rhythmic contour, or 'motion', but the present study is limited to distinct, rather than gradual, forms of differentiation. However, it is not normally necessary for the high and low points of a dynamic curve to be

3. Grosvenor W. Cooper and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago, 1960), pp.98-9.
4. Maury Yeston, The Stratification of Musical Rhythm (New Haven and London, 1976), p.44.
5. Cooper and Meyer, op. cit., p.26, Example 29.

printed in the score with precision for the rhythmic structure they represent to be explicit, unless they run counter to the metrical structure and phrase grouping that can be deduced by other means. Thus Yeston is mistaken in thinking that in Example 5/8 the crescendo and diminuendo do not create an exact point of division;[6] the high point of the dynamic curve is interpreted in relation to the existing metre and forms a metrical connection between bars 17 and 21. Similarly, those of Riemann's dynamic contours that do not simply match the phrase grouping generated by duration contour create the phrasing they indicate (see Example 2/50).

Articulation (according to the present usage) is concerned with differences in sounded notelength (that is, relative legato and staccato) and in the quality of attack. Except on keyboard instruments, the harp, and most percussion, a note joined to the previous one by a slur and legato has a diminished attack; structural timelengths of articulation are thus formed from one note of definite attack to the next. When off the beat, these structural timelengths have a powerful influence on phrase grouping, creating phrase boundaries before their structural accents. Where they coincide with metrical accents, it is debatable whether they turn metrical groupings that are not phrases into weak phrase groupings, although they do strengthen them at the expense of the relative degree of separation of any upbeat (Example 5/9). Whether musically appropriate or not, it is possible to add rhythmic interest by exotic articulated timelengths, such as Paganini's articulation in a passage from Beethoven's Violin Concerto (Example 5/10).

6. Yeston, op. cit., p.45.

A second form of articulation is that differences in sounded notelength may produce structural accentuation, as in Example 5/10.1, in which the _tenuto_ marks indicate optional agogic accents, agogic accentuation clearly being of the same type of differentiation. Included in this type of articulation is slurred grouping on keyboard and percussive instruments, which is achieved by making the last note of the grouping _non legato_ with the subsequent note. Such grouping is stronger than the first type of articulation, since it can produce phrase grouping when its structural accents coincide with metrical accents. However, unless the groups are small (two or three notes), such slurs are usually wrongly interpreted in this way, being influenced by bowing marks and employed merely to indicate _legato_. It is a convention of notation that when dynamic accents and slurs appear together, they represent this second form of articulation, with the slur indicating articulated grouping whether on or off the beat (Example 5/10.2).[7]

Despite its capacity to be perceived when placed almost anywhere, articulated grouping is, in general, decorative and does not cancel structurally important phrase grouping. Of the many varied instances of articulated grouping given by Cooper and Meyer,[8] their Examples 38, 70, and 71 (Examples 5/11 to 5/13) show that articulated grouping is stronger than duration contour. In Example 5/11, however, the duration closure is not obliterated by the articulated upbeat and is shown as a subsidiary structure. Thus it appears that articulated grouping is stronger than duration contour in a manner similar to upbeat repetition, in that it does not override essential duration closure. In Example 5/12, the closure on the crotchets is not essential,

7. See, for example, Cooper and Meyer, _op. cit._, p.21, Examples 20 and 21.
8. Cooper and Meyer, _op. cit._, pp.15-54.

since the articulated phrase grouping is a duration phrase of the 'ambiguous' closed trochee type. Likewise, in Example 4/59a, although the duration string grouped by articulation is the same as in Example 5/11, the proportions within the bar are radically different and the issue is one of separating a relatively weak upbeat from its duration of closure as opposed to turning a strong duration of closure into a very weak upbeat, as in Example 5/11; the subsidiary structure is correspondingly weaker than in Example 5/11. In Example 5/13, no phrase grouping ends on the first crotchet, because the articulated grouping is aided by repetition. In Example 5/14, on the other hand, duration closure generates a phrase ending which is then extended, but not superseded, by articulation.

Example 5/14 is an instance of Keller's phrase-end concealment (see p.77). His own example involves a slur placed over the second half of bar four of Mozart's Sonata in B♭, K.333, III (see Example 4/87); as with duration closure, such articulation does not cancel the phrase grouping generated by dissonance resolution. Likewise, articulated grouping does not efface upbeat repetition. It appears, then, that other phrase groupings can coexist with articulated grouping. This opinion is shared by Lerdahl and Jackendoff,[9] but their example of incongruence between durational grouping and articulation (Example 5/15) reveals the need to take metre into account: if the first two notes are an upbeat (top diagram), the duration closure on the minim is minimal and the separation following that note is diminished by the slur; if the higher-level grouping begins on the first note, however (bottom diagram), the durational structure is more prevalent than the articulated one.

9. Ray Jackendoff and Fred Lerdahl, 'Generative Music Theory and its Relation to Psychology', Journal of Music Theory, 25/1 (1981), 45-90 (p.64).

Metrically, the structural accents of articulation are weak: they appear to be stronger than those of pitch patterning (Example 5/16a), but the latter is normally affected by implied harmonic rhythm, against which articulation is undoubtedly weaker (Example 5/12). While Lerdahl and Jackendoff also note the predominance of articulation over pitch pattern repetition, they believe that the former overrides the grouping of the latter.[10] In Example 5/16b, however, without articulation, two pitch patterns coexist (top two brackets); either of these can be heard as a subsidiary structure when articulation is added (third bracket).

Unlike dynamics and articulation, tempo is not a structural characteristic in the normal sense, but several aspects of its effect on rhythmic structure have already been observed. It has been seen that tempo may influence the balance of forces among the structural characteristics in a passage by helping or, if slow, hindering the connection of structural and metrical accents and the awareness of structural and metrical timelengths. Similarly in phrase grouping, the association of two adjacent notes has been shown to be affected by their proximity in real time as well as by proportional duration. Thus, through tempo, the awareness of a structural timelength created by repetition was found to be strong enough in Example 3/78b for the timelength to be preceded by an upbeat (see p.115), but not in Example 3/118a (p.157). In Examples 3/72 and 4/142, with equivalent structural timelengths created by harmonic rhythm, tempo was likewise insufficient to make the first bar an upbeat (pp.117 and 215-6). In Example 3/178, however, an upbeat was considered valid, the proportions of the harmonic rhythmic timelengths being sufficient to outweigh the slowness of tempo (pp.163-4). The effect of tempo on upbeats has also been discussed in Chapter 3, Section A (pp.115-8).

10. ibid.,p.70.

In phrase grouping, where the proportional division of a metrical unit at the highest level produces a strong sense of separation (for example, the proportions 3:1), such separation can be surpassed by another characteristic - duration closure in the accompaniment (Example 3/215), dissonance resolution (Examples 4/95-4/97) or its counterpart, harmonic association (p.228), and articulation (second type) - but not if the tempo is too fast (see especially Examples 4/110 and 4/111). Correspondingly, the weaker the durational separation, the faster the tempo required to maintain the separation in opposition to such characteristics.

The effect of tempo on the relative strengths of characteristics is complicated by the relationship between tempo and hierarchical level. The diminishing awareness of structural timelengths at progressively higher levels, which was seen to heighten the conscious awareness of their unsounded subdivisions in Example 3/55 (p.112), parallels that produced by a decrease in tempo. Both reflect the fact that the mind most easily focuses on a small band of two or three metrical levels, at a given tempo. The phrase groupings at these levels predominate over those of smaller dimensions. According to Sachs, a tempo range of about MM60 to 80, that is, a steady walking pace or the speed of a normal heartbeat, has provided a reference pulse, or '<u>tempo giusto</u>', throughout the history of Western music.[11] This band of tempi closely corresponds to that put forward in Chapter 3 as the borderline range between default downbeat and upbeat structures (pp.116-7). The two notions are not inconsistent, since raising the tempo above this band focuses attention on the level above that of the prospective upbeat and gives greater prominence to the lower-level structural accent(s) on

11. Curt Sachs, <u>Rhythm and Tempo</u> (London, 1953), pp.202-3.

which the main beat of the upbeat structure comes to be perceived in preference to the default downbeat position.

Tempo is not the only criterion of metrical focus, however. A slow beat may not be divisible (Example 3/72); repetition may emphasize units smaller than those of the predominant phraselength; taking harmonic rhythm into account may cause shorter or longer units to predominate than otherwise; conversely, if a phrase is repeated with two or more notes for every former one, the music seems faster, though tempo and harmonic rhythm remain constant (see also Example 3/3). Thus the relative importance of phrase groupings cannot be determined solely by finding the metrical level closest to MM60 - 80, but must take into account the number of lower levels and the strengths of all the characteristics present, especially in relation to those which form metrical connections on the *tempo giusto* level. Such an evaluation cannot be undertaken within the terms of the present enquiry, as it would demand a more precise quantification of relative strength than has been attempted here. As has been seen, these relative strengths are partly dependent on the tempo of the passage.

Because of insufficient knowledge, not only of the relative strengths of characteristics, but also of our perception of time, it is likely that the best assessment of the central hierarchical level is the intuitive one given by the time signature, qualified, if appropriate, by Sach's concept of *tempo giusto*, harmonic rhythm, or repetition. The smallest unit of our experience of time has not been agreed upon and possibly may vary according to the different processes it evokes,[12] a notion which is in accordance with that of musical speed being dependent on the rate of change as well as metronomic tempo. Since music unfolds in time, our experience of changing musical events is as much an experience of time as time is a factor in our experience of music. But it is clear that in music no fixed 'time-window' represents the perceptual 'now', since processing takes place on several levels simultaneously and involves both retrospective connections spanning many minutes and the anticipation and fulfilment or otherwise of future events. Thus the Gestaltist notion of whole and instant perception cannot apply to musical structure, but only to events that are simultaneous or very close in time, in other words to timbre, chords, and some arpeggiated harmony.

B. THEORETICALLY PREDICTED METRE AND THE SCORE

The relationship between the metrical structure generated by the recognition of structural characteristics and the metre indicated in the score is an important test of the predictive value of the present theory, since it can normally be assumed that the composer's notation matches musical intuition. In scores where barlines either are not present or seem to contradict intuition, however, this relationship is of considerable importance to the analytical or musical interpretation of the rhythmic structure. Provided that it does not itself contradict intuition, the theory has much to reveal about metre in such music.

The question of the correct metre in music which predates the use of barlines is largely avoided editorially when the mensural divisions are indicated by vertical lines placed between the staves.

12. See, for example, Natasha Spender, 'Psychology of Music', in <u>The New Grove Dictionary of Music and Musicians</u>, 20vols(London, 1980), XV,388-421(pp.407-8).

As an editorial problem, this question has been discussed by Houghton[13] and lies outside the scope of the present enquiry. Where editorial barlines are given, however, the metrical interpretations of a piece can differ widely and two examples of Renaissance music will be considered below, to show how the present theory provides a rational basis for evaluating the different metrical interpretations suggested by intuition in such music. The first example is the chanson 'Bon jour mon coeur' by Lassus. The tree diagram of Example 5/17 refers to the top line of the piece relative to the overall rhythmic texture. Duration phrases have been separated by both dotted-line and broken-line beams, the former emphasizing the separation between phrase groupings and the latter the continuity of grouping reflected in any implied structural grouping on the next level.

The metrical structure of the diagram differs in several places from the editorial barlines (HAM No.145a)[14] and from the alternative metrical interpretation by Grout (Example 5/18).[15] The initial upbeat is justified by the tonic accentuation and pitch unity of the second and third chords and by the stress pattern of the text. The pitch unity establishes a semibreve multiple (8), whose automatic continuance has been judged to predominate against the 3/4 cross-rhythm put forward by duration contour. The latter is partially congruent with the metrical accentuation in the HAM edition, while Grout's interpretation matches the metrical timelengths that may be derived from the longer-note accompaniment. In all of these interpretations,

13. Edward Houghton, 'Rhythm and Meter in 15th-Century Polyphony', Journal of Music Theory, 18(1974), 190-212.
14. Historical Anthology of Music, edited by Archibald T. Davison and Willi Apel, 2 vols, I (Cambridge, Massachusetts and London, 1946), p.159.
15. Donald Jay Grout, A History of Western Music (London, 1962), p.222.

an overall duration phrase is established at the end of bar 5 by the point of repetition and is strengthened by a conventional cadential formula. Bars 6 to 10 are an exact repetition of bars 1 to 5.

In bars 11 and 12, repetition has been considered stronger than the semibreve multiple, whose maintenance would require strong dynamic accentuation on the syllable 'tou'. With the multiple upset, the next three metrical accents on this level (bars 13 and 14) are determined by duration contour and form irregular metrical timelengths in the pattern 4:6:4. The resulting duration phrase, including the initial timelength 2 in bar 13, is of length 16, which suggests a possible binary subdivision (see the broken-line structural grouping). However, the articulation of this duration phrase is incompatible with the text; conversely, the lack of its articulation aids the continuity of the musical sense up to the end of the next-level duration phrase (on '-mour'). Articulated separation after '-se' (bar 13) would turn the timelengths 6 and 4 into an upbeat, further limiting the effect of the duration closure on 'mes' (bar 14).

The following three duration phrases (bars 17 to 19, 20 to 22, and 23 to 25) are alike in structure and durational content. Each is a ternary phrase grouping containing a binary one that is separated by articulation, a structure for which the dual branch has been employed in preference to a broken-line beam. There seems little doubt that a semibreve multiple is prevalent throughout these phrases and that it produces syncopation at the beginning of bar 26, in the form of an unsounded metrical accent. Bars 26 and 27 do not challenge this pre-established multiple with any strong metrical structure of their own and it continues throughout the final four-bar phrase.

The present theory does not reveal any higher level of organization than that shown in the tree-diagram. Intuitively, the contrast in bar 11 groups the initial ten bars, and the three similar phrases may also be grouped together. The last two duration phrases (bars 26 to 31) are connected by a dominant to tonic progression and by textual anticipation. But even without the recognition of such further grouping, no adjacent phrases are ever entirely independent: their juxtaposition ensures at least a minimal association between them. This factor has significance for the tonal interpretation of the present chanson. Although the individual cadential tonics are normally the predominant tonal centres for their respective phrase groupings, the piece's triadic sequence as a whole is not simply a concatenation of independent tonalities, but can also be seen as a single 'journey' within tonal space, in which the overall tonic at any given moment is the root of the current triad.

The analysis of 'Bon jour mon coeur' has shown that the present theory may be used to evaluate different possible metrical interpretations. In this example, however, as in much Renaissance music, the metrical preferences are weak and in such cases the choice of the most likely structure does not necessarily lead to the outright rejection of all alternatives. In both structural ambiguities and weak preferences, the uncertainty is an important factor in making the rhythm interesting, and outstanding cross-rhythms, in particular, cannot be dismissed simply because the metre they suggest does not predominate.

A second example of metrical evaluation involving weak preferences concerns the opening of the madrigal 'Quando lieta sperai' by Rore, three interpretations of which (by Schering, Sachs, and Gombosi) are quoted by Houghton (Example 5/19).[16] Schering's edition follows the _alla breve_

16. Houghton, _op. cit._

of the mensuration. Comparison of Sach's interpretation with the full score (Example 5/20) reveals no grounds for an initial 3/4 metrical unit: some positive reason would be required to avoid the automatic continuance of the opening minim timelength as a multiple, and the single-voice pitch unity of the Es can hardly be stronger than the alternative double-voice pitch unity of the D minor thirds, especially since the latter are congruent with the minim multiple. As a cross rhythm generated by duration contour, 3/4 is the correct metre for Sach's sixth bar, but, as an overall interpretation, it would result in the metrically more important bass voice having the pattern |𝄽 𝅗𝅥| , which is resisted by that voice's own duration contour.

The 3/4 of Gombosi's interpretation (3/2 in Example 5/20) is only minimally different from <u>alla breve</u>. Both presuppose the minim multiple. If the phrase grouping after four minims is given a binary subdivision by implication, such an implied metrical connection is weak. Alternatively, it is possible that the tempo establishes sufficient momentum to create a structural grouping between the relatively long durations, and thus a metrical timelength of 6 (𝅝.), but it does so only marginally; this metrical connection, then, is also weak, although it is aided by the repetitive entry of the alto voice. Gombosi's bar of 6/8 is equivalent to Sach's 3/4 and may be criticized for the same reasons. The potential 3/2 multiple does not, however, last far beyond the entry of the bass voice. Because of the longer-note accompaniment in the bass, specifically the semibreves in bars 7 and 9, the multiple must give way by bar 10; whether the necessary 4/2 metrical unit occurs immediately after the cadence in bar 5 or immediately before the cadence in bar 10 is ambiguous.

However finely the discrimination among characteristics may be determined, there will always be examples that are inconsistent with the present theory, if only because the composer's wishes are at odds with preferences that give 'correct' results in other examples. If the given metre is clearly the composer's intention, the performer's task is to consider how best to communicate it to the listener. This can often be achieved by dynamic accentuation, as noted in Section A above, but the barlines do not necessarily imply dynamic accents, even though most performers will use dynamics to aid the differentiation among notes, including metrically accented ones. Moreover, dynamic accentuation inferred from the barlines cannot (even with added articulation) be guaranteed to generate any desired metre in opposition to the prevailing characteristics. Even if it can do so, the amount of accentuation required may contradict the dynamic markings in the score. If tied notes or rests are notated at the beginning of the bar in all parts, no intended metrical accent that contradicts the prevailing characteristics will be heard.

While scores containing perceptually unlikely metrical interpretations are comparatively rare, several examples are worthy of mention. One of the most famous is the unacknowledged switch from 6/8 to 3/4 in the last movement of Schumann's Piano Concerto. A well-established multiple cannot survive indefinite incongruence with other characteristics, unless sustained consciously and deliberately, which Schumann's interpretation would require. Example 5/21 shows both the strength and the limitation of an established multiple. Brahms successfully places dynamic accentuation, articulation, and bass-accented pitch patterning against the established beat, but only temporarily; by the end of the passage these characteristics are providing the predominant metre and an extra semiquaver is heard (in bar 29). Yet it is hard to say that Brahms' scoring is wrong. The precise point of metrical change is indeterminable; the metrical ambiguity may be deliberate or the structure may be an ideal which performers and listeners are supposed to learn to conceive as written.

The notion of a metrical structure which is contrary to perceptual norms, but is nevertheless what is intended, has already been encountered in Examples 4/72 and is difficult to refute, although an individual intended structure might be too hard to imagine in comparison with the most likely interpretation. Equally, such perceptually unlikely structures cannot be regarded as indubitably 'correct', since prior knowledge of the score is essential to their perception. Even though the mind may consciously avoid any ambiguity between the intended structure and the perceptually normal one, it is hardly possible to regard the latter as literally written off by the composer.

Examples 5/22 to 5/26 show further instances of perceptually unlikely scoring; in each case, the theoretically predicted structure is given above. Janáček's scoring, which contradicts duration contour, can be communicated by dynamic accentuation inferred from the barlines. In Bach's Badinerie and Bizet's theme, the intended metre may be understood through familiarity with the rhythm of the gavotte. Otherwise, the structural accentuation of the tonic in the Bach theme and insufficient tempo in the Bizet theme preclude the desired upbeats. In the Mozart theme, an initial upbeat to the start of the accompaniment is the perceptual norm, despite the adagio tempo. It is possible that Mozart's scoring has been prompted by the harmonic unity of the dominant chord in the second bar. In the Berlioz example, triple time gives the simplest subdivision of the metrical units generated by repetition and scored as three bars long. However, pitch patterning and implied harmonic rhythm generate the structure shown in the tree diagram: pitch separation and the return to the tonic produce a phrase ending after the fourth crotchet beat and the subdivision of this phrase is given dynamic emphasis by the composer.

Examples 5/27 to 5/31 all have longer-note accompaniments that are inconsistent with the notated metre. In the first Brahms example and the Dvořák theme, this discrepancy occurs at the beginning of the piece, giving the music a metrical interpretation which will be reiterated on the repetition of the theme, despite any irregular metre. In the Tchaikovsky example and the second Brahms example, the established metre has already been undermined by the longer-note characteristic before the discrepancy arises. In the Tchaikovsky Concerto, this occurs from the middle of bar 198; in the Brahms Symphony, between bars 132 and 134. The metrical irregularity may well be intentional and merely notated in the simplest way for performers, ease of reading being a principal function of musical notation. Such a view is supported in the Tchaikovsky example by the appearance of the figure ♩ 𝅗𝅥 ♩ in the same metrical position as previously, according to the present theory.

Example 5/31 is a clear case of a composer's ideal. The theoretically predicted duple metre, derived from duration contour and reinforced by repetition, is chosen by Shostakovich for the full orchestral version of the theme, beginning at bar 113. The notated triple metre of Example 5/31 is not aided by the given articulation and can be derived only from the longer-note accompaniment on the triangle. Yet, although instrumental considerations have largely been bypassed in the present work, the dynamic contrast between the triangle and the clarinet is too great for the longer-note characteristic to predominate; low pitch might have compensated for low dynamics, but the triangle does not have this either. In the repetition of the theme (bar 42 ff.), Shostakovich underscores the theoretically predicted duple metre with string <u>pizzicati</u>. Although side-drum rolls support the claim for triple metre in the same passage, these lack the harmonic rhythmic property of the string chords and the mind is unlikely to abandon the metrical interpretation of the theme's first statement, without strong reasons.

The concept of a metrical ideal should not be confused with that of polymetre, as Meyer has done in the case of a passage from Stravinsky's Histoire du Soldat (Example 5/32).[17] Meyer apparently believes that Stravinsky has notated an ideal and that the true metre is 2/4 throughout, because of the repeated bass pattern. But it is possible for one characteristic or set of characteristics to predominate without obliterating altogether the normal metrical interpretation of a distinctive voice. Alongside the Stravinsky passage, Meyer quotes a example of polymetre whose rhythmic texture is equivalent to Stravinsky's (Example 5/33a) and which may have influenced a similar passage by Ravel (Example 5/33b). In each of these two examples, the structural timelengths between the longest durations in the top part are equivalent to metrical timelengths, but do not provide the predominant metre, being analogous instead to the durations in the upper voice of Example 5/33c. Similarly, even if Meyer were correct in his view that duple metre predominates in the Stravinsky passage, this does not mean that Stravinsky's metre is invalid for the upper voice; rather, the composer has chosen to highlight the subtlety of this metre in preference to the obvious metre of the bass pattern.

In fact, it is quite likely that Stravinsky's interpretation does predominate, considering that the relative strengths of the incongruent characteristics must already be reasonably close for polymetre to be perceptible. From previous statements of the theme (in bars 7 and 15), the beginning of bar 48 is already associated with a metrical accent, and the theme's recurrences here and in bars 51, 54, and 56 also justify metrical accents. (The last of these is not acknowledged by Stravinsky.) If duration contour and dynamic accentuation are added to this metrical

17. Leonard B. Meyer, Emotion and Meaning in Music (Chicago, 1956), pp.119-121.

analysis, Stravinsky's interpretation is derived (apart from bar 56), duration contour affecting the metrical accentuation at the beginning of bars 50, 53, and 58, and dynamic accentuation in bars 49, 52, 53, and 58. Stravinsky may intend the dynamic accent in bar 56 to be strong enough to counter the effect of repetition. Thus, Stravinsky's passage presents a metrical conflict between two sets of repetition, the weaker of which is the bass ostinato involving bass accentuation and the stronger structural accentuation of the tonic. A similar conflict occurs in Example 5/34 and here, too, the pitch pattern repetition of the oscillating bass is metrically weaker than the repetition in the melody line.

On the question of polymetre in general, the present lack of refinement in assessing the relative strengths of characteristics makes it extremely hard to draw the line between a subsidiary metre within polymetre and a subsidiary characteristic (or set of characteristics) which is not normally heard metrically in the given context. As in the case of the weak metrical preferences in sixteenth-century music, this is not necessarily a disadvantage, since a metrical sense that has to be so refined is not likely to be shared by many listeners. The opening of the second movement of Ravel's String Quartet (Example 5/35), also cited by Meyer as an example of polymetre, illustrates this point, presenting not only polymetre between the 3/4 First Violin part and the 6/8 pitch pattern repetition of the Second Violin and Viola parts, but also metrical ambiguity within these inner parts, for instance pitch pattern repetition *versus* dynamic accentuation in bar 2, and metrical change, for example the probable predominance of 6/8 in bar 1 and 3/4 in bar 2. A single time signature and tree-diagram would not be appropriate for such a piece.

While Meyer may be incorrect in his remarks about the Stravinsky passage above (Example 5/32), his argument that some of the metrical assumptions behind the notation of twentieth-century music are ill-founded can be illustrated instead by the first piece of Schoenberg's Opus 19 (Example 5/36a), which has been partially rebarred as Example 5/36b, largely following duration contour. Schoenberg's initial upbeat is particularly dubious, because there is nothing to assert the first downbeat of the piece; duration contour thus generates a minim multiple which is subdivided by the F♯ at the end of bar 1.

A further discrepancy between theoretically predicted metre and musical notation concerns initial rests. In fugue subjects in general and in those of Bach's '48' in particular, the notation seems to reflect what may sometimes only be perceived retrospectively or on a second hearing, once the start of the subject has been assigned a place within the bar by the fuller information available on the entry of the second voice. Such opening rests in fugues can be regarded as a mannerism, knowledge of which lessens the degree of metrical ambiguity. Where such prior knowledge is not available, as in Example 5/37, the case for an initial rest is likely to be very weak. In this example it seems to depend on the right-hand part in bar 3 being interpreted metrically as in the score; then on the accompanying figure in that bar being reinterpreted retrospectively so that its repeated statements have identical structures. Not only does the slow tempo make this procedure unlikely, but it is probable that an alternative semibreve multiple will have been generated by the first repetition of this accompanying figure, as shown in the tree-diagram.

CONCLUSION

The object of the present work has been to put forward the structural characteristics and preferences that give rise to metre and phrase grouping. Within the mechanistic viewpoint that has been adopted, it has been shown that a limited number of structural accents and means of separation, together with certain perceptual preferences, will account for the generation from relatively unstructured data of the rhythmic structures most likely to be perceived, namely those which intuitively appear to be 'correct'. Metre has been shown to be largely a product of one or more of three factors: (a) a mental connection between structurally accented notes or chords, (b) structural timelengths, especially those of harmonic rhythm, and (c) the automatic continuation of a pre-established multiple due to a perceptual preference for regular metre. Many of the structural accents and timelengths have a physical basis: certain durations are longer than other preceding, following, or accompanying ones, certain pitches are higher or lower than others, certain notes are louder, certain sounded notelengths longer. Phrase grouping is the result of the relative separation of events, either physically, as in the relative lack of proximity of attacks or pitches, or conceptually, as in the resolution of dissonance and the grouping of tonal chords.

Metre and phrase grouping have been shown to be interdependent as well as independent, the highest existing phrase groupings sometimes giving rise to metre and the hierarchical level of a phrase grouping being determined principally by the highest-level structural grouping on which it may be observed. When metre is determined only by phrase grouping, the distinction between the two fades and their separate representation in the tree-diagram notation becomes of little relevance.

It has been shown that the structural characteristics are not of equal strength and that the strength of a characteristic is not necessarily the same for both metre and phrase grouping. If the main structural characteristics are arranged in order of relative strength, the following hierarchy applies to the perception of metre:

1. (Pre-established Metre)
2. Dynamic Accentuation
3. Harmonic Rhythm
4. Longer-note Accompaniment
5. Bass Accentuation
6. Duration Contour
7. Repetition
8. Structural Accentuation of Tonic
9. Articulation
10. Pitch Patterning

For the perception of phrase grouping, the hierarchy is as follows:

1. Articulation
2. Repetition
3. Dissonance Resolution
4. Recognized Tonal Cadences
5. Longer-note Accompaniment
6. Duration Contour
7. Pitch Separation
8. Directional Grouping

It should be stressed that these hierarchies are only a summary and cannot do justice to the explicit observations made in respect of individual examples. They do not show sets of characteristics, of which there are many possible configurations, nor do they take account of general perceptual preferences, such as the preference for regular metre. The titles of some characteristics are only generalizations: for example, the various forms of harmonic rhythm vary in function; similarly, with duration contour, duration values function both as proportional timelengths and as a means of distinguishing between equal metrical timelengths. But, most important, the hierarchies cannot consider the wide range of content within each characteristic: the degree of durational and pitch separation, different types of harmonic progression and dissonance resolution, types of repetition, differences in tempo and hierarchical level. It has been shown in many examples that these differences are significant to the general relationship between any pair of characteristics.

The notions of relative strength and perceptual preference belong to a probabilistic view of rhythmic structure in which there may be structural ambiguities and important subsidiary structures, depending on the relative strengths of the characteristics concerned. Thus there is usually no single 'correct' structure, but rather differences of likelihood between alternative structures. The quantification of relative strength would provide the neatest way of calculating perceptual probability and is an area ripe for further investigation. It is clear that the different types of content associated with a characteristic require a range of values, to reflect the varying degrees of their effect on metre and phrase grouping. The characteristics can therefore be expected to have different ranges of values on the same scale, though whether separate scales of values are required for metre and phrase grouping remains to be seen. Likewise, how to account quantitatively for general perceptual preferences, the inter-relationship between metre and phrasing, and differences in hierarchical level cannot be pursued at present.

Taken together, the many observations of different configurations of characteristics and their effect on rhythmic structure constitute a network of perceptual preferences with which any quantification must be consistent. To have laid out each observation as a preference rule in symbolic form, however, would have required either the separate labelling or the quantification of different types of content within each characteristic, either of which approach would have obscured the discussion. Each observation nevertheless represents, either as a condition or operation, a separate criterion required for the mechanistic perception of rhythmic structure.

While it is not appropriate to speculate here on the possible forms of a rhythm-perceiving algorithm, it has been seen that structural characteristics and preferences cannot be treated as entirely independent acts of perception, but that the full perception of one characteristic is very often dependent on aspects of the perception of another. For instance, harmonic rhythm may be affected by lower-level metre and a longer-note accompaniment; the metrical effect of duration contour is structurally ambiguous; and dissonance resolution is affected by a longer-note accompaniment. However, there are other aspects which may be treated relatively independently: the pre-metrical grouping of duration contour and some duration closure, bass accentuation, tonic accentuation, pitch separation and directional grouping, the metrical effect of a longer-note accompaniment, triadic associations and tonal interpretation (for harmonic rhythm) using the tonal map, repetition, and structurally accented tonics, not to mention dynamics and articulation indicated in the score.

Since perceptual dependence can be expected to vary with different types of content, it is more reasonable to envisage one aspect of a characteristic triggering the perception of another, either of the same or a different characteristic. Although the sequence of such triggers is almost certain to vary from one piece to another, because of differences in content and the configuration of characteristics, duration phrases may form a basis for the perception of phrase grouping in most music, while the longer-note characteristic and harmonic rhythm may likewise establish a working framework for metre.

Thus the perception of rhythmic structure, at least in a mechanistic sense, involves the perception of individual aspects of characteristics, either by primary observation or from the structures and aspects already perceived. Each aspect may trigger the perception of another aspect, help to determine further structures, or alter those already perceived. Observations on the perceived structures may also be stored and collated in such a way as to generate a learnt characteristic or aspect which may alter a previously perceived structure. The modelling of such a learning process seems necessary in order fully to understand tonality and its effect on rhythmic structure. In preference to presenting intuitive groupings of triads that cannot be accounted for without at least already being able to perceive the tonal context, some initial premises and observations of a learning process for tonal grouping have been put forward.

The interdependence of the perceptual components extends to the lowest levels, making artificial the boundary between the perceptual processes of the present work and their proposed input (as discussed in Chapter 1, Section C). Nevertheless, the capacity to derive structure from the input can aid the perception of the latter. Such an approach has been adopted by Longuet-Higgins (1976), using expected duration values to rationalize the real-time durations performed on a electronic keyboard. The ability to rationalize input in order to perceive familiar structures also helps to explain the pitch tolerances required to accomodate equal temperament, vibrato, and slightly out-of-tune performance. While the perception of duration, pitch, musical lines, and the melody line has been taken for granted in order to study further perceptual processes, an advanced program could incorporate a learning process initiated by an imperfect perception of the data, particularly of its linear organization.

Despite the obvious relevance to musical comprehension of the listener's expectations, the implications they generate in the music, and the capacity to evaluate originality, it has been shown that a considerable amount of comprehension, in the sense of structural interpretation, is open to the listener with the ability (whether innate or learnt) to perceive and rank certain characteristics, however new to him a piece might be. The present work has aimed to be as neutral as possible with respect to past experience, since such experience must be based on initial acts of perception, which presumably correspond to at least some of the aspects considered in this study. Furthermore, musical knowledge varies from listener to listener, according to the amount of music he has heard, his capacity for memory and recall, his perceptual and hierarchical skills, and his conscious knowledge of such items as forms and scales. Nevertheless, certain items from the European cultural background have been incorporated in the present theory as perceptual preferences: regular metre, the perference for multiples of 2 and 3, and the special importance given to binary groupings.

The form of the tree-diagram notation has been determined largely by the need to show the interdependence and independence of metre and phrase grouping, and limited diagrammatically by the constraints of two dimensions and a single colour. By contrast, a computer representation would handle with ease subsidiary structures, structural ambiguities, polyphony, and the transformations of reduction. The notation has aimed to be illustrative and unambiguous and is not claimed to be an ideal representation of rhythmic structure. The need for the separate notation of articulation, dynamics, and the structural timelengths of harmonic rhythm, and the difficulties of showing subsidiary structural timelengths (for example, between off-beat dynamic accents) without producing a spaghetti-like web of beams and branches are examples of deficiencies in the written notation, but would present no fundamental obstacles to its computer equivalent.

The tree-diagrams may be read either merely as a combined structure of metre and phrase grouping or as such a structure plus the configuration of characteristics and preferences that gives rise to it. To have tree structures as the sole output of a computer program would contribute very little to knowledge: they may be derived manually for use as program input. Their strength lies in being read in relation to their constituent characteristics and preferences, so that not only is rhythmic structure seen as involving harmony, pitch patterning, dynamics, articulation, and repetition, as well as duration, but the structural groupings and phrase groupings no longer have the equality of status they are accorded in a tree-diagram that is viewed simply as branches and beams (this equality being, of course, subject to the hierarchical grading inherent in the diagram).

Not only may the tree-diagrams be viewed as compound structures, but any of their component structures and subsidiary structures may be extracted from the whole. As new characteristics have been introduced by showing their effect on the overall rhythmic texture, the structures put forward by individual characteristics have, in many cases, been altered or superseded; where altered, they have nevertheless been readable within the whole. For instance, in Example 4/85 (Mozart,K.332,I), while duration contour puts forward the phrase grouping of Example 5/38a, this is altered by repetition and dissonance resolution to give the durational grouping of Example 5/38b. Similarly, it was found in Example 2/40 (Mozart,K.331,I) that repetition caused the phrase grouping beginning on the point of repetition in bar 2 to predominate over the same grouping plus the preceding quaver upbeat, but was not strong enough to alter the phrase grouping from duration contour which generated the upbeat. Repetition therefore suggests the extraction of the duration string .

Thus the structures and structured content derived from individual characteristics or groups of characteristics may be read both within the context of the whole tree or, if different, as subsidiary structures in their own right. In addition, as has been held throughout this study, the structures of individual musical lines may be read in their own right or as influenced by the overall rhythmic texture. The tree diagrams also allow a phrase grouping (or part of it) to be extracted with or without the branch on the next level, that is, to be viewed as metrically interpreted or uninterpreted. Similarly, a tree structure need not be viewed with all of its levels taken into account; tree-diagrams in various stages of metrical interpretation have been presented in the examples.

There are occasions when the precise content of a characteristic is not required. For example, the chords of different harmonic sequences may be omitted if they are equivalent in harmonic rhythm, the structures being shown as affected by harmonic rhythm, but read as having any chord sequence with the appropriate harmonic rhythmic properties. Likewise, durations may be omitted, especially in reductions, to show durational equivalence within a harmonic unit or phrase structure (or both), the diagrams being read as having any duration values or timelengths that would not alter the given structure. In many examples with a distinctive phrase contour, that is, one not having equal timelengths, the essential character of a phrase can be depicted by extracting the phrase contour with its metrical interpretation.

For instance, Example 5/39a has the character of a Classical antecedent-consequent phrase, even though the music is atonal and the exact sequence of durations has probably never occurred before or since. Its metrically interpreted phrase contour is given as Example 5/39b.

In the reading or extraction of the component elements and structures of the tree diagrams, rhythmic structure puts forward Gestalten that will be of use in the development of techniques for comparative style analysis, that is, analysis that is concerned with finding material common to different pieces. Having isolated such material in one piece, the extent to which the element or structure concerned is present in the piece is at least partly determined by its relative strength within the rhythmic structure. In addition to the perception and selection of structures derived from individual characteristics or sets of characteristics, the following individual elements of a tree-diagram are relevant to comparative analysis: structural groupings, phrase groupings and phraselengths, metrical units and metrical timelengths, structural units and structural timelengths, upbeat and afterbeat structures. In many ways, then, the selection and relative importance of segments for the purposes of comparative analysis is implied in the view of metre and phrasing as a compound rhythmic structure. However, the development of techniques for such analysis is beyond the scope of the present work.

Any concept of rhythmic structure that looks beyond the confines of the structures of individual pieces must sooner or later consider the equivalence conferred by transformation. This topic lies beyond the present study, but arises from it, because of the close relationships that can exist between nominally different rhythmic structures. Three types of transformation may be mentioned as worthy of further investigation in relation to rhythmic structure: reduction, contraction and related operations, and the temporal realignment or elimination of characteristics and structures. The relevance of reduction has already been seen in harmonic rhythm and in relating structures that are the same but for the lowest-level, surface detail (Example 4/173.1). The contraction, expansion, and elision of phrase structures was explored by Riemann (1903)[1] in support of his theory of the standard binary phrase, but such transformations may establish equivalence relationships without the binary phrase necessarily being regarded as a norm.

The equivalence of realignment arises from not having to read rhythmic structures in their entirety. For instance, in the case of a weak upbeat versus a default downbeat (as, for example, in a gavotte), the two structures are the same up to the level of the ambiguous metrical accent and equivalent up to the higher level through the operation that relates the alternative higher-level structural groupings. Likewise, such an equivalence relationship relates Example 5/40 to Mozart's original theme, in which the accompaniment begins a crotchet later; the recognition of metrical realignment at the minim level is similar to comparing the two versions of the melody at the crotchet level of the melody alone, but also takes the accompaniment and harmony into account.

The content of each characteristic has been considered here only in its effect on metre and phrase grouping. Much work remains to be done in the functional classification, as opposed to the mere listing, of duration patterns, perhaps in the manner of Meyer's classification of melodies (1973). Melody itself epitomizes the distinction between structure and function; just as pitch contour has been examined only as a medium in which discrete patterns may be found, so duration contour has been examined not as contour, but only as a generator of structure.

1. Hugo Riemann, System der Musikalischen Rhythmik und Metrik (Leipzig, 1903), pp.241-304.

The present structural diagrams represent skeletons whose flesh and blood are the contours of duration, harmonic movement, pitch, dynamics, articulation, agogics and tempo change, timbre, similarity and repetition versus contrast, as well as the interplay between different musical lines, the development and transformation of ideas, and the working out of formal processes. A reappraisal of the work of Cooper and Meyer (1960), who study the overall rhythmic effect and structure of these contours rather than their causes, is a possible extension of the present theory, particularly once the relative strengths of characteristics have been quantified.

The greatest scope for development of the theory, however, lies in the study of twentieth-century music, particularly of the post-war period. It is not sufficient to say simply that many of the present concepts break down; if the experienced listener finds coherence, a theory that finds chaos needs to be expanded. The inadequacy of traditional concepts is far-reaching. Notated metre becomes less a reflection of what is communicated and more what the composer wishes to be understood or simply a means of keeping performers together. Duration patterns become too complex to notate and give rise to proportional notation; what, then, is perceived? Harmonic and timbral complexity surpasses aural analysis but not comprehension. Structural ambiguity is commonplace. In polyphonic music, changes in balance between performances lead to differences in what is heard; with aleatoric techniques, improvisation, and 'graphic' scores, these differences become fundamental changes of content. In almost every aspect of structure, an increase of uncertainty can be found, but artistic communication may no longer depend on a single concept or structure being transmitted. Greater uncertainty does not necessarily lead to a breakdown of rhythmic structure, and even music which makes no attempt to establish goals is not likely to be structurally interpreted as arhythmic.

To conclude: the present work has attempted to separate from their many combinations the often elusive forces that shape the foreground structure of traditional Western music at its lowest and most fundamental levels. Hardly any of the structural characteristics can claim to be an original discovery; yet, if they are to be convincing as the features we are used to observing, they cannot be unfamiliar as well. Our understanding of musical cognition is still in its infancy, but if the present work does no more than stimulate discussion and raise important questions, it will have achieved its purpose.

APPENDIX

THE GROUPING THEORY OF LERDAHL AND JACKENDOFF

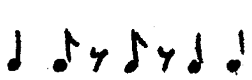
A recent paper by Lerdahl and Jackendoff,[1] which has appeared too late for commentary in the main body of the present work, puts forward various means of rhythmic grouping that are analogous to some of the phrase grouping characteristics of the present theory and are a direct application to music of two of the perceptual principles of *Gestalt* psychology: proximity and change. In a sequence of four consecutive notes (n_1, n_2, n_3, and n_4), Lerdahl and Jackendoff place a group boundary between the middle pair ($n_2 - n_3$) if that transition involves greater separation than the transitions between the other consecutive pairs of notes (n_1-n_2 and n_3-n_4), in respect of articulated timelength (Slur/Rest Rule), attack interval (Attack Point Rule), or pitch interval (Register Rule). For change, they place a group boundary between n_2 and n_3 if that transition involves a change in dynamics (Dynamics Rule), duration value (Length Rule), or articulation (Articulation Rule) and the transitions n_1-n_2 and n_3-n_4 do not. (In fact, they classify pitch separation with change, rather than proximity, and also recognize the possibility of timbral change as a means of grouping.) Each grouping boundary is marked with a small circumflex and labelled according to the number of the preference rule which generates it. The predominant grouping is, however, marked with a slur (see Chapter 2, Section C, p.82). Higher-level groupings are created by repetition ('parallelism'), symmetry ('the ideal subdivision of groups into two parts of equal length'), and by comparing different group boundaries: 'Where the effects

1. Ray Jackendoff and Fred Lerdahl, 'Generative Music Theory and its Relation to Psychology', *Journal of Music Theory*, 25/1 (1981), 45-90.

picked out by [the preference rules of proximity and change] . . . are relatively more pronounced, a relatively larger group boundary may be placed' (Intensification Rule).[2]

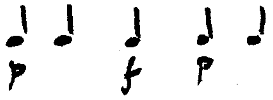
Lerdahl and Jackendoff's grouping preference rules are related to the present observations on repetition and on phrase grouping by duration contour, pitch separation, dynamics, and articulation. However, the present theory does not recognize durational change as a principle of grouping and the Length Rule is musically inconsistent in the opening theme of Mozart's 40th Symphony (Lerdahl and Jackendoff's Example 24), sometimes classing the two upbeat quavers as a group and sometimes not. In support of the preference rules' condition that a transition must be distinctive with respect to both adjacent transitions, one example is given for each characteristic, illustrating a transition that is distinctive with respect to only one adjacent transition (Lerdahl and Jackendoff's Examples 20 and 22). It is claimed that these examples show uncertainty of grouping, but the present theory can produce grouping in each case:

(Slur) Minim structural timelengths of articulation (first type) cause the third crotchet to be clustered with the next note and create a $\frac{3}{4}$ metrical unit.



(Rest) Articulation (second type) creates a $\frac{3}{4}$ metrical unit and a phrase grouping of its notes, though the sense of separation of this means of grouping is weak. Lerdahl and Jackendoff's preference rules find a grouping when there is only one quaver and rest; the addition of a second or third quaver and rest merely extends the grouping.

2. *ibid.*, p.67.

	(Change of articulation)	The example is equivalent to one of the above, according to its type of articulation.
	(Dynamic change)	Dynamic accentuation produces a strong structural accent which may be seen as metrically accented in anticipation of a succeeding metrical accent. The first two <u>piano</u> notes are thus an upbeat; the second two are separated by dynamic change and by upbeat repetition in anticipation of a succeeding metrically accented <u>forte</u> note.
	(Change of register)	The tonic accent (third note) produces a rhythmic structure equivalent to that of the example of dynamic change. Alternatively, the structural timelengths formed by the lower pitches create metrical accents on the first and fourth notes and are grouped in pairs; the third note thus becomes an upbeat because of its change of register.
	(Attack interval)	Duration contour groups the first note with the second and separates the final crotchets from the second minim, in anticipation of a succeeding longer note. The first minim may be seen as metrically accented in anticipation of a succeeding metrical accent. Lerdahl and Jackendoff's Length Rule would place a group boundary after the second minim.
	(Change of duration value)	Duration contour creates a metrical connection between the first member of each pair of minims. The crotchet is clustered with the succeeding note and is perceived as an upbeat. Neither Lerdahl and Jackendoff's Attack Point Rule nor their Length Rule find a group boundary in this example.

The above examples reveal two faults in Lerdahl and Jackendoff's theory: the stipulation that a transition must be distinctive with respect to both adjacent transitions, and the omission of the effect of metre on phrase grouping. The conjunction of their Attack Point Rule and

Intensification Rule appears to correspond to the pre-metrical grouping of durations (Chapter 3, Section A), but it is not a clustering technique (as seen in the last two examples above) and takes no account of metrical considerations, which can prevent a duration phrase from forming part of a larger duration phrase ending on the next succeeding longer note. For example, the Attack Rule and the Intensification Rule would produce the erroneous grouping of Example 3/9 (amended in Example 3/14), unless overridden by the Symmetry Rule. The omission of metre also causes their preference rules to miss certain duration phrases that end on the last branch of a metrical unit (see, for instance, Example 1c, bar 1) and are specified by Closure Rules 2 and 3, with amendments for the string 3 1 2 and its variants (see pp.129, 130, and 147).

Two further weaknesses in Lerdahl and Jackendoff's grouping theory are the acknowledged lack of formalism in their Parallelism Rule[3] and insufficient consideration of differences in the relative strengths of their preference rules. Lerdahl and Jackendoff are aware of such differences and the fact that congruent preferences reinforce the perception of a grouping boundary, while incongruent preferences do not necessarily cause all but the strongest grouping to be obliterated.[4] However, the predominant rhythmic structure plays a large part in characterizing the perception of a passage. Before one can construct a formal procedure for deciding which grouping is predominant, it is necessary to consider as many configurations of grouping characteristics as possible. On their own admission, Lerdahl and Jackendoff 'have not completely characterized what happens when two preference rules come into conflict'.[5] Thus, while their theory aims to be formal, they

3. ibid.,p.71.
4. ibid.,p.58.
5. ibid.,p.72.

acknowledge not having developed a formal procedure for the derivation of overall grouping preference.[6] Although they consider general differences in strength between certain pairs of rules,[7] the contradictions which they acknowledge in such judgements[8] are indicative of the need to consider other influences in greater detail, especially differences of content and the relationship between metre and phrase grouping. The latter is not a matter of noting merely that metre and grouping interact to create upbeats and afterbeats, and masculine and feminine endings.[9]

6. ibid.,p.73.
7. ibid.,pp.64,70.
8. ibid.,p.72.
9. Fred Lerdahl and Ray Jackendoff,'On the Theory of Grouping and Meter', Musical Quarterly,67(1981),479-506(pp.494-500). This paper refers to different forms of accent that might influence the perception of metre, but metre is seen only as a pattern of regular accents; why an irregular pattern should sometimes predominate is not explored.

BIBLIOGRAPHY

'A Glossary of the Elements of Graphic Analysis', The Music Forum, 1(1967),260

Barber, Paul J., and David Legge, Perception and Information (London, 1976)

Barlow, Harold, and Sam Morgenstern, A Dictionary of Musical Themes (London, 1949)

Beach, David, 'A Schenker Bibliography', Journal of Music Theory, 13(1967),2

Bent, Ian D., 'Analysis', in The New Grove Dictionary of Music and Musicians, ed. Stanley Sadie, 20vols(London, 1980),I, 340-388

————, and John Morehen, 'Computers in the Analysis of Music', Proceedings of the Royal Musical Association, 104(1977-8),30

Bernstein, Leonard, The Unanswered Question (Cambridge, Massachusetts, 1976)

Berry, Wallace, Form in Music (Englewood Cliffs, New Jersey, 1966)

Boretz, Benjamin, 'In Quest of the Rhythmic Genius', Perspectives of New Music, 9(1971),149

Bower, Gordon H., and David Winzenz, 'Group Structure, Coding and Memory for Digit Series', Journal of Experimental Psychology, 80(1969)

Cooper, Grosvenor W., 'Accent' and 'Tonic Accent', in Willi Apel et al, Harvard Dictionary of Music, revised second edition (London,1970),24,857

————, and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago, 1960)

Deutsch, Diana, 'Music Perception', The Musical Quarterly, 66(1980), 165

Dowling, W., 'Rhythmic Groups and Subjective Chunks in Memory for Melodies', Perception and Psychophysics, 14(1973),37

Everitt, Brian, Cluster Analysis (London, 1974)

Fay, Thomas, 'Perceived Hierarchic Structure in Language and Music', Journal of Music Theory, 15(1971),112

————, 'Context Analysis of Musical Gestures', Journal of Music Theory, 18(1974),124

Fokker, Adrian D., New Music with 31 Notes, translated by Leigh Gerdine (Düsseldorf, 1974)

Forte, Allen, 'Schenker's Conception of Musical Structure', Journal of Music Theory, 3(1959),1

————, The Structure of Atonal Music (New Haven and London, 1973)

Frankel, Robert E., Stanley J. Rosenschein and Stephen W. Smoliar, 'A LISP-Based System for the Study of Schenkerian Analysis', Computers and the Humanities, 10(1976),21

Gabura, James A., 'Musical Style Analysis by Computer', in The Computer and Music, edited by Harry B. Lincoln (Ithaca and London, 1970),223

Grout, Donald Jay, A History of Western Music (London, 1962)

Hiller, Lejaren A., and Leonard M. Isaacson, Experimental Music (New York, 1959)

————, and Ramon Fuller, 'Structure and Information in Webern's Symphonie,Op.21', Journal of Music Theory, 11(1967),60

Holtzman, Steven R., 'A program for key determination', Interface, 6/1(1977),29

Houghton, Edward, 'Rhythm and Meter in 15th-Century Polphony', Journal of Music Theory, 18(1974),190

Jackson, Roland, 'The Computer as a "Student" of Harmony', International Musicological Society Congress Report,X Ljubljana 1967,435

Kanizsa, Gaetano, 'Subjective Contours', Scientific American, 234(1976), 48

Keller, Hermann, Phrasing and Articulation, translated by Leigh Gerdine (London, 1966)

Komar, Arthur J., Theory of Suspensions (Princeton, New Jersey, 1971)

LaRue, Jan, Guidelines for Style Analysis (New York, 1970)

Laske, Otto E., 'On Musical Strategies with a view to a Generative Theory of Music', Interface, 1(1972),111

————, 'In Search of a Generative Grammer for Music', Perspectives of New Music, 12(1973-4),351

Lerdahl, Fred, and Ray Jackendoff, 'Toward a Formal Theory of Tonal Music', Journal of Music Theory, 21(1977),111

————, 'Generative Music Theory and its Relation to Psychology', Journal of Music Theory, 25(1981),45

———, 'On the Theory of Grouping and Meter', The Musical Quarterly, 67(1981),479

Longuet-Higgins, H.C., 'Letter to a musical friend' and 'Second letter to a musical friend', The Music Review, 23(1962),244,271

———, and M.J. Steedman, 'On Interpreting Bach', Machine Intelligence, 6(1971),221

———, Perception of melodies', Nature, 263(1976),646

Lyons, John, ed., New Horizons in Linguistics (Middlesex, 1970)

Macpherson, Stewart, Form in Music (London, 1908, revised 1912,1915)

Matthay, Tobias, Musical Interpretation (London, 1913)

Meyer, Leonard B., Emotion and Meaning in Music (Chicago, 1956)

———, 'Meaning in Music and Information Theory', Journal of Aesthetics and Art Criticism, 15(1957),412, reprinted in Leonard B. Meyer, Music, The Arts, and Ideas (Chicago and London, 1967), pp.5-21

———, Explaining Music (Berkeley, California, 1973)

Meyer-Eppler, Werner, 'Informationstheoretische Probleme der musikalischen Kommunikationen', Die Reihe, 8(1962),7; English translation, Die Reihe, 8(1968),7

Narmour, Eugene, Beyond Schenkerism (Chicago and London, 1977)

Parsons, Denys, The Directory of Tunes and Musical Themes (Cambridge, 1975)

Payne, Anthony, Schoenberg (London, 1968)

Perle, George, Twelve-Tone Tonality (Berkeley, California, 1977)

Patrick, Howard P., and Karen Strickler, 'A Computer-Assisted Study of Dissonance in the Masses of Josquin Desprez', Computers and the Humanities, 12(1978),341

Piston, Walter, Harmony, revised by Mark DeVoto (London, 1978)

Piszczalski, Martin, and Bernard A. Galler, 'Computer Analysis and Transcription of Performed Music: A Project Report', Computers and the Humanities, 13(1979),195

Rameau, Jean-Philippe, Génération Harmonique (Paris, 1737)

Réti, Rudolph, The Thematic Process in Music (London, 1961)

Riemann, Hugo, Musikalische Dynamik und Agogik (Hamburg and St. Petersburg, 1884)

———, System der Musikalischen Rhythmik und Metrik (Leipzig, 1903)

Rosen, Charles, The Classical Style (London, 1971)

Sachs, Curt, Rhythm and Tempo (New York and London, 1953)

Salzer, Felix, Structural Hearing (New York, 1952, revised 1962)

Samuel, Claude, Conversations with Olivier Messiaen, translated by Felix Aprahamian (London, 1976)

Schachter, Carl, 'Rhythm and Linear Analysis', The Music Forum, 4(1976),281

Schenker, Heinrich, Neue musikalischen Theorien und Phantasien, III, Der Freie Satz (Vienna, 1935), translated and edited by Ernst Oster as Free Composition (New York and London, 1979)

Schoenberg, Arnold, Style and Idea (New York, 1951)

———, Structural Functions of Harmony (London, 1954)

———, Fundamentals of Musical Composition, revised by Gerald Strang and Leonard Stein (London, 1967)

Smith, Charles, J., 'Rhythm Restratified', Perspectives of New Music, 16(1977),144

Smither, Howard E., 'The Rhythmic Analysis of 20th-Century Music', Journal of Music Theory, 8(1964),55

Smoliar, S.W., 'Process Structuring and Music Theory', Journal of Music Theory, 18(1974),308

Spender, Natasha, 'Psychology of Music', in The New Grove Dictionary of Music and Musicians, 20 vols(London, 1980),XV,388-421

Stockhausen, Karlheinz, 'How Time Passes', Die Reihe, 3(1957),10

Tovey, Donald Francis, 'Prelude XXI', in J.S. Bach, Forty-Eight Preludes and Fugues, ed. Tovey, 2 vols(London, 1924),I,158

Türk, Daniel Gottlob, Klavierschule (1798,1802)

Winograd, Terry, 'Linguistics and the Computer Analysis of Tonal Harmony', Journal of Music Theory, 12(1968),2

Wolff, Konrad, The Teaching of Artur Schnabel (London, 1972), second edition as Schnabel's Interpretation of Piano Music (London, 1979)

Wörner, Karl H., Stockhausen: Life and Work, translated by Bill Hopkins (London, 1973)

Xenakis, Iannis, <u>Musiques formelles: nouveaux principes formels de composition musicale</u> (Paris, 1963); Eng. trans. as <u>Formalized Music: Thought and Mathematics in Composition</u> (Bloomington, Indiana, 1972)

Yeston, Maury, <u>The Stratification of Musical Rhythm</u> (New Haven and London, 1976)

Youngblood, Joseph E., 'Style as Information', <u>Journal of Music Theory</u>, 2(1958),24

Zuckerkandl, Victor, <u>Sound and Symbol</u>,I,<u>Music and the External World</u>, translated by Willard R. Task (London, 1956)

LIST OF MUSICAL EXAMPLES

Dvořák,A.:
'Cello Concerto in B minor,Op.104,I:3/211,4/102;II:3/142a
Piano Concerto in G minor,Op.33,II:2/30
Slavonic Dances,Op.46,I:5/28
Symphony No.6 in D,Op.60,III:5/5
Symphony No.8 in G,Op.88,II:3/79a;III:3/79b;IV:3/153

Elgar,E.:
Pomp and Circumstance,Op.39,March No.4:3/112

Franck,C.:
Symphony in D minor,I:4/168b

Grieg,E.:
Peer Gynt,Suite No.1,Op.46,'Åse's Death':3/63,3/103a
Sonata in C minor (Violin and Piano),Op.45,I:3/57

Handel,G.F.:
Tolomeo,'Non lo diro col labbro':3/33
Sonata in D (Violin and Piano),Op.1/13,IV:4/157
Water Music,VII,'Air':3/16

Haydn,F.J.:
Quartet No.39 in C,Op.33/3,IV:2/23
Quartet No.44 in B♭,Op.50/1,III:4/133
Sonata in E minor,Hob.XVI/34,III:3/165
Symphony No.97 in C ('Salomon'),IV:5/13
Symphony No.101 in D ('Clock'),I:3/74,3/78;II:3/25,3/129
Symphony No.104 in D ('London'),I:3/118c;IV:3/91f

Holst,G.:
The Planets,Op.32,I,'Mars':3/126,4/77

Janáček,L.:
Sinfonietta,IV:5/22

Joplin,S.:
Piano Rag,The Entertainer:3/52

Kodály,Z.:
Suite:Háry János,V,'Intermezzo':4/42

Lassus,O.:
Chanson,'Bon Jour Mon Coeur':5/17

Mendelssohn,F.:
Symphony No.3 in A minor ('Scotch'),Op.56,IV:3/96a
Symphony No.4 in A ('Italian'),Op.90,I:2/36;IV:3/1