

Appendix 4: Particle Stream and Wave Representations of the Experience of Metre

The two-beat groove.

Steady but flexible, this rhythm is as old as walking ...

It is an unyielding reference point ... the final word.¹

This appendix explores the experience of directional movement in music as particle stream and phenomenological wave, presenting the concept via the example of 2/4 metre.

Similar to what has previously been noted, the following conceptual analysis applies to any musical parameter that can be represented as a polar couplet cell. For the sake of simplicity of demonstration, the example of 2/4 metre is used.

Metre as particle stream

A *traditional* view of simple metre considers it as analogous to a *stream* of audible sounds — as beats, separated by the silence between them. In such a view, the structure of metre is analogous to a *stream of pulses or particles*. Represented as pulses or particles, the “events” of metre capture the non-vectorial concept of tempo. In this rudimentary representation, as particles or pulses, the events of metre mark time but are themselves dimensionless. Such a *particle stream* representation of metre may be graphically represented as below:

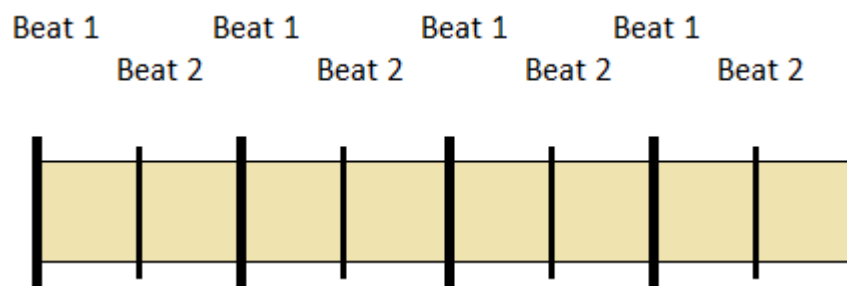


Figure 1: 2/4 metre — representing *particle stream*

Metre as form-void particle stream

A particle stream representation of metre can also be characterised as a particle stream of form and void *events* or *states*. Such a concept is most simply demonstrated by using the *absolute* attributions of form and void — sound and silence.² In the case of metre represented in this way, the sounds of beat 1 and beat 2 function as form.

¹ Wynton Marsalis, “Music as Metaphor,” Wynton Marsalis Lecture Series, Harvard University, 28 April 2011. <https://www.youtube.com/watch?v=5mAM405w2Sg>

² The description of sound and silence as absolute form and void is used in reference to the four proposed representations of form and void described in Chapter 1 under *Phenomenological form-void polarities*, the other representations being dominance and non-dominance, steady state and change, and expectation fulfilment and surprise.

Conceptually, metre represented as form-void particle stream has two alternative representations. The first of these is where form (the sound of the beats) is represented as a *demarkating event*.³ The second is where form and void are represented as *oscillating states*.

Each of these alternative representations are further considered below.

Metre as form-void particle stream — demarcating event representation

Figure 37 is a conceptual representation of metre as form-void particle stream, where form is represented as a *demarkating event*.

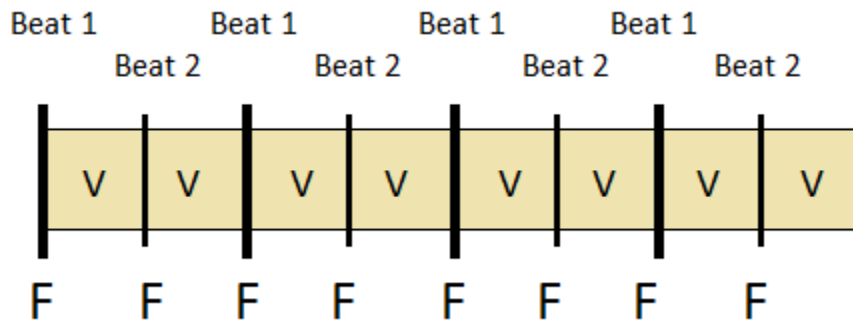


Figure 2: 2/4 metre as form-void particle stream — representing *demarkating events* (V = void; F = form)

In such a representation, beats functioning as form have *positions in time*. As demarcations, they function as separators between adjacent void states. Form *divides and sections* void into equal segments. The demarcating events of form (beats 1 and 2) do not themselves have a time duration. Metre is akin to darkness (void) with a demarcating flash of light (of zero duration) blinking at two intensities — a high intensity (representing beat 1) and a low intensity (representing beat 2). The demarcating events of form (beats 1 and 2) are akin to ideal platonic shapes — they are representable only in an ideal and abstract way.

Just as platonic shapes (e.g., a rectangle), having only two dimensions, cannot exist in three-dimensional space, neither can the form component of metre (the sound of the beat) be represented in terms of durational time. In this representation — form as demarcating events has position but not duration. Form, represented in this way, is simply the interface, separation, change, or “demarkation” between adjacent sections of void.⁴

Metre as form-void particle stream — oscillating state representation

An alternative representation of metre as form-void particle stream is where form and void are represented as *oscillating states*. Musical form (as sound), rather than being a demarcation that divides and sections void (silence), is then one of two oscillating states, the other state being void. Figure 38 represents an “oscillation of form and void states” model, in its most rudimentary form.

³ The concept of the beats of the measure as *demarkations points* of metre is described by Zuckerkandl in *Sound and Symbol*, 169.

⁴ Zuckerkandl in *Sound and Symbol*, 169.

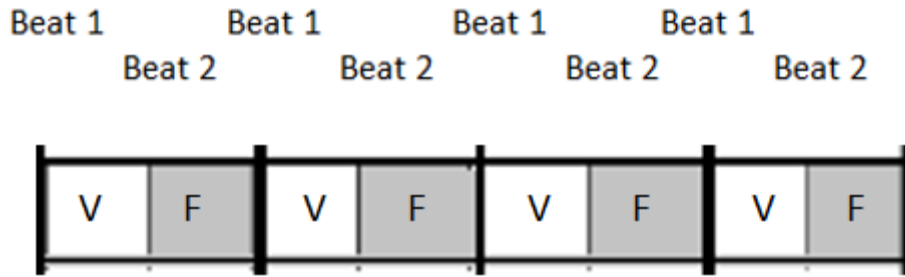


Figure 3: 2/4 metre as form-void particle stream — representing *oscillation of states*
(V = void; F = form)

In this representation, beat 1 is the home or void state, and beat 2 is the away or form state. In this rudimentary representation, form and void instantaneously switch between states. There is no “slope” in the transitioning between form and void states, and there are no gradations of the intensities of form and void. Thus, metre, represented in this way, is like a switch between form and void states.

Quantum phenomenological mechanics perspective — metre as oscillation between undeveloped and developed, stable and unstable phenomenological states.

In this representation of the 2/4 measure, the void state (as silence) may be considered, relative to the form state (as sound), an *undeveloped and stable state*. Conversely, the form state (as sound or beats) may be considered a *developed and unstable state*.

This representation of metre is characterizable as a particle stream of states that oscillate between stable (void) and unstable (form) states. The representation of metre as a form-void particle stream comprising *oscillating states* between undeveloped and developed, and stable and unstable phenomenological states is analogous to Planck’s characterisation of the quantum behaviour of electrons at atomic level.

As described by Planck, quantum behaviour involves the “jumping” of electrons between low (stable) and high (unstable) energy states in adjacent atomic orbitals.⁵ The inner (stable) orbital may be considered an undeveloped state, and the outer (unstable) orbital a developed state.

In the case of metre, the cyclic oscillation between low (stable, undeveloped) and high (unstable, developed) phenomenological energy states — beat 1 and beat 2, respectively — is analogous to this quantum behaviour. This concept is demonstrated in Figure 39 below. Figure 4

⁵ Rosenblum and Kotter, *Quantum Enigma*, 56.

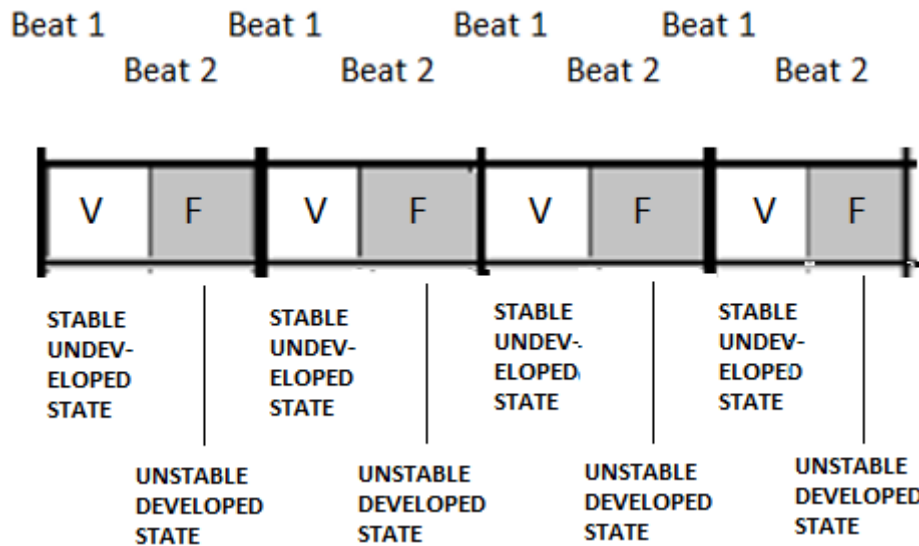


Figure 4: 2/4 metre as analogy of quantum mechanics oscillation between stable and unstable states

Metre — switch and taijitu representations

The representation of metre as an oscillation between form and void states, akin to a particle stream, is arguably a closer approximation to the way metre is phenomenologically experienced than the preceding representation, where form functions only as a demarcating event.

Such a *particulate* representation of the transition between the experience of form and the experience of void as being instantaneous, like a switch, is, however, still a very basic representation of metre. A more complex, but arguably more accurate representation of the way in which form (as sound or beats) and void (as the silence between the beats) are phenomenologically experienced is one that represents the transition between these oscillating phenomenological experiences of form and void as having certain tempering characteristics. This includes being experienced not as a switch between sound and silence but as a phenomenological penumbra of expectation and memory of the beats.

To elaborate, experience of form and void is proposed as occurring as a phenomenological *penumbra* of expectation and memory around the audible beat. Thus, the state of form is experienced not only for the duration of the sound of the beat but also for the duration of both its *expectation* and its *memory*.⁶ In other words, there is a period within the 2/4 measure that is experienced as “part of the experience of the beat”, even though the beat itself may not have yet commenced (experienced as expectation) or may no longer be sounding (experienced as memory).

Furthermore, the phenomenological experience of form and void would seem to be non-linear in time. This is because expectation and memory are not linear in time. Otherwise expressed, expectation and memory are influenced by *proximity in time* effects — memory is strongest just after a beat, and

⁶ The Merriam Webster Dictionary defines *penumbra* as “a space of partial illumination (as in an eclipse) between the perfect shadow on all sides and the full light” (<https://www.merriam-webster.com/dictionary/penumbra>).

The concept of a *penumbra* is thus typically applied to light rather than sound. Applied to sound, the concept means that the “beat” of metre functions as form not only when it is physically sounding but also in its expectation and its memory. Thus, the experience of metre is *informed* by the sound itself — while, as a phenomenological experience, it is something separate from it. The simplest example of this concept is the recognition that if the sound of beat 1 or beat 2 is intermittently eliminated, the experience of metre nonetheless continues.

Examples of this in Western music include reggae, where the first beat of the bar is commonly omitted in the bass. In Eastern music, this is apparent in *teentaal*, where the ninth beat *khali* (meaning “empty”) indicates a similar concept.

expectation is strongest just before a beat. During a single 2/4 measure, memory and expectation thus vary in intensity. Between these points, memory wanes and expectation waxes.

Metre may be considered as a cyclic transition between a *memory-dominant* state (just *after* the beat) and an *expectation-dominant* state (just *before* the beat). Represented in this way, the experience of metre may be characterised not as a stream of particulate events but rather as a phenomenological wave. Such a characterisation of metre — as a dual phenomenological wave defined by peaks of expectation and memory positioned within the extremities of the measure — is further described in the next section.

Metre as a phenomenological wave

Our interest is not in the dividing points [the beats], but in what goes on between them ... We discover that it [metre] is not in the demarcating beats but where at first we did not look at all, where nothing happens, where time simply passes — it is in the apparent vacuum between the demarcating beats that musical meter is born.⁷

This concept of metre as a phenomenological wave originated in Zuckerkandl's (1956) appropriately called *Wave Theory of Metre*. Zuckerkandl gave his reasoning for why the experience of metre may be characterised as wave motion:

With every measure we go through a succession of phases characteristic of wave motion: subsidence from the wave crest, reversal of motion in the wave trough, ascent toward a new crest, attainment of the summit, which immediately turns into a new subsidence, a new wave has begun.⁸

In the oscillation of form and void states, the particle stream representation of a simple metre means that the transition between form and void states operates like a switch — that is, it permits an instantaneous transition between one discrete state and the next.

In contrast, rather than transitioning between form and void states in a discrete and “switch-like” way, when metre is considered as a wave, form *emerges from* void and *returns to* void in a fluid and continuous way.

The transitioning between form and void states is thus characterizable as a *swelling* (away from void) *to form* and a *decaying* (away from form) *to void*. Just as sound itself is *physically* a waveform, the *phenomenological* experience of metre can also be considered wave-like. Such a recognition allows the phenomenology of metre to be represented not as a stream of particles but as an undulating phenomenological wave.⁹

This is the concept that Zuckerkandl refers to in his wave theory of metre, as described in the above quote. Graphically, the concept of metre as a wave may be represented as shown below:

⁷ Zuckerkandl, *Wave Theory of Metre* 169.

⁸ Zuckerkandl, *Wave Theory of Metre* 168.

⁹ Zuckerkandl, *Sound and Symbol*, 168.

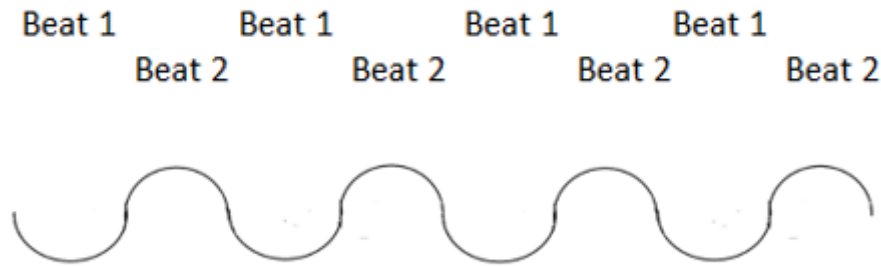


Figure 5: Simple representation of metre as a phenomenological wave

Metre as a dual phenomenological wave of expectation and memory

In seeking to characterise the phenomenological experience of simple metre, it is necessary to introduce a final concept for this section — the concept of the experience of simple metre as a dual phenomenological wave of both *memory and expectation*.¹⁰

The reason for this is that, in experiencing metre, the experience of musical form — a musically *developed* state — includes more information than the sound itself. Using Zuckerkandl’s terminology, the sound — for example, the sound of the first dominant beat of the 2/4 measure — functions as a trigger for a richer phenomenological experience *beyond that of the sound itself*. According to Zuckerkandl, the meaning within music lies not externally but rather internally — in the richer embellishment of meaning that arises from the “pointer”¹¹ (i.e., the experiencer).

The temporal penumbra of expectation and memory

In using the term *penumbra*, I am describing the *phenomenological fields* of anticipation and memory that surround the actual physical sound of beats in metre.

As in optics, a penumbra has the meaning of a “partially shaded outer region of the shadow cast by an opaque object [as occurs during an eclipse]”.¹² As the concept is used in the dissertation, it means the *shadow in time* that accompanies a sound event. In simple terms, this involves two components — the *expectation* of the sound event and the *memory* of the sound event.

Memory and expectation as phenomenological vectors

Since memory and expectation are phenomenological experiences that occur within a shared temporal framework, the experience of memory and expectation (from a phenomenological mechanics perspective) is representable as mirror-image vectors of one another. Thus, expectation is the converse of memory and vice versa.

Being related in this way, it is possible to combine the phenomenological waveforms of the experiences of expectation and memory of a musical event (such as the beats of metre) to produce a graphic representation of the experience of metre, which includes a *penumbra* of its experienced expectation and memory of the sound itself.

¹⁰ Earlier, I introduced the idea that expectation has two representations — a field of cultural expectation and a field of parameter anticipation. To distinguish between these two meanings of expectation, where the distinction is more clearly expressed in this way, I also use the term *anticipation* to represent the latter of these two meanings of expectation as a phenomenological field. (Kouvaras, *Loading the Silence*, 56.)

¹¹ Zuckerkandl, *Sound and Symbol*, quoted in Dahn, *A Summary and Reflection on Victor Zuckerkandl’s Sound and Symbol*.

¹² See <https://www.encyclopedia.com/science-and-technology/astronomy-and-space-exploration/astronomy-general/penumbra>

Logically, such a position is derivable based on memory and expectation as the phenomenological representations of past and future events, along a common timeline. This is not, however, the evidence on which I propose such interdependence between memory and expectation.

Rather, in making this proposition I am characterising the interdependence between memory and expectation based on the way that metre is *experienced* — specifically, in my own experience. In listening to 2/4 metre, for example, what I experience is a cyclic alternation between memory and expectation — memory of the beat that has just gone and anticipation of the beat that I expect will follow.

My personal experience of metre may be further qualified as follows. At any point in the duration of listening to a 2/4 measure, my experience is either *memory-dominant* or *expectation-dominant* — that is, my experience of where I am in time is referenced against the memory of the beat that has just passed or the beat that I expect to hear next.

In the *first* part of experiencing the 2/4 measure, I am in a *memory-dominant* state — my position in time is referenced against the beat that has just passed. Conversely, in the *second* part of experiencing the 2/4 measure, I am in an *expectation-dominant* state — my position in time is referenced against the beat I am expecting.

The transition from a memory-dominant to an expectation-dominant state is not a discrete one — rather, it is a continuous transitioning.

It is not a linear experience — memory of the beat that has just passed seems to sustain at a high level and then rapidly fades away. Similarly, expectation of the beat to follow seems to be low at first and then, as time moves closer to the anticipated next beat, it seems to rise rapidly. The trajectory of this experience is non-linear in the way that the speed of a pendulum bob is non-linear — it starts slowly and non-linearly accelerates.

Otherwise expressed, my experience of metre is a repeating cycling of *memory fading* and *expectation swelling* in a non-linear way. The geometric form of this experience is, therefore, characterizable as a wave. Figure 41 represents this concept.

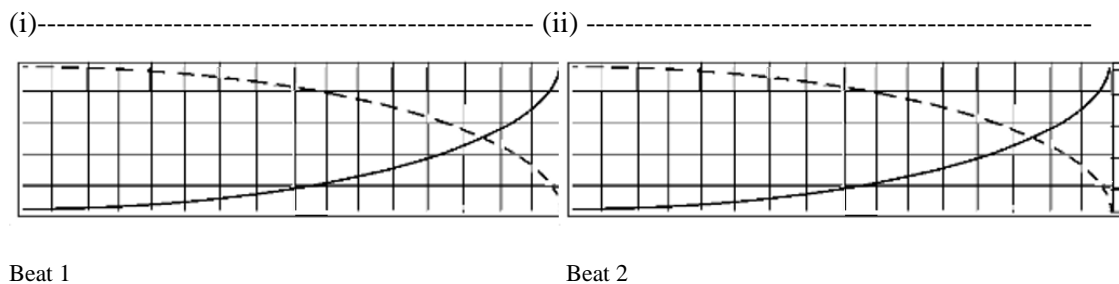


Figure 6: Phenomenological fields of memory (broken line) and expectation (unbroken line) and memory of beat 1 and 2 over duration of 2/4 measure represented as *absolute* displacements

This figure represents memory and expectation in terms of *absolute* displacements — it does not reference the fading of memory and the swelling of expectation relative to a common zero point.¹³ The latter is, however, represented in the figures that follow.

¹³ The representation of memory and expectation as absolute displacements is initially presented in this way because it is easier to represent in contrast to the “amplitude” representation where, in considering the experience of metre as a phenomenological wave, memory and expectation have a “zero point” around which they both oscillate.

Memory and expectation as dual phenomenological waveform

Memory and expectation in metre may also be represented not in terms of absolute levels but in terms of *amplitude* — that is, directional (up and down) *displacements from a central void position*. In such a representation, both memory of the preceding event and expectation of the event to follow are vectorial experiences.

In the convention I have used, memory is represented as a *negative* displacement and anticipation is represented as a *positive* displacement. Therefore, the alternating experiences of memory and of anticipation are characterizable as an oscillation between negative form (memory) and positive form (anticipation).

Further, both memory and expectation are characterizable as displacements from a central void position. That central void position is the experience of metre, not in terms of the memory of the preceding beat, nor in terms of the expectation of the beat to follow, but exactly in the middle of these experiences.

That phenomenologically determined “middle point” between experiencing metre as the memory of sound that has passed and the expectation of sound that is yet to come is a representation of experiencing metre *in the present moment*.

Graphically, Figure 42 represents 2/4 metre in this way — as a *dual phenomenological waveform of memory* (represented as a broken line with negative amplitude) *and expectation* (represented as an unbroken line with positive amplitude).

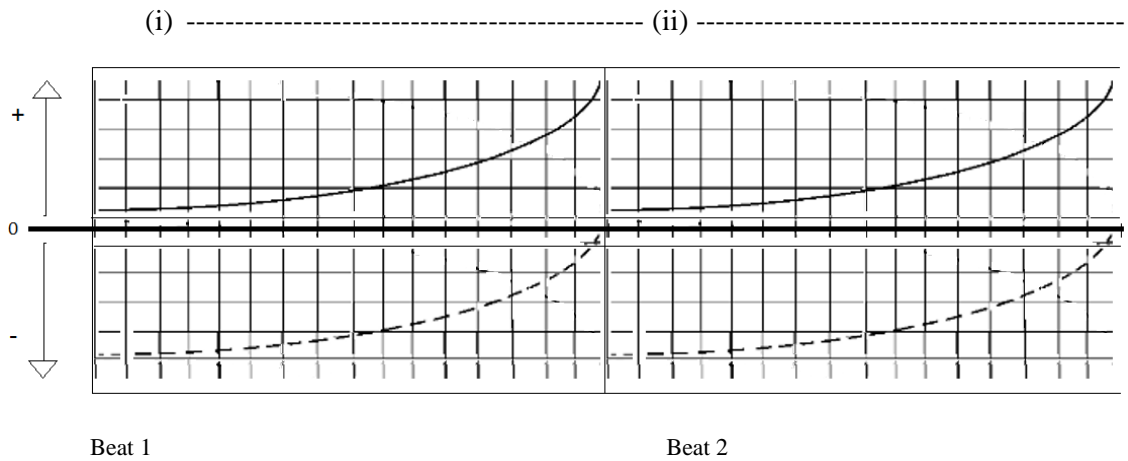


Figure 7: Phenomenological fields of expectation and memory over duration of 2/4 measure (memory is the broken line; anticipation is the unbroken line)

The representation of the vectors of memory and expectation in this way has an advantage. It demonstrates the points in time in 2/4 metre where metre is experienced as maximally phenomenologically *charged*. These points in time are at point (i), just after the sounding of a beat when memory is at its maximum intensity and where the waveform is maximally *negative*, and at point (ii), just before the next anticipated beat where the waveform is maximally positive.

Memory and expectation as combined waveform

This concept is represented in Figure 43 below, where the central line represents an aggregation of the waveforms of memory of the preceding beat and expectation of the beat to follow. The point at which this summated waveform crosses the zero point — the point where there is neither negative displacement of the waveform (memory) nor positive displacement of the waveform (expectation) — is a conceptual representation of the experience of metre as a dual wave of memory and expectation at the point in the measure where the experience of metre is neither memory-dominant nor expectation dominant.

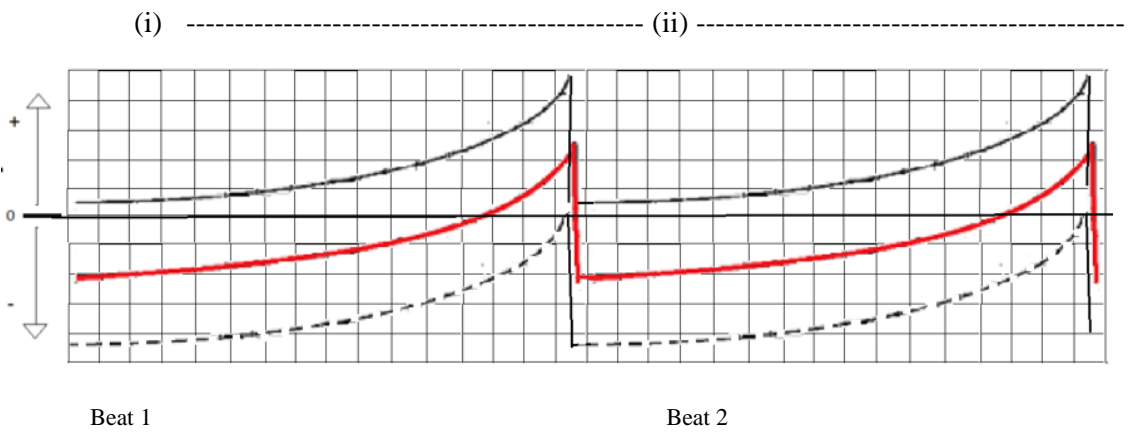


Figure 8: Phenomenological fields of expectation and memory over duration of 2/4 measure (memory is the broken line; expectation is the unbroken line; combined waveform is the line in the middle)

The concept of memory-dominant and expectation-dominant phases of the 2/4 measure

In examining the figure above, it is apparent that, in the phenomenological experience of 2/4 metre, within each 2/4 measure there is a *memory dominant phase* corresponding to the part of the measure where the combined memory-expectation waveform is *below* the zero point of the wave and an

expectation dominant phase where the combined memory-expectation waveform is *above* the zero point of the waveform. Figure 44 represents the same concept, using the wave concepts of troughs and crests to represent memory and expectation.

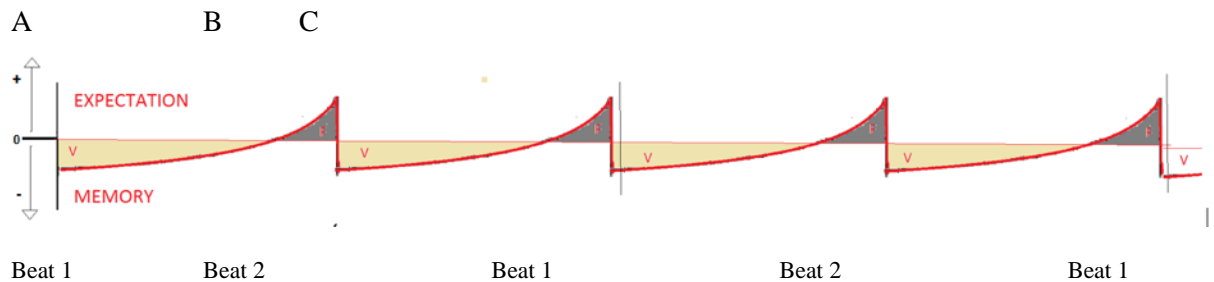


Figure 9: 2/4 metre as a combined wave of memory and expectation, where troughs correspond to the memory-dominant phase and crests correspond to the expectation-dominant phase (AB = troughs; BC = crests)

When the wave form is *below* the central zero amplitude, the metre is in the *memory-dominant* part of its cycle. As is evident in the figure, this occurs at the start of the measure between points A and B. The *memory-dominant* part of the metric cycle thus starts immediately after the sounding of a beat, decaying from that point.¹⁴ Conversely, when the wave form is *above* the centre zero amplitude, the metre is in the *expectation-dominant* part of its cycle. It thus starts at the point where the wave crosses the centre line [B], continuing and swelling in amplitude until the expectation of sound is met [C] and the cycle recommences in its memory-dominant form.

The concept of gated form-void cut-offs

Describing the nature of his (1956) wave theory of metre, Zuckerkandl states:

Our interest is not in the dividing points [the beats], but in what goes on between them...We discover that it is not in the demarcating beats but where at first we did not look at all, where nothing happens, where time simply passes – it is in the apparent vacuum between the demarcating beats that musical meter is born.¹⁵

The representation of the experience of metre as a dual phenomenological wave of memory and expectation may be further refined, re-introducing the idea of the penumbra — the surrounding transition zone of a transformation. The concept of penumbra, used in the novel sense, is not used to indicate the transition between light and dark but the transition between musical form and void as experienced in 2/4 metre.

The experience of *now* conceptually represented

The experience of “now” would seem not to be a dimensionless transition point between the metre experienced as memory and the metre experienced as expectation. Rather, the experience of now refers to the area of transition between the beats, which is experienced as neither strongly memory-dominant nor strongly expectation-dominant.

Borrowing the concept from the principles of sound engineering, the duration of the period that is neither strongly memory-dominant (just after the beat) or strongly expectation-dependent (just before the beat) is representable in terms of a *gated cut-off*. In other words, even when the waveform is in the

¹⁴ Though the waveform for memory appears to be *increasing*, it is in fact *decreasing*. This is so because it is moving back to zero. Effectively, it is reducing its negative displacement towards zero.

¹⁵ Zuckerkandl, *Sound and Symbol*, 169.

crest form, metre is only experienced in terms of memory if it is sufficiently displaced from the zero line, and similarly for expectation.

The experience of metre in the present, which occurs in the “vacuum between the demarcating beats”,¹⁶ is not instantaneous but persists for a measurable duration, as demonstrated in Figure 45.

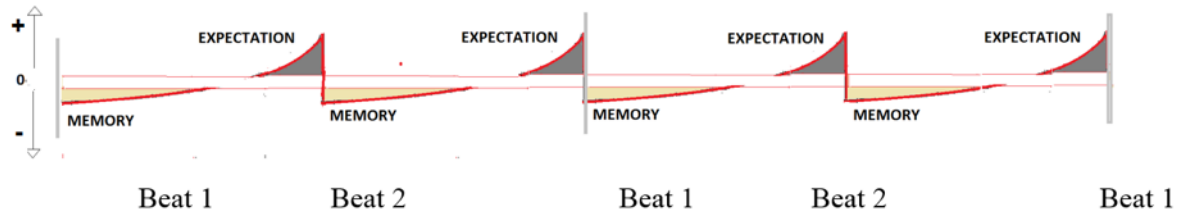


Figure 10: Memory (of preceding beat) and expectation (of forthcoming beat) represented as a phenomenological wave with transition from memory to expectation via *gated cut-offs*

It is visually apparent in the figure that the experience of the beats of 2/4 metre, phenomenologically considered, is more complex than a simple demarcation between sections, as was represented in Figure 2: 2/4 metre as form-void particle stream — *representing demarcating events*. Rather, in the wave form represented in Figure 10, the following is apparent. The experience of 2/4 metre as beat 1 and beat 2 extends beyond the physical sounds themselves — specifically, the beats of metre are experienced inclusive of their expectation and their memory. Thus, they are experienced not as a demarcating line but as a phenomenological penumbra of memory and expectation.

The shapes of the waveforms for expectation and memory are non-linear and non-equal. As represented in the figures, this arises from proposed properties of temporality or phenomenological time, which are different from the properties of physical time itself. This includes non-linearity.¹⁷

When one considers metre as a cycling oscillation between form and void, the sound of the beats and their phenomenological penumbras of memory and expectation represent form, and the space between them represents void. Figure 46 represents the last of these concepts.

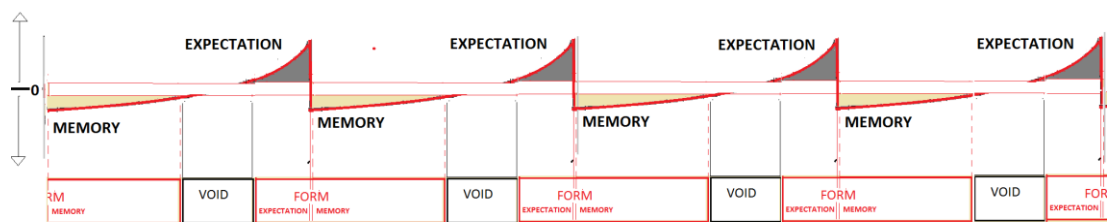


Figure 11: Experience of 2/4 metre as phenomenological wave of oscillating form and void states

How long is now?

The final concept in the representation of metre as a phenomenological wave necessitates considering an interesting psychological question: *how long is now?*

When the experience of directional motion in music is considered from a phenomenological mechanics perspective, the question is an important one. The reason for this is that, arguably, the duration of the experience of “now” corresponds to the limit of the time duration between the beats where metre can be experienced as metre rather than as disconnected and unrelated events.

¹⁶ Zuckerkandl, *Sound and Symbol*, 169.

¹⁷ An example of non-linearity of phenomenological time is the common anecdote that time slows down when one is involved in a critical incident — such as just before a motor vehicle accident.

A detailed consideration of this question is beyond the scope of this dissertation. *New Scientist* magazine has investigated the question, however, and proposes that the experience of now is somewhere between two and three seconds.¹⁸

A preliminary interpretation of this observation as it applies to phenomenological mechanics is that for metre tempos where the duration between beats 1 and 2 is less than three seconds (tempos of $\downarrow = 20$ and above), the memory of the beats remains experienced as form. Beyond that (tempos below $\downarrow = 20$, which are not characteristic of normal music), the memory of sounds, as required for the experience of metre, probably disintegrates. In such circumstances, the “sounds” of metre are experienced not as components of a singular phenomenon on (metre) but as disconnected and unrelated events.

Particle and wave representations of complex metre — hierarchical organisation

RP 1A proposes a *phenomenologically determined, hierarchically organised, multi-parameter, form-void vector field* model for the experience of directional motion in music.

Under this model, the concept of hierarchical organisation is represented most easily via the parameter of metre. Metre is represented as hierarchically organised, both from particle and wave perspectives. The same structure applies, it is proposed, to the musical parameters, including those of melody, harmony, modulation, and global form. Figure 12 offers a basic representation of these concepts as demonstrated for *simple* metre, complex metre (involving two hierarchical levels of metric organisation), and *further complex metre* (involving three hierarchical levels of metric organisation).¹⁹

This concept is exemplified in the analysis of *Oscillation 1*, where the three main levels of metric organisation are identified in the 24-beat metre.²⁰ Hierarchically organised, complex metre is representable both in particle stream and wave representations of complex metre, as shown in Figure 12.

¹⁸ New Scientist, *How Long is Now? Fascinating Answers to 191 Mind-boggling Questions* (London: Quercus, 2004).

¹⁹ In the case of the wave representation, analogously to the relationship of a fundamental wavelength to its harmonic wavelengths (whole number divisions of a standing wave), the various hierarchical levels of complex metre may be represented as whole-number divisions of a fundamental wavelength.

²⁰ The 24-beat metre of *Oscillation 1* is divided into the following groups of beats: Layer 1: 3 +3+4+3+3+4+4; Layer 2:10 +10 +4; Layer 3: 24-beat cycle.

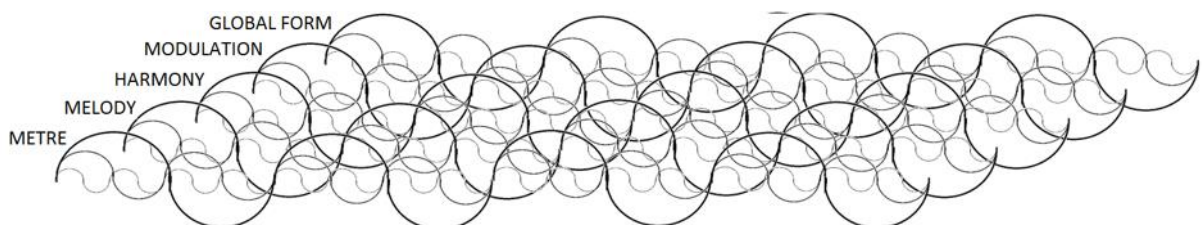
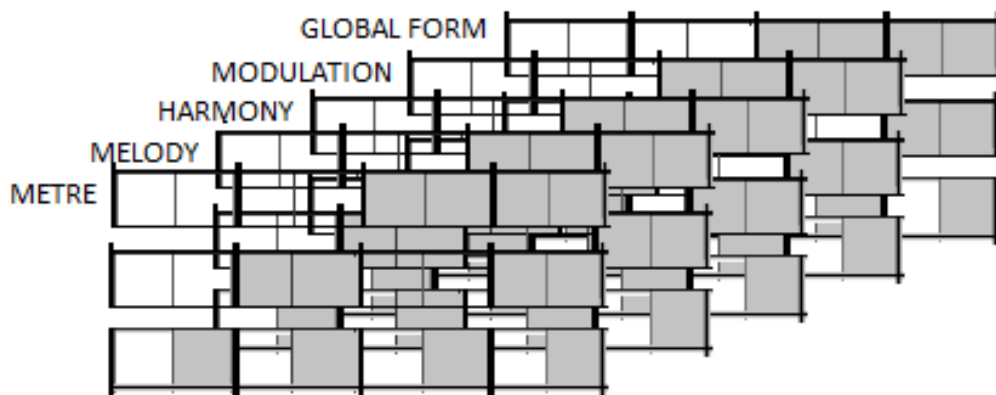
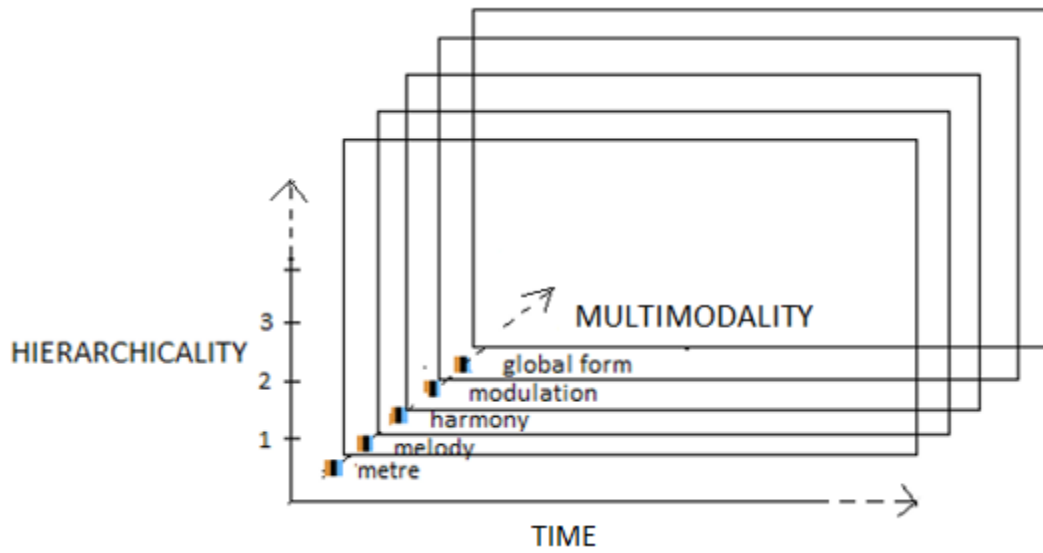
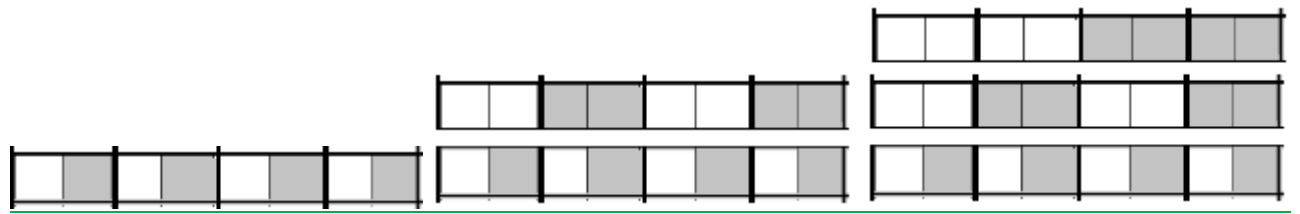


Figure 12: Primary RP 1A — Cartesian, particle stream, and phenomenological wave representations