Abstract: For David Epstein (Shaping Time, 1995) the organisation of time is dual in nature. This duality yields two modes of structure, a clock-like organisation (chronometric time) and an organisation that is unique to a particular experience (integral time). For him, chronometric time is periodic in nature and structured by constant factors, whereas integral time is structured by elements intrinsic to its unique situation. Epstein also suggests that the duality of the time organisation is also present in the durational aspects of music. In this manner, meter corresponds to chronometric time, and rhythm to integral time. In this paper it will be suggested that the rhythm/meter bifurcation yields dual time systems that are processed in parallel. These systems intersect on various levels, mutually affecting the forms and articulations that each assumes; this leads in turn to conflicts and resolutions of tensions between rhythm and meter. The interaction of these music parameters infer in listeners a sense of motion (kinesis): the piece departs from a point arriving at another slower or faster, in an orderly or disorderly fashion. Although not exclusively, the perception of kinesis is in great part due to the rhythmic structure of music – durations over a metrical context. Using the concept of the hierarchy in gravity, this article proposes an empirically based theoretical construction that explains the operation and function of meter within the perception of kinesis in a piece of music. Besides the importance of this issue to the overall music community, the explanation of the operation of kinesis in music is also relevant for other performance arts that interact with music, such as drama and dance.

Introduction

Musical meter is a psychological construct based on the organization of sounds which constitute a music piece; its expression comes in the shape ‘measures’; ‘measure’ is a virtual unit constituted by a number of ‘beats’; a ‘beat’ is the minimum virtual unit of the musical meter.

1 – Empirical Theory

Lerdahl and Jackendoff (1983) point out that after developing a music theory in considerable detail, and if the rules proposed correspond at all closely to principles unconsciously known and used by the listener, one must still ask how the listener manages to learn them; of all the possible organisations one could attribute to the music theory, why does the listener infer the ones s/he does? The only answer found defensible by the authors is that much of the complexity of musical intuition is not learned, but is given by the inherent organisation of our mind, itself determined by the human genetic heritage; this is what Lerdahl and Jackendoff term the principle of musical innateness. They believe that the existence of different universes of music theory, resulting from cultural diffusion or historical accident, does not affect the core cognitive competences of all human beings - innate aspects of mind that transcend particular cultures or historical periods. As an example of this, the authors feel safe in conjecturing that even though some musical universes differ in metrical possibilities, there is no music that makes use of metrical regularities 31 beats apart (1983:282).

Though Lerdahl and Jackendoff’s concept of musical innateness does not address physiological matters, it is my belief that these are as relevant as psychological ones. According to Maury Yeston (1976:27), besides supplying a bank of common data for use by all theorists, a theory that grounds the process of music perception in physiology and psychology has never been systematically formulated. He also believes that such study should be closely linked to a physiological model based on either internal
biological rhythms (heartbeat, pulse, alpha waves, and other internal clocks) or external activities (walking, skipping, riding a horse, etc.). A gestalt-orientated approach would then seek to uncover the intrinsic operations or constructions of perception, such as the presumably innate human tendency to group a series of steady pulses into recurrent sets of two or three.

On the physiological side, David Epstein (1995) cites numerous scientists from Einstein, Gooddy, Lashley, and Poppel, to the cybernetics of Wiener, in developing his theory of the biological clock. In this theory the human body works like a big clock which itself reacts to the conjunction of smaller clocks represented by the different body organs; the ‘final clock’ is an abstraction, arrived at by a mathematical summation of all the subsidiary forms of time keeper - the innumerable clock forms - of which the body consists. The primary basis of the ultimate clock is the rhythmic mode by means of which the nervous system acts and transmits signals.

Even though our organs and muscles produce a continuous performance such as movement or sensation, this is a result of an intermittent process. It has long been recognised as a fundamental principle of nervous activity that all nerve units (neurones) transmit by impulse, and not by any kind of continuous signal. In this way, each neurone acts as an ‘all-or-none’ response. A nerve impulse passes along a nerve fibre in an on-and-off manner, the rate of transmission being determined by a number of physiological factors which are specific for that nerve fibre, and which provide a specific rate of performance for each fibre. There is a sense, then, in which all our bodily existence is based on a binary yes or no signals.

2 – Binary and Ternary Organizations

The Gestalt psychological concept of the unity of the temporal pair proposes a mental organisation of temporal sequences by pairs of contiguous pulses. According to Koffka (1935), for us to hear two taps as a pair they must be held together by forces of some kind. The basic problem with this assumption is that the first tap ceases to exist when
the second one appears. Thus, the conclusion that forces are required to produce the unity of the pair of taps compels the Gestalt psychologist to assume that, although the first tap has ceased to exist, something must have remained which serves as one of the points at which the forces apply. This something is known as a ‘trace’.

Furthermore, for Koffka the temporal aspect of the perceived series will differ from that of the real stimulus: the intervals between two members of one pair will appear smaller than the intervals between the second member of one pair and the first of the next. In Fig. 1 the upper dots represent the objective temporal sequence of taps, while the lower ones represent the sequence as it is heard.

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  . . . . . . . . . . . . . .
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Fig. 1
Gestalt grouping of events

These facts would seem quite unintelligible on the assumption that the location of the trace is the same as that of the process, because if it were, the trace of the first excitation would be so completely changed by the second excitation that it would lose its identity. In this manner, Gestalt psychologists believe that the basic perceptual organisation of a temporal sequence is by pairs, triggered by the dynamic interchange between an excited area and the trace of a former excitation.

External environmental issues are a further possible factor contributing to the perceptual preference for binary organisation. One can easily provide an extensive list of ‘pairs’ confronting us in everyday life: night and day, sun and rain, earth and sky, and many more. Of course there is a circularity here: these pairs are not so given in nature as mediated by human cognition, in this way resulting from the psychological and physical factors I have outlined. But that only serves to underline the importance of those factors.

A good example of this is the logical pair 0-1, the basis of contemporary digital technology. For George Rochberg (1972), the human brain is the model for the computer; the psychologist Ulric Neisser (1967) finds of extreme importance the
philosophical reassurance that the analogy between the mind and a computer program provides. Although a program is nothing but a flow of symbols, it has reality enough to control the operation of very tangible machinery that executes very physical operations.

For Neisser, another advantage of the ‘program analogy’ is that – like other analogies – it is a fruitful source of hypotheses: a field which is directly concerned with information processing should, in particular, be rich in ideas that can be used by psychologists. In fact, this kind of approach has been already addressed in this study, in relation to the work of Steedman (1977), Longuet-Higgins & Lee (1982; 1984), Povel and Essens (1985) and Lee (1985), all of which are based on the two-way relationship between mathematics (computer science) and psychology (cognition).

So far, I have not discussed ternary organisation. This is because it is difficult to find ternary structures in human physiological and psychological organisation. More recently, Christopher Hasty (1997) has returned to the issues of binary and ternary organisation in his Projective Process theory of meter. For him there are only two metrical types: duple (or equal) and triple (or unequal). Hasty believes that, when presented with series of isochronous pulses at a moderate tempo, a listener will spontaneously create groups of two or three (or multiples of two or three), and not groups of five or seven. And if a group of five is given to a listener at a moderate tempo, s/he will hear this as a composite of duple and triple groups. For Hasty, then, the evidence of musical practice and experience shows that duple and triple (or equal and unequal) measures constitute the two basic forms of metrical organisation. At the same time, however, he ascribes a certain primacy to binary forms. As he explains, since projection is a binary effect based on two consecutive terms, a projective account of triple meter will always be more problematic than one of duple meter. The major problem arises with the appearance of the third beat, which tends to unbalance the hierarchical organisation of the measure; nevertheless, just as in binary forms, the first beat is always stronger than the second one.

All these theories, concepts, and empirical data have as their common denominator the belief that the cognitive system favours binary and ternary organisations, and suggest the following propositions:
1 – The perceptual process will primarily group events in a binary or ternary fashion.
2 – Besides having an intrinsic identity, groupings such as five or seven may also be perceived as a composite of binary and ternary groups.
3 – In the case of perceptual doubt between binary and ternary organisation, the former will prevail.

3 – The Gravitational Concept

According to Gestalt principles towards cognitive organization of units, it is proposed that the first unit of a group is perceived as more salient. Therefore, applying this principle to musical meter, this justifies the reason why it is accepted that the first beat of a measure is perceived as the strongest. In this way, it is also understandable why the second of a two-beat measure can be perceived as the weakest.

In my view, the kinesis – the sense of musical motion - implied by a particular rhythmic construct results from the difference between the perceptual strength of the beats. I would like at this point to introduce the physical concept of gravity – often invoked in the discussion of tonal structure - as a metaphor for rhythmic kinesis. The difference of mass between objects creates what is called a difference of potential; in this manner, the smallest object is attracted towards the larger. Even though it is psychological in nature, the difference between the weight of the first beat and that of the second seems to create a similar difference of potential between them. The first beat can then be assessed as strong and stable, while the second beat is weak and unstable as a result of its kinetic potential; in other words, the kinetic qualities of beats are inverse to their perceptual weight. (Fig. 2 is a schematic representation of this gravitational motion in a binary measure.) Moreover, the gravitational concept implies that there is a consistent decrease of weight from the first to the last beat of a measure; as will be seen, this principle then interacts with the principle of hierarchical organisation within measures.
Although I have explained the idea of kinetic potential as a psychological gravitational field within a measure, the principle also applies between measures: in a rhythmic sequence, the kinetic motion is towards the first beat of the next measure, with the kinetic potential of the weak beats being realised on the following strong beats (Fig. 3).

From the performer’s point of view, drummer-extraordinaire Bob Moses (1984) expresses this by saying that playing a note on the first beat of a measure settles the meter but tends to stop the rhythmic motion, whereas a note played on the second beat will tend to propel the motion.

From a musicians’ point of view, the drummer Bob Moses (1984) realizes the previous concept by saying that playing a note on the first beat of a measure stops the rhythmic motion, while playing a note on beat two tends to move the piece forward.

The previous gravitational concept was empirically tested in Lopes (2003), departing from the following hypotheses: a) in line with the gravitational concept, there is in a ternary metre a decrease of perceptual weight from the first to the last beat; (2) in a quaternary metre there will be either (a) a decrease of perceptual weight from the first to the last beat, or (b) the beat hierarchy 1, 3, 2, 4 (from strongest to weakest).

The experiments confirmed the proposed internal organisation for ternary meters. For quaternary meters, the very small percentage reporting a 1-2-3-4 weight organisation seems to be conclusive in excluding it as a perceptual reality; although the results for beats 2 and 4 were not as predicted in hypothesis (2b), and were in any case not very
clear-cut, there was strong confirmation of the predicted strength of the third beat. This
indicates that quaternary meters tend to be heard hierarchically, based on superimposed
binary meters. I shall discuss this further on. The following formulation of the metre
stratum is based on these findings and further case studies can be found in Lopes
(2008a; 2008b).

4 – Binary Meters

Binary meters play a primary role in the process of metrical organisation in music.
Meters of this kind are composed of two beats, with the first beat perceptually
accentuated (Fig. 4).

Notation Legend:

- Measure Line
- Beat
. - Perceptual Weight (the
more dots the stronger the beat, as
in Lerdahl and Jackendoff’s

| . | . | . |

Fig. 4
Internal organisation of
a binary meter.

In order to address the qualitative issues inherent in binary meters, it is helpful to revive
the Greek concepts of thesis and arsis, which were applied to metrical feet. Curt Sachs
(1953:128) explains these as follows: “of the two sections in every metrical foot, one
had a strong and one a weaker weight, however such weight may have been realized or
simply suggested.... The Greeks called the stronger of these weights the thesis or basis,
‘downtread’, or simple kato, ‘down’, because the chorus conductors marked it with a
stamp of the foot. The weaker weight, coinciding with the lift of the stamping foot, was
called *arsis*, ‘lifting’, or simply *ano*, ‘up’. Accordingly, the earlier Romans spoke of *positio* and *sublatio*.”

The action performed by the Greek conductor of stamping the foot in the first part of the metrical foot, and lifting it in the second part, is a clear realisation of the perceptual qualities of binary meters. When conducting a binary metre, a modern conductor still performs a similar action with the down and up movement of the baton. Using the gravitational concept, we can describe this as follows: the weight of the first beat tends to stabilise the motion, as shown in the foot stamping or downward movement of the baton; the weakness of the second beat creates a kinetic potential which seeks stability, and is realised in the upward movement of the foot or baton.

5 – Ternary Meters

I suggested previously that ternary patterns represent a kind of elaboration of the primary binary organisation. We may therefore conceive a ternary metre as a binary metre to which an extra beat has been added (Fig. 5).

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|   ●  ●  +●  |

Fig. 5
Derivation of a ternary meter
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What weight should then be assigned to the extra beat? The principle of successively weaker beats from the first to the last was confirmed by the experiment reported earlier in this chapter, and gives rise to the organisation of a regular ternary metre shown in Fig. 6.
6 - The Emancipation of Quaternary Meter

A simple application of the gravitational concept, along the same lines of binary and ternary meters, would give rise to a quaternary metre in which each beat was weaker than the preceding one (Fig. 7).

However, the data derived from the experiment regarding the organisation of quaternary metre was in accordance with the common idea that quaternary metre is a hierarchical elaboration of the primary binary metre (Fig. 8). One should bear in mind that the cognitive principle of binary and ternary organisation works at all stages of the rhythmic inference process; any organisation derived from each new step of the rhythmic model is at first always measured against a preferable binary or ternary organisation. Therefore, only if it is not possible to base an organisation on a binary and ternary unit is another considered (a good example of this is the preferred binary sub-subdivision level of a ternary subdivision rhythm cell). It comes as no surprise, then, that any meter above the primary binary and ternary meters is liable to be constructed as an elaboration of these.
Although it can in this way be seen as an elaboration of a binary metre, I believe that widespread use of the quaternary metre in different musical cultures and genres has led to its separation from the binary metre and the rise of its own identity. After all, a quaternary metre is different from a binary metre precisely in the alteration of stronger and weaker parts of beats, which give it an additional dimension and complexity of its own. Considering once more the gravitational concept, all metrical points which are at different distances from the gravitational center should have different weights. In the previous example, beats two and four cannot have the same perceptual weight (as shown in Fig. 8). Therefore, combining the experimental data with empirical knowledge, one can propose an internal organization for the quaternary meter as the one shown in Fig. 9 – in which the last beat of the measure is the weakest.
7 - Other Meters (5, 7)

As previously explained, meters that do not imply any kind of binary or ternary organisation within the tactus range are hard to infer; moreover, even within the tactus range, the successful inference of a quintuple metre is only achieved if the rhythm stratum, or another music parameter, maintains a clear and ongoing accentuation of the first beat. Meters based on prime numbers such as 5 and 7 may then be defined in terms of the gravitational concept, in other words a continuous decrease from the first to the last beat, as shown in Fig. 10.

![Fig. 10](image1)

Internal organisation of a quintuple meter

Nevertheless, the effects of the perceptual primacy of binary and ternary organisation apply especially to meters comprising an uneven number of beats, such as 5 or 7. The cognitive importance of binary and ternary organisation is such that they are liable to break up into two or three-beat parts: for instance, towards the low range of the tactus, the quintuple metre will take the shape of either a binary metre followed by a ternary metre (Fig. 11 a)), or a ternary metre followed by a binary metre (Fig. 11 b)).

![Fig. 11](image2)

Two possibilities derived from a relatively slow quintuple meter
From the cognitive point of view, meters that in their most basic form are not binary, ternary, or quaternary will always be difficult to be inferred. The success in their inference will depend upon other factors besides the simple rhythmic structure of music. Fig. 11a) shows a good example of a meter that if played at a relatively fast tempo will tend to be inferred as binary, with different sized beats (in a 2+3 relation). Considering that the musical meter is like a clock that organizes the time aspects in music, one that consists of units with different sizes is well beyond what our cognitive systems looks for. This would be like having our life organized by a watch in which its seconds would vary in size (we all experience how hard sometimes it is to adjust to the 28 days of February). Although one can find in Lopes (2003) a broader discussion on irregular meters, the complexity of this issue is well beyond the scope of this article — therefore, we will leave this issue for another time.

Conclusions

The formulation proposed in this article which defines the operation of the main qualities of the most common meters in traditional western music is relevant not only to the music community but also to other arts. It was proposed that the inner organization of meter plays a significant role in the suggestion of kinesis. In this way, the knowledge of the different organizations of meters allows the control and extrapolation of this important perceptual quality (i.e. the notion of movement) by composers or musicians. One can conclude, then, that by placing events (i.e. musical sounds) in weaker parts of a particular meter a certain sense of kinesis is released. Conversely, the placement of sounds on stronger metrical points tends to stabilize the motion of a piece. Although the concepts in this article were base on empirical data, the results are well in accordance with the practical knowledge. One can easily observe that in jazz music — a genre that is known for its kinetic qualities — there are recurring accentuations of beats two and four of a quaternary meter. Also, highly kinetic quality and syncopation present in many popular music genres is also due to the recurring placement of sounds on weak metrical points.

The knowledge of the kinetic qualities of music is also of interest for other performance arts. In dance (as well in drama), the relation between performer and the kinesis of
music can be very efficient from an audience’s perceptual point of view. The understanding of the operation of this quality can then be of great use for performers, choreographers, as well as other creators of art.

Bibliography


