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A NEW APPROACH TO MUSICAL METER: CONTRIBUTIONS TOWARDS A THEORY OF METRIC PERCEPTION IN MUSIC

By

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ABSTRACT

A NEW APPROACH TO MUSICAL METER:
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Much music theory is based upon personal observations and stands or falls depending upon the degree of acceptance of these observations by a wider audience. Rhythm and meter in music are the subject of study by both music theorists and psychologists. By applying the experimental data and observations of psychologists to the theoretical constructions of the music theorists, it is possible to arrive at a theory which relies less on personal observation.

Meter is a psychological construction which organizes time points in a hierarchical fashion and makes it possible to more accurately distinguish the durations of sound and silence in music. It is posited that when present, meter is the background, in the <u>Gestalt</u> sense, upon which rhythm is understood and percieved.

Metric organization results from the interaction of several musical parameters including dynamics, harmonic structure, melodic structure, various forms of rhythmic grouping, macro-durations, micro-durations, and others. These parameters have varying ranges of potential salience.

A parameter's potential-salience range can be ranked by the degree of attention each parameter initially receives due to the past experience of a listener. The manifest salience in a given situation of a particular parameter to metric organization is determined by the simplicity of that parameter's accent stream and the relative attention given that parameter. Simplicity is defined as the degree of conformity to "standard" metric grammars.

The discussion and understanding of meter is complicated by its nature. As a psychological construction, it can not be observed directly. Meter is the hierarchical organization of time which is effected by the musical stimulus, but is not constantly reinforced by it. Rhythmic grouping, which is defined as a grouping structure which is directly effected by the events of a musical work, is defined by many of the same parameters that effect meter, making it difficult to separate these two phenomenon.

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APPROACH

The number of studies concerning the rhythmic structure of music has been on the rise. Although pitch organization continues to receive a great deal of attention, some first steps have been taken in understanding the other parameters of music. Modern theorists, including Cooper and Meyer, Yeston, Berry, Lerdahl and Jackendoff, and Lester, have focussed their attention on the organization and structure of rhythm and meter. These theorists consider meter as a perceptual entity and not just a notational device. Each has posited theories in which meter is created through the interaction of several parameters. Although these theories clearly do contain insight into musical meter, they are primarily based upon the intuitive judgments of their author or authors. There is little evidence presented, if any, that these judgments apply to a larger population of listeners. The acceptance or rejection of such a theory must be largely based upon the acceptance or rejection, in whole or part, of the intuitive judgments of its author or authors.

Rhythm and meter have also been the object of many studies by psychologists.[1] These studies, however, tend to concentrate on a single parameter in music without full consideration of the effects of other parameters. In most cases, other parameters are eliminated from the study. For example, a string of rhythmic values is played without change of pitch, timbre, etc. in order to study rhythmic organization. This type of study fails to consider that various parameters interact and coexist in music. (In the case of meter, music theorists consider the interaction of various musical dimensions most certainly to be the case.)

"In all thinking, writing, and teaching about music, if we are to progress beyond a catalogue of personal reactions we must employ some objective framework for our reflecting."[2] There have been few attempts to marry the objective data of the psychologists with the theoretical constructs of the music theorists in a comprehensive manner. This study will take a new approach to the study of meter by attempting a synthesis of the intuitive judgments of music theorists with scientific data of the psychologists. This will allow a greater understanding of the strengths and weaknesses of these intuitive judgments.

It may be impossible to prove in total a theory of musical meter through empirical evidence. Nevertheless, it should be the goal of any theory to account for all data which has been collected concerning the object of that theory. Most music theorists seem unaware of, or have been unwilling to consider, the data which does exist concerning musical meter. It is hoped that the present approach will lead to new insights concerning the perception of musical meter. This study shall work towards a viable theory which can serve as a frame for future consideration by both musical theorists and psychologists.

THE COMMUNICATION OF MUSIC

In his review of Yeston's book, Smith warns of an important distinction which should be made. "It is difficult to see how any successful theory of rhythm and meter could avoid incorporating an (at least) threefold distinction between various domains of musical entities: music-as-sound, music-as-notated-object, and music-as-cognitive-entity."[3] Music is related to a communication process. Before a piece of music is finally perceived and conceptualized by a listener, it undergoes a chain of transformations. We often do not distinguish these various steps in the communication process called music, and quite often the differentiations of these steps are of little concern.

Another problem found in much of the writings on musical meter is the lack of consideration given to aspects which occur in the music-as-sound and are not represented in the music-as-notation. This might be attributed to an attempt to remove as much personal interpretation of the music-as-notation as possible from theoretical consideration. Unfortunately, it also serves to remove all factors of interpretation, including those that most musicians might agree upon, from inclusion in the theory. These theories may explain the way in which notated elements are involved in metric organization, but these theories are necessarily incomplete. To come to a more complete understanding of meter in music, the steps in the communication chain should be distinguished.

Metric understanding may have different functions at various points during the process we call music. We must therefore consider the communication of music from its inception to its perception. In the process called music, there are three primary classes of participant--composer, performer, and listener.

Meter can exist at several different points in this process, and the communication of meter may not be completely successful at any link in the communication chain. Further, it is possible for metric understanding to change at any link without detriment to musical understanding. For example, a performer may impose a meter upon a passage to better perform the durations involved; however, it may not be intended for this metric ordering to be communicated (by the composer or performer). Instead, the listener may construct a different metric organization or may find the music ametrical.

Suppose a composer has a meter which he intends to project. The composer attempts to communicate this meter through musical notation, Smith's "music-as-notated-object." Due to the limitations of musical notation, the notation of this meter may or may not be very clear. Cone contends that Mozart shifts the meter within the first movement of his Piano Sonata, K.331, but the notational conventions of the time did not allow him to change the meter within a movement of this type.[4] Notation can also be more complicated than the meter organized by the listener. Kenyon observes this in some compositions of the twentieth century.[5]

The performer examines the notation and interprets it. This interpretation, including metric structure, must now be performed. The performer uses his interpretation to guide the performance of music in an attempt to make the music audible. The performer produces Smith's "music-as-sound."

The listener organizes a metric structure based on the sounds the performer produces. This perceived meter, presumably, is what Smith means when he uses the term "music-as-cognitive-entity."[6] The meter first perceived by the listener is subject to reexamination. It is possible, and in some cases likely, that the meter which the listener first comprehends may be changed as more of the piece is revealed. Some pieces play upon this type of reorganization; for example, a specific technique sets 6/8 and 3/4 meters in conflict.

Each of the three classes of participants in the music process, as described above, has certain musical parameters which might be more strongly associated with that participant than with the other two.[7] The composer traditionally controls the textural, melodic, harmonic, macro-dynamic[8] and macro-durational structures. The performer traditionally contributes the micro-durational, micro-dynamics, and other subtle, but possibly significant, structures to the musical sound. (These structures can only be vaguely indicated by the composer and are subject to the interpretation and alteration by the performer.) Some of the features of interpretation are difficult to discover due to changes from performance to performance. Finally, the listener has certain expectations and capabilities which will influence the perception, and thereby the metric organization, of the musical stimuli. The contributions of each participant in the above communication chain will be considered in various chapters.

[1] Most notable are the studies by Bengtsson, Deutsch, Fraisse, Gabrielsson, Handel, Sloboda, and Sears.

[2] Jan La Rue, "Forum: On Style Analysis," Journal of Music Theory 6 (1962): 91.

[3] Charles J. Smith, "Rhythm Restratified," review of The Stratification of Musical Rhythm, by Maury Yeston, Perspectives of New Music 16, no. 1 (Fall-Winter 1977): 145.

[4] Edward T. Cone, "Communications," Perspectives of New Music 1, no. 2 (Spring 1963): 208.

[5] Max Kenyon, "Modern Meters," Music and Letters 28 (1947): 171-172.

[6] Both the composer and performer may be said to produce "music-as-cognitive-entity" before any sound may be produced. Cognition occurs at all links in the communication chain. It might be argued that the cognition of the listener, however, is what determines whether a sound stimulus is "music" or noise. (It also might be argued that the composer and performer are acting as listeners while such "music" exists.)

[7]There are certain types of music which change these contributions. Electronic music gives the composer full control of all aspects of the music-as-sound. The following are generalizations based on Western Art music of the period being studied.

[8] The composer has the option of indicating guidelines for dynamics; however, these indications seem more vague than those associated with pitch and rhythm. The performer has the option of introducing slight variations, and in some cases considerable dynamic changes, in a realization of a work. It should also be recognized that during the early part of the common-practice period dynamic markings were often sparse or totally absent.

Chapter 2
DEFINITIONS AND SCOPE

Music is unique among the arts in its degree of control over the dimension of time. Although, like music, drama and dance exist as arts within time, they do not structure time to the degree that music does. These arts structure the sequence of events, but not the exact duration of those events as they unfold. Music, however, does control the duration, at least proportionately, of the events which make up an art work.

The study of time is a difficult task. Even the definition of time varies from discipline to discipline. The physicist considers time one of three fundamental quantities. It is possible to measure it with great precision by considering the other quantities. The psychologist defines time as an aspect of consciousness. Two periods of time which the physicist would consider equal are found to be unequal by the psychologist. To the psychologist, it is the experience of time which defines it. These and other definitions provide insight, but none seem to describe and define "time" completely. Perhaps Saint Augustine summed it best, "What is time? If someone asks me, I know. If I wish to explain it to someone who asks, I know not."[1]

Within music, the temporal dimension is strongly associated with two terms--meter and rhythm. Like "time," the definitions of these words seem somewhat fluid and changing. Different writers have different views as to what these terms mean.[2] This confusion makes comparison of ideas difficult. Because of these different uses, meter and rhythm (and those terms related to them) must be defined for a study to be completely understood.

PULSE AND BEAT

Pulse in music is a psychological construction which divides time into spans of functionally equivalent durations. A pulse usually divides time into perceptually equal durations; however as Lester explains, this definition fails to consider such common musical occurances as ritardando, accelerando, rubato, and other tempo variations.[3] Listeners will allow modifications of the actual time-spans between the points in time[4] which make up a pulse to maintain this construct. This allows manipulations of tempo without disrupting the feeling of pulse.

As a psychological construction, pulse is not always manifest in physical events. Once a set of events establishes the organization of a pulse, a listener maintains this pulse until a significant amount of information contradicts it. Sound events do not have to occur on a pulse in a regular fashion for it to be maintained. The degree of tolerance of allowable contradictory information is a matter which needs to be investigated.

Pulses occur at different levels. These levels represent different temporal spans; each level generally, thought not always, nests within the level above it. In Western music of the common-practice period,[5] these different levels nest in very specific ways. Groups of either two or three pulse spans of one level correspond with the next level of pulse. This may be better understood by considering musical notation.

Musical notation has developed a hierarchical system where two or three of one rhythmic note value is equivalent to the next larger value. That is, in 4/4 time, two eighth notes occupy the equivalent temporal space of a quarter note, two quarter notes are equivalent to a half note, etc. This hierarchy implies several pulse levels which nest. Once part of the hierarchy is established, the listener can use normative practice, derived from his experience of music, to postulate other levels.

In a piece of music, once two eighth notes are sounded, a listener can establish an eighth-note pulse. Some other factor, or factors, may then be used by listeners to group these eighth notes into a larger value--either a quarter note or dotted-quarter note.

Frequently it is easy to find agreement among listeners on a certain pulse level which is considered the primary pulse level. This paper will use the term beat to indicate this primary level.[6] The beat is the pulse level which a conductor usually indicates with his baton, listeners tap their toes, and/or marchers' feet hit the ground. The beat tends to be of moderate speed[7] and can change with tempo. As the tempo increases, most listeners will consider a higher (greater note value) pulse level as the beat.[8]

METER AND ACCENT

Individual pulses of a particular level differ from one another in accentuation--some pulses within a level are marked for greater attention. Accentuation is often used by the listener to organize a pulse level into a predictable pattern. An organizational scheme of at least one pulse level constitutes a meter and is often created by an accentuation pattern.

Meter most often refers to an organizational pattern of strong and weak beats. In the music of the common-practice period, the types of meter are somewhat more limited. A pulse level is organized by the pulse level above it. (This is not the case in such meters as 5/8, 7/8, etc. In these, a pulse level is organized by accentuation, but the accentuation pattern does not form another pulse level due to the unequal time-spans which are marked by that accentuation pattern.) Rahn describes meter of the common-practice-period type as a "pulsation within a pulsation."[9]

Pulses, and thereby meter, may be regarded as composed of time-points which are durationless events.[10] They mark time with a series of points, thereby organizing the temporal dimension. This concept emphasizes the functional difference between rhythm and meter. Meter is a psychological construction; conversely, rhythm involves actual durations. Meter marks "distances" within the dimension of time, while rhythm actually occupies temporal space.

Perhaps the best definition of accent is Cooper and Meyer's. They define accent as some event which is "marked for consciousness."[11] Both temporal space (rhythm) and time points (meter) can be accented by this definition.[12]

Accent is a relational concept, so one point in time is accented when compared with another. To say that something is accented, we must consider what is unaccented as a result of this statement. For example, in 4/4 time, beats 1 and 3 are both "strong beats" compared with the "weak" beats on 2 and 4, yet beat 1 is considered more accented than beat 3. Beat 3 is a weak beat compared with beat 1, but a strong beat when considering the whole measure (beats 2 and 4).

Using Cooper and Meyer's definition, accent can be created by a number of different methods. To be "marked for consciousness," an event must be in some way different from its surroundings. Most musicians recognize an accent as a tone which is louder than those immediately surrounding it. There are other well-known forms of accent however. For instance, the so-called agogic accent is produced by a tone which is held longer than those around it. It represents a change in temporal distance.

The most basic accent occurs with any change of a perceptual musical dimension. Changes in a stimulus can have a profound effect on the perception of an event, possibly due to the attention listeners give to changes. An experiment by Kubovy shows the effect that accent can have.[13] This experiment took the seven pitches of a diatonic scale and sounded them together at equal amplitudes. One tone was reduced in amplitude, then restored. The experimenters expected: (1) to hear a click at the point of the reduction of the tone, (2) the seven tones would sound softer, (3) a click upon the restoration of the amplitude, and (4) finally the tone cluster would sound as it did before. The first three steps above transpired as expected; however, the final step did not occur. The cluster did not sound as it did before the reduction of the single pitch. The pitch which had been altered was heard as a distinct entity, separate from the rest. It was perceived as louder than the other six tones, despite its equal amplitude. (Subjects described the sound as chime-like.) The change in amplitude accented that pitch sufficiently to make it possible to play tunes with the technique.

The degree of accent is related to the amount of change occuring at that point in time, the attention given to the parameter which is being altered, and the limitations of the listener's ability to discriminate the change which is occuring.

Meter becomes especially clear when few or no conflicts occur between the various types of accent. It is not the effect of a single parameter which must be considered in understanding the organizing of meter by a listener, but the accentual effects of all the parameters present and how they reinforce, or cloud, various metric interpretations.

RHYTHM AND DURATION

The New Harvard Dictionary of Music identifies two levels of modern musical use for the word "rhythm."[14] In its widest sense, rhythm is set beside the terms melody and harmony. Rhythm, in this sense, encompasses all the temporal aspects of musical sound.

The second level of usage, identified by the New Harvard Dictionary, is narrower and more specific. This use of the term rhythm "denotes a patterned configuration of attacks that may or may not be constrained overall by a meter or associated with a particular tempo. . . . it is necessary only that there be more than one attack, that the attacks not be too far apart, and that the musical convention in play accept the succession of attacks as mutually connected and not independent of each other. . . . A perceivable pattern of temporal space between attacks constitutes a rhythm."[15]

New Harvard's definition implies that the durations of sound and silence are unimportant to rhythm. Although the temporal placement of attacks might be a particularly salient feature of rhythm, the durations of musical sound are also important to the concept of rhythm. The two passages found in Figure 1 share the same temporal locations for attacks, but on an instrument capable of sustained

Figure 1
The attack points of these two scales are the same, but the rhythmic effect differs due to changes in the length of sound and silence.

sound, these passages would have a different rhythmic effect.

Differences in rhythmic effect created by silence are touched upon in the latter part of the New Harvard definition. Silence often plays a part in determining whether a succession of attacks is considered "mutually connected and not independent of each other." It seems, however, that the differences in musical effect created by different degrees of silence, such as those found in Figure one, should be addressed directly within a definition of rhythm. In addition to attacks, rhythm involves the use of temporal space.

Western art music has produced a large repertoire of multi-part music. It is not uncommon in this music for attacks to occur at different temporal locations in different parts. It is unclear in the New Harvard definition whether the relationships found between the attacks of various parts in multi-part music are to be considered part of "rhythm" in the narrower sense. The relationship of the attacks of each part, whether moving together (as in homophony) or independently (as in polyphony), should also be addressed in a definition of rhythm.

This study defines rhythm as the durations and temporal relationships of sound and silence in music. Event durations are an important element used by listeners to create meter. Oddly enough, meter seems to help the listener to determine these durations more accurately; this relationship makes the understanding of meter and rhythm very complex.

Two aspects of duration must be distinguished. One aspect of duration involves the difference between a quarter note and an eighth note. One might say that the quarter note is twice the length of an eighth note. Although most musicians would find this statement true, a scientifically precise measurement of the duration of an eighth note and quarter note within a performance would find this to be only roughly true.

This alludes to the other aspect of duration which must be considered in the perception of meter. Given two eighth notes, one with a tenuto mark over it and the other with a staccato indication, a trained musician would play the eighth note with the tenuto marking longer. Durational differences of this type will be called micro-durations. Macro-durations are those which are notationally equivalent with respect to rhythm.[16] Two eighth notes have equivalent macro-durations, but may have different micro-durations.

The study of micro-durations considers the silences between the pitches. Further, it is also possible for individual spans marked by pulses to be of different actual duration. Some studies have shown that although beats are perceived as equal, they can be of different micro-durations. This will be taken up later in more depth.

METRICAL MUSIC

All music has rhythm, but not all music has meter. In order for meter to exist, a piece of music must have certain qualities. For meter to be organized effectively, event durations must be defined. It must be fairly clear when events begin and end. Imagine trying to accurately measure the width of the yellow band of a rainbow in a picture. In this picture, the colors of the rainbow run together, leaving hazy bands whose borders are not well defined. At what specific point is the band yellow? A ruler might be an accurate measuring device, but an estimate of the yellow band's width, without the use of a ruler, may be just as accurate (and/or arbitrary) as a measurement made with the ruler. Why spend the time getting out the ruler? If the music does not have clearly defined durations, meter will not be invoked; it would be an ineffective device for temporal understanding.

In order for metric organization to be invoked, a piece of music must progress with some sense of steady motion. Some music progresses too erratically to satisfactorily establish a unit of measure upon which to base metric organization. Other works progress so slowly that listeners cannot establish a satisfactory unit of measure; in these cases, hierarchical structure cannot be imposed because the time units involved span beyond the psychological present. There is a steady motion, but the time spans involve the use of long-term memory. Meter, therefore, cannot be used as a method of abstraction for this long-term memory and is without purpose.

Despite the limitations described above, a large repertoire of metrical music exists. This study will concentrate on such music. The repertoire considered here will further be limited to Western Art music of the common-practice period. Although many of the considerations raised by this study may be applied to earlier and later music, concentration on the common-practice period is for practical reasons. Pitch relations are among the various considerations for metric organization. Since pitch relations of the common-practice period music are best understood by current theory, it seems logical to limit this study to this period.[17] Although the study will concentrate on this period, it will attempt to generalize to other periods when possible.

[1] Samuel A. Goudsmit, Robert Claiborne, et. al., Time, Life Science Library Series (Alexandria, Virginia: Time-Life Books, 1980) 9.

[2] Two considerations of some modern definitions of these terms include:

Russell Jones, "A Dialectic Analysis of Selected Contradictions Among Definitions of Meter in Music," Council for Research in Music Education Bulletin no. 83 (Summer 1985): 43-56.

Jaap Kunst, Metre, Rhythm, Multi-part Music, Ethno-Musicologica, 1 (Leiden: E.J. Brill, 1950).

[3] Joel Lester, The Rhythms of Tonal Music (Carbondale: Southern Illinois University Press, 1986) 45.

[4] Note that a point in time is durationless, much as a point in geometry is dimensionless. A time point does not occupy temporal space; it simply marks it.

[5] The use of the term "common-practice period" is not without problems, but the debate concerning its use falls outside the thrust of this study. It is used here to mean the historical period starting about the time of Bach and extending into the 19th century.

[6] Defining the beat as a pulse level is not always the way in which this term is intuitively used. Meters, such as 5/8, can have an unequal time-spans which might be considered the "beat" by many listeners. Although the definition used in this paper will allow such meters, they would not have a "beat," but a strong accentuation pattern which replaces it.

The definition used for "beat" here, however, operates well in music of the common-practice period. Cases where the "beat" would not be a pulse level are extremely rare (perhaps nonexistent) during this period.

[7] Dowling and Harwood found that the average preferred beat speed is 1.67 beats/second (approximately a metronome marking of 100). They reinterpret a number of experiments' data to arrive at this figure.

W. Jay Dowling and Dane L. Harwood, Music Cognition, Academic Press Series in Cognition and Perception, edited by Edward C. Carterette and Morton Friedman (New York: Academic Press, 1986) 189.

[8] Edlund indicates that not all listeners will change the level of the beat at the same tempo. He calls the span of tempos in which the pulse level considered the beat changes "pulse-shift regions." In these regions, the beat is somewhat ambiguous for a population of listeners.

Bengt Edlund, Performance and Perception of Notational Variants: A Study of Rhythmic Patterning in Music, Studia musicologica Upsaliensia, Nova series, 9 (Stockholm, Sweden: Almquist & Wiksell International, 1985) 36.

Although the beat may be ambiguous for a population of listeners, an individual listener could identify a single pulse level as a beat. The individual may be aware that the chosen level is more ambiguous at certain tempos than others, and in this sense, the beat may be more stable at certain tempos than others. In sum, listeners are more likely to change the pulse level of the beat in a pulse-shift region than outside of it.

[9] Jay Rahn, "Evaluating Metrical Interpretations," Perspectives of New Music 16, no. 2 (Spring-Summer 1978): 36-37.

[10] "Like markings on a ruler, the only property it [pulse] possesses in theory is a position within the given dimension, [time] . . . ."

Michael Talbot, "Harmony and Metre: A Study in Relationships," Music Review 33 (1972): 48.

[11] Grosvenor W. Cooper and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago: The University of Chicago Press, 1960) 4.

Leonard B. Meyer, Emotion and Meaning in Music (Chicago: University of Chicago Press, 1956) 103.

[12] "Accent" will generally be applied to time points in the context of our discussion.

[13] Michael Kubovy, "Concurrent-Pitch Segregation and the Theory of Indispensable Attributes," Perceptual Organization, edited by Michael Kubovy and James R. Powerantz (Hillsadale, NJ: Lawrence Earlbaum Associates, 1981) 66.

[14] The New Harvard Dictionary of Music, edited by Don Randel (Cambridge, Massachusetts: Belknap Press, 1986) 700.

[15] The New Harvard Dictionary of Music, edited by Don Randel (Cambridge, Massachusetts: Belknap Press, 1986) 700.

[16] When the context of the discussion makes it clear which type of duration is meant, the prefix may be eliminated.

[17] It is hoped that less time can be spent developing and defending ideas related to pitch constructs of various periods. By limiting ourselves to a period in which we have greater understanding, it will be possible to spend more time on the subject at hand.

Chapter 3
METER AND THE LISTENER

THE FUNCTION OF METER

Humans have a strong propensity towards attempting to find patterns in temporal sequences of sound. Even when presented with a random temporal sequence, subjects will treat some elements as exceptions to a pattern to create what would then seem to be an orderly sequence.[1] The reasons for the occurrence of this organizational process are unclear.

Propensitites to organize temporal sequences do not seem to be the only reason for metric organization. Metric structure makes it possible for listeners to discriminate tone durations more effectively. Studies have found that subjects consider isolated tones differing in duration by less than approximately 10 per cent as equivalent.[2] Within an established musical meter, finer distinctions are possible. Povel found that listeners could discriminate pulse variations of 2-3 per cent.[3] This suggests that meter makes it possible for listeners to more accurately discriminate event durations.

Metric structure may also function as a memory aid. Psychologists have found that humans do not remember total events well. We do not encode all of the details of an event. Instead, we seem to remember abstract symbols of our own design to recall events. For example, in one study, a story was read to subjects. These subjects were then asked to recount the story as exactly as possible. The study found that the subjects did not use the original text of the story, but the events in the story's retelling were essentially unchanged from the original.[4] More compelling evidence is provided by another study.[5] Subjects were presented with sentence pairs such as:

1a. The woman stood on the stool and the mouse sat on the floor beneath it.

1b. The woman stood on the stool and the mouse sat on the floor beneath her.

2a. The woman stood beside the stool and the mouse sat on the floor beneath it.

2b. The woman stood beside the stool and the mouse sat on the floor beneath her.

The subjects were told to memorize the sentences. After a short time was allowed to memorize the material, subjects were shown one of the sentences in the pair and asked whether it was the first or second. In sentence pairs such as 1a and 1b, the subjects could not remember the order, yet in pairs such as set 2, the order was easily remembered. The syntactic differences between the two pairs of sentences are the same, but the second pair of sentences differs in meaning, while the first pair does not. The second pair produces different abstractions in memory.

Structure is important in the way that we encode the events of a piece of music in our memory. Hirsch conducted a study which provides evidence that cognition is involved in the temporal perception of auditory stimuli.[6] This study found that two sound events needed to be separated by only a few milliseconds to be heard as different. With this short separation, subjects could identify changes between two sounds. (For example, subjects could tell whether the timbre of the two events changed.) A longer separation, however, was required to identify the order of two sounds. Events must be separated by 15-20 milliseconds before subjects can perceive the temporal order of two sound events. "Because the judgment of temporal order requires temporal separations of as much as 20 milliseconds, we conclude that more of the perceptual system is involved than merely the ear itself."[7]

Metric structure may be important in the way humans code rhythmic events. There is, however, evidence that pitch and rhythmic events are not coded separately.[8] Perhaps it would be more accurate to say that metric structure may be one part of the abstraction used to code musical events for memory.

Many music theorists have considered it likely that the beat is used to help the listener to organize and understand durational patterns found in music.[9] Meter is a sort of "yardstick" used to measure duration and record the rhythm. This idea is supported by the work of Essens and Povel. They found that subjects were more successful at tapping back a rhythmic pattern which could be easily metrically interpreted than a pattern which must be "forced" into a metric interpretation.[10] This study suggests that the internal representation of rhythm within a metric context is more efficient. One might assume the listener would attempt to find a metric organization which was suitable for a sound stimulus, if this was possible. If metrical organization is not possible, or overly complicated, it is possible to encode the sounds for memory by other methods. (This is certainly the case for music which is considered ametrical.) Nevertheless, it seems that metric organization is an efficient method of abstraction; therefore, listeners will create meter when practical.

Povel has proposed a model for perception similar to that of the music theorists above.[11] Like the theorists, he believes that listeners map all event durations on a series of beats. Povel performed a series of experiments which show that when listeners were asked to tap back attack points, the subjects of the experiment drifted away from the exact reproduction of the rhythm towards a realization which was beat-oriented. Povel's subjects included both musicians and non-musicians. There were only two cases where any significant difference existed between these two subject groups. In these two cases, the musicians were more successful. Povel hypothesizes that this is because the musicians were more adept at using the beat model, and the non-musicians did not have sufficient information to establish a beat.[12]

It was found that there was little variance in the durations equivalent to the beat as compared with smaller values in performance.[13] Durations shorter than the time-span marked by the beat were found to be at greater variance from the exact proportions suggested by the notation than those equivalent to the beat. (Beat-level time-spans vary less.) Clarke, summarizing a variety of studies, states, "It is therefore suggested that rhythms are internally represented around a series of temporal markers, or beats. In performance, it is these beats that are directly timed [as opposed to each note's duration]."[14] This notion is supported by both Morton's and Shaffer's studies above. The beat level varies less in performance because it is directly timed. According to Clarke, the subdivisions are cognitively represented as parts of the beat, rather than timed directly. If one sudivision's duration is stretched or shortened, the performer is more likely to change the value of the other part or parts of the beat than to change the duration of the directly-timed beat.

This data concerns performance and not the interpretation of the performed sounds, yet it seems likely that listeners would use similar structures to organize music for memory.[15] In searching for structures that listeners would use for abstraction, it is difficult to ignore structures imposed and made audible by the performer,[16] and thereby found in the structure-as-sound.

Both Povel's and Clarke's models of rhythmic interpretation are strongly related to traditional musical notation. In traditional notation, performers are not provided exact timed durations, but proportions of a beat (and/or measure). The performer is in fact given some latitude in the duration of the beat which serves as a standard. (The performer is generally given some guidelines as to the actual duration of the beat in the form of a tempo indication. Generally these guidelines become more specific as we move into the twentieth century; however, the tempo is still in the hands of the performer.) It has been shown that physical reproduction of the beat, through tapping or clapping, improves rhythmic reading and performance abilities.[17] Understanding and being able to produce the beat is apparently important to understanding music notation. This provides further evidence of the importance of the beat to organizing, recalling and understanding rhythm.

These studies do not explain why more than one pulse level is organized. In order for Clarke's model to function, one must have a beat (primary pulse level), but it is not necessary for this beat to be organized into a meter. Cone and Barela shed some light on this problem. Meter becomes more important when longer musical units are of interest. During the Baroque era, it was not unusual for metric displacement to occur without profound effect upon the music. For example, the answer of Bach's C Major Fugue (Well-Tempered Clavier, book 1) starts on beat 3 of the notation, where the subject begins on beat 1 (see Figure 2). The effect of moving a theme of the Classic era by one half of a measure might be more profound.[18]

In the Classic era, music begins to call upon larger architectonic units.[19] The Baroque might be said to rely more heavily on motives of relatively short duration, while the Classic era begins to call upon phrases and themes which are longer structural units. Phrases and themes are more easily measured in terms of groups of beats (measures) than in beats. Meter may become increasingly necessary to measure and record the larger patterns which occur with increasing frequency in later music. Essentially these

Figure 2
Johann Sebastian Bach's C Major Fugue,
measures 1 - 3, from the Well-Tempered Clavier, book 1

larger units require a larger map upon which to organize and understand the music. (Larger archetectonic units, and thereby the need for these larger maps, existed before the Classic era, hence the development of metric notation before the Classic era.)

By organizing an existing measuring device, namely the beat, listeners would be conserving mental effort. Hierarchical (and therefore redundant) constructions, such as common-practice-period meter, are ideal for reducing mental effort.[20] Meters rely on structural recursion. Once the basic rules for creating grammatically correct meters are understood, it requires little effort to store meter.

ASPECTS OF METRIC PERCEPTION

Meter, once organized, is persistent. Zuckerkandl points out that once meter is established, a composer must in some way prevent the listener from continuing it in order for it to be changed.[21] Meter is not constantly reorganized when the events of a piece do not constantly reinforce it.

This is not the view of all theorists. Berry views "accent to be the defining metric determinant."[22] Berry believes that meter is a form of grouping which is constantly being formed in reaction to the musical stimulus. Berry's position fails to account for certain phenomena.

Seashore found that a series of undifferentiated tones is still perceived as forming a meter.[23] There is no "accent" within this stimulus to form a meter as Berry defines it. Also, when listeners are asked to tap back a stimulus, they adjust their performance towards a "metrical" interpretation. Berry's definition of meter implies that it is a reaction to the stimulus. This evidence seems to indicate that meter serves to structure musical perception, therefore we will view meter as a psychological construction. The stimulus affects the choice of meter, but the stimulus at any given moment does not determine meter.

Simon and Summer found that humans are more likely to make interpretations which allow for an established pattern to continue rather than to establish a new interpretation.[24] The listener does not actively "look" for a new meter once one is established. A new meter must be "forced" upon the listener for it to be adopted. If the organizational process, which is used for memory storage is changed, then it will require some other abstraction to recall which organizational process is being used. It is, therefore, only after a significant breakdown in a meter's usefulness that a listener will discard it.

Meter's persistence allows such musical phenomena as rubato, accellerando, ritardando, and other changes in the actual speed of a pulse without metric reinterpretation. It also allows a meter to endure such devices as hemiola and syncopation. In fact, metric persistence allows such devices to exist. Without this persistence, upon hearing a metrically nonconformant rhythm (i.e. hemiola), a new metric scheme might be organized.

When one listens to music, certain assumptions and strategies for understanding it occur. The manner in which musical sounds are organized and understood by a listener is complex. Although music seems to be a form of cognition, therefore learned to some extent, some organizational strategies seem to be innate. Parallels in the structure of music and language[25] imply that the innate understanding often associated with music may be its ties with language. Perhaps most music has structures within it which are self-defining and can be discovered upon repeated listening using strategies common to language.[26]

Musical stimuli influence metric organization, but do not always determine it. A stimulus may lack enough evidence to definitively determine a meter. A listener may impose a metric structure which helps him or her to better comprehend the music based upon past experience with similar music. No two listeners will have the same past experience, therefore the same metric understanding. This contributes to the difficulty of creating a theory which explains metric perception and also offers insight as to why listeners may have differing views as to the meter of a work. (These differences are usually ones of level. One listener may perceive one pulse level as the beat while another perceives a higher or lower pulse level as the beat. Rarely will listeners pick "conflicting" metric organizations, though this may be possible in some works.)

Lerdahl and Jackendoff create a concept which they call the "experienced listener."[27] This idealization represents a listener who has sufficient experience with a musical idiom to have grasped the basic concepts and organizational patterns found in that idiom. "Such a listener is able to identify a previously unknown piece as an example of the idiom, to recognize elements of a piece as typical or anomalous, to identify a performer's error as possibly producing an 'ungrammatical' configuration, to recognize various kinds of structural repetitions and variations, and, generally, to comprehend a piece within the idiom."[28]

Although this idealization recognizes the effect of listeners' experiences on musical understanding, Lerdahl and Jackendoff do not attempt to provide any verifiable evidence that their ideas represent the workings of a population of such listeners. As with a great deal of current musical theory, they assume that their own observations are the same as those of their idealization, thus Lerdahl and Jackendoff become the "experienced listener." No theory of music can completely avoid such assumptions. It is difficult, if not impossible, for a theorist to exclude personal observation from consideration.[29] It is possible, however, to test key points of a particular theory with a population of "experienced listeners" rather than relying solely upon personal observation.

To illustrate the problem with assumptions related to personal observation, consider Lerdahl and Jackendoff's observations concerning their metrical preference rule number four (4). In example 4.21b of A Generative Theory Theory of Tonal Music,[30] it is indicated that experienced listeners would prefer an interpretation which divides a continuing pattern of eighth notes, consisting of three consecutive eighth notes with dynamic accents followed by a "regular" eighth note (as in Figure 3, part A), immediately before the middle of the three accented notes (as in Figure 3, part B) over an interpretation which divides the pattern before the unaccented note (as in Figure 3, part C). Experimental evidence indicates that listeners will avoid placing structural boundaries such that they divide like elements.[31] This suggests that the "less preferred" pattern in Lerdahl and Jackendoff's example 4.21b is actually the preferred organization.[32]

Figure 3
Illustration of Bar Line Placement

The listener's role in creating meter might be further illuminated by a study by Hopkins.[33] Hopkins took three accomplished musicians from three musically different cultures (Indian, Greek/Turkish, and Western European) and exposed them to Norwegian folk music. These musicians were told that this unfamiliar music had a particular rhythmic organization, though they were not told what it was. Taped interviews of the three musicians' conversations were used to study the cognitive aspects of the musicians' attempt at understanding this new type of music.

Hopkins found that past experience, knowledge, and learning played an important part in each musician's attempt to understand the Norwegian music. Each musician seemed more capable of making judgements about aspects of the Norwegian music which their particular culture uses within its music. These musicians seem to have developed strategies for listening and understanding which were very useful in their own music, but not entirely successful in understanding the Norwegian music. In summary, Hopkin's states:

> Aural Perception, like visual perception, obviously involves the grasping of structural features. In an attempt to apply these features across cultural boundaries, the abstraction of cognitive elements is influenced by concepts of appropriateness that are themselves determined by previous knowledge. . . . Perhaps it would be closer to the truth to adopt the concept that any time we hear a piece of unfamiliar music, we perceive it automatically through comparisons with familiar music.[34]

Hopkins' work suggests that a listener develops strategies for understanding music (and probably all aural occurances) based upon previous experiences.[35] Certain general assumptions are probably made by the listener before the music even begins. This also suggests that shortly after a work starts, further assumptions may be made based upon the listener's knowledge of a particular style.

Presuppositions by a listener have been hypothesized by Meyer.[36] Listeners have certain expectations based upon their knowledge of the style of a particular music. It is these expectations which may assist and allow a listener to create pulse and meter from minimal information.

Other music theorists have suggested that listeners are predisposed towards certain metric structures, although they have offered different reasons for these assumptions. For example, Schenker implies that duple meters are the most "natural."[37] He suggests that this type of grouping is innate. Meyer would argue that most Western art music is in duple meter, therefore it would be the most probable expectation. It is difficult to know whether most music is duple because this is innately part of the human condition, or humans are conditioned to expect duple music because much of what they have experienced is duple. Whether duple-meter preference is innate or learned, there is evidence that it exists.

While listening to an undifferentiated series of clicks, Bolton found that listeners grouped these clicks into twos or fours.[38] Subjects reported a difference in intensity (which did not physically exist in the stimulus). Subjects were prompted by asking about the grouping of the clicks. This invitation to group the clicks sheds some doubt upon the study. Was there any grouping before the question? Regardless of the reason for the grouping's existence, the subjects did choose a duple grouping.

Madsen and Straum found that duple-meter melodies are less susceptible to recall interference than triple-meter melodies.[39] Listeners take more time, and apparently more effort, in coding triple-meter melodies for memory, suggesting that the listener is predisposed to duple meter.

Research by Tindall also supports the concept that duple music is more quickly grasped than triple.[40]

Lerdahl and Jackendoff also recognize duple-meter preference in their theories. They include the following injunction in their theories: "Prefer metrical structures in which at each level every other beat is strong."[41] They draw their evidence from observations of another aspect of music. When measures are acting in a metrical fashion (as hypermeasures), they are most often arranged in a duple fashion. In fact, it is difficult to consider a situation where this would not be true. This premise is not without problems. The use of the two-measure hypermeasure may be due to the limitations of memory rather than a duple preference. The longer time-spans involved in higher pulse levels make it difficult for a listener to effectively perceive a three-measure hypermeasure, especially at slower tempos. For any pulse level where three or more pulses occur within the psychological present, Lerdahl and Jackendoff's preference rule may be inappropriate.

This does not mean that Lerdahl and Jackendoff's preference rule is totally invalid on lower levels. It may be that the duple-preference "learned" on higher levels is applied to lower levels of pulse.

It seems that all things being equal, a pulse level will be organized into a duple meter, alternating strong and weak pulses. This probably is a rather weak preference, however, and would be rather quickly discarded if some aspect or aspects of a musical stimulus were to indicate another organization.

Duple-meter preference, such as that described above, is an example of a listener-induced structure. There may be no factor within a given stimulus which suggests such a metric perception. Listeners may anticipate a structure upon the sounding of the first pitch, then revise it after the first few measures. The structure is created by the listener to improve duration discrimination and the efficiency of memory coding.

Metric expectations have a profound effect upon our perceptions. Studies have shown that when performers are told to reproduce a tune presented aurally, they produce rhythms which conform to standard metric notation (even when the original does not).[42] As has been stated, meter seems to have an important place in our perception of rhythm.

Because of the importance of expectation for metric perception, it is necessary to consider what metric structures generally were used in the common-practice period. Experience of this music allows the listener to more easily identify the music's salient features.[43] A listener uses this knowledge to help organize and quickly comprehend meter.

It has been implied that certain metric structures found in twentieth-century music were not in use during the common-practice period. By limiting the scope of our study to the common-practice period, it is possible to be more specific about the expectations of a listener. Bengtsson observes that in a given point of history, there are a relatively limited number of meters which were being used.[44] One can effectively know that a Mozart piano concerto will not be in 5/8 time, for example.

Each meter might be considered a type of grammar, signified by a time signature. Within a grammar certain structures are allowed and others are not.[45] As in language, it is possible to break the rules of a grammar, but this sheds doubt upon the meaning (which in this case is the meter). A limited number of grammars would allow a listener to quickly eliminate certain meters based upon features found early in a movement or work.

During the common-practice period, all metric grammars had certain aspects in common. A pulse level always starts with an accented pulse and ends with an unaccented pulse,[46] and each pulse level nests within the pulse level above it. Further, two adjacent pulse levels are such that either two or three pulses of one level combine to mark the same time-span as the level above it. (As stated earlier, the time span marked by two pulses combined is more commonly equivalent to the pulse level above it, although this is less true for lower levels.) Generally the attacks of all tones fall upon some point in time marked by a pulse, but this is not always so.[47]

At certain levels, a pulse and its grouping are more easily grasped. At some level, most often above the measure, the rigidity of a metric system breaks down.[48] This level is in part determined by the limitations of the psychological present. In order for meter to exist above the time span of the psychological present (usually 2-5 seconds),[49] long-term memory must be used. Most current theories of memory contend that beyond the temporal limits of the psychological present, we do not remember events, but abstractions of those events. Within memory, these abstractions are generally organized around some set of principles. Depending upon the musical stimuli involved and the listener, these principles may or may not allow metric interpretation.

Short-term memory, which includes the confines of the psychological present,[50] provides the material which is being subject to abstraction for long-term memory. Meter seems to be a part of the organizational process involved in this abstraction. It may be that structure is more flexible at higher levels because the listener is now considering information stored in long-term memory rather the events found in short-term memory. Because of the change in the nature of the information, there may be a change in the cognitive structure associated with it. Cone disagrees with those theorists who treat larger rhythmic structure "simply as metric structure on a higher level."

> Now I do not deny that such alternation [of strong and weak] often occurs, especially in the case of short, fast measures; but I insist that on some level this metric principle of parallel balance must give way to a more organic rhythmic principle shape. . . .[51]

At some level, the rigidity of meter may break down and be replaced by another organizational system.[52] This organizational system can operate in much the same manner as meter with a rather rigid and predictable architectonic structure, or it can become extremely flexible, while continuing to be created by many of the same musical parameters as meter. This more organic structure must rely on stronger structural cues, due to its less predictable nature; however, a regular periodic structure is not required. Organic structure gains in temporal flexibility, but loses subtlety in structural cues.

These two types of structure (metrical and organic) might be thought of as opposite ends of a continuum. A regular structure may be able to become more flexible on higher levels while still being essentially architectonic in nature. Irregularities in the structure are produced by some particularly evident transformation in the regular structure. Such a transformation, for example, might be an obvious extension of a phrase. The architectonic structure has been altered in an understandable and easily definable manner. Conversely, a more organic structure can use the metric expectations of the listener to assist in creating closure and grouping.

SUMMARY

Meter seems to have two predominant functions. It allows listeners to discriminate rhythmic durations in music more accurately through the use of a beat. The second function of meter is to assist in the organization of music for memory, serving as a basis for abstraction. Using Gestalt terms, meter is the background upon which rhythm (the foreground) is perceived.[53]

Meter is a psychological construction created by the listener to fulfill the above functions. This construction is fairly durable and, once invoked, does not need continual reinforcement. In fact, it takes a large amount of contrary information for a meter to be changed or abandoned.

Metric organization is influenced by the experience of the listener. Normative practices of a musical idiom, and a listener's experience of the idiom, influence the metric organization chosen for a particular piece. For example, it has been suggested by several music theorists that there is a tendency to organize a duple meter (as opposed to a triple meter) when possible. It has been found that the metric expectations have a profound influence upon musical perception. "The perception of [metrical] accent in tone sequences is a constructive process in which physical cues are matched against anticipated accents."[54] It is important, therefore, to understand the normative practices of meter during the common-practice-period.

At some higher level, the regular periodic structure of meter sometimes breaks down to be replaced by a more fluid grouping of events. Both forms of temporal organization, meter and this organic grouping, use the same (or similar) musical parameters to define structural boundaries. It has been proposed that there exists a boundary created by the length of short-term memory which make a more flexible organizational system as efficient as meter for abstraction of temporally longer events. Structure at these higher levels can exist within the bounds of a continuum starting at one end with a regular, periodic, metric-like structure and ranging to an organic structure with irregularly spaced boundaries.

[1] H. A. Simon and R. K. Summer, "Pattern in Music," Formal Representation of Human Judgement, edited by B. Kleinmuntz (New York: John Wiley, 1968) 221.

[2] C. Douglas Creelman, "Human Discrimination of Auditory Duration," Journal of the Acoustical Society of America 34 (1962): 582-593.

A summary of work done in this area can be found in Herbert Woodrow, "Time Perception," Handbook of Experimental Psychology, edited by S. S. Stevens (New York: John Wiley & & Sons, 1951) 1224-1227.

[3] Dirk-Jan Povel, "Internal Representations of Simple Temporal Patterns," Journal of Experimental Psychology: Human Perception and Performance 7 (1981): 3-18.

[4] Thomas Fay, "Perceived Hierarchic Structure in Language and Music," Journal of Music Theory 15 (1971): 115.

[5] David E. Rumelhart, "Schemata: The Building Blocks of Cognition," Theoretical Issues in Reading Comprehension: Perspectives from Cognitive Psychology, Linguistics, Artificial Intelligence, and Education, edited by Rand J. Spiro, Bertram C. Bruce, and William F. Brewer, The Psychology of Reading Series (Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1980) 50.

[6] Ira J. Hirsh, "Auditory Perception of Temporal Order," Journal of the Acoustical Society of America 31 (1959): 759-767.

[7] Ira J. Hirsh, "Auditory Perception of Temporal Order," Journal of the Acoustical Society of America 31 (1959): 767.

[8] It has been found that subjects were much more successful recalling both rhythm and pitch together rather than as two distinct phenomenon.

Stephen Schellenburg and Randall S. Moore, "The Effect of Tonal-rhythmic Context on Short-term Memory of Rhythmic and Melodic Sequences," Council for Research in Music Education Bulletin no. 85 (Late Fall 1985): 207-217.

[9] Some recent examples include:

Joel Lester, The Rhythms of Tonal Music (Carbondale: Southern Illinois University Press, 1986) 52.

W. Jay Dowling and Dane L. Harwood, Music Cognition, Academic Press Series in Cognition and Perception, edited by Edward C. Carterette and Morton Friedman (New York:

Academic Press, 1986) 179.

C.B. Monahan, "Parallels Between Pitch and Time: The Determinants of Musical Space," Ph.D. dissertation, University of California, Los Angeles, 1984.

James Tenney, Meta + Hodos: A Phenomenology of 20th Century Musical Materials and an Approach to the Study of Form, Mater's thesis, University of Illinois at Champaign-Urbana, 1961 (Oakland, California: Frog Peak Music, 1986) 45.

Deryck Cooke, The Language of Music (New York: Oxford University Press, 1959) 36.

John L. Mursell, The Psychology of Music (New York: W.W. Norton, 1937) 195-198.

10 Peter J. Essens and Dirk-Jan Povel, "Metrical and Nonmetrical Representations of Temporal Patterns," Perception and Psychophysics 37 (1985): 1-7.

Patterns in which all durations were a multiple of the shortest duration were considered metrically simple. For example, a pattern of 200, 400, 400 microseconds would be metrically oriented, while a pattern of 200, 300, 500 microseconds would be more difficult to understand metrically.

Essens and Povel explored ways of measuring the degree to which a pattern is metrical in another series of experiments.

Dirk-Jan Povel and Peter Essens, "Perception of Temporal Patterns," Music Perception 2 (1985): 411-440.

11 Dirk-Jan Povel, "Internal Representations of Simple Temporal Patterns," Journal of Experimental Psychology: Human Perception and Performance 7 (1981): 3-18.

Povel's ideas were further tested and explored. "We have given evidence that the internal representation of a pattern completely depends on whether, and which, clock [beat] is internally induced. Instructive in this respect is that subjects do not recognize the same pattern in different clock contexts [meters]."

Dirk-Jan Povel and Peter Essens, "Perception of Temporal Patterns," Music Perception 2 (1985): 411-440.

A similar theory is proposed by Martin; however, he considers only hierarchical organization. Povel's model is more flexible because only the beat is fixed. See J.G. Martin, "Rhythmic (hierarchical) Versus Serial Structure in Speech and Other Behaviors," Psychological Review 79 (1972): 487-509.

12 Dirk-Jan Povel, "Internal Representations of Simple Temporal Patterns," Journal of Experimental Psychology: Human Perception and Performance 7 (1981) 16.

[13] L. H. Shaffer, "Performances of Chopin, Bach, and Bartok: Studies in Motor Programming," Cognitive Psychology 13 (1981): 361.
W. B. Morton, "Some Measurements of the Accuracy of the Time-Intervals in Playing a Keyed Instrument," British Journal of Psychology 10 (1919/1920): 197.

[14] Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 224.

[15] "A listener is therefore engaged in a process that is the reverse of a performer--extracting beat intervals from a sequence and organising individual notes around markers."
Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross and Robert West (New York: Academic Press, 1985) 224.

[16] Additionally, it is impossible to directly observe the cognitive activity of a listener.

[17] John David Boyle, "The Effects of Prescribed Rhythmical Movements on the Ability to Sight-read Music," Ph.D. dissertation, University of Kansas, 1968.

[18] Cone also considers this aspect of meter. ". . . a Classical theme is tied more firmly [than a Baroque one] to its metrical position." Edward T. Cone, Musical Form and Musical Performance (New York: W.W. Norton, 1968) 72.
Margaret Mary Barela, "Motion in Musical Time and Rhythm," College Music Symposium 19, no.1 (Spring 1979): 82.

[19] La Rue writes of a lengthening of the "dimension of action." This dimension of action moves from the quarter note in Vivaldi to two or more measures in the mature Classic style.
Jan La Rue, "Forum: On Style Analysis," Journal of Music Theory 6 (1962): 103-104.

[20] One study found that subjects were more successful at recognizing and identifying repeating eight-element patterns when the pattern had the same element occur in the first and fifth position. These patterns could be divided into two four-element parts which corresponded to "beats." Apparently it is easier to recognize these two smaller

patterns alternating than to discover a larger eight-element pattern.

Persis T. Sturger and James G. Martin, "Rhythmic Structure in Auditory Temporal Pattern Perception and Immediate Memory," Journal of Experimental Psychology 102 (1974): 377-383.

Similar results were found by Wood. Robert W. Wood, "The Perceptual Processing of Rhythmic Auditory Pattern Temporal Order," Ph.D. dissertation, Michigan State University, 1980.

These results suggest that metric structure reduces mental effort.

[21] Victor Zuckerkandl, The Sense of Music (Princeton, New Jersey: Princeton University Press, 1959) 110.

One might liken this to the Gestalt law of good continuation. In the law of good continuation, however, a set of stimuli is organized into a whole. Here the whole (meter) continues to exist without support.

[22] Wallace Berry, "Metric and Rhythmic Articulation in Music," Music Theory Spectrum 7 (1985): 12.

[23] Carl E. Seashore, The Psychology of Music (New York: McGraw-Hill Book Company, Inc., 1938; reprint edition, New York: Dover Publications, 1967) 138.

[24] H. A. Simon and R. K. Summer, "Pattern in Music," Formal Representation of Human Judgement, edited by B. Kleinmuntz (New York: John Wiley, 1968) 221.

[25] Parallels have been suggested by many. Some writings which include such ideas are:

Leonard Bernstein, The Unanswered Question: Six Talks at Harvard (Cambridge, Massachusetts: Harvard University Press, 1976).

Fred Lerdahl and Ray Jackendoff, A Generative Theory of Tonal Music, The MIT Press Series on Cognitive Theory and Mental Representation (Cambridge, Massachusetts: The MIT Press, 1983).

Deryck Cooke, The Language of Music (New York: Oxford University Press, 1959).

[26] A study by Oléron found that subjects' movements associated with the temporal structure of a piece of music increased upon repeated listening of the piece.

G. Oléron, "Influence de la repetition sur la structuration temporelle des mouvements d'accompagnement de la musique," Annee Psychologie 56 (1956): 13-26; cited in Alf Gabrielsson, "Experimental Research on Rhythm," The Humanities Association Review 30 (1979): 74.

[27] Fred Lerdahl and Ray Jackendoff, <u>A Generative Theory of Tonal Music</u>, the MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 3-4.

[28] Fred Lerdahl and Ray Jackendoff, <u>A Generative Theory of Tonal Music</u>, the MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 3.

[29] Testing all observations with a population of listeners would be ideal, but this would prove to be very cumbersome. There are certain observations which are widely accepted as "fact." It is the observations which raise questions of opinion which must be concentrated upon. A theorist must ask how widely a particular observation is likely to be challenged, refuted, or dismissed and weigh the needed proof accordingly.

[30] Fred Lerdahl and Ray Jackendoff, <u>A Generative Theory of Tonal Music</u>, the MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 79.

[31] Fred L. Royer and Wendell R. Garner, "Response Uncertainty and Perceptual Difficulty of Auditory Temporal Patterns," <u>Perception and Psychophysics</u> 1 (1966): 41-47.

W. R. Garner and Richard L. Gottwald, "The Perception and Learning of Temporal Patterns," <u>Quarterly Journal of Experimental Psychology</u> 20 (1968): 97-109.

D. Preusser, "The Effect of Structure and Rate on the Recognition and Description of Auditory Temporal Patterns," <u>Perception and Psychophysics</u> 11 (1972): 233-240.

Wendell R. Garner, <u>The Processing of Information and Structure</u>, The Experimental Psychology Series (New York: John Wiley & Sons, 1974).

[32] Perhaps the most preferable interpretation would divide the pattern after the unaccented eigth note. This interpretation provides for both Lerdahl and Jackendoff's preference rule <u>and</u> the experimental findings discussed, but this interpretation does not appear in the cited Lerdahl and Jackendoff's example.

33 Pandora Hopkins, "Aural Thinking," Cross-Cultural Perspectives in Music, edited by Robert Falck and Timothy Rice (Toronto: University of Toronto Press, 1982) 144-161.

34 Pandora Hopkins, "Aural Thinking," Cross-Cultural Perspectives in Music, edited by Robert Falck and Timothy Rice (Toronto: University of Toronto Press, 1982) 158.

35 An experiment by Sloboda found that more experienced listeners were more successful at identifying meter. Although the data is somewhat limited, it appears that the ability to identify meter develops over years of listening to and performing music.

John A. Sloboda, "The Communication of Musical Metre in Piano Performance," Quarterly Journal of Experimental Psychology 35A (1983): 393.

36 Much of Meyer's work considers the importance of expectation as axiomatic. In terms of rhythm, his thoughts are probably best summarized in Leonard B. Meyer, Explaining Music: Essays and Explorations (Chicago: University of Chicago Press, 1973).

37 Heinrich Schenker, Neue Musikalische Theorien und Phantasien, III. Der Freie Satz, 2nd edition, edited and annotated by Oswald Jonas (London: Universal Edition, 1956) 184.

38 Thaddeus Bolton, "Rhythm," American Journal of Psychology 6 (1894): 145-238.

Similar results were obtained by J.E. Wallace Wallin, "Experimental Studies of Rhythm and Time," Psychological Review 18 (1911): 208-209.

39 C.K. Madsen and M.J. Straum, "Discrimination and Interference in the Recall of Melodic Stimuli," Paper presented at the Music Educators National Conference, Mineapolis, April 1981; cited in Patricia E. Sink, "Effects of Rhythmic and Melodic Alterations on Rhythmic Perception," Journal of Research in Music Education 31 (1983) 102.

40 Danny Huffman Tindall, "The Effect of Subdivision and Non-subdivision on Beat Prediction Accuracy," Ed.D. dissertation, University of Georgia, 1978.

[41] Fred Lerdahl and Ray Jackendoff, A Generative Theory of Tonal Music, The MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman, and Samual Jay Keyser (Cambridge, MA: The MIT Press, 1983) 101.

This paper would use the term pulse rather than beat in this statement.

[42] Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 223.

[43] Dowling and Harwood use a similar idea in considering listener's knowledge of melodic construction. They call these expectations and probabilities melodic schema.

W. Jay Dowling and Dane L. Harwood, Music Cognition (New York: Academic Press, 1986).

[44] Ingmar Bengtsson, "On the Relationships Between Tonal and Rhythmic Structures in Western Multipart Music," Studier till gnade Carl-Allan Moberg 5 Juni 1961, edited by M. Tegen (Stockholm: Svensk Tidskrift for Musikforskning, 1961) 59.

[45] Meter is considered in terms of a grammar by H.C. Longuet-Higgins and C.S. Lee, "The Rhythmic Structure of Monophonic Music," Music Perception 1 (1983-84): 424-441.

A concept used in cognitive psychology which is related to grammar is schema. A summary of schema and related ideas can be found in David E. Rumelhart, "Schemata: The Building Blocks of Cognition," Theoretical Issues in Reading Comprehension: Perspectives from Cognitive Psychology, Linguistics Artificial Intelligence, and Education, edited by Rand J. Spiro, Betram C. Bruce, and William F. Brewer, The Psychology of Reading Series (Hillsdale, NJ: Lawrence Erlbaum Associates, 1980) 33-58.

[46] Certain non-Western meters do not comply with this aspect.

Dalia Cohen, "Meter and Rhythm in Music and Poetry," Israel Studies in Musicology 1 (1978): 114.

[47] There are a limited number of allowable nonconformant rhythms, however. These would be triplets or duplets in notational practice.

[48] "As one moves away from the beat level, listener's acuity of metrical perception gradually fades; and, correspondingly, greater liberty in metrical structure becomes possible without disrupting his sense of musical flow."

Fred Lerdahl and Ray Jackendoff, A Generative Theory of Tonal Music, The MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman, and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 490.

[49] A summary of the work on determining the temporal confines of the psychological present is offered in W. Jay Dowling and Dane L. Harwood, Music Cognition, Academic Press Series in Cognition and Perception, edited by Edward C. Carterette and Morton Friedman (New York: Academic Press, 1986) 180-181.

Fraisse, summarizing several experimenters' work, identifies three levels of temporal preception. Durations less that 100 milliseconds are perceived instantaneously. Durations between 100 milliseconds and 5 seconds are within the perceived present. Durations greater than 5 seconds involve the use of long-term memory.

Paul Fraisse, "Perception and Estimation of Time," Annual Review of Psychology 35 (1984): 29.

[50] A study by Vos considered the duration of measures in a recording of Bach's Well-Tempered Clavier. His results found 1.75 seconds for 2/4, 3.0 seconds for 3/4, and 4.8 seconds for 6/4. These fall within the accepted range for the psychological present of 2-5 seconds. This may explain why the measure is less often found to be metrically non-conformant than the phrase level.

Peter G. Vos, "Identification of Metre in Music," Report 76 ON 06, University of Nijmegen, 1976; cited in Paul Fraisse, "Rhythm and Tempo," The Psychology of Music, edited by D. Deutsch (New York: Academic Press, 1982) 171.

[51] Edward T. Cone, Musical Form and Musical Performance (New York: W.W. Norton, 1968) 26.

[52] This distinction is found in other writings as well. See Dirk-Jan Povel, "A Theoretical Framework for Rhythm Perception," Psychological Research 45 (1983-1984): 332.

[53] ". . . there is clear evidence of division of music into attentional streams, which may stand in figure/ground relationships similar to those found in vision."

Robert West, Ian Cross, and Peter Howell, "Modelling

Perceived Musical Structure," Musical Structure and Cognition (New York: Academic Press, 1985) 47.

[54] Joseph M. Thomassen, "Melodic Accent: Experiments and a Tentative Model," Journal of the Acoustical Society of America 71 (1982): 1596.

Chapter 4
THE PERFORMER'S ROLE IN METRIC PERCEPTION

To perform a piece of music, performers need more information than is provided by even the most carefully notated score. This can sometimes be observed when one compares two performances of the same work. Both performances may be correct, even if they differ radically in some ways. These differences in performance usually involve parameters which are not notated with much precision. In some cases, there may be no indication of the composer's intentions.

The performer may introduce aspects which, if done in a systematic way,[1] could contribute to the listener's ability to organize a meter. A study by Sloboda found this to be true. Some of the interpretative features of music, introduced by the performer, allowed listeners to more easily grasp meter.[2]

Certain notational devices, specifically time signatures, barlines, and beams, have definite implications for meter. Unlike the indications of pitch or macro-duration in traditional music notation, these devices do not have specific performance implications associated with them. Smith calls devices such as these relation-determining symbols.[3] These symbols provide information about the structure of the music, but not specific performance directions. It seems these relation-determining symbols trigger certain variations, sometimes unconscious, in music performance. The variations might differ from performer to performer, but generally are consistent within a specific performance.

The simplest hypothesis would be that these symbols directly trigger specific variations in the way that music is performed. An example of such a triggering effect would be that the first beat of every measure might be played a little louder than the beats immediately surrounding it. Unfortunately, close examinations of musical performances have found this simple triggering effect not to be the case. A variety of devices are at the performer's disposal, and no single technique is associated with a particular notational device. However, a set of experiments by Sundberg, Askenfelt, and Fryden found that performances by a computer which applied a specific set of rules, based on the relation-determining symbols in the notation, to modify the exact proportional durations suggested by the rhythmic notation were judged better by listeners than performances without any modifications to the exact proportional durations.[4] This type of triggering effect is a step in the right direction, but is not what occurs in performance.

Sloboda undertook a study to see what techniques pianists use to mark strong beats for attention. He discovered that the pianists in his study primarily used three techniques to accent strong beats--loudness, legato (less silence following the pitch), and tenuto (longer beat). No particular device seemed to be associated with a particular beat, but events on strong beats usually used one or more of the three devices. Sloboda also found that the more experienced pianists in his study used a greater variety of devices to accent strong beats.[5]

A study by Clarke attempted to show how the notational setting of a melody influenced musicians' performances of it.[6] He asked several performers to play pairs of melodies which had identical sequences of pitch and macro-durations, but one melody was displaced metrically by an eighth note when compared with the other. For example, if melody A started with an eighth-note anacrusis, then melody B might start on the first beat. The melodies were constructed such that both versions made harmonic sense, avoiding implied chord changes in uncharacteristic metric positions. The experiment found that the metric position in the notation did influence the way that a note was performed. Most differences between the melody pairs could be explained by changes in metric position or new group boundaries. It seems that the relation-determining symbols associated with meter are also used to determine motivic shape. A change in metric setting might change the motivic grouping of a melody. Like Sloboda, Clarke found that the performers used dynamics, articulation (the micro-duration of the sound event), and timing (changes of duration between events, particularly pulse micro-durations) to express the metric setting.[7]

These two studies seem to indicate that three major devices are available to the performer for communicating metric information to the listener. These devices include changes of loudness (as in the traditional dynamic accent), changes in the micro-duration of a sound event, and changes in the micro-duration of successive attack-point intervals, thereby changing individual pulse lengths.

INTENSITY, ACCENT, AND METER

Traditionally, young musicians are taught that the first beat of the measure is accented.[8] In this case, accented means that the stronger beats are played slightly louder than the surrounding beats.[9] Psychologists have found that this will indeed cause grouping of pulses to occur, with the more intense pulse starting the group.[10] These experiments also found that manipulations of other parameters can negate and take precedence over this grouping principle.

Although playing strong beats with greater intensity than weak beats may be the case for performances by beginning musicians, one study showed that dynamic accent was sometimes used on weak beats of the notated meter leaving the strong beat "unaccented."[11] In a study of two pianist's interpretations of a pair of works, Henderson found that performers played the first notated beat louder than adjacent beats only nineteen per cent of the time.[12] Clarke, however, found that there seems to be a high concordance between strong beats and dynamic accent.[13] It seems that a dynamic accent is most likely to occur on a strong beat, but a strong beat is not necessarily marked by a dynamic accent.

Kolinski notes that dynamic accents could not be the sole factor in generating meter because dynamic accents can be placed on weak pulses.[14] This is supported by Vos, who found that even with all intensity changes eliminated, meter could still be organized by listeners.[15] Further, how could instruments incapable of dynamic change (e.g. organ, harpsichord) be capable of producing meter? In support of the traditional view, however, Clarke concludes that his data suggests "that metrical information may be most unambiguously conveyed by means of dynamic difference."[16] Intensity can be used to generate metric structure, but it generally does not do so exclusively.[17]

MICRO-DURATIONS

The study of micro-durations is hampered by the human condition. Human performers of music introduce certain random changes in each realization of a piece. The problem in studying micro-durations is separating the random "errors" from genuine manipulations and intentions. Further, for these manipulations to be of assistance to the listener, they must be systematic to be recognized, even if subconsciously, as manipulations and not extraneous information.

Studies have established that many micro-durational aberrations persist from performance to performance, seemingly indicating that these manipulations are not random mistakes. Shaffer studied several pianists' multiple performances of the same piece. He found recurring inconsistencies between the precise rhythms suggested by the notation and the actual micro-durations in repeated performances.[18] Changes in micro-durations seem to be part of the performance and not random error.[19] Although this may be related to the changing difficulty of various passages, Sloboda found "extremely strong evidence to support the hypothesis that pianists vary their performance in response to changes in notated meter."[20]

The studies by Sloboda and Clarke (see above) found that different types of micro-durational manipulations are used to accent strong beats. One type of micro-durational manipulation involves the duration of a sound event, onset to end,[21] without altering pulse durations. In a series of quarter notes, not all quarter notes are necessarily equal in micro-duration. Some of the sound events may be longer than the others, while maintaining a constant attack-point interval. In other words, an event may be longer or shorter with a corresponding shorter or longer silence following the pitch. These manipulations might be characterized as changes in articulation and can be indicated by the composer through the use of slurs, staccato, and legato markings. Additional manipulations, sometimes more subtle, can be introduced by the performer. Two events with the same notated articulation can be differentiated by micro-duration without necessarily compromising the composer's intentions.

There is a close connection between intensity and articulative micro-durations. Subjects sometimes convert a dynamic accent into a slight agogic accent when asked to tap back a rhythm on a telegraph key.[22] The lengthening of the duration in question is only slight, certainly within the acceptable tolerences of musical performance.

Other studies have found that for short durations (less than two seconds), as a tone is held longer, it sounds louder to listeners, even when there is no amplitude change in the stimulus.[23] This has interesting repercussions for music. A micro-durational agogic accent applied to a stimulus causes the stimulus to sound louder to listeners, even though no real change in amplitude occurs. That which is perceived as a change in loudness may actually be a change in micro-duration.[24]

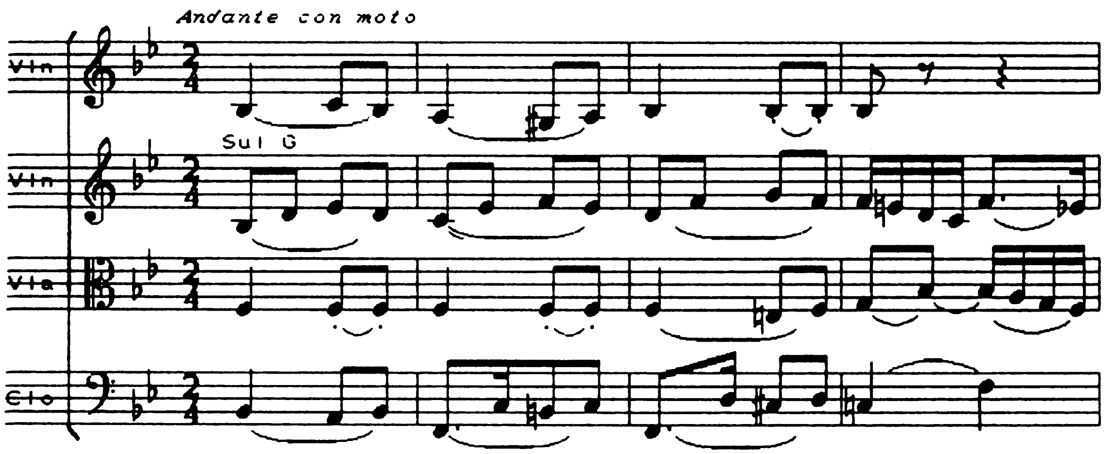
Micro-durational, agogic accents might provide the listener with significant clues for effective metric organization. Two experiments have found that a slight lengthening of micro-duration produces an accent in a series of otherwise undifferientiated tones.[25] In actual music, Sloboda found the use of legato, a micro-durational lengthening of a note, to be one of the techniques that pianists use to mark strong beats.[26]

The use of articulative micro-durations to assist the listener in organizing meter is complicated by other factors. Articulations are often associated with other forms of grouping, such as motives and sequences. It is this function that interested Vos and Woodrow. Woodrow found that lengthening a note had a group-ending effect.[27] Vos discovered that less silence between events causes the event to be grouped together.[28] These groups can sometimes subtly be used in opposition to meter, although perhaps they most often support the meter.

Consider the articulations indicated in Ludwig van Beethoven's String Quartet, opus 18, no. 3 (refer to Figure 4).[29] In the second movement (Figure 4, part A),

Figure 4
Ludwig van Beethoven
String Quartet, Opus 18, Number 3

Part A: Second Movement



Part B: Fourth Movement

the slurs create groups which support the indicated meter. The last movement (Figure 4, part B) contains a set of articulations which oppose the meter indicated. In order for the meter to be heard as notated, some other parameter must clarify the contrametric position of these articulative groupings. (Dynamic accent could be used for example.)

Another micro-durational manipulation of interest involves changes in the actual time span of specific pulses. These changes can best be measured in terms of attack-point intervals. Some early scientific studies of the temporal aspects of music discovered that performances did not maintain a strict, steady pulse. Although pulse levels were perceived as being equal, there were sometimes significant variations in individual pulse durations. Sears found that successive measures in church hymns, performed by experienced organists, sometimes differed in durations greater than 0.2 seconds.[30] A study of piano player rolls by Hartman also found such variations,[31] and similar results have been found in non-keyboard performances.[32] If variations in individual pulse length proved to be systematic, the listener could subconsciously be using these variations as clues for metric organization.

Studies comparing the pattern of the micro-durations of individual pulses with notated meter have been somewhat inconclusive. A lack of accentual effect of changes in pulse micro-duration is supported by studies in pauses. Fraisse studied the effect of pauses upon melodic patterning.[33] He introduced pauses in random locations in melodies. These pauses were not disruptive of structure, provided the pause was not overly long. When asked, listeners did not even perceive that pauses were of different length. It seems that unless a pause lasted a certain length, it is all but eliminated from structural consideration. This seems to indicate that a change in the attack-point interval (within certain tolerances) does not create an accent, since such accents would probably affect pattern recognition.

Other studies considered the micro-durations between attack points to discover the changes in actual pulse length. These studies show a regular pattern of long and short micro-durations of individual beats in conjunction with meter within individual pieces.[34] Some studies find that strong beats tend to have longer micro-durations than weak beats, while other studies discovered the reverse. It seems that pulse micro-durations may be assisting the listener in determining and maintaining the meter through a regularity of pattern rather than a longer (or shorter) micro-duration always being associated with a specific accentual effect. (This is not true for macro-durations, where a longer duration is associated with accent.)

Clynes attempted a different method to study this effect. He found that by applying a regular pattern of micro-durational change to pulse length that he could improve the quality (as judged by several listeners) of a computer-controlled performance.[35] Using the same technique, Repp discovered that a pattern of micro-durational pulse lengths was specific to a composer's style. For example, the same pattern could be applied to all Schubert works, but a different pattern applied to Beethoven works.[36]

Gjerdingen finds it questionable whether micro-durations can be structured for long-term memory.[37] This might offer some explanation for Fraisse's study above. If durations are stored in memory as relations to a beat, micro-durations would not be very accurately stored. It seems that listeners might store information concerning broad articulation differences, particularly while listening to the same piece repeatedly; however, the micro-durations studied by Fraisse and the others often involved more subtle changes than found between articulations. It seems that if these micro-durations are going to have an effect, it would be upon the structure of the events within the psychological present (2-5 seconds). Outside of this time span, micro-durational data is not stored, or not stored particularly accurately, in long-term memory. These ideas are supported by the work of Povel and Okkerman.

The results of experiments by Povel and Okkerman suggest that we must modify our position on accentual effect of pulse duration.[38] In their experiments, Povel and Okkerman gradually increased the attack-point interval of every other tone of a series of repeating tones while maintaining the same pitch, amplitude and micro-duration of each tone. They found that a difference of 5-10 per cent between attack-point intervals produced an accent on the tone with the shorter attack-point interval. An increases in the attack-point interval of greater than 10 per cent accented the tone with the longer attack-point interval. This effect is limited to relatively short attack-point intervals, 250 milliseconds or less.[39] In musical terms, this would involve the eighth-note pulse (or lower) in a common-time movement at a metronome marking of 120 beats per second. This implies that accentuation does occur as a result of changes in the micro-duration of the attack-point interval for pulse levels which would usually be below that of the beat.

SUMMARY

Previous studies have identified three performer-contributed parameters listeners could use to organize meter in musical performances. Changes in individual pulse micro-durations may contribute to the organization of a pulse level into meter.[40] For example, performances of Viennese waltzes regularly made beat 1 shorter and beat 2 longer than the average beat duration.[41] This regular pattern of aberration may contribute to organizing the beats into measures. The pattern establishes a viable duration for a higher pulse level. This patterning of pulse micro-durations does not, however, indicate accentuation for pulse levels which have a pulse duration of 250 milliseconds or longer. Apparently, longer pulse duration at the beat level and above is not associated with accent. The pattern of pulse micro-durations suggests a duration for a higher pulse level, but it does not indicate a starting point.[42]

Changes in the micro-duration of a sound event (without changes in pulse duration) and/or changes in amplitude have the effect of accent. They are closely connected, and to a certain extent, listeners cannot distinguish between these two parameters. By using a regular pattern of accent through one, both, or a combination of these devices, the performer can clearly communicate meter. Most performances, however, use a more subtle approach and only use these devices when artistically appropriate. A clear and regular pattern is unlikely to be found. Consequently the listener is generally left with only a partial picture from which to organize meter through these devices.

[1] All music performances by humans will contain certain random changes in duration, intensity, etc. It is only those variations which are systematic that are of interest here. One of the major obstacles in experimentation is separating the random changes from those which are intended.

For a more complete discussion of systematic variation, consult Ingmar Bengtsson and Alf Gabrielsson, "Rhythm Research in Uppsala," Music Room and Acoustics: Papers given at a Seminar, Organized at the Royal Institute of Technology in Stockholm by the Royal Swedish Academy of Music, the Center for Human Technology, and the Center for Speech Communication Research and Musical Acoustics in April 1975, edited by Johan Sundberg, publications issued by the Royal Swedish Academy of Music, 17 (Stockholm: Royal Swedish Academy, 1977) 30.

[2] John A. Sloboda, "The Communication of Musical Metre in Piano Performance," Quarterly Journal of Experimental Psychology 35A (1983): 389-395.

[3] Charles Smith, "The Notation of Analysis: An Approach to a Theory of Musical Relations," In Theory Only 9, no. 9-10 (December 1975/January 1976): 14.

[4] J. Sundberg, A. Askenfelt, and L. Fryden, "Musical Performance: A Synthesis-by-rule Approach," Computer Music Journal 7 (1983): 37-43.

[5] John A. Sloboda, "The Communication of Musical Metre in Piano Performance," Quarterly Journal of Experimental Psychology 35A (1983): 393.

[6] Eric F. Clarke, "Generative Principles in Music Performance," Generative Processes in Music: The Psychology of Performances, Improvisation, and Composition, edited by John A. Sloboda (Oxford: Oxford University Press, 1988) 12-14.

[7] An earlier study by Gabrielsson found these three devices to be evident when three musicians were presented with short excerpts (3-5 beats in length) and asked to perform them.

Alf Gabrielsson, "Performance of Rhythm Patterns," Scandinavian Journal of Psychology 15 (1974): 63-72.

[8] Many young musicians are taught that this is the cause of metric organization. This rather unsophisticated idea is easily challenged. Consider performances on instruments that do not have a great deal of control of dynamic shading.

Is it not possible to create meter on the harpsichord?

[9] The concept of a dynamic accent on the first beat is relatively new in the history of music. Instruction books of the seventeenth and early eighteenth century do not consider accentuation through dynamic stress. Not until the second half of the eighteenth century does dynamic accent become a factor in meter in music instruction books.

George Houle, Meter in Music, 1600-1800: Performance, Perception, and Notation, Music Scholarship and Performance, Thomas Binkley, General Editor (Bloomington, Indiana: Indiana University Press, 1987) 122-124.

[10] Herbert Woodrow, "Time Perception," Handbook of Experimental Psychology, edited by S. S. Stevens (New York: John Wiley & Sons, 1951) 1232.

[11] Ingmar Bengtsson, Alf Gabrielsson, and S.-M. Thoren, "Empirisk rytmforskning," Svensk Tidskrift für Musikfoskning 51 (1969): 99.

In another study, Gabrielsson reports that when subjects were asked to play several different rhythms, the highest peak amplitude within the notated measure occured equally often on the first, second, or third beat of 4/4-time performance examples. In this study, amplitudes seemed to covary with pitch; however, the author warns that the sample was too limited to make any conclusions with respect to this data.

Alf Gabrielsson, "Performance of Rhythm Patterns," Scandinavian Journal of Psychology 15 (1974): 63-72.

Both of these studies used contrived examples of limited length. It could be that these were acted upon cognitively in a different manner by subjects than an actual piece of music.

[12] Henderson got similar results studying performances on phonograph records.

M.T. Henderson, "Rhythmic Organization in Artistic Piano Performance," University of Iowa Studies in the Psychology of Music, volume 4, Objective Analysis of Musical Performance, edited by Carl E. Seashore (Iowa City: Iowa University Press, 1936) 286-287.

[13] Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 216.

The study did find that not all pitches of greater intensity were on strong beats, nor were strong beats always of greater intensity.

[14] Mieczyslaw Kolinski, "A Cross-Cultural Approach to Metro-Rhythmic Patterns," Ethnomusicology 17 (1973): 495.
It has also been found that syncopated rhythms are more strongly accented through intensity than metric time-keeping accents.
H. E. Weaver, "Syncopation: A Study of Musical Rhythms," Journal of General Psychology 20 (1939): 409-429.

[15] Peter G. Vos, "Temporal Duration Factors in the Perception of Auditory Rhythmic Patterns," Scientific Aesthetics 1 (1976-77): 197.

[16] Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 216.
Edlund and Gabrielsson both support this position. Bengt Edlund, Performance and Perception of Notational Variants: A Study of Rhythmic Patterning in Music, Studia musicologica Upsaliensia, Nova series, 9 (Stockholm, Sweden: Almquist & Wiksell International, 1985) 178.
Alf Gabrielsson, "Performance of Rhythm Patterns, Scandinavian Journal of Psychology 15 (1974): 63-72.

[17] This is also postulated by Victor Zuckerkandl. He argues that dynamic accent is certainly not the only way in which meter is communicated. When intensity is used to constantly communicate the bar, Zuckerkandl states this "is certainly the surest way to drive all life out of the music and make nonsense of it."
Victor Zuckerkandl, The Sense of Music (Princeton, New Jersey: Princeton University Press, 1959) 110.
In computer-controlled performances, it was found that a more convincing performance had a regular change in amplitude related to the beat with modifications related to melodic contour and composer.
Manfred Clynes, "Music Beyond the Score," Communication and Cognition 19 (1986): 172.
Manfred Clynes, "Secrets of Life in Music," Analytica: Studies in the Description of Music, edited by Anders Lonn and Erik Kjellberg, Series Studia Musicologica Upsaliensia, 10 (Stockholm, Sweden: Almqvist & Wiksell, 1985) 3-15.

[18] L.H. Shaffer, "Analysing Piano Performance: A Study of Concert Pianists," Tutorials in Motor Behavior, edited by George E. Stelmach and Jean Requin, Advances in Psychology, 1 (New York: North-Holland Publishing, 1980) 443-455.

[19] Schmidt indicates that it requires a greater degree of change in amplidtude than micro-duration to have an effect on grouping structure.

E. M. Schmidt, "Uber den Aufbau rhythmischer Gestalten," Neue Psychologische Studien 14 (1939): 1-98; cited in W. Brown, "Temporal and Accentual Rhythm," Psychological Review 18 (1911): 336-346.

[20] John A. Sloboda, "The Communication of Musical Metre in Piano Performance," Quarterly Journal of Experimental Psychology 35A (1983): 384.

[21] This is a simplification. The human ear is not always capable of detecting the exact onset and end of a particular sound. This means that the onset and end may differ from person to person. Generally some threshold is established to measure the beginning and end of an event. When the event falls below that threshold, the event is considered not to exist for the listener.

[22] James L. Mursell, The Psychology of Music (New York: W.W. Norton, 1937) 172.

[23] J. J. Zwislocki, "Temporal Summation of Loudness: An Analysis," Journal of the Acoustical Society of America 6 (1969): 431-441.

F. Miskolczy-Fodor, "Relation Between Loudness and Duration of Tonal Pulses: I. Response of Normal Ears to Pure Tones Longer than Click-Pitch Threshold," Journal of the Acoustical Society of America 31 (1959): 1128-1134.

Franklin M. Henry, "Discrimination of the Duration of a Sound," Journal of Experimental Psychology 38 (1948): 734-743.

It seems as durations become longer, amplitude and duration become independent. Listeners are able to more easily distinguish the two parameters.

C. Douglas Creelman, "Human Discrimination of Auditory Duration," Journal of the Acoustical Society of America 34 (1962): 582-593.

S.M. Abel, "Duration Discrimination of Noise and Tone Bursts," Journal of the Acoustical Society of America 51 (1972): 1219-1223.

[24] The reverse is probably also true; however, most experimenters report that listeners usually report an intensity change rather than a change in micro-duration. This phenomenon has not been subjected to statistical consideration.

[25] M.T. Henderson, "Rhythmic Organization in Artistic Piano Performance," University of Iowa Studies in the Musical Performance, edited by Carl E. Seashore (Iowa City: Iowa University Press, 1936) 292.

Dirk-Jan Povel and Hans Okkerman, "Accents in Equitone Sequences," Perception and Psychophysics 30 (1981): 570.

[26] John A. Sloboda, "The Communication of Musical Metre in Piano Performance," Quarterly Journal of Experimental Psychology 35A (1983): 389-395.

[27] Herbert Woodrow, "Time Perception," Handbook of Experimental Psychology, edited by S.S. Stevens (New York: John Wiley & Sons, 1951) 1224-1236.

Also Thaddeus Bolton, "Rhythm," American Journal of Psychology 6 (1894): 145-238.

[28] Peter G. Vos, "Temporal Duration Factors in the Perception of Auditory Rhythmic Patterns," Scientific Aesthetics 1 (1976-77): 183-199.

[29] Keep in mind that the performers have some degree of a latitude, even within these indicated articulations.

[30] Charles H. Sears, "A Contribution to the Psychology of Rhythm," American Journal of Psychology 13 (1902): 56.

The average irregularity in successive measure-length was 0.1 seconds.

[31] A. Hartman, "Untersuchungen über metrisches Verhalten in musikalischen Interpretationsvariaten," Archiv für die gesamte Psychologie 84 (1932): 103-192.

[32] Studies by Seashore and Small discovered the average change in successive measures was about ten per cent in the performances which they studied. It may be that the performers in these studies were more "romantic" in their interpretations than is the norm for today; nevertheless, these studies do show that meter can endure considerable flexibility in pulse durations.

Harold Seashore, "An Objective Analysis of Artistic Singing," Objective Analysis of Musical Performance, edited by Carl E. Seashore, University of Iowa Studies in the Psychology of Music, 4 (Iowa City: University Press, 1936) 109.

Arnold M. Small, "An Objective Analysis of Artistic Violin Performance," Objective Analysis of Musical Performance, edited by Carl E. Seashore, University of Iowa

Studies in the Psychology of Music, 4 (Iowa City: University Press, 1936) 221.

[33] Paul Fraisse, "Time and Rhythm Perception," Handbook of Perception, Volume VIII: Perceptual Coding, edited by Edward C. Carterette and Morton P. Friedman (New York: Academic Press, 1978) 244.

[34] Bengt Edlund, Performance and Perception of Notational Variants: A Study of Rhythmic Patterning in Music, Studia musicologica Upsaliensia, Nova series, 9 (Stockholm, Sweden: Almquist & Wiksell International, 1985) 49.

Alf Gabrielsson, "Current Research on Musical Rhythm" Second International Symposium of Music Education for the Handicapped, edited by Rosalie Rebollo Pratt (Bloomington: Frangipani Press, 1983) 28-29.

Alf Gabrielsson, "Perception and Performance of Musical Rhythm," Music, Mind, And Brain: The Neuropsychology of Music, edited by Manfred Clynes (New York: Plenum Press, 1982) 166.

L.H. Shaffer, "Performances of Chopin, Bach, and Bartok: Studies in Motor Programming," Cognitive Psychology 13 (1981): 326-376.

M.T. Henderson, "Rhythmic Organization in Artistic Piano Performance," Objective Analysis of Musical Performance, edited by Carl E. Seashore, University of Iowa Studies in the Psychology of Music, 4 (Iowa City: Iowa University Press, 1936) 290.

[35] Manfred Clynes, "Music Beyond the Score," Communication and Cognition 19 (1986): 169-194.

Manfred Clynes, "Expressive Microstructure in Music Linked to Living Qualities," Studies of Music Performance, edited by J. Sundberg, Publications issued by the Royal Swedish Academy of Music, 39 (Stockholm, Sweden: ADEBE Reklam & Truckservice, 1983) 76-181.

[36] Bruno Repp, "Expressive Microstructure in Music: A Preliminary Perceptual Assessment of Four Composers' 'Pulses'," Music Perception 6 (1989): 243-274.

[37] Robert O. Gjerdingen, A Classic Turn of Phrase: Music and the Psychology of Convention, Studies in the Criticism and Theory of Music (Philadelphia: University of Pennsylvania Press, 1988) 45.

[38] Dirk-Jan Povel and Hans Okkerman, "Accents in Equitone Sequences," Perception and Psychophysics 30 (1981): 565-572.

The experimenters got similar results when working with groups of three.

[39] Povel and Okkerman believe that the effect is due to the processing of each tone by the subject. The processing of a tone is interrupted by the sounding of the next tone. At first the two tones are perceived as a group because they are temporally "closer" to each other. The first tone of this group is then perceived as accented. As the silence between tones increases, the tone in the shorter attack-point interval is processed less fully and thus the accent is lower for the shorter interval.

Dirk-Jan Povel and Hans Okkerman, "Accents in Equitone Sequences," Perception and Psychophysics 30 (1981): 565-572.

[40] "It has been demonstrated that these fluctuations in beat timing are related to structural characteristics of the music being performed, indicating that the programming of clock rate has access to information concerning musical structure."

Eric F. Clarke, "Structure and Expression in Rhythmic Performance," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 230.

[41] Ingmar Bengtsson and Alf Gabrielsson, "Rhythm Research in Uppsala," Music Room and Acoustics: Papers given at a Seminar, Organized at the Royal Institute of Technology in Stockholm by the Royal Swedish Academy of Music, the Center for Human Technology, and the Center for Speech Communication Research and Musical Acoustics in April 1975, edited by Johan Sundberg, Publications issued by the Royal Swedish Academy of Music, 17 (Stockholm: Royal Swedish Academy, 1977) 34.

[42] There are studies which suggest that the order of events first encountered is favored over other orders in a repeating pattern.

Chapter 5
NOTATIONAL ELEMENTS OF METER

Within the tradition of Western art music, a composition begins with the work of an individual. A composer works towards the conception of a piece of music, a process which differs greatly from composer to composer. Eventually, the composer arrives at a final conception which is recorded in the form of music notation.[1] Music notation, however, is rather imprecise in some respects and consequently is subject to interpretation. Sometimes these interpretations are quite different and can produce considerably differing performances of the same work. There are certain factors, however, which all interpretations must have in common to be accepted as an allowable performance of a particular musical work. Music notation is rather clear about these factors, and it is these factors which the composer can control most completely. During the common-practice period, the most notable of the parameters under a composer's control are pitch constructs[2] and macro-durations.

Certain notational devices (e.g. barlines, beaming, etc.) have implications for meter. These indications, however, do not have specific performance actions associated with them. Although many performers would consider these notations important clues for interpretation, they may not agree on how the devices should effect a realization of the work. These interpretive actions will be considered later.

THE EFFECT OF MACRO-DURATIONS AND RHYTHM ON METRIC INTERPRETATION

Accent has been defined as "marked for consciousness." In a piece of music, all those points in time which correspond to the initiation of a sound event are accented when compared with those points in time where a pitch is sustained or silence occurs. In addition to providing new pitch information, the initial attack of an event seems to be largely responsible for the identification of timbre.[3]

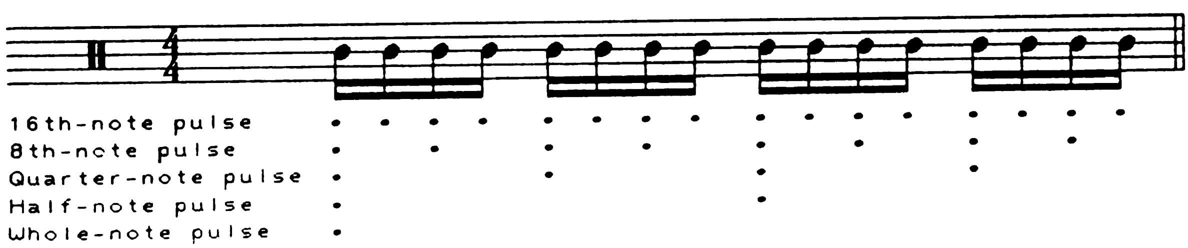
Yeston calls those points in time where a sound event initiates "attack points."[4] Attack points occur whenever sound replaces silence or a change of pitch occurs. The span of time between two attack-points is termed an "attack-point interval." This allows the consideration of certain rhythms, such as those in Figure 5, as equivalent. Intuitively, it seems that these intervals of time are more important to establishing pulse than the actual durations of an event.[5] The problems associated with the different micro-durations which are possible for the same symbol in music notation are thus temporarily avoided. (It is also possible for events of similar duration to be indicated in different ways within music notation.)

The listener can use past experience to assume that, in

Figure 5
Illustration of Equivalent Attack-Point Intervals

most cases, each attack-point corresponds to a point in time marked by a pulse of some level. It is this aspect of meter which has caused Deva to consider meter in a different light.[6] Since attack points correspond to individual pulses, once a level of pulse is established, it can be said that a pulse level consists of temporal locations which are more likely to initiate new sound events. Because the initiation of a new sound event is of particular interest to a listener, each pulse marks points in time which deserve more attention than the time-points within the spans marked by that pulse level. In the music being considered, meter consists of nested pulse-levels. Any pulse location, then, corresponds to a pulse location of all the pulse-levels below it, therefore as one moves to higher pulse-levels, it is more probable that an event will initiate at that temporal location due to the stacking of pulses from the pulse-levels below it.[7] Figure 6 adopts Lerdahl and Jackendoff's method for marking pulses to illustrate the way in which pulses correspond and "stack." According to Deva and others, meter is the psychological manifestation of a matrix of probabilities. Varying degrees of attention are given to various points in time due to the changing probability of a salient event occuring at that temporal location.

Figure 6
The "Stacking" of Pulses in 4/4 Time



The basic problem for the listener is organizing a meter which allows the attack-points encountered in a piece to correspond to some level of pulse.[8] The listener probably attempts to use the attack-point intervals found at the beginning of a piece of music to hypothesize time-spans marked by a pulse. Although this sounds like a very complex operation of trial and error, music of the common-practice period generally uses a relatively small number of

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macro-durations.[9] As a result of this, the listener must only consider a relatively small number of attack-point intervals while attempting to form and confirm various pulses.[10]

Certain normative aspects of music probably assist the listener in further simplifying the task of organizing acceptable pulses, and thereby meter. Using past experience and current context, the listener can decide if an attack-point interval seems a useful candidate for a pulse. As Lee points out, many studies of macro-duration and meter assume that longer durations tend to begin at temporal locations marked by higher pulse-levels.[11] (This is a manifestation of the probability matrix described above.)

Cognitive psychology has produced a model of perception which uses a concept called schema. A schema is a set of parameters which make up a particular concept. For example, certain aspects about a particular plant identify it as a tree. No two trees are identical, yet they can still be identified with the same term. Trees have certain aspects which they share in order to be considered a "tree." These common aspects, which define the concept "tree," are a schema. Schema are often made up of a set of other schemata. For instance, the schema for "face" might include the schemata for mouth, eye, nose, etc. Psychologists believe that certain aspects of an event or object (whether sound, visual, tactile, etc.) trigger appropriate schema which might trigger other schema, etc. As schema are considered, and adopted or rejected, they can create certain expectations while the mind attempts to confirm various schemata.

Pulse-levels and meters can be considered schemata. As certain pulses are adopted, other pulses can be eliminated from consideration. Various pulse-level schemata help to activate the schema for certain meters. As a meter becomes more likely to be adopted, it creates expectations for certain pulse-schemata to be present.

Once postulated, pulses can serve to predict likely (or perhaps "allowable" would be a more appropriate term) points in time in which a sound event may be initiated.[12] It is probably this aspect of pulse, and the listener's understanding of metric grammars, which allows listeners to discard, or ignore, temporal distances which do not become pulses. For example, consider the temporal distance represented by the dotted-half note within the framework of a 4/4 meter. This temporal distance is not generally considered a pulse. Once an eighth-note pulse is established, a dotted-eighth-note pulse becomes untenable within the Western art music tradition.

Let us consider the attack-point intervals encountered by the listener at the start of a new movement (or section following a long pause). The meter is not yet established. Only the expectations and predispositions of the listener have transpired. The listener probably assumes that early attack-point intervals are not syncopated[13] and that all attack points correspond with some point marked by a pulse. The listener will presumably attempt to establish pulses based on the early attack-point intervals. Once a particular attack-point interval occurs, then the listener extrapolates this value to predict a continuous pulse. The listener must now seek attack-points which will confirm or deny this predicted pulse.

A consideration in this model is a listener's ability to extrapolate a pulse. How many times must an attack-point interval be heard before a listener can construct a pulse? An experiment by Fraisse found that subjects could tap in conjunction with a pulse by the third attack.[14] A listener only needs two attack points to estimate the temporal position of the third. This experiment seems to indicate that a single attack-point interval is enough information to organize a pulse.

Consider the Gavotte from J.S. Bach's "French Suite number 5" (see Figure 7) in the light of the above ideas. During this discussion, attack-point intervals will be expressed in terms of number of the smallest rhythmic unit found in the notation. In this piece, the smallest unit is

Figure 7
J.S. Bach, "Gavotte" from French Suite No. 5

the eighth note which will be assigned the value one. The quarter note will be assigned two; the half note will be four, etc.

The listener first encounters an attack-point interval of two and would hypothetically extrapolate that time span into a pulse. As the movement progresses, the listener finds that an attack point occurs on this hypothetical pulse throughout most of the movement. Adopting this time span as a pulse, the listener knows, through previous experience, that either two or three of this pulse level will be equivalent to the pulse level above it. In the first complete measure, a value of four occurs in the alto voice. If the listener extrapolates this value as a pulse, it is confirmed in the second measure through an attack-point interval which this extrapolation would predict that the value of four could reccur.[15] A pulse level below the attack-point interval of two is suggested in the first measure. In this measure, the quarter-note attack-point interval is clearly divided into two parts.

It should be noted that the description of the discovery of the three pulse-levels above is not meant to be a description of the exact process in which a listener might arrive at these conclusions. It is only meant to demonstrate that macro-durations (in the form of attack-point intervals), and knowledge of how meters usually

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work, could allow the listener to establish three levels of pulse in a relatively short time. It is probable that metric organization does not occur through linear reasoning. Humans are capable of working on several aspects of data at the same time. The various levels of pulse may be organized nearly simultaneously.

Although macro-durations give the listener valuable information and clues for metric organization, meter cannot always be totally determined by them. Even when limiting the sample to a specific genre, composer, and period, rules cannot easily be formulated to use macro-durations to delineate meter. Longuet-Higgins and Steedman attempted to discover such a set of rules which defined the meter of the pieces in J.S. Bach's Well-Tempered Clavier.[16] They endeavored to write a computer program which would expose the metric structure of each piece by examining the macro-durations found in the notation. Using this limited sample, they were able to achieve some success; however, the program wrongly identified, or was unable to determine, the metric structure of several movements.

The most notable form of accent, if one only considers macro-duration, occurs when two levels of pulse mark the same point in time.[17] The highest level of pulse that can be easily established through macro-durations must be less than, or equal to, the longest attack-point interval. For example, if a work does not have a value longer than the beat, it would be difficult to determine length of the measure (while considering only macro-durations). Consider the Bach Gavotte above. It would be impossible to determine the grouping of the half-note pulse level unless we consider some aspect of the music besides macro-duration. Related to the use of the same point in time by multiple levels of pulse is the agogic accent.

THE "AGOGIC" ACCENT

The term "meter" first came into use while describing aspects of language. The term was inherited from Ancient Greece and literally means "measured." Greek is generally classified as primarily a quantitative language. An accent on a syllable was produced by making it longer in duration than the syllables around it. Romance languages produce accent primarily in another fashion, through stress. The term meter, however, is also applied to these languages. Meters which produce accent through stress are called qualitative meters. In Ancient Greek, the length of the syllable is "measured" (quantitative meter); however, in the Romance languages (qualitative meters), it is stress which is "measured."

Confusion between the different types of meter plagues both the study of language and music.[18] In musical meter, both stress and duration seem to play a definitive role.

Wimsalt and Beardsley point out that this is an important distinction between poetic meters and musical meters.[19] Musical meters more strongly coordinate <u>both</u> stress and time, while poetic meters tend to coordinate primarily one of these elements. (Most often we think of stress because English uses primarily a qualitative meter.)

Accent in music is most often thought of as a slight increase in loudness, similar to the the qualitative meters in language. The musical equivalent of a quantitative stress is often termed an agogic accent. A pitch which is held longer in macro-duration than its surroundings is said to be agogically accented.[20] This differs from many other types of accent because it is not known upon the onset of the event that the event is accented.[21]

An agogic accent, of the macro-durational type, may be marked for consciousness because of the information which it can give the listener about metric structure. A longer attack-point interval may tell the listener how to best group the pulse levels below it. It presents a new time-span as a potential pulse.

Longer durations also provide other information pertinent to metric organization. As has already been mentioned, there is a tendency for longer events to intitiate on higher pulse-levels. Since a longer attack-point interval includes multiple lower-level pulses, the attack point of an event of longer duration is more likely to be a point in time marked by a higher pulse level. For example, suppose that a series of eighth notes has established a pulse of that time span. The listener then encounters a quarter note. Even if the quarter note does not become a pulse (as in 6/8), it seems more likely that it will occur on a beat. (Intuitively, a pattern is more common than a pattern.) In certain notable cases (e.g. the scotch snap, syncopation, hemiola, etc.), this set of tendencies is not true; nevertheless, the tendency does present the listener with a set of normative practices which seem of sufficient weight to mark longer durations for greater attention, thus the existence of the term "agogic accent."

LINEAR PITCH CONSTRUCTS AND METER

Experiments by Oleron found that when the pitch content of monophonic melodies was removed, it became more difficult for listeners to tap the beat.[22] An experiment by Mursell indicated that the abilities of listeners to tap back a series of rhythmic clicks and tapping back the rhythm of a melody were related, but <u>distinct</u> abilities.[23] Woodrow concluded that pitch plays a part in grouping; however, Woodrow did not consider how these groupings were related to meter.[24] These experiments provide empirical evidence to support the findings of Longuet-Higgins and Steedman[25] in their attempt to use macro-durations exclusively to define meter. Tonal information plays a part when the listener organizes metric structure.

There are several aspects of linear pitch-constructs which effect accentuation, and thereby meter. One aspect is related to the function of a melodic pitch within the key currently established.[26] More tonally stable events tend to occur in stronger metric positions. Unfortunately, it is sometimes difficult to separate whether these events are tonally stable because they fall on strong beats, or whether the beats are strong due to the stability of the pitch.[27] Further trouble is encountered because of the significant number of exceptions to the tendency. It is difficult to formulate under what conditions this tendency operates. Exceptions are so common that tonal stability's metric implications are all but impossible to formulate.

Melodic construction, particularly contour, often has metric implications. Leaps, of comparatively larger size than their surroundings, accent those pitches more strongly than leaps of smaller intervals. An experiment by Thomassen invited listeners to establish a metric organization through dynamic accents in a tone sequence.[28] These dynamic accents were confined to an early section of the tone sequence. Embedded within each stimulus was a smaller sequence of tones which appeared in different metric positions during different trials of the experiment. Thomassen found that when a change of interval occured, these notes were perceived as accented. He also found that a change in melodic direction accented the note upon which the change of direction transpired. Although Thomassen's experiment did not measure the degree of accent, it could be hypothesized that the size of the interval change is related to the degree of accent.

Related to contour are melodic sequences and repeated patterns. Since these groups of notes (usually also related by an identical or similar rhythmic pattern[29]) tend to cause certain sets of time points to be perceived as a coherant group. This effect can often function to help form metric structure. If all other factors are the same,[30] the point of initiation of these patterns would be accented over any pulses found within the group. In this way, a sequence or repeated pattern can be used to create or reinforce meter.[31]

To examine the meter-producing effects that contour and sequences can have, let us consider Schubert's "Valse Sentimentale," opus 50 (see Figure 8). This piano work calls upon a common pattern in the left hand. This pattern involves a leap down to the lowest note in the texture on the first notated beat of each measure followed by two block

Figure 8
Franz Schubert, "Valse Sentimentale," Opus 50
Meaures 1-8

chords. Because this pattern is found in several walzes (which characteristically have the same meter), the listener's experience might be called upon to quickly organize the meter as it is notated.

Let us suppose that a listener has little experience with such a pattern. The repeated pattern suggests groups of three quarter notes. As has already been mentioned, humans will generally not place pattern boundaries between two like objects.[32] It is unlikely that a listener would consider the pattern to be chord, low note, chord (Figure 9, part A). This leaves low note, two chords (Figure 9, part B) or two chords, low note (Figure 9, part C) as possibilities. Since the low note appears first, more

Figure 9
Possible Barline Locations in the Left-hand Pattern of the Schubert Waltz

pattern repetitions could be organized using the low note, two chords model (Figure 9, part B).[33] Additionally, pitches in the right hand during measure four hold through the sounding of the first chord. This is further evidence that the attack point marked by the low note corresponds to a higher-level pulse.

HARMONY AND METER

Music theorists have long debated the relationship of meter and harmony.[34] Many insist that harmonic rhythm and function are the primary aspects which determine meter. A recent example might be Lester's statement, "Harmonic change is the single most powerful meter-producing factor."[35] Lester and others argue that a pattern of stable and less stable harmonic function produces strong and weak beats.

Other theorists argue that this is not the case. Harmonic factors are related to meter, but do not determine it. Berry writes, ". . . harmonic rhythm is, like motivic and other rhythms, often concurrent with meter, yet a distinct mode of articulation at times subtly opposed [to meter] . . . ."[36]

Although harmonic change may be an important factor in helping a listener to establish a metric organization, it is not always the "most powerful meter-producing factor." Lester seemingly dismisses the strong metric quality sometimes found in monophonic music of our own culture and others. Even within Western Art music of the common-practice period, there are non-monophonic examples which defy his generalization. Imagine a work in which the surface harmonic function changes at the measure pulse level. Seemingly there are strong and a weak beats without change in the harmonic function. In such a situation, metric organization seems to be occuring without benefit of harmonic change.

An example of such a piece might be the first movement of Beethoven's Piano Sonata, opus 14, number 1 (please refer to Figure 10). It is clear that the harmonic function changes at the whole-note (measure) pulse level. At the indicated tempo, allegro, listeners would probably choose the quarter-note or half-note pulse level as the beat.[37] At either of these pulse levels, multiple pulses have the same harmonic function. If harmony is the "most powerful meter-producing factor," why would a listener choose the half-note or quarter-note pulse level as the beat? It seems that using Lester's premise that the beat would come at some higher level. The first change of harmonic function occurs at the whole-note level.

Within each of the first three measures, there is some harmonic change, though no functional change, at the half-note pulse level. Lester might argue that this

Figure 10
Ludwig van Beethoven, Piano Sonata No. 9 in E Major, Opus 14, No. 1
Movement I, measures 1-4

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f
t
a
b
s

t

harmonic information gives the listener the location of the beat. The movement from the dominant to the tonic in the top voice is a change from a presumably less stable harmonic function (the dominant) to a more stable function (the tonic), yet the listener seemingly organizes the two pulses as moving from strong to weak. Perhaps Schachter said it best, "The analogy between metrical accent and tonal stability, then, ought not to be overdrawn."[38]

It is difficult to see how a listener uses harmony as the "single most powerful" factor in organizing this passage into the meter which seems correct. Some set of factors in this Beethoven passage seems to take precedence over harmony. As has been stated earlier, listeners prefer a pulse level of moderate speed as the beat. The harmonic rhythm of this example is quite slow; consequently, harmony was not an effective tool for listeners to use to determine the beat. Harmonic change, and specifically harmonic function, is only one factor among many that a listener may use to organize a meter.

To further illustrate the problems associated with harmony as the primary meter-determining factor in music, consider Figure 11. In this Figure, part A illustrates a metrically undefined two-voice counterpoint. Notice the changes in harmonic function that result from the different metrical settings found in Parts B and C. This illustates the importance of meter in assisting to define harmonic meaning.[39]

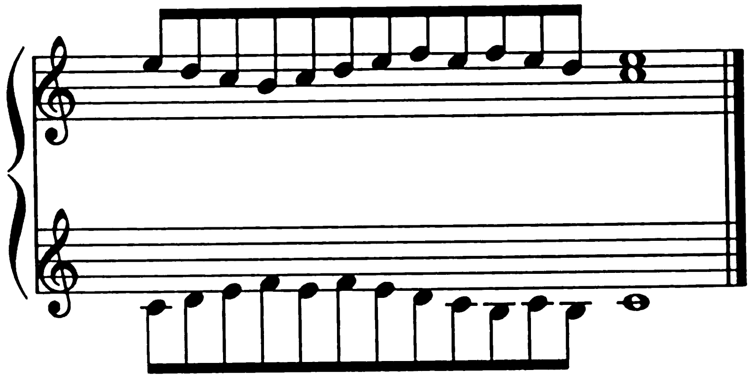
Berry's stance seems more palatable, but it is not without problems. If harmonic rhythm is often concurrent with meter, could not a listener be using it to assist in the creation of meter? Downbeats do often correspond to stable harmonic events. With this expectation in mind, the listener could use harmony as a factor in organizing metric structure.

Certain aspects of the normative practice of common-practice-period harmony might be particularly helpful in assisting the listener to organize meter. A basic "rule," taught to many student composers of tonal music, is that one should not repeat a chord over a bar line.[40] From the listener's point of view, this might be considered part of the grammar[41] of tonal music. Humans prefer boundaries that do not separate similar sound events.

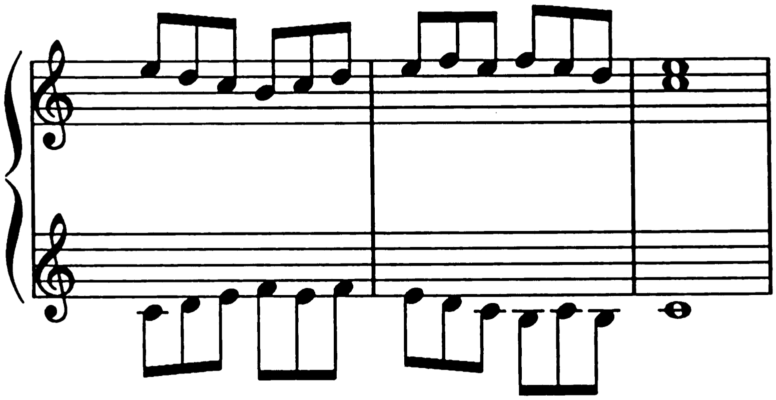
The above "rule" might be explained by the Gestalt principle of similarity. Events or objects which are similar will be grouped as a single larger unit. Royer and Garner performed an experiment which found this principle to be true for temporal auditory patterns.[42] They had subjects listen to a nine-element repeating sequence of two doorbells with different sound characteristics. The

Figure 11
Meter's Effect on Harmonic Function

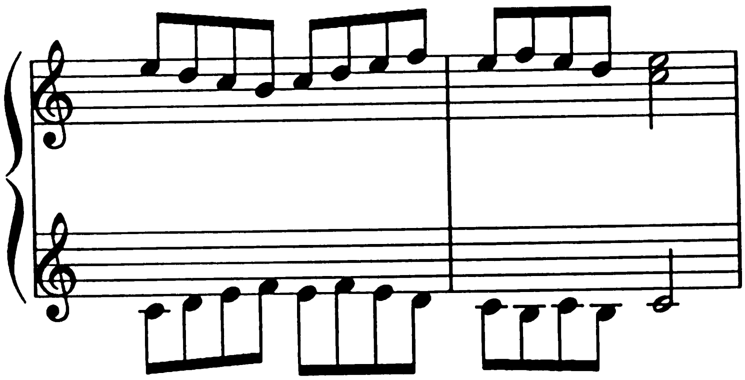
Part A



Part B



Part C



subjects were asked to indentify the sequences. Since each sequence was continually repeating, there were up to nine possible correct answers; a correct answer with the sequence starting on each element. Royer and Garner discovered several organizational principles. Of particular interest, subjects never broke a run of the same element when describing a sequence. For example, if a sequence of three parts consisted of XXO and was continuously repeated (i.e. . . . OXXOXXOX. . .), subjects would not describe the sequence as XOX.[43] A measure, therefore, usually does not begin with the second sounding of a repeated chord.

Understanding the interaction of meter and harmony is a difficult task. It seems that in certain cases metric organization arises, at least to some extent, through harmonic means. Although harmony is not involved in establishing the lower pulse levels of the Beethoven example, harmonic change clearly establishes the whole-note (measure) pulse level. Clear harmonic change can be a powerful pulse-defining and organizing force. In other contexts, however, harmony requires meter to be fully understood; functional and embellishing tones are defined through metric position. In sum, harmony can be used to articulate meter, but metric organization can also arise from other factors; meter can even be used to articulate and define harmonic meaning.

SUMMARY

Three areas have been identified in this chapter as having an effect on metric perception. Perhaps the most significant is macro-durations. Earlier we established two major functional reasons for metric organization by a listener--meter serves to allow greater discrimination of the durations of sound events and serves as a method of abstracting and storing temporal information for memory. A meter, therefore, must effectively serve as a grid upon which the macro-durations can be measured and recorded for long-term memory. In this way macro-durations play an important part in metric organization. Quite often, however, macro-durations alone do not provide enough information to adequately define a single meter. In many cases, several meters may effectively map the macro-durations present, yet listeners seem to clearly prefer one of these choices. This suggests that meter is used as a grid to store more than just durational information, therefore macro-durations alone will not account for metric organization. They simply reduce the number of possible metric grammars which will effectively serve the listener.

Two other classes of devices are found in this chapter which involve linear and harmonic pitch constructs. Linear constructs include contour accents and accents found at the beginning of melodic groups, such as motives or sequences. (The latter type of accent can also be found in harmonic sequences.) Harmonic change can have a meter-producing effect--through accentual weight associated with stable harmonies and strengthening certain time-points (and time-point intervals) through harmonic density. The beginning of a new harmony marks a point in time for more attention, thereby accenting it, by virtue of the value of the information a new harmony brings in traditional tonal music.[44] Harmonic rhythm can be meter-producing; however, it can also create patterns in subtle opposition to meter. It has been demonstrated that harmony sometimes relies on meter for clarification. This interaction makes it difficult to define the ways in which harmony supports metric organization without defining a specific context.

[1] Many composers use music notation in the process of arriving at their "final" version of a work of music. It is the notation which is meant to be used in performance to which we refer. Although a composer's earlier versions can shed light upon the creative process and perhaps provide clues for interpretation of the final version; such clues are not always readily available, nor did the composer feel these indications were needed to successfully interpret the work.

[2] Certain aspects of pitch, particularly intonation, are sometimes in the control of the performer. There is no indication that these aspects of a musical performance have any influence on metric organization. (Such factors would fit into the current terminology as micro-pitch however.)

[3] Robert Erickson, Sound Structure in Music (Berkeley: University of California, 1975) 60-61.

This lends further support to the idea that the intitiation of a pitch is particularly "marked for consciousness."

The importance of timbre should not be underestimated. One study found that under certain conditions, timbre was more important than tempo in choosing which of two conflicting pulses was favored as a beat. (A rapid attack and decay pattern was favored.)

James S. Oshinsky and Stephen Handel, "Syncopated Auditory Polyrhythms: Discountinuous Reversals in Meter Interpretation," Journal of the Acoustical Society of America 63 (1978): 936-939.

Stephen Handel and James S. Oshinsky, "The Meter of Syncopated Auditory Polyrhythms," Perception and Psychophysics 30 (1981): 1-9.

[4] Maury Yeston, The Stratification of Musical Rhythm (New Haven: Yale University Press, 1976) 39.

[5] The micro-duration of an event, however, is involved in determining accent.

[6] Bigamudre Chaitanya Deva, "Perception of Rhythm," Journal of the Music Academy Madras 38 (1967): 132.

[7] It has already been implied that an attack point is a particularly salient feature of any musical event.

[8] It is possible under certain conditions for an attack point to occur in metered music without a corresponding pulse. These conditions include two basic classes of

devices. The first are transformations which allow a pulse unit to be divided in a different manner than the metric grammar would normally allow. These would include triplets in a duple subdivision and duplets in a triple subdivision.

The other class of device involves pitch changes which fall outside of the realm of "measured" rhythm. These devices are easily identified by the listener because they normally change more quickly than the tolerances for pulse will allow. These would include trills, some grace notes, some turns, and other decorative devices of this nature. These pitch changes occur at such a great speed that they fuse psychologically into one rhythmic event. A trill on a pitch notated by a half note, for example, is considered the same macro-duration as a half note without a trill. Perhaps these devices indicate a weakness in our definition of attack point.

[9] Fraisse studied fifteen movements of works from Beethoven to Bartok and found that between 80 and 90 per cent of the notes were of two durations. Further, these durations were often in a 2:1 ratio.

P. Fraisse, "Rhythm and Tempo," The Psychology of Music, edited by D. Deutsch (New York: Academic Press, 1982) 172.

A study conducted to reconsider these findings is reported in an appendix of this paper. Although the results did not find as high a percentage of two durations as Fraisse's study, it was found that in most cases, a majority of the macro-durations in the notation were of two values. In all the cases studied, three notational values accounted for a majority of the macro-durations.

[10] As discussed earlier, attack-point intervals do not have to be precisely the same to be organized into a pulse level. The listener develops certain tolerances from past experience. The listener considers attack-point intervals that differ less than these tolerances as equivalent.

Although there has not been a great deal of experimentation concerning these tolerance levels, one experimenter estimates the tolerance for the beat to be approximately 0.1 to 0.2 seconds.

H.C. Longuet-Higgins, "The Perception of Music," Interdisciplinary Science Review 3 (1978): 152.

[11] C.S. Lee, "The Rhythmic Interpretation of Simple Musical Sequences: Towards a Perceptual Model," Musical Structure and Cognition, edited by Peter Howell, Ian Cross, and Robert West (New York: Academic Press, 1985) 56-57.

This discussion adopts this assumption as well. Although there are obvious exceptions to this tendency, it seems sound.

[12] As stated earlier, there are certain rhythms which do not correspond with a pulse. These would be triplets in a duple setting or duplets in a triple setting. These devices are limited and fall outside the grammar of a meter. Consequently, the shed doubt upon the metric understanding.

[13] In order for a rhythm to be understood as syncopated, meter must be established. This does not prevent syncopated rhythms from occuring at the beginning of a work. It simply means that they will not immediately be perceived as such. Only after a meter becomes established will the listener recognize the rhythm as syncopation.

[14] Paul Fraisse, "Rhythm and Tempo," The Psychology of Music, edited by D. Deutsch (New York: Academic Press, 1982) 155.

[15] If this second half note had occured a quarter note earlier, then the half note might not be a good time span for a pulse.

[16] H.C. Longuet-Higgins and M.J. Steedman, "On Interpreting Bach," Machine Intelligence 6, edited by B. Meltzer and D. Michie (Edinburgh: Edinburgh University Press, 1971) 221-241.

Mark J. Steedman, "The Perception of Musical Rhythm and Metre," Perception 6 (1977): 555-569.

[17] The only other type of accent possible would be through the use of pattern of macro-durations. The pattern would have to be distinctive enough to be recognized as an entity. This often happens in music through the use of pitch contour as well as macro-duration; however, it becomes more difficult to discover when one eliminates the pitch information.

[18] This type of problem is readily apparent in Maury Yeston's The Stratification of Musical Rhythm. Numerous reviewers point out that Yeston fails to distinguish several different types of accent in this influential work concerning musical rhythm.

[19] W.K. Wimsatt and Monroe C. Beardsley, "The Concept of Meter: An Exercise in Abstraction," Hateful Contraries: Studies in Literature and Criticism (Lexington: University of Kentucky Press, 1966) 123.

[20] This may also be true of micro-durations. A pitch played legato might be said to be accented when compared with a pitch played staccato of the same macro-duration.

[21] Graybill infers that this makes the agogic accent inherently weaker than other types of accent, because other forms of accent are more immediately perceived.

Roger Graybill, "Phenomenal Accent and Meter in the Species Exercise." In Theory Only 11, nos. 1-2 (May 1989): 20.

[22] G. Oleron, "Les mouvements rythm s induits par la Musique," Ann e Psychologie 57 (1957): 33-50; cited in S. Ehrlich, "Rhythm: Recent French Contributions," Acta Psychologica 17 (1960) 171.

[23] James L. Mursell, The Psychology of Music (New York: W.W. Norton, 1937) 151.

[24] Herbert Woodrow, "The Role of Pitch in Rhythm," Psychological Review 18 (1911): 54-77.

[25] See above.

[26] Sundberg, Friberg, and Fryden speak of this phenomenon in terms of "melodic charge." There is a higher charge for less stable tones. The degree of charge is related to the circle of fifths in their writing.

Johan Sundberg, Anders Friberg, and Lars Fryden. "Rules for Automated Performance of Ensemble Music." In Music, Mind and Structure, edited by Eric Clarke and Simon Emmerson, Contemporary Music Review, 3 (New York: Harwood Academic Publishers, 1989) 94-96.

[27] Yeston spends considerable time making the distinction between rhythm-to-pitch and pitch-to-rhythm theories. He points out that many theories seem to fall into a logical trap. Tones are stable because they fall on strong beats beats, while beats are strong because they have stable tones.

Maury Yeston, The Stratification of Musical Rhythm (New Haven: Yale University Press, 1976).

This circular reasoning is difficult to avoid because of the interdependence of meter and functional tonality. The structural importance of a particular pitch often seems related to many factors, including scale degree and metric position.

[28] Joseph M. Thomassen, "Melodic Accent: Experiments and a Tentative Model," Journal of the Acoustical Society of America 71 (1982): 1596-1605.

29 There is experimental evidence that rhythm effects pitch segregation. This is certainly true for melodic patterns.

Herbert Woodrow, "The Role of Pitch in Rhythm," Psychological Review 18 (1911): 54-77.

Mari Riess Jones, Gary Kidd, and Robin Wetzel, "Evidence for Rhythmic Attention," Journal of Experimental Psychology: Human Perception and Performance 7 (1981): 1059-1073.

30 A rather unlikely event in "real" music.

31 These patterns can also subtly oppose a metric structure which is already established by other parameters. This type of noncongruence can be used to create tension.

32 See the discussion of Royer and Garner's work above.

33 It has been found that, in addition to Royer and Garner's rules above, subjects more often describe a repeating pattern of tones by the first appearance of the pattern. This suggests that the pattern boundaries of Schubert's Waltz might also tend to be organized in this way.

David Preusser, W.R. Garner, and Richard L. Gottwald, "The Effect of Starting Pattern on Descriptions of Perceived Temporal Patterns," Psychonomic Science 21 (1970): 219-220.

34 William Caplin has written an article considering the history of various theorists' views on the part harmony plays in creating meter. "Tonal Function and Metrical Accent: A Historical Perspective," Music Theory Spectrum 5 (1983): 1-14.

35 Joel Lester, The Rhythms of Tonal Music (Carbondale: Southern Illinois University Press, 1986) 66.

Talbot makes a similiar argument claiming that strong beats in a measure are a "property which belongs to the realm of harmonic progression alone."

Michael Talbot, "Harmony and Metre: A Study in Relationships," Music Review 33 (1972): 48.

36 Wallace Berry, "Metric and Rhythmic Articulation in Music," Music Theory Spectrum 7 (1985): 7.

37 This is an intuitive judgement.

38 Carl Schachter, "Rhythm and Linear Analysis," The Music Forum, vol. 4, edited by Felix Salzer (New York: Columbia University Press, 1976) 320.

[39] In his review, Martin creates a similar illustration to show a harmony-meter interdependence.

Henry Martin, Review of The Stratification of Musical Rhythm, by Maury Yeston, In Theory Only 2, no. 5 (August 1976): 17.

[40] There are other "rules" which may help the listener in organizing meter as well. For example, bass repetitions starting on a weak beat and proceeding to a strong beat are avoided. Royer and Garner's work below can be applied to this rule as well as the example included in the text.

[41] Keep in mind that a grammar can be broken, but this sheds doubt upon meaning.

[42] Fred L. Royer and Wendell R. Garner, "Response Uncertainty and Perceptual Difficulty of Auditory Temporal Patterns," Perception and Psychophysics 1 (1966): 41-47.

Also Wendell R. Garner, The Processing of Information and Structure, The Experimental Psychology Series (New York: John Wiley & Sons, 1974) 53.

[43] The subjects would choose XXO or OXX according to Royer and Garner's findings.

[44] Intuitively, it seems that a single harmonic entity carries more accentual weight than a single melodic event. Often, where these two events coincide is a point of particular metric importance.

Chapter 6
THE PROCESSING OF DIFFERENT PARAMETERS IN METRIC ORGANIZATION

Meter can be important in the perception and mental processing of the temporal activities found in music. It seems that humans are more capable of perceiving and recording durations within the context of a meter than outside of it. Metric organization is such a useful tool that listeners will even impose it upon a stimulus where it is not manifest in the sound events. Povel and Essens write that tone sequences without change of amplitude, duration, or pitch "yield a quite strong impression of accented and unaccented tones. It is even difficult for subjects to believe that all tones are really identical."[1]

Previous chapters have discussed a number of musical parameters which are involved in metric organization. These parameters have been proven capable of influencing and creating specific meters in tightly controlled situations. Earlier we discussed two theorists' (Lester and Berry) opposing views on the effect of harmony on meter. The problem that both of these theorists are tackling is a very complex one. When and to what degree do the musical parameters found in a work take part in forming a particular metric organization? How are accents caused by different parametric changes related to each other?

THE INTERACTION OF MUSICAL PARAMETERS IN METER

In "real" music, it is rare for various parametric accent streams to be heard in the highly structured and regular, hierarchical fashion suggested by meter. More often, each musical parameter produces an irregular stream of accented and unaccented time-points. Sometimes a stream coincides with the perceived meter; at other times, it does not. It is the combination of accent streams which is interpreted by the listener to organize meter.[2]

How, then, do listeners organize meter given incomplete and/or conflicting streams of accents? This is a particularly perplexing question when one considers that most listeners familiar with an idiom agree on the metric hierarchy, although there may be some ambiguity as to the pulse level which is identified as the beat.[3]

The simplest solution to this problem is that each meter-producing parameter has a different degree of potential salience. When two given parameters A and B suggest different meters, parameter A will always be adopted. An accent caused by a parameter of greater potential salience has a greater effect upon metric organization than an accent created by a parameter of lesser potential salience.

The rank of a parameter's potential salience would be related to listeners' experience. How often, and therefore how likely, does a particular parameter's accent stream correspond to meter? If a particular parameter, within a musical idiom, corresponded to metric organization nearly always, then that parameter would deserve greater attention. Potential salience is a measurement of this greater or lesser attention.

Many current theories of musical meter, either explicitly or implicitly, assume that a modified ranking of potential parametric-salience exists.[4] Lester's view concerning the importance of harmony in metric organization has already been discussed. He considers harmony the most salient parameter to meter in common-practice-period music. Lester, however, fails to consider that this salience is only a potential which must manifest itself in the music as a meter-producing pattern to be realized.

In their writings, Lerdahl and Jackendoff define a set of "preference" rules which designate how certain parameters interact to produce the "experienced listeners' hearings of any particular work."[5] Although Lerdahl and Jackendoff do not rank their preference rules, the assumption implicit in their use of these rules is that, once the rules are sufficently developed, a specific ranking of parametric importance exists and can be explicitly worked out.

Benjamin provides a ranked list (based upon the work of Berry) of meter-producing events.[6] Benjamin works out a point system to explain how certain types of accents interact to produce a particular metric organization in some specific examples. Benjamin admits that this ranking is incomplete; it leaves out parameters which are important to meter, notably dynamic accent.[7] A large sample of works would find Benjamin's ranking lacks general validity, yet this is possibly the most well-defined theory of potential salience currently published. Benjamin provides a viable method of defining a model of potential salience.

Discovering a widely adaptable ranking of parametric salience to meter is elusive. In a specific musical work or movement, it is sometimes possible to identify a single parameter, or small set of parameters, which seem to determine metric organization. Generalizing from these individual works is difficult. A parameter which is particularly salient to metric structure in one work is subsumed by another parameter, or parameters, in a different work. The linear motive repeated in the bass part of the "March" from the Notebook for Anna Magdalena Bach (Figure 12, part A) is a particularly salient feature in making the notated meter audible. The motive found in the bass part of Brahm's Piano Sonata No. 3 (Figure 12, part B) creates a rhythmic grouping which opposes the notated metric structure (established earlier in the the work). The same parameters may be in both works, yet their relative salience is reversed. Given these conditions, how can a specific ranking of potential salience exist? It seems that competing cues for metric boundaries "may interact to produce different effects."[8]

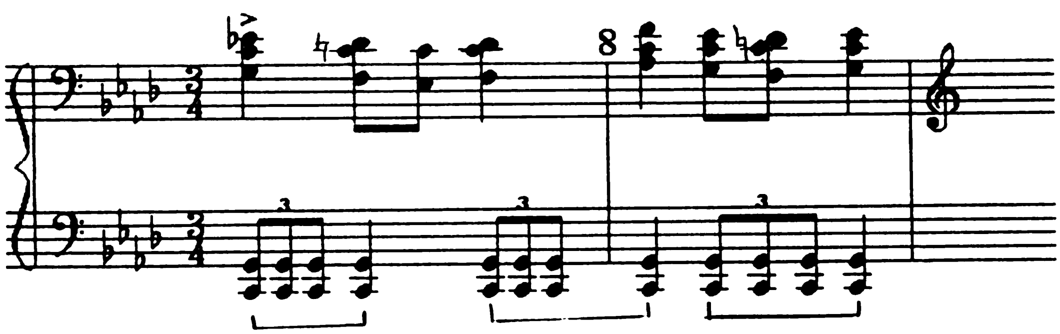
One explanation for these results is that it is possible for parameters to combine to increase their relative salience. This is explicitly the case in Benjamin's model. For argument's sake, let us suppose that harmony is the most powerful meter-producing feature of a particular musical idiom. There are six eighth notes in a measure and the harmony suggests groupings of three eighth notes (as in 6/8); conversely, both the melodic patterning and dynamic stress (hypothetically of lesser potential salience individually) suggest eighth-note groupings of two (as in 3/4). The latter two accent-streams might combine to produce a metric organization of 3/4 due to their combined salience.

The potential salience of a parameter could be additive. This would make it possible for any given parameter, no matter what its potential salience, to form a pattern which does not conform, in whole or in part, to metric organization. Additionally, this is consistent with with our ideas of metric function. It is more efficient to use a meter which will accommodate the greatest number of accent streams. By allowing potential salience to be

Figure 12
A Parameter's Salience Changes From Work to Work

Part A
"Four Pieces: March" from
<u>Notebook for Anna Magdalena Bach</u>

Part B
Johannes Brahms' <u>Piano Sonata no. 3</u>, op. 5
Allegro Maestoso, measures 7-8



additive, the economy of meter as a memory aid is preserved. A greater overall number of accents can correspond to the metric norms if accents of different parameters can combine to become more salient.

To further complicate the construction of a ranking of potential salience, different parameters may more strongly effect different pulse levels within a meter. It may be possible that a parametric ranking of potential salience that is applicable to low-level pulses must be altered for higher-level pulses. This problem becomes evident when one considers certain parameters which cannot be applied to the lowest pulse levels because they require two or more sound events to create a single unit. For example, a melodic sequence requires several pitch events to create a recognizable pattern. It becomes more difficult to create such a pattern on the lower pulse levels of a meter (and often impossible on the lowest metric level), therefore the potential salience of that parameter for lower pulse levels should be quite low. On higher levels, such patterning has greater potential salience.

What factors activate a parameter's potential salience? The existence of an accent stream created by a particular parameter does not always indicate that the stream will have its potential salience activated. Certain qualities of an accent stream cause the potential salience of that parameter to be activated.

Handel attempted to discover how certain musical parameters interacted and effected the organization of some musical stimuli by listeners.[9] The parameters considered included pitch, macro-duration, intensity, and the interval of silence between each pitch. Auditory patterns were constructed so that different metric organizations were suggested by different parameters and/or sets of parameters. Handel found that, although some principle of organization could always be identified, no single parameter was consistantly used more than others to organize the stimulus. Handel's analysis of his experiments' results stated that the simplicity of the pattern formed by the various parameters determined which parameter was to take precedence.[10] Listeners chose a meter which organized the stimulus in the "simplest" way.[11]

It seems that in addition to the attention given to a particular parameter (its potential salience), a pattern formed by a parameter has a varying degree of metric-producing quality. A "simple" pattern will be more readily adopted for metric organization than a complex one. Experiments by Povel and Essens have shown that the complexity of an auditory temporal pattern, as judged by listeners, is related to the ability of a listener to form a beat.[12]

This suggests that "simplicity" might be defined, as far as metric organization is concerned, as the degree to which a pattern corresponds with normative metric organization which are found in listeners' experience. Consider the pattern created through articulation in opening movement of Mozart's Piano Sonata, K. 333 (see Figure 13). The articulations indicated here suggest a grouping of the eighth-note pulse in measures of 2+3+3. Given the conceptual framework suggested by the style of the work,

Figure 13
Wolfgang A. Mozart, Sonata for Piano, K. 333
Movement I, Measures 1-3

listeners will not adopt a meter which will conform to the pattern suggested by these articulations. In this style period, dividing an eighth-note pulse into groups of 2+3+3 is considered "complex" for purposes of meter, therefore articulation will not have its salience potential activated at this metric level.

If simplicity is the factor which activates potential salience,[13] then the salience of a particular parameter is not binary. It is not a simple case of salient or unimportant.[14] There is a range from simple to complex which effects the realized salience of a parameter. In addition to the attention given a particular parameter due to a listener's past experience (its potential salience), a listener adjusts the salience of a parameter based upon the simplicity of the pattern formed by it. The ranking of potential salience must be adjusted to form a ranking of ranges of potential salience. It seems likely that these ranges will overlap to some degree, further complicating the formation of a working model.

SUMMARY

Meter is a dynamic, psychological construction. Metric organization results from the interaction of several musical parameters which have varying ranges of potential salience. A parameter's potential-salience range can be ranked by the degree of attention each parameter initially receives due to the past experience of a listener. (It seems likely these ranges overlap.)

The manifest salience of a particular parameter to metric organization in a particular work is determined by the simplicity of that parameter's accent stream and the relative attention given that parameter. Each parameter must be considered in the context of its surroundings. How does a particular parameter's accent-stream compare in simplicity and potential salience to other parameters? A parameter's salience may also be influenced by another parameter's accent-stream. This can occur in two ways. The pattern formed by the combined accent-streams may be simpler and/or the combined attention given both parameters may overcome the potential salience of another parameter.

RECOMMENDATIONS FOR FURTHER STUDY

Most models of musical perception do not allow for "double meanings" or multiple interpretations.[15] The above framework assumes that a listener organizes only one meter in a given piece of music at any given moment. Is it possible for two meters to be perceived (and/or later understood to exist) at a given point in a piece of music?[16] If this is possible, the functions which have been proposed for meter must also be questioned.[17]

There is not enough experimental evidence currently available to fully support the above theory of parametric interaction in meter. The three variables, potential salience, pattern simplicity, and additive salience, need to be more fully defined through experimentation. What specific qualities are involved in pattern simplicity? Although a working definition is described above, it would be desirable to have a more precise description of what makes a pattern "simple." A workable scale of pattern simplicity should be developed.

To what degree do the potential salience and pattern simplicity of a parameter interact? Although it seems unlikely, it may be possible that all parameters receive approximately the same attention until certain parameters become prominent due to the simplicity of the patterns formed by those parameters. If this is true, then potential salience does not really exist. This hypothesis seems unlikely in view of the effect of expectation upon perception; however, varying parametric attention has not been directly tested experimentally.[18] In most experiments, it has simply been assumed to exist.

To what degree do repeated listenings to a particular work effect metric structure? There is evidence that study and repeated listening of a work effect understanding;[19] meter, however, was not closely monitored in these studies. If meter serves as a memory-encoding aid, then it would be detrimental to learning for a listener to change metric organization upon repeated performances. It might be particularly instructive to consider examples with ambiguous meters to see if repeated listenings strengthen a particular meter. Can or does the listener change meters upon repeated listenings? Are listeners more "successful" using a particular meter for encoding an "ambiguous" work?

[1] Dirk-Jan Povel and Peter Essens, "Perception of Temporal Patterns," <u>Music Perception</u> 2 (1985): 414.

[2] Berry writes of meter as "an organic array of interactive events."

Wallace Berry, "Metric and Rhythmic Articulation in Music," <u>Music Theory Spectrum</u> 7 (1985): 16.

Experiments by Handel and Lawson suggest that meter is the result of the interaction of several parameters. In their experiments, a single parameter was not found to be more salient than any other. Meter "is dependent on perceptual interactions . . . . and not on simple acoustical, temporal, or perceptual factors."

Stephen Handel and G.R. Lawson, "The Contextual Nature of Rhythmic Interpretation," <u>Perception and Psychophysics</u> 34 (1983): 104.

Supporting experimental evidence can be found in:

James S. Oshinsky and S. Handel, "Syncopated Auditory Polyrhythms: Discountinuous Reversals in Meter Interpretation," <u>Journal of the Acoustical Society of America</u> 63 (1978): 936-939.

Stephen Handel and James S. Oshinsky, "The Meter of Syncopated Auditory Polyrhythms," <u>Perception and Psychophysics</u> 30 (1981): 1-9.

[3] This was discussed earlier in regard to Edlund's pulse-shift regions. At certain tempi, there is some ambiguity as to the pulse level which is the beat. This ambiguity is confined to the identification of the beat level and does not involve the existance of the two pulse levels in question. Both pulse levels exist for all listeners, the ambiguity concerns which is primary.

[4] Morgan traces the assumption that accents are related to each other as far back as the early nineteenth century. Gottfried Weber made the this assumption about meter which continues to dominate theoretical thought today.

Robert P. Morgan, "The Theory and Analysis of Tonal Music," <u>Musical Quarterly</u> 64 (1978): 437.

[5] Lerdahl and Jackendoff define two sets of rules. One set is designated "well-formedness" rules, and the other set is termed "preference" rules. "Well-formedness" rules are designed to describe the possible normative structures that can be found in music. "Preference" rules are designed to consider how an experienced listener decides between various possible normative structures.

Fred Lerdahl and Ray Jackendoff, <u>A Generative Theory of Tonal Music</u>, MIT Press Series on Cognitive Theory and

Mental Representation, edited by Joan Bresana, Lila Gleitman, and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 8-9.

[6] Benjamin does qualify his list as merely an illustration as to how a formal ranking might be presented.
William E. Benjamin, "A Theory of Musical Meter," Music Perception 1 (1984): 366-67.

[7] William E. Benjamin, "A Theory of Musical Meter," Music Perception 1 (1984): 368.

[8] Robert West, Ian Cross, and Peter Howel, "Modelling Perceived Musical Structure," Musical Structure and Cognition (New York: Academic Press, 1985) 46.

[9] Stephen Handel, "Perceiving Melodic and Rhythmic Auditory Patterns," Journal of Experimental Psychology 103 (1974): 922-933.

[10] Stephen Handel, "Perceiving Melodic and Rhythmic Auditory Patterns," Journal of Experimental Psychology 103 (1974): 933.

[11] The Gestalt law of Pragnanz states that the mind seeks to form the simplest patterns out of a given stimuli.
Carl F. Haenselman, "Toward a Theory of Rhythm," Canadian Association of University Schools of Music 1 (1971): 39.

[12] Dirk-Jan Povel and Peter Essens, "Perception of Temporal Patterns," Music Perception 2 (1985): 437.
Other studies have found that regular patterns, like those suggested by a strict metric organization, are more easily recalled and discriminated.
Persis T. Sturger and James G. Martin, "Rhythmic Structure in Auditory Temporal Pattern Perception and Immediate Memory," Journal of Experimental Psychology 102 (1974): 377-383.
Robert William Wood, "The Perceptual Processing of Rhythmic Auditory Pattern Temporal Order," Ph.D. dissertaion, Michigan State University, 1980.

[13] The ability to form a "pattern" seems to draw the attention of a listener to that particular parameter. Sink discovered that the relative importance of rhythm and melody to discrimination and recall was related to the presence of a pattern.
Patriicia E. Sink, "Effects of Rhythmic and Melodic Alterations on Rhythmic Perception," Journal of Research in Music Education 31 (1983): 101-113.

[14] It is this point that theorists, such as Lester, have failed to consider. Harmony is often cometric; therefore harmony has great potential salience. There are cases, however, where another parameter (or parameters) forms a "simpler" solution to metric organization.

[15] Robert West, Ian Cross, and Peter Howel, "Modelling Music as Input-Output and as Process," Psychology of Music 15 (1987): 12.

[16] Gestalt theories have also explored this problem in the visual world. Certain drawings can be percieved as two totally different scenes. A person can see both interpretations of the drawing, but can a person perceive both interpretations simultaneously or must one switch between the two interpretations?

[17] It is difficult to study processes involving memory because memory cannot be observed directly.

[18] Establishing a workable scale of pattern simplicity would make such experiments much easier. It would be possible to note if two equally simple patterns using two different parameters were found to be as metrically strong. If both parameters receive equal attention, then the two examples would be judged equal; if not, then one parameter must be given more attention and therefore have greater potential salience.

[19] L.L. Cuddy and H.I. Lyons, "Musical Pattern Recognition: A Comparison of Listening to and Studying Tonal Structures and Tonal Ambiguities," Psychomusicology 1 (1981): 15-33.

Chapter 7
RHYTHMIC GROUPING, METER, AND MOZART

Perhaps the most perplexing problem is that meter defines a very specific class of recurrence which is not always supported by the music. Listeners seem to establish a meter and maintain it without need for constant re-enforcement. It has been posited that meter is a background (in the *Gestalt* sense of this word) upon which rhythm is understood and perceived. To operate in this capacity, meter *needs* to be relatively static; meter cannot constently change in response to the stimulus. Unless there is a great deal of evidence to support the mental effort required to reinterpret the grid upon which temporal understanding is based, the meter will remain the same.

In addition to meter, there is another form of temporal structure which is more strictly defined by the sound events of a movement.[1] This grouping structure, which will be termed rhythmic grouping, differs from meter because meter is not always represented directly by the sound events of a work at all times. Meter groups and organizes pulses, a psychological construction; rhythmic grouping always involves actual sound events.[2] Once established, meter is fairly static and difficult to change. Rhythmic grouping is constently subject to reinterpretation, new insight, and different guidelines. (It is the *Gestalt* foreground.)

Rhythmic grouping and meter interact and involve many of the same parameters in their organization. Rhythmic grouping can be involved in defining metric organization, and the converse is also true. This interaction makes it difficult to separate and understand these two phenomenon as different processes.

The distinction between rhythmic grouping and meter is not entirely new.[3] Rhythmic grouping defines such distinctions as afterbeat and up-beat. The fourth beat of a 4/4 measure can be grouped as an up-beat (as in an anacrusis) or as an afterbeat (as in a "feminine" cadence). Although these are important distinctions in rhythmic grouping, they do not change the position or function of the fourth beat in the meter; the fourth beat is still less accented than the first and third and approximately equal with the second. The fourth beat's location remains essentially the same, and the probability of an event occuring at that location remains the same.

Rhythmic grouping can sometimes challenge the metric organization. These points might be said to contain rhythmic phenomenon which are metrically dissonant. Metric dissonance is an event or set of events which imply rhythmic groupings which suggest another meter or a displacement of the current meter.[4] This type of dissonance can be used to change the meter with prolonged application.

MOZART: SYMPHONY NO. 40 IN G MINOR, K. 550

The following are some preliminary considerations of Wolfgang Mozart's Symphony No. 40 in G Minor, K. 550.[5] This analysis is based upon personal observation, and will stand or fall based upon its application to a wider population. It is provided as an example of the application of earlier hypothesis and as an exploration of the interaction of rhythmic grouping and meter, but this analysis suffers many of the same short-comings which have been leveled against other theories based upon personal observation.

It has been stated that most theorists do not consider the contributions of the performer to the music-as-sound. In order to compensate for this, a specific recording of this work has been used for this analysis, and those aspects of the music-as-sound which might be important to the analysis refer to the interpretation found in this performance.[6] Since methods of precisely measuring recorded multi-part music have not been developed sufficiently, personal observations will have to suffice.

When present, the organization of meter occurs in the early moments of any given movement (or section). Our analysis will concentrate on these early moments of each movement of Mozart's G-minor Symphony. Following this, the discussion will consider moments of metric dissonance and their effect on meter and the structure of the movement.

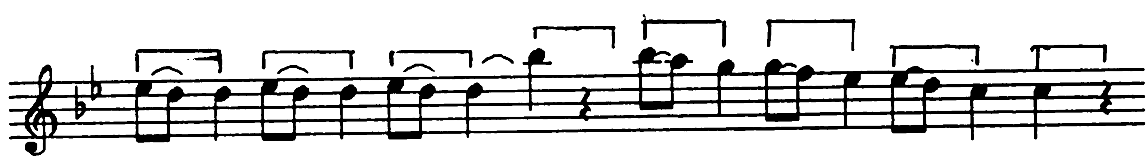
MOVEMENT I: MOLTO ALLEGRO

The accompaniment parts found early in the first movement of this symphony form very consistant patterns which probably are quickly adopted as pulses. The movement opens with a an eighth-note pattern in the viola line. This continual patter of eighth notes seems sufficient to establish a pulse of that duration. Additionally, these eighth notes form a repeating pattern which forms a rhythmic group equal in length to a half note. This rhythmic group might further be subdivided into two parts, each equivalent to a quarter note in length. These factors, all found in the viola part, support the organization of three, nested levels of pulse--eighth note, quarter note, and half note. The bass part consists of a quarter note with an attack-point interval of a whole note. This suggests another level of pulse which groups two half-note pulses together into a whole-note pulse.

The tempo for this movement is "Molto Allegro," and the pulse level which seems most likely to be adopted as the beat at performance tempo is the half note.[7] Overall, the accompaniment seems to confirm the notated meter (2/2).

If this interpretation is adopted, there is metrically-dissonant rhythmic grouping present early in this movement. Within the violin part (the melody), a pattern of two eighth notes and a quarter note consistently appears. This motive (see Figure 14) conceivably could form a pattern which might be interpretted as a half-note pulse. (This

Figure 14
Wolfgang A. Mozart, Symphony No. 40 in G Minor, K. 550
Movement I, Opening Theme



pulse does not correspond to the temporal location of the half-note pulse found in the patterning of the accompaniment; it falls a quarter note behind it.) This potential half-note pulse is also supported through the melodic contour of the violin part. The large leap to the Bb (measure three), for example, places an accent upon the second notated quarter note of that measure.[8]

Lerdahl and Jackendoff consider the patterning found in the melody as part of the rhythmic, as opposed to metric, grouping.[9] This seems a valid interpretation for several reasons. The pattern found in the accompaniment is formed first, and therefore, it seems the listener would be more likely to perceive the "new" pattern as foreground rather than the "old" pattern. The half-note pattern played by the viola corresponds to the whole-note pulse created by the bass in a grammatically consistent fashion; every other time point of the viola pulse falls in the same temporal location as the bass whole-note pulse. The last factor in support of the viola pulse is the way in which the violin part is performed. A dynamic accent is placed upon the notes which correspond to the viola half-note pulse.[10]

There are other points in which metric dissonance is found. During measures 58 through 62 and measures 241 through 244, the flute and bassoon entrance is offset from the rest of the orchestra by one beat, suggesting a shift of the metric grid in those parts. This type of emphasis is foreshadowed by the agogic accent (macro-durational) in the melody during measure 50. In both of these cases, there is a strong metric-conformant force present in other parts. This is not the case during measure 66 (and measure 254 of the recapitulation); all parts have a sfortzando on the second quarter-note of the notated measure. Metric dissonance is used here to help usher in the transition; the metric dissonance amplifies the harmonic instability and assists the motion to the new key.

There are other instances in which meter assists in articulating structure. Measure 43 is a rest; this prolonged silence serves to articulate the end of a section.

This measure rest does not give the sense of closure that that is found at the end of the work which has essentially the same music except it "fills" that measure with a tonic chord. In part, this is related to the sense of closure created by ending the section/movement in a relatively strong location, the first half-note in the measure at the end of the movement, while the earlier section (measures 42 and 43) ends on the second half note of a measure.[11]

MOVEMENT II: ANDANTE

The second movement also establishes an eighth-note pulse through the continuous use of that value. (This value also serves as the beat in this performance.) The bass suggests a triple grouping of that eighth-note pulse in the first and third measures through its attack-point interval and changes in the harmony (though the harmonic changes are not functional). This dotted-quarter pulse is also supported by the bass's melodic contour during the second measure; the measure starts with an attack at the beginning of the notated measure and a melodic "peak" occurs at the time-point marked by the suggested dotted-quarter pulse.

The notated measure is suggested by changes in the function of the harmony, the spacing of the entrances of the viola and violins, and through the use of a common melodic formula which moves up a fourth (or fifth) suggesting a dominant to tonic relationship. This formula is often used as an anacrusis to a "strong" beat (as it is notated in the violin and viola parts). This helps to "place" the attack-point interval (dotted-half note), which separates the viola and violin entrances, properly with respect to the eighth-note pulse.

This metric organization is not supported by the events of measure seven, though a normative meter does not present itself as an alternative. The sfortzandos on the second and fifth eighth notes of this measure are metrically dissonant. The third and final eighth notes receive a harmonic accent because of the tonic resolutions at these locations. (The meter suggests that the first and third eighth notes should be accented!) This metric dissonance may serve to help propel the listener towards a new statement of the subject with the addition of a counter-subject (during measures nine through twelve). A similar use of metric dissonance (during measure fifteen) also introduces a new idea in measure seventeen.

The two measures discussed above provide reason to question the metric organization, but no viable normative meter is suggested. This is not true of the passage during measures twenty through twenty-three. 3/4 is a normative meter, and melodic fragments in the violins and basses (measures 20 and 22) suggest a duple eighth-note grouping (or quarter-note pulse). This is heard after 20 notated measures of 6/8, and this tends to lead the listener to perceive and understand the passage as metrically dissonant in a 6/8 context which is reconfirmed be the harmonic rhythm in measure 24. This is a case where the persistence of meter creates a syncopated feeling rather than a new metric organization.

Metric dissonance is used in measures 39 and 40 to suspend the sense of closure. This is the end of an phrase which starts in measure 37. The phrase is repeated in the measures following, with some changes which remove the metric dissonance at the end of the passage. This create a greater sense of closure and a period. (See Figure 15.) This is similar to the effect described above with regard to the end of the exposition of the first movement and the end of that movement.

Figure 15
Wolfgang A. Mozart, Symphony No. 40 in G Minor, K. 550
Movement II, Violin Part, Measures 37-44

MOVEMENT III: MINUET

The accompaniment parts in this movement support the notated meter (3/4) through the use of measures consisting of either three quarter notes or a half note followed by a quarter note. The latter pattern groups the quarter-note pulse into groups of three, creating a dotted-half-note pulse corresponding with the agogically accented quarter-note pulse created by the half note in the pattern. Functional harmony changes also correspond to this pulse.

This metric organization is not so clear-cut in the melody line (flutes and violins). Attack-point intervals within measures one and two suggest a duple, quarter-note grouping (a half-note pulse). As a metric grouping, however, this is weakened by the presence of a characteristic contrapuntal device, the suspension. A suspension is normally initiated in a weaker metric position than when the dissonance occurs,[12] so the latter part of the half note should occur on a strong metrical position.[13] An experienced listener would recognize the suspension as an exception to some of the grammatical tendencies of metric organization.[14] That is, the suspension gives reason to create a metric organization in which a note of the melody agogically accents a metrically weak position. Further, this hypothetical half-note pulse suggested by the melody fails to provide for the existence of the factors which reinforce the dotted-half-note pulse. Also, the half-note pulse fails during measure four, where a half note is attacked and held through a pulse location (without a suspension).

If one accepts the suspension (which becomes a motivic device in the linear structure of this movement) as a common (and perhaps meter-producing) device, then most of the movement is metrically consonant. Besides the suspensions, the only challenge to the notated metric organization is during measures 23 through 25, where the second beat (the beat being the quarter-note pulse) is agogically accented. This relatively short span is not sufficient to break down the strongly established 3/4 metric grammar, however.

During the trio section of this movement, the dotted-half-note pulse, though not obscured, is not reinforced until the close of the two sections of the binary form (measures 57-60 and 81-85). The listener must impose the triple organization of the consistently reinforced quarter-note pulse.[15] The 3/4 meter assists the listener in making harmonic sense of the rather transparent orchestration of the trio.

MOVEMENT IV: ALLEGRO ASSAI

The melodic material (violins) found at the opening of the fourth movement quickly establishes a quarter-note pulse. The first two notes form a dominant-to-tonic relationship (discussed above) which implies that the first event is an anacrusis. This metric decision is also supported in performance through a dynamic accent on the notated downbeat.

The first attack-point interval in the bass is equivalent to a whole note. This interval occurs again in measures four and five, though the viola part does challenge this interval as a pulse within measures three and four (with metrically dissonant half notes) The performers do provide a slight dynamic accent, however, in support of the whole-note pulse suggested by the bass part.

The half-note found in the melody (violin) during measure two extends quite well as a pulse within its own part. It is particularly supported by the repeated melodic figure in measure three. It fits quite well with the expectations created by our interpretation of the whole-note pulse suggested by the bass part. (The four quarter notes grouped by the whole-note pulse have a maximally corresponding half-note pulse associated with them.) Additionally, the harmony during measure three supports the violin half-note pulse by attacking more stable events in conjunction with this pulse. (The second and fourth quarter note of that measure are secondary dominant leading to the more stable dominant chords.) Once again, this hypothetical pulse is challenged by the viola. The primacy of the outer parts, however, must also be considered.

Once established, the meter is supported throughout the movement, with the possible exception being that some events start with an anacrusis (as in the opening of the movement), while others do not (as in measure 133). The metric organization in these cases, however, is made clear through changes in harmonic function. Harmony has an important stabilizing effect on the meter in this movement. Although the surface harmonic rhythm is not a constant rhythmic value, it is metrically consonant.

SUMMARY

Notice that by extending attack-point intervals and considering a few key cues, it is relatively easy to develop a "standard" meter. In some cases, there are factors which suggest grouping which is contra-metric. These rhythmic groupings are sometimes cases of common figures which an experienced listener could discount (or explain) within the metric grid chosen.

Metric consonance and dissonance play a structural role. An example would be the increased sense of closure caused by the metric location of the final chord of the first movement as compared with the location of the final chord of the exposition. On a smaller scale, consider the effect of metric dissonance on the period illustrated in Figure 15.

It is important to note that rhythmic grouping occurs in addition to the grouping suggested by the meter. This grouping involves actual sound events, while meter groups pulses which are cognitive constructions created, in part, in response to the sound events, but not entirely controlled by them. In this sense, the first beat of every measure is accented, but the event initiated at that temporal location may not be.

[1] Some examples would include phases, motives, etc.

[2] A phrase or motive cannot exist without an event or events to define it. While a pulse is effected by sound events, an individual pulse can exist without the benefit of a specific event to define it. Once established, pulses have a "life" of their own.

[3] Lerdahl and Jackendoff introduce the concepts of grouping structure and metric structure separately in their book. Graybill extends Lerdahl and Jackendoff's ideas by suggesting that beats (this paper might use the term pulse) receive metrical accents, but an event corresponding to the same temporal location can not "directly possess the property of metrical accent."

Fred Lerdahl and Ray Jackendoff, A Generative Theory of Tonal Music, The MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman, and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983).

Roger Graybill, "Phenomenal Accent and Meter in the Species Exercise," In Theory Only 11, nos. 1-2 (May 1989): 36.

[4] Yeston uses the terms rhythmic dissonance in much the same way that metric dissonance is used here. Yeston defines rhythmic dissonance as two rhythmic strata which are not related by simple division or multiplication.

Maury Yeston, The Stratification of Musical Rhythm (New Haven: Yale University Press, 1976) 78.

[5] Mozart's G-minor Symphony was one of three symphonies composed during the summer of 1788. These three masterworks were the last symphonies that Mozart completed. Grout, in his music history text, that these three works should be considered a "summation" of the late eighteenth century.

Donald Jay Grout, A History of Western Music, 3rd edition (New York: W.W. Norton, 1980) 513.

[6] The performance which will be examined is by the Vienna Philharmonic, under the direction of Herbert von Karajan, recorded on London STS-15540.

[7] Cooper and Meyer identify the measure as the primary pulse level. This seems possible, but a little slow to this listener.

Grosvenor W. Cooper and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago: The University of Chicago

Press, 1960) 102.

[8] Lester considers this in depth.
Joel Lester, The Rhythms of Tonal Music (Carbondale: Southern Illinois University Press, 1986) 29-33.

[9] Fred Lerdahl and Ray Jackendoff, A Generative Theory of Tonal Music, The MIT Press Series on Cognitive Theory and Mental Representation, edited by Joan Bresana, Lila Gleitman, and Samual Jay Keyser (Cambridge, Massachusetts: The MIT Press, 1983) 27, 37.

[10] Lester claims that such a dynamic accent is not present in his discussion of this work; however, he does not cite any specific performance! Lester does agree that the meter is made clear by the accompaniment as is argued here.
Joel Lester, The Rhythms of Tonal Music (Carbondale: Southern Illinois University Press, 1986) 67.

[11] The degree of closure is also related to the presence of a lower Bb in the bass at the end of the work.

[12] The New Harvard Dictionary of Music, edited by Don Randel (Cambridge, Massachusetts: Belknap Press, 1986) 205-206.

[13] This is contrary to the concept of an attack point generally being accented when compared with a location in which an event is held or a location where there is no sound. A pitch which acts as a suspension is a special case where this rule does not apply.
In discussing this movement, Cooper and Meyer suggest that by suppressing the pulse locations (through the use of suspensions) in the dotted-half-note pulse, they become even more accented than those points which correspond to an attack!
Grosvenor W. Cooper and Leonard B. Meyer, The Rhythmic Structure of Music (Chicago: The University of Chicago Press, 1960) 103.

[14] The metric implications of a suspension are so strong that Komar suggests that it can be a meter-producing factor.
Arthur J. Komar, Theory of Suspensions: A Study of Metrical and Pitch Relations in Tonal Music, Princeton Studies in Music, 5 (Princeton, NJ: Princeton University Press, 1971).

[15] The listener must rely on experience. It is relatively rare for Mozart to change meters in a minuet, so the trio is probably in 3/4. Although not strongly reinforced, this is not challenged; meter is persistent.

GLOSSARY

GLOSSARY

The following is a glossary of terms created for this study or which have varying use in the literature. It is intended to be used for quick reference, and the definitions are not always complete. The ideas are more fully developed in the text. These short explanations concentrate upon important distinctions and differences.

Accent:

A relational concept which indicates one event is marked for greater attention than another. The term can be applied to both durationless events, such as time points, or events which occupy time, such as rhythms. Accents can differ in strength. When the term is used, one must consider that one event is accented when compared wiht other events, but may be "unaccented" with respect to yet another set of events.

Articulation:

The characteristics of attack and decay of an individual sound event in performance. The micro-duration of a sound event is effected by different forms of articulation. The composer is able to give some indications for articulation, but the performer can introduce finer distinctions and differences.

Beat:

The beat is the pulse-level that a listener (or most listeners) would consider the primary level of timekeeping.

Contour Accent:

An accent which results from a change in melodic direction. Experiments by Thomassen found that pitches which occur in the peaks and valleys of a melody are accented when compared with the surrounding pitches.[1]

Dynamic accent:

The traditional meaning of accent is an event which is given a dynamic stress as compared with other events in the immediate temporal area. This paper uses the term dynamic accent to distinguish this type of accent from other forms of accent.

Macro-durations:

These are the broad classifications of rhythm which the composer indicates in traditional music notation. For example, quarter notes, eighth notes, whole notes, etc. are all macro-durations. Macro-durations are equivalent in the music-as-notation.

Macro-dynamics:

This term applies to the dynamics which can easily be indicated in music notation. Although dynamic markings can be very specific, they are subject to more interpretation than pitch.

Micro-durations:

There are differences in the performance of the duration of sound events which are notated identically and which may be of importance to meter. For example, not all quarter notes are the same duration. A micro-duration is the the actual duration of an event in performance.

Micro-dynamics:

Certain dynamic effects are generally found in performance to enhance the musical interpretation. These are quite often relatively small changes, such as dynamic accents and small "swells," which are not always indicated by the composer in the notation. These subtle dynamic changes are differentiated from the larger dynamic inflections, which generally are indicated in the notation, by the term micro-dynamics.

Pulse:

A psychological construct which divides time into functionally equivalent spans. A pulse might be compared to a ruler with markings spaced equally upon it. Each individual pulse is durationless (just as a point in geometry is dimensionless and does not occupy space).

Rhythm:

The durations of sound and silence in music and their temporal relationships. Rhythm should be contrasted with meter. Meter marks time with durationless points, while rhythm occupies the temporal space which meter marks.

Syncopation:

This is a rhythm which places an accent upon a metric location normally unaccented. Meter must exist in order for syncopation to be understood. Cooper and Meyer discuss syncopation as an event "which enters where there is no pulse on the primary metric level (the level on which beats are counted and felt) and where the following beat on the primary metric level is either absent (a rest) or suppressed."[2]

Timing:

The micro-durations of individual pulses are not always equal, although listeners find them to be perceptually equivalent. Changes in individual pulse micro-durations are referred to as changes in timing, as opposed to changes of articulation (which involve changes in the event duration, but not necessarily a pulse duration). Changes in the micro-durations of individual pulses may effect metric organization, particularly if they are patterned in some way.

[1] Joseph M. Thomassen, "Melodic Accent: Experiments and a Tentative Model," _Journal of the Acoustical Society of America_ 71 (1982): 1596-1605.

[2] Grosvenor W. Cooper and Leonard B. Meyer, _The Rhythmic Structure of Music_ (Chicago: The University of Chicago Press, 1960) 100.

APPENDIX

APPENDIX

It has been postulated that listeners use attack-point intervals to hypothesize various levels of pulse. This becomes a more reasonable assumption if the listener is not inundated with such intervals to consider. This study is designed to consider the distribution of macro-durations in the notation of music. If a relatively small number of macro-durations are used much of the time, then the use of macro-durations to hypothesize pulse levels seems more palatable.[1] The listener will have fewer time spans to organize and coordinate into an acceptable meter.

Fraisse's study of macro-durations in music notation seems optimistic. The results raise some questions as to how movements were chosen and thus the validity of the results may be questioned. The specific works are not indicated. Although a wide variety of tempos and different movement positions are indicated as part of the sample, the data does not indicate the notated meter.

As a result of these problems, a study of the notated macro-durations in several keyboard works of the common-practice period was undertaken. Keyboard works were chosen because of the uniform timbre. Questions of orchestration, especially doubling of pitches, are thus eliminated. This genre also provides a variety of composers and styles throughout the period.

Fraisse chose to count all the notes in a particular movement. This study counts those notes which occur in the first twelve measures.[2] This seems sufficient time for the meter to be fully established, while still providing a sample of sufficient size to indicate the tendencies of the movement.

The works were chosen because of their popularity. An attempt has made to distribute them throughout the period in question. All the movements from each chosen work have been sampled. (Fraisse seems to have chosen only single movements from a work.) Every pitched macro-duration which is notated within the first twelve measures has been counted. Rests were not considered. Although some notes occur simultaneously, it was decided that the extra weight of a denser simultaneity should be reflected in the figures. It seems that the temporal location of a simultaneity[3], such as a chord, would be marked for greater attention than the location of a single note. Further, this method eliminates any interpretation. Since all notes are counted, there is no question as to how to handle structures that start simultaneously, but end at different times. For example, how would one handle a suspension? Should both values of the suspended voice be counted or only the value which does not start with the simultaneity?

Table 1

Summary of Results: Quantity of Each Notated Rhythmic Value Found in the First Twelve Measures of Selected Piano Works

Movement	Time Signature	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	♪.	♪	𝅘𝅥𝅯	𝅘𝅥𝅰	Other	Total
J.S. Bach, Prelude & Fugue in G major from the <u>Well-Tempered Clavier</u>												
Prelude	24/16							83	288			371
Fugue	6/8				1	9		56	93		2	161
L. Beethoven, Sonata for Piano, Opus 31, no. 1												
Largo; Allegro[1]	2/4	2				40		120			1	163
Adagio	3/4		21	3	3	43			7	9	9	95
Allegretto	3/8				5	4		12	71		13	105
L. Beethoven, Sonata for Piano, Opus 57												
Allegro assai	12/8		23		12	17		16	24		24	116
Andante con moto	2/4				12	43	11	29	13	15	15	138
Allegro ma non troppo	2/4				8	6	16	8	62			100

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[1] The introduction to this movement changes tempo several times, finally settling upon an Allegro in measure 9. It would be difficult to establish a meter before the tempo becomes constant. For this reason, the figures here represent the number of notes twelve measures after the final tempo begins.

Table 1 Cont'd

Movement	Time Signature	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	♪.	♪	𝅘𝅥𝅯	𝅘𝅥𝅰	Other	Total
J. Brahms, Sonata in F Minor for Piano												
Allegro maestoso	3/4		4	11	2	88	6	71/54[1]		12		248
Andante espressivo	4/8				8			31	100		22	161
Scherzo	3/4			8		140		14			6	168
Intermezzo	4/8					32	9	100	11	50		202
Allegro moderato	6/8				23	27		111	16		2	179
F. Chopin, Sonata in Bb for Piano, opus 35												
Grave; Doppio movimento[2]	2/2					2		175	177			
Marche funebre	4/4			8		216	24	12	23			283
Presto	2/2							288				288
M. Clementi, Sonata for piano, Opus 26, no. 1												
Maestoso e cantabile	4/4			15		4		80	41		78	218
Molto Allegro	2/4					2		31	92			125

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[1] The first figure is for regular eighth notes and the second is triplet eighth-notes.

[2] Since the four-measure introduction is of a different tempo, these figures begin in measure 5.

Table 1 Cont'd

Movement	Time Signature	whole	dotted half	half	dotted quarter	quarter	dotted eighth	eighth	sixteenth	thirty-second	Other	Total
J. Haydn, Sonata no. 48 in C major												
Andante con espressione	3/4		8	10		22	7	35	8		33	123
Rondo: Presto	2/4					23		53	12			88
W.A. Mozart, Piano Sonata no. 8 in A minor, K. 310												
Allegro maestoso	4/4			2		30	15	312	37		2	398
Andante cantabile	3/4					15	11	14	112	74	19	245
Presto	2/4			5	16	14		43				78
W.A. Mozart, Piano Sonata no. 11 in A major, K. 331												
Andante grazioso	6/8				3	50	10	77	12			152
Minuet	3/4			3		24		57	16		2	102
Alla Turca	2/4					8		108	14			130
W.A. Mozart, Piano Sonata no. 15 in C major, K. 545												
Allegro		2		2	3	30		48	106			191
Andante	3/4			3	1	6	6	8	178		3	205
Rondo	2/4				3			56	88			147

Table 2

Percentage of the Most Common Macro-durations Found in the Notation of Selected Keyboard Works.

Movement	Percentage of		
	most common duration	top two durations combined	top three durations combined
J.S. Bach, Prelude & Fugue in G major			
Prelude	78	100	100
Fugue	58	93	98
L. Beethoven, Sonata for Piano, Opus 31, no. 1			
Largo;Allegro	74	98	99
Adagio	45	67	77
Allegretto	68	79	84
L. Beethoven, Sonata for Piano, Opus 57			
Allegro assai	21	41	55
Andante con moto	31	52	63
Allegro ma non troppo	62	78	86
J. Brahms, Sonata in F Minor for Piano			
Allegro maestoso	50	86	91
Andante espressivo	62	81	86
Scherzo	83	92	96
Intermezzo	50	74	90
Allegro moderato	62	77	90
F. Chopin, Sonata in Bb for Piano, opus 35			
Doppio movimento	99	100	100
Marche funebre	76	85	93
Presto	100	100	100
M. Clementi, Sonata for piano, Opus 26, no. 1			
Maestoso e cantibile	37	56	62
Molto Allegro	74	98	100

(Table 2 cont'd)

Movement	Percentage of most common duration	top two durations combined	top three durations combined
J. Haydn, Sonata no. 48 in C major			
Andante con espressione	28	46	54
Rondo: Presto	60	86	100
W.A. Mozart, Piano Sonata no. 8 in A minor, K. 310			
Allegro maestoso	78	88	95
Andante	46	76	82
Presto	55	76	94
W.A. Mozart, Piano Sonata no. 11 in A major, K. 331			
Andante grazioso	51	84	91
Minuet	56	79	95
Alla Turca	83	94	100
W.A. Mozart, Piano Sonata no. 15 in C major, K. 545			
Allegro	55	81	96
Andante	87	91	94
Rondo	60	98	100

CONCLUSIONS

The results of this study found Fraisse's study overly optimistic. Several movements have more than 80 per cent of the notated macro-durations of only two durations (as in Fraisse's study); however, a number of these movements do not.

The primary concern of this study was to examine the number of macro-duration that a listener might have to consider in trying to hypothesize various pulses. Except for two of the movements studied, more than half of the macro-durations encountered within a movement were of two durations. In most cases, considerably more than half were of two macro-durations. In both of the movements which were exceptions, the majority of the macro-durations were of three values. Based upon this study, it seems that most music notation of the common-practice period is comprised primarily of two or three macro-durations. Listeners could concentrate their efforts on the more common attack-point intervals to hypothesize pulses. A metric framework which would successfully account for the two or three most common macro-durations could possibly fulfill much of the function of meter.

This study does not consider any of the aspects which might give the listener a clue as to the viability of a macro-duration for pulse. All appearances of each macro-duration were considered equal. As previously explained, only harmonic density is represented in these figures; other forms of accent are not represented. It is possible that several meters would successfully coordinate the most common macro-durations. Apparently other factors cause the listener to choose among the possibilities.

[1] Although attack-point interval and notated macro-duration are not always the same, they are usually parallel. Notated macro-durations require little interpretation to count once guidelines are set. For this reason, it was decided to consider these durations rather than attack-point intervals.

[2] Some exceptions were made when the structure of an individual movement seemed to warrant starting in a place other than the beginning of the work. For example, an abrupt change in tempo would not be conducive to establishing meter. These aberations in technique have been indicated in the data.

[3] Graybill points out that this is commonly called a "textural accent" in the literature.

Roger Graybill, "Phenomenal Accent and Meter in the Species Exercise," In Theory Only 11, nos. 1-2 (May 1989): 15.

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