Rhythmic and Metric Theorisation in Rock Music

The Bloomsbury Handbook of Rock Music Research, ed. Allan F. Moore and Paul Carr (forthcoming April 2020)

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Introduction

Rhythm is one of the most salient parameters in rock and many other popular musics, because of the explicit beat provided by the drums and the pervasive use of rhythmic dissonance throughout the texture. The normally steady tempos and explicit beat allow for greater rhythmic complexity in the other layers of the texture, and an intensified entrainment to the metre that facilitates bodily engagement with the music. While more theoretical and analytical attention has been given to pitch structures in both art music and vernacular musics, a growing body of research explores the parameters of rhythm and metre in various repertoires. This chapter first surveys theories of rhythm and metre that have been developed for Western art music and adapted or applied to rock music and related genres, and then addresses more recent theories developed specifically to model common rhythms in popular music. I examine the different conceptions of the relationship between rhythm and metre modelled by these theories. I also consider some other relevant temporal issues: the ‘binary default’ resulting in the overwhelming prevalence of duple and quadruple meters in Western musics, the status of the ubiquitous drum backbeat and its common variants, and the relationship of rhythmic patterns to dancing and other embodied responses.

Theories of Rhythm and Meter

Lerdahl and Jackendoff’s Model

Musical rhythm has often been understood in relation to spoken rhythm. Various theoretical models have been predicated on analogies between musical and textual rhythm, from the modal rhythms of the late medieval era through the rhythmic figures described by Baroque theorists to more recent theories such as that of Grosvenor Cooper and Leonard Meyer.¹ A distinction among these superficially similar paradigms is the extent to which contrasts between notes are conceived as primarily durational (long vs. short), primarily accentual (strong vs. weak), or a combination of the two.² Cooper and Meyer’s model identifies duple and triple groupings of strong and weak beats at all structural levels, using the traditional poetic feet (iamb, trochee, anapest, dactyl, and amphibrach). One criticism of this model is that it conflates rhythmic groupings and meter in a single nested hierarchy. This issue was rectified in the theory developed by composer and music theorist Fred Lerdahl and linguist Ray Jackendoff in A Generative Theory of Tonal Music.³

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¹ Cooper and Meyer, Rhythmic Structure. Cooper and Meyer’s theory is summarised in London, “Rhythm in Twentieth-Century Theory.”
² The linguistic equivalent of this distinction is between syllable-timed and stress-timed languages. Some evidence for the reflection of this linguistic difference in musics from different countries is offered in Patel and Daniele, “An Empirical Comparison;” Huron and Ollen, “Agogic Contrast” and Erin Hannon, “Perceiving Speech Rhythm,” among others.
grammars of common-practice tonal music that was intended to be analogous to Noam Chomsky’s generative grammar. Their theory comprises sets of rules governing pitch and rhythmic structures, organized into four hierarchies: grouping structure, shown with brackets, metrical structure, shown with columns of dots, and time-span reduction and prolongational reduction, both shown as tree diagrams. Universal ‘well-formedness rules’ prescribe what structures are possible, while style-specific ‘preference rules’ point toward the best interpretation of a given structure within its context. The aspects of their theory that deal with grouping structures and metric structures are the most fully developed and have had the greatest influence on later scholars. Richard Cohn has called this separation of grouping and meter “the birth of modern metric theory.”

In his theorization of cognition, David Temperley adapted Lerdahl and Jackendoff’s model of metric structure, discarding some of their rules and modifying others. In his discussions of rhythm in rock music, he posits additional rules in order to reconcile the conflict of metric and phenomenal accents in syncopated melodies. Because “the anticipatory syncopations of rock and related styles are not usually heard as destabilizing the underlying meter,” he interprets them as early displacements of a deeper-level consonant rhythm. Temperley asserts that listeners mentally resolve such rhythmic dissonances by understanding them — possibly unconsciously — as belonging to the following strong beat. Allan Moore has argued against this interpretation, describing syncopation as “endemic to popular song” and observing that “syncopation by anticipation is…so normative as to be expected.” Recent empirical research supports the view that listeners expect, readily perceive, and even enjoy the unpredictability of syncopation in groove-based music.

Example 1a shows Temperley’s transcription of the first three vocal phrases of Michael Jackson’s pop hit “Billie Jean,” and below it his regularization of the rhythm so that stressed syllables (shown in bold; highly stressed syllables are italicized) fall on strong beats. The hypothetical transformation of rhythmic consonances into dissonances is clearly demonstrated, but the argument that this represents listeners’ perception of the music on some level is unsupported, and his assumptions that the correlation of text stress with metric accent in common-practice art music holds true for popular music as well, and that rhythmic displacements are normatively early, go unquestioned. Because much popular music features a separate percussion layer that explicitly marks the beat, syncopated melodies are a standard convention in pop and rock and are most likely heard as complements of the marked strong beats rather than displacements of them.

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4 Cohn, “Meter,” p. 5 of chapter. Cohn cites Arthur Komar’s Theory of Suspensions (1971) as an early precursor to Lerdahl and Jackendoff’s theory in this regard.
5 Temperley, Cognition, 23–54.
6 Temperley, Musical Language, 66–86, and Temperley, Cognition, 237–64. Most of the discussion of meter in this latter chapter was previously published as Temperley, “Syncopation in Rock.”
8 See Moore, Song Means, 64–66.
9 Ladining et al., “Probing Attentive and Preattentive,” demonstrates that untrained adult listeners can readily distinguish between consonant versus syncopated rhythmic patterns and among differing degrees of syncopation. Vuust and Witek, “Rhythmic Complexity,” propose that medium degrees of syncopation lead to the highest rate of prediction error regarding anticipated rhythms (low syncopation unsurprisingly correlates with low prediction error, and high syncopation may be too complex to predict). Counterintuitively, higher rates of prediction error evoke more pleasure, possibly because our brains value prediction as a learning activity more than minimizing predictive errors.
Example 1a: Michael Jackson, “Billie Jean,” (Thriller, 1982), opening vocal melody (upper staff) and Temperley’s rhythmic regularization (lower staff). From Temperley, Musical Language, Ex. 4.6 A, 74.

Example 1b: Michael Jackson, “Billie Jean,” (Thriller, 1982), vocals and accompaniment at beginning of verse; brackets above the system show the grouping structure and dots below show the metric structure.
The rhythmic complementarity of melody and accompaniment would be more evident if the instrumental parts had been included in Temperley’s examples, as in Example 1b, which transcribes the accompaniment parts at the beginning of the verse and adds dots reflecting Lerdahl and Jackendoff’s metric structure as well as brackets for the grouping structure. The 4/4 metre of “Billie Jean” is clearly established by a standard backbeat in the drums and a walking bass in quavers. The 3+5 quaver groupings throughout most of the synthesiser part, with chords consistently on beats 1 and 2.5 (the ‘and’ of beat 2), superimpose a mild background syncopation but also clearly mark the downbeats of each bar, which are largely avoided in the melody. The melody also avoids accents on beats 2 and 4, which are emphasised by the backbeat snare. The accented syllables of the lyrics fall most consistently on beat 4.5 in all but the second and last bars of the example (although the stressed syllable at the end of the original third bar should be on beat 4, ‘what’, rather than 4.5, ‘do’), which supports the interpretation of anticipated downbeats. The next most consistently accented beat in the melody is beat 3, in the first three bars. In the fourth bar, this mid-bar accent is shifted one quaver earlier to beat 2.5, setting up the phrase fragmentation that follows; this shift is shown in Example 1b by subdividing the grouping bracket in the fourth bar as in the second bar (this analysis conforms to Lerdahl and Jackendoff’s Grouping Preference Rule 6 and Temperley’s Phrase Structure Preference Rule 3, both of which state that parallel passages should form parallel groups).10 The phrase fragmentation coincides with a destabilisation of the harmony, which moves from tonic to subdominant. The last four bars of the example, which are repeated, feature regular text accents anticipating beats 1 and 3 by a quaver (beats 4.5 and 2.5). Thus the rhythmic trajectory of this excerpt correlates with the harmonic trajectory in moving from greater to lesser stability, as the mid-bar accent shifts from beat 3 to 2.5 and the harmony moves away from the tonic.

Daphne Leong takes Lerdahl and Jackendoff’s model as a starting point for her model of metric contour, which unlike theirs is designed to accommodate nonisochronous (asymmetric) meters.11 She translates the layers of dots representing metric accent into an inversely correlated integer series, with 0 representing the downbeat, positive integers representing increasingly weaker beat subdivisions, and negative integers representing hypermetric strong beats, so that greater metric strength is represented by lower numbers. An additional integer string represents durations between attacks, which she calls the ‘pulse hierarchy.’ Leong posits a spiral model of displacement, from metric consonance through varying degrees of syncopation to the establishment of a new downbeat. Her model accounts for both metric accent and durational accent, distinguishing syncopes, events on weak beats or offbeats that are sustained through the following stronger beat, from offbeats that are not sustained and therefore present less of a challenge to the meter. Events displaced later rather than earlier also receive lesser metric weight. She offers six demonstrative analyses, of four excerpts from art music (Beethoven, Wagner, two Bartók) and two from jazz, showing progressively later displacements and rhythmic compression of a motive in an alternate take of Herbie Hancock’s “Madness,” and late displacements in a rendition of “What Is This Thing Called Love?” by Billie Holiday that can be interpreted as in a different — and, surprisingly in light of Holiday’s tendency to place notes behind the beat, a faster tempo than the band.12

11 Leong, “Generalizing Syncopation.”
12 Leong’s analysis of Billie Holiday’s characteristic delay as expressing an independent tempo follows that of Huang and Huang, “Billie Holiday and Tempo Rubato,” which posits a separate tempo for Holiday’s vocals in a 1941 recording of “All of Me.”
**Hasty’s Model**

In contrast to the architectonic and essentially static model of rhythm set forth by Lerdahl and Jackendoff, Christopher Hasty has proposed a dynamic model of metre as a process projected by rhythmic durations rather than an underlying fixed grid of durationless timepoints.\(^{13}\) Metre is created through the potential of a duration to be immediately repeated. Durations can function as anacruses, beginnings, continuations, or deferrals.\(^{14}\) His model of projection is fundamentally binary: each duration projects its repetition. Thus triple metre requires a special explanation: the third beat of a bar does not represent a continuation or an anacrusis, but rather defers the beginning of the next bar until the following beat.\(^{15}\) Hasty’s theory differs from most previous explanations in that metre has no inherent accent pattern, and is constantly constructed by the listener. As Justin London has pointed out, it powerfully models the process of identifying metre, but disregards the potential for listeners’ entrainment.\(^{16}\) Metre is never established and internalised but must be continually reinvented — a view that runs counter to empirical research on metre induction.\(^{17}\) Hasty’s model affords a very high level of metric particularity, distinguishing between countless different realizations of any given time signature, but it does not account for recognizable metric types such as sarabande, waltz, or backbeat.

Using Hasty’s theory as a lens, Robin Attas has explored the relationship of rhythmic groove with form.\(^{18}\) She identifies the rhythmic characteristics of buildup introductions: beyond the expansions of texture, timbre and register created through the addition of successive layers, buildup introductions often feature metric ambiguity, increasing metric complexity, anacrustic cues that signal the beginning of the next formal section, and ‘projection shift,’ which focuses a listener’s attention on different rhythmic durations as new layers are added. Similarly, increased intensity can be created in other formal sections through increasing the density of anacruses and syncopations.

Example 2 shows Attas’ transcription of the introduction of The Temptations, “My Girl,” annotated with Hasty’s symbols for rhythmic functions. Forward slashes are anacruses, vertical lines are beginnings, and backward slashes are continuations. The letters represent listeners’ projected expectations for the next duration based on the currently sounding one. This example demonstrates a projection shift from the repeated half-bar motive played by the bass (labelled Q and Q’) to the repeated one-bar motive in the guitar (labelled R and R’). Projection shifts like this are particularly notable within buildup introductions, but they can also help to create contrast between different formal sections such as verse and chorus, especially when the density of the drum pattern changes.

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\(^{13}\) Hasty, *Meter as Rhythm*.

\(^{14}\) Except for the last, these rhythmic functions resemble those of anticipative, initiative, reactive, and conclusive, which were proposed by Berry in *Structural Functions*, 301–424, and in “Metric and Rhythmic Articulation.” However, Hasty does not cite Berry’s work.

\(^{15}\) Roger Grant has pointed out that Hasty’s model is unique in theorizing an unequal triple meter with the second part (beats 2 and 3) twice as long as the first, which is the reverse of 16th- and 17th-century models of unequal triple, in which the first part (beats 1 and 2) is twice as long as the second. See Grant, *Beating Time*.

\(^{16}\) London, “Hasty’s Dichotomy.”

\(^{17}\) Experiments suggesting that not only beat induction but also meter induction are innate human abilities are documented in Honing et al., “Is Beat Induction Innate or Learned?” and Honing, “Without it No Music.”

\(^{18}\) Attas, “Meter as Process” and “Form as Process.”

Matthew Butterfield has applied Hasty’s theory to accompaniment patterns characteristic of jazz and rock: swung ride rhythms played on the cymbals, and the backbeat pattern, which has kick (or bass) drum hits on beats 1 and 3 and snare hits on beat 4. Following Hasty’s model, he asserts that shortening or accenting notes on weak beats and off-beats, as well as connecting them to the following strong beat through slurred articulation, enhances their anacrustic effect. Extending the model to the level of microtiming, Butterfield posits that early attacks are more anacrustic because they are unexpected and focus the listener’s attention forward, while late attacks, despite being temporally closer to the next beat, are continuational rather than anacrustic because they represent the delayed realization of an expected event.

A significant advantage of Hasty’s theory is that it can be applied to polyphonic music. This stands in contrast to earlier models such as Lerdahl and Jackendoff’s, which is fundamentally homorhythmic, interpreting a single rhythmic layer — normally the melody — as primary. Accompanimental rhythms are treated as subordinate or omitted as unimportant. Mark Butler has observed that the distinction between rhythm and metre in these models typically maps onto the distinction between melody and accompaniment, often explicitly in popular-music analyses but implicitly in classical-music analyses. Butler’s focus is electronic dance music, which often lacks a clear distinction between melody and accompaniment, so Hasty’s theory, with its conflation of rhythm and metre, is particularly appropriate, but Butler’s analyses are primarily indebted to Harald Krebs’s work on metric dissonance.

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Krebs’s Model

Harald Krebs’s theory was explicitly designed to address multiple layers of metric and rhythmic structures. His model of metric dissonance categorises rhythmic or metric conflicts as one of two basic types, an idea originating in Peter Kaminsky’s dissertation on Schumann’s music, and developed more extensively by Krebs, most famously in his book *Fantasy Pieces*, which also focused on Schumann. Displacement dissonances consist of patterns that have the same grouping with one layer shifted forward or backward in time, while grouping dissonances involve patterns of different, coprime cardinalities. An important distinction between these two types is that grouping dissonances periodically realign with the metre after the number of beats that is equal to the product of their cardinalities (i.e., a pattern of 2 against 3 will realign after 6 beats; 3 against 4 will realign after 12 beats). Displacement dissonances, in contrast, do not realign unless one of the parts is adjusted. Krebs refers to successive nonaligned patterns as indirect dissonances, and simultaneous conflicts as direct dissonances. Most of Krebs’s examples are indirect dissonances, but direct dissonances are fairly common in rock music, especially in subgenres noted for metric play such as progressive rock and math metal. Displacement dissonances in rock and other popular musics typically occur in only one or two layers of the texture, most often in the vocals or the rhythm guitar, while grouping dissonances more often participate in multiple layers of the texture, because their cyclic realignment with the metre presents less of a challenge to it. In an article on the music of Herbie Hancock, Keith Waters usefully subdivides grouping dissonances into ‘measure-preserving,’ in which the barlines are aligned but the beats are not (typically involving triplets or some other form of tuplet), and ‘tactus-preserving,’ in which the beats are aligned but the barlines are not. Brad Osborn presents similar categories of beat-preserving and beat-changing metric shifts, as well as direct grouping dissonances, in the music of Radiohead.

Krebs refers to displacement and grouping dissonances at all levels as metric. In a consideration of ‘crooked’ tunes in bluegrass and old-time country music, Joti Rockwell defines disruptions of the tactus groupings as ‘first order,’ which many listeners would interpret as metric, and disruptions of the level above that as ‘second order,’ which many listeners would interpret as hypermetric. My own work on metric dissonance in rock music categorises temporal dissonances as rhythmic, metric, or hypermetric. As noted above, rhythmic dissonances in rock music are a normative style feature, while hypermetric dissonances (above the level of the bar) are rarer and metric dissonances still more so. The different rates of dissonance at different structural levels likely derives from the origins of rock as dance music, in which regular metre and hypermetre are more important than regular rhythm. At the rhythmic level, phrases tend to begin and end in alignment with the metre, with rhythmic dissonances either comprising much of the middle of the phrase or arising just before the phrase ends, as in a

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22 Coprime numbers, also called relatively prime or mutually prime, have no common factors other than 1. The most common examples of grouping dissonances are 2 against 3 and 3 against 4.
24 Waters, “Blurring the Barline.”
26 Rockwell, “Time on the Crooked Road.”
27 Biamonte, “Formal Functions.”
cadential hemiola — although cadential displacements are also widespread. Metric and hypermetric dissonances are typically used either throughout a formal section, creating contrast with other sections, or at a boundary between sections, serving as a transition. Through a series of small corpus studies, I demonstrate that metric dissonance has increased in rock music overall since the late 1960s, as well as within the music of some individual bands, particularly the Beatles and Led Zeppelin.

An example demonstrating both grouping and displacement dissonance is the synthesiser introduction to Van Halen’s “Jump,” reproduced in Example 3. The rhythmic pattern formed by the right-hand chords is a series of triple groupings moving to duple — a ‘double tresillo’ rhythm, discussed below — that seems to begin on beat 2, although when the pattern repeats it becomes clear that it began with a silent triple grouping displaced a quaver early, rather than a crotchet late. The groupings are shown with numbers and brackets above the staff. In Krebs’s notation, this grouping dissonance is symbolised as G2/3: triple-quaver groupings in a prevailingly duple-quaver context (the consonant layer is given first), although that context does not become clear until after the introduction. The displacement dissonance could be described as either D8-1 (a quaver early) or D8+2 (a crotchet late). Most of Krebs’ examples are interpreted as late displacements; in contrast, Temperley assumes that displacements in rock music are normatively anticipatory. Correlations of rhythmic dissonance types with styles and genres would be a fruitful avenue for further exploration.


Mark Butler’s analyses of electronic dance music focus on ambiguities of downbeat and of metric type and on clear instances of displacement and grouping dissonances. He identifies heightened versions of each dissonance type: ‘turning the beat around,’ a displacement dissonance that is normalised by shifting the downbeat, and ‘embedded grouping dissonance,’ comprising nested layers of grouping dissonances on multiple structural levels. Butler’s conception of embedded grouping dissonance is a specific type of Richard Cohn’s complex hemiola, which consists of duple and triple grouping dissonances on multiple adjacent levels, but the dissonances need not be nested or even related, whereas in Butler’s model the lower-level grouping dissonance creates the higher-level one. One important distinction between Butler’s

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28 See Biamonte, “Rhythmic Functions.”
29 Butler, Unlocking the Groove. See also Butler, “Turning the Beat Around” and “Hearing Kaleidoscopes.”
30 Cohn, “Complex Hemiolas.”
31 Butler discusses embedded grouping dissonances in “Hearing Kaleidoscopes” and in chapter 4 of Unlocking the Groove. In neither work does he consistently adhere to Krebs’s convention of labeling the referential (or consonant)
model and the others discussed here — indeed, one of his central arguments — is that the multilayered grooves and high degree of repetition in electronic dance music allow for multiple metric interpretations, potentially even by the same listener in the course of the same hearing. Jeff Pressing makes a similar claim for ‘Black Atlantic’ rhythm, his term for African diasporic popular musics, which he characterises as based on predictable repetition, overlaid with less predictable rhythmic techniques that either afford perceptual multiplicity or derive from speech patterns.

**London’s Model**

The metric layers of Krebs’s model, as in Lerdahl and Jackendoff’s, are regular. Justin London’s theory of metre has the advantage of allowing for nonisochronous (asymmetrical) metres. London’s main principle is that of entrainment: “a synchronization of some aspect of our biological activity with regularly recurring events.” Thus metre is a behavior of dynamically focused attention that waxes and wanes, and that can be learned and practiced. Metric attending is subject to cognitive constraints based on empirical research in music psychology and neurobiology. London formalises these limitations into a set of well-formedness constraints that are presented as stylistic and cultural universals. He proposes that we typically attend to three basic levels of rhythmic activity: the bar, the beat, and the beat subdivision. More levels are possible; the number of salient layers is the ‘depth’ of the metre. The combination of a time signature and its levels of structure represent a metric type, which can be further distinguished by tempo. We normally attend to periodicities of between 100 milliseconds and 5 to 6 seconds, with our most accurate perception, or ‘maximal pulse salience,’ at around 600 milliseconds. London’s ‘many meters hypothesis’ mediates between the abstract conception of a work and its concrete realization in sound, suggesting that metres can be further particularised in performance by expressive variations such as patterns of timing and dynamics.

Most analytical representations of metre are tied to conventional Western notation, and are thus linear and discrete. London departs from these earlier models in representing metre as a continuous circle, which reflects its temporal organization as a repeated cycle or series of nested cycles as well as capturing the dynamic flux of listeners’ entrainment. Points of metric articulation, which also represent peaks of listener attention, are shown as dots arranged clockwise around the circle beginning at the noon position (much like the pitch-class clock face or the circle of fifths). Because of the presence of an explicit pulse layer in most popular musics, as well as the high degree of repetition in many drum patterns, London’s cyclic representation of metre is particularly appropriate for popular music. Example 4 shows his diagrams of an 8 cycle layer of a grouping dissonance first—although to be fair, Butler observes that in electronic dance music, competing metric layers are not hierarchical or only weakly so (*Unlocking the Groove*, 167). Nor does Butler follow Krebs’s convention for labeling grouping dissonances in the same family, representing the same conflict on different structural levels, which Krebs labels as multiples of one another (Gx/y, G2x/2y, G3x/3y, etc. See Krebs, *Fantasy Pieces*, 42 and 56). For instance, using Krebs’s labeling, the grouping dissonances in Azzido da Bass, “Dooms Night” (Timo Maas mix) should be labelled 4/3 at the quaver level (not 3/2) and 8/6 at the next higher level (not 4/3, because the durations in the part labelled synth 3 are dotted crotchets, not crotchets). See Butler, *Unlocking the Groove*, Ex. 4.15, 157.


33 Pressing, “Black Atlantic Rhythm.”

with 4-beat and half-bar cycles (dividing the bar into 8 quavers, 4 crotchets, and 2 minimis in 4/4); a ‘Charleston’ 3+5 rhythm, which combines the last two attacks of the 332 ‘tresillo’ rhythm; and two versions of the ‘double tresillo’ rhythm, 333322 and 33334. These rhythmic patterns are discussed further below.

Example 4: London’s cyclic representation of metre. From London, *Hearing in Time*, Fig. 5.6, 97; Fig. 9.6, 154; Fig. 9.10, 166. Descriptions added.

Yust’s Model

In his recent book *Organized Time*, Jason Yust models meter as a hierarchical network of timespans, as shown in Example 5. He describes this representation as unfolding London’s cycle, but it could also be thought of as refocusing on the durations between Lerdahl and Jackendoff’s hierarchical layers of timepoints. His larger project uses networks to explore the interactions of what he considers to be the three primary temporal dimensions of music: rhythmic, tonal, and formal structure. Yust, like Hasty, conceives of meter as a special case of rhythm, one that is perfectly regular and may include unsounded events.35 The exclamation point in Ex. 10.5 marks an imaginary timespan between beats 3 and 4 that is not marked by any musical event, but that is nevertheless subdivided by the quaver E, which depends on the dot at beat 3 to define its place in the meter (the other empty dots are unproblematic because none disrupt a relationship between filled dots). Networks of metric structure define ‘rhythmic classes’ as groups of rhythms related by transformations such as changing the meter, changing the beat subdivision, expansion, contraction, and syncopation.36 All of his musical examples are drawn from art music, but one concept that is likely to prove useful for popular-music analysis is ‘contrapuntal rhythmic dissonance’: the rhythmic conflicts of individual layers of the texture with the combined rhythmic structure of all the layers.37

36 Yust’s acknowledged model for these rhythmic transformations is the ‘non-commutative GIS [general interval system]’ presented in chapter 4 of David Lewin’s *Generalized Musical Intervals and Transformations*. See Yust, *Organized Time*, 109.

(a) The first four measures of the theme from Haydn’s “London” Symphony (no. 104),
(b) a metric structure including empty timepoints (shown with open dots), and (c) a rhythmic structure whose nodes include all the timepoints articulated in the melody

The Relationship of Rhythm and Metre

The five theoretical models considered thus far offer four different views of the relationship of rhythm and metre: as a single entity, with metre as a specific form of rhythm; as a two-layer figure/ground relationship, with metre as a background, a container, or a ruler; or as three cyclic layers — or more, depending on the ‘depth’ of the metre — that may be coordinated or nonaligned, with metre imposed by the listener rather than projected by the music. In Lerdahl and Jackendoff’s model, as well as Richard Cohn’s research on this topic, rhythm and metre are separate. Rhythmic structure is a concrete foreground figuration that normally supports the more abstract background of the metric structure, which comprises at least two isochronous pulse layers, with a slower layer grouping a faster one. Grouping and metre form recursive hierarchies on multiple levels, but listeners privilege one intermediate metric level as the tactus. Hasty, in contrast, conceives of rhythm and metre as inseparable. He rejects the idea of beats as durationless instants and as inherently accented or unaccented, and rejects the distinction between rhythm and metre as qualitatively different structures. In his theory, metre is created by the listener’s expectations regarding and interpretations of rhythmic durations: metre is a particular type of rhythmic patterning, based on note length rather than accent. Krebs’s view falls somewhere in between these two models: metre is created by rhythm, but they are separable. He defines metre as the interaction of the pulse layer (the fastest regularly recurring duration) and its subdivisions with slower-moving interpretive layers that group the pulses. When interpretive layers are in conflict, one normally acts as the consonant or referential layer. Krebs describes the large-scale interpretive layers that group bars together as hypermetric, but makes no categorical distinction among lower-level layers as either metric or rhythmic; however, in many of his analyses a distinction between rhythmic patterns and metric layers is explicit. London’s model, like Lerdahl and Jackendoff’s, maintains the traditional separation of rhythm

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38 While Lerdahl and Jackendoff’s and Hasty’s models of rhythm and meter have often been described in opposition, recent work by Danuta Mirka integrates the two approaches, combining Lerdahl and Jackendoff’s hierarchical dot notation with Hasty’s phenomenological projective arrows. See Mirka, *Metric Manipulations.*
and metre: metre is an attentional behavior, and rhythm is the patterned events to which we attend. Unlike most earlier conceptions of metre as having two basic levels, the beat and its grouping into bars, London’s model comprises at least three levels: the beat, its grouping into bars, and the beat subdivision.

Another distinction among these theories is that London’s and Hasty’s models foreground listener experience, albeit in quite different ways: London privileges entrainment to metric groupings, while Hasty privileges the perception of individual note onsets. In contrast, both Lerdahl and Jackendoff’s and Krebs’s theories foreground the notated score. Despite Lerdahl and Jackendoff’s framing of their theory as cognition-based, their analyses are fundamentally formalist, hierarchical interpretations of the score. Similarly, Cohn identifies four possible ‘locations’ of meter – sonic projection, mental pattern recognition, embodied response, and notated time signature, which he summarises as in sound, mind, body, or score – and claims that his model takes the domain of sound as its entry point, but the actual entry point is mental pattern recognition, as most of the discussion focuses on abstract groupings of pulse layers.

Rhythmic Patterns in Pop-Rock Music

Several theoretical models for the syncopated patterns so pervasive in rock music have been proposed. One oft-invoked principle is that of maximal evenness: the idea that rhythmic attacks tend to be spaced as evenly as possible. Jeff Pressing was the first to describe this principle in music, by which he related the pentatonic and diatonic scales to West African bell patterns that also have the interval patterns 22323 and 2212221. Jay Rahn labelled these ‘diatonic rhythms,’ by analogy with the diatonic scale. Diatonic rhythms are maximally even distributions of an odd number of attacks across an even number of pulses, just as the seven notes of the diatonic scale and the five notes of the pentatonic scale are maximally evenly distributed across the twelve notes of the chromatic scale; they are as even as possible without being absolutely even. Like the pentatonic and diatonic scales, diatonic rhythms have two sizes of steps, or adjacent intervals, and they also share the property of maximal individuation: each note has a unique set of relationships to the other notes.

In his study of electronic dance music, Mark Butler classified rhythmic patterns as even, syncopated, or diatonic. Even rhythms are consonant with the quadruple metre, dividing it equally. All of his examples are drum-kit patterns: the four-on-the-floor rhythm often played by the bass drum, which marks every beat; the backbeat pattern on beats 2 and 4, usually played by the snare drum; and off-beat patterns on the quavers and straight semiquavers, both of which are common hi-hat rhythms. Syncopated rhythms are created through rhythmic displacement, and feature accents on weak beats but preserve the basic metric structure. The most common diatonic rhythms are grouping dissonances that conflict with the metre, typically through a series of triple

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39 Cohn, “Meter,” pp. 3–4 of chapter.
40 The principle of maximal evenness in music was first explicitly described in relation to pitch collections in Clough and Douthett, “Maximally Even Sets.” It also reflects the behavior of electrons (Johnson, Foundations of Diatonic Theory), as well as the ways people arrange themselves in public spaces such as elevators.
41 Pressing, “Cognitive Isomorphisms.” Pressing does not use the term ‘maximal evenness,’ but observes that these patterns space their attacks as equally as possible.
42 Rahn, A Theory, 76–77, and “Turning the Analysis Around.” See also Stewart, “Articulating the African Diaspora.”
43 Butler, Unlocking the Groove, 81–85.
groupings, ending with a duple group that realigns with the metre, such as 332 and 33334 (the ‘tresillo’ and ‘double tresillo’ rhythms, respectively, discussed further below).

Because of their near-equal distribution and similar interval sizes, Justin London has observed that maximally even rhythms optimise the potential for entrainment and also facilitate regular kinesthetic engagement (such as foot tapping, dancing, headbanging). But some rhythms, such as 34333, are maximally even but not at all common in practice, while others, such as 35 and 333322, are very common in practice but not maximally even — although admittedly both of these latter examples are related to maximally even rhythms: 35 is a subset of 332, combining its last two attacks, and 333322 is a superset of 33334, dividing its last attack. London’s chapter “[Nonisochronous] Meters in Theory and Practice” describes numerous violations of maximal evenness. So while this principle may be aesthetically appealing, it does not seem to be the ideal explanation for the prevalence of these rhythmic and metric patterns.

‘Euclidean’ rhythms include the maximally even diatonic rhythms described above, but also rhythms that are not maximally even. This group of rhythms has been explained mathematically and related to various world musics by Godfried Toussaint, and Brad Osborn has explored their occurrences in the music of Radiohead. Osborn cites the 3322 groove of Radiohead’s “Morning Bell” (Kid A, 2000) as a common pattern in quintuple metre that is Euclidean but not maximally even; Dave Brubeck’s “Take 5” (1959) and Jethro Tull’s “Living in the Past” (1969), which are also in 5/4, use the same pattern (sometimes called the 5/4 clave). Yet the same issue obtains as with maximal evenness: there are many more Euclidean rhythms in theory than in practice.

Richard Cohn focuses on a different mathematical property to explain common rhythms in popular music: prime generation. Prime-generated patterns are created by repeatedly cycling an interval that is coprime with the cardinality of the larger unit: a pitch collection for scales, a pulse cycle for rhythm. Just as the pentatonic and diatonic scales can be generated from fifth cycles (a fifth comprises 7 semitones, coprime with the 12 semitones of the chromatic aggregate), triple cycles in the context of 4, 8 or 16 beats generate what Cohn calls a ‘funky rhythm.’ Complete cycles eventually realign with the metre (in the pitch analogy, a complete fifth cycle generates the circle of fifths), but it is common for the cycle to be adjusted to realign at an earlier point. When this happens, the final interval is a slightly different size than the others; Cohn refers to this difference in size as a comma, by analogy with the Pythagorean and Platonic commas. In the fifth cycle that generates the pentatonic scale, the last interval that wraps back around to the starting point is a minor sixth, while in the diatonic scale it is a diminished fifth; in both cases the comma is a semitone. In 3-generated ‘funky rhythms,’ the comma is also a single unit: the last

45 Ibid., 143–70.
46 Euclidean rhythms are based on the Euclidean algorithm, an ancient method for calculating the greatest common divisor of two integers by repeatedly subtracting the smaller number from the larger, and if needed, the remainder from the smaller number, until the remainder is 0. A more efficient modern version is to divide the smaller number into the larger. To translate this into a rhythm, the larger number represents the meter or pulse cycle, and the smaller the number of note onsets. For example, in an even distribution of 4 onsets in an 8-pulse cycle, the onsets are spaced 2 pulses apart (the greatest common divisor of 8 and 4 is 2, with no remainder). The algorithm is more complex when the numbers are coprime; for a clear explanation, see Panos Louridas, “Musical Rhythms.”
48 The concept of prime generation was introduced in Pressing, “Cognitive Isomorphisms;” 3-generated funky rhythms are described in Cohn, “Music Theory’s New Pedagogability,” and explored in much greater depth in “A Platonic Model.”
groups of the 332 ‘tresillo’ and 33334 ‘double tresillo’ rhythms differ from a triple group by one pulse. The 3-generated model nicely reflects the tendency of triple groupings to conclude with one or more duple groups. Cohn offers a variety of examples, including some impressively long cycles.

In response to Cohn, Scott Murphy offers a broader model intended to more closely reflect the rhythmic patterns used in popular music, including patterns that begin with duple groups. He diagrams all possible combinations of rhythmic groups of 2 and 3 (for reasons of space, he limits the combinations to cardinalities between 2 and 6), excluding rotationally invariant succesions. Among these, he calls the minimally even succesions that begin and end with different durations ‘Platonic,’ thus clustering the duple and triple groups separately. Platonic succesions whose beginning string of groups exceeds the ending string in duration are ‘Platonic-trochaic.’ All of Cohn’s examples are Platonic-trochaic; Murphy includes some Platonic-iambic examples, with longer ending strings than beginning strings, but these are far less common. He exchanges the concept of maximal evenness for that of ‘near realization,’ comprising looped patterns in which most of the durations realise their potential to immediately repeat. Nearly realised Platonic-trochaic rhythms, Murphy argues, optimise their periodicities and best represent the patterns used in recent popular English-language multimedia (which includes film and television soundtracks as well as popular songs). This model more closely reflects compositional practice: of Murphy’s fifteen Platonic-trochaic rhythms, the two that fit comfortably in 4/4, 332 and 333322, are among the most common syncopations in popular music. The Platonic-trochaic patterns in quintuple meter (32 and 3322) and septuple meter (223) are likewise very prevalent within the much smaller subset of songs in those meters.

Another explanation for the grouping patterns so prevalent in popular music lies not in their mathematical properties but their historical origin in the clave pattern, a two-bar grouping of 3342. It seems likely that this rhythmic pattern derives from West African music, which has a standard bell pattern that functions as a timeline; the bell pattern is in 12/8 in Western terms, but has the same durational proportions as the clave rhythm. The clave rhythm was probably transmitted to the Caribbean and Latin America through the slave trade, through Cuba and New Orleans, and then disseminated throughout the United States and elsewhere. The first bar of the clave rhythm is a 332 grouping called the tresillo, and I have called its extended version, 333322 or 33334, a double tresillo. An early version of such beat-preserving triple subdivisions in a quadruple context is the concept of ‘secondary rag.’ In 1926, Don Knowlton cited an unnamed black guitar player who explained primary rag as simple syncopation (a characteristic pattern is semiquaver–quaver–semiquaver) and secondary rag as groupings of three superimposed on groupings of four beats, typically realised as three-quaver groups in 4/4. Such patterns are extremely common in many genres of popular music, including jazz, rockabilly, rock, funk, and electronic dance music.

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49 Murphy, “Cohn’s Platonic Model.”
50 Murphy refers to the beginning succession of durational groups as the ‘run’ and the ending succession as the ‘comma’, although Cohn uses ‘comma’ to describe the difference between an ideal and an adjusted ending group, not the ending group or groups as a whole.
51 Knowlton, “Anatomy of Jazz.”
52 I briefly discuss clave-based patterns in Biamonte, “Formal Functions,” [6.4] and Example 8. Clave-based rhythms are also considered in Washburne, “The Clave of Jazz;” Brewer, “Habanera Rhythm;” Traut, “Simply Irresistible” (although Traut does not describe these rhythms as clave-related); Danielsen, Presence and Pleasure; Chor, “Cognitive Frameworks” and Moore, Song Means, 68.
The Binary Default

The overwhelming prevalence of popular music in 4/4 demonstrates what David Huron has identified as the ‘binary default.’ Huron surveyed the meters of more than 8000 ‘classical’ works listed in Barlow and Morgenstern’s *Dictionary of Musical Themes* (1948), a catalog of over 10,000 melodies drawn from recorded instrumental works of Western art music from the Baroque through the early twentieth century. He determined that duple and quadruple meters were twice as common as triple or other meters, and that simple meters with a binary subdivision were six times as common as compound meters. In popular music, duple and quadruple meters are even more prevalent. Alexander Stewart has documented the shift from compound meters with triple subdivisions of the beat and unequal duple subdivisions of the beat such as swung and shuffle rhythms to a simple-meter even subdivision in the middle of the 20th century. This shift is likely at least in part consequence of the use of faster tempos.

The binary default means not just that a majority of Western music is in duple or quadruple meter, but that this prevalence leads Western listeners to expect that beats and subdivisions will form binary pairs of strong and weak, or weak and strong, beats. The binary preference is likely related to our own body plan, which features bilateral symmetry: our right and left sides are mirror images, so we have two eyes, two arms and hands, two legs and feet, etc. It may also derive from physical processes related to this bilateral plan: we walk and breathe in a duple pattern, our heart beats in an unequal or swung duple pattern, and the motions of sexual intercourse — whether straight or swung — are also basically duple.

The Backbeat

The preference for duple and quadruple meters in popular music is reflected in the organization of the most common drum pattern, the backbeat. In pop, rock, and related genres from the early 1950s onward, the rhythm layer is typically some version of a crotchet backbeat in 4/4 played on a drum kit, with a bass drum on beats 1 and 3, snare drum on beats 2 and 4, and hi-hat cymbals on the quavers, or in disco and funk on the semiquavers. The repeated registral traversals of the backbeat from low to high suggest or impel motion, and may be a modern iteration of the foot stomps and hand claps in the African religious ritual of the ring shout. Whether intentionally or not, Queen famously returned to this early version of the pattern in “We Will Rock You” (*News of the World*, 1977).

The snare drum is higher in register, has a sharper timbre, and is louder than the bass drum, thus placing several types of phenomenal accent on what are traditionally the weak beats in 4/4. In practice, though, the backbeat pattern is treated as a rhythmic consonance. Backbeats normally remain fairly consistent throughout entire song sections or songs; they are foundational patterns that do not need to resolve. Because of the snare’s higher pitch, sharper timbre, and shorter duration compared to the bass drum, Matthew Butterfield and Robin Attas interpret it as normatively anacrustic in light of Hasty’s theory. I interpret backbeats as normatively

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54 Stewart, “‘Funky Drummer.’”
55 Iyer, “Microstructures of Feel.”
56 Robert Fink argues for the status of a four-on-the-floor rhythm, with bass drum hits on every beat, as a stable tonic rhythm in two songs by *The Temptations*, although in these examples the rhythm is absent for most of the songs. See Fink, “Goal-Directed Soul?”
continuational, because of the longer resonance of the bass drum, which connects it to the snare attack, and also because the snare hits are normally played behind the beat. A subdivision of the snare into two quavers would render it more anacrustic, while subdivision of the bass drum on 1 and 3 would render the snare backbeats more continuational.

The backbeat pattern creates a clear distinction between odd-numbered and even-numbered beats of the meter. Thus it normally articulates three levels of temporal organization: the bar, the beat, and the beat subdivision. Some exceptions are discussed by Trevor de Clercq, who presents convincing examples of half-time and double-time backbeats. He argues that an important criterion for defining a measure is absolute time, based on studies showing that the ideal tempo for beat perception is 120 beats per minute (and, more circumstantially, that most modern music production software programs default to 4/4 meter 120bpm), which translates into an average bar length of 2 seconds.

Rhythm and Dance

The rhythm layer played by the drums and auxiliary percussion reflects the origins of pop-rock as dance music. In addition to its basic timekeeping function, the drum part affords an intensified entrainment to the meter that facilitates bodily engagement, and it also allows for greater rhythmic complexity in the other layers. Research by Maria Witek suggests that syncopated rhythms also contribute to bodily engagement. She posits that the lack of phenomenal accents on accented beats in syncopated rhythms prompts listeners and dancers to fill in these metric spaces with motion. Through a small study, she provides empirical evidence that a moderate degree of syncopation in funk beats impels listeners to move — and is perceived as pleasurable — significantly more than low or high degrees of syncopation. Other small studies have found that dancers tend to synchronise head motions to low-frequency patterns and hand motions to high-frequency patterns, and arm motions to the beat and torso motions to the half-bar and bar. Much more work on this topic is needed.

Directions for Future Research

As noted, research on the relationship of rhythm in popular music to dance is still in its infancy. It would be helpful to have empirical research that goes beyond tapping studies and surveys to provide a better reflection of dancers’ embodiment to the beat. More motion-capture studies would be a step in the right direction, although it would be better still to study dancers in a less artificial setting, despite the many hurdles this would present regarding experimental

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58 de Clercq, “Measuring a Measure;” see also de Clercq, “Swing, Shuffle.”
60 Witek et al., “Syncopation, Body-Movement.” In the study, 66 participants rated 50 drum breaks without microtiming variations, largely reproduced from funk tracks, with some newly composed breaks using particularly low or high degrees of syncopation that were unavailable in the repertoire.
61 Burger et al., “Influences of Rhythm- and Timbre-Related Musical Features.”
62 Toiviainen et al., “Embodied Meter.” Unlike the studies cited immediately above, this article gives almost no information about the music that was used as a stimulus: “a piece of instrumental music in 4/4 time, played at four different tempi ranging from 92 to 138 bpm” (59).
design and controls. An examination of dancers on television, video, or even in dance-related computer games would be easier to set up and might present interesting results. It would be interesting to look for correlations of dance motions with different beats, such as a standard backbeat with quaver hi-hat, a dense backbeat with semiquaver hi-hat, and four-on-the-floor.

Surprisingly little analysis has been done on several genres in which the rhythm is an important foreground element: R&B (ironic, considering that ‘rhythm’ is part of the name), progressive rock, disco, and funk. In all four of these genres, but perhaps most especially in funk, it would likely be productive to examine the relationship between rhythmic patterns in the drums and the bass. It may also be possible to identify elements of rhythmic function, such as Fink’s conception of the tonic status of the four-on-the-floor pattern in Motown. Long-term goals for the discipline could be to identify the typical rhythmic and metric characteristics — levels and types of dissonances, early vs. late displacements, backbeat characteristics (whether the second kick-drum hit is on beat 3 or displaced, whether the cymbal ride rhythm is in quavers or semiquavers, etc.) — of particular chronological periods as well as specific genres.

Two parameters that lie outside the bounds of this chapter, but which would benefit from further study, are microtiming and hypermetre. Microtiming variations within the rhythm layer seem to have genre correlations that are as yet unexplored — for example, the snare backbeat is later in funk than in other genres. Much of the extant research focuses on variations within the drum kit or between the drums and bass; as yet there has not been much consideration of microtiming relationships among the other layers of the texture. Hypermetre may well be less consistently regular than we assume, and the closely related topic of phrase structure is underanalysed and undertheorised in this repertoire. As noted at the beginning of this chapter, rhythm is one of the most salient parameters in rock and related genres, and also one of the most complex, promising a rich field of inquiry for decades to come.