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Why Do Jazz Musicians Swing Their Eighth Notes?

MATTHEW W. BUTTERFIELD

In jazz, the function of durational inequality at the eighth-note level is the production of anacrusis on the offbeats, thereby generating the sense of forward propulsion and drive thought to typify the rhythmic quality known as "swing." The common use of relatively "straight" eighth notes by improvising soloists helps to sustain forward momentum, whereas the less even, triplet-like "swing" eighth notes used more frequently by drummers facilitate the perception of a quarter-note beat. Varying the Beat-Upbeat Ratio (BUR)—i.e., moving between straight and swing eighth notes—enables jazz musicians to manipulate the flow of motional energy across a phrase in systematic ways in conjunction with other melodic processes. Analyses of melodic phrases by John Coltrane, Lee Konitz, and Sonny Clark reveal the centrality of such aspects of microrhythmic expression to the affective power of jazz improvisation.

Keywords: anacrusis, beat-upbeat ratio, BUR, Sonny Clark, John Coltrane, rhythm, jazz, Lee Konitz, microrhythm, microtiming, motional energy, swing, swing eighth note, swing ratio

Although swing is the central rhythmic quality native to jazz, identifying its precise nature has been no less difficult than explaining its effects. The term "swing" designates the use of uneven eighth notes, to be sure, but it also refers to a lilting rhythmic groove emerging from the interaction of bass and drums as they maintain the beat. More importantly, however, swing designates a general rhythmic ethos—a mysterious quality purportedly transcending representation in musical notation—prompting active listener engagement, often expressed through spontaneous foot-tapping, head-bobbing, hand-clapping, finger-snapping, or even dancing.[1] Often casting this elusive phenomenon as a manifestation of an African-derived "hot rhythm,"[2] many writers have sought to capture it in language and explain the means of its production. André Hodeir called it "vital drive," a quality involving "a combination of undefined forces that creates a kind of 'rhythmic fluidity' without which the music's swing is markedly attenuated."[3] At the same time, he was at a loss to explain its cause: "If I weren't afraid of straying too far afield," he wrote, "I would suggest that this drive is a manifestation of personal magnetism, which is somehow expressed—I couldn't say exactly how—in the domain of rhythm."[4]

Undaunted by the fog of Hodeir's conception, Charles Keil later appropriated "vital drive" as an aspect of what he called "engendered feeling"—essentially, a more general term for swing or groove. Defined in opposition to Leonard Meyer's concept of "embodied meaning," engendered feeling concerns the non-syntactical, processual domain of expression Keil finds in groove-based musics such as jazz and polka.[5] Vital drive is central to engendered feeling for Keil, and he uses the term to designate a quality of energy and propulsion that stems from the cumulative tension achieved by "pulling against the pulse"[6]—i.e., the timing of note attacks either "on top" of or "behind" the beat, a practice he later termed "participatory discrepancies," or PDs.[7] Though many timing discrepancies are at play in any jazz performance, most work on the PD model has made the assumption that specifically "the gaps, large or small," between bass and drums in their joint articulation of the beat, "provide the push or layback feel of a particular performance."[8] Unfortunately, neither Keil nor anyone else has ever provided any evidence that such discrepancies are actually perceptible, much less that they do in fact generate the rhythmic quality we call swing. Indeed, there is significant evidence to the contrary.[9]

For Gunther Schuller, the defining character of swing involved both "a specific type of accentuation and inflection with which notes are played or sung" and "the continuity—the forward-propelling directionality—with which individual notes are linked together."[10] These features of jazz rhythm, he proposed, result from "the perfect equilibrium between the horizontal and vertical relationships of musical sounds."[11] However, what constitutes this

I would like to thank Eugene Narmour and Fernando Benadon for the invaluable feedback they provided in the early stages of this project.

1 "Swing," of course, also refers to music of the swing era. In this article, however, I am concerned only with the unique rhythmic quality specified by this term since one of its earliest appearances in print in Kingsley (1917).

2 See, for example, Waterman (1948).

3 Hodeir (1956, 207).

4 Ibid. (207–08).

5 On "embodied meaning," see Meyer (1956, 34–35). On his objection to Meyer and his argument for "engendered feeling," see Keil (1966, 337–39, 345–48) and (1995, 1). Briefly, Keil objected to the "deferred gratification" he thought was central to embodied meaning. He asserted instead that music operates on a more immediate and visceral level drawing participants into the experience in an emotionally pleasing way without requiring some level of denied expectation for the production of affect.

6 See Keil (1966, 341).

7 Keil (1987, 275–79).

8 Prögler (1995, 34).

9 Butterfield (2010).

10 Schuller (1968, 7).

11 Ibid.

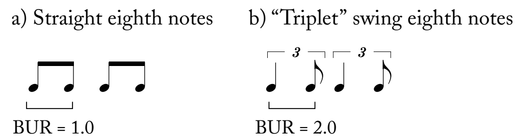
"perfect equilibrium" and how it is achieved, remain unexplained in Schuller's account of swing. He was concerned with detailing the emergence of swing as an outcome of the superimposition of a European metrical framework upon African rhythmic impulses, as opposed to explaining the expressive effects of swing or the specific means of its production.

More recently a number of scholars, whose work is detailed below, have taken a more limited approach to the swing phenomenon, concentrating more closely on the "swing ratio"—what I shall call, following Fernando Benadon, the "Beat-Upbeat Ratio," or BUR.[12] The BUR expresses the durational relationship between the long, downbeat eighth note and the short upbeat that follows it. Swing-ratio research has typically sought to define the average ratios used either by drummers or soloists. Though promising, this work has often seemed motivated by an interest in quantifying the essence of swing, as though finding the ideal "golden ratio," as it were, might unlock and define its mysterious character once and for all. As a result, it has generally failed to explain the affective consequences of the wide range of BUR values actually employed by jazz musicians in performance.

Surprisingly, what remains largely unexplored in most research on jazz rhythm is why jazz musicians swing their eighth notes in the first place. What do they gain from it? Vijay Iyer has observed that durational inequality between successive swing eighth notes "facilitates the perception of higher-level rhythmic structure." It induces perceptual grouping of eighth notes "into the larger regular interval, that is, the quarter note. If all subdivisions were performed with exactly the same duration, it would be more difficult to perceive the main beat."[13] Enhanced perception of the tactus, he suggests, supports the basis of swing rhythms in dance contexts, grounding swing "in the locomotive channel of human motion"—i.e., it draws perceptual attention from the eighth-note level to the slower-moving quarter-note pulse layer, facilitating listeners' motor engagement with the rhythmic groove.[14]

This is certainly one important consequence of swing eighth notes, especially as it pertains to rhythm section performance, as we shall see. But I would like to suggest that there are additional expressive effects of swing eighth notes beyond the rather functional explanation offered by Iyer, other ways in which the varied BUR values employed by jazz musicians contribute systematically to the production of swing—the engaging, forward-propulsive quality Hodeir, Keil, and Schuller sought to define and explain. In what follows, I present a theory of the expressive function of the swing eighth note. Swing, I suggest, is less a specifiable rhythmic essence than an active rhythmic process involving the skillful management of "motional energy" in the midst of performance. Jazz musicians achieve this in multiple ways, one of which is the microrhythmic variation of swing eighth-note durations over the course of a melodic phrase.

12 Benadon (2006, 74–76).
13 Iyer (2002, 404).
14 Ibid. (405).



EXAMPLE 1. *BUR values for straight and "triplet" swing eighth notes*

PRELIMINARY TERMINOLOGY

I use the phrase "motional energy" to designate the force of momentum with which some musical events are directed toward others. Motion perceived in music is often oriented around points of emphasis or stability; an upbeat moves toward the ensuing downbeat, for example, and a dissonance is drawn toward its implied resolution. But the motional qualities we perceive in music also exhibit varying degrees of velocity or intensity, as does motion we perceive in physical space, and it is this quality that I hope to convey with the term motional energy. Following this logic, a series of sixteenth notes imparts more motional energy than a series of eighth notes, and a strong dissonance is drawn toward its resolution with greater force than a weak one. Similarly, countercumulative durational patterning, movement from longer durations to shorter ones, typically entails an increase in motional energy, whereas cumulative durational patterning, movement from shorter durations to longer ones, tends to decrease motional energy and draw it toward closure.[15]

My treatment of the expressive function of the swing eighth note will be narrowly limited to the affective consequences of durational inequality on the production of motional energy on the short offbeats—a function of the BUR—and the attenuation or closure of such energy on the longer downbeats—a function of the UBR, or "Upbeat-Beat Ratio."[16] A broader range of affect ensues from durational inequality in conjunction with pitch events, but I will not treat this relationship systematically in the present essay, though some idea of its effects will emerge on an ad hoc basis in the context of analysis. I shall have more to say about the UBR later; for now, I will concentrate on the BUR.

The BUR is calculated by dividing the absolute duration of the long, downbeat eighth note by that of the short upbeat. Higher BUR values indicate greater durational inequality between successive eighth notes, whereas lower values tend increasingly toward evenness. Thus "straight" eighths, as shown in Example 1(a), are even and have a BUR of 1.0. The conventional assumption has been that swing eighth notes, though commonly notated as in Example 1(a), reflect an underlying triplet pulse and are performed as a quarter-eighth triplet pair with a BUR of 2.0, as shown in Example 1(b).[17]

15 "Durational cumulation" and "countercumulation" are terms drawn from Narmour (1990, 26).
16 Benadon introduces the acronym UBR, but does not in fact define it explicitly. Instead, UBRs emerge in his Example 4 as "hidden low BURs" created by pianist Bill Evans's insertion of three-note dactylic groups in the midst of a normative pattern of two-note groups (2006, 78–79).
17 On the tenacity of the "triplet" swing eighth note in the jazz literature, see Benadon (2006, 88–94). See also Povel (1981). Povel's experiments 1 and 2

Rose (1985) *Solo breaks on fifteen jazz recordings from the 1940s–60s*	Average BUR value: 1.43 Range of BUR values: 1.05 to 1.89
Ellis (1991) *Common melodic patterns performed by three contemporary saxophone players*	Average BUR value: 1.701 Range of BUR values: 1.474 to 1.871, declining slightly as tempo increases
Collier and Collier (2002) *Stop-time solos by Louis Armstrong on "Potato Head Blues" and "Cornet Chop Suey"*	Average BUR value: 1.61 Range of BUR values: not provided
Busse (2002) *Swing ratio figures for 281 measures of eighth-note passages by three contemporary professional jazz pianists*	Average BUR value: 1.74 Range of BUR values: not provided
Friberg and Sundström (2002) *Swing ratio figures for three horn players and three pianists from six post-bop jazz recordings made between 1960 and 1990*	Average BUR value: not provided Range of BUR values: 1.0–1.8, declining as tempo increases
Benadon (2006) *Eighth-note passages in recordings of five bop and post-bop jazz musicians*	Average BUR value: not provided Range of BUR values: 79%: 0.90–1.4; 19%: 1.5+

EXAMPLE 2. *A summary of empirical studies of BUR values among soloists*

Current research on the swing ratio has shown this assumption to be inaccurate, however; BUR values among jazz musicians are now known to range from an even 1.0 to as high as 3.5, varying with tempo and ensemble function (i.e., soloist vs. accompaniment), as discussed below. Naturally, this raises the question of just how swing eighth notes should be notated. One could surely represent passages with high BUR values in quarter-eighth triplet pairs, dotted eighth-sixteenth note figures, or one of several quintuplet variations. I will nevertheless continue to speak of BUR values at or above 2.0 in terms of eighth notes. In part, this is in keeping with conventional jazz notation practices: jazz musicians are accustomed to seeing eighth notes in notation and "swinging" them in performance. But this tradition also speaks to habits of thought concerning the division of the quarter-note beat in jazz: when playing "straight," one divides the beat into two equal parts, whereas swinging involves division into two unequal parts, the first of which is longer than the second. The degree of inequality does not stipulate a categorical distinction that would be reflected in notation; a BUR of 3.0, though considerably more uneven than a BUR of 1.5, is nevertheless conceived in the same way: as a pair of eighth notes made unequal; it would not be notated as a dotted eighth-sixteenth pair, even though that is technically what the ratio specifies. Consequently, in the transcriptions that follow, I will continue to employ ordinary eighth notes in notation with BUR values shown underneath the staff to indicate the degree of unevenness. This best reflects what I believe jazz musicians understand swing eighth notes to be.

reveal that, in the absence of a well-defined, beat-oriented context, listeners tend to assimilate durationally uneven ratios ranging from 1:4 to 4:5 to a simpler 1:2. Thus subjective interpretation of swing ratios tends toward the triplet model simply because any succession of unequal durations tends to sound to us like triplets.

RECENT RESEARCH ON THE SWING RATIO

Example 2 shows the BUR values reported for jazz soloists in a number of recent studies on the swing ratio.[18] All of these have shown a preference for BUR values well below the classic 2.0 "triplet" feel. Richard Rose reported BURs ranging from 1.05 to

18 Swing ratio figures of all studies cited in this essay have been converted to BUR values.

Rose (1989) *Timing relationships among piano, bass, and drums on a Jamey Aebersold play-along record*	Average BUR value: 2.38 Range of BUR values: not reported
Prögler (1995) *Swing ratio in Charles Keil's ridetap*	Average BUR value: 3.4–3.7 at 120 bpm; 2.0 at 240 bpm
Friberg and Sundström (2002) *Swing ratio figures for four jazz drummers on six post-bop recordings made between 1960 and 1990*	Average BUR value: not reported Range of BUR values: 2.2–3.5 below 150 bpm; 1.0–2.8 above 150 bpm, declining as tempo increases
Collier and Collier (1996) *Ride rhythm performed by three drummers on a MIDI drum pad*	Average BUR value: 2.36 (1.85, 2.23, 3.01) Range of BUR values: ≈1.0–3.5 for tempos at or above 100 bpm, declining as tempo increases
Honing and Haas (2008) *Ride rhythm performed by three drummers on a MIDI drum kit*	Average BUR value: not reported Range of BUR values: stable at about 2.2 for tempos below 170 bpm; declining to about 1.2–1.7 as tempo increases above 170 bpm

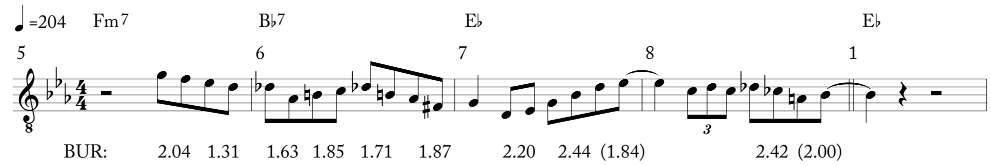
example 3. *A summary of empirical studies of BUR values within rhythm-section accompaniments*

1.89 in a study of solo breaks found on fifteen recordings of established jazz musicians from the 1940s–60s, with an average of about 1.43 irrespective of tempo.[19] Mark Ellis asked three professional jazz saxophone players to perform three melodic patterns "common to the swing style" over a twelve-bar blues with bass and piano accompaniment. In fifteen trials, three each at five different tempos, he found average BUR values ranging from 1.474 to 1.871, with a grand average BUR of 1.701.[20] Geoffrey and James Lincoln Collier identified average BUR values of 1.61 and 1.58 for Louis Armstrong's stop-time solos in "Cornet Chop Suey" and "Potato Head Blues," respectively,[21] and Walter Gerard Busse found a composite average BUR of about 1.74 in his study of eighth-note timings in 281 measures from thirty-three performances by three contemporary professional jazz pianists.[22] Anders Friberg and Andreas Sundström refrained from calculating an overall average in their study of six live jazz recordings by internationally renowned jazz musicians made between 1960 and 1990, but most of their figures reveal BUR values for soloists (three horn players and three pianists) of under 2.0, with a significant cluster around 1.0 at tempos above 260 bpm.[23] Finally, Benadon found that about 61% of 831 pairs of eighth notes drawn from the recordings of five internationally acclaimed bop and post-bop jazz musicians fell within the BUR range of 0.9–1.2; 79% were within the range of 0.9–1.4; but only 19% had shown BURs of 1.5 or higher.[24]

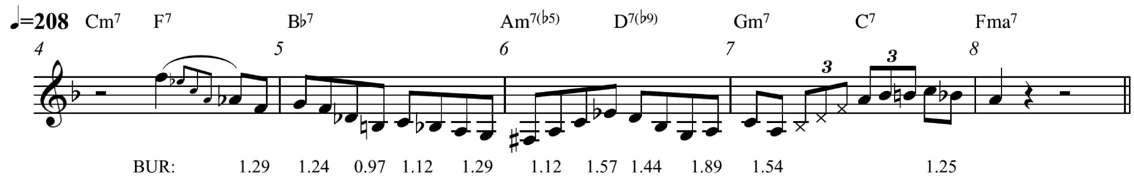
In contrast, studies of rhythm section accompaniment—particularly the drummer's "ride rhythm," the standard "ding-ding-a-ding" figure played on the ride cymbal since the bebop era—have found relatively higher BUR values, as shown in Example 3. In a detailed study of the timing relationships among piano, bass, and drums on a Jamey Aebersold play-along record, Rose found an average BUR of 2.38 at a tempo of about 130 bpm.[25] On the six recordings investigated in their study, Friberg and Sundström found BUR values among four internationally renowned jazz drummers active since the 1960s to be as high as 3.5 at slower tempos (less than ca. 150 bpm), but they tended to level off as tempo increased until they reached 1.0 at

19 Rose (1985, 14–15).
20 Ellis (1991, 710–12).
21 Collier and Collier (2002, 476).
22 I have calculated this figure from an average of the "composite swing style derived" measures reported by Busse in his Table 8 (2002, 454). The swing percentages Busse reports in his Tables 1–7 measure the upbeat swing eighth note against the downbeat defined by a metronome pulse instead of the note actually played by the performer, which was uniformly played after the metronome's beat. Consequently, only Busse's figures from Table 8 are comparable to the other figures reported here.

23 Friberg and Sundström (2002, 341; see especially Figure 5).
24 These figures are calculated from Benadon's Figure 1, which shows individual BUR histograms for Bill Evans, Cannonball Adderley, Miles Davis, John Coltrane, and Dexter Gordon. See Benadon (2006, 87).
25 Rose (1989, 84–86).



EXAMPLE 4. *Coleman Hawkins, tenor sax solo (excerpt) on " 'S Wonderful," recorded in 1944. BUR values for each pair of consecutive eighth notes are shown below the staff. (The articulation of the progression by the rhythm section is understood but not transcribed here.)*



EXAMPLE 5. *Charlie Parker, alto sax solo (excerpt) on "Confirmation," recorded in 1953. BUR values for each pair of consecutive eighth notes are shown below the staff. (The articulation of the progression by the rhythm section is understood but not transcribed here.)*

about 300 bpm.[26] Collier and Collier's data also revealed this leveling-off effect at fast tempos in a study of three contemporary professional jazz drummers who performed the ride rhythm on a MIDI drum pad. They also compared these drummers' performance of swing eighth notes with strict triplets and found "a tendency for the swing ratios to be *more* rather than *less* extreme than the triplet ratios"—i.e., to exhibit higher BUR values.[27] In a more tightly controlled experiment involving three professional drummers recorded on a MIDI drum kit, Henkjan Honing and W. Bas de Haas also found the leveling-off effect at faster tempos. However, they did not find that swing ratios continued to scale linearly with tempo—as did Friberg and Sundström—but, rather, that drummers' BUR values tended instead to "stabilize" at around 2.2 at tempos below about 170 bpm.[28]

Friberg and Sundström nevertheless found a similar tendency toward increased evenness at high tempos in soloists' swing eighth notes, a finding seen by Ellis in two of the three saxophonists who participated in his study. This leveling-off effect seems to be less pronounced, less systematic, and less universal among soloists than among drummers, however. Busse, for example, found that "there appears to be no relationship between upbeat note placement and performance tempo" among the piano players in his study,[29] and Benadon found "no systematic interdependence between tempo and subdivision ratios" except at extremely fast tempos or slow tempos that clearly evoke a 12/8 feel.[30] Instead, he found evidence of systematic variation of BUR values in relation to phrase structure—a factor not considered in other studies.

What is clear from this research is that jazz soloists have generally tended to divide the quarter notes more evenly than drummers at most tempos, in most swing styles, since at least the 1940s, when the ride rhythm became the foundational component of jazz drumming, though the difference in BUR values does tend to diminish at the fastest tempos. What is not clear, however, is what this means. Why do drummers and soloists approach swing eighth notes so differently? Do high or low BUR values generate greater motional energy? And what are the expressive effects of changing BUR values over the course of a melodic phrase? Consider in this regard the passages in Examples 4 and 5.

Example 4 shows an excerpt from Coleman Hawkins's tenor saxophone solo on the Gershwin composition " 'S Wonderful, " recorded in 1944.[31] The excerpt shown in Example 5 is drawn from Charlie Parker's alto saxophone solo on his original tune "Confirmation," recorded in 1953.[32] Each passage consists almost entirely of an extended series of eighth notes across a four-bar phrase that closes an eight-bar period at the end of a thirty-two-bar chorus. Each is performed at a fast jazz tempo of just over 200 bpm. Both passages involve a return to tonic harmony via cyclic-fifth motion, though the Parker progression is a bit more complex and uses a faster harmonic rhythm. In short, these passages are quite similar and provide a good basis for comparing each musician's conception of swing.

BUR values for each pair of consecutive eighth notes are shown below the staff.[33] How much the BUR must vary for the

26 Friberg and Sundström (2002, 337–40).

27 Collier and Collier (1996, 479, emphasis in original). Collier and Collier reported BUR values for their drummers as high as about 6.2, but these were at particularly slow tempos—at or below 67 bpm—employed by jazz musicians only in the most relaxed ballad performances. At such tempos, jazz drummers do not generally employ the ride rhythm figure in the way in which they were asked to in the Colliers' experiment. These figures have therefore been omitted from Example 3. At more conventional swing tempos (i.e., at or above about 100 bpm), their figures correspond more closely to those provided in Friberg and Sundström (2002) and Honing and Haas (2008).

28 Honing and Haas (2008, 475).

29 Busse (2002, 457).

30 Benadon (2006, 83).

31 Hawkins (2000).

32 Parker (1957).

33 BUR values in all musical examples included in this study were calculated by the author. The digital sound-editing program Audacity was used on a

difference to register perceptually can be extrapolated from research on the just-noticeable difference (JND) for deviations from isochrony in patterns with cyclic displacement—i.e., tone sequences in which every other tone is lengthened, similar to a sequence of swing eighth notes. Data reported by Gert ten Hoopen et al. in their Experiment 3 suggest a constant absolute JND of around 10 ms for Inter-Onset Intervals (IOIs) below about 240 ms (i.e., tempos above 250 bpm), and a constant relative JND of about 4.5% for IOIs ranging from 240 to 720 ms (i.e., tempos between 83–250 bpm); Anders Friberg and Johan Sundberg corroborate these figures.[34] This means that under ideal listening conditions, listeners should be able to perceive a BUR differential of ±.045 for tempos below 250 bpm. In actual jazz listening contexts, however, listeners probably require a larger differential—I would estimate between ±.10–.20 based on my subjective experience with recorded examples for which I have calculated the BUR values, though a more systematic empirical study is, of course, needed.[35] At any rate, it seems reasonable to assume that, in Example 4, for instance, listeners will perceive minimal variation in the BUR values of m. 6, but a significant shift in m. 7. Similarly, listeners probably will not register a significant BUR shift until midway through m. 6 in Example 5.

What is immediately apparent from Examples 4 and 5 is that Hawkins generally employs higher BUR values than Parker. With one exception, Hawkins's BURs in this melody line remain *above* 1.6; his average is 1.93 (*SD* 0.32), reflecting a very uneven, triplet-like swing conception. In contrast, Parker's BUR values generally remain well *below* 1.6, with one exception; his average is 1.34 (*SD* 0.26), reflecting the greater evenness of his idea of swing.

What difference does this make? Which passage swings more? Jazz critic Harvey Pekar favored Parker and other beboppers over their swing-era predecessors. "The extremely infectious swing of a good bop performance . . . ," he wrote, resulted in part from the use of ". . . eighth note lines [BUR 1.0] in places where many swing era musicians employed dotted eighth-sixteenth note figures [BUR 3.0]." By contrast, "[t]he playing of some swing musicians, like Coleman Hawkins, who relied on dotted eighth-sixteenth note lines, seemed to chug rather than swing."[36] In Examples 4 and 5, to be sure, Hawkins's eighth notes are not quite as uneven as Pekar suggests, nor are Parker's as even. I am nevertheless inclined to agree with him that Hawkins's line "chugs" along, whereas Parker's exhibits greater forward propulsion and drive, and that the difference emerges chiefly from the widely divergent BUR values employed by these musicians.

Equally important in both passages, however, are several expressive nuances which stem from *variations* in their BUR values as their phrases develop. Benadon has observed a tendency for BUR values to increase at phrase endings, a phenomenon he calls the "BUR surge,"[37] which can be seen in both Examples 4 and 5 along with some interesting consequences. Hawkins's eighth notes become especially uneven through the rising gesture in m. 7, an elaboration of a tonic triad. The E♭$_4$ at the end of the measure nevertheless arrives "early" in relation to the preceding pairs of eighth notes, creating a significant decline in the BUR of beat 4 (1.84). Similarly, the B♭$_3$ at the end of m. 8 also arrives slightly "early," making the BUR decrease from 2.42 to 2.00. Both of these notes are syncopations anticipating the ensuing downbeat and their early arrivals enhance the surprise effect generated by the syncopation. The high 2.42 BUR on beat three of m. 8 further reflects a lengthening of the D♭$_4$ which allows Hawkins to draw out the expressive effect of the dissonant and very bluesy ♭$\hat{7}$ over tonic harmony.

Parker's phrase in Example 5 shows a BUR surge in m. 6 interrupted by the sequence of triplets in m. 7, the first few of which are ghosted. Higher BUR values entail longer downbeat eighth notes and therefore greater downbeat emphasis; this generally results in an enhancement of the slower quarter-note level at the expense of its more rapid division. In this respect, Parker seems to move from one "metrical type" to another in mm. 5 and 6.[38] Here, however, the more triplet-like swing eighths in m. 6 prepare the change to actual triplets in m. 7. Had Parker maintained m. 5's low BUR values in m. 6, one might perceive the triplets in m. 7 as metrically dissonant—a change from a duple to a triple division of the beat.[39] Instead, the triplets in m. 7 emerge as metrically consonant with the triplet-like swing eighths of m. 6, thus setting up a dramatic acceleration into the cadence through a rapidly rising melody line. The overall effect is of continuous intensification of motional energy over the course of the phrase.

In both passages, then, BUR values vary locally in relation to aspects of syntactical structure. These variations bring out specific melodic and rhythmic features and serve to modulate the flow of motional energy across the phrase in very subtle ways. In

Macintosh computer to identify the onset of each note from a visual and aural analysis of its waveform. From these figures, IOIs between successive notes were defined and then employed to calculate the BUR values. There is inevitably some degree of uncertainty in identifying the attack point of each note, as noise and other onset ambiguities can render an exact determination impossible. By employing a consistent set of criteria to resolve ambiguities, I am confident that my figures are accurate to within ±5 milliseconds, which translates into a BUR value accuracy of ±.05 at the tempos shown in Examples 4 and 5.

34 See ten Hoopen et al. (1994, 114–15) and Friberg and Sundberg (1994, 340).

35 Friberg and Sundström report a JND of 20% in a music example at a tempo of 170 bpm (2002, 346). Friberg acknowledges that this figure is "extremely large" and speculates that it results from a categorization effect: "it is either played swing or not" (personal communication). A more systematic study of the JND for changing BUR values in a jazz melody would have to involve excerpts of recorded jazz, complete with rhythm section accompaniment, to improve ecological validity. Ideally, the researcher would be able to manipulate BUR values in the melody line, and participants would be asked to judge whether they increase or decrease over the course of a phrase.

36 Pekar (1974, 11).

37 Benadon (2006, 80–81).

38 On "metrical types," see London (2004, 73–75). Specifically, Parker moves here from an 8-cycle with 1–3–5–7 and 1–5 subcycles to a 12-cycle with 1–4–7–10 and 1–7 subcycles.

39 In Harald Krebs's terms, this would be understood as an "indirect grouping dissonance" (see Krebs [1999, 45–46]).

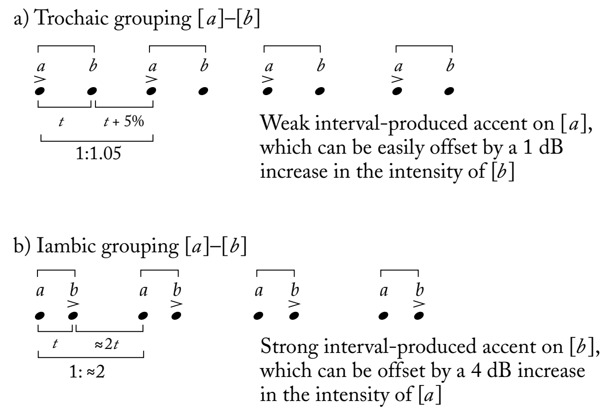
the theory presented below, I develop a more systematic way of understanding the role of varied eighth-note durations in generating the sense of forward propulsion and drive characterizing the rhythmic quality we call swing; furthermore, I evaluate the effects of these varied durations on the production and expressive manipulation of motional energy.

THE EXPRESSIVE FUNCTION OF THE SWING EIGHTH NOTE

It has long been known that listeners will tend to organize an isochronous series of tones into groups of two, three, or four.[40] "Subjective rhythmization," as this phenomenon is called, is spontaneous but unpredictable—one cannot determine with any degree of certainty how a given listener will group the tones.[41]

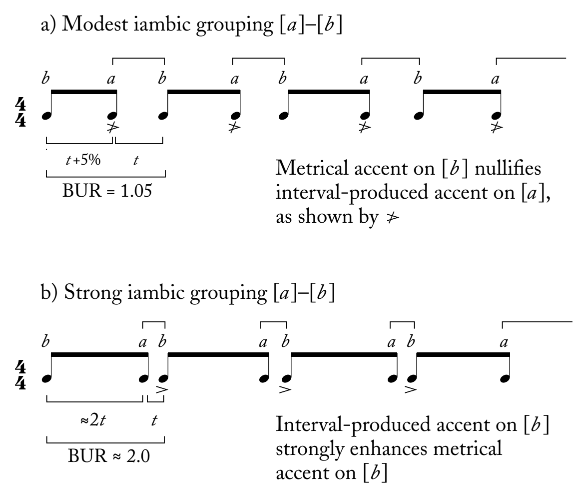
In a series of experiments on the perception of "equitone sequences"—i.e., sequences of tones identical in all respects, including frequency, spectral composition, intensity, and duration—Dirk-Jan Povel and Hans Okkerman established that if the inter-onset interval (IOI) between every other tone is lengthened by just 5%, perception of a duple grouping begins to emerge, as shown in Example 6(a) by the brackets atop the notes.[42] Moreover, listeners will tend to hear a slight accent on the first tone [*a*], suggesting a trochaic organization.[43] This accent is an emergent feature of perception produced by the lengthened temporal interval itself, and not by any increase in the intensity of the tone—i.e., it is not a phenomenal accent. It is quite weak, however, and can be easily offset with a very slight increase in the intensity of the second tone [*b*]—no more than about 1 dB is required, according to Povel and Okkerman.[44] As the temporal interval [*b*]–[*a*] is increased further, listeners gradually hear the accent shift to the second tone [*b*] and intensify substantially, suggesting an iambic organization, as shown in Example 6(b). The accent on [*b*] is perceived to be quite strong; it requires a considerable increase in the intensity of [*a*] to balance it—up to about 4 dB, in fact. Certainty as to when exactly the shift from trochaic to iambic grouping takes place varies according to each listener, but Povel and Okkerman's data suggest that most listeners will tend to hear a decisive accent on the second tone at ratios above about 1:2, a tendency present but less pronounced and uniform beneath that ratio.

We can imagine this tone sequence in a metrical context as a series of eighth notes in common time. If we reverse the polarity



EXAMPLE 6. *Perception of accent and grouping in an equitone sequence in which every other interval is lengthened (after Povel and Okkerman [1981])*
Each tone is identical in all respects: frequency, spectral composition, intensity, and duration: inter-onset interval (IOI) is indicated by t, accent marks show interval-produced accents perceived by the listener when t is increased between every other tone; they do not indicate phenomenal accents

and assume just enough context such that the listener will understand [*b*] as the downbeat and [*a*] as the upbeat—perhaps through counting off a measure before the sequence begins, or through the simple decision on the part of the listener to perceive [*b*] as the downbeat—lengthening the temporal interval [*b*–*a*] will produce a series of swing eighth notes. A mere 5% increase in this interval—i.e., a BUR of 1.05—generates the grouping shown in Example 7(a). In Example 6(a), this



EXAMPLE 7. *Perception of accent and grouping in a metrical context of eighth notes in which every other interval is lengthened, producing swing eighth notes*
Sufficient metrical context is assumed for preparing listeners to perceive b *as a downbeat and* a *as an upbeat, inter-onset interval (IOI) is indicated by t*

40 Bolton (1894).

41 For more on subjective rhythmization, see London (2004, 14–15) and London, "Rhythm §I: Fundamental concepts and terminology," in *Grove Music Online*, section 3 (Durational patterns and rhythmic groups), http://www.oxfordmusiconline.com:80/subscriber/article/grove/music/45963pg1 (accessed 26 October 2010).

42 Povel and Okkerman (1981). Incidentally, their figure of 5% corresponds roughly to the 4.5% JND for deviations from isochrony in patterns with cyclic displacement found by ten Hoopen et al. (1994), discussed above.

43 My characterization of the grouping and accent structure of consecutive musical events as trochaic or iambic has a precedent in Cooper and Meyer (1960), though my use of poetical feet in analysis is considerably more limited than theirs.

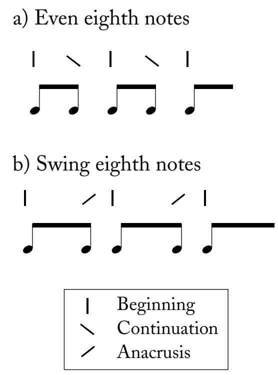
44 Povel and Okkerman (1981, 570, especially Figure 6).

lengthening produced a weak accent on [*a*], creating a trochaic organization. In 7(a), the addition of a metrical context stipulates a metrical accent on [*b*], which I believe will tend to nullify the weak interval-produced accent on [*a*]. Consequently, listeners will likely perceive a modest iambic grouping of [*a–b*] instead of the trochaic grouping found in Example 6(a). Increasing the interval [*b–a*], as shown in Example 7(b), results in a higher BUR value. As in Example 6(b), this also entails a shift of the interval-produced accent from [*a*] to [*b*] and the intensification of its effect, here further enhanced by the metrical accent on the downbeat [*b*]. This produces an increasingly decisive iambic grouping as the BUR approaches 2.0.

With respect to swing eighth notes, Povel and Okkerman's study suggests, and Example 7 intends to show, that once durational inequality between successive eighth notes is perceived, whether consciously or not, grouping emerges linking the offbeat eighth note to the ensuing downbeat. To the extent that the downbeat eighth note acquires accent of any kind, this grouping is iambic, and the offbeat eighth note will be perceived as anacrustic. Crucially, I believe, it is from anacrusis that swing eighth notes draw their motional energy.

The energizing power of anacrusis on the offbeat swing eighth note is best seen by comparison with the continuative nature of straight eighth notes. In his theory of metric projection, Christopher Hasty distinguishes rhythmic events with respect to function.[45] Some events serve as beginnings; they open up the potential for the becoming of duration, and are represented with a vertical dash [|].[46] Other events serve to continue durations begun earlier, as opposed to initiating new ones. A continuation, represented with a backwards slash [\], is directed toward the expansion and fulfillment of "a presently emerging (and 'reproducible') durational quantity."[47] It keeps the becoming of the earlier event open and alive, yet also draws it toward a conclusion.

Anacrusis, by contrast, is a special kind of continuation oriented toward a new beginning: "Anacrusis," writes Hasty, ". . . seems rather like a continuation released from its dependency on a prior beginning, unanchored, and (in some cases) seeming to come, [as] it were, 'from nowhere.' " Whereas continuation "in a sense points backward as a denial of ending for a prior beginning," anacrusis "points forward; it is anticipatory, directed toward a future event."[48] The crucial point here is that anacrusis, represented with a forward slash [/], keeps the becoming of a prior event's duration alive, while enhancing expectation for a new beginning. This expectation confers motional energy upon the anacrustic event for, unlike continuation, anacrusis engenders an active anticipatory orientation. It prompts a more aggressive cognitive strategy from the listener, one directed toward the emergence of a new event, rather than the completion of a present duration.[49]

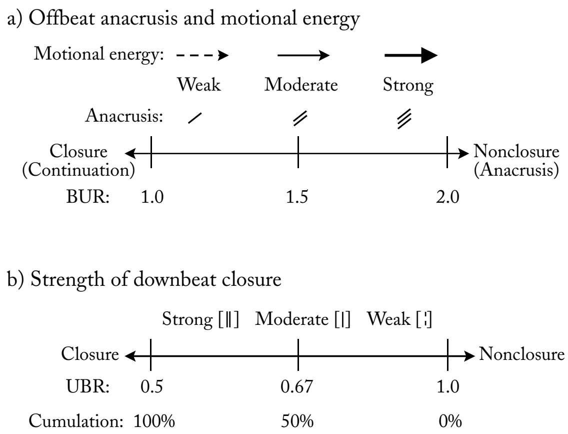


example 8. *Beginning, continuation, and anacrusis in straight and swing eighth notes (after Hasty [1997])*

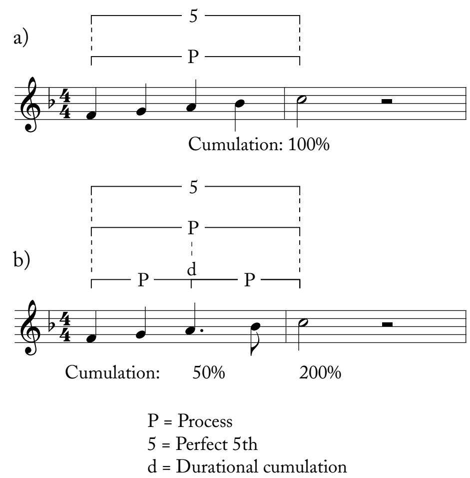
Thus, in a series of straight eighth notes, as shown in Example 8(a), in which only enough context is assumed to define the downbeats as such, each downbeat functions as a beginning, and the offbeats, all other things being equal, serve as continuations—they complete the quarter-note duration promised on the downbeats. By contrast, in Example 8(b), which presents a series of swing eighth notes, offbeat anacruses, generated from durational inequality, draw more attention toward future becoming and thereby produce a motional energy that a series of straight eighth notes lacks. To be sure, in any musical context, numerous factors (including, for example, harmony and counterpoint) can lead to different interpretations of the offbeats than those shown in Example 8. My point here is simply this: when taken *tout court* in the absence of a greater context, straight eighth notes will serve as continuations of the quarter-note duration of which they are a part, whereas swing eighth notes will serve as anacrusis and thereby generate greater motional energy toward the ensuing downbeat. This, I believe, is the principal musical factor motivating jazz musicians to swing their eighth notes.

As illustrated in Example 9(a), the relative force of anacrusis generated on the offbeat swing eighth note is proportional to the BUR value. Insofar as it creates an expectation for a new beginning, an anacrustic event denies closure and sustains the forward flow of motional energy. In one sense, this is true of a continuative event, as well; it denies closure of the larger duration of which it is a part. But relative to anacrusis, simple continuation is closural in the sense that it draws a larger duration toward its conclusion without necessarily calling forth expectation for a new beginning. Thus continuation is shown in Example 9(a) as closural in relation to the nonclosural nature of anacrusis. Low BUR values produce minimal anacrusis, and only weak motional energy directed toward the ensuing

45 Hasty (1997).
46 Ibid. (69–76, 104).
47 Ibid. (108).
48 Ibid. (120).
49 For a more detailed account of the energizing "power of anacrusis," see Butterfield (2006, 10–16). See also Mine Doğantan's entry for "Upbeat" in the *New Grove Dictionary of Music and Musicians*: "An anacrusis is in essence an initiation on a non-accent, and as such it is rhythmically unstable: its most fundamental characteristic is the forward rhythmic impulse it generates towards the accent" (Doğantan [2001]) http://www.oxfordmusiconline.com:80/subscriber/article/grove/music/28812 (accessed 26 October 2010).



EXAMPLE 9. *Motional energy produced by offbeat anacrusis across a range of BUR values and downbeat closure as a function of UBR value*



EXAMPLE 10. *Durational cumulation in a simple melody*

downbeat.[50] The offbeats tend toward closure as the BUR approaches an even 1.0 at the left side of the scale, where anacrusis gives way to continuation. In contrast, as BUR values increase, offbeat anacrusis acquires progressively greater strength, and a concomitant increase in motional energy directed toward the ensuing downbeat. Offbeats thus tend increasingly toward nonclosure at high BUR values; they exhibit greater implicative force.[51]

However, a high BUR value does not necessarily lead to greater forward propulsion. Instead, a series of highly uneven swing eighth notes tends to feel halting and choppy—it lacks continuity, for there is simply too much starting and stopping. This is, in part, a function of durational cumulation—movement from a relatively short duration to one that is relatively long. Eugene Narmour has proposed that cumulation of 50% beyond the realized duration of a particular note's immediate predecessor leads to melodic closure and the structural transformation of a melodic pitch.[52] Therefore, as seen in Example 10(a), a series of ascending quarter notes produces a melodic process [P] uninterrupted until it reaches closure on the half note C, which is twice the length of the preceding quarter notes and thus represents a cumulation of 100%.[53] A perfect-fifth dyad emerges from the transformation of the initial and terminal tones of this process. In contrast, the 50% cumulation on the dotted quarter note in Example 10(b) (i.e., a quarter note plus half its value) is sufficient to produce closure, leading to the structural transformation of A and the materialization of a higher-level process [P] linking F, A, and C, such that an F major triad emerges at level two, and a perfect-fifth dyad at level three.

Narmour's "50% rule" draws empirical support from Paul Fraisse's findings that listeners employ two working durational categories: short and long, generally related in a 1:2 ratio.[54] Asked to reproduce a sequence of unequal durational intervals, Fraisse's subjects routinely gravitated in their responses toward a ratio of 1:2, even when the longer stimulus interval was less than double the shorter one.[55] On the other hand, subjects tended to equalize durations when the interval ratio between them was only slightly above 1:1. This implies that listeners tend to normalize durational eccentricity in order to form internal representations of rhythms in the simplest possible ratios. Following this principle, Narmour's 50% rule suggests that, for the purposes of melodic implication, listeners will tend to assimilate ratios of less than 1:1.5 to an even 1:1. Thus, when durational cumulation is less than 50%—i.e., when the ratio from short to long is less than 1:1.5—the longer tone remains within the short durational category, such that melodic implication remains in effect and any ongoing durational process remains open. In contrast, when cumulation exceeds 50%—i.e., when the ratio from short to long rises above 1:1.5—the longer tone veers toward the long durational category. It is the categorical shift from short to long that elicits the perception of closure.

BUR values indicate the unevenness of a given pair of swing eighth notes, and from this we can get a sense of the motional energy that arises from offbeat anacrusis. But because the grouping of a pair is iambic (i.e., upbeat to downbeat), the BUR does not provide a measure of downbeat closure. For this,

50 My usage in Example 9(a) of double and triple forward slashes to indicate moderate and strong anacrusis respectively is an expansion of Hasty's symbology—he does not distinguish degrees of anacrusis. My usage is nevertheless consistent with his theory of metric projection in that anacrustic events, like continuations, are limited to the level of their occurrence and do not transform to higher levels of metric structure—i.e., they can never function as beginnings for the projection of larger durations.

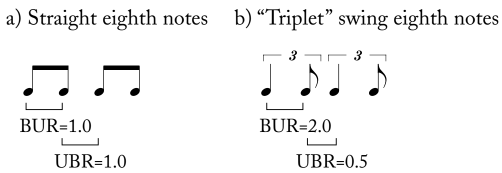
51 This claim is consistent with Eugene Narmour's use of parametric scales in the implication-realization model. In his theory, sameness or similarity of consecutive elements generates a weak implication of continuation (A+A->A). In contrast, differentiation of consecutive elements generates a strong implication of change (A+B->C). See Narmour (1990, 297–315) and (1996, 287–91).

52 Narmour (1990, 105–12).

53 Strictly speaking, durational cumulation here is perhaps perceived as greater than 100%, since nothing follows the half-note C.

54 Fraisse (1946, 1956).

55 Fraisse's findings were strongly confirmed in Povel (1981), though Povel also found that a beat-based context facilitates the perception of slightly more complex durational ratios, such as 1:3 or 1:4.



EXAMPLE 11. *BUR and UBR values for straight and "triplet" swing eighth notes*

I propose we must instead consider the UBR,[56] which provides an indication of the durational cumulation that accrues on a given downbeat. No systematic study has yet been done on the UBR, since swing ratio studies have only been concerned with the determination of BUR values. As I will show, however, the UBR's effects on motional energy are highly significant because of its impact on downbeat closure.

The UBR is calculated by dividing the absolute duration of the upbeat eighth note by that of the ensuing downbeat. BUR and UBR values converge at 1.0, the point at which both designate straight eighth notes, as shown in Example 11(a). In contrast, "triplet" swing eighth notes, like those shown in Example 11(b), have a BUR of 2.0 (i.e., 2:1), but a UBR of 0.5 (i.e., 1:2), reflecting durational cumulation of 100%.

Superficially, BUR and UBR values may appear to be mathematical inverses of one another—i.e., given one, we should be able to calculate the other—this would be the case if they were calculated from the same upbeat and downbeat. They are not, however: the UBR is calculated from the ensuing, not the preceding, downbeat eighth note. Thus, a BUR of 2.0 does not necessarily entail a subsequent UBR of 0.5 because in actual performance the downbeat eighth note from which the UBR is calculated may be longer or shorter than the one used in calculating the preceding BUR. In general, however, as BUR values increase in a melodic line consisting of a sequence of swing eighth notes, UBR values tend to decrease.

If we accept Narmour's claim of closure with durational cumulation at 50%, a threshold UBR value of 0.67 (i.e., 1:1.5) emerges. UBRs beneath this value will tend toward strong closure, and those above it will tend toward weak closure or nonclosure as the value approaches 1.0, as illustrated in Example 9(b).

If we now compare Examples 9(a) and 9(b) we see that a rise in BUR values corresponds to a fall in UBR values, and that motion left on either scale is toward closure, whereas motion right is toward nonclosure.[57] An increase in motional energy on the offbeats—motion right in Example 9(a)—is therefore typically opposed by an increase in strength of closure on the downbeat—motion left in Example 9(b).

It is important to understand that Examples 9(a) and 9(b) are not perfectly symmetrical with one another, however, and that consequently the effects of rising BUR values are not exactly inversely proportional to those of falling UBRs. Whereas motional energy increases gradually with durational inequality (i.e., rising BUR values), the strength of downbeat closure increases slowly as UBRs drop from 1.0 to the 0.67 threshold, and then quite rapidly beneath that. This is because perceived accent accrues to downbeats with greater force below that threshold, and this supplements the closural effects of durational cumulation. This reflects Povel and Okkerman's findings of the difference in the perceived intensity of accents produced by lengthened temporal intervals, discussed in relation to Examples 6 and 7. The intensity of this accent is very low for UBRs above the 0.67 threshold—it can be offset by increasing the intensity of the unaccented pitch by just 1 dB. Below that threshold, the intensity of the interval-produced accent increases quite rapidly—a UBR of about 0.56 requires an increase of 4 dB on the unaccented tone to offset the accent.[58] This suggests that weak motional energy can overcome the weak closure of UBRs above the 0.67 threshold because durational cumulation is not supported by an interval-produced accent on the downbeat. In contrast, strong motional energy cannot overcome the increasingly strong closure of UBRs below about 0.56 because durational cumulation exceeds 50% and is supplemented by a very strong interval-produced accent. Moderate motional energy will most likely not overcome moderate closure of UBRs in the vicinity of the 0.67 threshold because durational cumulation is at 50%, even though the effects of interval-produced accent are not very strong there.

Example 12 illustrates the interaction of motional energy and downbeat closure across a range of corresponding BUR and UBR values. In Example 12(a), offbeat anacrusis generates strong motional energy as a result of high BURs in the vicinity of 2.0. The low UBRs around 0.50 entail durational cumulation of 100% coupled with a strong interval-produced accent, however, and this provides strong closure.[59] Moreover, the very short duration of offbeats entailed by high BUR/low UBR values—especially at faster tempos—simply leaves insufficient time for listeners to experience their motional energy, despite its strength, before it is swallowed up in the durational cumulation that follows. Consequently, the arrows designating strong motional energy are short, indicating the brevity of its effect and the inhibition of forward momentum from one beat to the next. Listeners, I suggest, will tend to perceive the durational cumulation on the downbeats with greater closural force than the nonclosural power of the offbeat. This draws attention away from the eighth-note level to the slower quarter-note level that groups it, entailing a net decrease in motional energy.

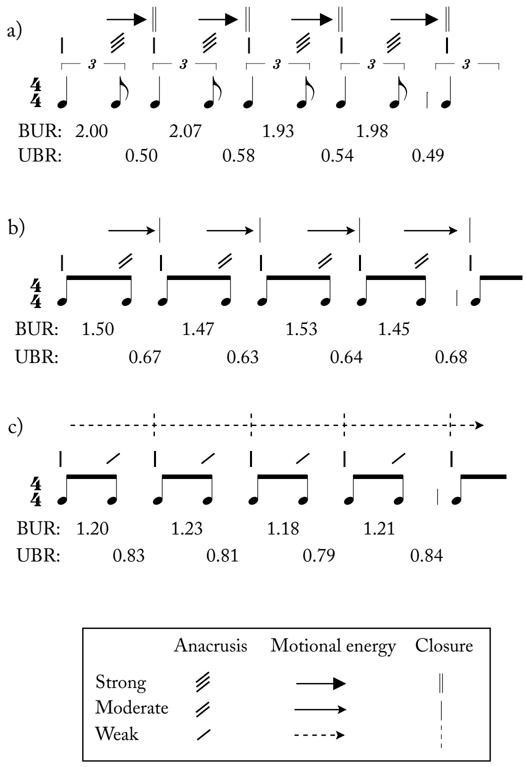
Example 12(b) illustrates the same effects around the threshold UBR of 0.67. Here, BURs in the vicinity of 1.5 result in relatively moderate motional energy, which is again offset by sufficient durational cumulation (approximately 50%) to induce

56 Benadon (2006, 78).

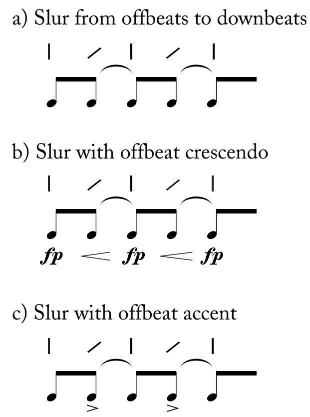
57 The correlation of motion left/closure and motion right/nonclosure is consistent with Narmour's use of these terms as they apply to parametric scales in the implication-realization model. See Narmour (1990, 297–303 and 1992, 19–20).

58 Povel and Okkerman (1981, 570, Figure 6).

59 BUR and UBR values are varied in this and subsequent examples to remind the reader that they are not mathematical inverses of one another, as discussed above, and that the actual sounding durations from which such values are calculated in musical performance vary considerably.



EXAMPLE 12. *Motional energy vs. downbeat closure*



EXAMPLE 13. *Additional means of producing offbeat anacrusis*

the perception of closure, all other things being equal. In Example 12(c), however, the low BURs of about 1.2 generate weak motional energy from offbeat anacrusis, to be sure, but enough to overcome the weak closure produced by durational cumulation for UBRs of around 0.83. The net effect is a modest degree of forward momentum sustained from beat to beat, indicated by the long dashed arrow that extends through each point of closure.

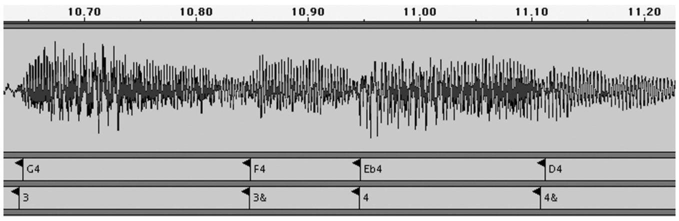
To generate greater motional energy from the minimal forward momentum arising from durational inequality at low BUR values, the anacrusis must be more powerful on the offbeat (motion right on the motional energy scale of Example 9[a]) without increasing downbeat closure (motion left on the durational cumulation scale of Example 9[b]). Durational inequality and two aspects of articulation contribute to this effect: first, I have observed that jazz musicians—particularly wind players—tend to slur from offbeats to downbeats, producing an offbeat anacrusis through articulation, as shown in Example 13(a); second, in conjunction with this slur, downbeat and offbeat are frequently played at different levels of intensity, although instrumentation makes an important difference in this regard.

James Lincoln Collier has observed that "especially with wind players, there is a natural tendency, in playing strings of eighth notes, to accent the first of each pair at the expense of the second."[60] This can be seen quite clearly in Example 14, which shows the waveform envelopes of a sequence of eighth notes played by Coleman Hawkins on tenor saxophone (drawn from Example 4). The downbeats G_4 and $E\flat_4$ clearly have a wider amplitude than the offbeats F_4 and D_4, indicating they are played more loudly. This tendency of wind players to underplay the offbeats in a series of swing eighth notes generates anacrusis by means of what Narmour refers to as a "dynamic process": the slight crescendo from upbeat to downbeat, shown in Example 13(b).[61] This type of crescendo, write Grosvenor Cooper and Leonard Meyer, "indicate[s] the tendency, the leading toward a goal, of a tone or a group of tones. That is, the crescendo creates an expectation that an accent will follow, and the tone bearing the crescendo is heard as leading toward, and grouping with, the expected accent."[62] In conjunction with the slur commonly applied from upbeat to downbeat, this crescendo enhances the strength of anacrusis on the offbeat.

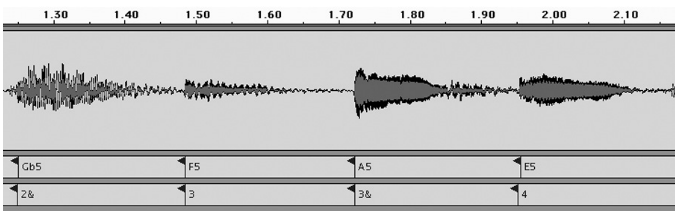
In contrast, Iyer has observed that "often in practice, the second note of the swung pair is given a slight accent in intensity, as if to compensate for its shorter duration."[63] This tendency, which is documented empirically by Busse,[64] is more typically used by pianists rather than wind players.[65] It can be seen in Example 15, which shows the waveform envelopes of a sequence of eighth notes played by Sonny Clark on piano. Offbeat accent has two complementary effects. First, it works against the customary strong-weak grouping we expect from downbeat to offbeat. This presents a perceptual challenge, prompting a more forward focus of attention toward an upcoming downbeat to settle any potential confusion. The result is offbeat anacrusis, as shown in Example 13(c).[66] Second, an offbeat accent weakens closure on

60 Collier (1993, 63).

61 Narmour (1992, 46).
62 Cooper and Meyer (1960, 15).
63 Iyer (2002, 404).
64 Busse (2002, 451–52, Tables 1–4).
65 Indeed, Iyer's claim likely emerges out of his own experience as a professional jazz pianist. My own training in learning to swing on piano was greatly facilitated by a teacher who advised me to play my eighth notes evenly, but accent the offbeats. This is not to say that wind players cannot or do not accent the offbeats, but the mechanical aspects of performance on wind instruments do not generally favor it.
66 On the role of accent in producing anacrusis, see Hasty's Example 9.12(e) and accompanying discussion (1997, 121–22). See also Butterfield (2006, 11–15).



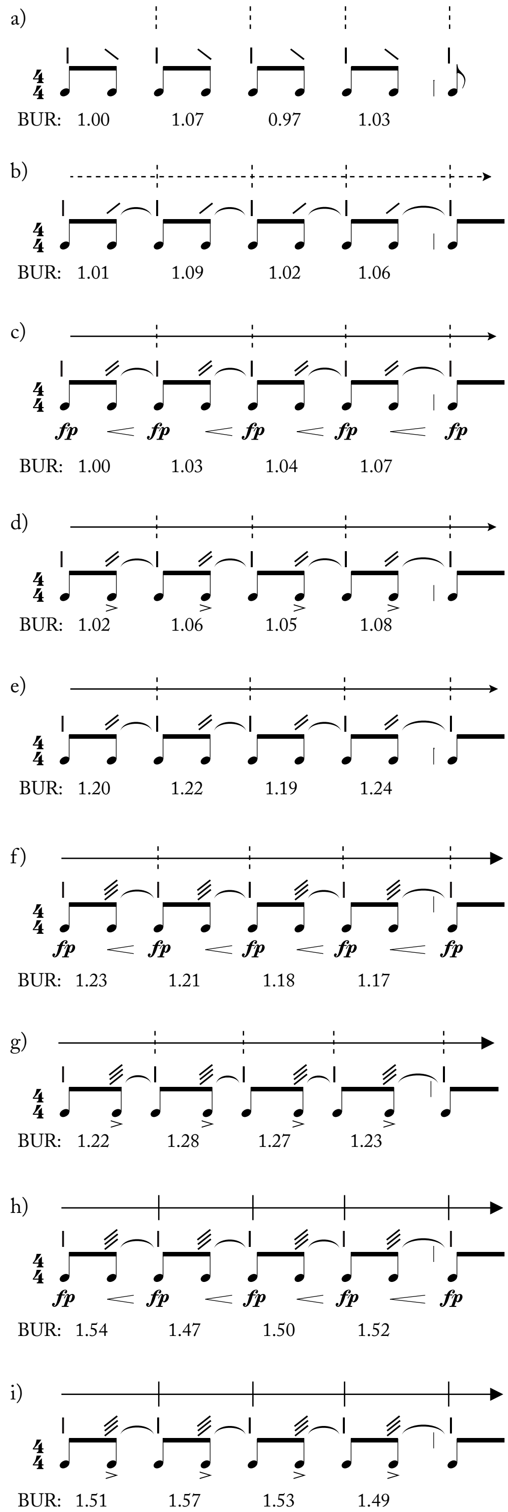
EXAMPLE 14. *Waveform envelopes of a series of eighth notes played by Coleman Hawkins (tenor saxophone) on "'S Wonderful"*
Four eighth notes are shown here with pitch letter names and beat locations given below the diagram: wave amplitudes of downbeat pitches (G_4 and $E\flat_4$) are wider than those of upbeat pitches (F_4 and D_4), indicating that they are played more loudly



EXAMPLE 15. *Waveform envelopes of a series of eighth notes played by Sonny Clark (piano) on "Can't We Be Friends"*
Four eighth notes are shown here, pitch letter names and beat locations shown below the diagram; wave amplitudes of upbeat pitches ($G\flat_5$ and A_5) are wider than those of downbeat pitches (F_5 and E_5), indicating that they are played more loudly

the ensuing downbeat. Again, as discussed above in connection with Example 6(b), Povel and Okkerman found that an accent in intensity on [*a*] could offset the interval-produced accent that emerged on [*b*] at higher ratios.[67] We can extrapolate from this that an increase in the intensity of an offbeat accent can counteract downbeat closure, enabling one to sustain forward momentum as BUR values increase and UBRs decrease.

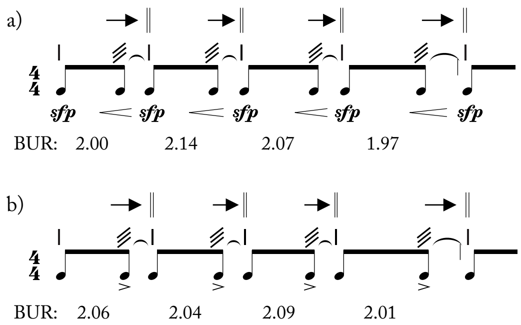
I propose that these methods of producing anacrusis—durational inequality, slurring from offbeats to downbeats, and varying the intensity of the downbeats and offbeats—may work singly or in conjunction, producing anacruses of varying qualities and degrees. Example 16 shows their effects at low BUR values, at which downbeat closure is minimal. A series of straight eighth notes (i.e., BURs in the vicinity of 1.0) devoid of both offbeat accent and articulation from offbeat to downbeat are continuative, as shown in Example 16(a). A weak sense of closure ensues on the downbeats from the realization of quarter-note metrical projections, but little motional energy is conveyed from one beat to the next. If the offbeat eighth note is slurred to the ensuing downbeat, as shown in Example 16(b), it acquires anacrusis and generates weak motional energy that overcomes the weak metrical closure arising on the downbeats. Applying a crescendo to the offbeat, typical of wind instrument performance, supplements the effect of the slur, as shown in



EXAMPLE 16. *Motional energy in relation to offbeat anacrusis at low BUR values*

Example 16(c), and generates moderate motional energy that easily drives through the weak closure on the ensuing downbeat, as does coupling the slur with an offbeat accent, characteristic of piano performance, shown in 16(d).

67 Povel and Okkerman (1981, 570).



EXAMPLE 17. *Motional energy in relation to offbeat anacrusis at high BUR values*

Similar enhancements to the strength of anacrusis apply as the BUR value rises. At a BUR of around 1.2, motional energy is weak, all other things being equal (see Example 12[c]). Slurring from offbeat to downbeat enhances the strength of anacrusis and generates moderate motional energy, as shown in Example 16(e). Supplementing the slurs with offbeat crescendos (Example 16[f]) or accents (Example 16[g]) then produces strong motional energy that easily sustains momentum through the weak closure on the downbeats. Examples 16(h) and 16(i) show the same effects at BURs around 1.5, the level at which strong motional energy overcomes the moderate closure produced on each downbeat.

At BURs above the 1.5 threshold, these various procedures for generating and strengthening anacrusis on the offbeats become less and less effective. As the BUR rises (and the UBR falls), the intensity of interval-produced accent on the downbeat increases (as shown in Examples 6 and 7). In conjunction with an offbeat crescendo of shorter duration, this produces greater differentiation between offbeat and downbeat, the effects of which are strongly closural.[68] As a result, strong downbeat closure terminates the strong motional energy generated on the offbeats, as shown in Example 17(a). Similarly, at higher BUR values, offbeat accent will continue to counteract downbeat closure only with a substantial increase in intensity. At BURs at or above 2.0, in particular, such accent becomes difficult to achieve and impractical to sustain. Offbeat anacrusis, no matter how strong, consequently entails strong downbeat closure, as shown in Example 17(b).

This, I believe, explains why jazz soloists since at least the Bebop era have tended to prefer lower BUR values in general. Lower BURs (and the higher UBRs they engender) facilitate the maintenance of forward momentum in a melody line by producing offbeat anacrusis while minimizing downbeat closure. Offbeat slurs, crescendos, and accents all serve to enhance the power of anacrusis and to strengthen motional energy without increasing durational cumulation on the downbeats. By contrast, BURs at or above 1.5 (and the lower UBRs they engender) produce durational cumulation on the downbeats that becomes increasingly difficult to overcome, entailing an emphasis on the slower quarter-note pulse rather than the faster eighth-note pulse. High BUR values thus tend to counteract forward momentum, and their use leads to melodies that tend, to return to Pekar's description, to "chug" along rather than swing.

HIGH BURS IN THE RHYTHM SECTION

It is especially curious, then, that rhythm section players should employ such high BUR values in their maintenance of the beat. For if the function of the rhythm section is to generate and sustain forward propulsion and drive, effects best achieved by means of low BURs, how is this to be accomplished when high BURs produce so much sense of closure on each downbeat?

It is important to remember the functional difference between melody and accompaniment. Rhythm section players have a rhythmic responsibility quite different from that of soloists: specifically, they must keep time. In general, an improvised melody in jazz moves at double the rate of the pulse: when the pulse is in quarter notes, the melody is in eighth notes. In order to time their eighth notes accurately, soloists need to hear something from the rhythm section that has a clear, steady, quarter-note beat. In this regard, the perceptual grouping of swing eighth notes into the "larger regular interval, that is, the quarter note" described by Iyer (and discussed above) is especially consequential, and high BUR values are most effective at generating this perception.[69] When bass players play eighth notes in the context of a walking bass line, for example, they tend to sustain their downbeats and inflect the offbeats more like grace notes, resulting in high BUR values. This enables them to bring out and maintain the quarter-note pulse clearly and consistently.

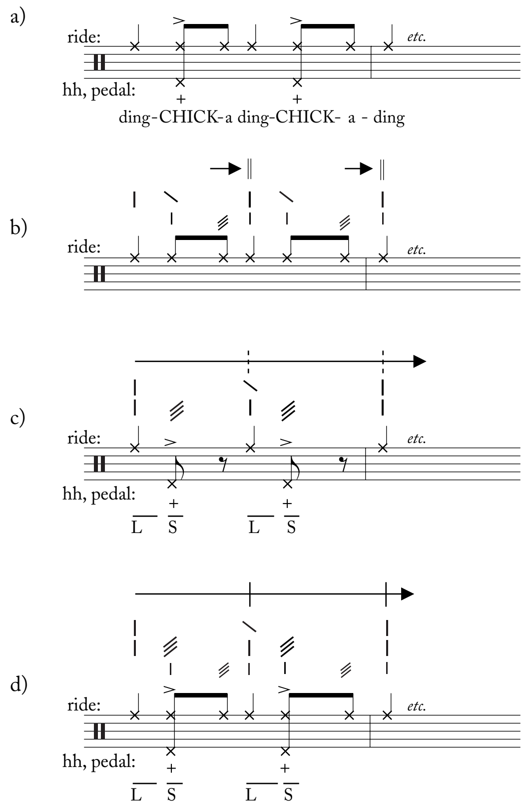
Drummers' use of high BUR values also facilitates perception of the quarter-note beat. Friberg and Sundström found a constant absolute duration of about 100 ms for the drummer's short ride tap (i.e., the offbeat eighth note on the "and" of beats two and four in the standard ride rhythm) for tempos above about 150 bpm, "suggesting a practical limit on tone duration that may be due to perceptual factors."[70] Honing and Haas dispute this claim, finding instead that the second note's duration increases linearly with beat duration. Nevertheless, their figures show that at tempos as low as 133 bpm (a beat duration of 450 ms), their drummers' short-tap durations were virtually all beneath about 130 ms in absolute duration—minimally longer than the 100 ms threshold identified by Friberg and Sundström.[71] Clearly, drummers have a preference for very short offbeat durations at moderate to fast tempos, a preference that helps them produce not just the perception of the quarter-note level, but the effect of quarter notes on every beat. In conjunction with Honing and Haas's finding that the drummers in their study

68 In terms of the implication-realization model, a dynamic process (i.e., the crescendo) combines with a dynamic reversal (i.e., the accented downbeat and the non-accent that ensues). This enhances the closure on the downbeat emerging from both meter and duration (Narmour, personal communication).

69 Iyer (2002, 404).

70 Friberg and Sundström (2002, 333).

71 Honing and Haas (2008, Figure 3b in color plate section).



+ closed hi-hat (i.e., played with foot pedal)

Example 18. *Motional energy in relation to the drummer's ride rhythm*

"maintain a highly consistent swing ratio and performed with little variability," this is an aid to their maintenance of a clear temporal reference for improvising soloists.[72]

Despite the strong closure that arises from the use of high BURs, other structural features of the drummer's ride rhythm serve to generate considerable forward propulsion. The ride rhythm, shown in Example 18(a), consists of two rhythmic layers: 1) the "ding-ding-a-ding" rhythm played on the ride cymbal, and 2) the hi-hat cymbal, closed with the foot pedal on the backbeats (i.e., beats two and four), creating a short, accented "chick" sound. The composite rhythm—"ding-chick-a-ding-chick-a-ding"—produces anacrusis on two levels. Example 18(b) presents an analysis of the ride cymbal pattern. The first cymbal strike serves as a beginning [|]; it opens up the potential for the becoming of duration. The second cymbal stroke serves as a continuation [\] of that duration, but it also functions as the beginning [|] of a new quarter-note duration, for which the offbeat cymbal stroke serves as anacrustic continuation [/] (recall that anacrusis is a special kind of continuation). Assuming a high BUR value on beats two and four (and a low UBR value), this anacrusis generates strong motional energy that is nevertheless met with strong closure, as indicated above the staff in the example.

Example 18(c) is an analysis of the interaction between ride cymbal and hi-hat at the quarter-note level. Here, the ringing of the ride cymbal on beats one and three is long, whereas the hi-hat cymbal, clipped shut on beats two and four, is short, as shown underneath the example, and given a sharp dynamic accent. Hasty proposes that in such circumstances—i.e., given two equal beats, when the first serves as a beginning and consists of a tone or event of relatively long sounding duration, and the second consists of a shorter sounding tone or event that does not fill its projected duration— "shortening the second sounding duration might enhance its potential for becoming an anacrusis" because "silence during the realization of a projected duration" (e.g., the remainder of beat 2 in Example 18[c]) "will lead to some insecurity" in the prospects for completion of that duration, and "for this reason we may be more inclined to focus our attention on the emergence of a new event that would reduce this indeterminacy." Similarly, "providing the second tone with a dynamic accent…can also enhance expectancy for a new beginning," as discussed above in connection with the offbeat swing eighth note, and "accenting and shortening combined should further intensify the potential for anacrusis."[73] The net effect, in my opinion, is that because of its relative brevity, the hi-hat generates a sort of spring-like bounce, a feeling of leaping directed toward a landing on the next quarter-note downbeat. Consequently, beats two and four acquire a forward anticipatory energy directed toward new beginnings on beats one and three of every bar, as shown. Here there is no durational cumulation on beats one and three, only weak closure produced on these beats stemming from the realization of projected quarter-note durations, as indicated above the staff in the example.

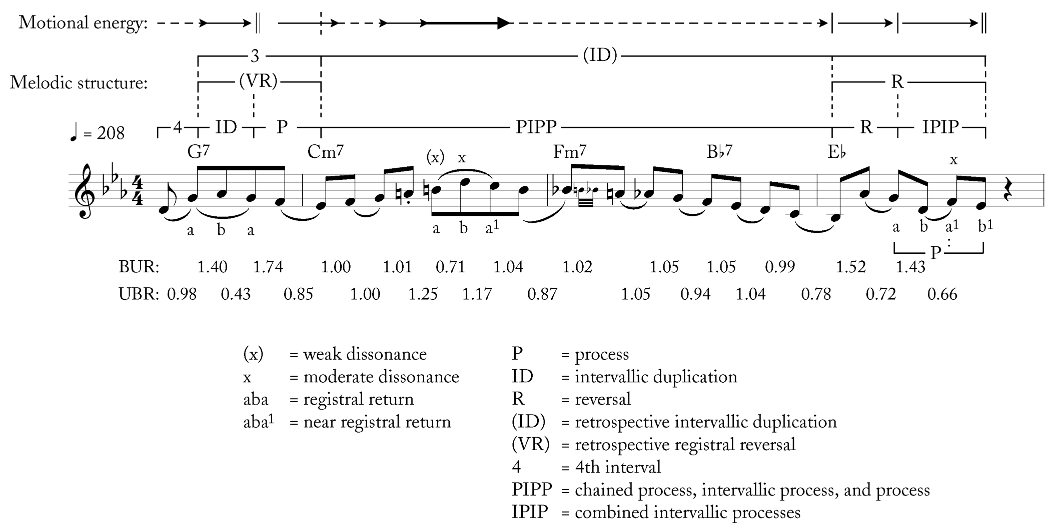
The cumulative effect of the composite rhythm is shown in Example 18(d). The strong closure produced by durational cumulation in Example 18(b) is here offset by the strong motional energy that emerges at the quarter-note level in Example 18(c). That is, the robust anacrusis that emerges on beats two and four from the hi-hat offsets the firm closure otherwise emerging on the downbeats. In this way, high BUR values do not attenuate forward propulsion in the drum part, as they do in a soloist's melody line. Rather, they facilitate perception of the quarter-note pulse without compromising the motional energy of the groove.

The divergent BURs generated by soloists and drummers thus appear to correspond to the performers' different rhythmic functions. Drummers perform the ride rhythm with high BUR values that exhibit minimal variability in performance in order to bring out the quarter-note pulse as a nearly uniform temporal reference for the rest of the ensemble. The pattern itself, in conjunction with the walking bass line, generates considerable forward propulsion. Drummers employ variable comping rhythms and cross-rhythms on the other drums and cymbals of the drum set in order to generate expressive effects above this foundation. These effects, however, provide mere enhancements to the motional energy generated by the pattern itself, which on its own is sufficient to induce listeners to tap their feet, bob their heads, and so forth—as anyone listening to Max Roach's ride tap through the first few choruses of Sonny Rollins's "Blue 7" will surely recognize.[74]

72 Ibid. (473).

73 Hasty (1997, 122, explicating his Examples 9.12 [d] and [e]).

74 Rollins (1956).



example 19. *Analysis of a passage from John Coltrane's solo (tenor sax) on "I Hear a Rhapsody"*

By contrast, soloists are responsible for neither keeping time for the ensemble nor generating and sustaining the forward propulsion of the swing groove. Instead, against the steady template provided by the rhythm section, they employ lower BUR values that often vary considerably over the course of a single phrase.

What expressive effects ensue from the interaction of low and high BURs between soloists and rhythm section, respectively? Friberg and Sundström explained the disparity between their BUR values as a consequence of downbeat delay by the former. Soloists, they found, tend to synchronize their offbeat eighth notes with the drummer's offbeat ride stroke, but they will often delay their downbeats, frequently following the drummer by a considerable margin. This technique, they propose, "create[s] both the impression of the 'laid-back' soloist, which is often strived for in jazz, and at the same time an impression of good synchronization."[75] Benadon takes this view one step further to offer a possible explanation for the "BUR surge," the common increase in BUR values toward the end of soloists' phrases. Soloists, he suggests, "tend to increase their BURs at phrase endings in order to synchronize both downbeats and offbeats with the rhythm section, thereby incorporating a phrase-ending expressive device." Moving from low to high BURs is "in effect 'resolving' from a microrhythmically dissonant state to a consonant one."[76] These are compelling accounts of the expressive consequences of differing BUR values between soloists and drummers, which explain some significant effects that emerge from their interaction. Irrespective of this interaction, however, there are other effects of BUR variability in a soloist's melody line itself. Analysis of short excerpts from three improvised jazz solos will illustrate how variable BUR values in the melody line modulate the flow of motional energy across a phrase or series of phrases in conjunction with other aspects of syntactical structure.

75 Friberg and Sundström (2002, 345).

76 Benadon (2006, 80).

analyses

The model proposed in this study suggests that variation in BUR/UBR values serves to regulate motional energy and closure, particularly in improvised melody lines. Movement from high BURs to low dampens the strength of anacrusis on the offbeats, but weakens downbeat closure, resulting in a net increase of motional energy from one beat to the next. By contrast, movement from low BURs to high strengthens offbeat anacrusis, but not enough to offset downbeat closure, resulting in a net loss of motional energy. In each of the passages discussed below, these effects of BUR/UBR variability will be shown to supplement a variety of other parametric means for producing anacrusis and closure in an improvised melody line.[77] Interaction between fluctuating BUR/UBR values and other features of melodic and rhythmic organization serves thereby either to enhance or attenuate the force of motional energy. Such interaction is especially important in phrase-ending BUR surges, which do indeed function to induce the perception of closure, as Benadon proposes, but not merely because they bring the soloist into greater microrhythmic consonance with the drummer. Rather, as my analyses demonstrate, a BUR surge often works with other aspects of melodic structure to generate a substantial increase in the strength and frequency of closure at phrase endings and a shift in emphasis from an eighth-note pulse to the slower quarter-note pulse that groups it.[78]

Example 19, an analysis of a rather simple phrase taken from the final chorus of John Coltrane's tenor saxophone solo on the

77 Two of these excerpts, the Coltrane and Konitz passages, were also analyzed briefly by Benadon (2006, 77–78). I include them here to offer a contrasting but complementary view on the effects of the BUR surge.

78 Rhythm section parts contribute to the modulation of motional energy in an improvised solo in a variety of very important ways. Nevertheless, addressing the expressive effects of drum fills, cross-rhythms, the counterpoint of the bass line against the soloist's melody, chord substitutions, and piano comping patterns in relation to the solo line is beyond the scope of

jazz standard "I Hear a Rhapsody,"[79] illustrates significant correspondences between varied BUR and UBR values and some procedures for generating anacrusis and closure in other musical parameters. The passage begins with pickups into the final A section of this tune in thirty-two-bar AABA song form. The first segment opens with a leap to G_4 and its upper-neighbor embellishment. This is followed by a scalar passage that ascends from $E\flat_4$, turns around C_5, then descends to $B\flat_3$. The final segment begins with a large ascending leap from $B\flat_3$ to $A\flat_4$ followed by a zigzagging movement which zeroes in on the tonic at the end of the phrase. The BUR values for each pair of eighth notes, shown beneath the staff, reflect this phrase structure. Coltrane begins with relatively high BURs on the first few beats, then plays a series of quite even eighth notes through the scalar passage in the middle, concluding with a BUR surge.

This segmentation is further reflected in the melodic structure, an analysis of which is shown above the staff, drawing on Narmour's implication-realization model.[80] For the present analyses, the critical issue is less the specific type of each melodic structure—the various Ps, IDs, VRs, etc.—than the points of initiation and termination of each one and the means whereby its closure is either achieved or deferred. In the implication-realization model, only notes that initiate or terminate melodic structures "transform" to the next hierarchical level, where they participate in larger melodic implications and their realizations. Thus, in Example 19, the first complete melodic structure—the intervallic duplication [ID] shown after the opening leap up a perfect fourth—begins and ends on G_4. Those notes transform to the next level of structure, but not the intervening $A\flat_4$. Instead, at the second level, the two G_4s generate an implication of continued registral direction and intervallic similarity (i.e., G + G implies continuation, most likely with another G), an implication partially realized in the retrospective registral reversal [(VR)], which terminates on beat one of the next measure. The initial and terminal tones of this structure then transform to a third level, where together they form the interval of a major third. However, what is again significant here is not the specific structures themselves, but the hierarchical depth generated by their regular rate of melodic closure.

A number of features contribute to the closure of melodic structures in the implication-realization model, including metric emphasis, durational cumulation, strong resolution of dissonance, and reversal of melodic direction, among others. Similarly, a number of factors can prevent such closure, including dissonance on metrical accents and various kinds of ongoing processes involving the implication of continuation. Each of these tends to envelop metric accent and override its closural effects, which in turn causes basic melodic structures either to combine (e.g., the IPIP structure at the end of Example 19) or to form longer chains (e.g., the PIPP structure in the middle).[81]

In the first segment of Coltrane's solo (Example 19), the regular rate of melodic closure generates two higher-level structures, as we have seen: first, a retrospective registral reversal [(VR)] at level 2, and then a nonimplicative major third dyad at level 3. By contrast, Coltrane avoids melodic closure in the middle segment and produces instead a long PIPP chain. This chain begins with an ascending melodic process [P] through which melodic nonclosure escalates—at the top of the line, intervallic motion increases from major seconds to a minor third, the constituent tones of which ($B\natural_4$ and D_5) are both dissonant against the underlying harmony (Cm^7), as indicated by the (x) and x above the notes. This forces the process [P] to combine with an intervallic process [IP] and a descending process [P] to form the PIPP chain. Melodic closure is thereby avoided for two full measures, and no higher-level structures emerge through this passage.

The third segment resumes a steady rate of melodic closure and the hierarchic depth it entails. Following an extended passage of stepwise motion, the large minor seventh leap from $B\flat_3$ to $A\flat_4$ comes as a surprise. Resolution to G_4 realizes an implied reversal [R], which leads into a combination of intervallic processes [IPIP] that produce a networked process [P] through near registral return [aba^1b^1], shown beneath the staff—i.e., the G_4–F_4–$E\flat_4$ motion at the end of the phrase.[82] Another reversal is generated at the second level, the initial and terminal tones of which are transformed again to realize a retrospective intervallic duplication [(ID)] at the highest level. The relatively large leaps and many changes of registral direction may have prompted the BUR surge here. What is crucial, however, is that UBR values decline rapidly in the final measure to arrive at the 0.67 threshold, and durational closure thus emerges on the downbeats supplementing the melodic closure achieved by reversal of registral direction.

These effects are borne out in the analysis of motional energy, given at the top of Example 19, which shows the combined effects of varying BUR and UBR values with the melodic structures just discussed. The initial ascending fourth D_4–G_4 exhibits weak motional energy. The 0.98 UBR indicates that

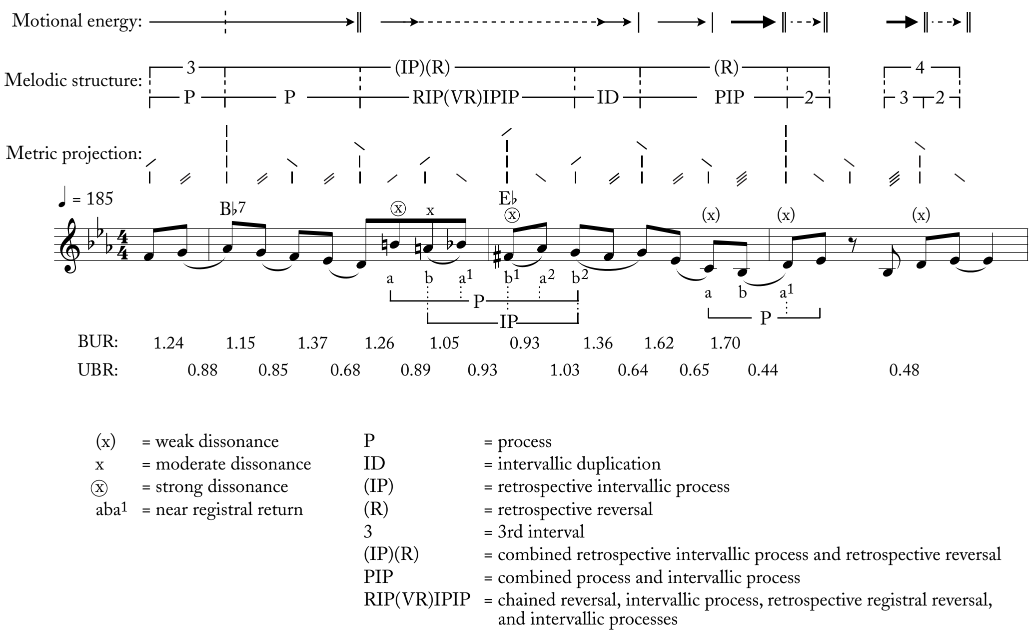
the analyses presented here, which assess instead manipulation of motional energy within the solo line itself.

79 Coltrane (1958). Cf. Benadon (2006, 77). My analysis of the eighth-note timings of this passage and the BUR values that ensue differs slightly from Benadon's, but the overall microrhythmic profile is the same.

80 Narmour (1990, 1992). A brief overview of the basic melodic structures used here is provided in the Appendix.

81 Readers are referred to Narmour (1992, 1–41), for a more comprehensive summary of the basic theory of melodic implication and realization; Appendix 1 (361–69) for an overview of the rules of the theory; Appendix 2 (370–78) for a glossary of terms; and Appendix 5 (390–96) for a catalog of the basic melodic structures and combinational structures defined in the theory. More recently, Narmour has updated the terms and symbols used in his theory (Narmour [2003]). I nevertheless refer to the older volumes for the more comprehensive explanations of the underlying bases of the theory.

82 Near-registral return [aba^1] stems from a nonimplicative relation between two or more discontiguous tones in close registral proximity to one another—no more than a major second, in fact. The networked process that emerges here from near registral return reflects a tonal descent $\hat{3}$–$\hat{2}$–$\hat{1}$ that is significant to the overall structure of the phrase, but that nevertheless fails to emerge from the implicative structures shown above the staff.



example 20. *Analysis of a passage from Lee Konitz's solo (alto sax) on "On Green Dolphin Street"*

these notes are essentially even, but the slur from offbeat to downbeat creates a weak anacrusis and, as a result, weak motional energy. Moderate motional energy emerges on the ensuing G_4–$A\flat_4$–G_4 figure as a result of the higher BUR value, but this is offset with strong closure on the second G as a result of substantial durational cumulation (i.e., the UBR of 0.43). The high 1.74 BUR at the end of the bar, coupled with the slur from F_4–$E\flat_4$, generates moderate motional energy that easily overcomes the weak closure that occurs on the downbeat. As Coltrane's eighth notes even out in the ascending scalar passage that follows, motional energy weakens slightly, but strengthens for a variety of reasons as the line proceeds. First, ascending melodic motion itself generates some degree of anacrusis, as Cooper and Meyer explain:

> Because the more a tone seems to be oriented toward a goal, the more it tends to function as an anacrusis, rising melodic lines, particularly conjunct ones, tend to become anacrustic. The energy and striving implicit in a rising line make each successive tone move *toward* the one which follows it, rather than *from* the one preceding it.[83]

Four additional factors contribute to an intensification of motional energy at the top of the line: the escalation of interval size observed above, the early arrival of the offbeat D_5 (reflected in the low 0.71 BUR), the dissonance of both the $B\natural_4$ and the D_5, and the slur extending from $B\natural_4$–D_5–C_5. Collectively, these factors produce a quasi-slingshot effect on the turn at the top of the phrase. The line then descends with weak motional energy to the $B\flat_3$ that begins the final measure largely on the basis of slurs from offbeats to downbeats. The net effect is a sense of unimpeded flow and forward momentum through the series of straight eighth notes in the middle portion of this phrase. This comes to an end in the final measure, however, when Coltrane returns to swing eighth notes. Here, an increase of motional energy stemming from higher BUR values and clear phrasing from offbeats to downbeats is unable to sustain forward momentum against three sources of closure: the abrupt change from stepwise motion to leaps, the zigzagging changes in registral direction, and the rapid decline in UBR values. These factors collectively entail an increase in the rate and strength of closure, resulting in a net loss of the fluidity and forward propulsion characteristic of the middle of the phrase.

Example 20 presents an excerpt from Lee Konitz's alto saxophone solo on the classic jazz standard "On Green Dolphin Street."[84] As with Coltrane's melody in Example 19, Konitz's phrase, taken from the beginning of the B section of the tune's thirty-two-bar ABAC form, contains three fairly discrete segments. It opens with diatonic stepwise melodic motion, moving first from F_4 up to $A\flat_4$, then down to D_4, essentially outlining the tritone interval between the third and seventh of the dominant $B\flat^7$ harmony. The second segment begins with a large leap to $B\natural_4$, the dissonant ♭9 of $B\flat^7$, followed by a zigzagging, staircase-like descent through two very prominent chromatic dissonances on the downbeats ($A\natural_4$ and $F\sharp_4$) leading to G_4, the third of the newly arrived tonic E♭, which is then embellished with its lower neighbor $F\sharp_4$. A third segment ends the passage with a conventional diatonic closing lick outlining a descending tonic triad and closing on the tonic itself; its final gesture is then repeated, like an echo.

In this phrase, the middle passage stands out in vivid relief against the more conventional melodic material that frames it.

83 Cooper and Meyer (1960, 15), italics in the original.

84 Konitz (1974). Cf. Benadon (2006, 78). Again, my BUR figures differ slightly from Benadon's, but the microrhythmic profile of the phrase is the same.

The outer segments are both entirely diatonic, whereas the middle is densely chromatic and dissonant. Moreover, as the BUR values beneath the staff show, Konitz (like Coltrane) swings the eighth notes in the outer segments, but plays them almost perfectly straight in the middle. Finally, Konitz reverses his articulation in the middle; whereas the outer segments exhibit iambic slurring from offbeat to downbeat, the middle passage shifts to trochaic slurring from downbeat to offbeat for a period of two beats. Clearly, Konitz means to highlight the central portion of this phrase, drawing it out of the surrounding material in a way that produces expressive tension against an otherwise conventional background.

As in the Coltrane example, dissonance generates a melodic chain [RIP(VR)IPIP] in the middle passage, which defers melodic closure until the G_4 on beat two of the second measure. Not until the second G_4 on beat three, however, does it becomes apparent that the zigzagging motive has come to an end. At this moment, Konitz reverts to iambic slurring from offbeat to downbeat and proceeds diatonically. Durational cumulation also crosses the 50% threshold, as reflected in the low 0.64 UBR on this second G_4. Thus the intervallic duplication [ID] in level 1 falls within a larger combinational structure [(IP)(R)] in level 2.

These aspects of the melodic structure help to explain the flow of motional energy across this phrase, an analysis of which is shown at the top of Example 20. The prevailing BUR values through the first few beats and the iambic slurring generate offbeat anacrusis of moderate strength, as shown in the analysis of metric projection just above the staff. Moreover, successive melodic processes [P] offer little resistance to the forward momentum of Konitz's melody line. Consequently, moderate motional energy carries through the first segment, terminating only on the D_4 at the bottom of the descending process [P]. Here, strong closure results from durational cumulation, as indicated by the 0.68 UBR, enhanced by a reversal of registral direction and the switch from small intervals to large.

Even eighth notes across the second segment and the reversal of slurred articulations, which changes offbeats from anacrusis [/] to continuation [\] as shown, suggest a pronounced attenuation of motional energy. Indeed, there is a feeling of stasis across these several beats. Motional energy, albeit weak, nevertheless emerges here because of the operation of anacrusis at higher levels of rhythmic structure, shown in the analysis of metric projection above the staff in Example 20. The B♮$_4$ is of course anacrustic because of the 1.26 BUR and its strongly dissonant quality (indicated by ⊗), but the B♭$_4$ and A♭$_4$ on the ensuing offbeats are continuative because Konitz slurs from downbeat to offbeat, as indicated above. However, moderate and strong dissonances on the downbeats (shown by the x and ⊗ over the A♮$_4$ and F♯$_4$ respectively) support anacrusis at upper levels of structure. The G_4 on beat two, though ostensibly serving to resolve the accumulated dissonance which precedes it, also exhibits anacrusis at the quarter-note level because it arrives amidst harmonic uncertainty: the harmonic accompaniment in this passage, provided only by the bass, does not provide a clear articulation of an E♭ harmony until late in the bar. Consequently, the harmonic status of this first G_4 is initially inconclusive, clarified only by its reiteration on beat three. Due to the anacrusis at higher levels of metrical structure, this passage sustains a flow of weak motional energy even as BUR values remain around 1.0 and phrasing is momentarily trochaic.

With the BUR surge in the third segment of this phrase, offbeat motional energy increases from moderate to strong. As in the Coltrane example, however, this is met with an increase in the rate and strength of closure. Durational cumulation crosses the 50% threshold with the G_4 on beat three (as indicated by the 0.64 UBR); it exceeds 100% with the D_4 on the ensuing beat one (UBR 0.44). Strong durational closure thus increasingly inhibits the forward momentum of the melodic line despite the nonclosural effects of dissonance [(x)] on both the C_4 and D_4.[85] The offbeat E♭$_4$ then emerges weakly, not as anacrusis, but as a continuation that serves only to complete the quarter-note duration of which it is a part. The final echo at the end of the bar then furthers the depletion of motional energy as it draws the phrase to a close.

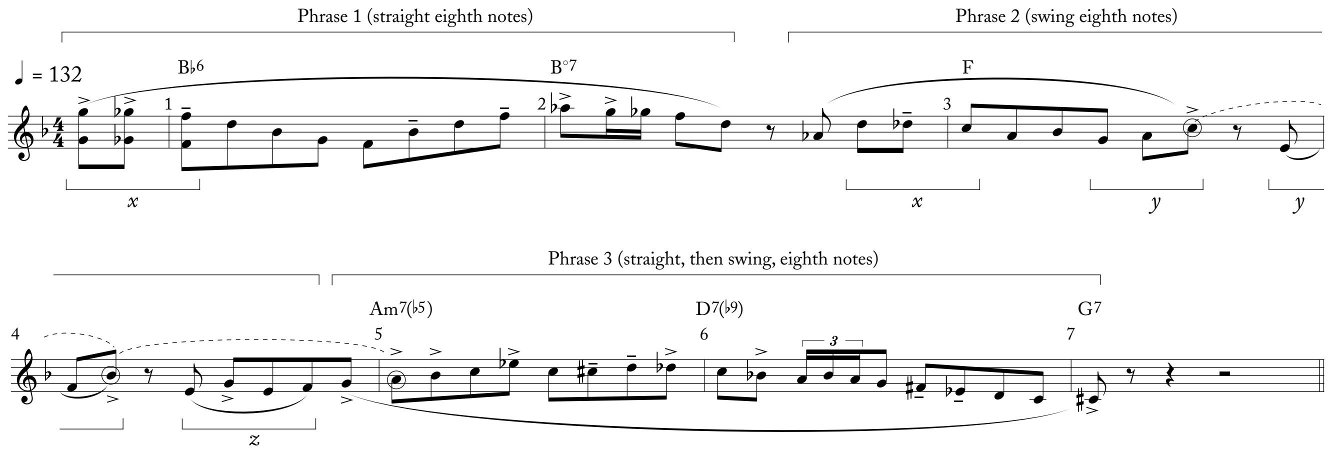
In both of these passages, an increase in the frequency and strength of melodic closure toward the end of the phrase corresponds to a movement beneath the threshold UBR value. In other words, there is motion left toward closure on multiple parametric scales, and thus an attenuation of motional energy. One final example will illustrate in more detail the effects of varying eighth-note durations on motional energy across a more extended passage, an excerpt from Sonny Clark's piano solo on "Can't We Be Friends," a jazz standard in thirty-two-bar AABA song form.[86]

The passage is drawn from the bridge and consists of three phrases, as shown in Example 21. The first phrase (mm. 1–2) simply arpeggiates a B♭^{6} chord and a B^{ø7} (IV^6 and vii^{ø7}/V in F major), embellished here and there by a neighbor note or chromatic passing tone. It begins with $\hat{6}$–♭$\hat{6}$–$\hat{5}$ of B♭, labeled motive *x*, a motion reiterated at the outset of the second phrase at the end of m. 2, this time in relation to the tonic F. This motivic "call-and-response" is complemented by a shift from straight eighth notes in the first phrase to swing eighths in the second, as indicated above the staff in Example 21 and by the BUR values in Example 22.

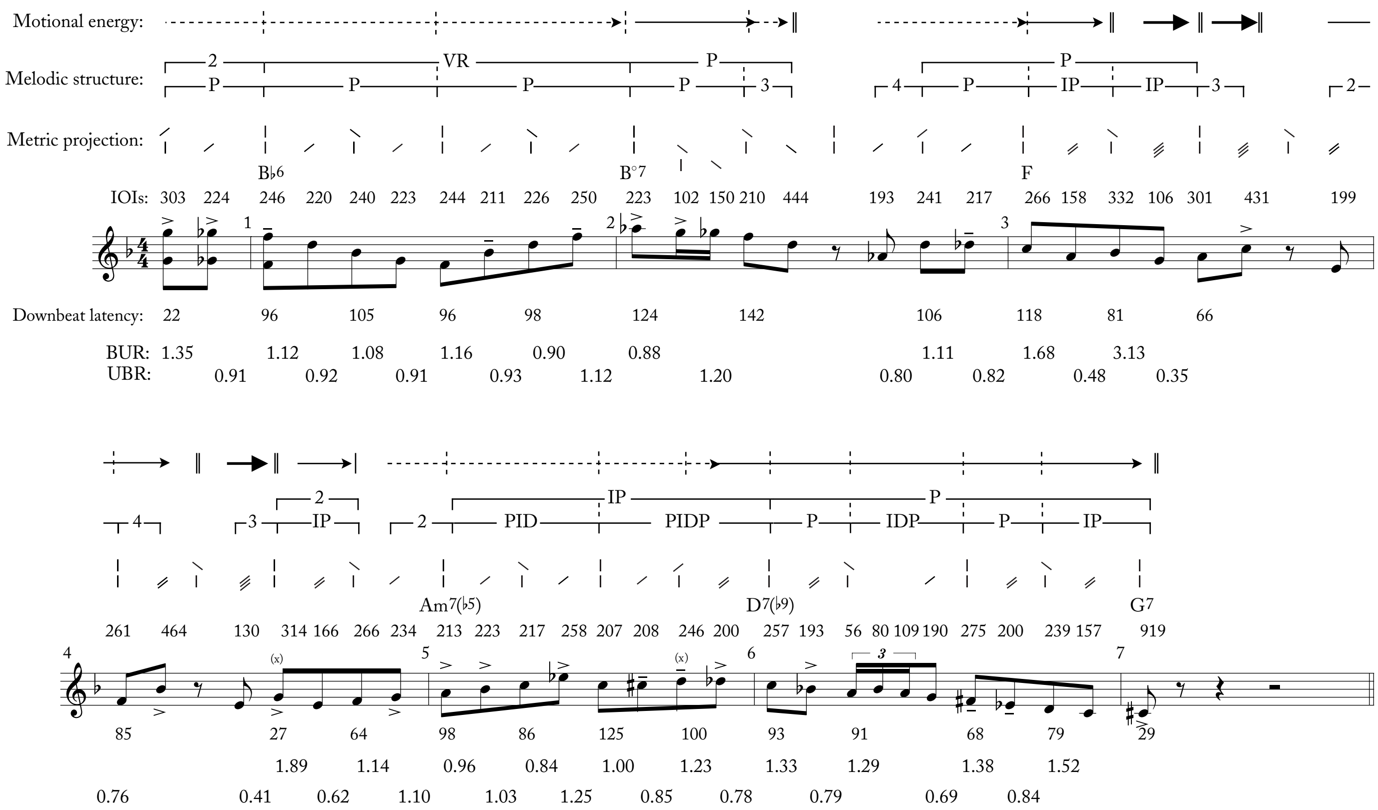
The second phrase (mm. 3–4), constituted mainly of a descending "staircase" figure elaborating the descent $\hat{5}$–$\hat{4}$–$\hat{3}$ of F, seems to end relatively quickly, however—less than halfway through a projected two-bar duration (mm. 3–4). To balance the abbreviated second phrase against the length of the first and

85 The weak dissonances [(x)] on the two D_4s of the last measure do not deny closure here to produce melodic combinations or chains, as would otherwise be expected. In the implication-realization model, a weak dissonance functions transformationally—i.e., it does not cause a combination or chaining but ascends instead to the next level of melodic structure—with durational cumulation of 100% or more, which is seen here as UBR values drop below 0.50. On the different degrees of dissonance and their potential for structural transformation in melodic implication, see Narmour (1992, 209–16 and 247–52).

86 Clark (1959).



EXAMPLE 21. *Phrase structure and motivic development in a passage from Sonny Clark's solo (piano) on "Can't We Be Friends"*



(x)	= weak dissonance	P	= process
>	= strong dynamic accent	IP	= intervallic process
–	= light dynamic accent	VR	= registral reversal
aba1	= near registral return	2	= 2nd interval
		PID	= combined process and intervallic duplication
		IDP	= combined intervallic duplication and process
		PIDP	= combined process, intervallic duplication, and process

EXAMPLE 22. *Analysis of a passage from Sonny Clark's solo (piano) on "Can't We Be Friends"*

	Average value	Standard deviation	Maximum value	Minimum value
IOI between downbeats (bass and drums)	453 ms	9 ms	472 ms	436 ms
Duration of downbeat eighth notes (piano)	254 ms	35 ms	332 ms	207 ms
Duration of upbeat eighth notes (piano)	198 ms	38 ms	258 ms	106 ms
BUR values	1.32	0.52	3.13	0.84
UBR values	0.84	0.24	1.25	0.35
Downbeat latency (piano)	87 ms	31 ms	142 ms	22 ms
Upbeat latency (piano)	8 ms	16 ms	48 ms	-12 ms

example 23. *Timing statistics for Sonny Clark's "Can't We Be Friends," figures estimated to be accurate to within ±5 ms; BUR and UBR values estimated to be accurate to within ±0.05*

to fill out its duration over the static tonic harmony, Clark echoes the last few notes in a brief motivic development, here labeled motive *y*. The C_5 which ends the first iteration of this motive is continued with the $B\flat_4$ which ends the second, clearly implying further continuation to an A_4—which would echo and augment the $\hat{5}$–$\hat{4}$–$\hat{3}$ motion of m. 3. But Clark avoids a third iteration that would have provided resolution to the expected A_4, substituting instead the figure shown as motive *z* as a kind of response to *y*. Motive *z* closes around the tonic F_4; consequently, the $B\flat_4$ is suspended until it is resolved by the A_4 which begins m. 5.

It would appear from the notation that the third phrase begins with an extended anacrusis midway through m. 4; however, this belongs to the second phrase, as motive *z*. Dynamic accents on the ascending G_4–A_4–$B\flat_4$ and a sudden and dramatic shift from swing eighth notes to straight set these notes apart, with the third phrase clearly beginning on the "and" of beat four. From this point on, the melody line consists primarily of diatonic stepwise motion varied by a few small leaps and chromatic passing tones. For the most part, Clark emphasizes chord tones on quarter-note downbeats, conveying the harmony through his melody line. The C♯ in m. 7 comes as a surprise, of course; given the chord progression and the direction of the melodic line, listeners would probably expect the C_4 at the end of m. 6 (the seventh of D^7) to resolve to B_3 (the third of the G^7). Instead, Clark turns to the ♯11 and closes the phrase there in a slightly "Monkish" gesture that leaves the dissonance lingering through the final two bars of the eight-bar bridge.

The melodic structure of this passage is quite simple, as can be seen from the analysis above the staff in Example 22. The only melodic chain occurs in m. 5, where weak dissonance [(x)] prevents melodic closure on the D_5, thereby generating a short PIDP structure.[87] The few combinations that arise emerge from the tendency of melodic process [P] to override the closural effects of meter (the PID structures) or from the denial of melodic closure on a metrical non-accent (the IDP structure). The registral reversal [VR] shown on level 2 of mm. 1–2 captures the affective quality of the $A\flat_5$, the slight sense of surprise that emerges there following the sweeping arpeggiations down and then up the $B\flat^6$ chord in m. 1. In general, however, the melodic structure of this entire passage lacks the melodic complexity of the Konitz passage or the hierarchical depth of the Coltrane solo. It suggests instead a fairly straightforward melodic motion at both levels. An abundance of melodic processes [P] or simple combinational structures involving process [PID and IDP] at both levels of melodic structure generates a fairly unimpeded melodic flow, though there are significant differences within each phrase.

A number of figures pertaining to Clark's timing in this passage are shown in Example 23. The average IOI between downbeats was calculated from the onsets of bass or drums on each beat, whichever attack came first. The pulse maintained in the rhythm section is remarkably consistent, as indicated by the low standard deviation. By contrast, the durations of Clark's downbeat- and upbeat-eighth notes vary widely, as can be seen from the IOI figures provided above each note in Example 22, but he does clearly prefer more straight eighth notes, as shown by his average BUR and UBR values in Example 23.

87 The weak dissonance [(x)] on the G of m. 4 does not deny closure and cause a melodic chain because duration cumulates more than 100%. See Note 85 above.

Of greatest interest, however, is the figure for downbeat latency in the piano, a measure of how far behind the onset of bass or drums Clark's downbeat attacks begin. His average latency, 87 ms, is just short of a sixteenth note (about 113 ms at this tempo). Clearly, he prefers to "lay back" on his downbeats to a substantial degree. By contrast, his upbeat eighth notes tend to be quite closely synchronized with the upbeat attacks of bass and drums (the short ride tap struck on the "ands" of beats two and four, as well as the occasional offbeat snare-drum hit or bass pickup note): the average upbeat latency in the piano is only 8 ms, with a standard deviation of 16 ms.[88]

Clark's downbeat delay varies significantly over the course of the passage, however, as can be seen from the downbeat latency figures just below the staff in Example 22. This has an effect on his BUR values: in general, given the relative invariance of his upbeat timings, the greater the downbeat latency, the lower the BUR value, and vice versa. This means that the segments with the lowest BUR values tend to exert a kind of drag on the pulse defined by bass and drums. This has significant effects on the motional energy generated across this passage, as we shall see.

The analysis of metric projection, here limited to the first two levels (i.e., eighth-note and quarter-note durations) since upper levels revealed little of significance, shows anacrusis on most of Clark's offbeat eighth notes despite the very low BUR values employed through much of the passage and the lack of slurs from offbeats to downbeats (he generally employs a staccato attack). In the first phrase (mm. 1–2), his eighth notes are minimally uneven, but exhibit just enough swing to generate weak anacrusis on the offbeats, hence weak motional energy. His very slight offbeat accents on the ascending arpeggio at the end of m. 1 strengthen this energy a little, but not enough to overcome the weak closure that emerges on beat one of m. 2. Closure here results not from durational cumulation on the downbeat, but from other parameters: a change of harmony, a reversal of registral direction in the melody, and, most importantly, the substantial delay of the onset of the $A\flat_5$. Clark arrives on this note more than a sixteenth-note's duration (124 ms) behind the downbeat defined by bass and drums. This little pause, I suggest, is just enough to disrupt the phrase's flow of motional energy.

The sixteenth notes in m. 2 generate a slight increase in motional energy, but it is short-lived, quickly overtaken by a cumulative durational process in which each successive note lasts longer than the last, such that Clark arrives on the F_5 even further behind the beat (142 ms) than he had been with his arrival on the $A\flat_5$. This produces the impression of slowing down, as though he were actively decelerating. Consequently, moderate motional energy quickly weakens, and strong closure brings the phrase to its conclusion.

Toward the end of m. 2, the second phrase opens with weak motional energy generated by anacrusis at both the eighth-note and quarter-note levels. The BUR surge in m. 3 produces moderate and then strong motional energy, but increasingly strong closure, as indicated by the corresponding drop in UBR values. No BUR value can be provided for beat three since there is no attack on beat four to determine the absolute duration of the C_5 on the "and" of three, but we can extrapolate from the absolute duration of the A_4 on beat three (a relatively long 301 ms) that the increasingly uneven durational patterning of beats one and two continues on beat three. Downbeat delays decline here, as well. As Clark "catches up" with the pulse of his accompaniment, however, his rhythmic articulation becomes less fluid and more bouncy, as though the languid stride of his first phrase yields to a little jog in the second. Listeners may feel an increase in motional energy here, but the greater strength and frequency of downbeat closure precludes its continuity and impedes the maintenance of forward momentum and drive. Instead, the substantial increase in BUR values in m. 3 draws emphasis away from the faster eighth-note level to the slower quarter-note pulse.

No BUR can be determined for beat four of m. 3 or for beat one of m. 4, of course. The absolute durations of the E_4 and F_4 suggest, however, that this sequence of eighth notes is less even than those of m. 1, but more even than those of m. 2. From this, I extrapolate moderate motional energy through the second iteration of the *y* motive. The very low UBR (0.41) on beat three of m. 4, coupled with a dynamic accent on the G_4, generates strong closure. Following this pickup, moderate motional energy continues through motive *z*. Moderate closure emerges on the F_4 of beat four because of the relatively low UBR value (0.62), supplemented by the resolution of the double neighbor figure around F_4 and completion of the *z* motive.

As Clark moves into a sequence of fairly straight eighth notes beginning with the accented G_4 at the outset of the third phrase (the end of m. 4), weak motional energy emerges largely because of offbeat anacrusis generated by dynamic accents. BUR values drop below 1.0 in m. 5 because of the rise in the downbeat latency and because Clark attacks the accented $E\flat_5$ at the top of the line early and sustains it slightly for emphasis, further postponing arrival on the ensuing C_5. The weak anacrusis generated from dissonance [(x)] on the D_5 is then strengthened with a rise in the BUR value and placement of a dynamic accent on the following $D\flat_5$. As the downbeat delay decreases from there and BUR values increase, weak motional energy gives way to moderate for the rest of the phrase.

The effect of this final BUR surge is different from those seen in m. 3 or in the Coltrane and Konitz examples, however. In all of those cases, the BUR surge served as a phrase-ending device not merely because it brought the soloist into greater microrhythmic consonance with the bassist and drummer, but because it was met with a corresponding drop in UBR values to below the 0.67 threshold supplemented by other parametric forms of closure. This resulted in an increase in the strength and frequency of melodic closure and inhibition of the forward flow of motional energy. Here in m. 6, however, Clark manages to keep the UBR above the 0.67 threshold, thus sustaining an

88 This corroborates Friberg and Sundström's finding for a tendency among the soloists in their study to lay back on the downbeats while synchronizing their upbeats with the drummer (2002, 342–43).

unimpeded flow of moderate motional energy through the end of the bar. As a consequence, there is no preparation for the end of the phrase, no attenuation of its forward momentum; its abrupt conclusion on $C\sharp_4$—the dissonant ♯11 of the new G^7 harmony in m. 7—is thus doubly surprising.

Clark gains considerable expressive nuance by moving from straight to swing eighth notes either between phrases or within a single phrase. He makes his eighth notes more even by lying far back on the beat as defined by the bassist and drummer. This enables him to sustain a minimal degree of motional energy while projecting a laid-back quality, in the manner suggested by Friberg and Sundström. He sounds almost aloof from the groove defined by bass and drums, in fact, until he moves into higher BUR values at the ends of his phrases—the resolution of microrhythmic dissonance described by Benadon. As he moves more into phase with the drummer's higher BUR values, he can either increase the rate and strength of closure to draw the phrase toward its conclusion, as he does in the second phrase, or subvert that closure to sustain the motional energy of the phrase for dramatic effect, as he does in the third phrase. At issue, quite simply, is the degree of inequality between his downbeat and upbeat swing eighth notes.

* * *

Why, then, do jazz musicians swing their eighth notes? The central claim of the theory presented here is that jazz musicians swing their eighth notes to produce anacrusis on the offbeats, an effect that generates motional energy directed toward the ensuing downbeat as a consequence. By subverting downbeat closure in one way or another, jazz musicians can sustain the sense of forward propulsion characteristic of the rhythmic quality we call swing.

This theory supplements extant research on the swing ratio with an explanation of the affective consequences of BUR variability. I have endeavored to show how since at least the Bebop era jazz musicians have exploited the affective nuances of varying degrees of durational inequality as an expressive resource. The analyses presented above reveal ways in which three acclaimed jazz musicians vary their BUR values in conjunction with other features of melodic structure in order to regulate the flow of motional energy. The apparent stream of eighth notes in their respective phrases conceals underlying microrhythmic processes that either facilitate or impede the forward propulsion thought to typify swing.

These are just three very brief examples, to be sure, limited in stylistic range and historical scope, but they do help clarify the effects of microrhythmic nuance in the production of swing. Analysis of phrases by additional musicians would surely reveal other ways in which varying BUR values helps to shape phrase structure in terms of motional energy, and the analysis of a complete improvised solo might offer insight into the modulation of BUR values in relation to motivic development and large-scale structure. Moreover, a systematic comparison of eighth-note timings across different historical periods might illuminate the varied motional qualities characteristic of each particular style. This is beyond the scope of the present study, however, the aim of which is primarily to present a theory of the expressive function of the swing eighth note and its role in generating swing. Swing is not a specifiable quantity, of course, nor is it a quality that is precisely quantifiable; it is rather a feeling that emerges from quantifiable processes, both rhythmic and microrhythmic, syntactical and subsyntactical, as I have sought to demonstrate. We come closer to understanding this feeling when we recognize the plurality of sources and the variety of means for its production.

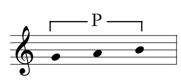
appendix

A summary of melodic structures drawn from the implication-realization model used in the analyses, based on Narmour (1992, 370–71 and 390–91).

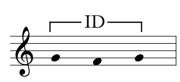
For each of the basic structures shown below, the first two tones generate an implication for a third that is more or less specific as to interval size and registral direction. That implication is either realized (as with process P or reversal R) or denied, either fully or partially, to some expressive effect (as with all of the other structures).

Basic melodic structures may form combinations if closure is denied on the third tone by means of dissonance or some other factor. If denial of closure continues, basic melodic structures may form chains.

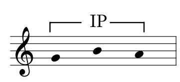
P — Process
small interval followed by similarly small interval
with continuation of registral direction



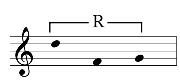
ID — Intervallic Duplication
small interval followed by identical small interval
with change of registral direction



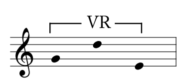
IP — Intervallic Process
small interval followed by similarly small interval
with change of registral direction



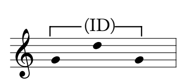
R — Reversal
large interval followed by small interval
with change of registral direction



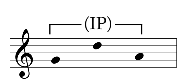
VR — Registral Reversal
large interval followed by larger interval
with change of registral direction



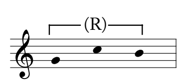
(ID) — Retrospective Intervallic Duplication
large interval followed by identical large interval
with change of registral direction



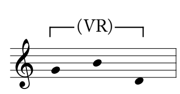
(IP) — Retrospective Intervallic Process
large interval followed by similarly large interval
with change of registral direction



(R) — Retrospective Reversal
mid-sized interval followed by small interval
with change of registral direction



(VR) — Retrospective Registral Reversal
small interval followed by larger interval
with change of registral direction



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