Swing Rhythm in Classic Drum Breaks From Hip-Hop's Breakbeat Canon

Andrew V. Frane
University of California, Los Angeles

Certain recorded drum breaks, i.e., drum patterns played without other instrumentation, have achieved iconic status, largely as a result of being frequently "sampled" in other recordings. Although these highly influential drum breaks (sometimes called breakbeats) have been integral to much of the hip-hop and other music produced in recent decades, there has been little scholarly investigation of their rhythmic features. To that end, this study examined 30 classic drum breaks from the "breakbeat canon," focusing primarily on sixteenth-note swing (a systematic delay of even-numbered sixteenth-note divisions of the pulse). Such swing was common among the examined drum breaks, though the magnitude of swing was often fairly subtle (median swing ratio = 1.2:1). In contrast to some findings regarding jazz drumming, the magnitude of swing was uncorrelated with tempo, though the ranges of both variables were somewhat constrained. Backbeat delay (a systematic delay of snare drum at even-numbered beats) was found to be frequently present at beat 2, but not at beat 4. Additionally, this study introduces a quantity called "swing density," defined as the proportion of even-numbered divisions (at the swing level) that contain events. The importance of this quantity to the perceptual effect of swing is discussed.

Received: October 12, 2015, accepted May 1, 2016.

Key words: swing, microtiming, hip-hop, breakbeats, sampling

Much of the music recorded in recent decades has used *samples*, i.e., short excerpts of the audio from a previous recording, recontextualized into a new composition. Frequently, these samples come from a *drum break*, sometimes called a *break* or *breakbeat*, which can be defined as a portion of a song that is not necessarily a "drum solo" per se, but in which a drum pattern is played without other instrumentation.[1] Some drum breaks—typically from funk, soul, and rock records of the late 1960s through early 1980s—have been sampled so frequently that they have achieved iconic status, earning a place in what some authors have appropriately called the "breakbeat canon" (Oliver, 2015; Williams, 2014). The present study refers to these as *classic drum breaks*.

Perhaps the most celebrated classic drum break comes from James Brown's "Funky Drummer," which has been sampled in thousands of recordings (Schloss, 2014), including hip-hop songs by Run-D.M.C. ("Run's House"), Kwamé ("The Rhythm"), and L. L. Cool J ("Mama Said Knock You Out" and others). In fact, Oliver (2015, p. 180) noted that "Funky Drummer" has been "sampled and recontextualized so extensively as to achieve near-ubiquity in a wide range of popular music genres." Yet other classic drum breaks have arguably achieved even greater and more enduring prominence than "Funky Drummer" as standard sources for sampling.

For example, the drum break from The Honey Drippers' "Impeach The President" has provided the principal rhythmic backing for countless well known hip-hop recordings, such as Nice & Smooth's "Funky For You," Kris Kross' "Jump," Notorious B.I.G.'s "Unbelievable," J Cole's "Wet Dreamz," L. L. Cool J's "Around The Way Girl," and De La Soul's "Ring Ring Ring (Ha Ha Hey)," not to mention popular recordings outside of hip-hop, such as Janet Jackson's "That's The Way Love Goes," Meredith Brooks' "Bitch," and Alanis Morissette's "You Learn." Samples of the drum break from Melvin Bliss' "Synthetic Substitution" have been similarly prevalent, appearing in a multitude of well known hip-hop recordings (e.g., Naughty by Nature's "O.P.P.," Public Enemy's "Don't Believe The Hype," The Pharcyde's "Ya Mama," and Gang Starr's "Dwyck"), as well as in pop songs (e.g., Justin Bieber's "Die In Your Arms" and Hanson's "Mmm Bop").

Although the sampling of drum breaks is perhaps most associated with the rap and R&B music of "hip-hop's Golden Era" (c. 1986-1993), the practice has spread profusely into other genres (Oliver, 2015). In fact, the drum

[1] The terms *break* and *breakbeat* are less consistently defined than *drum break*, and are sometimes applied to passages that include additional instrumentation besides drums. But for the purposes of the present study, the three terms may be taken as equivalent.

Music Perception, volume 34, issue 3, pp. 291–302, issn 0730-7829, electronic issn 1533-8312. DOI: https://doi.org/10.1525/mp.2017.34.3.291

break from The Winstons' "Amen, Brother" has been recognized as a staple—and even a foundational element—of some genres of electronic dance music, such as *jungle* (Butler, 2006; Edwards, 2009; Harrison, 2015; Oliver, 2015; Ratcliffe, 2014; Shapiro, 1999). The "Amen, Brother" break has often been "chopped up" and rearranged into new rhythms, rather than simply looped in its entirety, but the chopped fragments are typically long enough to preserve phrases from the original pattern (e.g., in the jungle song "Original Nuttah," by UK Apachi with Shy FX).

Given the influence of classic drum breaks on popular music—an influence that undoubtedly extends far beyond the numerous recordings that have sampled these breaks directly—it is surprising that there has not been much formal analysis focused on the rhythmic features of the breakbeat canon. These breaks may be especially satisfying, as evidenced by their repeated use, and therefore would seem to be of interest from a music perception point of view. Of course, rhythmic features alone do not explain why certain drum breaks have become classics. Other factors, such as the tonal qualities of the drum sounds (McDermott, 2012) and the notoriety of the songs in which the breaks were sampled, are also relevant, but are beyond the scope of this paper.

One important feature of rhythm is *microtiming*: Notes are often not played exactly at *isochronous* (evenly timed) metric divisions of a bar, but rather, slightly earlier or later. Schloss (2014, p. 141) remarked that in sample-based hip-hop, rather than striving for computer-perfect timing, "producers actively seek a balance between sounding mechanically precise and overly loose," an aesthetic ideal that presumably applies to most other styles of music as well. In sample-based music, this balance largely reflects the sampled material. Indeed, as Schloss correctly noted, "since one is working with samples of live musicians, the rhythms *within* the samples themselves may not be precise" (p. 140). However, not all microtiming in drum breaks is mere "looseness" created by expressive whim or by the random variation of human error. On the contrary, some forms of microtiming, such as *swing* (defined in the following section), are highly systematic.

SWING

Swing is a systematic delay of even-numbered divisions in a pulse.[2] This delay is applied at a specific *swing level* (typically the eighth-note or sixteenth-note level). For instance, in traditional jazz, eighth-note swing is achieved by "swinging" (i.e., slightly delaying) the onset of each even-numbered eighth-note division. In certain funk and rock rhythms, sixteenth-note swing is achieved by swinging each even-numbered sixteenth-note division (each "ee" and "uh" in the "one-ee-and-uh-two-ee-and-uh . . . " paradigm). Although swing has received considerable attention in some genres (primarily jazz), it has been relatively unexamined in some other genres, such as hip-hop.

The perceptual effect of swing—*swing feel*—is difficult to describe without invoking figurative language. Loosely speaking, swing can make rhythms sound less mechanical and more organic ("making the notes come alive"; Prögler, 1995, p. 21), and has been described as creating a sense of "forward propulsion" (Butterfield, 2011, p. 3 and throughout) that helps music to "groove" and inspire movement in the listener (Scarth & Linn, 2013).

SWING RATIO

Swing magnitude can be measured in absolute time by estimating the milliseconds of displacement applied to even-numbered divisions. However, swing magnitude is more typically quantified by the *swing ratio* (Friberg & Sundström, 2002), i.e., the ratio of an odd-numbered division's duration to an adjacent even-numbered division's duration, where "duration" is defined as the interonset interval between the given division and the following division. A 1:1 swing ratio corresponds to *straight* (isochronous) divisions, meaning no swing whatsoever. Ratios near 2:1 correspond to a *triplet feel* (sometimes called a *triple feel*; Friberg & Sundström, 2002). Figure 1 shows how two eighth notes would theoretically be played with eighth-note swing, using 1:1, 2:1, and 3:1 swing ratios. For sixteenth notes played with sixteenth-note swing, simply halve all the note values in Figure 1. In fact, for any given swing ratio, eighth-note swing at a given tempo produces the same interonset intervals as sixteenth-note swing at half that tempo; the difference is in where the *tactus* (the main pulse) is perceived relative to the swing level.

In practice, swing ratios tend to fall in between the simple integer ratios in Figure 1, and hence do not to map neatly onto conventional notation. Indeed, although jazz swing is often conceptualized as having a 2:1 swing ratio, that does not reflect the way that swing is typically applied (as noted by Benadon, 2006; Butterfield, 2011; Freeman & Lacey, 2002; Friberg, & Sundström, 2002; Honing & Haas, 2008; Prögler, 1995).

[2] Swing may alternatively be conceptualized as a shift in when notes are played relative to the divisions (i.e., relative to an isochronous grid), rather than as a shift in the division onsets themselves. But for the purposes of this study, the two conceptualizations are effectively equivalent and the latter is more convenient.

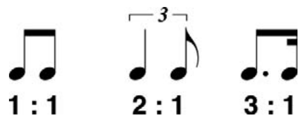

FIGURE 1. How two eighth-notes would theoretically be played using eighth-note swing, with 1:1, 2:1, and 3:1 swing ratios.

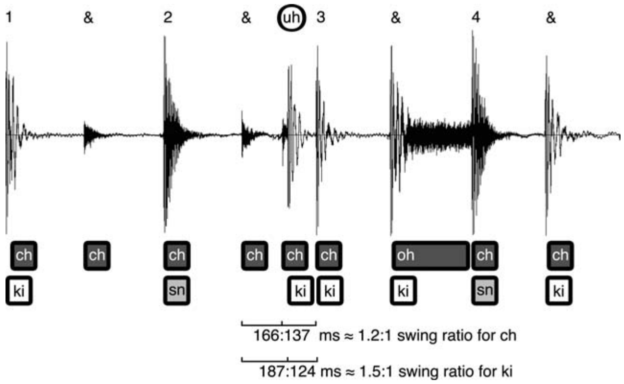

FIGURE 2. "Impeach The President" drum break. ch = closed hi-hat event; oh = open hi-hat event; ki = kick drum event; sn = snare drum event. The counts above the waveform indicate the divisions at which one or more events occur; the circled count indicates a swingable division.

Different authors have observed different swing ratios to be typical in jazz, largely because those authors based their assessments on different musicians playing different material, sometimes on different instruments (see reviews by Benadon, 2006; Butterfield, 2011). Even within a given performance, a jazz drummer's swing ratio may vary from one passage to another, and the drummer's swing ratio is often higher than the swing ratios of other musicians in the ensemble (Butterfield, 2011; Friberg & Sundström, 2002). Analyses of jazz drummers' ride cymbal rhythms found that, at least for tempos in excess of 200 quarter notes per minute, eighth-note swing ratio decreased as tempo increased (Collier & Collier, 1996; Friberg & Sundström, 2002; Honing & Haas, 2008). For slower tempos, this trend was less consistent, both between and within studies (see Figure 2 in Honing & Haas, 2008).

It is notable that Roger Linn, who was largely responsible for designing the Akai MPC series of drum machines that became industry standards in hip-hop music production, incorporated an adjustable "swing setting" into his products (Scarth & Linn, 2013). Unlike swing ratio, the swing setting is expressed as a percentage (specifically, the percentage of two adjacent divisions' combined duration that is occupied by the odd-numbered division). However, there is a one-to-one correspondence between the two systems of measurement. For instance, a 50% swing setting corresponds to a swing ratio of 50:50 = 1:1, and a 75% swing setting corresponds to a swing ratio of 75:25 = 3:1. Some popular drum machines by other designers have adopted the same percentage system. For example, the Oberheim DMX offered six discrete swing settings: 50%, 54%, 58%, 62%, 66%, and 71%, which could be applied at either the eighth-note or sixteenth-note level (Sofer, 1982, pp. 9-10).

THRESHOLD FOR SWING

No particular magnitude of displacement has been established as the definitive perceptual boundary between straight and swinging. Note that an experimentally determined threshold of swing detectability does not necessarily indicate the "visceral" threshold of swing feel. Moreover, a threshold that is determined using an explicit judgment task does not necessarily apply in authentic contexts of music listening. However, if a heuristic threshold separating straight from "detectably not straight" must be chosen, then there are useful estimates in the literature.

Friberg and Sundström (2002), based largely on psychoacoustic data summarized by Friberg and Sundberg (1995), proposed a heuristic threshold of 10 ms for "cyclic displacement," meaning that a shift in the onsets of swung divisions would become noticeable at a magnitude of roughly 10 ms (except at slow tempos).[3] Butterfield (2011), based on personal experience studying excerpts of jazz recordings, loosely estimated the just-noticeable difference in swing ratio as somewhere between 0.1 and 0.2, meaning that a just-noticeable deviation from 1:1 would be a swing ratio somewhere between 1.1:1 and 1.2:1.

Note that the 10 ms threshold estimated by Friberg and Sundström (2002) is in terms of absolute time shift, whereas Butterfield's (2011) lower and upper bounds [1.1:1, 1.2:1] are in terms of swing ratio. However, the two heuristics are compatible for sixteenth-note swing when the tempo is in the range of roughly 70-140 quarter notes per minute (as the tempos of classic drum breaks typically are). For example, at a tempo of 100 quarter notes per minute, isochronous sixteenth-note divisions would each be 150 ms in duration. Hence,

[3] For swing-level interonset intervals > 250 ms (i.e., for tempos < 120 quarter notes per minute when swing is at the eighth-note level, or < 60 quarter notes per minute when swing is at the sixteenth-note level), the authors described the threshold as a roughly 10% change in swing ratio (e.g., from 1.0:1 to 1.1:1), rather than as an absolute time shift. However, the drum breaks examined in the present study are considerably faster than 60 quarter notes per minute.

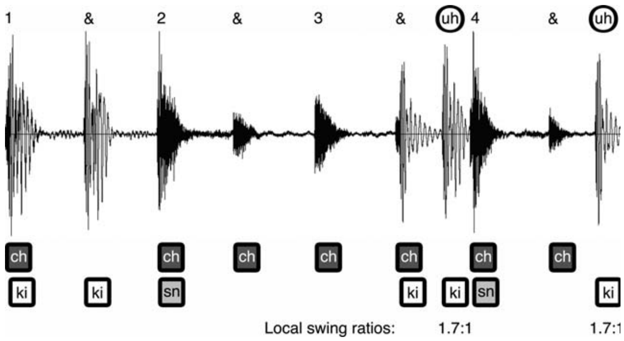

FIGURE 3. "It's A New Day" drum break. ch = closed hi-hat event; ki = kick drum event; sn = snare drum event. The counts above the waveform indicate the divisions at which one or more events occur; the circled counts indicate swingable divisions.

applying a 10 ms delay to the even-numbered division onsets would make the odd-numbered divisions 160 ms and would make the even-numbered divisions 140 ms—producing a swing ratio of 160:140 = 1.14:1.

When referencing a threshold is useful, this paper uses the 10 ms heuristic estimate. However, such references should always be taken with the caveat that the "true" boundary between straight and swinging is blurry, subjective, and probably contextually dependent.

SWING DENSITY

Swing ratio quantifies the shift of events at even-numbered divisions, but does not take into account how frequently such events actually occur. To address the latter, the present author proposes a quantity called *swing density*, defined as the proportion of "swingable" divisions (i.e., even-numbered divisions at the swing level) that contain one or more events. For example, as shown in Figure 2, the "Impeach The President" break has one even-numbered sixteenth-note division that contains events, and has eight even-numbered sixteenth-note divisions in total (because there are eight even-numbered sixteenth-note divisions in any 4/4 bar). Thus, this break has a sixteenth-note swing density of 1 / 8 = 12.5%. Figure 3 shows another example: This bar from Skull Snaps' "It's A New Day" has two even-numbered sixteenth-note divisions that contain events, and thus has a sixteenth-note swing density of 2 / 8 = 25%. Note that unlike swing ratio, swing density is insensitive to the magnitude of swing; a bar with events at every even-numbered sixteenth-note division has a sixteenth-note swing density of 100%, even if the swing ratio is 1:1.

Swing density overlaps substantially with general *rhythmic density*, which could be defined as simply the frequency that events occur in a passage. However, the two quantities are not equivalent. Swing density reflects the rhythmic density among only a specific subset of divisions, namely the even-numbered divisions at the swing level. Thus, not all events that contribute to general rhythmic density contribute to swing density. For instance, events at eighth-note divisions (i.e., at odd-numbered sixteenth-note divisions) do not contribute to sixteenth-note swing density. Nor do events at even-numbered 32nd-note divisions, though that is usually not an issue in classic drum breaks, which tend not to include fast, complex phrases.

BACKBEAT DELAY

Another form of systematic microtiming is a slight delay of the *backbeats*, where backbeats are defined as "a strongly accented snare drum stroke or handclap on beats two and four of a four-beat metric cycle" (Iyer, 2002, p. 405). Iyer proposed that backbeat delay helps to maintain a relaxed feel, and that delayed backbeats are frequently preferred in African American music—a broad category that presumably includes most of the songs that classic drum breaks come from, as well as a large proportion of the songs that have sampled them. Other anecdotal evidence corroborates Iyer's assertions (e.g., Bowman, 1997, pp. 61-62).

On the other hand, Linn disputed the importance of backbeat delay, at least for electronically programmed drum rhythms. In fact, Linn expressed doubt regarding the effectiveness of any microtiming—systematic or not—other than swing (Scarth & Linn, 2013): "I've heard lots of theories over the years about other timing tricks, like introducing random timing variations into the notes of the beat, or delaying the snare on 2 and 4, but I've never found these to do much good. In fact, I'd suggest that if the note dynamics and swing are right, then the groove works best when the notes are played at exactly the perfect time slots." In an online experiment, Frühauf, Kopiez, and Platz (2013) found that for a simple, programmed rock rhythm (alternating kick and snare quarter notes at 120 beats per minute, with isochronous hi-hat eighth notes), music students at German universities indeed gave the highest "quality" ratings to a version of the rhythm that had no displacements. However, versions with kicks or snares that were late-shifted by 15 or 25 ms were rated as higher quality than versions with kicks or snares that were early-shifted by corresponding amounts.

Freeman and Lacey (2002, p. 550) analyzed microtiming in the "Funky Drummer" break and observed that "by far the most obvious feature" was a consistent lagging of beat 2, by 2.8% of beat duration on average. However, the researchers found that beat 3 also tended to be late (by 1.8% of beat duration), and that beat 4 was "the most accurate beat," displaced by only 0.6% of beat duration on average (see McGuiness, 2005, p. 65 for a visualization of this accelerative trend, based on the Freeman and Lacey data). De Wannemaeker (2013) observed a somewhat similar pattern of within-bar acceleration in an excerpt from James Brown's "Hot Pants." De Wannemaeker noted that the acceleration was not consistent with Iyer's description of backbeat delay, but was consistent with Danielsen's (2006, p. 73) observation that in funk rhythms, beat 1 is typically played "on top" (i.e., slightly early).

THE PRESENT STUDY

This study explores four research questions regarding classic drum breaks. First, what swing ratios are typical of these passages? Second, is swing ratio correlated with tempo in classic drum breaks, as some have observed in jazz drumming (e.g., Friberg & Sundström, 2002)? Third, do drum breaks with higher swing density differ qualitatively from drum breaks with lower swing density? And fourth, is the backbeat delay that was described by Iyer (2002) evident in classic drum breaks?

Method

EXAMINED MATERIAL

Thirty classic drum breaks were examined. The principal criterion for a given break to be considered as "classic" was that it had been prominently sampled by multiple known songs. Most of the examined breaks had also been anthologized in breakbeat compilations, such as the landmark *Ultimate Breaks and Beats* series assembled by Leonard "BreakBeat Lenny" Roberts and Louis "BreakBeat Lou" Flores (for the importance of these collections, see Schloss, 2014). Each break was in 4/4 time and was at least one bar long. For breaks that were several bars long, only the most commonly sampled portion was examined (a subjective judgment in some cases).

Breaks containing instrumentation other than drums and unpitched percussion were excluded from the analysis. For example, the opening passages from Bob James' "Take Me To The Mardi Gras" and James Brown's "Funky President," though certainly classic, were not considered as drum breaks by this study. However, exceptions were made for percussive vocalization in "Funky Drummer" and, in a few breaks, for brief, percussive notes on the first beat of bar 1. A few classic drum breaks were excluded because the durations of sixteenth-note divisions could not be measured with sufficient precision; this could occur when a drum break was rhythmically sparse at the eighth-note level (Billy Squier's "The Big Beat," Joe Tex's "Papa Was Too") or when the principal swung elements were shaken percussion sounds with gradual attacks (Lyn Collins' "Think," Gaz's "Sing Sing," Tom Scott's "Sneakin' In The Back"). One break (Led Zeppelin's "When The Levee Breaks") was excluded because it featured *slap delay* (an "echo" effect) that was difficult to distinguish from articulated drum hits.

As is typical of funk rhythms (Ashley, 2014; Danielsen, 2006; Stewart, 2000), all the drum breaks had accented events on beat 1 (usually a kick drum) and on beat 2 (usually a snare), at least in the first bar. In most cases, there was also an accented snare on beat 4. Other emphases varied across drum breaks.

SWING RATIO COMPUTATIONS

Using the waveform editor in Pro Tools LE 8 software, sixteenth-note divisions of each drum break were marked at event onset times (i.e., at the time points when a drum hit occurred). Subtle snare drum rolls without clear metric positions were disregarded, as were some percussion elements other than drum kit (e.g., the bongos in The Incredible Bongo Band's "Apache"), but such instances were fairly rare.

For each even-numbered sixteenth-note division that contained one or more events, the *local swing ratio* was computed as the ratio of the adjacent (odd-numbered) division's duration to the given (even-numbered) division's duration.[4] The swing ratio for each break was then computed as the mean of the break's local swing ratios. All local swing ratios, even those < 1:1 ("inverted swing"), were included in the swing ratio computations, but local swing ratios substantially lower than 1:1 were rare.

In some cases, there was ambiguity regarding where divisions should be marked, because two different events (e.g., kick drum and hi-hat) could have slightly different onset times, even though they occurred at the same division. When in doubt, the hi-hat was usually given precedence, because it was the most regularly occurring element and thus was considered the principal timekeeper. When hi-hat onset was obscured by snare drum onset, the two onsets were considered as coincident.

Selecting one kind of event or another as the most rhythmically relevant did not generally have a large impact on the overall swing ratio, but there was a notable

[4] The "adjacent" division was either the immediately preceding division or the immediately following division, depending on which had a measurable duration. When both had measurable durations, the mean of the two was used.

exception: As shown at the bottom of Figure 2, in the "Impeach The President" break, the hi-hat exhibits a swing ratio of roughly 1.2:1, whereas the kick drum exhibits a swing ratio of roughly 1.5:1. In fact, it is likely that this "dual swing ratio" gives the break much of its rhythmic character. As a compromise, the mean of the two ratios is reported as this break's swing ratio and 1.5:1 is reported as its maximum local swing ratio.

TEMPO COMPUTATIONS

Tempo (beats per minute) was computed for each break as the number of quarter-note divisions divided by the number of minutes (converted from milliseconds).

SWING DENSITY COMPUTATIONS

Swing density was computed for each break as the proportion of even-numbered sixteenth-note divisions containing one or more events.

BACKBEAT DELAY COMPUTATIONS

Quarter-note beat onsets were marked for each break. Even-numbered beat onsets were marked at the snare onset, because backbeat delay has been said to apply specifically to snare drum (Iyer, 2002). *Standardized durations* of each beat were then computed as percentages of the encompassing bar's duration (e.g., four beats of exactly equal length would each have a standardized duration of 25%). When a break was multiple bars long, the mean standardized durations across bars were used. A grand mean across breaks was then computed for each of the four standardized beat durations.

Backbeat delay was evaluated in two analyses. In the primary analysis, a given beat was considered as delayed if the preceding beat's standardized duration was longer than 25% of bar duration. In the secondary analysis, which served as a verification of the primary analysis, a given beat was considered as delayed if the preceding beat's duration was longer than the beat duration preceding it. The breaks were considered as loops, so that beat 4 was considered as "preceding" beat 1.

Results and Discussion

SWING RATIO

Table 1 gives the observed swing ratios in order of increasing magnitude. Displayed values are rounded to avoid false implications of precision. Only the numerator of the swing ratio is displayed, as the denominator is always 1. For example, "1.2" in the table indicates a swing ratio of approximately 1.2:1. The numerators of the swing ratios ranged from 1.0 to 2.1, but were mainly $\leq$ 1.3 ($M = 1.3$, $SD = 0.25$, $Mdn = 1.2$).

Conveniently, if 10 ms of displacement is taken as the detection threshold for swing, and if displacement is estimated as half the difference in duration between adjacent sixteenth-note divisions, then all the rounded swing ratios $\leq$ 1.1:1 are subthreshold, and all the rounded swing ratios $\geq$ 1.2:1 are above threshold (except for "Amen, Brother," which is considerably faster than the other breaks).[5] Thus, the six swing ratios that were approximately 1.1:1 should arguably be considered as effectively straight. Indeed, Greenwald (2002, p. 262) noted the "straight sixteenths" that characterize the hi-hat in "Funky Drummer." But if rhythms with swing ratios of 1.1:1 are really just straight rhythms with added statistical jitter, then why is that jitter so directionally biased, rather than roughly symmetric around zero? In other words, why were several swing ratios of 1.1:1 observed, but no swing ratios of 0.9:1?

One possible explanation is that funk drummers are accustomed to frequently playing with swing, and are therefore more apt to favor that direction in their unconscious variations, even when playing straight. Moreover, slipping into a slight swing now and then might be inconsequential to an ostensibly straight groove, whereas slipping into an unconventional, inverted swing might be mildly jarring and disruptive, especially if other musicians in the ensemble are playing with a slight swing in the standard direction. Thus, drummers may have often become conditioned to marginally "err on the side of swing" when playing straight rhythms. Of course, these are only speculations.

The median swing ratio, 1.2:1, may typically be a perceptible departure from isochrony, but it is still fairly subtle. In fact, a 1.17:1 swing ratio would be equivalent to a 54% swing setting—a setting that Linn praised specifically for its subtlety: "a swing setting of 54% will loosen up the feel without it sounding like swing" (Scarth & Linn, 2013). Moreover, an experiment by Friberg and Sundberg (1994) found that a 1.2:1 swing ratio constituted the just-noticeable magnitude of swing in an electronically programmed synthesizer melody.

However, there is an important respect in which the swing ratios of most classic drum breaks differ

[5] Although the "Amen, Brother" break exhibited only 7 ms of delay at swingable divisions on average, hip-hop songs that have sampled "Amen, Brother" have generally slowed down the break considerably, possibly making microtiming more perceptible. For example, N.W.A.'s "Straight Outta Compton" loops one bar from the break at 102 beats per minute, presumably sampled from the first volume of the *Ultimate Breaks and Beats* compilation, which included an edited version of "Amen, Brother" with the break slowed down to that tempo (by playing the 45 rpm record at 33 1/3 rpm). On the other hand, when sampled in electronic dance music, the break is often sped up to even faster than its original tempo.

TABLE 1. *Characteristics of 30 Classic Drum Breaks*

Song Title of Drum Break Source	# of Bars	BPM	Swing Ratio	Max LSR	Swing Density (%)
Love's Theme	1	96	1.0	1.0	100.0
Theme From The Planets	2	79	1.0	1.1	93.8
I'm Glad You're Mine	2	81	1.0	1.2	50.0
You Can Make It If You Try	1	103	1.0	1.2	50.0
Breakthrough	4	85	1.1	1.2	96.9
Apache	2	117	1.1	1.2	25.0
Funky Drummer	2	101	1.1	1.2	100.0
I'm Gonna Love You Just A Little More Baby	2	84	1.1	1.2	100.0
Hihache	1	100	1.1	1.2	25.0
You're Getting A Little Too Smart	2	94	1.1	1.3	18.8
Kool Is Back	4	104	1.2	1.4	46.9
Funky Worm	1	82	1.2	1.2	12.5
Amen, Brother	4	138	1.2	1.6	43.8
Here Comes The Meter Man	2	94	1.2	1.4	62.5
The Jam	1	109	1.2	1.3	50.0
God Made Me Funky	4	94	1.2	1.4	31.2
You & Love Are The Same	2	121	1.2	1.3	12.5
Kissing My Love	4	92	1.3	1.5	96.9
Ashley's Roachclip	1	98	1.3	1.4	100.0
Do The Funky Penguin Part II	1	106	1.3	1.3	25.0
N.T.	1	99	1.3	1.5	87.5
Synthetic Substitution	2	96	1.3	1.7	50.0
Impeach The President	1	95	1.4	1.5	12.5
Fool Yourself	1	78	1.5	1.7	25.0
Long Red	1	93	1.5	1.5	25.0
You'll Like It Too	4	104	1.6	2.0	96.9
Get Out My Life Woman	2	91	1.6	1.7	25.0
Don't Change Your Love	1	92	1.6	1.7	37.5
It's A New Day	1	95	1.7	1.7	25.0
Sing A Simple Song	1	101	2.1	2.1	12.5

Notes. # of bars = number of bars examined. BPM = beats per minute. Max LSR = maximum local swing ratio. See the discography for recording artist, year, and label information.

from Linn's swing settings and from the swing ratios in the Friberg and Sundberg (1994) experiment. Namely, the local swing ratios in classic drum breaks often vary within a passage, so that the overall swing ratio may understate the peak magnitude of swing in the excerpt. For instance, the "Synthetic Substitution" break has a swing ratio of 1.3:1, but has a maximum local swing ratio of 1.7:1. As shown in Figure 4, bar 2 of the "Synthetic Substitution" break is a replaying of the same pattern from bar 1 (notwithstanding a single substitution of open hi-hat for closed hi-hat), but the local swing ratios in bar 2 are increased across the board.

Songs that have sampled different portions of "Synthetic Substitution" have consequently exploited different amounts of swing from the break. For example, The Pharcyde's "Ya Mama" uses the first bar, whereas Naughty by Nature's "O.P.P." capitalizes on the added "bounciness" of the second bar, most noticeable at the pickup to beat 4 (the maximum local swing ratio of the break). Pop singer Justin Bieber's "Die In Your Arms" also uses the second bar of the break, but *quantizes* the pattern, so that the microtiming is removed and the event onsets land at isochronous grid positions. The result is a "squarer," more mechanical rhythm that, to the present author, lacks much of the vitality of the original break.

RELATION BETWEEN TEMPO AND SWING RATIO

The Pearson correlation between tempo and swing ratio was negligible, $r(28) = -.01$, 95% CI [−.37, .35], $p = .94$. And a scatterplot (Figure 5) revealed no pronounced association between the two variables. Thus, tempo and swing ratio may be essentially independent in classic drum breaks. However, the ranges of both variables were fairly constrained.

SWING DENSITY

As shown in Table 1, a wide range of swing densities was observed and no particular swing density emerged as

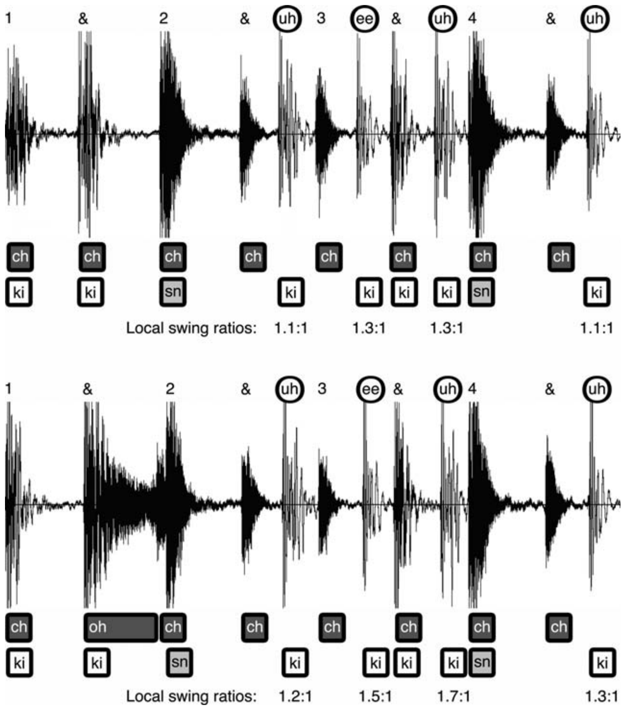

FIGURE 4. Bars 1 (top) and 2 (bottom) of the "Synthetic Substitution" drum break. ch = closed hi-hat event; oh = open hi-hat event; ki = kick drum event; sn = snare drum event. The counts above each waveform indicate the divisions at which one or more events occur; the circled counts indicate swingable divisions.

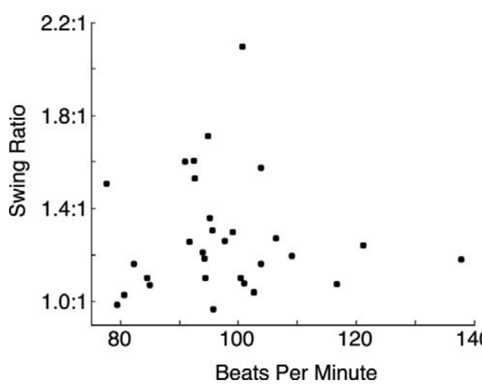

FIGURE 5. Swing ratio as a function of tempo among 30 classic drum breaks.

typical. However, the observed swing densities can arguably be divided into two categories: high swing densities of $\geq$ 87.5% and lower swing densities of $\leq$ 62.5%. High swing densities invariably reflected continuous (or nearly continuous) hi-hat sixteenth notes, or in the case of Soul Searchers' "Ashley's Roachclip," continuous tambourine sixteenth notes. In breaks with lower swing densities, hi-hat was usually confined to eighth-note divisions, so that the only swingable events were kick and/or snare drum (though there were a few exceptions).

High swing density can also be distinguished from lower swing density in terms of swing feel, at least in the present author's opinion. Indeed, although sensations of forward propulsion can be produced in both cases, low-density swing is more localized, and thus tends to direct its propulsive energy toward specific target positions. For example, the swung division in "Impeach The President" (Figure 2) creates a "pull" into beat 3, as if pulling the listener's head forward as it nods to the beat. Similarly, the swung kick drum in "It's A New Day" (Figure 3) pulls into beat 4 and pulls again into beat 1 of the coming bar, emphasizing the tactus at those "target beats." However, the swing energy dissipates after each target beat, so that the overall pattern of swing feel is an intermittent "pull and release," rather than a constant pull.

In contrast, the swing in Bill Withers' "Kissing My Love"—maintained by sixteenth notes on the hi-hat—distributes its propulsive force more consistently across the passage, rather than concentrating the swing exclusively at one or two points. As a result, the swing seems to pull the listener along without letting go—a sustained transportive quality that was used to great effect in Dr. Dre's "Let Me Ride," which prominently features a one-bar loop from "Kissing My Love." That is not to say that the swing energy in "Kissing My Love" is completely uniformly distributed. On the contrary, kick drum occasionally occurs at swung divisions along with the hi-hat, thus emphasizing the local swing here and there.

By expressing swing more frequently, high swing density can convey—in a sense—"more" swing. For example, the break from Sly & the Family Stone's "Sing A Simple Song," which had the highest swing ratio (2.1:1) of all the examined drum breaks by a considerable margin, does not exhibit the "most" swing per se, because there is only one swung event in the bar, arguably making swing behave more as a local coloration than as a global characteristic of the rhythm itself. By comparison, the break from Funkadelic's "You'll Like It Too" has a lower swing ratio (1.6:1) and a similar tempo, but due to its high swing density conveys a more consistent swing feel. In other words, the swing in breaks such as "Impeach The President" and "Sing A Simple Song" is something that "happens" at a particular point in the passage, whereas the swing in breaks such as "Kissing My Love" and "You'll Like It Too" is a constant presence that "nudges" the pulse along, asserting influence at nearly every opportunity.

Although readers may disagree with the present author's subjective impressions regarding swing feel, readers will likely at least agree that the extent to which

TABLE 2. *Standardized Beat Durations Compared to a Hypothetical Standardized Duration of 25%*

Beat	Mean Duration as % of Bar Duration	95% CI	SD	$t(29)$	p
1	25.21	25.06, 25.37	0.42	2.83	.01
2	25.02	24.85, 25.19	0.45	0.26	.80
3	24.95	24.77, 25.13	0.48	−0.61	.54
4	24.75	24.62, 24.87	0.33	−4.17	.0003

Notes. The given unadjusted CIs and *p* values reflect two-sided one-sample *t*-tests. Because the distributions of standardized durations showed some departure from normality, two-sided Wilcoxon signed-rank tests were conducted to confirm the *t*-test results, yielding a similar pattern of *p* values for the four comparisons: .01, .54, .54, and .0003, respectively.

swing is applied locally versus globally can affect the swing feel that is conveyed. Thus, swing is perhaps better described by swing ratio and swing density in combination than by swing ratio alone. Low swing density when swing ratio is substantial suggests that swing is used only locally, whereas high swing density when swing ratio is substantial suggests a constant swinging pulse that is explicitly articulated, perhaps on hi-hat. And substantial swing density when swing ratio is near 1:1 suggests that there are many events that could have been swung but were instead played decidedly straight.

BACKBEAT DELAY

Table 2 gives the four standardized beat durations (averaged across breaks), which were compared to a hypothetical standardized duration of 25%. At $\alpha = .05$, beat 1 duration was longer than 25% to a statistically significant extent, and beat 4 duration was shorter than 25% to a statistically significant extent. Both significances were robust to a Bonferroni correction accounting for the four comparisons. The durations of beats 2 and 3 were not statistically distinguishable from 25%, even without Bonferroni correction, and beat 3 was actually nominally shorter than 25%.

These results are not consistent with a delayed beat 4, but are consistent with a slightly delayed beat 2. Beat 4 duration showed the greatest deviation from 25% on average and was at least nominally shorter than 25% of bar duration in 27 of the 30 breaks, suggesting that the beat 2 delay could be conceptualized as beat 1 earliness (consistent with the "on top" beat 1 described by Danielsen, 2006, p. 73). Note that although the means in Table 2 suggest a trend of acceleration from the beginning to the end of a bar on average, such strictly monotonic within-bar acceleration rarely actually occurred in individual breaks.

TABLE 3. *Pairwise Comparisons Among Standardized Beat Durations*

Beats Compared	Mean Difference as % of Bar Duration	95% CI	SD	$t(29)$	p
1 − 2	0.19	−0.07, 0.45	0.70	1.52	.14
1 − 3	0.27	0.00, 0.54	0.71	2.07	.05
1 − 4	0.47	0.24, 0.70	0.63	4.11	.0003
2 − 3	0.08	−0.24, 0.39	0.84	0.49	.63
2 − 4	0.28	0.06, 0.49	0.58	2.59	.01
3 − 4	0.20	−0.04, 0.45	0.66	1.67	.10

Notes. The given unadjusted CIs and *p* values reflect two-sided dependent-samples *t*-tests. Two-sided Wilcoxon signed-rank tests were conducted to confirm the *t*-test results, yielding a similar pattern of *p* values for the six comparisons: .17, .05, .0005, .45, .03, and .12, respectively.

Table 3 gives the pairwise differences among the four standardized beat durations. Although not all pairwise comparisons were directly relevant to the research question, all pairwise comparisons are nonetheless reported for the sake of completeness. At $\alpha = .05$, beat 1 duration was longer than beat 4 duration to a statistically significant extent, even after a Bonferroni correction was applied to account for all six pairwise comparisons. As a benchmark, this mean difference (0.47% of bar duration = 1.88% of beat duration) corresponds to 12 ms at 95 beats per minute, the median tempo of the examined breaks. Beat 1 duration was at least nominally longer than beat 4 duration in 22 of the 30 breaks. In contrast, beat 3 duration was not longer than beat 2 duration—even nominally—on average or in a majority of breaks. Thus, the primary and secondary analyses of backbeat delay agree: Whether backbeat displacement is evaluated relative to the encompassing bar or relative to the preceding beat, it appears that backbeats were often (albeit not always) slightly delayed at beat 2, but not typically delayed at beat 4.

Summary and Conclusions

Most drum breaks had swing ratios that were fairly low (i.e., between 1.0:1 and 1.3:1), and the median swing ratio was 1.2:1, which might be described as perceptible but subtle. However, even among effectively straight drum breaks, swing ratios exhibited a central tendency above 1:1, suggesting a bias toward swing even at subthreshold levels. Swing ratio was also found to be uncorrelated with tempo.

In the present author's opinion, swing feel varied not only with swing ratio, but also with swing density. Researchers examining swing ratio in future studies may wish to include swing density (or some similar measure) in their analyses. High swing density typically reflected continuous hi-hat sixteenth notes, which in some cases seemed to facilitate a sustained sense of motion. When swing density was low, swingable events were usually kick or snare drum. With regard to backbeat delay, there was often a slightly delayed beat 2 (or equivalently, a slightly early and elongated beat 1), but beat 4 was typically not delayed.

Samples of classic drum breaks in commercially released music appear less frequently today than during hip-hop's Golden Era (Oliver, 2015; Schloss, 2014). However, the cultural significance of these breaks endures. In fact, the most exploited classic drum breaks may have entered what could be called the "collective musical unconscious." Yet the breakbeat canon—including numerous breaks that were not analyzed in the present study—remains relatively unstudied scientifically. It is likely that more can be learned from continued exploration of these passages, not only in terms of microtiming, but also in terms of dynamics and other features beyond the scope of this study.

Author Note

Correspondence concerning this article should be addressed to Andrew Frane, UCLA Psychology Department, 7531 Franz Hall, Los Angeles, CA 90095. E-mail: avfrane@ucla.edu

References

Ashley, R. (2014). Expressiveness in funk. In D. Fabian, R. Timmers, & E. Schubert (Eds.), *Expressiveness in music performance: Empirical approaches across styles and cultures* (pp. 154-169). Oxford, England: Oxford University Press.

Benadon, F. (2006). Slicing the beat: Jazz eighth-notes as expressive microrhythm. *Ethnomusicology, 50*, 73-98.

Bowman, R. (1997). *Soulsville U.S.A.: The story of Stax Records*. New York: Schirmer.

Butler, M. J. (2006). *Unlocking the groove: Rhythm, meter, and musical design in electronic dance music*. Bloomington, IN: Indiana University Press.

Butterfield, M. W. (2011). Why do jazz musicians swing their eighth notes? *Music Theory Spectrum, 33*, 3-26. DOI: 10.1525/mts.2011.33.1.3

Collier, G., & Collier, J. (1996). The swing rhythm in jazz. In B. Pennycook & E. Costa-Giomi (Eds.), *Proceedings of the 4th International Conference on Music Perception and Cognition* (pp. 477-480). Montreal, Canada: McGill University.

Danielsen, A. (2006). *Presence and pleasure: The funk grooves of James Brown and Parliament*. Middletown, CT: Wesleyan University Press.

De Wannemaeker, X. (2013). *Formalized groove* (Unpublished bachelor's thesis). Institute of Sonology, The Hague, the Netherlands.

Edwards, C. (2009). Music and computers. *Engineering and Technology, 14*(8), 18-21.

Freeman, P., & Lacey, L. (2002). Swing and groove: Contextual rhythmic nuance in live performance. In C. Stevens, D. Burnham, G. McPherson, E. Schubert, & J. Renwick (Eds.), *Proceedings of the 7th International Conference on Music Perception and Cognition, Sydney* (pp. 548-550). Adelaide, Australia: Causal.

Friberg, A., & Sundberg, J. (1994). Just noticeable difference in duration, pitch, and sound level in a musical context. In I. Deliège (Ed.), *Proceedings of the 3rd International Conference on Music Perception and Cognition, Liège* (pp. 339-340). Liège, Belgium: ESCOM.

Friberg, A., & Sundberg, J. (1995). Time discrimination in a monotonic, isochronous sequence. *Journal of the Acoustical Society of America, 98*, 2524-2531. DOI: 10.1121/1.413218

Friberg, A., & Sundström, A. (2002). Swing ratios and ensemble timing in jazz performance: Evidence for a common rhythmic pattern. *Music Perception, 19*, 333-349. DOI: 10.1525/mp.2002.19.3.333

Frühauf, J., Kopiez, R., & Platz, F. (2013). Music on the timing grid: The influence of microtiming on the perceived groove quality of a simple drum pattern performance. *Musiciae Scientiae, 17*, 246-260. DOI: 10.1177/10298649 13486793

Greenwald, J. (2002). Hip-hop drumming: The rhyme may define, but the groove makes you move. *Black Music Research Journal, 22*, 259-271. DOI: 10.2307/1519959

Harrison, N. (2015). Reflections on the Amen break: A continued history, and unsettled ethics. In E. Navas, O. Gallagher, & x. burrough, (Eds.), *The Routledge companion to remix studies* (pp. 444-452). New York: Taylor and Francis.

Honing, H., & Haas, W. B. (2008). Swing once more: Relating timing and tempo in expert jazz drumming. *Music Perception, 25*, 471-476. DOI: 10.1525/mp.2008.25.5.471

Iyer, V. (2002). Embodied mind, situated cognition, and expressive microtiming in African-American music. *Music Perception, 19*, 387-414. DOI: 10.1525/mp.2002.19.3.387

McDermott, J. H. (2012). Auditory preferences and aesthetics: Music, voices and everyday sounds. In R. J. Dolan & T. Sharot (Eds.), *Neuroscience of preference and choice: Cognitive and neural mechanisms* (pp. 227-256). London, England: Academic Press.

McGuiness, A. (2005). *Microtiming deviations in groove* (Unpublished master's thesis). Australian National University, Canberra, Australia.

Oliver, R. (2015). Breakbeat syncretism: The drum sample in African American popular music. In J. Metcalf & C. Spaulding (Eds.), *African American culture and society after Rodney King* (pp. 177-192). Farnham, England: Ashgate.

Prögler, J. A. (1995). Searching for swing: Participatory discrepancies in the jazz rhythm section. *Ethnomusicology, 39*, 21-54. DOI: 10.2307/852199

Ratcliffe, R. (2014). A proposed typology of sampled material. *Dancecult: Journal of Electronic Dance Music Culture, 6*(1), 97-122. DOI: 10.12801/1947-5403.2014.06.01.06

Scarth, G., & Linn, R. (2013, July 2). Roger Linn on swing, groove, and the magic of the MPC's timing. *Attack Magazine*. Retrieved from http://www.attackmagazine.com/features/roger-linn-swing-groove-magic-mpc-timing

Schloss, J. G. (2014). *Making beats: The art of sample-based hip-hop*. Middletown, CT: Wesleyan University Press.

Shapiro, P. (1999). *Drum 'n' bass: The rough guide*. London, England: Rough Guides.

Sofer, D. (1982). *DMX owner's manual* (3rd ed.). Los Angeles, CA: Oberheim Electronics.

Stewart, A. (2000). 'Funky Drummer': New Orleans, James Brown and the rhythmic transformation of American popular music. *Popular Music, 19*, 293-318.

Williams, J. A. (2014). Theoretical approaches to quotation in hip-hop recordings. *Contemporary Music Review, 33*, 188-209. DOI: 10.1080/07494467.2014.959276

Discography

Bieber, Justin. (2012). Die in your arms. On *Believe* [album]. Island.

Bliss, Melvin. (1973). Synthetic substitution. On *Synthetic substitution* [single]. Sunburst.

Brooks, Meredith. (1997). Bitch. On *Blurring the edges* [album]. Capitol.

Brown, James. (1970). Funky drummer. On *Funky drummer* [single]. King.

Brown, James. (1974). Funky president (people it's bad). On *Reality* [album]. Polydor.

Cole, J. (2014). Wet dreamz. On *2014 Forest Hills Drive* [album]. Columbia.

Collins, Lyn. (1972). Think (about it). On *Think (about it)* [album]. Polydor.

De La Soul. (1991). Ring ring ring (ha ha hey). On *Ring ring ring (ha ha hey)* [single]. Tommy Boy.

Detroit Emeralds. (1973). You're getting a little too smart. On *I'm in love with you* [album]. Westbound.

Dorsey, Lee. (1965). Get out my life, woman. On *Get out my life, woman* [single]. Amy.

Five Stairsteps & Cubie. (1968). Don't change your love. On *Don't change your love* [single]. Curtom.

Funkadelic. (1980). You'll like it too. On *Connections and disconnections* [album]. L.A. International.

Funk Inc. (1971). Kool is back. On *Funk inc.* [album]. Prestige.

Gang Starr. (1992). Dwyck. On *Ex girl to next girl* [single]. Chrysalis.

Gaz. (1978). Sing sing. On *Sing sing* [single]. Salsoul.

Graham Central Station. (1975). The jam. On *Ain't no 'bout-a-doubt-it* [album]. Warner Brothers.

Grassroots, The. (1969). You & love are the same. On *Lovin' things* [single]. Dunhill.

Green, Al. (1972). I'm glad you're mine. On *I'm still in love with you* [album]. Hi.

Hanson. (1997). Mmm bop. On *Middle of nowhere* [album]. Mercury.

Hayes, Isaac. (1974). Breakthrough. On *Truck Turner* [album]. Enterprise.

Headhunters, The. (1975). God made me funky. On *Survival of the fittest* [album]. Arista.

Honey Drippers, The. (1973). Impeach the president. On *Impeach the president* [single]. Alaga.

Incredible Bongo Band, The. (1973). Apache. On *Bongo rock* [album]. MGM.

Jackson, Janet. (1993). That's the way love goes. On *Janet* [album]. Virgin.

James, Bob. (1975). Take me to the Mardi Gras. On *Two* [album]. CTI.

Kool & the Gang. (1971). N.T. On *Live at P.J.'s* [album]. De-Lite.

Kris Kross. (1992). Jump. On *Jump* [single]. Ruff House.

Kwamé. (1989). The rhythm. On *The rhythm* [single]. Atlantic.

Lafayette Afro Rock Band. (1974). Hihache. On *Voodounon* [album]. Makossa.

Led Zeppelin. (1971). When the levee breaks. On *Untitled* [album]. Atlantic.

Little Feat. (1973). Fool yourself. On *Dixie chicken* [album]. Warner Brothers.

L.L. Cool J. (1990). Around the way girl. On *Around the way girl* [single]. Def Jam.

L.L. Cool J. (1990). Mama said knock you out. On *Mama said knock you out* [single]. Def Jam.

Meters, The. (1969). Here comes the meter man. On *Cissy strut* [single]. Josie.

Morissette, Alanis. (1995). You learn. On *Jagged little pill* [album]. Maverick.

Mountain. (1972). Long red. On *The road goes ever on* [album]. Windfall.

Naughty by Nature. (1991). O.P.P. On *O.P.P.* [single]. Tommy Boy.

Nice & Smooth. (1989). Funky for you. On *Nice & Smooth* [album]. Fresh.

Notorious B.I.G., The. (1994). Unbelievable. On *Juicy* [single]. Bad Boy.

N.W.A. (1988). Straight outta Compton. On *Straight outta Compton* [album]. Priority.

Ohio Players. (1973). Funky worm. On *Funky worm* [single]. Westbound.

Papetti, Fausto. (1974). Love's theme. On *18a raccolta* [album]. Durium.

Pharcyde, The. (1992). Ya mama. On *Bizarre ride II the Pharcyde* [album]. Delicious Vinyl.

Public Enemy. (1988). Don't believe the hype. On *It takes a nation of millions to hold us back* [album]. Def Jam.

Run-D.M.C. (1988). Run's house. On *Tougher than leather* [album]. Profile.

Scott, Tom, & the L.A. Express. (1974). Sneakin' in the back. On *Tom Scott & the L.A. Express* [album]. Ode.

Skull Snaps. (1973). It's a new day. On *Skull Snaps* [album]. GSF.

Sly & the Family Stone. (1969). Sing a simple song. On *Stand*! [album]. Epic.

Sly & the Family Stone. (1969). You can make it if you try. On *Stand*! [album]. Epic.

Soul Searchers. (1974). Ashley's roachclip. On *Salt of the earth* [album]. Sussex.

Squier, Billy. (1980). The big beat. On *The big beat* [single]. Capitol.

Tex, Joe. (1966). Papa was too. On *Papa was too* [single]. Dial.

Thomas, Rufus. (1971). Do the funky penguin part II. On *Do the funky penguin* [single]. Stax.

UK Apachi with Shy FX. (1994). Original nuttah. On *Original nuttah* [single]. Sour.

Wansel, Dexter. (1976). Theme from the planets. On *Life on mars* [album]. Philadelphia International.

White, Barry. (1973). I'm gonna love you just a little more baby. On *I've got so much to give* [album]. 20th Century.

Winstons, The. (1969). Amen, brother. On *Color him father* [single]. Metromedia.

Withers, Bill. (1972). Kissing my love. On *Still Bill* [album]. Sussex.