MCFlow: A Digital Corpus of Rap Flow

Dissertation

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By

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Abstract

This dissertation describes the motivation, methodology, structure and content of a new symbolic corpus of rap vocal transcriptions known as the Musical Corpus of Flow (MCFlow). This corpus is intended to afford and inform research into the sonic organization of rapped vocals. An operational music theory of rap is presented, identifying the most artistically important features of rapped vocals and their most basic organizational structures. This theory informs and motivates the sampling and encoding scheme of MCFlow, which is described in detail. The content of the current MCFlow dataset is described as well: the current dataset includes transcriptions of 124 hip-hop songs by 47 artists, comprising 6,107 measures of music which contain 54,248 rapped words. Several preliminary descriptive analyses of the current dataset are presented as illustrations of MCFlow's usefulness for: (1) identifying normative structures in rap; (2) comparing the styles of different artists; (3) studying the historical evolution of rap artistry. Information regarding access to MCFlow data and tools for analyzing the data are presented and the MCFlow online Graphical User Interface—usable by any user with no special software requirements—is described.

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Publications

Research Publications

N. Condit-Schultz "The Musical Corpus of Flow: A digital corpus of rap transcriptions." *Empirical Musicology Review*, (forthcoming).

N. Condit-Schultz & D. Huron "Word Intelligibility in Multi-voice Singing: the Influence of Chorus Size." *Journal of Voice*, (forthcoming).

J. Devaney, A. Arthur, N. Condit-Schultz & K. Nisula "Theme and Variation Encodings with Roman Numerals (TAVERN): A new data set for symbolic analysis." *Proceedings of the International Society of Music Information Retrieval (ISMIR) conference*, 2015.

N. Condit-Schultz & D. Huron "Catching the Lyrics: Intelligibility in Twelve Song Genres." *Music Perception*, 32(5):470–483, Jun. 2015.

N. Condit-Schultz "Rhyme, Reason, and Rhythm: Elision, Enjambment, and Entropy in the Phrasing and Rhyme Schemes of Rap." *ICMPC-APSCOM Joint Conference Proceedings*, Aug. 2016.

Fields of Study

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Chapter 1: Introduction

This dissertation describes the motivation, methodology, structure and content of a new symbolic corpus of rap vocal transcriptions known as the Musical Corpus of Flow (MCFlow). This corpus is intended to afford and inform research into the sonic organization of rap vocals, especially research aiming to improve our understanding of the psychology that underlies the artistic and aesthetic appeal of rap to listeners. The motivational philosophy of MCFlow is not critical analysis, either of rap as whole or of specific artists or pieces. Rather MCFlow is intended to support empirical research and theory regarding the "natural" perception of rap, especially by lay listeners—what David Temperley calls *descriptive theory* (Temperley, 1999).

Chapter 2 presents a brief overview of rap, including its history and culture, and reviews the existing scholarly research on rap. This chapter also introduces some important rap terminology that will be used throughout the dissertation.

MCFlow is intended as a tool for data-driven, evidence-based, research. However, in order to gather and encode symbolic data it is first necessary to identify the most important sonic features of rap and develop an effective scheme for encoding these features; We must ask "what features of rap's sound are most important to its aesthetic/ artistic expression, and how can we transcribe them?" Answering these questions requires at least a basic *a priori* theoretical framework for understanding rap's sonic

organization and artistry, which can motivate and guide sampling and encoding decisions. Chapter 3 presents such a theoretical framework, including an overview of the most important rudimentary elements of rap sound and simple observations concerning their artistic organization. This rudimentary theory is grounded in the existing literature, especially the theories of Kyle Adams (2008; 2009), but is fleshed out—using concepts and terminology from music theory, poetics, and linguistics—into a more comprehensive framework. Theoretical elements and structures are illustrated using examples from commercially released rap music, including many works which are part of the current MCFlow sample.

The rudimentary theory presented in Chapter 3 provides the operational framework for the MCFlow encoding scheme, which is described in Chapter 4. Sampling methods and details of the current dataset are also described. Chapter 5 then offers a few simple preliminary analyses of the MCFlow corpus. Descriptive statistics for the variation of several rap rudiments—speed, rhyme density, and the metric position of rhymes and phrases—between artists, between songs, and across time are presented. These sample analyses are meant merely to illustrate the potential usefulness of MCFlow to future research.

Chapter 6 presents information regarding the availability of the MCFlow dataset. The www.rapscience.net website is described, including the MCFlow Graphical User Interface which allows the anyone to explore MCFlow data online.

I conclude with a reiteration of the strengths and weaknesses of the MCFlow dataset and a discussion of possible avenues for research with MCFlow. In addition, four appendixes are included: Appendix A contains the complete list of songs targeted for inclusion in the complete MCFlow corpus. Appendix B contains the complete list

of songs which have been transcribed as of April 22, 2016. Appendix C contains a complete example of a MCFlow transcription. Finally, Appendix D describes the complete set of files contained in the MCFlow data package and provides detailed instructions for its access.

Chapter 2: Hip-Hop Music

This chapter offers a limited overview of the cultural context in which rap exists, as well as a discussion of the definition of rap and how rap relates to other styles of vocal performance. Important hip-hop terminology that is used throughout the dissertation will be introduced—this terminology is summed-up in a table at the end of the chapter (page 26). The chapter also includes a review of the hip-hop-related scholarly research which is most pertinent to the current project.

2.1 History

Rap is just one facet of the broader cultural movement known as *hip-hop*.[1] Hip-hop culture includes distinctive mannerisms, slang, clothing fashions, and a vibrant graffiti tradition (Ogg and Upshal, 1999, pp. 19–21). Hip-hop performance traditions include breakdancing[2], beatboxing, and of course, hip-hop music (Ogg and Upshal, 1999, pp. 15–17). Hip-hop music has two distinct components: the musical beats created by *DJs* and the rapped vocals performed by *MCs* (Ogg and Upshal, 1999, pp. 8–9). Hip-hop music originated at large block parties in New York City, especially the

[1]The historical outline of hip-hop given here is greatly indebted to the work of Alex Ogg and David Upshal, specifically their book "The Hip Hop Years: A History of Hip Hop." This book, a companion to a documentary TV series of the same name, traces the history of hip-hop by drawing on extensive interviews with hip-hop performers.

[2]Ogg and Upshal point out that, despite the later dominance of rap, breakdancing was the most popular aspect of hip-hop culture for many years (Ogg and Upshal, 1999, p. 60).

Bronx, in the 1970s (Ogg and Upshal, 1999, pp. 8–15). At these events, a DJ would play music while one or more MCs would talk to the audience.[3] The acronym MC is often spelled out phonetically as *emcee*—this is the spelling that will be used throughout this dissertation.

DJing was the original core of hip-hop music, serving as the "definitive basis for the culture of hip hop" (Ogg and Upshal, 1999, p. 9). Hip-hop DJs innovated and expanded the role of the traditional Disc Jockey, inventing a new style of music based entirely on manipulating, layering, and splicing prerecorded music (Ogg and Upshal, 1999, pp. 13–37). Among the many musical textures and sounds pioneered by hip-hop DJs the most emblematic is the rhythmic *scratching* effect created by physically manipulating the record as it spins. Early DJs largely sampled popular music of the era, including R&B, funk, and disco—which was hip-hop's "most recent antecedent" (Ogg and Upshal, 1999, pp. 17–18)—, though rock also became a significant source in the mid 1980s (Ogg and Upshal, 1999, pp. 79–80). In the 1990s and 2000s, sampling became less central and more original musical material was incorporated.[4] The musical grooves created by DJs, which serve as the accompaniment for most rap, are referred to as *beats*. It should be made clear that in the context of hip-hop the term *beat* refers to the entire musical accompaniment, not just an abstract metric pulse or a specific drum pattern.

At early hip-hop parties, the duties of the emcee were similar to the duties of the Master of Ceremonies at any public event: to act as the official host, lead the event, and maintain the enthusiasm of the audience. Over time, hip-hop emcees increasingly

[3]In the earliest days of hip-hop, DJs MCed their own events (Ogg and Upshal, 1999, p. 39).

[4]This decline may be attributed, in part, to copyright issues (Ogg and Upshal, 1999, pp. 103–104).

incorporated wordplay and rhythmic chanting into their interactions with the audience, a practice which evolved into rapping (Ogg and Upshal, 1999, pp. 39–41; Adams, 2008). The sonic aspects of rap—the rhythm, phrasing, and parallelism—came to be referred to as *flow* (Edwards, 2009, pp. 63–130). The new art of rapping did not emerge out of a vacuum, but had precursors in numerous practices, including West African *griots*, Jamaican *toasting*, *patter song*, *talking blues*, and African-American traditions such as the *Ring Shout* (Floyd, 1991), *signifying* (Bradley, 2009, loc. 2486), and *the Dozens* (Wald, 2012; Ogg and Upshal, 1999, p. 39). More immediately, examples of highly rhythmic song with relatively little emphasis on pitch can be found in other American popular music styles in the decades preceding hip-hop's appearance—for instance, in the music of James Brown.

In the 1990s, the status of the DJ waned in comparison to to the emcee (Adams, 2008, footnote 10); Whereas rap marketing of the 1970s–1980s often presented DJs and MCs as performers of roughly equivalent status, emcees have generally been the focus of attention since the 1990s (Ogg and Upshal, 1999, pp. 9). For example, the emcee/actor Will Smith (a.k.a. the Fresh Prince) originally released music in the 1980s as part of a duo with his partner DJ Jazzy Jeff, but released music under his own name in the later part of 1990s. Though the title and role of the DJ continues in live hip-hop performance, in studio-produced music the creating of musical beats increasingly became a supporting role, the responsibility of a *producer*. Dr. Dre began his career in the 1980s as a DJ for several rap groups, but was known mainly as as behind-the-scenes producer by the 1990s, making beats for other emcees. As DJs transitioned into supporting roles as producers in the studio, other elements of hip-hop culture evolved or fell out of style as well, including breakdancing. As a result,

the broad cultural movement of hip-hop became increasingly synonymous with rap and rapping; indeed, the terms rap and hip-hop have often been used interchangeably since at least the late 1980s, especially by outsiders (Ogg and Upshal, 1999, p. 8). Unfortunately, this means that the word rap can refer to a genre as a whole, to specific performances of rap, or to the act of performing rap. In this dissertation, I will refer to the musical genre as a whole as hip-hop, and use the word rap either as a verb (the practice of rapping) or in reference to specific passages of rapped vocals.

The first commercial recordings of hip-hop music appeared at the end of the 1970s. Hip-hop gradually expanded its presence in commercial music throughout the 1980s, rapidly accelerated its growth through the 1990s, and reached a commercial peak in 2004, when nearly a third of Billboard's *Hot 100* singles were hip-hop (Figure 2.1). In this period rap achieved a commercial and cultural status comparable to the other major genres of western popular music (e.g. rock, pop, country). Since 2004, hip-hop's presence on Billboard has shrunk to about the level it held in the early 1990s, yet hip-hop's musical and commercial influence remains strong. In fact, this apparent drop in popularity may be more attributable to changing genre definitions than an actual decline in popularity, as hip-hop has diffused into and merged with other popular styles.[5] Hip-hop's short and well-documented history offers a unique opportunity to observe the development of a musical genre from its genesis to the present. Hip-hop commentators have made much of a shift between *old school* and *new school* rap, which is generally placed in the mid to late 1980s (Krims, 2001, p. 49; Adams, 2009); New school rap introduced more complex, sophisticated elements to flow, as well as relatively serious subject matter (Krims, 2001, p. 49). Of course,

[5]Declines and/or changes in the overall music industry may also be a factor.

the shift to the new school occurred approximately thirty years ago, and hip-hop has continued to evolve since then.

Early on, rap developed a strong improvisational tradition known as *free-style*.[6] Free-style rap is strongly rooted in rap's competitive tradition of rap *battles*—a tradition with clear precedents in the Dozens (Wald, 2012, pp. 187–188,194–195). The improvisational, free, nature of rap has important repercussions in rap's structure, as will be observed at several points in Chapter 3.

Hip-hop music is primarily focused on a single musical (and literal) voice: the lead emcee. However, in live performance the lead emcee is often accompanied by a *hype man* who supports the lead's flow with interjections, exclamations, commentaries, or responses. The hype man's principle responsibility in live hip-hop performances is to "hype up" the audience, generally trying to maintain a high level of energy. Hype men may also rap in unison with the lead emcee on certain phrases or words in order to add emphasis. The material added by a hype man is referred to as *hype*. When the lead's part is difficult to perform, hype men may take over and rap some phrases, allowing the lead emcee to take a breath. In rap groups the role of hype man may be shared by one or more members of the group; for instance, each of the three emcees in the Beastie Boys (Mike D, MCA, and Ad-Rock) take turns as lead vocalist, while the other two emcees add hype. In the studio emcees are able to record their own hype.[7] The practice of double-tracking (recording the same part twice to fatten the sound) certain words or phrases to add emphasize is extremely common;

[6]The term free-style did not always have this meaning, but has been the accepted term for improvised rap since at least the 1990s (Edwards, 2009, pp. 181–182).

[7]In the context of studio recording, hype material is often to referred to as *ad libs*.

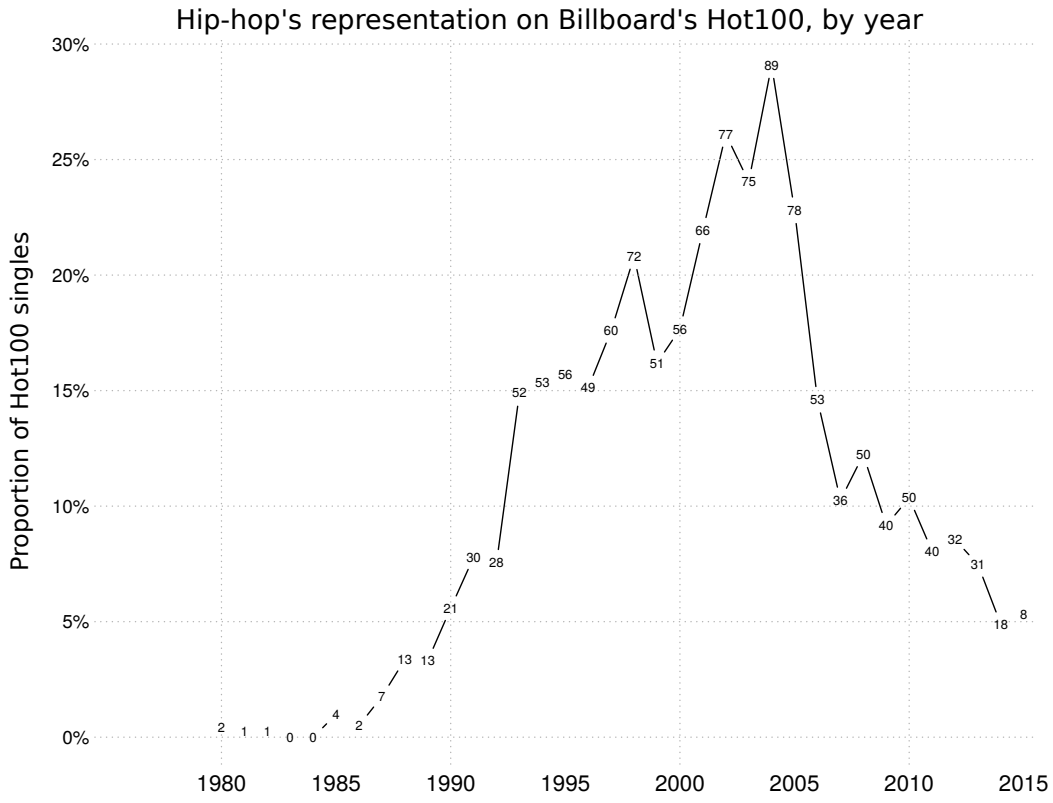

Figure 2.1: Hip-hop's representation on Billboard's *Hot100* between 1980–2014. Height on the y-axis indicates the proportion of singles that year that were hip-hop. The number at each point indicates the total number of hip-hop singles on the chart that year. (Note that some rap singles may overlap years, and thus be counted twice.) The small number (8) in 2015 is due to incomplete data in that year.

in fact, some emcees double-track entire verses (Edwards, 2009, p. 282).[8] Figure 2.2 illustrates several examples of hype in studio-recorded rap.

A common practice in hip-hop is for emcees to collaborate. Typically, collaborating emcees each rap a verse of a song—for example, the first verse of 2Pac's "California Love" (1995) is rapped by Dr. Dre while the second is rapped by 2Pac himself. In other cases, emcees may take turns rapping back and forth within a single verse. For instance, Wiz Khalifa and Snoop Dogg split the first verse of "Young, Wild, and Free"

[8]Vocal double-tracking vocals is common in many popular music styles.

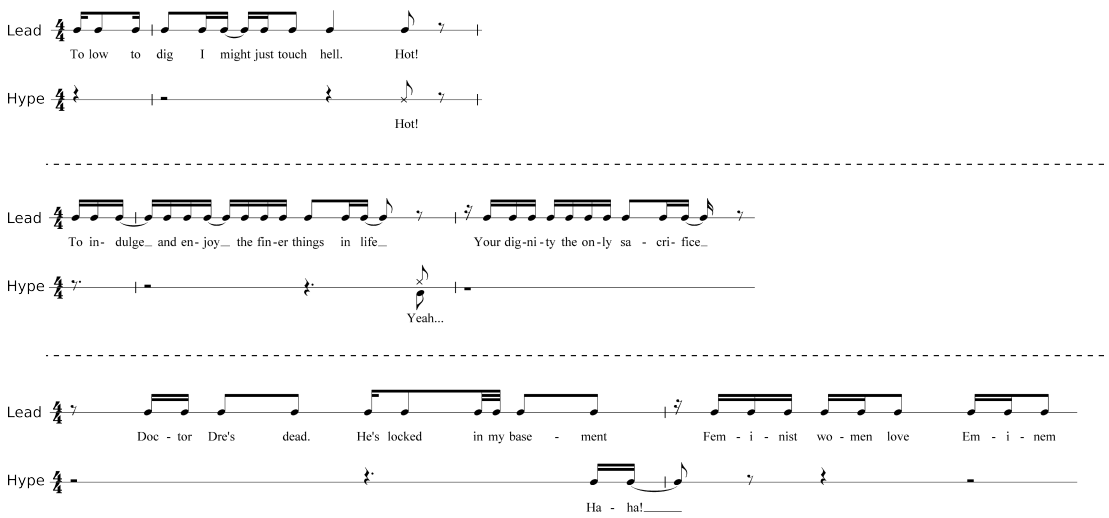

Figure 2.2: Examples of *hype* in recorded rap. The top example is from OutKast's "B.O.B." (2001)—at ≈0:32—wherein the lead emcee (Andre 3000) speaks the word /hot/ which is doubled by a hype voice. The middle example is from OutKast's "Knowing" (2003)—at ≈1:19—wherein two distinct hype voices (one spoken, one whispered) fill in a rest in Big Boi's flow. The bottom example is excerpted from Eminem's "The Real Slim Shady" (2000) at ≈0:34. Whereas the identity of the hype man on each of the OutKast examples is difficult to discern, Eminem's hype is clearly recorded by himself.

(2011) between them (two eight measure sections), while trading off every two or four measures in the second verse. Often collaborating emcees act as hype men for each other, perhaps even engaging in call and response. Some emcees are members of rap groups (e.g. the Beastie Boys, Wu-Tang Clan, D12, Junior M.A.F.I.A.), and thus collaborate with their fellow group members in nearly all their work. Another common practice is for emcees to appear as *featured* guests on other emcees' recordings. All these practices parallel similar practices in jazz, wherein artists frequently collaborate with other performers as part of permanent groups or as guests on each other's recordings: emcees take turns rapping just as jazz players take turns soloing.[9]

[9]"Turn-based" practices in rap may also be traced to the tradition of the *cypher*. A cypher is an informal gathering (often taking place outdoors) wherein a group of emcees stand in a circle and

2.2 Words or Music?

2.2.1 The Music or the Message?

Much discussion of rap assumes that the meaning of the words—the message—is what attracts hip-hop listeners (Adams, 2009, p. 9; Bradley, 2009, pp. 3–5,32,64). As a result, the message of rap lyrics may generally be given undue attention compared to the music: according to musicologist Robert Walser, "Chuck D's words would not have reached millions of people as... political commentary"—only as music (1995, pp. 193–194). In his book *Decoded*, Jay-Z himself echoes Walser's comments:

> Chuck D famously called hip-hop the CNN of the ghetto, and he was right, but hip-hop would be as boring as the news if all MCs did was report. Rap is also entertainment—and art (2010, loc. 318).

The non-meaningful sonic organization of rap—the *flow*—is just as important to rap as the lyrics' meaning (Edwards, 2009, p. 64). In fact, the meaning of rap lyrics may actually be *secondary* to the sound of their performance (Bradley, 2009, loc. 604): Rap scholar Adam Bradley points out that even listeners with no understanding of English listen to English-language rap and enjoy it (2009, loc. 215–223). Some hip-hop emcees themselves emphasize the importance of flow relative to message: emcee Baba Zumbi (of the hip-hop duo Zion I) says, "I think flow comes first... the meaning is a close second" (Edwards, 2009, pp. 64–66). Describing a passage from a Run D.M.C. song, Jay-Z points out that the "words themselves don't mean much" (being "a simple rhyme about holding weed in a gym locker") but that "the point is to bang out a rhythmic idea, not to impress you with the meaning of the words" (Jay-Z, 2010, loc. 727). Even when one understands the lyrics, it is difficult to deny that the meaningful content of

take turns rapping. Like so many elements of rap culture, the cypher has precedents in the Dozens (Wald, 2012).

many rap lyrics is genuinely not very interesting. The same can be said for any number of popular and folk songs, which feature relatively "derivative" lyrics: There is an old expression that all great Tin-Pan Alley lyrics essentially say "'I love you' in thirty-two measures" (von Appen and Frei-Hauenschild, 2015). Taking an even more extreme position, philosopher Theodor Gracyk states plainly that (in rock music) "lyrics don't matter very much" (Gracyk, 1996, p. 63,65). Of course, the relative importance of lyrics and music varies between artists and between listeners—many artists, and many listeners, may value lyrical content above all else. Still, it seems clear that *every* lyric doesn't need to be a political manifesto or a deep philosophical exploration of the meaning of the human condition. Uninteresting lyrics can be acceptable if the musical/poetic creativity of the song provides sufficient artistic enjoyment to listeners. The music and the message may each contribute to artistic enjoyment, with or without the other. In order to counterbalance the emphasis on lyrical content in most discussions of hip-hop, MCFlow is mainly intended to support research regarding "the music" of rap, not "the message."[10]

2.2.2 Music or Poetry?

In Western nomenclature, poetry and music are considered distinct artistic traditions. However, the dichotomization of music and poetry may ultimately hurt our understanding of many arts by imposing what David Burrows calls "a false clarity on the subject" (Burrows, 1989, p. 391). As a prime example, the most ubiquitous and popular form of music in all human cultures—*song*—(Feld and Fox, 1994) is fundamentally a synthesis of music and poetry. In the words of ethnomusicologist Tyler

[10]This is not a complete discussion of the message/music dichotomy in hip-hop music, only in rapped vocals specifically. Hip-hop's beats are of course musical as well, and can also convey meaning.

Bickford, song "mediates music and poetry" (2007, p. 462). More broadly, ethnomusicologists have noted many artistic traditions around the world which do not fit neatly into Western categories, including: the songs of the Kaluli of New Guinea (Feld, 1982); North American Indian Peyote songs (Nettl, 1953); Shavante *dawawa* wailing (Graham, 1984, p. 173); Kamsa ritual language (McDowell, 1983); Pan-Asian religious chant traditions (Gerson-Kiwi, 1961); Alaskan Yupik Eskimo Discourse (Woodbury, 1985); various Hopi verbal arts, including *announcement* (List, 1963, pp. 3–5); Korean *P'ansori* (Willoughby, 2000); and finally Western *sprechstimme*, recitative, rap, beatboxing, and even auctioneering (List, 1963, p. 6). The Maori have four distinct forms of speech/song art, three that Westerners would consider forms of chant, and another (*hakka*) which is more like sprechstimme (List, 1963). None of these traditions can be fruitfully classified as either music or poetry—depending on one's definitions they each might be considered either, both, or neither.

The common element that ties all the artistic traditions mentioned above together is the use of the human voice, in particular the sounds of speech. As Bickford notes,

> The presence of language sounds in music integrates verse and song in ways that cut across the near-totality of each, exposing assumptions and yielding insights about the boundaries between speech and song (2007, p. 466).

Language organizes sound to encode meaningful information. The artistic traditions listed above add additional dimensions of sonic organization to speech, creating an aesthetic element which is absent from "normal" speech. This practice has been dubbed *heightened speech* (List, 1963, pp .3). In heightened speech, the structure of

speech is exaggerated, elaborated, or organized to evoke an emotional or aesthetic impact beyond the meaning of the words, maintaining "an elevated, ceremonial distance from regular speech" (Bradley, 2009, loc. 925). This draws "precategorical" sonic information into our awareness, drawing our attention to the speech's sound, not just its meaning (Tsur, 1992). Timbre, rhythm, pitch, and dynamics may all contribute to speech heightening.[11] Heightened speech can serve artistic/aesthetic purposes, but is often more rhetorical (story telling and oratory) or ceremonial (preaching, chanting, auctioneering, etc.). Poetry and song both constitute types of heightened speech, as they each "organize...utterances in forms not native to language" (Bickford, 2007, p. 439). For example, music and poetry are often structured around steady isochronous pulses which are not found in normal speech.

Dichotomizing heightened speech from "music" may ultimately be counterproductive as they each share common features and may in fact achieve their aesthetic impact through the exploitation of common psychological principles (e.g. expectations, gestalts). Even within the Western literary tradition, poetry is often described as being musical: according to scholar T. Walter Herbert, "no mere figure of speech is the age-old saying that [poetic] devices give to verse somewhat the quality of music" (1937, pp. 433–434). As Herbert suggests, the affinity of music and poetry has been noted for centuries (Bradley, 2009, loc. 109–117). Modern poetic scholars too make frequent analogies between poetry and music: Robert Beum and Karl Shapiro say that rhyme gives a "musical quality" to poetry (1965, pp. 96–98) while John Strachan and Richard Terry argue that "rhyme, as well as other sorts of sound-patterning, acts as a sort of musical accompaniment to a poem" (Strachan and Terry, 2001, p. 61).

[11] Speech may also be heightened by purely meaningful manipulations—such as elaborate metaphor or unusual grammar—but for the my purposes I will focus on the heightened use of speech sound.

Music theorists have also pointed out the affinity between music and poetry (Lerdahl, 2001). These intuitive affinities suggest that, as sonic arts, music, song, and heightened speech all appeal to the same underlying psychological structures. As Herbert argues, "rhythm in music corresponds to rhythm in poetry, both in its means and *in its end*" (my emphasis) (1937, p. 436). In all sonic arts, events are organized in time to create regular predictable structures, often with clear teleologies, dynamic contours, and logical forms. Notably, parallelism and repetition are important features of both language arts and music (Bickford, 2007, pp. 443–444). Phrasing, as regards basic grouping as well as formal structure, is also important in music, poetry, and rap.

Heightened speech is an extremely broad category. To facilitate communication it can be helpful to have more precise categories—like the categories poetry and music with which we began the discussion—, even if these categories are somewhat arbitrary. Music in particular is a category whose meaning and boundaries are jealously guarded and hotly disputed. It is not uncommon to hear it asserted, sometimes quite forcefully, that rap is *not* music (Krims, 2001, p. 28). This assertion is not necessarily intended to be dismissive or insulting—rap doesn't have to be music to be valuable—but is often one or both (Walser, 1995, p. 195). Of course, rap is typically delivered over accompaniments that are more likely to be acknowledged as music, though even this is sometimes questioned (Walser, 1995, pp. 193–199). Hip-hop fans clearly consider hip-hop to be music, and refer to hip-hop "songs" just as they refer to pop or rock "songs." For many listeners, the lyrical, timbral, and rhythmic content of music are often the most salient and valued dimensions, and from this perspective hip-hop (including its vocals) has very much in common with other genres of popular

song. Nonetheless, whether or not rapping itself is "musical" certainly remains a grey area even within the hip-hop community. The argument can be made that if purely percussive music is music than rap must be music as well. Still, professional and educated musicians of the Western tradition often consider discrete-pitch organization to be central to the definition of music (Burrows, 1989, p. 392), and thus are likely to think that rap does not qualify.

2.2.3 Singing or Speaking?

In the context of heightened speech, the distinction between music and not music is ultimately tied to the distinction between singing and speaking. This distinction, as with many arguments regarding the definition of music, is often focused on the usage of pitch. Indeed, George List discussed his concept of *heightened speech* mainly with respect to the use of pitch (List, 1963, p. 3). According to List: "song has stable pitches, scalar structure, and little if any influence from speech intonation" (1963, p. 3). This can be contrasted with many forms of heightened speech, including rap, which and are strongly influenced by normal speech intonation, wherein "the information appears to be carried in [pitch] changes themselves, rather than in [pitches] which are relatively stable" (Moore, 2008, p. 956). However, even in "song" the stability of pitch is relative—singers often glide smoothly between discrete pitch categories (though in some styles more than others). The boundary between rhetorical intonation parallelism and the "singing" of someone like Bob Dylan can by a muddy one. Thus, the activity of singing and the activity of speaking are not distinct categories, but endpoints on a continuum of behaviors (Burrows, 1989, pp. 391–392). List makes

the observation that normal speech intonation is actually in the middle of this continuum, and can be heightened either by levelling off intonation into discrete plateaus or exaggerating pitch contours (1963, pp. 6–7). Many forms of heightened speech, including rhetorical speech, story telling, and rap, feature exaggerated pitch intonation and "parallel intonation contours" (Graham, 1984, p. 172; Wennerstrom, 2001, pp. 200–221). In contrast, Edith Gerson-Kiwi, like List, observed the importance of unnaturally static pitch contours in "chant" traditions (Gerson-Kiwi, 1961). Rap can heighten speech intonation in either, or both, of these directions. Figure 2.3 illustrates the contrast between the two extreme uses of pitch in a single rap verse: the figure shows the fundamental pitch trace (F0 contour[12]) of Eminem's voice in the third verse of "Lose Yourself" (2002). The first half of the excerpt shows the sort of intonation contours found in most rap, similar to the sorts of contours observed in natural speech but exaggerated. In the second half of the excerpt, Eminem dramatically switches to a stable chant-like pitch contour.

Taking the discussion a step further, List introduces a second dimension to his model of the relationship between heightened speech and song—see Figure 2.4 (1963, pp. 6–12). The east-west axis in List's model represents motion along the continuum discussed in the previous paragraph. List does not clearly explain the north-south axis of his model, but it seems to roughly reflect the timbral qualities of vocal sounds which contribute to the sound's *pitch salience* (Plack et al., 2005). There are a number of features of acoustic signals which correlate with the subjective, auditory, experience of pitch salience. One acoustic measure known to correlate with pitch salience is *jitter*: micro-fluctuations in the frequency of harmonics in a waveform

[12]F0 refers to the frequency of the first partial, or fundamental, of a harmonic waveform (like the voice). F0 is known to correlate closely with the perceived "pitch" of a sound.

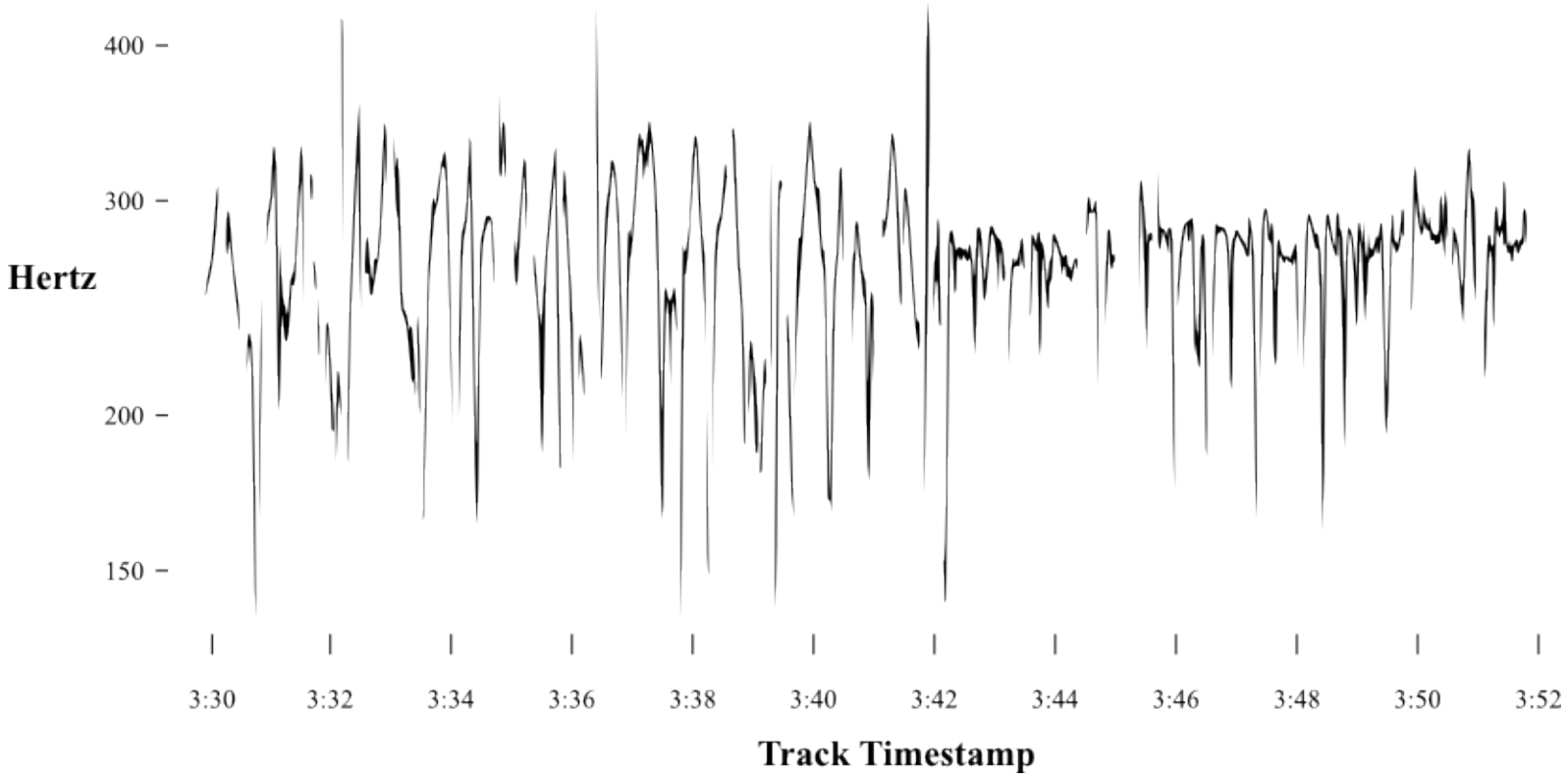

Figure 2.3: Two extremes of "heightened" speech intonation in rap, illustrated in an excerpt from the third verse from Eminem's "Lose Yourself" (2002). The plotted line shows the F0 contour of Eminem's vocals at ≈3:30–3:50 in the song, extracted from an acapella version of the recording using the software Praat (Boersma, 2001). The change to a relatively flat pitch contour occurs at ≈3:43, on the words /and it's gettin' even harder/.

(Dai, 2000). As a simple exploratory experiment, forty recordings of three emcees' isolated voices (Biggie Smalls, Eminem, and André 3000) either talking, rapping, or singing were gathered, and the average jitter of each recording was calculated. "Spoken" recordings were further divided into two categories: speech (taken from interviews) and "oratory" (taken from more theatrical "skits"). This dataset is very limited: the sample is small and uneven, and the recording setups and audio quality are not equivalent across all recordings. Figure 2.5 presents the posterior estimates of average jitter, based on an exploratory Bayesian statistical analysis of the data.[13] As can be seen, Song clearly contains less jitter than Speech or Oratory, while the amount of jitter in rapped vocals seems to lie somewhere in between speech and song. This variation in jitter may reflect some of the variation in voice quality which is roughly represented by the north-south axis of List's model.

Emcees themselves often evince a categorical distinction between rapping singing: In "Machine Gun Funk" (1994) Biggie Smalls follows a reference to Tina Turner by singing "What's love gotta do with it?" before returning to his "normal" rapping. Biggie similarly quotes a single line from Barrington Levy's "She's Mine" in his song "Dead Wrong" (1999[14]). By clearly contrasting these sung quotes with his normal flow, Biggie emphasizes the distinction between rapping and singing. Biggie's entirely sung "Playa Hater" is also strikingly distinct from the rest of the (rapped) songs on on his album *Life After Death* (1997). Similarly, Eminem's "Halie's Song" (2002) contrasts two sung verses with a third rapped verse: In the intro and outros of this song, Eminem draws attention to that fact that he is going to "sing," and he begins his rapped

[13]Hierarchical parameters for each emcees' voice were included, and the prior distribution for each measurement was weakly biased towards the "null hypothesis" that all vocal performances would be the same.

[14]This song was released posthumously.

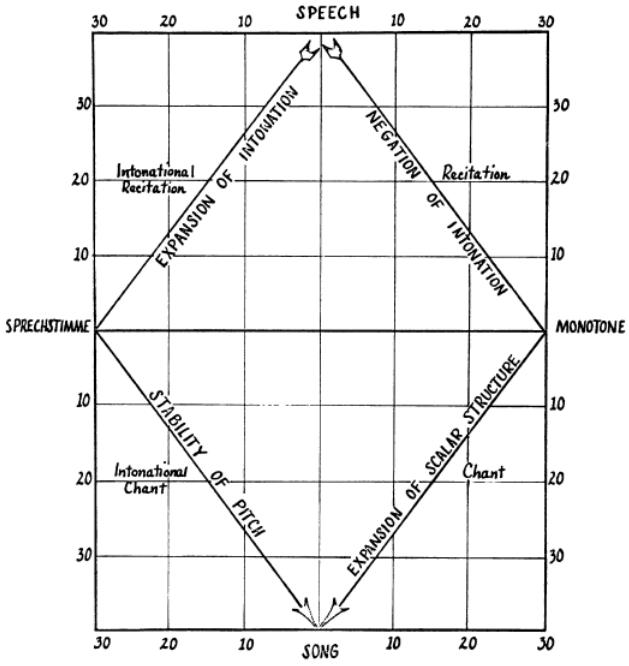

Figure 2.4: George List's two-dimensional model of pitch in vocal art. Reproduced from "Boundaries of Speech and Song," Figure 9 (1963).

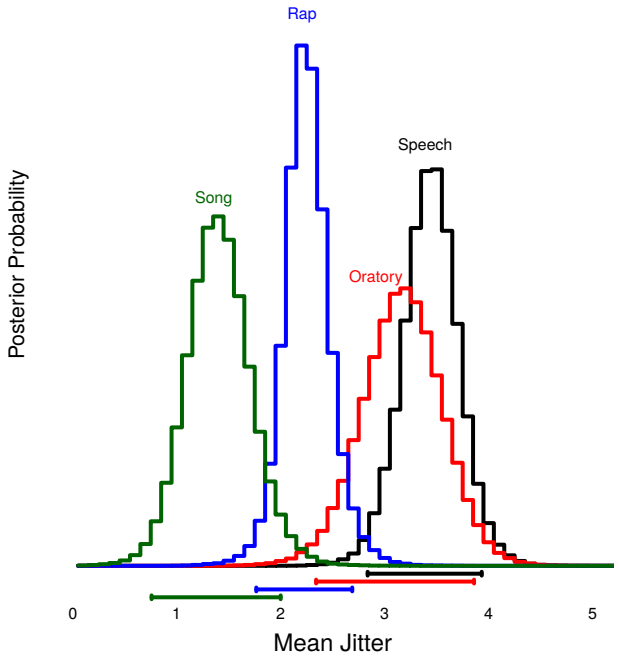

Figure 2.5: An acoustic comparison of *jitter* in speech, oratory, rap, and song. Each color coded histogram represents the posterior distribution of the mean jitter for that category. The jitter (x-axis) is measured on Praat's "ddp" scale, which ranges from 0–6.

verse with the words /Man, if I could sing, I'd keep singing this song to my daughter/—all suggesting that Eminem himself draws a clear distinction between "rapping" and "singing."

Pitched Rap

Though a categorical distinction between rapping and singing is often articulated in hip-hop (as in the Eminem and Biggie Smalls examples in the previous section), there are nonetheless many examples of hip-hop vocal performances that blur this distinction. It is not uncommon for rapped vocals to be delivered with recognizable musical pitches (Edwards, 2009, pp. 251–256; Jay-Z, 2010, loc. 726), resulting in "pitched rap." "Pitched rap" is most common in rap choruses, often providing a contrast with the "pure" rap in verses. However, pitches can also be incorporated into rapped verses: In OutKast's "Da Art of Storytellin'" (1999), emcee André 3000 smoothly switches in and out of pitched rapping at several points—the F0 contour from an excerpt of André 3000's verse is shown in Figure 2.6. In the figure, it can be seen that André 3000 settles on a steading reciting tone on the pitch F♯, briefly jumps to A on the words /chillin' like a villain/, and drops to D on each rhymed word /night : lights : right : spite/—the outlined triad matches the key of the accompaniment. This pitched rapping is clearly reminiscent of similar vocal performance in reggae music, and has also been widely adopted in mainstream rock by bands like Sublime and the Red Chilli Peppers. The widespread use of autotune after approximately 2005 further complicates the distinction between rapping and singing, as musical pitches can now be artificially added to rap. For instance, in Lil' Wayne's "Lollipop" (2008) the entire rapped verse is fed through an autotuner, giving it a clear melody.

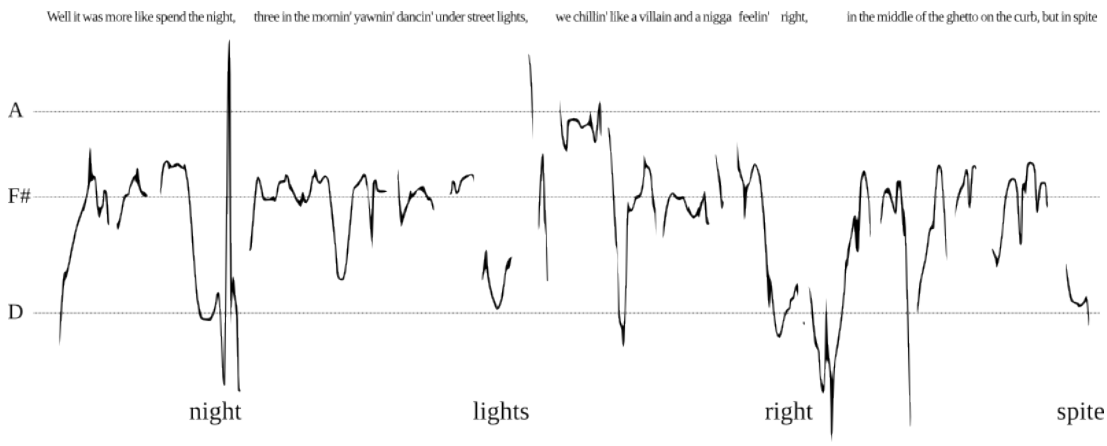

Figure 2.6: Example of "pitched rap" with clear discrete musical pitches. The F0 contour is from Andre 3000's verse of "Da Art of Storytellin'" (1999), extracted from an acapella recording using Praat (Boersma, 2001).

If rap can contain musical pitches, what then (if anything) distinguishes it from singing? As in the OutKast example above, pitched rap tends to use a limited set of pitches, and repeats pitches more, than typical "singing." However, the most important differences between rapping and singing are actually rhythmic, not pitch based. In general, the deemphasis of pitch in rap frees emcees to make much more extensive, variable use of poetic patterns and rhythm. In rap, syllables typically appear at a faster pace than in other forms of song and are not sustained—in this sense, the rhythm of rap is more like the rhythm of speech. Rap is also more rhythmically variable than most song, and even fully pitched rap will generally not evince the sorts of regular formal structures associated with "melodies," such as periods. Adam Bradley contrasts rap with poetry by pointing out that since emcees don't "carry the burden of representing the meter... the range of [the emcee's] rhythmic freedom is potentially broader than (a poet's)" (Bradley, 2009, loc. 642). Similarly, since emcees are freed from the burdens of melodic structure, there range of freedom in phrasing, rhythm,

and rhyme is broader than singers (Bradley, 2009, loc. 110). This trade-off between complexity in pitch organization and complexity in rhythmic/poetic structures, can be seen as an example of what Temperley has called *communicative pressure* (2004). Since it incorporates more pitch structure than "normal" rap, pitched rap is generally less complex in terms of rhythm, phrasing, and the usage of rhyme. Lil' Wayne's "Lollipop" (mentioned in previous paragraph) features some of the simplest flow in the MCFlow corpus.

2.3 Literature

As mentioned before, scholarship concerning hip-hop has predominantly explored its social and cultural dimensions, with work published in fields such as sociology, social psychology, education, and African-American studies. Much of this research has explored the impact and/or role of hip-hop in urban communities. Generally, much more attention is given to the content of rap lyrics than to any aspect of rap's musicality (Walser, 1995, pp. 193–194). Musicological work also tends to focus on rap culture, but several scholars have given some consideration to rap's sonic artistry: In an early paper, Musicologist Robert Walser includes a close-reading of rhythm in a single song by Public Enemy, noting the use of polyrhythms among other features (1995). Ethnomusicologist Cheryl Keyes' book, *Rap Music and Street Consciousness* also includes a handful of illustrative transcriptions of rap (2002). Music analyst Adam Krims' book *Rap music and the poetics of identity* was the first work to include a generalized music theory concerning rap flow, though his theory is limited to stylistic classification (2001): Krims identifies three primary flow styles—*sung*,

percussion-effusive, and *speech-effusive*—which he distinguishes by features of phrasing, rhythm, rhyme, and articulation (2001, pp. 49–52). Adam Bradley's book *Book of Rhymes: The Poetics of Hip-Hop* explores both poetic and meaningful aspects of rap artistry in great depth, including much emphasis of musical features of rap (Bradley, 2009). However, as a literary scholar aiming his work at a lay, non-musician audience, the music theory presented is understandably limited, lacking many basic music theory concepts such as beat-subdivisions, hypermeter, and syncopation. Paul Edwards' book *How to Rap: The Art & Science of the Hip-Hop MC* is especially interesting for its basis in interviews with actual emcees, including artists of some considerable repute, who share fascinating insights about their craft Edwards (2009). However, neither Edwards nor his interviewees offer a coherent theoretical description of rap as music. This is not surprising: like Bradley, few emcees have any sort of formal musical training to help them articulate their musical intuitions.

The most substantive contribution to rap music theory has been the work of Kyle Adams (2008; 2009). Adams' 2009 paper presents detailed music theoretic close-readings of three raps, focusing his analyses on the placement of rhyming syllables, the placement of accented syllables, the degree of correspondence between syntactic units and measures, and the number of syllables per beat—what Adams calls "metrical techniques" (2009). Adams contrasts different styles of rap flow, particularly the difference between flow which is extremely regular in its placement of rhyme and its relationship to the meter, and flow which misaligns or conflicts with the meter to various degrees. This contrast roughly corresponds to the difference between Krims' sung and effusive style categories. Adams also gives examples of rhythmic motives in several raps, and how the rap flow can relate to the beat (2008).

Rap has also received some research attention in linguistics, mostly regarding rhyme. H. Samy Alim (2003) offers a close-reading of rhyme in works released by the emcee Pharoahe Monche. Linguist Jonah Katz has presented more detailed linguistic analysis of rhyme in rap, including work which applies theories from music cognition (2008; 2010). Heidi Holtman's 1996 dissertation includes a comparative analysis of rhyme in literary verse, nursery rhymes, rock/pop lyrics, and rap (1996, pp. 199–239). Holtman found that rap evinced a greater variety and density of *imperfect rhyme* than the other genres she studied (1996, p. 244). Finally, in computer science, Hirjee and Brown conducted a corpus analysis of the texts from several thousand rap songs by 25 popular artists (2010). Hirjee and Brown noted a marked increase in the complexity of rhyme patterns found in rap between 1980 and 2000—a pattern previously noted by Krims (2001, p. 49). They also found that different emcees could be distinguished with fairly high accuracy based on their usage of rhyme.

The body of research listed here, especially the theoretical work of Kyle Adams, heavily influenced the theoretical framework presented in Chapter 3. However, the theory presented in Chapter 3, which serves as a model for MCFlow transcriptions, builds off the existing research by more rigorously defining the nature of the sonic/linguistic components of rap. By enabling the analysis of a much larger dataset of rap flow, MCFlow will enable Krims' and Adams' ideas to be expanded upon and rigorously tested. MCFlow will also enable the exploration of historical trends and artist comparison, similar to the achievements of Hirjee and Brown but with far more detailed information about the sonic features of rap (Hirjee and Brown's work is entirely text based).

2.4 Terminology

The following table summarizes important terms introduced in this chapter.

Table 2.1: Summary of hip-hop terminology used in this dissertation.

the *Beat*	The musical accompaniment to rap.
Emcee	A performer of rap (a.k.a. M.C.).
Featured	A featured emcee is a guest on another emcees' record.
Flow	The artistic sonic organization of rap.
Free-style	Improvised rap.
Heightened Speech	A vocal performance which violates the norms of speech, drawing attention to speech sound for aesthetic or ritual effect.
Hip-hop	A cultural movement. Here used to refer to the musical genre which features rap.
Hype	Supporting rap vocals.
Pitched Rap	Rap with clearly identifiable "musical" pitch, which is nonetheless not truly "singing"—mainly due to the fast irregular rhythms of rap.
Old School Rap	The oldest style of rap flow which fell out of style in the mid 1980s.
	(verb) The act of rapping vocals. (noun) A passage of rapped vocals.

Chapter 3: Flow Rudiments

In most music theory work the basic elements of music—intervals, scales, triads, phrases, melodies—are taken for granted. In contrast, the basic elements of rap flow—flow's *rudiments*—are not well established. In order to effectively transcribe or analyze rap, the important rudimentary elements of flow and their artistic functions music be precisely identified and classified. Accordingly, this chapter enumerates the structure and artistic usage of the most important rudimentary elements of rap flow. This rudimentary framework is informed by basic *a priori* theoretical observations, interpretations, and assumptions regarding raps' artistic expression. Theoretical observations first articulated by Kyle Adams underly much of the theory (Adams, 2008, 2009). However, the my own intuitions and theoretical intuitions flesh out, and hone, many of Adams' observations, especially by incorporating more concepts and terminology from linguistics.

The higher-level organizational context of hip-hop music—meter, tempo and form—are presented first, followed by a breakdown of the basic sonic material of rap vocals. In the process, the most basic structures formed from these materials (rhyme schemes, phrases, etc.), and their artistic usage, are introduced. Important terminology introduced in the chapter is summarized at the end of the chapter (page 79).

3.1 Flow's Context

3.1.1 Meter and Tempo

Rhythm in hip-hop music is organized in relation to metric hierarchies similar to those observed in other genres of Western music. However, as an oral tradition, hip-hop does not contain explicit time-signatures, barlines, beamed noteheads, or other explicit definitions of meter. As a result, how emcees conceive meter and the organization of rhythmic time cannot be assumed. Still, vernacular musicians can be expected to have intuitive understandings of metric structures even if they cannot articulate them theoretically, just as native language speakers can freely understand and produce perfectly grammatical sentences without training as linguists. Most emcees do have at least some theoretical/terminological frameworks for understanding rhythm, such as familiarity with conventions of counting time (Edwards, 2009, p. 68–71).

Duple relationships dominate metric hierarchy in hip-hop to a degree even greater than in rock or pop music. Triple subdivision of the tactus beat—as in traditional *compound duple*—is very occasionally encountered, but other deviations from strict duple relations are nearly unheard of. In fact, the vast majority of rap can be fruitfully counted in traditional $\frac{4}{4}$ time (Bradley, 2009, loc. 150; Jay-Z, 2010, loc. 196)—according rap theorist Mitchell Ohriner, hip-hop songs which are not in $\frac{4}{4}$ meter "can be counted on one hand" (Ohriner, 2015). The duple hierarchy extends to hypermetrical levels as well, with phrasing, parallelism and repetition in rap typically occurring every two, four, eight, or sixteen measures. However, violations of duple organization at hypermetrical levels are far more common than at lower metrical levels: four-measure blocks may be broken while maintaining a two-measure hyper meter—for instance, in verses of ten or fourteen measures. More rarely, odd-numbered measure

groups break even the two-measure hypermeter: a famous example is the Jay-Z track "Brooklyn's Finest" (1996), which features a five-measure beat. Another example—found in the current MCFlow dataset—is the beat in Biggie Smalls' "Sky's the Limit" (1997), which consists of four repetitions of a four-measure phrase followed by a single-measure extension, resulting in a seventeen-measure verse.

The duple metric hierarchies of most rap can effectively be transcribed using the framework of traditional $\frac{4}{4}$ meter. However, there is still an important issue to consider: Which metric level is the "primary" beat or *tactus*—the beat which would correspond to a ♩ duration in $\frac{4}{4}$? Answering this question is difficult due to variation in both hip-hop beats' tempos and in the rhythmic density of flow. Converging evidence from a number of sources has found that listeners (on average) prefer to hear tactus beats approximately 500–700 milliseconds in duration (London, 2004, p. 31; Semjen et al., 1998). However, there is a high degree of variability in how listeners experience tactuses and it is unlikely that there is ever an objectively "correct" tactus for any given passage.

In the MCFlow encoding scheme the tactus is defined by the *backbeat* in the accompaniment, which by definition lands on beats two and four of a $\frac{4}{4}$ meter. The backbeat is essential to the rhythmic "feel" of American jazz and popular music, and the vast majority of rap beats contain snare drum, or snare-drum-like, attacks on recognizable backbeats. Only one verse in the current MCFlow dataset contains significant ambiguity regarding the backbeat: the first verse of Kanye West's and Jay-Z's

"Niggas in Paris" (2013).[15] These two features (importance to feel and ease of identification) are the motivation for MCFlow's backbeat-defined tactus heuristic. However, this heuristic has potential weaknesses. Consider the excerpt from Metallica's "Ride the Lightning" shown in Figure 3.1. In this excerpt, an identical guitar riff is repeated three times while the drummer repeatedly halves the speed of his backbeat pattern. This sort of drum-isolated timing switch is common in rock, especially heavy metal music, where it is commonly referred to as switching to "half-time feel." The upper and lower staves in Figure 3.1 show alternative notations of this passage: The upper stave shows what is likely the most intuitive (and common) notation, with the notated tempo kept consistent throughout—notice that the position of the backbeat in the $\frac{4}{4}$ measure changes. In contrast, the lower stave shows how the backbeat-defined tactus heuristic would notate this passage, with notated tempo changes requiring repeated diminution of the repeated guitar riff but keeping backbeat snare strikes on beats two and four. Which of these interpretations best represents the experience of the listener, or of the performers, is not clear. Fortunately, passages like the one shown in Figure 3.1 do not seem to occur in rap. Nevertheless, the excerpt illustrates the potential weaknesses of the backbeat-defined tactus heuristic.

Tactus interpretation has important repercussions in later analyses, especially when comparing songs with very different tempos. Prototypically, rap flow is organized around phrases, repeated patterns, and rhymes every measure. However, at faster tempos (especially 130 bpm or higher) flow may be structured principally around two-measure units—*up-tempo* flow. Conversely, at slower tempos (especially

[15]The MCFlow transcription of this song is notated with a ♩-note tactus of 70 beats per minute (bpm) but the accompaniment in verse 1 (with no clear backbeat) could be interpreted with the tactus at twice this speed.

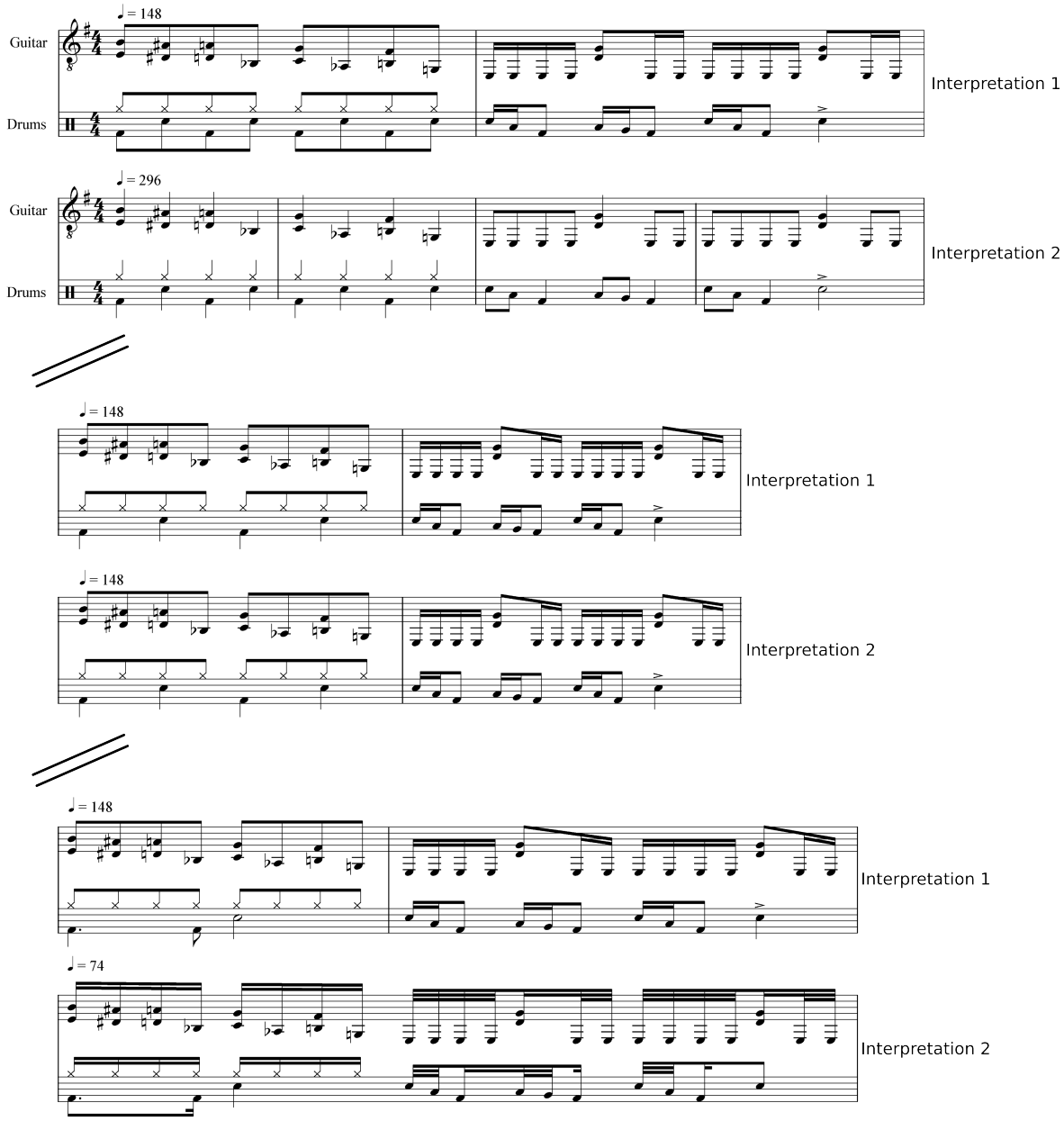

Figure 3.1: Illustration of alternate metric interpretations of the tactus in Metallica's "Ride the Lightning" (1984), and their relationships to the backbeat. In the upper staff of each system the music is notated with an unchanging tempo (148 bpm), causing the location of the drums' backbeat pattern to shift in the measure. In the lower staff of each system the music is notated with changing tempos, so that the backbeat is always interpreted as landing on beats two and four.

below 72 bpm) flow may primarily be structured around two-beat phrases—*down-tempo* flow. This suggests that songs evincing up-tempo flow could be notated in diminution (with the tempo halved) and vice versa for down-tempo pieces, putting all pieces in a "one-measure, one-phrase" framework. Figure 3.2 illustrates how two different rap passages could be notated, ignoring backbeats, to match their phrase lengths to one measure. In MCFlow, the slowest tempos currently sampled (based on backbeat defined tactuses) are 63 and 68 beats per minute—corresponding to 952 and 882 millisecond beats respectively. It is possible that these songs (like "Niggas in Paris") would better be understood with a tactus one metric level lower—at 126 or 136 bpm (476 or 441 millisecond beats)—, which would put them closer to the preferred 500–700 millisecond tactus range. The theoretical proposition underlying the backbeat-defined-tactus heuristic is that down-tempo/two-beat phrase flow, mid-tempo/one-measure phrase flow, and up-tempo/two-measure phrase flow each represent different feels. This proposition is empirically falsifiable. As a simple test, if the metric distribution of ♪ across up-tempo/two-measure phrases tends to mirror the distribution of 𝅘𝅥𝅯 across mid-tempo/one-measure phrases this would suggest that diminution of the up-tempo flow would be appropriate. Similarly, if the metric distribution of 𝅘𝅥𝅰 across down-tempo/two-beat phrases mirrors the distribution of 𝅘𝅥𝅯 across mid-tempo/one-measure phrases, augmentation of the slow-tempo transcription might be appropriate. This issue will be further explored in Section 5.1.3 (page 132).

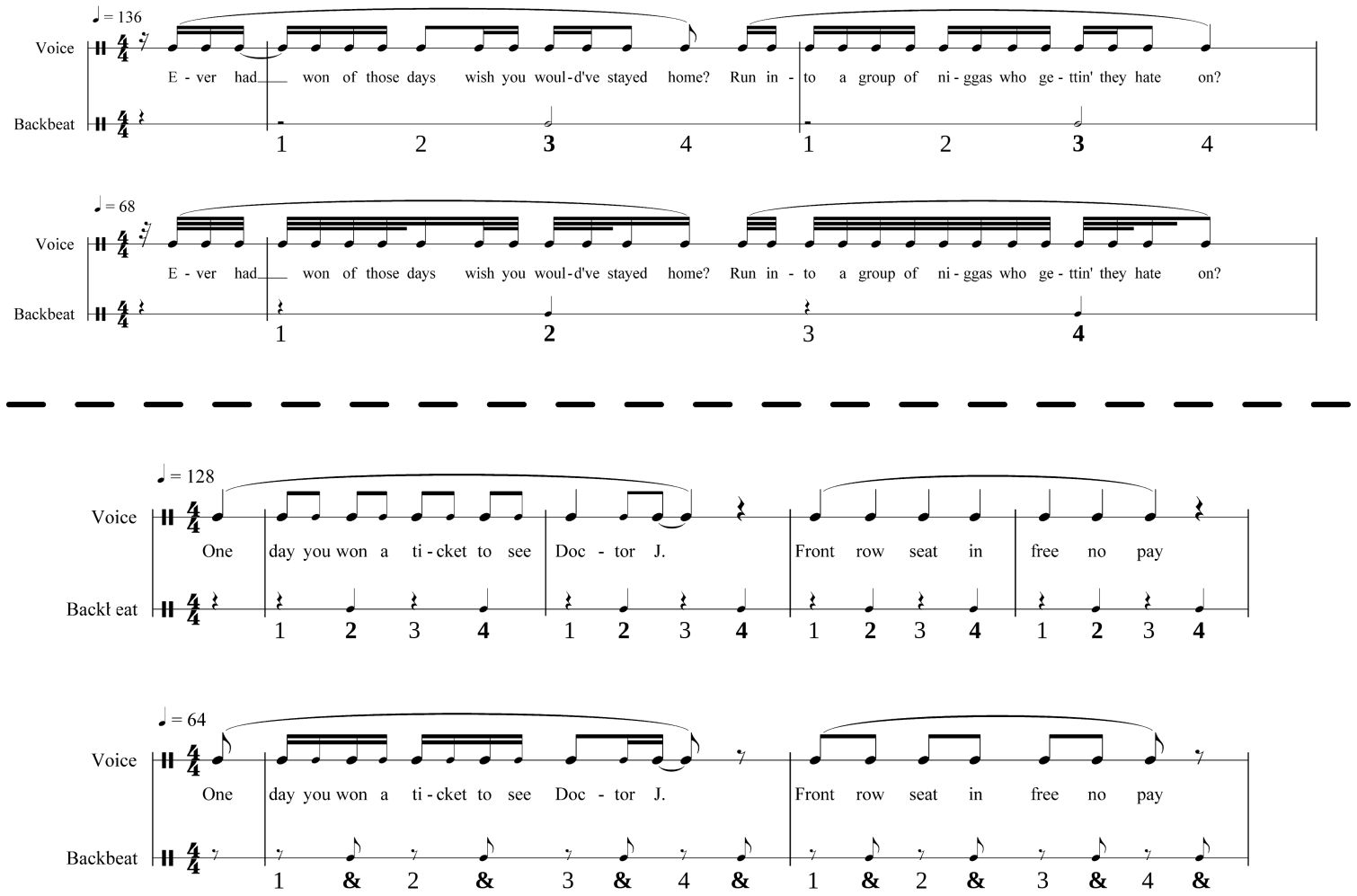

Figure 3.2: Illustration of alternate metric interpretations of the tactus in T.I.'s "Dead and Gone" (2009) and Run-D.M.C.'s "You Be Illin'" (1986). Note each interpretation's relation to the backbeat in the accompaniment.

3.1.2 Form

Form in rap, as in most popular song, is sectional. Most musical material is presented in two main formal sections: the *verse* and the *chorus*. The main body of most rap songs consist of an alternation of verses with choruses (usually three alternations). The prototypical rap song begins with an introduction, often consisting of the emcee(s) talking as the accompaniment beat is introduced—this material is often referred to as the *ad lib* (Jay-Z, 2010, loc. 1056).[16] After the verses and choruses have finished, an outro may follow, often with the emcee(s) again speaking over the beat as it fades.

Though the term *verse* is used very much in parallel to its application in other popular music styles, rapped verses are quite different than pop or rock verses (von Appen and Frei-Hauenschild, 2015). The concept of "the verse" in most song traditions (rock, folk, blues) is rooted in *strophic form*, wherein a musical section repeats with little or no variation except that the lyrics are different each time (Tilmouth, 1980). Though "verses" in rock and other popular music styles follow this strophic model, hip-hop verses generally do not. Though emcees sometimes repeat similar rhythmic ideas from verse to verse, it is more often the case that the rhythmic material, rhyme schemes, and phrase structure of verses within the same hip-hop song are significantly different. Intra-verse form and phrasing is also more variable in hip-hop than in comparable song forms: Whereas most pop/rock/folk verses are structured into parallel melodic phrases—such as the classical period or sentence—hip-hop verses

[16]In addition to spoken material in intros and outros, the term *ad lib* may also refer to spoken material throughout a song, including material that might alternatively be characterized as hype. The material is likely called *ad lib* because it is improvised in recording sessions.

are generally *through-composed*: the repetition of phrase structures over long periods (or across sections) is relatively unusual. As mentioned in Section 2.2.3, this irregularity and lack of melodic structure is part of what distinguishes rapping from singing, even when rap is pitched. I believe the highly variable, repetition averse, and through-composed nature of rap stems from its free-style (improvised) tradition; In all these features rapped verses are actually more akin to improvisatory *solos* in jazz than to rock/pop verses.

The structure and nature of hip-hop choruses is highly variable. Hip-hop choruses are often sung, or feature "pitched rap" that is closer to singing (more pitch, more repetitive etc.). Choruses may mix rapping and singing in call and response, or have more involvement from hype. Often a guest singer (or a sample of a singer) performs the chorus, with the emcee simply tacit, or perhaps interacting with the singer. Often, like choruses in other popular music styles, the chorus of a hip-hop song contains the "hook" of the song, as well as the title lyrics.

Other musical sections—dance breakdowns, interludes, etc.—may also appear in hip-hop songs. In more recent mainstream hip-hop, a recognizable *bridge* section will appear after the second chorus, usually featuring sung vocals and a change of tonal area in the accompaniment.

In typical hip-hop, the basics of the beat (especially the drum pattern and bass line) stay the same throughout a song; Other instrumental lines, and timbral textures, may come and go throughout the song, in order to delineate sections, but the basic groove remains stable throughout. The principle exception are beat *drops*, wherein the drum beat briefly stops in a dramatic effect similar to *stop-time* in rock/pop. There are of course many variations of this prototype. Some hip-hop, especially

non-mainstream and oldschool hip-hop, will have different beats come and go in different sections. In some cases, even different verses of the same song will have different beats (sometimes even at different tempos.[17]).

3.2 Flow's Palette

Whether musical, rhetorical, or poetic, all vocal-art traditions exploit the sonic palette of the human voice. The voice is a uniquely powerful artistic instrument with an unparalleled ability to express emotion (Bachorowski, 1999). It is not only the sound of the voice but specifically the sounds of *language* that serve as rap's basic material. Whereas the expressive power of vocal timbre is infinitely subtle, varied, and personal—making it difficult to systematically organize and even more difficult to study—language provides a concrete set of perceptual categories which lend themselves to artistic organization. As put by Tyler Bickford:

> Because the sounds of language are already parsed into functionally and perceptually relevant units, the sounds of language provide a material grounding that can help constrain the slippery acoustic bounds of musical forms (2007, p. 440).

Still, speech-timbre categories do not lend themselves to the sort of complex hierarchical organization that has been achieved with pitch (i.e. musical tonality). Instead, more basic organizational principles—repetition, parallelism, and similarity—are exploited.

To understand how rap flow organizes speech sounds for artistic effect, we must first enumerate and understand the basic sounds of speech. Speech sound structures can be divided into two classes: the sub-syllabic and the super-syllabic. At the sub-syllabic level, the discrete events from which rap is assembled are syllables and

[17] Only two out of 124 songs currently in MCFlow feature tempo changes.

their constituent phonemes. Phonemic relationships between syllables are the basis of the ultimate poetic device: rhyme. Articulation is also an important part of the sub-syllabic dimension of speech sound. Sonic features at the super-syllabic level (including rhythm, pitch, and timbre) can be understood in terms of the linguistic concept of prosody. Prosody is essential to the organization and expressiveness of rap flow.

3.2.1 Rhythm

The rhythm of rap flow is largely musical in nature; Rap's rhythm can be conceptualized in the framework of traditional music theory (meter, syncopation, rhythmic motives, etc.), and as such, can be effectively transcribed using music notation. However, two issues complicate any discussion of rap rhythm. First, the natural rhythms of speech influence the rhythm of rap: This issue is not unique to rap, occurring in all forms of song to some extent, but it may be of special importance in rap. Second, rap is full of musical *micro-timing* and other rhythmic nuances which are not captured in traditional notation. Again, these nuances are not unique to rap but are common in all popular music styles. As a third complication, one might reasonably suspect that poetic theories of rhythm and meter might be relevant to rap flow. However, this does not seem to be the case.

Speech Rhythm

In all song the natural rhythms of language are constrained by the conflicting rhythmic ideals of music—in Bradley's words, "one type of rhythm (that of language) [is fit] another (that of music)" (Bradley, 2009, loc. 95). However, the extent to which musical rhythm dominates speech rhythm varies between song genres: consider the

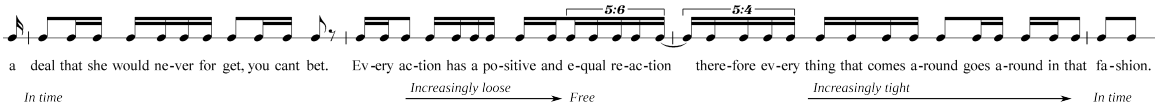

Figure 3.3: In this passage from OutKast's "Knowing" (2003)—rapped by Big Boi at ≈2:21—the influence of speech rhythm is increased during the words /every action has an equal and positive reaction. . . / before gradually shifting back into musical time.

difference in rhythm between an operatic aria and an operatic recitative. Though rap's rhythm is predominantly musical, natural speech rhythm (non-isochronous, non-metrical) also has a clear influence. The degree to which rap flow evinces musical rhythm versus natural speech rhythms is variable between songs and between emcees, and can even vary within a single performance. Figure 3.3 shows a transcription of a passage from OutKast's "Knowing" (2003), in which Big Boi shifts between musical rhythm and speech rhythm to add variety to his delivery. The passage begins and ends with relatively tight musical timing, but the middle part of the passage (especially the words /positive and equal reaction/) are delivered relatively freely—i.e. under the influence of natural speech rhythm. If the influence of musical rhythm becomes too weak, a passage may cease to be identified as rap at all, becoming a less heightened form of speech. An excellent example is the introduction to Eminem's "If I Had" (1999): "If I Had," like many rap songs, starts with a spoken introduction before the true rapping begins. However, this introduction goes on for considerably longer (≈42 seconds), introduces many more ideas, and is generally more poetic than most rap introductions, to the extent that it seems like Eminem is "almost" rapping. Still, when musical rhythm takes over and the "true" rapping begins (at ≈0:43) it is unmistakable.

Articulation

Musical rhythm is generally characterized as the relationship in time between instantaneous events (onsets, offsets). In reality all sound events take place over time and determining when exactly an event "happens" is subjective. This is especially the case with spoken syllables, which evolve over time in a highly variable fashion depending on their phonemic content, their delivery, and their context. The precise point in time at which a given syllable is experienced as occurring—known as it's *perceptual-center*—is highly variable (Gordon, 1987; Scott, 1998). As a result, the rhythms of spoken syllables are inherently somewhat vague and imprecise.

The precise rhythmic envelope of rapped syllables is related to the issue of *articulation*. The articulation of syllables is important for the rhythmic character of flow, especially as it contributes to the speech rhythm/musical rhythm relationship. Articulation is an important factor in Krims' rap flow taxonomy (2001). Adams also notes the importance of "articulative techniques" in rap flow—specifically "the amount of legato or staccato used" and "the degree of articulation of consonants"—but does not explore them in detail (2009). Unfortunately, the current MCFlow dataset also contains little information regarding articulation.

Rhythmic Nuance

Even when the influence of natural speech rhythm is absent, musical performances (by human performers) always diverge from the idealized durational categories represented by music notation. This variation has both stochastic and systematic dimensions (Hellmer and Madison, 2015). In addition to the unique issues of speech rhythm and articulation, rap flow often evinces systematic musical rhythmic nuances similar

to those found in related musical styles (Funk, R&B, Jazz)—what Anne Danielsen has poetically called "highly accurate inaccuracy" (2006, p. 78) or what Charles Keil calls *participatory discrepancies* (1987). According to Danielsen, in nuanced rhythmic environments "the correct location—the core of the beat—becomes more a center of gravity...than a fixed point in a metrical framework"; rhythmic events are "pulled toward the beat but never touch...it" (Danielsen, 2006, p. 79). Particularly common is a tendency for rappers to lag *behind the beat*, a performance practice that has been widely observed in popular music and jazz. Several studies have measured jazz bass players playing consistently roughly 40–190 milliseconds behind the beat articulated by the drums (Iyer, 2002; Prögler, 1995, p. 410). A similar range of behind-the-beat lag can be heard in many rap performances.

Many rhythmic nuances occur at a time-scale too small to be experienced as rhythmic in the musical sense (Iyer, 2002, pp. 395–396). Thus, J.A. Prögler refers to rhythmic nuances, such as playing behind the beat, as occurring at a "subsyntax" level (1995). Similarly, Kyle Adams considers rhythmic nuances examples of "articulative techniques," not "metrical techniques" (Adams, 2009). In contrast, traditional music notation and rhythm theory concerns the "syntactic" level, wherein rhythm is perceived in terms of discrete, idealized, categorical relationships between instantaneous rhythmic events. This syntactic level of rhythm is the "core" of the beat referred to by Danielsen, around which micro-variations in timing occur. Music theory regarding the syntactic level of rhythmic perception is well established. In contrast, the exact role of subsyntactic rhythmic nuance is not well understood, though it is widely believed to be important to rhythmic feel and *groove* (Busse, 2002; Davies et al., 2013; Fruhauf et al., 2013; Hellmer and Madison, 2015; Keil, 1987; Zagorski-Thomas, 2007)

and for clarifying rhythmic structure (London, 2004, p. 28). Iyer notes the importance of behind-the-beat playing as part of the *laid-back* feel and aesthetic prized in African-American culture (Iyer, 2002, p. 410).

Both syntactic and subsyntactic levels of rhythmic perception are likely to be important parts of the experience of music. Danielsen conjectures that rhythmic aesthetics like *groove* result from the "interaction between (syntactic) rhythmic structure and the sounding realizations (micro-timing) of that structure" (2010, p. 6). This multi-level model of rhythmic perception—a syntactic core combined with subsyntactic variety—is widely assumed by music theorists and researchers but has not been formally tested in any rigorous way. The possibility that a different model of rhythmic perception, perhaps in which all the details of rhythm are perceived holistically, should be kept in mind. However, the complex reality of rhythmic timing in music, especially in of vocal parts, is not an issue which is unique to rap: understanding the role of systematic and stochastic rhythmic nuance in the music is a much broader project than the focus here on rap entails. Throughout this dissertation it is assumed that the idealized, categorical, conception of rhythm and meter (the syntactic level) is an important part of the experience of rap which can be fruitfully studied independently of subsyntactic levels.

Poetic Meter

The rhythm of rap flow differs from rhythm in (especially literary) poetry in that it is set against an independent metric hierarchy which is provided by the accompaniment: liberating "the MC to pursue innovations of syncopation and stress that might otherwise sound chaotic" (Bradley, 2009, loc. 91). Whereas the spoken syllables of a

poem must themselves evince a poetic meter, in hip-hop the accompanying beat provides the emcee with a clear meter. Most rap freely mixes poetic feet (dactyls, iambs, etc.) and doesn't arrange prosodic feet into regularly recurring patterns. Thus, poetic meter, and poetic feet, are not necessarily important parts of the organization of rap. This is not surprising, given that the historical origins of rap were predominantly traditions of oral oratory and popular music, not literary poetry.

To illustrate how analyzing rap in terms of poetic meter can be misleading, consider an analysis found on the Wikipedia article for the song "the Way I Am" (2000) by Eminem.[18] The article describes the vocal rhythm of "the Way I Am" as *anapestic tetrameter*, a poetic meter consisting of four short-short-long feet. The song's flow is indeed largely based on a short-short-long rhythmic motive, encoded ♬ in my transcriptions. However, crucial features of the rhythm are left out or misconstrued by this anapestic-tetrameter description. First of all, the ♬ rhythm is set to the musical meter in a highly syncopated manner. Figure 3.4 illustrates the true metric notation of this passage (top stave) as well as an alternative metric setting (lower stave). The description of "the Way I Am" as anapestic tetrameter does nothing to distinguish these two metric interpretations, even though they have vastly different musical feels. A second issue is that the rhythmic motive in "the Way I Am" is not always grouped into units of four, so a regular tetrameter is not really evident. Of course, the musical meter regularly articulates a four-beat meter, but this is independent of the structure of the vocal part. This emphasizes the point that flow and meter are independent in rap to a degree not evident in poetry.

[18]The article in question has been improved somewhat since I first encountered it, but still refers to anapestic tetrameter as of April 22, 2016.

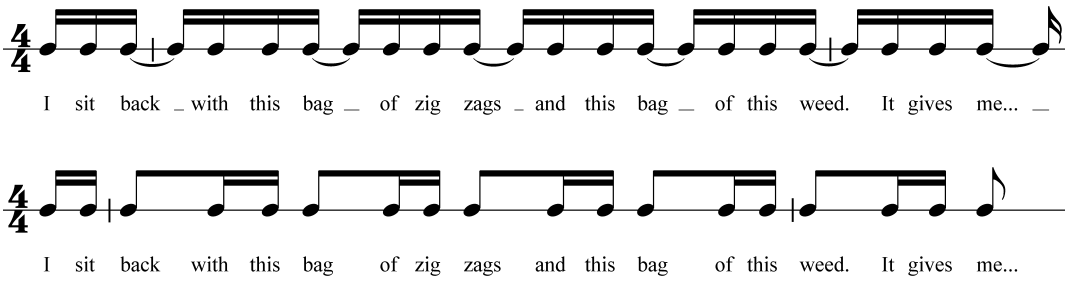

Figure 3.4: Illustration of two metric settings of the rhythmic motive—or "anapestic foot"—in Eminem's "the Way I Am" (2000). The top stave shows Eminem's actual rhythmic setting. The bottom stave shows an alternate metric setting which is identical in terms of poetic meter, but is very different in terms of musical meter.

Musical Rhythm

Finally, we consider the syntactic, "musical," dimension of flow rhythm. Even ignoring the influence of speech rhythm and subsyntactic rhythmic nuances, there is a great deal of rhythmic variety found in rap. Rap's rhythms are closely related to the sorts of rhythms found in American popular music in general, especially funk and R&B. This includes a preponderance of syncopation, including *shift syncopation*—wherein important rhythmic events are "shifted" off of strong beats (Temperley, 2001, pp. 240–252)—and syncopations created through *cross-rhythm*. Cross-rhythms consist of "rhythms based on different schemes of pulsations...played in parallel" (Danielsen, 2006, p. 45); in the case of rap, cross-rhythms occur when vocal parts articulate odd-numbed streams of pulsation in parallel with the even, duple pulses of the meter. As in other popular music styles, complete cross-rhythmic cycles are not common. Rather, cross-rhythmic patterns are usually curtailed so as to fit into the dominant duple meter, as in the ubiquitous duration patterns /♩. ♩. ♩/ and /♪. ♪. ♪. ♪. ♩/. Thus, rather than true cross-rhythms, rap is infused with, as put

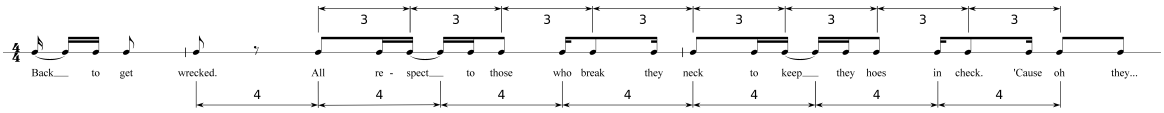

Figure 3.5: An example of a ♪. against ♩ cross-rhythm in rap, performed by 2Pac in his song "I Get Around" (1993) at ≈0:21. A three-𝅘𝅥𝅯 rhythmic pattern (bracketed above staff) is crossed against the four-𝅘𝅥𝅯 grouping (below staff) implied by the ♩ beat.

by Danielsen,"counter-rhythm with a tendency towards cross-rhythm" (2006, p. 62). However, longer cross-rhythmic patterns do occur, as in the opening measures of 2Pac's "I Get Around" (1993), shown in Figure 3.5.

One very basic feature of speech rhythm that influences all rap flow is its speed. Rap generally proceeds at much faster rates than other forms of song, with very few sustained syllables or rests of significant duration. As mentioned in Section 2.2.3, these features are part of what distinguishes rapping from singing. Empirical descriptions of rap speed in MCFlow are presented in Section 5.1.1 (page 125). Due to the avoidance of longer durations, rap flow is typically focused on a small number of durations. Indeed, most raps are dominated by two principle rhythmic durations which are related by a ratio of two to one—for instance ♪/𝅘𝅥𝅯 or ♩/♪. In most raps of moderate tempo (≈80–120 bpm), the rhythms are dominated by ♪ and 𝅘𝅥𝅯, with a handful of ♪. and ♩.

Some rap songs evince clear rhythmic motives that reoccur throughout the flow—such as the anapestic foot in "the Way I Am" (discussed in previous section). However, generally the rhythmic patterns in rap flow are highly variable. Rap's rhythmic variability is another feature that relates flow more to improvisatory solos than to strophic melody.

3.2.2 Prosody

The term *prosody*, as used by linguists, refers to super-syllabic elements of speech sound: features of entire speech utterances as opposed to individual syllables or phonemes. The principle dimensions of prosody are rhythm, stress, intonation (pitch), and timbre—due to rap's musical nature, rhythm has already been discussed as a distinct topic above. Prosody is important in normal speech for several reasons, many of which occur in rap either in their natural form or in a heightened form. Two roles of prosody are of special importance in rap flow: (1) prosody influences the rhythmic shape of flow by creating agogic, dynamic, and tonic (pitch) accents or *prominences*; (2) prosody plays an essential role in the segmentation and phrasing of rap.

Stress, Accent, Prominence, and Rhythmic Layering

The term *stress* refers to the relative prominence of syllables created by contrasts in loudness and vowel articulation.[19] Stress in spoken English is necessary to differentiate multi-syllabic words (lexical stress) and to clarify grammatical and semantic meaning (prosodic stress). At a minimum English features two stress levels (stressed/unstressed). However, many linguists differentiate primary and secondary stresses, creating three-level models.[20] Other linguists argue that extra levels of prominence are actually a separate dimension from stress created by *pitch accents*, and this is the interpretation adopted in MCFlow. Pitch accents consist of an intonational peak (or more rarely a nadir) on a particular syllable, emphasizing that syllable. Pitch accents

[19]In English speech, vowels in unaccented syllables undergo *vowel reduction*, wherein the vowel is shortened and the timbre of the vowel is moved towards the lax |ə| sound. Vowel reduction is a feature of speech rhythm/articulation which is always present in rap, subtly undermining the precise timing ideals of music.

[20]Models which distinguish four levels of stress exist as well.

work independently, but in parallel, with stress to contribute to variation in syllable prominence.

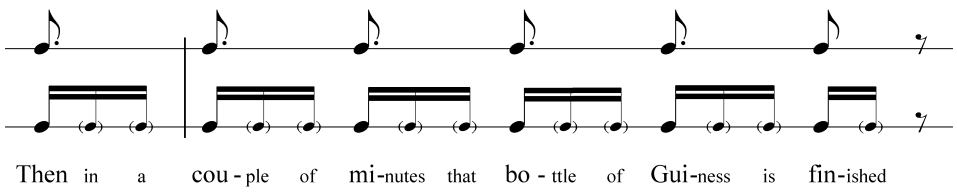

Figure 3.6: Illustration of the relative unimportance of unstressed syllables in flow. In this excerpt from Eminem's "Drug Ballad" (2000)—at ≈0:54—stresses on every third 𝅘𝅥𝅯 syllable form a more prominent rhythmic layer consisting of 𝅘𝅥𝅮. (top stave). The unstressed 𝅘𝅥𝅯 are less perceptually salient, as represented by the ghost-note notation in the bottom stave of the figure.

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The combination of stress, intonation (pitch accents), rhythm (especially duration), timbre, and loudness give syllables varying levels of *prominence* (Wennerstrom 2001, p. 200; Cruttenden 1986, pp. 10–11). Variations in prominence influence the meaning of utterances as particular words or clauses are emphasized or deemphasized. In rap, variations in prominence are also important rhythmically as they help articulate what Adams calls independent *rhythmic layers* (2009). Unstressed syllables are the least prominent events, and thus the "lowest" rhythmic layer, functioning like relatively unimportant musical "ghost notes." For example, the passage in shown in Figure 3.6 is heard mainly as a series of 𝅘𝅥𝅮. delineated by the stressed syllables, not a stream of 𝅘𝅥𝅯. In contrast, the presence of pitch accents, timbre accents, loudness, or hype (doubling the lead vocalist) can form increasingly abstract, "high-level," rhythmic layers. Due to their special phenomenological features (discussed below, in Section 3.2.3), rhymed syllables articulate the highest rhythmic layer in rap flow, forming a structural scaffold around which surface rhythms are organized. Four rhythmic layers in rap flow are illustrated in Figure 3.7.

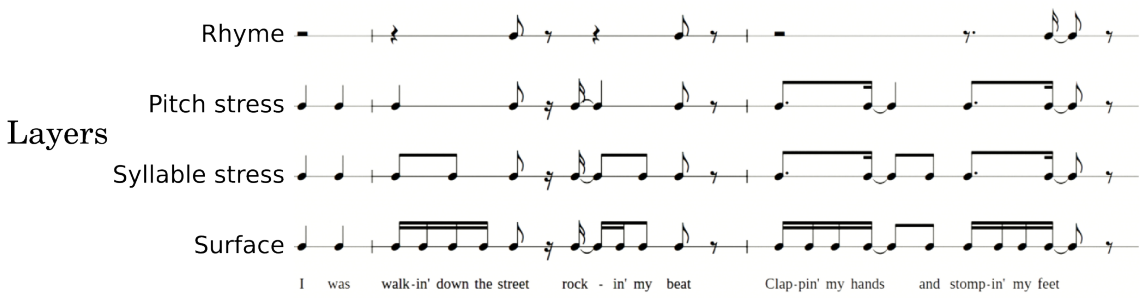

Figure 3.7: Illustration of four rhythmic layers in Kool Moe Dee's "Go See the Doctor" (1986)—at ≈0:42. The bottom layer contains all syllables ("the surface") while the second layer only includes stressed syllables. The third layer contains yet more prominent syllables created by pitch accents. The highest layer consists of rhymed syllables.

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Segmentation

Prosody is essential to the segmentation of speech, as rhythmic breaks and conventional pitch contours serve as important *boundary cues*. These boundaries create *prosodic units*, which in rap play a role similar to that of musical phrases, written sentences, and/or poetic lines.

Pitch is essential to prosodic segmentation. The prototypical prosodic unit begins with a leap up to a relatively high pitch, followed by a gradual declination as the speaker's breath dissipates. In general, average pitch, and the range of pitch variability, tends to fall towards ends of utterances (Cruttenden 1986, pp. 126–130; Wennerstrom 2001, pp. 24–25). This pitch declination forms the normalized overarching structure of English prosody (Moore, 2008, p. 956), against which violations or delays can be used to articulate sub-boundaries or communicate a particular segment's position within the larger prosodic shape. Prosodic units can be nested within each other, just as melodies can contain sub-phrases within larger phrases. Sub-phrases end with relatively high terminal pitches, leaving the lowest pitches to mark the end

of the complete phrase. Conversely, the size of the leap to a new high pitch at the beginning of an utterance also indicates the strength of a boundary: A small leap may indicate continuation or a related thought, while a large leap indicates a completely new idea. Emcees make use of all these distinctions to help structure their flow. Consider Figure 3.8, which shows the F0 contour from an excerpt of Eminem's "Without Me" (2002). Eminem's flow is clearly broken into *declination units* of equal length, beginning with a leap up to high in his range and gradually sliding down to a nadir before jumping up again. These declination units coincide perfectly with a four-measure hypermeter. Within these large four-measure groups, individual subunits are articulated by relatively small declinations (not easily visible in the figure, but easy to hear).

The overall normative structure of pitch declination is elaborated with certain short-range pitch contours—what Woodbury calls *terminal shapes*—that are consistently used in both normal and heightened speech to delineate phrases (1985). Figure 3.9 shows the fundamental frequency (F0) pitch contour of two phrases from Biggie Smalls' "Suicidal Thoughts" (1994). Steeply dropping terminal shapes on the words /hell/ and /tell/ delineate the two phrases. Of course, rhythm also makes an important contribution to speech segmentation, either with actual pauses/rests or through the lengthening of terminal syllables (Cruttenden, 1986, pp. 39–40). Placing emphasis on the final syllable of each line is prototypical in English poetry (Lerdahl, 2001), a practice which is also followed in rap, further clarifying prosodic boundaries.

Register

In addition to intonational contours, overall pitch register is also important in rap flow. According to Alan Cruttenden, "most people speak in the lower third or their

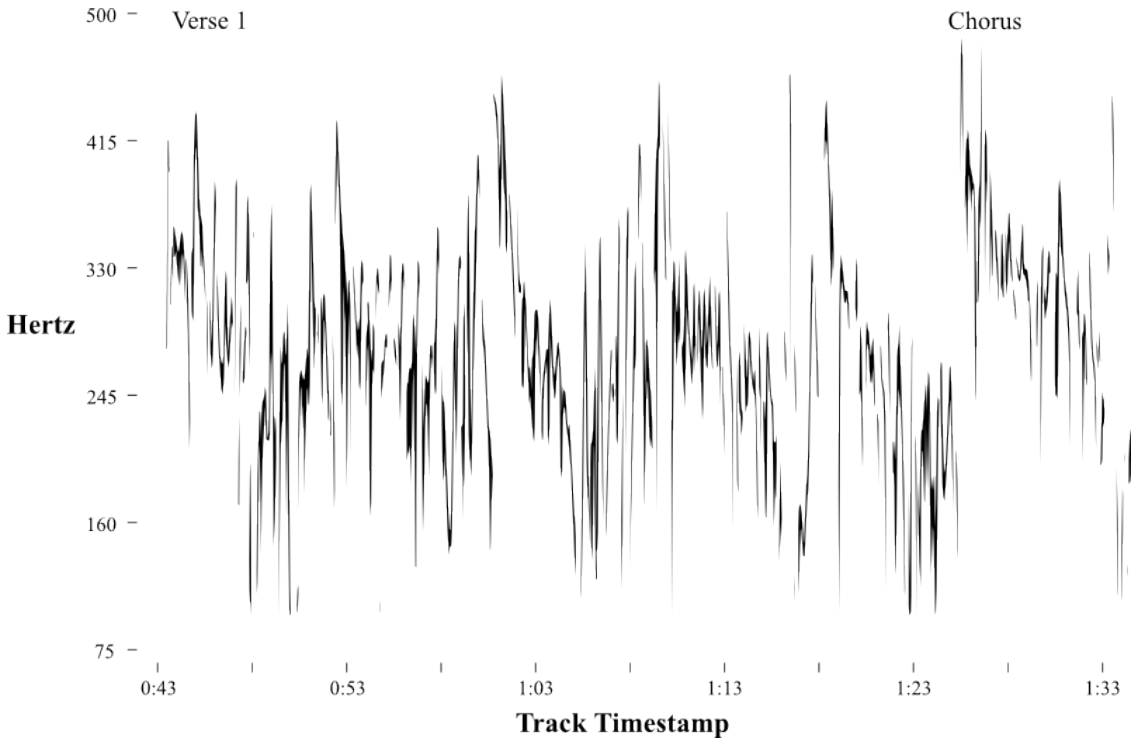

Figure 3.8: Four-measure pitch declination units structure Eminem's flow in "Without Me" (2002). The F0 contour for the first verse (20 measures), and the first phrase of the first chorus, are shown. The repeated saw-like pattern repeats with every four measures of music.

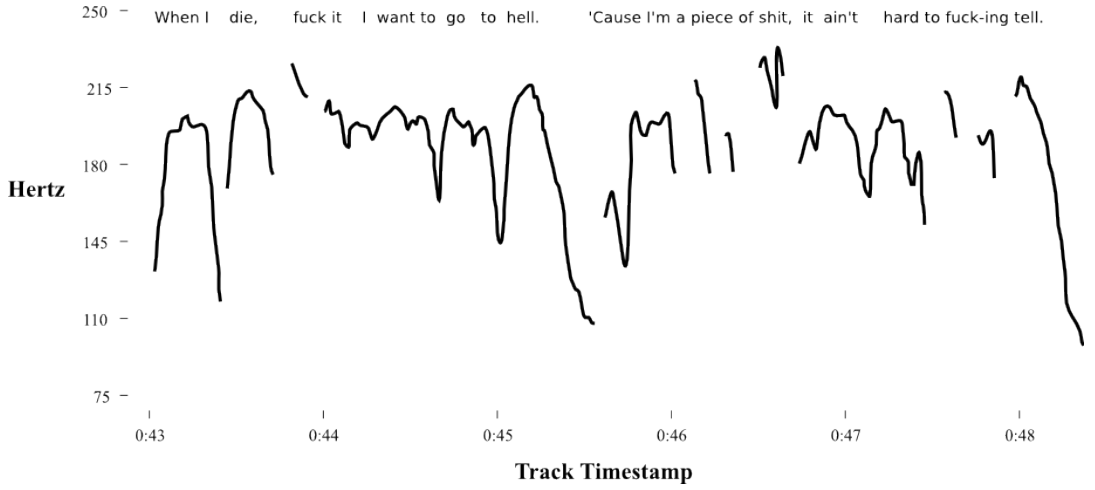

Figure 3.9: Illustration of prototypical phrase-final pitch contour (*terminal shapes*) in an excerpt from Biggie Smalls' "Suicidal Thoughts" (1994). The plotted line represents the F0 contour of Biggie's voice. In addition to the terminal pitch drops on /hell/ and /tell/, notice the pitch accents on /fuck/ and /shit/ respectively.

total pitch range" (1986, p. 53). In contrast, emcees often rap high in their vocal range where there is more "unused pitch range available" for expressive, emotionally charged, intonation (Cruttenden, 1986, pp. 53,55,129,130). Different vocal registers may be used to mark the feel or emotional message of particular passages: in a relatively personal, introspective rap, an emcee might use his or her natural spoken vocal register, while favoring a lower-than-normal register in angry rap, or a higher-than-normal register in comical rap. Changes in vocal timbre may serve similar functions. Ann Wennerstrom notes that "storytellers use paratones to mark component shifts in narratives just as lecturers do to delineate topics" (2001, p. 200). Similarly, emcees may use register/timbre to delineate sections or topics within a verse: in D12's "Purple Pills" (2001), emcee Proof begins his verse deep in his vocal range, with a raspy timbre, before quickly switching to a (relatively) high register at the beginning of the next hypermetrical group (≈2:02–2:14). Recall Eminem's contrasting of stable and unstable pitch contour in "Lose Yourself" (Figure 2.3, page 18), which achieves a similar artistic effect.

Pitch Melody

Emcees also structure their flow with "parallel intonation contours" (Graham, 1984, p. 172), often in combination with parallel rhythm and rhyme. For instance, emcees often deliver multi-syllable rhymes with the same distinct pitch contour, like a melodic motif. Each of the first four phrases of the first and third verses of Ludacris' "Money Maker" (2006) end with an exaggerated upward scooping contour—a marked reversal of the normal terminal shape—which creates a clear parallelism from measures to measure. Similarly, each declination unit in Eminem's "Without Me" (Figure 3.8) ends with a recognizable "melodic" motif in the second half of each four-measure

group—the motif is not readable in the figure but is easy to hear in the recoding, especially each time he raps "it would be so empty without me."

3.2.3 Rhyme

Rhyme is the core of rap's artistry; in the hip-hop community the word *rhyme* can even serve as a synonym for rap. Thus, to understand rap it is essential to understand rhyme. Most English speakers become familiar with the basic concept of rhyme at a very young age, as rhyme is commonplace in most English nursery-rhymes, poetry, and song. As a result, rhyme is often taken for granted—it seems like a straightforward and well understood phenomenon, with a clear definition. On the contrary, rhyme is an extraordinarily complex phenomenon, the psychological basis of which is not well understood and which has received surprisingly little research attention. In a *60 Minutes* interview, emcee Eminem responded to the notion that the word /orange/ has no rhyme by rapping "I put my *or-ange*, *four-inch*, *door-hinge* in *stor-age* and ate *porr-idge* with *Geor-ge*" (Cooper, 2010)—as Adam Bradley puts it: "rap... goes by the ear rather than by the book" (2009, loc. 958). This section will attempt to identify and explain the many complex dimensions of rhyme and, in the process, suggest a new framework for understanding the broad concept of rhyme. This will include discussions of rhyme phenomenology, psychology, and artistry.

In the familiar colloquial usage, *rhyme* refers to a relationship between two words wherein the words each contain the same stressed vowel phoneme and all subsequent phonemes. For instance, the word pairs /cat : bat/ and /cattle : battle/ are considered rhymes. When *60 Minutes* interviewer Anderson Cooper suggested to Eminem that /orange/ has no rhyme, it was clearly this colloquial definition of rhyme that

he had in mind. However, as Eminem demonstrated, this relationship—the so-called *perfect rhyme*—is but one of many varieties of similar phenomena which can broadly be understood as forms of rhyme. A great host of terms have been coined to classify rhyme types, including but not limited to: slant rhyme; half rhyme; semi rhyme; forced rhyme; oblique rhyme; syllabic rhyme; imperfect rhyme; internal rhyme; bridge rhyme; broken rhyme; near rhyme; single, double or dactylic rhyme; rich rhyme; masculine rhyme; feminine rhyme; mosaic rhyme; consonance; assonance; para rhyme; bridge rhyme; and alliteration. Unfortunetaly, these myriad terms do not represent a well defined scheme for rhyme classification; their usage is not consistent between scholars and many of the terms reflect very different perspectives on rhyme classification. In fact, English scholar Stephen J. Adams has noted that the wealth of rhyme terms in use reflect four distinct criteria for the classification of rhyme: (1) by nature of sonic similarity; (2) by relationship to stress patterns; (3) by relationship to word boundaries; (4) by position in line/stanza (Adams, 1997). These four criteria represent very different perspectives on the phenomenon of rhyme, each of which is worth considering in depth.

The following discussion requires familiarity with some basic linguistic terms.[21] Firstly, the constituent sounds which make up spoken syllables are known as *phonemes*, which can broadly be classified into two groups: vowels and consonants (Harley, 2006). Consonants can further be grouped into five classes: plosives, fricatives, affricates, nasals, and approximants (Harley, 2006). In addition, plosives, fricatives, and affricates can either be voiced (spoken with the vocal chords vibrating) or unvoiced (spoken without the vocal chords vibrating); English includes eight pairs of

[21]Linguistic discussions throughout this dissertation are entirely specific to American English.

phonemes which differ only in their being voiced or unvoiced. For a description of English phonemes and the International Phonetic Alphabet symbols used in this dissertation see Table 4.7 on page 116. All spoken syllables contain a core phoneme known as the syllable *nucleus*, which is usually a vowel but may occasionally by a nasal or approximant (Harley, 2006). Some syllables contain only this single nucleus phoneme, but most contain one or more phonemes before and/or after the nuclues. Phonemes that occur before a syllable's nuclues are said to occupy the syllable *onset*—English syllable onsets can contain up to three phonemes, as in the word /street/ (Harley, 2006). Phonemes that occur after a syllable's nuclues are said to occupy the syllable *coda*—English syllable codas can contain up to four phonemes, as in the word /texts/ (Harley, 2006).

(1) Rhyme by Similarity Type

Rhyme occurs when there is similarity between two spoken events. However, perfect similarity between two events is generally not considered rhyme, but rather repetition. Differentiating repetition from rhyme is not always a simple matter. For one, some sources consider total sonic similarity to constitute rhyme if the meaning of the two events is different—so called *rich rhyme*, as in /through : threw/. Another issue is that a perfectly repeated syllable, or even word, may form part of a larger rhyme (discussed below). Still, rhyme is generally associated with *partial* repetition of speech phonemes: when some, but not all, phonemes are shared between two spoken events.

The position of "shared phonemes" within syllables is crucial to the concept of rhyme: for a rhyme to occur the phonemes shared between spoken events must occupy parallel positions in their syllables. For instance, the |b| phonemes in /bat : cab/ do

Table 3.1: Examples of various types of rhyme with shared phonemes in different syllable positions.

#	Event 1		Event 2	Location of shared phonemes	Traditional label
1	won	:	won	ONC	Repetition
2	won	:	one	ONC	Rich rhyme
3	stick (noun)	:	stick (verb)	ONC	Rich rhyme
4	bat	:	cat	NC	Perfect rhyme
5	bat	:	bag	ON	Reverse rhyme
6	bat	:	beat	O C	Arch rhyme(?)
7	bat	:	bing	O	Alliteration
8	bat	:	cam	N	Assonance
9	bat	:	kit	C	?

not rhyme because they occupy the syllables' onset and coda respectively. What's more, many well known rhyme terms are defined by the syllable position of the shared phonemes. Some illustrative examples are presented in Table 3.1—the third column in the table indicates which syllable segment contains the shared phoneme (O = onset, N = nucleus, C =coda). Most of the rhyme types illustrated in Table 3.1 have traditional labels which are used with some consistency (given in last column of the table). Notice that all these examples involve rhyme relationships between single syllables. Multi-syllabic words which combine these various types are entirely possible (and commonplace in rap), but no terms to classify these possibilities are known to the author.

The rhyme types illustrated in Table 3.1 all feature exact repetition of phoneme(s) within a syllable segment. However, rhymes can also occur when the phonemic similarity is inexact—so called *imperfect rhyme*.[22] Despite the characterization as "imperfect," these sorts of rhyme are perfectly legitimate and artistically effective. Imperfect rhymes can be heard in literary verse, nursery rhymes, and rock/pop lyrics, though

[22]Terms like *half rhyme*, *slant rhyme*, and *near rhyme* are essentially synonymous with *imperfect rhyme*.

Table 3.2: Examples of rhymes which vary in the nature of their phonemic similarity.

#	Event 1		Event 2	Modification
1	bust	:	pus	coda /t/ deleted
2	grow	:	road	onset /g/ deleted
3	mom	:	bombed	coda /d/ inserted
4	fasts	:	last	coda /s/ inserted
5	masts	:	fats	coda /s/ deleted
6	bomb	:	gone	coda /m/→/n/
7	bad	:	cat	coda /d/→/t/ (voiced→unvoiced)
8	lap	:	cat	coda /p/→/t/
9	beat	:	bit	nucleus /i/→/ɪ/

they are significantly more common, and more varied, in rap (Holtman, 1996, p. 244). Two distinct forms of imperfect similarity can occur: (1) extra consonants may be inserted or deleted from either onset or coda (illustrated in Table 3.2, rows 1–5); (2) phonemes can be swapped with similar sounding phonemes (illustrated in Table 3.2, rows 6–9). What constitutes a "similar phoneme" is somewhat flexible and subjective, but is generally determined by shared articulatory features of the phonemes (Hirjee and Brown, 2010, p. 122). Despite the great variety of imperfect rhyme in rap observed by Holtman, she nonetheless found that emcees' rhymes were constrained by logical phonemic similarities: "it is not true, even in rap songs, that any consonant can be rhymed with any other" (Holtman, 1996, p. 244). Vowels may swap with vowels which are articulated with similar mouth and tongue positions, such as |ɪ : i|. In the case of consonants, the most common substitutions are between phonemes of the same class, especially between voiced/unvoiced phoneme pairs, such as |g : k|. For a detailed review of phonemic substitutions in a corpus of rap (and poetry), see Holtman's dissertation (1996).

(2) Rhyme by Stress Type

Stress plays a crucial role in rhyme: Several common rhyme terms (e.g. masculine rhyme and feminine rhyme) refer to the position of stresses within multi-syllable rhymes. More generally, rhymes do not occur between (isolated) unstressed syllables. For example, the words /taking : riding/ don't rhyme unless the speaker unnaturally emphasizes the unstressed /ing/. Such "unnatural" examples do appear, as when Andre 3000 rhymes /hell**o** : ghett**o**/ in the OutKast song "B.O.B." (2001) by lengthening the second (unstressed) syllable in each word. Similarly, the term *wrenched rhyme* is used to describe the rhyming of a stressed syllable with an unstressed syllable—also a rare, and weak, form of rhyme. An example of wrenched rhyme occurs in the second verse of Eminem's "Lose Yourself" (2002), when he rhymes /gaping : taking : make me king/: The unstressed /ing/ syllables in /gaping/ and /taking/ rhymes with the stressed /ing/ in /king/.

Though unstressed syllables only rarely create noticeable rhymes on their own—as in the "wrenched" examples above—, they frequently take part in larger multi-syllabic rhymes. For instance, in Eminem's rhyme /gaping : taking/ the unstressed /ing/ is clearly *part* of the rhyme, even though it would not rhyme on it's own.[23] Generally, unstressed syllables only rhyme when they abut a stressed syllable that also rhymes. Unfortunately, when unstressed syllables become "absorbed" into multi-syllabic rhymes, and when they do not, is not always clear.

[23]Notice also, the |p→k| substitution in the rhyme between /gaping : taking/.

(3) Rhyme Boundaries and Units

Rhyme is a relationship between two spoken events. However, it is not clear what sort of "events"; What is the "unit" that rhymes? In the colloquial definition the two rhymed events are words; for instance, the words /cat/ and /bat/. However, the issue is complicated by the possibility of rhymes between multi-syllabic words and between multiple words—both of which are frequent occurrences in rap. Consider the rhyme-pairs shown in Table 3.3 (rows 1–7): Due to the position of word boundaries, different terms have been proposed to describe each of these rhymes. If the unit of rhyme is the word then example 1 represents a single rhyme while example 3 represents two separate rhyme pairs—/other : brother/ and /hood : wood/. Example 2 (mosaic rhyme) is difficult to segment at all, since one event consists of two words and the other a single word. To complicate things further, the second word in example 4 (/wood/) repeats exactly and thus might not be considered part of the rhyme at all. In an artistic context it seems likely that listeners would consider examples 1–4 all to be essentially the same sort of rhyme relationship, and that they would best be considered one rhyme each. Example 5 is quite different: the reversal of the word order does seem to split the pair into two independent rhyme relationships. Examples are 6–7 also single rhymes but have a different character because only one syllable rhymes in each example. Examples 1–7 in Table 3.3 suggest that: (1) word boundaries are not relevant to the phenomenon of rhyme and (2) that the word cannot be the essential defining unit of rhyme.

Examples 6 and 7 in Table 3.3 suggest that the syllable is a more promising candidate for the basic unit of rhyme. The importance of phonemes' syllable positions (onset, nucleus, coda) and syllable stress patterns also suggests the syllable as a

Table 3.3: Examples illustrating the relationship between rhyme and word boundaries.

#	Event 1		Event 2	Traditional label
1	motherhood	:	brotherhood	Perfect rhyme
2	other hood	:	brotherhood	Mosaic rhyme
3	other hood	:	brother wood	Broken rhyme
4	other wood	:	brother wood	Perfect rhyme + repetition
5	hood other	:	brother wood	Perfect rhyme + perfect rhyme
6	good	:	motherhood	Perfect rhyme
7	mother	:	brotherhood	apocopated rhyme
8	stoke the fire	:	choke the tire	
9	stoke the fire	:	choke a tire	
10	I stoke the fire	:	I choke a tire	
11	I stoke the fire	:	why choke a tire	
12	I choke the fire	:	I choke the tire	
13	I choke the fire	:	why choke the tire	
14	choke while your car turns	:	stroke until the fire burns	
15	choke while the car turns	:	stroke while the car burns	
16	stoke fire	:	choke the tire	

candidate for rhyme "unit." However, the existence of multi-syllable rhymes poses the same issue to syllables as multi-word rhymes do to words. For instance, is example 1 actually a chain of three different rhyme pairs? If this were case, only the first syllables /mo-/ and /bro-/ actually rhyme, while the other two syllables /-ther hood/ are perfect repetition, not rhyme.

Next consider Example 8 in Table 3.3: Is this an example of two independent rhymes (/stoke : choke/ and /fire : tire/), or a single three-syllable rhyme? The second interpretation seems preferable, but is /the/ part of this rhyme, or simply repetition lodged between rhyming syllables? Example 9 replaces the repetition of /the/ with a rhyme between /the : a/—is example 9 perceptually different from example 8? Examples 10 and 11 extend the rhyme by adding another syllable (/I/ or /why/) at the beginning. /I : Why/ is a legitimate perfect rhyme on it's own (though unstressed), but does the repetition of /I/ get counted as part of the (now) four-syllable rhyme?

Examples 12–15 continue to expand upon this example with added syllables which are either perfect rhymes or perfect repetition. These examples are meant to illustrate the difficulty of identifying the boundaries of rhyme units, especially when some parts of rhyme are in unstressed syllables or include perfect repetition. As mentioned above, unstressed syllables and perfect repetition generally do not rhyme on their own. However, when delivered immediately after syllables which do rhyme, unstressed and repeated syllables can become "absorbed" into a larger rhyme event. Generally, it seems that all rhyme units begin with a stressed non-repetition syllable. Unstressed or repetitive syllables that immediately follow this initial syllable may be "absorbed" into the rhyme. Example 16 (in Table 3.3) illustrates another interesting possibility which is quite common in rap: two adjacent rhymed syllables in one event rhyme with syllables in another event which are separated by an unstressed syllable. In this case, it seems that the unstressed /the/ syllable is not truly part of the rhyme unit—the word /me/ in Emimen's /gaping : taking : make me king/ rhyme has a similar status.

(4) Rhyme by Position

Finally, many rhyme terms refer to the position of the rhyme within the line or stanza. The prototypical form of rhyme is the *end rhyme* which lands at the end of a line (or in the case of rap, a phrase). The term in *internal rhyme* broadly refers to any rhymes that are not end rhymes, including *bridge rhymes* which cross multiple lines/phrases but are not placed at the end of the line/phrase. Emcees' placement of internal rhymes in phrases is highly varied and creative (Alim, 2003). The placement of rhymes in phrases is a very important aspect of rap artistry, especially as it relates to predictable rhyme schemes.

Rhyme placement might seem to be irrelevant to the identification of rhyme units, or to rhyme psychology. However, due to the preponderance of end rhymes, which are generally reinforced by prosodic parallelism at phrase ends, end rhymes are generally easier to identify than internal rhymes. Even a very weak rhyme relationship is likely to be heard as a rhyme if placed at the end of a phrase. In contrast, if the same weak rhyme were delivered as an internal rhyme, it might not be recognized as a rhyme at all. Thus, the relationship between rhyme and prosodic phrases and contours is non trivial.

Time Frame of Rhyme

It is tempting to think of rhyme as an abstract, objective relationship between sonic events. However, rhyme is a subjective psychological phenomenon. An important feature of rhyme's subjective phenomenology is that spoken events must be fairly close together in time in order to be perceived as rhyming. In a sufficiently long utterance every word is bound to "objectively" rhyme with some other word eventually. However, for the events to truly rhyme they must be near enough in time for the similarity to be perceived. It seems that as each spoken event fades in memory it becomes less likely to be heard as a rhyme with a new event. Thus, there is a sort of rhyme *decay time*. The length of the decay time between rhymed syllables is not clear and is likely context dependent. For instance, rhyme decay time may vary depending on the density of intervening material. Rhyme decay time might also vary based on the strength/type of the rhyme. For instance, alliteration (repetition of onsets) seems to require that rhymed events are placed very close together in time: In modern English poetry (and rap) alliterative rhymes are often placed in adjacent stressed syllables, as in /Peter Piper picked a peck of pickled peppers/. Generally, the

rhyme decay threshold seems to be approximately 12–16 seconds, which is perhaps related to the limits of short-term memory (Snyder, 2000). In terms of rap, spoken events separated by more than four measures are unlikely to be perceived as rhyme, though this is only a very rough rule of thumb.

Rhyme Chains

Up to this point rhyme has been discussed as a relationship between *two* events. Of course, the same relationship may exist between many events. In this dissertation, I refer to a series of two or more rhyming events as a rhyme *chain*. Each rhymed unit forms a *link* in the chain. For example, in the line

> To all the ladies in the place with style and grace, allow me to lace these lyrical douches in your bushes.
> —from Biggie Smalls' "Big Poppa" (1995).

the words /place : grace : lace/ form a rhyme chain with three links.

Generally, adjacent links in rhyme chains are the focus of attention. This is especially the case if each link is spaced out enough that no more than two links ever fall within the rhyme decay threshold. However, emcees sometimes rap three or more rhyme links within the rhyme decay window (as in the Biggie line above). Table 3.4 shows the rhymes ending the first eight phrases of Eminem's "Drug Ballad" (2000). Notice that the strongest rhyme relationships (between 1 and 3 or between 5 and 7) are not between adjacent rhymes.

Rhyme chains with many imperfect relationships can lead to an interesting phenomenon, first described by Walter Herbert (1937), which I call *rhyme modulation*: In a rhyme modulation, a series of imperfect-rhymes drift away from the original event, rather like words in the children's game "telephone." The result is a chain of rhymes

Table 3.4: Transformation of rhymes over the course of a rhyme chain in Eminem's "Drug Ballad" (2000).

1	**Marky Mark**	|mar-ki mark|
2	**party start**	|par-di start|
3	Ba**cardi** dark	|kar-di dark|
4	**hardly talk**	|hard-li tak|
5	**pro'bly crawl**	|pra-bli kral|
6	**pro'bly barf**	|pra-bli barf|
7	**pro'bly fall**	|pra-bli fal|
8	**hallway wall**	|hal-weI wal|

wherein the last link does not rhyme with the first link, such as: /cat→ bat→ blat→ blast→ last→ lass→ glass→ glad→ glam→ lamb→ limb/. The rhyme chain from "Drug Ballad," shown in Table 3.4, is also an example of rhyme modulation, as the first and last links don't really rhyme—/Marky Mark : hallway wall/.

The first link in any rhyme chain represents a special case. If we hear a spoken event such as /maze/, we don't know that it is part of a rhyme chain until we hear the word /blaze/. Thus, /maze/ is only a rhymed syllable *retrospectively*, and it is unclear whether it is appropriate to treat /maze/ as part of the rhyme chain. In an actual rapped context—where end-rhymes are extremely common and prosody typically emphasizes them—a listener might very well guess that an event will rhyme before it is actually rhymed. For example, upon hearing Eminem end his first phrase with the utterance /Marky Mark/, a listener might reasonably anticipate that the next phrase will rhyme this first event. Such events can be said to be *marked* for rhyme.

Rhyme Schemes

The most obvious feature of rhyme in poetry and song is their arrangement in predictable *rhyme schemes*. A repeated rhyme scheme allows listeners to predict which events will rhyme, and when. The resulting anticipatory drive is perhaps the most striking aesthetic feature of much poetry—as described by Beum and Shapiro,

> A pattern of parallels in sound color is set up, and as we... listen, our expectation is continually... raised and then satisfied.... Rhyme helps pull us through and pull us in deeper, as we anticipate the scheme (Beum and Shapiro, 1965, p. 96).

The phenomenological experience created by rhyme schemes is central to many forms of heightened speech. As mentioned above, when context or rhyme scheme imply that a particular sonic event will rhyme with an upcoming event, this event can be said to be *marked* for rhyme. According to Strachan and Terry "the introduction of a new rhyme term gives us a pin-prick of anticipation as the mind's ear casts ahead for a for a word that will continue or clinch the rhyme" (Strachan and Terry, 2001, p. 61). When such a marked syllable is "resolved" by the anticipated rhyme, I borrow Strachan and Terry's word and refer to this as the rhyme being *clinched*.

A common practice in rap is to set up the expectation of a rhyme clinch at a particular point, but then to to delay or belay the arrival of the expected rhyme. Bradley explains that, "by temporarily denying the listener's expectation of rhyme, [the emcee] creates a sense of heightened anticipation and increased attention" (Bradley, 2009, loc. 184). Whats more, many rhymes may appear which do not form part of a regular scheme—for example, consider Biggie's /place : grace : lace/ rhyme chain from the previous section. These non-schematic rhymes are completely unpredictable, and the first link in such rhyme chains can only be identified retrospectively. Still, most

emcees include enough predictability in their flow to keep the listener actively anticipating rhyme. Thus, "even in the case of a highly irregular arrangement of the rhyme words: we still feel ahead, expecting the sound colors to find their mates some-where [sic]" (Beum and Shapiro, 1965, p. 96).

Rhyme schemes have two elements: (1) the location of rhymes in phrases (2) the length of rhyme chains. The prototypical rhyme scheme consists of two-link end-rhyme chains (simple couplets)—as in /AA BB CC DD/. In rap, the location of rhymes in the meter, which may or may not align with phrase positions, is also important. In many poetic traditions a single definite rhyme scheme is repeated throughout the poem. In contrast, emcees often switch and vary rhyme schemes throughout a verse. Emcees rarely create complex, "long range," rhyme schemes in which two or more rhyme chains alternate: such as /ABAB CDCD/ or /ABAC DBDC/. Only a handful of songs in the current MCFlow dataset contain rhyme schemes of this sort—for instance, Run D.M.C.'s "It's Tricky" (1987) and LL Cool J's "Control Myself" (2006) both repeat the scheme /AABBA/ throughout the song. It is not that emcees don't overlap multiple rhyme chains—on the contrary, many emcees overlap numerous rhyme chains in quite complex webs. Rather, emcees vary the placement and delivery of rhymes so much (often with dense internal rhymes) that clear rhyme schemes rarely emerge. The simple end-rhyme couplet arrangement (/AA BB CC DD/) is the only unambiguous rhyme scheme that frequently occurs in rap, though the rhyme chains are often lengthened and overlapped to create patterns more like /AAAABABCCD-CDDDEDEDEE/.

Rhyme Phenomenology

Despite the extensive discussion so far, the most important question regarding rhyme has gone unasked: Why is the "rhyme" relationship between spoken events used in poetry and lyrics? What artistic, or psychological, effect does it achieve? The most salient aspect of rhyme is often the anticipation created by regular rhyme schemes. In fact, rhyme is so closely associated to rhyme schemes that people fail to recognize the possibility of non-schematic rhyme. However, rhyme has a distinct phenomenological quality which exists independently of its organization into regular schemes: Rhyme seems to draw attention to a syllable or word, adding to its perceived prominence (Tsur, 1992). Non-schematic rhymes appear in many short idiomatic expressions ("let's walk and talk") and aphorisms ("birds of a feather flock together"), making the expressions seem more truthful than non-rhyming counterparts (McGlone and Tofighbakhsh, 2000). When we occasionally rhyme by accident in normal conversation, the event tends to "jump out at us"—sometimes invoking laughter. Rhymes are also perceived as connected in time (Tsur, 1992, pp. 62,84)—what Bradley calls the "echo of sound from one word to another"(Bradley, 2009, loc. 857). These phenomenological qualities—especially prominence and connection— which are evoked even by non-schematic rhymes, are part of what affords rhyme its artistic usefulness. As explained in Section 3.2.2, rhymed syllables form the highest, most abstract, rhythmic layer in rap flow, serving as a basic rhythmic structure around which phrases and "surface" rhythmic patterns are articulated. This position as the "top" rhythmic layer is attributable to the prominent and connected perceptual quality of rhymes.

What gives rhyme these phenomenological qualities? To date, the most significant attempt to answer this question is the theory of *cognitive poetics* pioneered by literary

theorist Reuven Tsur (1992). Tsur suggests that the phenomenological experience of rhyme arises because rhyme causes non-categorical sonic information, which is normally discarded during speech processing, to be retained. According to Tsur, when we listen to normal speech,

> we translate a stream of acoustic information into a stream of phonetic representations, which in turn we translate into a stream of semantic representation... resulting in a string of abstract phonetic categories, [such] that very little sensory information reaches consciousness (1992, p. 57).

In other words, we don't really hear the *sounds* of speech, just the meaning. In contrast, Tsur argues that poetic devices (heightened speech) cause this precategorical sound information to be retained and brought into conscious awareness, drawing our attention to the speech's sound. The heightened awareness of speech's sound may account for the rhymes' "prominent" or accented quality. Similarly, Tsur's theory offers a plausible explanation of rhymes' "connected" phenomenology: According to Tsur, rhyme's effect on short-term memory and audio processing causes "acoustic confusion" which in an "aesthetic context... may be perceived as 'harmonious fusion' or 'musicality'" (1992, p. 62). As a result, rhyming units are perceived as closely knit together, even though they may be rather spread out in time. Tsur argues that,

> the memory traces of two words considerably apart in time may be fused and perceived as if simultaneously present... such fusion of auditory information may be perceived as if spread over the intervening section of the poetic passage.(Tsur, 1992, pp. 84)

Unfortunately, Tsur does not explicitly address why rhyme (or other poetic devices) have these effects, nor does he offer empirical evidence to support his theory. Why would heightened language trigger the retention of precategorical sonic information? A possible answer to this question lies in the broad cognitive phenomenon of *implicit*

learning[24], which is known to play an important role in the cognition of language (Perruchet and Pacton, 2006; Romberg and Saffran, 2010).

All spoken languages makes use of a finite set of phonemes ($\approx$ in 41 American English dialects). In addition, there are many constraints on the combinations of these phonemes in syllables (Harley, 2006; Kessler and Treiman, 1997). Since the relationship between language sounds and language meaning is for the most part arbitrary (with the exception of onomatopoeia), these phonemes are essentially distributed randomly in any particular utterance.[25] As a result, a certain amount of phonemic repetition is expected to occur by chance. Native speakers of a language have implicit knowledge regarding the likelihood of various phoneme collections (Jusczyk et al., 1993; Vitevitch et al., 1991). Thus, native speakers can implicitly recognize improbable sound patterns. Under normal speech situations, it makes sense for the brain to discard unnecessary sonic information. However, when highly unlikely sonic patterns occur, it is prudent to draw these "fishy" patterns into conscious awareness—to raise a red flag and say "pay attention, there's something going on." Thus, rhymes' perceptual quality may simply be evoked by improbable phonemic repetition.

An implicit statistical explanation of rhyme accounts for many aspects of the usage of rhyme. For one, placing rhyme in predictable locations increases their unlikelihood. For instance, the chance that two consecutive sentences would both contain a word ending with |əp| is not particularly low. However, the chance that two adjacent sentences would both *end* with |əp| is much lower, since the scope of attention (and the probabilistic space) is reduced to only two events. The statistical perspective

[24]Implicit learning is also also known as *statistical learning*.

[25]The use of the word "randomly" here is closer to its usage in statistics than to its colloquial usage.

also offers another perspective on rhyme's "decay time." The longer a time window considered the more likely that phonemic parallelism will occur by chance, lessening the phenomenological impact. Conversely, if events very close together in time share phonemes, this is less likely, increasing the phenomenological impact. Earlier, it was noted that alliteration (in English) typically occurs in a string of adjacent words, as in /Peter Piper picked a peck of pickled peppers/. This constraint on alliteration may reflect the statistical distribution of phonemes in English. Many English syllables begin with the phone |p|—thus, in order for this phoneme to invoke the phenomenological experience of rhyme (without being combined with other phonemes), a large number of proximate syllables must include the phoneme. The use of assonance in rap illustrates a similar situation. Since there are a limited number of vowels, and essentially all syllables contain vowels, natural utterances will frequently repeat vowels. Thus, evoking the experience of rhyme purely through vowels is difficult. Only if a vowel is used often enough, or regularly enough, does it start to sound like a rhyme. For instance, the phrase /he threw the apple back to the girl/ is unlikely to be perceived as containing any rhymes. However, the phrase /Matt whacked the apple back at the cad/—with six stressed repetitions of the |æ| vowel—is likely to evoke assonance. Another approach emcees have adopted for evoke rhyme using only vowels is to create rhyme links that consist of a string of several vowels (with matching stress patterns). For instance, each rhyme in Snoop Dogg's "Beautiful" (2003) consist of the two vowel pattern |u ɪ|, with the first vowel in a stressed syllable and the second unstressed. Other phonemes (consonants) come and go throughout the song, sometimes adding to the rhyme, but the two vowels are the only common element. Some examples of these double-assonant rhymes in the second verse of "Beautiful" are:

/b*oo* sh*i*t : f*oo*l-*i*sh : pur-s*ue* *i*t : m*o*ve *i*t : l*o*se *i*t : m*o*ve *i*n' : cr*u*-s*i*n' : bl*ue* n'/. Alone, the syllables /fool : move/ do not particularly evoke a sense of rhyme—two words sharing the |u| vowel is not particularly remarkable. On the other hand, Snoop repeats the |u ɪ| motive so often that random chance is not a reasonable explanation; As a result, the |u| in /fool : move/ is clearly rhymed.

Rhyme Defined

Having considered some of the rhyme's many complex dimensions, we can now propose an operational definition of "a rhyme."

A rhyme is a relationship between two or more spoken events which are relatively close together in time. A total set of events, such that each event shares the rhyme relationship with at least one other event in the set, is known as a rhyme chain. Each individual event may be referred to as a rhyme or, to avoid confusion, as a link. Each rhyme link consists of one or more stressed syllables which are separated by no other stressed syllables. Unstressed syllables immediately before, after, or between, these stressed syllables may or may not take part in the rhyme relationship. The stress pattern of the two events should match, though exceptions are allowed. In general, each syllable in the rhyme link must match a syllable in another link.

The rhyme relationship itself consists of an ordered, syllable-position matched, set of one or more phonemes, or similar sounding phonemes, which are shared between two (or more) rhyme events. This set of phonemes is referred to as the rhyme's *motive*. The rhyme motive must not make up all the phonemes in the event, as this would constitute complete repetition—at least one syllable must contain at least one phoneme that does not form part of the rhyme motive. The only exception is if the meaning of the repeated utterance is different (i.e. rich rhyme). At least one phoneme

in the rhyme motive must occur in each syllable in the rhyme event. For rhyme to be perceived, the repetition of the rhyme motive must seem improbable due to chance. Whats more, at least two of the events which evince a rhyme relationship (i.e. share a rhyme motive) must occur within a time window no greater than 12–16 seconds. The more phonemes that make up the rhyme motive, the stronger the rhyme. Weak rhyme relationships (with short rhyme motives) must occur relatively close together in time, and include more rhyme links in the time window in order to be perceived. It is possible, even common, for subsections of a rhyme event to occur as independent "sub" rhyme chains, so long as the subsection itself fulfills the requirements for being a rhyme. It is also possible for one or more syllables to simultaneously connect to two different rhyme chains. For instance, the set of words /Peter Piper picked a viper/ contains two rhyme chains: /Peter : Piper : picked/ and /Piper : viper/, with the word /Piper/ independently involved in both chains.

Predictable placement of rhymes in phrases/meter (especially at the end of phrases) will increase the strength of the rhymes. Rhyme relationships are also strengthened by simultaneous prosodic parallelism—whether it be rhythmic, prosodic, or timbral. In artistic context, prosodic parallelism and structural parallelism may occasionally be used to "force" an event to rhyme which might not otherwise (it may be a repeated event, or simply an event which evinces no phonetic parallelism). In other words, an event which clearly doesn't rhyme is delivered as if it does. Non-phonetic parallelism which functions like rhyme will be referred to here as *chyme*. In general, separating the phonetic parallelism of rhyme from prosodic parallelism of chyme may be a fruitless endeavor.

Events which fulfill all these criteria may occasionally not sound like rhymes, while events which violate these criteria do. Different listeners may disagree about what rhymes, and what doesn't. Ultimately, identifying rhyme is always subjective, but the framework outlined here guides the MCFlow rhyme annotation scheme and process (Section 4.2.5 on page 115).

3.2.4 Phrasing

In written poetry, the author directly indicates segmentation by organizing text in *lines* and *stanzas* on the page. As an oral tradition, rap does not explicitly contain an equivalent explicit segmentation. Still, rap typically consists of a series of clearly delineated phrases that are very much akin to poetic lines. The primary feature of flow which delineates these phrases is prosody—as discussed above (Section 3.2.2), pitch intonation and rhythm segment speech into prosodic units. Phrases are typically given additional structure by the presence of rhymes, which are strongly associated with phrase ends (Bradley, 2009, loc. 828). However, there is an additional dimension to rap phrasing: the semantic/syntactic organization of the words. In normal speech, prosodic information is used to clarify and reinforce semantic boundaries. Likewise, in most rap prosodic units coincide clearly with semantic and syntactic units. However, prosodic structure and syntactic/semantic structure can shape utterances separately, and rather than agree they may collide or elide, creating effects similar to poetic *enjambment* (Adams, 2009; Lerdahl, 2001; Woodbury, 1985). Figure 3.10 shows two examples of "enjambment" in rap, wherein the prosodic/musical phrasing does not align with the syntactic/semantic units.

Enjambment is one form of a broader class of phenomenon known as *elision*. Elision occurs when an event is simultaneously connected to preceding events and ensuing events. Enjambment is an example of elision because a spoken event is connected to preceding events in one dimension (perhaps prosody) and to ensuing events in another dimension (perhaps syntax). Other forms of elision also occur in rap flow. For example, consider the syntactic elision in the following line:

> I'm a venereal disease like a menstrual bleed through the pencil and leak on the sheet of the tablet in my mind.
> —Lil' Wayne, from "A Milli" (2008).

the words /menstrual bleed/ at first seem to be a noun phrase ending a syntactic unit. However, as the utterance continues it becomes clear that /bleed/ is being used as a verb and that a syntactic boundary may actually have occurred between /disease/ and /like/. Thus, the syntactic position of the word /bleed/ is ambiguous, which in real-time listening results in a perceived elision.

As mentioned before, prototypical rap flow delivers roughly one phrase per measure of music. However, one-measure phrases often contain two-beat subphrases, or may alternate with genuine two-beat phrases. Cross-rhythmic phrases that don't match any phase of the meter may also occur: Figure 3.11 shows examples of three-♩ and five-♪ phrasing in raps by Biggie Smalls and Jay-Z. However, phrase length is only part of the picture, as phrases can be set against the meter in many ways. For instance, a one-measure phrase may begin as a pickup to beat one and end on beat three, or may begin after beat one and end on beat four. Thus, both phrase length and metric position are variable in rap. Typical raps mix phrases of a variety of lengths and metric placements, both within and between verses/songs.

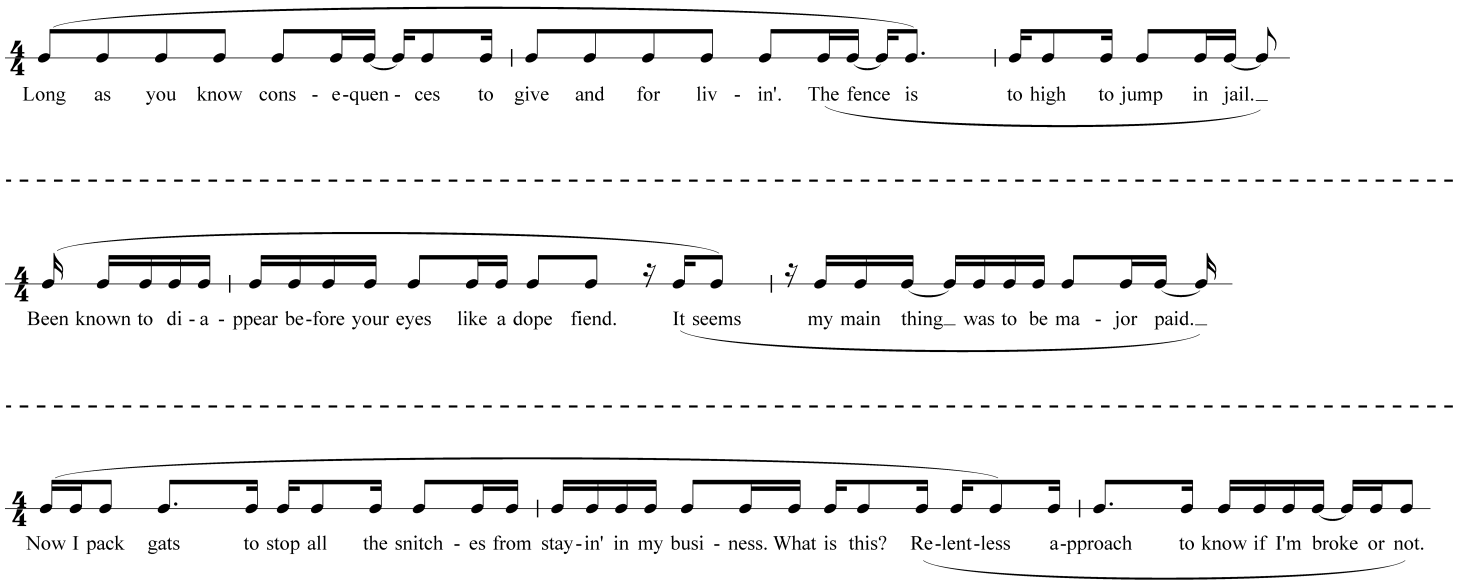

Figure 3.10: Three examples of elision/enjambment in rap flow. The top example is taken from the first verse of OutKast's "B.O.B." (2001)—rapped by Andre 3000 at ≈0:28: Rhyme and rhythmic parallelism connect /the fence is/ to the previous material, and a dropping pitch contour on the /the fence is/ also marks it as an ending. The middle example is from 2Pac's "All Eyez on Me" (1996) at ≈0:56. In this example, the words /it seems/ are somewhat ambiguous as they may apply to the thought before, or the thought after (my interpretation). However, the rhyme connects /seems/ to the material before. As a result, this passage may be interpreted as either enjambment or as syntactic elision. In the third example—from Biggie Small's "Machine Gun Funk" (1994) at ≈1:17—the overall prosodic trajectory and rhyme scheme connects /relentless/ to the previous material.

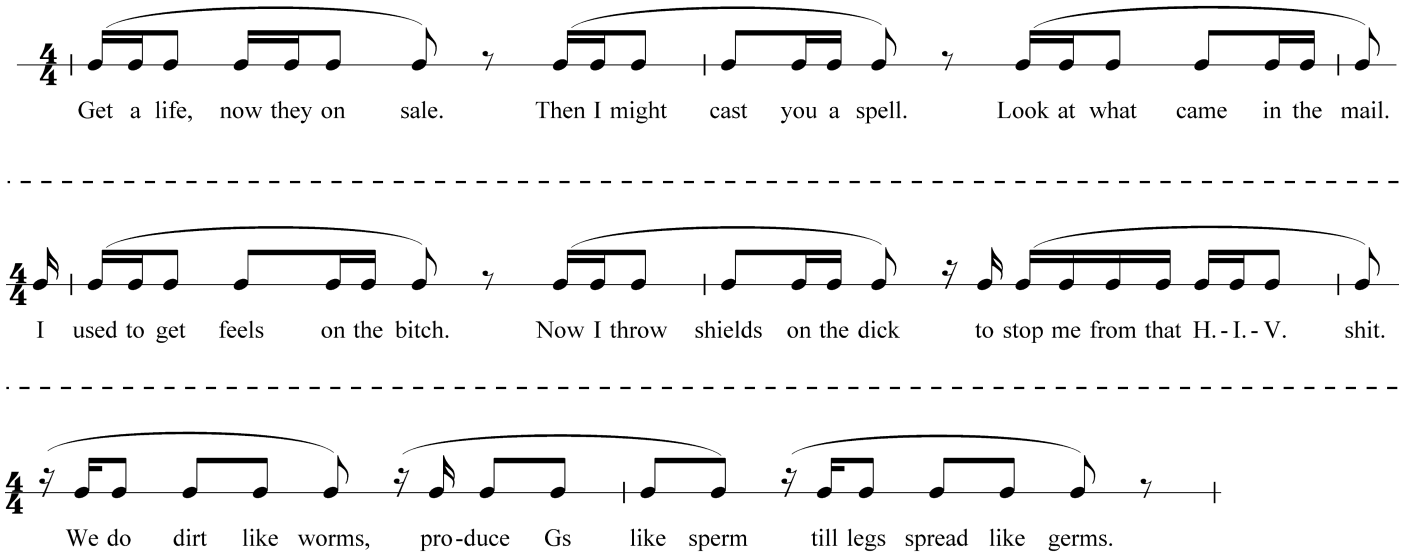

Figure 3.11: Examples of $\frac{3}{4}$ and $\frac{5}{4}$ cross-rhythmic phrasing in rap. The top and middle examples show very similar $\frac{3}{4}$ phrase schemes in the OutKast song "B.O.B." (2001)—rapped by Andre 3000 at ≈0:34—and the Biggie Smalls song "The What" (1994)—rapped at ≈0:11—respectively. The bottom $\frac{5}{4}$ example is excerpted from Jay-Z's "Can't Knock the Hustle" (1996) at ≈2:26.

3.3 Flow's Structure and Artistry

Ultimately, the real question of interest is how the rudimentary elements of flow are organized in time to create an emotionally engaging and aesthetically interesting artistic experience. Though it is hoped that MCFlow will serve as a tool to help develop answers to this question, no attempt to address this question in detail will be made here. Nevertheless, the framework of "flow rudiments" presented in this chapter is necessarily informed by basic intuitions and ideas concerning the artistic organization of these rudiments. Therefore, it is appropriate to include a few basic observations and conjectures about flow's structure and artistry. In the process, we can attempt to identify what the most important questions about rap artistry might be.

The sonic structure of rap flow operates on multiple levels. Near the musical "surface" a variety of syntactic rhythmic techniques (syncopation, cross-rhythm, rhythmic motive, etc.) interact with subsyntactic rhythmic dimensions (articulation, the influence of speech-rhythm, micro-timing) to create an enormous variety of rhythmic textures and gestures. This rhythmic surface is itself multi-layered, with variations in syllable prominence (created by stress, pitch accents, and/or hype) giving the surface a varied rhythmic profile; The rhythmic surface of some emcees' flow can be as artistically engaging as a rock or jazz drum solo. "Higher-level"[26] creativity in flow arises from the interaction between prosodic phrasing, syntactic/semantic segments, rhyme schemes, and the musical meter. Variation in the length and position of phrases, and how various rhythmic layers articulate and interact with phrasing, is essential to rap

[26]Use of terms like "higher" and "lower," or "surface" and "structure," do not reflect judgements of importance or value. Low-level, surface features may be just as important, or more important, to rap flow than high-level structures.

artistry. Rhymes may simply reinforce phrasing in a high-level rhythmic-layer, or may jump across and bridge between phrases. Simultaneously, prosodic units may align or misalign with semantic/syntactic units. Countless arrangements are possible.

As in most art, balancing regularity and predictability with variety and surprise is essential to artistic expression. Bradley observes how "a talented MC creates moments of calculated rhythmic surprise" (Bradley, 2009, loc. 259), by first creating a predicable pattern and then breaking it. Emcees can move their flow back and forth between regularity and variety, or may balance the two in the same moment in different dimensions of their flow. In "the Way I Am" (2000) the same "anapestic" rhythm (♫) dominates the rhythmic surface, yet the length of phrases and syntactic segments, and their relationship to the rhythmic motive, varies throughout the song. In contrast, in the Beastie Boys' "Intergalactic" (1998) the entire song evinces essentially the same phrase scheme, yet surface rhythms in each phrase vary considerably—this arrangement is prototypical in much rap. In general, much rap flow (especially that of the most widely respected emcees) features a huge amount of unpredictability and surprise compared to repetition and predictability. As mentioned before, in this sense rap flow is more like an improvised solo than a typical melody.

Even casual rap listeners will likely observe that emcees' vary in their flow style. In fact, Hirjee and Brown found that they could train a computer to accurately differentiate emcees' flow based on their usage of rhyme (Hirjee and Brown, 2010). However, emcees do not always rap in the same exact style. Emcees shape their flow to fit the expressive intent and mood of songs, and interact with the rhythmic invents in the beat (Adams, 2008). A dark ballad may not be the appropriate place for dense rhyming and puns, whereas an upbeat dance track might call for relatively

fun, simplistic, flow. This raises an interesting question: does flow vary more across songs (within emcees) or across emcees? This question becomes especially interesting because emcees frequently rap together on songs. When Jay-Z and Kanye West rap together on a song, do they each change their flow to match the feel of the song, or do they maintain their own distinct styles? Hirjee and Brown note that when analyzing Biggie Smalls' collaboration with the rap group Bone Thugs-n-Harmony on "Notorious Thugs" (1997) their algorithm categorized Biggie's flow as being in the style of Bone Thugs-n-Harmony (Hirjee and Brown, 2010, p. 136). Thus, Biggie altered his flow style to match that of his featured guests.[27]

In Section 2.2.1 (page 11) it was argued that a significant part of rap's aesthetic value arises from the sonic organization of rap, independent of the lyrics' meaning. This argument does not imply that the lyrical message is irrelevant. It seems likely that in most cases the lyrical message and sonic musicality of rap *both* contribute to the artistic experience, though the relative importance of the two may vary between songs, emcees, and between listeners. What's more, though a major assumption of the dissertation is that lyrical message and sonic musicality *can* be fruitfully discussed independently, the two dimensions likely combine and interact to create an emergent artistic experience that is greater than the sum of its parts. In particular, meaningful language has a clear teleological structure which gives spoken utterances a unique attentional focus: once an utterance is begun, their is a natural tendency for the listener to anticipate the continuation. Thus, even if the lyrics are not interesting, the presence of meaningful syntactic text in rap flow may draw the listeners' attention and constantly demand anticipation and continuation. MCFlow, and this dissertation as a

[27]Biggie's change of style on this track is, in fact, obvious to anyone familiar with his style.

whole, are biased towards study of the non-meaningful sonic organization of rap—this bias is an intentional counterbalance to the huge body of lay, scholarly, and political discussion which focuses solely on rap's message and culture. However, MCFlow transcriptions (described in the next chapter) do encode both sonic information *and* meaningful information. Thus, MCFlow is a resource which can be used to potentially study rap's message, rap's flow, and how they interact.

3.4 Flow Terminology

Table 3.5: Summary of terminology pertinent to the discussion of rap flow music theory.

Behind the Beat	A common "subsyntactic" rhythmic effect, wherein rhythmic events are delivered slightly later than the idealized beat.
Cross-Rhythm	Rhythms which outline a non-duple pulse against the duple meter.
Chyme	Prosodic parallelism which functions like rhyme.
Declination Unit	An overarching prosodic unit create by gradual pitch declination.
Down-tempo flow	Flow rapped over a relatively slow tactus beat, likely to focus on two-beat structures, rather than four-beat structures.
Elision	An overlap, or ambiguous boundary, between rapped segments. Often caused by *enjambment*.
Enjambment	Conflict between syntactic/semantic grouping and prosodic grouping.
Phrase	The primary unit of segmentation in rap, roughly equivalent to a poetic line. Primarily defined by prosody.
Pitch Accent	A pitch extreme which increases the prominence of a syllable.
Prosody	Super-syllabic features of utterances, including pitch, rhythm, timbre, and stress. Used to segment utterances and to create prominences.
Rhyme	A parallel sonic relationship between two or more spoken events.
Rhyme *Chain*	A set of two or more spoken events which rhyme.
Rhyme *Link*	A single spoken event which rhymes, forming part of a rhyme chain.
Rhyme *Decay Time*	The time-window within which two spoken events must occur in order for a rhyme to be perceived.
Rhythmic Layer	An abstract rhythmic stream created from syllables of similar prominence.
Stress	A basic distinction in the prominence of syllables, with lexical and prosodic functions. A basic feature of the "rhythmic shape" of an utterance.
Subsyntactic rhythm	The aspects of rhythm ignored by traditional music notation. Small, subtle, nuances that elaborate the basic syntactic rhythms.
Syntactic rhythm	The aspects of rhythm captured by traditional music notation. Characterized by simple integer relationships between exact durations.
Terminal Shape	A intonational contour (often accompanied by rhythmic emphasis) which marks the ending of a phrase.
Up-tempo flow	Flow rapped over a relatively fast tactus beat, likely to focus on two-measure structures.
Verse	A section in a hip-hop song that contains rapped vocals. A single, continuous, passage of rap.

Chapter 4: The Musical Corpus of Flow

This chapter provides a detailed description of the Musical Corpus of Flow. The sampling methodology and an overview of the music which has so far been sampled will be presented, as well as details of MCFlow transcription encodings.

Before constructing a dataset, it is crucial to consider possible goals of the research the data is meant to afford, as both sampling and encoding decisions will determine the usefulness of the corpus. All encoding decisions were informed by the overview of flow rudiments and structures presented in the previous chapter. However, due to time limitations not all elements of flow could be transcribed, nor could extremely precise measurements of all elements be made. The encoding scheme outlined below (in Section 4.2.1) attempts to capture a reasonable amount of detail about the most important features of rap flow. An example of a complete MCFlow transcription is presented in Appendix C. Of equal importance to encoding, however, is the issue of sampling, which will be considered first.

4.1 Sampling

4.1.1 Sampling Philosophy

A crucial question in any research is sampling: what specific objects do we study? People are naturally most interested in the exceptional music that they as a culture, or as individuals, value most—musical exemplars or "great works." It is thus appropriate that humanist scholars tend to focus their attention on highly esteemed works, seeking to understand the unique, special, features that make these works great and deepen our appreciation of them. However, value and greatness are highly subjective—who decides what is great? Greater objectivity can be achieved by incorporating the opinions of "experts"—for instance, magazines, fan-sites, and blogs offer lists of the "greatest" or "most influential" rappers and songs—but the fundamental issue of subjectivity is not resolved, only attenuated. What's more, there is an even more fundamental problem with focusing research on "great works": by definition, one cannot recognize, or appreciate, the exceptional without reference to the typical. This observation is especially true for music, since individual musical passages and pieces are always understood in terms of a broader musical culture. Listeners experience music in light of a large body of enculturated knowledge that they have gathered from listening to other music. Thus, analyzing a few great works in isolation without a broader comparative context tells us little about the experience of music. Of course, when music theorists analyze individual pieces ("close-reading"), we do implicitly compare specific passages to broader musical norms. However, our intuitive impressions of the broader "norms" are necessarily imprecise. The main appeal of corpus-based research, as opposed to close-reading, is the opportunity to study averages and distributions rather than specific passages. These averages and "norms" are

often interesting in and of themselves, but can also be used as a point of comparison for studying individual pieces. Just as few people are exactly average in height or appearance, few musical pieces are exactly "normal" in all features—each piece offers unique structures, which can best be appreciated if we understand how they differ from the norm. It is also advantageous that this approach mirrors the way people perceive music, with our generalized "enculturated" knowledge shaping our experience of any particular piece of music as it unfolds in time.

Identifying and analyzing "the typical" raises its own difficulties. How does one identify the typical? No single work will ever be totally typical in all dimensions. Rather the typical must be generalized from a large body of pieces. Furthermore, there is rarely one exact prototypical form of an artistic structure, but rather some variety of relatively common forms, a greater variety of relatively uncommon forms, a variety of somewhat rare forms, a large body of truly rare forms, etc. Many empirical research methodologies are designed to tackle the analysis of the "typical" and all its variations. In particular, empirical work relies on *inferential statistics* to make generalizable inferences about the norms of complex, variable objects. Careful sampling is crucial to statistical methodology. The logic of statistical inference is that one can make generalizable observations about a "population" of "objects," by analyzing a randomly sampled subset of the "population." Regarding the study of rap, we might seek to generalize about the "population" of, say, every rapped syllable ever recorded, by *randomly* sampling examples of recorded rap syllables. Explicitly modeling randomness is central to statistical modeling, and random sampling is crucial to the project. In contrast, information gleaned from nonrandom samples may or may not be relevant to objects outside of the sample.

Unfortunately, applying statistical/scientific research methodologies to music is not a simple matter. First of all, it is difficult (if not impossible) to achieve randomness in practice, calling into question the validity of statistical generalizations. Often, practicalities limit our sampling choices; for instance, we couldn't possibly sample from the population of "every rapped syllable ever recorded" because only a small, non-random, subset of this population is conceivably available to us. Second, it is not really clear what the "population" we're interested is, nor what the "objects" that make up this population are. Every measure of rap ever recorded? Or perhaps only professionally recorded songs? Every song? Every syllable? Given our humanistic interests, maybe the population we should aim to represent is the population of *great rap* songs.

Creating a logical sampling procedure with clear goals that balances the conflicting aims of empirical and humanistic research is difficult. The sampling plan outlined in the following sections attempts to do so, though it is certainly biased towards an empirical/statistical approach. Sampling decisions are especially difficult because MCFlow is not intended to support any specific hypotheses, but rather to serve as a general tool for a variety of research. This requires compromise between different sampling criteria. Ultimately, as is often the case in real research, practical constraints and simple convenience shaped sampling decisions just as much as *a priori* theory. MCFlow has been a long term project, and elements of the sampling plan have actually evolved over time.

4.1.2 Sampling Units

The first sampling step is to identify the type of "object" that will be sampled. Possible units of rap flow include (from largest to smallest): artists, albums, songs, verses, measures, or syllables. Smaller units result in more independent data which is ideal for statistical analysis (most statistical models assume data independence). However, small units may not realistically be treated as independent: for example, rap music is not experienced as series of independent syllables—the meaning and function of each syllable depends on the context. Thus, in order to facilitate a wide variety of realistic musical analyses the sampling unit must by large enough to encapsulate any significant musical relationships. With these concerns in mind, an object of intermediate scope—the song—was selected as the sampling unit. Events within songs are likely to influence and relate to each other—for instance, a rhythmic idea introduced at the beginning of a song might return at the end of the song. On the other hand, dependence across songs seems to be limited in rap—i.e. musical ideas aren't often shared across songs. Of course, one major source of data dependence does exist at the supra-song level: the emcee; It seems likely that two songs by the same emcee are more likely to share musical structures than two songs by different emcees. Still, this high-level dependence is relatively simple to incorporate into statistical models.

Specifically, the objects targeted for sampling in MCFlow are songs by artists that are primarily identified as hip-hop/rap artists, which feature at least one verse of rap. Only rapped portions of these songs are transcribed in MCFlow. Determining what is, or isn't rap, is usually simple—most songs by hip-hop/rap artists feature clearly delineated "true rap" verses. However, in some cases identifying rap can be subjective:

for instance, some might argue the autotune in Lil' Wayne's "Lollipop" discounts it as rap. Generally, the observations and ideas discussed in Section 2.2.3 (page 21) shaped the decisions regarding what constitutes rap, and what does not. Fortunately, the vast majority of sampled songs contain material that is not ambiguous regarding its status as rap. Most "true rap" in hip-hop songs occur in sections which are clearly "verses" (as defined in Section 3.1.2). However, occasionally passages of rap occur in sections that would better be described as "bridges" or "breakdowns." All rapped vocals in sampled songs are transcribed regardless of their formal location.

Another issue regarding sampling dependence arose during the transcription process. As pointed out in Section 3.1.2 (page 34), most rap verses are through-composed with very little exact repetition. However, very rarely emcees do repeat significant passages of rap—this is most common in non-verse sections (like bridges) but also occurs in some verses. On the one hand, repeats represent completely dependent data which is essentially redundant, suggesting that they should be ignored. On the other hand, these repeats are genuine parts of the listening experience. The same issue arises in studying any type of music with repeats: if one wished to perform a corpus study of modulation schemes in sonata-from symphonies, would one count repeated expositions in your tallies? Whether to include repeated passages in transcriptions was decided on a somewhat ad-hoc basis, based on the intuitions of the transcriber. For example, the last verse[28] of Lil' Wayne's "Love Me" (2013) consists of four-measures of rap that are then repeated exactly—only these four measures were sampled. In contrast, the last verse of Kriss Kross' "Jump" (1993) includes two

[28]This section might be better considered a bridge.

one-measure patterns that are each repeated four times—in this case, the repeated measures were all fully transcribed.

4.1.3 Sampling Goals

In the introduction it was stated that MCFlow is meant to afford research regarding the psychologically and aesthetics of rap listening. Thus, the sampling scheme for MCFlow targets rap consumption rather than rap production. The use of a musical corpus as a tool for understanding the psychology of rap listening is motivated by the implicit/statistical learning hypothesis: the theory that listeners' experience of music is shaped by statistical regularities and patterns they've implicitly extracted from previous musical listening experiences. This theory suggests that statistical regularities observed in a corpus which mirrors the listening experience of an "typical" listener may reflect the implicit knowledge that underlies typical listeners' musical experiences. Though sampling directly from the population of "typical listening experiences" is impossible, this population may be adequately approximated by sampling the most widely listened to rap. Thus, a sample of the most widely listened to rap should roughly represent the "norms" of rap experienced by typical listeners. Since people (presumably) listen to music they buy, commercial sales ought to approximately reflect the music that is heard the most. Following this chain of logic, the MCFlow sampling scheme seeks to represent the population of "rap listening experiences" using domestic US sales of commercially recorded, English-language, rap music. Another positive aspect of sampling by commercial success is that commercial success does not reflect the biases or opinions of a single individual but rather the collective choices of millions of consumers. By targeting consumption the judgement of

quality is deferred to the population of rap listeners: commercial success presumably indicates a certain level of artistic success, which may correlate with "greatness."

Commercial success is operationalized using charting position on the Billboard *Hot 100*. The Billboard chart is intended to represent the most widely listened to music, thus forms a reasonable basis for a representative sample of rap consumption. However, the use of the Billboard chart, of course, has several issues. In particular the *Hot 100* only represents songs released as singles, which may differ systematically from album tracks, resulting in a distorted representation of the target population. Unfortunately, the proportion of consumers' time spent listening to singles compared to album tracks is unknown. The *Hot 100* is also not a direct measurement of record sales but of the relative sales within a given week—a record which sold gradually for many years might never enter the chart.

Sampling from the most popular hip-hop singles may serve as an adequate representation of the "norms" of rap heard by typical listeners. However, to make MCFlow a more valuable resource for a wider range of possible research, it is pertinent to consider other sampling criteria. Two goals which might particularly interest researchers are: (1) artist comparison (especially of "great" artists) and (2) historical trends. Thus, these two criteria were incorporated into the sampling scheme. Historical trends can easily be incorporated by targeting the most successful rap by year. In fact, the weekly nature of Billboard *Hot 100* favors such an approach, as the exact week of commercial peak can be identified. Comparison of artists is more difficult to reconcile with the plan outlined above as it necessitates sampling of multiple songs from the same artist. Specifically, it was estimated that a sample of five songs from

each emcee would be necessary to accommodate reasonably precise comparisons of emcees' styles.

4.1.4 Sampling Scheme

Billboard data was collected via the site bullfrogspond.com.[29] This data contained some errors in terms of genre indications: many songs had no genre indication while others were clearly mislabeled (e.g. many R&B acts were labelled as Rap).[30] These errors were corrected through a combination of automated and manual error checking. Some errors certainly remain but are likely not egregious. The corrected dataset includes a total of 1,314 hip-hop songs that peaked on the *Hot 100* chart between January 1980 and March 2015 (Figure 2.1 on page 9). At the time of access, data for the year 2015 was incomplete, so MCFlow sampling was restricted to the years 1980–2014.

Even limited to the Billboard *Hot 100* data there are multiple ways to operationalize charting success—peak position, time on chart, time in Top 40, etc.. Songs with the highest peak position (the lowest number) were targeted, with the number of weeks spent in the Top 40 as a tie-breaker. Using this measure, the top five songs from each year were selected, creating a Yearly-Top-5 sample target. Songs were sampled by the year that they peaked, which was not necessarily the year the song was released or entered the chart. If you consider Figure 2.1 (page 9) a problem with this sampling strategy is evident: only 10 hip-hop singles appeared on the *Hot 100* before 1987. Thus, the earliest years of hip-hop (especially 1980–1986) are underrepresented

[29]This site has since closed

[30]It is not clear if these genre errors are unique to the bullfrogspond dataset, or if they are present in the original Billboard data.

in the Yearly-Top-5. This represents a significant hindrance to historical comparison, especially regarding the oldschool/newschool rap distinction. To ameliorate this issue, all additional songs that charted before 1990 (in the years 1987–1989) were added to the sample, adding more sample weight relatively early in hip-hop history. This created a new Yearly-Top-5+Oldschool sample target, containing a total of 168 targeted songs. To better represent the very earliest hip-hop it will be necessary (in future work) to reference a source other than the Billboard *Hot 100*.

The Yearly-Top-5+Oldschool sample contains works by 73 artists. However, most artists (38) appeared only once in the sample. Recall that in order to make meaningful comparisons between the styles of different emcees it was estimated that at least five songs from each each would be required. Fortunately, nine artists already appeared five or more times in the sample. However, to better support artist comparison research, additional "great" artists were targeted for extra sampling. Returning to the complete Billboard dataset, hip-hop artists were ranked by their number of singles on the chart, with time in the Top 40 again used as a tie-breaker. Based on this ranking the top thirty artists were selected. All nine artists who appear five or more times in the Yearly-Top-5+Oldschool sample also appear in this Top-30 list. Songs released by individual members from rap groups, such as the Fugees' Lauryn Hill and Wyclef Jean, are counted together with the group. In addition, two additional artists who first achieved commercial success before 1990 were targeted: the Beastie Boys and Run D.M.C.. The resulting target of thirty-two successful artists are listed in Table 4.1 from most successful to least.[31] As a secondary sampling goal, five additional

[31]Note that the operationalization of "success" here is consistent with the sampling goals. Given the previously noted assumptions regarding rap consumption, these thirty-two artists reasonably represent the most widely listened to emcees.

top songs from each of the additional 32 artists were targeted. In the initial stages of the MCFlow project, these additional songs were sampled from the Top 32 artists on a somewhat *as hoc* basis. Generally, Top-32 artists' highest peaking *Hot 100* songs, or most popular songs in given years, were sampled. However, eventually a more concrete sampling scheme was chosen: each Top-32 artists' five most popular unique songs which did no already appear in the Yearly-Top-5+Oldschool sample were targeted. This brings the total sampling target to a total of 252 songs. The list of all songs in the target sample is presented in Appendix A.

4.1.5 Current Sample

At the time of writing, the total sampling target has not yet been reached. Nevertheless, a significant amount of data has already been encoded. This includes complete transcriptions of 124 songs by 47 artists, comprising a total of 374 verses[32] and consisting of 6,107 measures of music. These measures contain 54,248 words (66,034 syllables). The songs that have been transcribed so far are listed in Appendix B. Ten of the forty-seven artists are actually groups with two or more members; for instance, OutKast consists of the emcees Big Boi and Andre 3000. In addition, seventeen songs include featured emcees. As a result, the sample actually includes performances from a total of 86 emcees.[33] Figure 4.1 shows the proportion of measures in the corpus rapped by each emcee. Dashed pie wedges indicate the thirty-two emcees deemed highly successful (listed in Table 4.1): they make up 59% of the measures in the corpus. Figure 4.2 shows the proportion of measures in the current corpus by year.

[32]Of the 124 songs, 84 contain three verses, 17 contain two verses, 16 contain three verses, 5 contain five verses, and 1 each contain seven and ten verses.

[33]However, samples from several of these 86 emcees are extremely small.

Table 4.1: The thirty-two most "successful" emcees on Billboard's *Hot 100*

Artist	# singles	Top 40 Time (weeks)	# in yearly Top 5	Charting Years
Jay-Z	52	335	4	1996–2014
Eminem	43	305	10	1999–2014
Lil Wayne	42	231	3	2000–2014
T.I.	33	173	3	2003–2014
Kanye West	31	268	6	2004–2015
Nelly	27	272	7	2000–2013
Ludacris	26	231	3	2000–2013
50 Cent	25	195	5	2003–2012
LL Cool J	25	157	7	1987–2008
Pitbull	24	226	5	2004–2015
Snoop Dogg	21	137	2	1994–2012
2Pac	20	102	1	1993–2005
Busta Rhymes	17	105	1	1996–2014
Bow Wow	17	102	0	2000–2011
the Black Eyed Peas	16	290	6	2001–2011
Will Smith	16	145	7	1988–2005
OutKast	15	140	3	1994–2006
Rick Ross	15	20	0	2006–2014
the Notorious B.I.G.	14	113	4	1994–2006
the Fugees	14	88	1	1994–2008
Fabolous	13	136	0	2001–2013
Nas	13	30	0	1994–2007
Puff Daddy	12	155	6	1997–2002
Ja Rule	12	140	3	1999–2005
Fat Joe	12	75	1	1993–2012
Young Jeezy	12	52	0	2005–2013
Salt 'n Pepa	11	103	3	1988–1998
Wiz Khalifa	11	51	1	2011–2015
DMX	11	12	0	1998–2003
Missy Elliott	10	100	1	1999–2015
M.C. Hammer	10	72	5	1990–1994
the Beastie Boys	7	22	3	1987–2009
Run D.M.C.	5	27	4	1986–1993

It may be of interest to observe some basic demographic information about the artists whose work is represented in the sample. Only six of the 86 emcees are women (7%). Though the self-identified race/ethnicity of the emcees is not known, according to Wikipedia's biographical descriptions the 86 emcees include: 74 African-Americans, 7 White-Americans, 2 Latin-Americans, 1 Filipino-American and 1 African-European. Birth dates for twelve of the 86 emcees could not be determined, but the 74 remaining emcees were born between 1956 and 1988, with half born in the decade between 1967 and 1977. All but four emcees in the sample are still alive, as of April 22, 2016.

Official studio-recorded single versions of songs were accessed via YouTube in order to make transcriptions. Due to rap's frequent use of offensive lyrics, censored—"clean"—versions of many songs exist. In some cases, radio stations or record companies censor lyrics by muting or "bleeping" offensive words, not necessarily with the supervision or approval of the artist. In other cases, emcees themselves write and record clean versions of songs using alternate wording. The available Billboard dataset does not indicate which version of songs (clean or "dirty") are purchased more. Thus, a data-driven decision could not be made. The chosen approach was to transcribe the "dirty" versions of recordings because they represent the uncensored artistic intent of the artist.

4.2 Coding

4.2.1 Symbolic Encoding and Human Annotation

MCFlow is a corpus of *symbolic* encodings of rap, created through human annotation (i.e. transcriptions). It is pertinent to discuss the advantages and disadvantages

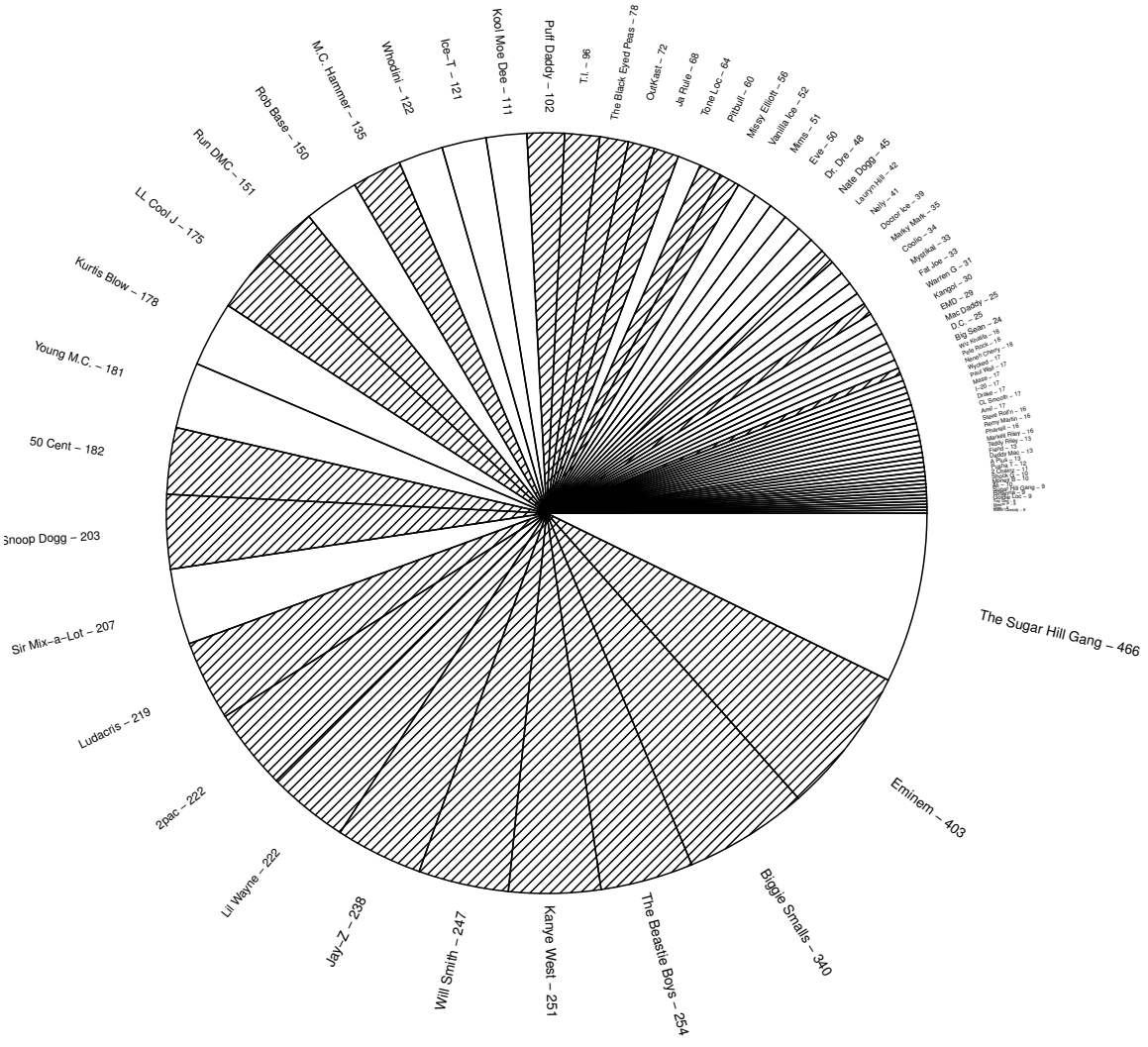

Figure 4.1: Proportion of measures in current sample by emcee (indicated by size of pie wedges). The total number of measures from each emcee are printed next to their names. Shaded wedges indicate emcees in the Top-32 list.

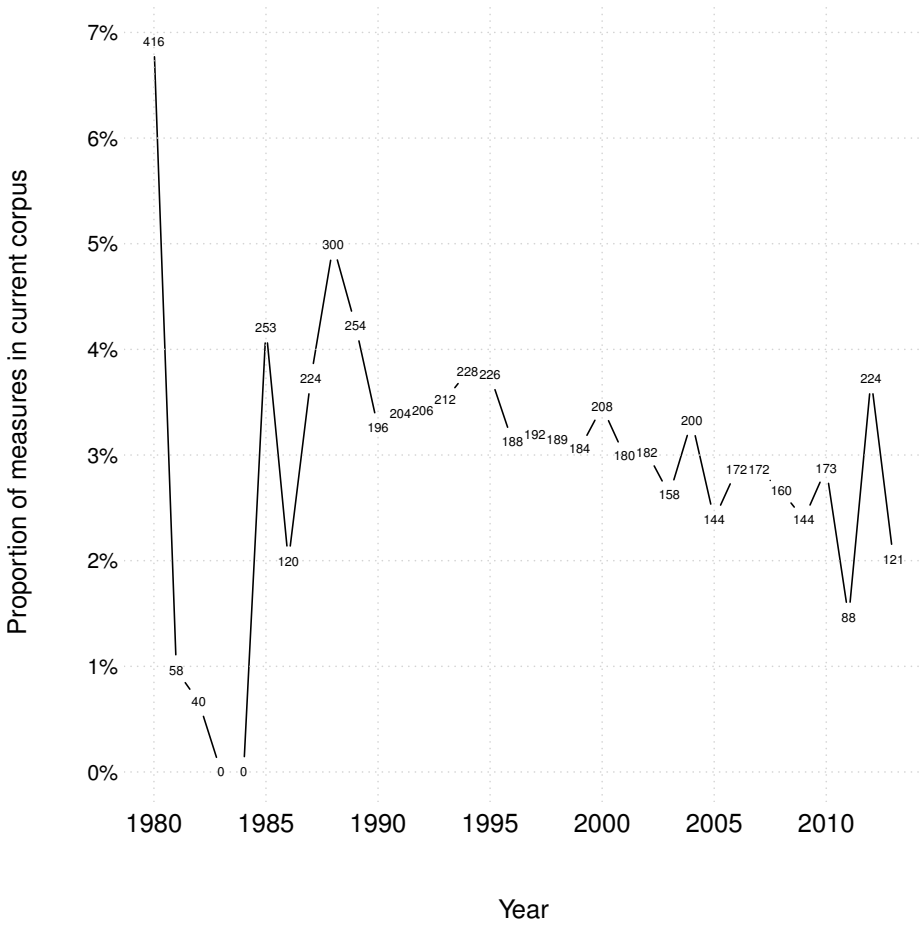

Figure 4.2: Proportion of measures in current sample by year. Height on y-axis indicates proportion of corpus. Numbers at each point indicate total number of measures.

of manual symbolic encoding compared to automated acoustic analysis. After all, the raw acoustic signal is what listeners actually hear—why would researchers wish to study a symbolic corpus rather than the sound itself? As stated in the introduction, MCFlow is intended to serve as a resource for studying the psychological experience of rap listening. However, human perception involves complex processing of acoustic signals, the precise nature of which is not well understood. This includes many complex processes, including: event identification, grouping and segmentation, auditory scene analysis, feature extraction, and categorization. "High-level" features of the perceptual experience—expectations, enjoyment, emotional expression, etc.—are thus very far removed from the acoustic signal. Though researchers have made extraordinary headway in understanding and approximating these processes, much work needs be done before even basic, low-level, perceptual processes can be reliably replicated through computer analysis. Automatically extracting accurate representations—i.e. that are faithful to the experience of listeners—of the rudimentary elements of rap flow presented in Chapter 3 is not yet feasible.

Since understanding the human perceptual experience is the goal, using the human perceptual system itself to extract and categorize features is entirely appropriate. The greatest disadvantage is that this process is labor intensive, limiting the amount of material that can be studied. However, there are other legitimate concerns about manual encoding as well: human transcription will almost certainly introduce human error (stochastic) and human bias (not stochastic). A key assumption is that, through thoughtful introspection, analysts can consciously reproduce the feature processing that they normally perform subconsciously. However, this is clearly not always true: our own conscious ideas, theories, and value judgements may lead us to analytical

interpretations which are not faithful to our "natural," intuitive, experience. What's more, the personal intuitions of the analyst may not reflect other listeners' experiences.

A symbolic transcription is never more than a simplified model of the true performance. The process of transcription is essentially a form of analysis, which inevitably discards information which is present in the acoustic signal. This includes discarding details considered unimportant or irrelevant to the immediate goals and discretizing complex continuous, multi-dimensional, phenomena into a finite set of categories, represented symbolically. This analytical reduction makes analysis of lower-level structures impossible using the transcription, and also makes analysis of all higher-level structures dependent on the assumptions of the coding process. For example, as mentioned earlier, I assume throughout this dissertation that *some important part* of the perception and enjoyment of rhythm in music arises solely at what Prögler calls the "syntactic" level of rhythm—ignoring rhythmic nuances (1995)—and MCFlow rhythmic transcriptions reflect this assumption. However, this assumption may be flawed: what if the way people experience and enjoy rhythm in music actually involves a more holistic processing of all the details of rhythm? If this were true, it would be essential to encode lower-level rhythmic information, such as the time in milliseconds between syllable centers. But what if syllables aren't really perceived as instantaneous events but as complex events that unfold over time? In this case, we might encode the onset, offset, and peak volume of each syllable, or the exact timing in milliseconds of each consonant in the syllable. However, even these measurements might not be detailed enough. If we cannot agree on any basic assumptions about the perceptual process we must return to analyzing the raw acoustic signal, losing the advantages

of symbolic transcription all together (but not really resolving any fundamental issues). Ultimately, we must acknowledge that symbolic encoding requires subjective assumptions based on our own intuitions. The best we can do is clearly state these assumptions and our reasoning in arriving at them. The theoretical assumptions and intuitions presented in detail Chapter 3 shaped the MCFlow transcriptions process. The legitimacy of the project rests on the presumption that the author's encoding choices capture some useful information about the music, and that this information is somewhat analogous to the natural feature processing that occurs in listeners' minds.

4.2.2 Humdrum syntax

MCFlow transcriptions conform to the Humdrum syntax (Huron, 1999). Each transcription is encoded in a single unicode text file. Musical time is encoded in data *records* (text-file lines) ordinally, with later events below earlier events. The syllable is considered the basic coding unit, with each syllable occupying one record. Seven humdrum *spines* (tab-delimited columns) are used to encode the details of each syllable in the lead vocal of the rap. One additional spine encodes any additional rapped voices (e.g. hype) in the recording—although in less detail. The specific way data is encoded in a humdrum spine is known as a *representation*; the most commonly used Humdrum representation is **kern. The eight spines in MCFlow transcriptions each use their own original data representation, though two of them (**recipx and **lyrics) are closely modeled on existing humdrum representations (**recip and **silbe respectively). The eight data representations in each MCFlow transcription, and what they encode, are presented in Table 4.2. The following sections will describe the encoding format, and transcription process, of each representation.

Table 4.2: Overview of Humdrum representations in MCFlow transcriptions.

**recipx	Rhythm.
**stress	Syllable stress.
**tone	Pitch intonation (peaks, nadirs, glides, and parallelism).
**break	Prosodic boundaries.
**rhyme	Locations of, and relationships between, rhymed syllables.
**ipa	Pronunciation.
**lyrics	English text, with semantic and syntactic boundaries.
**hype	Hype (extra vocal parts).

4.2.3 Prosody

Four data spines in each MCFlow transcription encode prosodic information: The **recipx spine, **stress spine, **tone spine, and **break spine. These four spines only capture a very limited amount of the complexities of prosody in rap. Most notably, no information on timbral quality is encoded. Two of the prosodic spines in MCFlow (**tone and **break) are inspired by elements of the Tone-and-Break Index (ToBI) transcription system[34], specifically ToBI's "Tone tier" and "Break tier." Full implementation of the ToBI scheme is not possible because recordings of isolated rap vocals are not available for all songs. As a result, the prosodic information encoded in MCFlow is less precise than would be found in a conventional ToBI analysis. Whats more, since rap flow often features artistic violations and exaggerations of normal speech prosody, consistent application of the standardized ToBI scheme is not always feasible.

[34]ToBI is "a scheme for transcribing intonation and accent in English" developed by linguists at Ohio State University (Beckman et al., 2005).

Rhythm

Rhythms in MCFlow are transcribed according to the musical judgement of the author, quantized to the nearest 16th, triplet-16th, or 32nd note as appropriate. Passages which lag "behind the beat," and other examples of systematic micro-timing, are normalized so that they are transcribed on the beat. Thus, as discussed in Section 3.2.1 (page 39), MCFlow transcriptions only encode rhythm at the syntactic level. This means that MCFlow is not suitable for analysis of rhythmic nuance or fine rhythmic details in rap. Unfortunately, the ubiquity of subsyntactic rhythmic nuance in rap introduces a good deal of subjectivity into the encoding process. Describing James Brown's music, Danielsen notes rhythmic attacks "which arrive a little before, yet almost on, the fourth beat. . . ambivalent [such that they] could possibly be both on and off" (2006, p. 78). In this kind of rhythmic environment associating a particular syllable with a particular metric position can be difficult. Accordingly, all rhythmic analyses conducted with MCFlow should be treated with a grain of salt.

Rhythms in MCFlow are encoded in an adaptation of Humdrum's native "reciprocal" duration system. Humdrum's reciprocal duration system (**recip) is based on traditional music notation, wherein durations are understood as fractions of a complete $\frac{4}{4}$ measure. For instance, in **recip the data token /8/ refers to $\frac{1}{8}$ of a measure (♪). As in traditional notation, a dot after a duration token indicates that the duration is lengthen by 50%, while two dots indicate a lengthening of 75%. This duration system is laudably faithful to traditional music notation. However, rap is not a notated genre so faithfulness to music notation conventions is not necessary. In fact, the native humdrum **recip representation of rhythm carries with it one feature of traditional music notation which is not ideal: the need to use two or more separate

noteheads which are "tied" together to represent a single musical event. The use of tied notes in traditional notation occurs for two reasons: (1) to encode durations that cannot be represented as whole-number reciprocals—for instance, a duration of five 𝅘𝅥𝅯; (2) to indicate where durations cross points in the metric hierarchy, especially the downbeats represented by barlines. MCFlow encodes rhythmic durations in an adaptation of **recip labelled **recipx, in which every syllable can be encoded in a single data record without the need for ties. Since the numbers in **recip represent fractions, **recipx simply allows complex fractions using the symbol %, as in /16%5/[35]: for example, the **recipx duration token /16%5/ represents the fraction $\frac{1}{\frac{16}{5}}$, which is equivalent to the duration of five 𝅘𝅥𝅯. Using this system any duration can be coded—some examples of complex fractional durations are illustrated in Figure 4.3. In **recipx encodings, durations are also allowed to cross any metric position, including downbeats, resulting in durations that "spill" across barlines: The coding of meter-indifferent durations is illustrated in Figure 4.4. This coding scheme is highly problematic for human reading but simplifies analysis and is more true to the oral (as opposed to written) music. Base Humdrum functions do not recognize the special features of **recipx duration data. Several modifications of base Humdrum commands (*timebasex*, *durx*) are included in the MCFlow package which do understand **recipx, described in Appendix D.

As in standard **recip, rhythmic encodings in MCFlow **recipx encodings represent syllable durations, not simply inter-onset-times. Accordingly, rests are encoded as well. Rest durations are recorded in the **recipx spine like any other duration,

[35]This complex-fraction approach was suggested to me by Craig Sapp at Stanford University's Center for Computer Assisted Research in the Humanities.

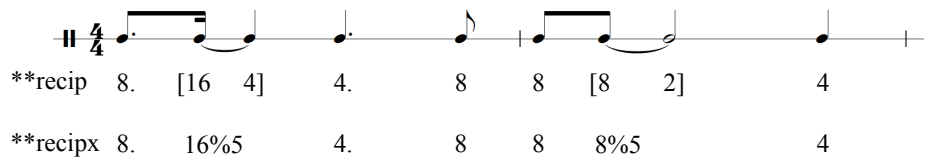

Figure 4.3: Illustration of complex-fraction duration tokens in **recipx.

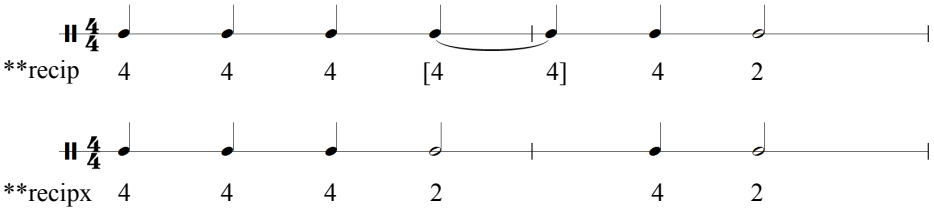

Figure 4.4: Illustration of meter-insensitive duration tokens in **recipx.

with an /R/ in the **ipa spine to indicate the rest.[36] However, consistent with common practice in music notation, only very explicit silences are encoded as rests. More precise durational information, such as traditional staccato marks, are not included, nor is articulative information.

Stress

MCFlow transcriptions encode two levels of syllable stress in the **stress spine: stressed (coded 1) or unstressed (coded 0). Stressed and unstressed syllables were labeled manually by the encoder. Generally stress can be predicted quite accurately by the following features: loudness (stressed syllables are louder); duration (stressed syllables have longer durations); pitch accents (only occur on stressed syllables); and

[36] /R/ is used in place of **kern's normal /r/ since /r/ can also be a IPA symbol

vowel reduction (indicates unstressed syllable). What's more, there is a strong tendency in English for stress and unstressed syllables to alternate. As a result, a simply algorithm might be used to automatically encode syllable stress—this is the approach taken by Mitch Ohriner in his transcriptions of rap (Personal communication, November 2015). For instance, stressed syllables in multi-syllable words can be automatically identified using using a pronunciation dictionary, while stressed syllable in strings of single-syllable words can be assumed to occur on longer syllables, or syllables placed on stronger beats. However, though emcees usually pronounce multi-syllabic words with their standard stress patterns, they do occasionally mis-stress words in order to fit a desired rhythmic pattern or create a rhyme. An automated stress algorithm would likely miss such rule violations.

Pitch accents—which are encoded in the **tone spine—can combine with syllable stress to encode finer distinctions in syllable prominence. Though the author sought to differentiate basic stress from pitch accent (encoded in the **tone spine) it can be difficult not to conflate the two. Ultimately, the goal of the **stress spine is to faithfully capture the rhythmic "shape" of rap utterances, especially identifying unstressed syllables which are relatively unimportant parts of the rhythmic surface, as discussed in Section 3.2.2 on page 45.

Pitch

Limited pitch intonation information is included in the MCFlow **tone spine. As mentioned before, the **tone spine is inspired by features of the ToBI "Tone-tier" (Beckman et al., 2005). Like the ToBI Tone-tier, **tone is primarily used to label *pitch accents* and pitch contours that indicate prosodic boundaries—known in ToBI as "boundary tones." Pitch accents are typically created by local peaks (less often

Table 4.3: Key to data tokens in **tone interpretation.

Symbol	*Meaning*
+	Local pitch peak
_	Local pitch nadir
-	Local "average" pitch
/	Pitch glide up
\	Pitch glide down
^	Overall increase in pitch register
v	Overall decline in pitch register

nadirs) which emphasize particular syllables. The typical terminal shape in rap is a drop in pitch on, or after, the last accented syllable in a phrase. Return to Figure 3.9 on page 49 to see prototypical examples of pitch accents and terminal shapes in the F0 contour of a rap performance.

The **tone/ToBI coding for pitch accents and terminal shapes are illustrated in Table 4.3. The symbols /+/ and /_/ (underscore) are used to indicate local pitch peaks and nadirs respectively—/+/ usually as an accent, /_/ usually as a boundary tone. In addition, forward-slash and backslash symbols are used to indicate pitch glides up or down respectively. Prosodic shapes which involve multiple syllables can be grouped using parentheses—for instance, a common two-syllable contour is /(_)/. In some cases, a multi-syllable contour may contrast one or more pitch extremes with a middle-range pitch; in these cases the /-/ symbol is used to explicitly represent a middle-range pitch. Two additional symbols /v/ and /^/ are used to encode overall changes in pitch register. These may occur within a phrase, but more often occur between phrases.

Aside from the basic set of pitch data tokens described above, **tone also encodes two other intonational features when appropriate: (1) actual "musical" pitches and (2) intonational parallelism or "chyme." In cases where musical pitch is incorporated into flow ("pitched rap" or just plain singing) **kern-style pitch encodings can simply be included in the **tone spine. Unfortunately, the current corpus contains almost no musically pitched material within the rapped verses. As discussed in Section 3.2.3 (page 69), even when not rapping or singing "musical" pitches, emcees frequently repeat prosodic "motives" that function much like rhyme, which I call chyme. The **tone spine can be used to encode important chymes in the flow using the **rhyme rhyme-encoding scheme, described below. The main goal is to identify which groups of syllables share a recognizable intonational parallelism. The roman-letters and parentheses of the rhyme/chyme encoding scheme can be combined with the standard **tone data tokens. For example, two syllables marked with /+/ in the **tone spine would simply indicate pitch accents on those syllables. However, if the two syllables were each marked /A+/, this would indicate not only that the two syllables received pitch accents, but that the two pitch accents are recognizably the same (the same pitch, the same contour, etc.). Multi-syllabic rhymes are generally accompanied by multi-syllabic chyme. Thus, marking parallelism in the **rhyme and **tone scheme is often redundant. In general, intonational chyme is only marked when not accompanied by rhyme.

Prosodic boundaries

The final prosodic spine in MCFlow transcriptions is the **break spine. The **break spine parallels the ToBI Break-index tier, encoding the perceived disjuncture between consecutive syllables. Thus, the **break spine serves as the primary marker

of prosodic phrase boundaries in MCFlow (**tone also encodes some boundary information). Disjunctures, *breaks*, between syllables are created by a variety of prosodic features, including rhythm, stress, and pitch. Notably, the presence of a rest is often a cue to a break. Since, the **tone spine records pitch patterns which indicate prosodic boundaries, the **break spine is somewhat redundant with the **tone spine—an intentional feature of the ToBI system. However, due to the musical nature of rap, the redundancy/accord between the **break and **tone spines in MCFlow transcriptions is not as clear cut as that between the corresponding tiers in an ToBI transcription.

The data tokens in **break are identical to the tokens used in ToBI Break-tiers (see Table 4.4): Numbers from 0–5 to are used to mark boundaries of increasing strength. Each syllable's token encodes that syllable's disjuncture with the previous syllable. Thus, boundary tokens mark the first syllable of new prosodic phrases. A /4/ token indicates the conclusion of a complete declination unit (an "intonation group" in ToBI). A /3/ indicates a significant prosodic boundary, indicated by a boundary tone, which nonetheless does not completely end a declination unit, but is rather part of a larger overall unit (an "intermediate group" in ToBI). In most rap /3/ marks the principle phrases, while /4/ marks 'supra-phrase' groups. A /2/ token indicates sub-phrase boundary, created either by rhythmic disjuncture (a rest or a relatively long duration) with no intonational boundary, or vice versa. A /1/ indicates a "normal" syllable boundary, and since this is the assumed default boundary, /1/ tokens are generally not actually included in transcriptions. Finally, a /0/ token indicates a weak, or ambiguous syllable boundary, where it is difficult to determine if one or two syllables are being rapped; for example, words like /little/ and /fire/ are often spoken in such a manner that it's difficult to say if they are one or two

Table 4.4: Key to data tokens in **break interpretation. Based on the ToBI Break-tier.

Symbol	*Meaning*	*Explanation*
0	weak syllable boundary.	
1	normal syllable boundary	Default boundary, not explicitly encoded in transcriptions.
2	Sub-phrase boundary	Intonation boundary without rhythmic break, or vice versa.
3	Phrase boundary	Sub-declination unit.
4	Hyper-phrase boundary	Complete declination unit.

syllables. MCFlow, like ToBI, does not contain annotations regarding lower-level prosodic boundaries, such as prosodic feet.

4.2.4 Lyrics

The **lyrics spine is the one part of MCFlow transcriptions which specifically encodes information about the meaning of rap utterances, *not* the sound. Since the transcriptions are syllable based, multi-syllable words are split across records using a /-/ symbol before and/or after each syllable. Melismas (very rare in rap verses) are encoded using the /|/ symbol. This basic framework is identical to the predefined humdrum **silbe interpretation. However, the MCFlow **lyrics representation also includes a specific framework for spelling, capitalization, and punctuation. Most importantly, punctuation is used to encode basic information about syntactic and semantic boundaries, complementing the prosodic boundaries encoded in the **tone and **break spines. The independent encoding of syntactic (**lyrics) and prosodic (**break) units allows MCFlow to be a resource for studying enjambment, and similar effects, in rap.

Lyrics for sampled songs were accessed via the Internet, principally from the Original Hip-Hop Lyrics Archive (www.ohhla.com). Many OHHLA lyrics had errors which were corrected based on the judgement of the author, usually with reference to another lyrics site, www.genius.com. In some cases, identifying the actual words intended by the emcee proved impossible so the best guess of the author was used. Meaningless grunts and gibberish sounds were transcribed using what seemed to be the most intuitive spellings.

Spelling

Emcees rap in a variety of English dialects. Such dialects are often transcribed with colloquial spellings which attempt to represent variations in pronunciation—for instance, /runnin'/. However, this colloquial orthography is generally not standardized and is used inconsistently. For instance, the contraction of the word /because/ may be written /cuz/, /'cos/, /cause/, or /'cause/. Fortunately, details of pronunciation are encoded much very precisely in the **ipa spine (Section 4.2.4, below). Thus, the **lyrics spine is freed to focus on information about the meaning of the lyrics, not their sound. Words in MCFlow **lyrics spine are thus encoded in standard spellings, without regard to their actual pronunciation. This does not suggest that various dialectic pronunciations, or their colloquial spellings, are "wrong" ways of speaking or writing. It is simply a convenience which will facilitate comparison of word usage across emcees, and especially with other corpora. Furthermore, using standardized spelling often clarifies ambiguous meanings: For instance, emcees frequently pronounce the words /you/ or /your/ as /ya/. By encoding the intended meaning (/you/ or /your/ determined by context) semantic analysis is facilitated. However, there are limits to the reasonable standardization of spelling. Contractions

which combine multiple words into a single word are not standardized—for instance, /gonna/ is not transcribed as /going to/. However, colloquial contractions of multisyllabic words are encoded in their standard spelling; most notably /'cause → because/ and /'bout → about/.

In standard English orthography, capitalization serves multiple purposes, resulting in potential ambiguity in large scale analysis. In contrast, in the MCFlow **lyrics spine capitalization is used *only* to identify proper nouns—beginnings of syntactic units are not capitalized, nor is the word /I/. Rap is full of obscure references to specific individuals, places, and objects, making the unambiguous identification of proper nouns highly useful in any potential content analysis. Consider the sentence /Because the row won't bow down to no man/ from 2Pac's "California Love" (1995). This phrase is difficult to understand unless you realize that /row/ refers to 2Pac's record label, Death Row records. Thus, this lyric is transcribed in the **lyrics spine as /be-cause the Row won't bow down to no man/, maintaining the distinction between the proper noun /Row/ and the common noun /row/. Multi-word proper nouns are connected by the /_/ (underscore) symbol. This distinguishes, for example, common language like /a fifty cent coin/ from the proper name of the emcee /Fifty_Cent/. Acronyms are also connected by /_/, with no periods, but are not capitalized unless the acronym is of a proper name: thus /TV (television) → t_v/ and /N.Y.P.D. (New York Police Department) → N_Y_P_D/. Emcees often spell words out: these instances are also connected by /_/ and capitalized if spelling out a proper noun—as in /S_N_O_O_P_Dogg/. Single letter abbreviations (such as /G/ for gangsta) are simply written as a single letter (only capitalized if the letter is functioning as a proper noun).

Quotations in the lyrics—such as /She said "How are you?"/ are placed in double quotes /" "/. Question marks are placed after questions but exclamation marks are not used. Other punctuation symbols are used in non-standard ways to precisely encode segmentation information, as explained in the next section.

In some cases emcees purposely use puns or double entendres involving homophonic words. For instance, in "Hypnotize" (1997) Biggie puns on the homophony between /escargot/ and /S-car go/ and between /peace/ and /piece/. A more sophisticated example can be found in Biggie's "Going Back To Cali" (1998) where he raps /recognize a real don when you see one/ but pronounces the last word in such a way that it might be heard as /Juan/—as in /Don Juan/. In other cases, it may simply difficult to determine exactly what word was intended. In cases where a purposeful double meaning seems to be intended, both versions of each syllable are encoded, separated by a forward slash. In cases where the word is unsure, a backslash is used instead.

Syntactic Units

In addition to the lyrics themselves, the **lyrics spine of each MCFlow transcription also contains information concerning syntactic and semantic boundaries. Not surprisingly, the syntax of rap rarely follows the clear structures of written prose; rather, rap syntax combines the loose syntax of conversational speech with unconventional artistic/poetic structures. Appropriately marking syntactic boundaries is made difficult by this idiosyncratic language. For instance, emcees frequently begin thoughts with conjunctions even when there doesn't seem to be any meaningful connection to the previous thought. Conversely, emcees may leave out conjunctions and other function words (articles, pronouns, etc.), and sometimes even sentence subjects.

For instance, a emcee may deliver a serious of thoughts with verbs and objects but no subject—depending on context, it may be that the emcee himself is implicitly the subject. In such cases syntactic analysis requires imagining "implied" actors, actions, conjunctions, etc.. Detecting these implied words requires interpretation of the meaning of sentences, words, or phrases, which in some cases is difficult due the excessive use of slang, references, quotes, allusions, metaphors, and similes.

The prototype of the single syntactic "thought" is the *sentence*, consisting of a *noun phrase* and *verb phrase* with optional *prepositional phrases*. However, sentences and their constituent phrases can themselves have other phrases and sentences embedded within them recursively (complex sentences), can be chained together in long series using coordinating conjunctions (compound sentences), or both. In contrast, it is entirely common for simple phrases, or even single words, to to express a complete thought without forming a complete sentence—as in /Hello./ or /Wow!/. Emcees frequently string together a large number of short independent syntactic units, such as noun phrases, without forming complete sentences.

Syntactic segments in MCFlow are annotated using the four symbols /./|/;/,/ placed in the **lyrics spine after the last syllable of each segment. The period /./ always indicates the end of a concrete syntactic unit that cannot be interpreted as being syntactically embedded in a higher unit. These period-defined units range in scope from extremely short sentences, exclamations, or noun phrases, to complex-compound sentences with multiple embedded clauses. Where appropriate, the semicolon /;/ and pipe /|/ symbols are used to delineate syntactic sub-units within complex utterances: /;/ indicates real or implied coordinating conjunctions between independent units (compound sentences), while /|/ indicates a large syntactic unit (such as a sentence)

embedded within another (complex sentences). Smaller embedded segments, such as lists of noun or verb phrases, are separated by comma /,/. Table 4.5 illustrates the use of some of the **lyrics segmentation symbols in a verse by Ludacris. The lines and line numbers in the table are included simply for convenience of presentation here, they are not in anyway encoded in MCFlow—only the shown punctuation symbols encode boundaries in the actual transcription. Notice how lines 14–17 are encoded as a single compound-complex unit: this is because lines 15–17 are all embedded within the verb phrase that begins /but don't forget about/ in line 14. Similarly, line 8 is embedded within the thought beginning "I keep" in line 7—in this case I interpret an implied conjunction: "I keep my mind on my money (and my) money on my mind." Also notice how the "but" which begins line 14 does not really create a conjunction with line 13. Finally, notice how repeated words (1 and 5) are ignored.

The ellipsis (...) is used to mark syntactic phrases that transition directly into the chorus (line 18 in Table 4.5). These phrases do not really constitute complete thoughts and may be best ignored in some analyses. The tilde /∼/ symbol is used to mark grunts and other non-syntactic, meaningless, sounds which are interspersed into flow but don't appear to belong to any meaningful or syntactic group. In the case of syntactic ambiguity or elision, syntactic punctuation tokens are placed at all possible interpretation points, but all except one preferred interpretation are marked with an /x/—e.g. /;x/. Users of MCFlow that wish to ignore these ambiguous boundaries may simply ignore any **lyrics segmentation token that is followed by an /x/.

Semantic units

In addition to syntactic boundaries, MCFlow **lyrics spines include super-syntactic information about the meaningful grouping of syntactic units. Colon /:/ may be

Table 4.5: Example of **lyrics syntactic segmentation of the first verse of Ludacris' "Money Maker" (2006). Parenthetical texts are "implied," and are not included in the MCFlow transcription of this song, nor are the line numbers.

1 shake shake shake your money maker|
2 like you were shaking it for some paper.
3 took your momma nine months to make you.
4 might as well shake what your momma gave you.
5 you you looking good in them jeans.
6 i bet you'd look even better with me in between.
7 i keep my mind on my money| (and my) money on my mind;
8 but you're a hell of a distraction when you shake your behind.
9 i got J_O up on my right side pouring some cups.
10 my whole hood is to my left;
11 :and they ain't giving a fuck.
12 so feel free to get loose and get carried away;
13 so by tomorrow you forgot what you were saying today.
14 but don't forget about this feeling that i'm making you get,
15 and all the calories you burn from me making you sweat,
16 (and) the mile high points you earn when we taking my jet,
17 and how everywhere you turn I'll be making you wet.
18 because you can...(Chorus: shake your money maker)

placed at the end (after the /./|/;/,/) or beginning of a syntactic segment to indicate any kind of meaningful dependence: A colon at the end of a syntactic unit indicates that some sort of answer or continuation is implied—a forward-looking reference. Conversely, colons at the beginning of syntactic units indicate that the unit depends on some piece of information in the previous unit—a backward-looking reference. The most common "backward reference" is a pronoun—in line 11 in Table 4.5 the pronoun /they/ refers to /my whole hood/ in the previous line.

Another possible super-syntactic relationship occurs when emcees string together a serious of short syntactic units, often noun-phrases—such as a list of people or things. For instance, a line in Biggie Smalls' "Juicy" (1994) simply consists of three noun phrases: /Fifty inch screen. Money green. Leather sofa./. In these cases, a serious of syntactically independent objects may still essentially express one thought. To indicate such relationships, the plus symbol /+/ can be placed at the end of a unit (after the syntactic punctuation) to indicate it's connection to a larger super-syntactic collection—/Fifty inch screen.+Money green.+Leather sofa./.

At a higher level, it can be useful to mark more abstract, topical, relationships between utterances. This "high level," semantic organization of rap is highly variable: Some songs have a clear coherent, topic, theme, or idea, which the entire rap relates to, while other raps consist of a string of unrelated ideas approaching a stream-of-consciousness. Some raps tell a coherent narrative, describing a series of linear events, while others are more like timeless soliloquies. Only very general shifts in semantic comment are encoded in MCFlow—for instance a change of topic, scene in a narrative, etc.. Curly braces {} are used to bracket related thoughts. Segments can be bracketed recursively to add detail, /{{Thought 1 Thought 2} {Thought 3 Thought 4}}/. In

Table 4.6: Key to segmentation in **lyrics interpretation.

Symbol	Meaning
.	End of completely independent syntactic unit.
;	Conjunction between two independent units.
|	Boundary between embedded sentences.
,	Boundary between embedded phrases.
:xxx	Backwards reference to previous unit.
xxx:	Forward reference to next unit.
+	Connection between small independent units.
{}	Recursively enclose meaningful topics.
>	Indicates progression in linear time in a narrative.

the case of narration the />/ symbol can be placed before an opening curly brace to indicate a linear flow of time from one segment to the next.

Table 4.6 summarizes the syntactic and semantic segmentation scheme used in MCFlow **lyrics spines.

Pronunciation

The sampled emcees speak in a variety of English dialects. What's more, emcees sometimes pronounce words in idiosyncratic manners to serve their artistic purposes (Bradley, 2009, loc. 931,1465). For example, the word "and" is pronounced many different ways by various rappers in various contexts, including |ænd|, |æn|, |ɪ n|, and |n|. To record the actual pronunciation of rap, all syllables in MCFlow are encoded in the International Phonetic Alphabet (IPA) in the **ipa spine. IPA encodings were created using an automatic translation of lyrics downloaded from www.ohhla.com. The translator makes use of a modified amalgamation of the MRC Psycholinguistic Database (from the University of Western Australia) and the Carnegie Mellon University Pronouncing Dictionary (Coltheart, 1981; Lenzo, 2014). Entries in the

dictionary were altered to represent American pronunciations. Other perceived errors in the dictionary were also fixed. Finally, a large number of words and terms that were encountered in rap lyrics were added to the dictionary as each rap was translated. Each translation was then edited by ear by the author to match as closely as possible the actual pronunciation in the recording.

The set of phonemes used in MCFlow represent the set of phonemes used in the author's dialect of American English. Many rappers speak different dialects from the author, and phonetic distinctions which may be important to them may be difficult to discern by the author; likewise, some emcees may not distinguish all the same phonemes as the author. The author's native dialect has undergone the "cot/caught" merger. As such, in MCFlow the same symbol |a| is used to transcribe either sound. "Merry," "Mary," and "marry" are also considered the same vowel sounds by the author (the |ɛ| vowel). However, the author does distinguish |ɪ| and |ɛ| whereas many emcees speak in dialects which have undergone the "pin/pen" merger, and thus treat these two vowels as the same sound—this makes it difficult to pick which of these two vowels is the "correct" encoding for a syllable. The set of phonemes used in the current transcriptions are shown in Table 4.7. Throughout this dissertation, IPA transcriptions in the text body are surrounded by /| |/, as in |kæt|.

4.2.5 Rhyme

Even with the definition of rhyme proposed in Section 3.2.3 (page 69) as an operational framework, identifying rhymes in actual rap is a somewhat subjective endeavor. In fact, of all the subjective aspects of rap transcription, annotating rhymes may be the most susceptible to bias. This is especially the case with the emcees who use

Table 4.7: Set of forty-one IPA symbols used in MCFlow **ipa interpretations, and examples of their pronounciation as understood by author.

	Vowels	
Symbol	*Type*	*Example*
i		b**ea**t
ɪ		b**i**t
ɛ		b**e**t—(m**e**rry, m**a**rry, or M**a**ry)
æ		b**a**t
ʌ	stressed	ab**o**ve
ə	unstressed	**a**bove
ɛ˞		B**er**t
u		b**oo**t
ʊ		b**oo**k
a		b**ough**t—(c**augh**t or c**o**t)
eɪ		b**ai**t
aɪ		b**i**te
aʊ		b**ou**t
ɔi		b**oy**
oʊ		b**oa**t
	Consonants	
t	plosive (unvoiced)	**t**ip
d	plosive (voiced)	**d**ip
p	plosive (unvoiced)	**p**it
b	plosive (voiced)	**b**it
k	plosive (unvoiced)	**k**ill
g	plosive (voiced)	**g**ill
ʔ	plosive (unvoiced)	go**tt**a → like "gah-uh"
ɾ	tap (voiced)	go**tt**a → like "gah-duh"
s	fricative (unvoiced)	**s**ap
z	fricative (voiced)	**z**ap
ʃ	fricative (unvoiced)	**S**ean
ʒ	fricative (voiced)	**g**enre
f	fricative (unvoiced)	**f**an
v	fricative (voiced)	**v**an
θ	fricative (unvoiced)	**th**in
ð	fricative (voiced)	**th**is
h	fricative (unvoiced)	**h**and
dʒ	affricate (voiced)	**g**in
tʃ	affricate (unvoiced)	**ch**in
n	nasal	ba**n**e
m	nasal	mai**m**
ŋ	nasal	ba**ng**
j	approximant	**y**es
w	approximant	**w**est
l	approximant	**l**ed
r	approximant	**r**ed

the most rhyme: as emcees pack more rhymes into their flow they tend to use more loose abstract rhyme motives, which are often the most difficult to identify. A good example is single syllable assonance: a rhyme motive consisting of a single vowel. If an emcee delivers a large number of stressed syllables in a row that all share the |u| vowel, one may hear these as assonant rhymes. But from that point on are all |u| vowels now part of a rhyme chain? When does it stop? Bias may occur because the transcriber might make different decisions depending on the emcee. For instance, when transcribing Biggie Smalls (a dense rhymer), the transcriber might mark a weak internal rhyme between /cart : bought/, whereas the same two syllables in a Beastie Boys or Run D.M.C. song (emcees who generally rhyme less) would be ignored. This sort of bias might potentially exaggerate the difference in rhyme density between emcees. On the other hand, this sort of context-specific rhyme identification may reflect the listening experience—listening to emcees who rhyme more often may make us more sensitive to subtle rhymes.

Rhyme is easiest to identify when reinforced by chyme (prosodic parallelism). In fact, as discussed in Section 3.2.3, strong chyme can even give the false impression of a rhyme that is not really there. In general, the correlation between rhyme, phrasing, and prosodic parallelism introduces potential confounds in the transcription process. The presence of an obvious rhyme may lead the transcriber to note a phrase boundary where prosody does not suggest one. Likewise, the presence of a clear prosodic boundary might lead a transcriber to annotate a rhyme where they might otherwise not. All these caveats aside, I believe that the rhyme annotations in MCFlow represent reasonably objective interpretations of rhyme that the majority of listeners would agree with.

The annotation scheme in MCFlow **rhyme spines is simple, yet flexible enough to capture the huge variety of rhyme relationships which exist in rap. Figure 4.5 illustrates how MCFlow **rhyme annotations work. In this example a single rhyme motive—|ʌɛ˜ʊd|—stretches across three syllables with the stress pattern stress-unstressed-stressed. The complete rhyme motive creates a rhyme chain between /motherhood : brotherhood/. However, subsets of the rhyme motive also connect /mother : other : brother/ and /-hood : good : -hood/ respectively, forming two distinct rhyme "sub" chains. This complex relationship (the likes of which are quite common in rap) can be effectively be broken into two dimensions. First, for each syllable which is part of a rhyme link, other syllables which parallel that syllable must be identified. The curved lines in Figure 4.5 indicate these relationships, which are indicated in MCFlow using arbitrary roman letters (case sensitive). Generally, lower case letters are reserved for unstressed syllables, and the same letter is used as for the stressed rhyme it is adjacent to. Roman letters are unique within every rap verse, and are generally used in order, though this is not required. If all 52 letters are exhausted in a single verse, double letters (e.g. AA, BB) are used. The second dimension of rhyme is the grouping of adjacent syllables into larger rhyme units. In 4.5, four distinct rhyme units—/motherhood/, /good/, /other/, and /brotherhood/—are indicated by boxes around the text. In MCFlow, whenever a rhyme link extends across more than one syllable these syllables are grouped using parentheses. In rhyme links which consist of more than two syllables, intermediate syllables are marked with marked with /_/ (underscore) to indicate that they are part of a larger chain. At the bottom of Figure 4.5, the **rhyme annotation scheme is illustrated. This two dimensional system has

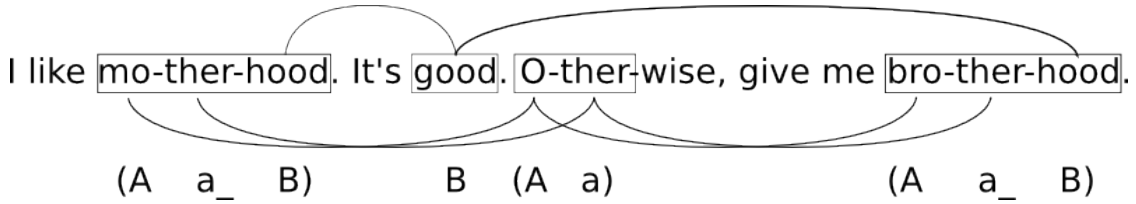

Figure 4.5: Illustration of "two-dimensional" rhyme annotation. Curved lines connect syllables with parallel phonemes. Boxes delineate rhyme units.

proven very flexible, capable of clearly annotating the great variety of rhyme relationships that occur in rap. The repetition of /-ther-/ is an example of a unstressed repeated syllable which is absorbed into a larger rhyme, and is marked with /_/ to indicate that it is part of a larger rhyme link. Combining the information in the **rhyme spine with the pronunciation information in the **ipa and **stress spines affords very detailed analysis of rhyme in the MCFlow corpus.

The **rhyme coding scheme includes several more details. Very weak rhymes, or rhymes that seem ambiguous are marked with a /?/ symbol next to their roman letter. If a rhyme is clearly implied by prosody or by the rhyme scheme but the actual event does not rhyme (or is simply repetition), a /∼/ symbol is placed before the roman letter. Another possibility is repetition which appears in a context where rhyme is expected, also marked with /∼/. Researchers may elect to discard these rhymes marked with /?/ or /∼/ during analysis. In some cases, a repeated multi-syllabic pattern may feature syllables that don't contain parallel syllables, but still seem to partake in the rhyme unit. For example, in "California Love" (1996) 2Pac rhymes /mash out : peel out : steel out/. The words /peel out : steel out/ form a clear rhyme, but the word /mash/ has no sonic similarity with /peel/ or /steel/. However, each two syllable unit ends with the word /out/. On it's own, /out/ is pure repetition,

not rhyme. However, since the second and third instances of /out/ are part of a two syllable rhyme, there is some (weak) impetus to connect /mash out/ to the rhyme chain. (Prosodic chyme also reinforces this interpretation.) In this sort of odd (rare) situation, a parenthesis is included to connect /mash out/ but /mash/ receives no roman letter, since it does not actually contain any phonetic parallelism. Thus, the chain /mash out : peel out : steel out/ is encoded /(I) : (H I) : (H I)/.

As mentioned in Section 3.2.3 a single syllable may be involved in two independent rhyme relationships with other syllables. For instance in the lines,

> Hangin' pictures on my wall.
> Every Saturday, Rap Attack, Mr. Magic, Marley Marl.
> —Biggie Smalls, "Juicy" (1994).

the syllable /Marl/ rhymes with the syllable /wall/ and at the same time alliterates with the words /Mr./Magic/Marley/. Thus, in the MCFlow transcription of "Juicy," one letter (C) is used to encode the relationship between /wall : Marl/ and another letter (E) encodes the relationship between /Mr. : Ma- : Mar- : Marl/. In the **rhyme spine of the /Marl/ syllable record, the two letters appear separated by a space, as in /C E/.

One additional annotation is included in the **rhyme spine. In some cases, two or more independent rhyme events reoccur repeatedly in the same order (a form of rhyme scheme). Where analytically appropriate, square-bracket symbols ([ ]), are used to group such rhyme patterns.

4.2.6 Hype

The **hype spine records limited information about prominent hype in the music. Essentially, **recipx, **ipa, **stress, and **lyrics data for any hype are compressed

into a single data token, as **recipx**ipa(space)**stress(space)**lyrics: as in /8jə 0 ya/. However, if a hype voice simply doubles the lead line only a single /D/ token is placed in the **hype spine for each doubled syllable. Since double-tracking is nearly ubiquitous in some rap, not all double tracked vocals are transcribed in the **hype spine. Only intermittent doubling which emphatically emphasizes certain syllables is encoded, as well as call and response and other hype responses. In some cases hype syllables may rhyme with syllables delivered by the lead emcee—the hype may even provide the response that "clinches" an expected rhyme scheme. In these cases, the rhyme is annotated in the **rhyme spine of the data record containing the hype syllable, just as any other rhyme is encoded. Similarly, if a hype voice creates its own prosodic phrase, prosodic boundaries are indicated in the **break spine like any others. Only a handful of such cases exist in the current sample.

4.2.7 Metadata

Several pieces of additional, non-musical information are encoded in each MCFlow transcription. Following standard humdrum practice, *reference records* beginning with /!!!/ are included at the end of each each MCFlow file, encoding general "library-type" information about the piece Huron (1999). Thirteen predefined humdrum reference records, as well as two newly defined records, are included, summarized in Table 4.8. In addition !!!RRF: records describe, in brief, each of the MCFlow exclusive interpretations. Information about songs and artists was gathered from wikipedia.org or allmusic.com. Billboard information is drawn from the *bullfrogspond* billboard

dataset. The birth/death dates for emcees who are still alive (the majority) are encoded as "sometime after" the date the reference record was encoded, using the />/ symbol.

In all MCFlow reference records, the composer(s) are assumed to be the emcee who delivers the lyrics. Though most emcees write their own rhymes, some emcees make use of ghost-writers—a famous example being Dr. Dre. However, identifying the names of ghost-writers has proven difficult. Even in cases where it is widely believed that a rap's lyrics were written by a ghost writer, it is not clear to what extent the rhythmic/prosodic delivery of the lyrics is determined by the composer verses the performer. Dr. Dre may not write his own words, but does he choose how to deliver them?

Sections in each transcription are encoded using standard Humdrum tandem interpretations: *>Verse1, *>Verse2, etc.. Comment data records are used to indicate the identity of the actual emcee in each measure of the rap. A comment following the formant /!MC:Emcee's Name/ is placed at every change of rapper. In most cases, there is simply one emcee comment at the beginning of each verse. However, when two rappers both rap consecutively within a single section, a /!MC:/ comment is inserted at each point the emcee changes.

Barlines

Standard humdrum barlines (=) are included in all transcriptions (though recall that **recipx rhythmic encoding ignores barlines). Barlines are numbered consecutively within each section of the rap. Any pickup to the first measure is encoded in a complete measure zero (=0). These =0 pickup measures are identified by the overall hypermeter of the rap beat. Likewise, when a rap ends with a line "spilling"

Table 4.8: List of reference records included in MCFlow transcription files. Asterisks indicate reference codes that are unique to MCFlow, all other codes are predefined humdrum codes. Dates are encoded in humdrum **date format (year/month/day).

Code	Meaning	Example
Song info		
!!!OTL:	Title of song	Go See the Doctor
!!!RTL:	Title of album	Kool Moe Dee
!!!RMM:	Record label	Jive/Rooftop
!!!RC#:	Recording catalog number	1041
Billboard info:		
!!!BPP:*	Billboard peak position	89
!!!BPD:*	Billboard peak position date	1987/04/25
Artist info:		
!!!COC:	Corporate name (official artist)	Kool Moe Dee
!!!COL(#):	Composer(s)'s (stage) name	Kool Moe Dee
!!!COM(#):	Composer(s)'s (given) name	Mohandas Dewese
!!!CDT(#):	Composer(s)'s birth/death dates	1962/08/02->2016/01/29
Encoding info:		
!!!ENC:	Encoder of transcription	Nathaniel Condit-Schultz
!!!EED:	Editor of transcription	Nathaniel Condit-Schultz
!!!RDT:	Date encoded	2014/-2016/
!!!EST:	Encoding status	In progress
!!!RDF**recipx:	Describe **recipx	**recip interpretation with complex-fractional, meter-insensitive, durations.
!!!RDF**stress	Describe **stress	Syllable stress encoded as either 1 or 0.
!!!RDF**tone:	Describe **tone	Encoding of pitch peaks, nadirs, glides, and parallelism.
!!!RDF**break:	Describe **break	Encoding of prosodic disjunctions as 0,1,2,3, or 4.
!!!RDF**rhyme:	Describe **rhyme	Two-dimensional encoding of rhyme relationships between syllables.
!!!RDF**ipa:	Describe **ipa	41-symbol IPA encoding of syllable pronunciation.
!!!RDF**lyrics:	Describe **lyrics	Encoding of text and syntactic/semantic boundaries.
!!!RDF**hype:	Describe **hype	**recipx, **ipa, **stress, and **lyrics encoding of hype vocals.

over slightly into the beginning of the next hypermetric unit, the spillover measure is encoded with a negative number. For instance, if a sixteen measure verse ends with a syllable on the downbeat of what would be the seventeenth measure this measure is encoded '=-17.'

One other special use of barlines is used in MCFlow. As mentioned above, changes of emcee are indicated with /!MC:/ comment lines. When emcees change within a section without overlapping in time, the /!MC:/ comment line can simply be placed between the end of one emcee's rap and the beginning of the next emcee's. However, in some cases the beginning of the new emcee's line overlaps in time with the previous emcee. In these cases, the same measure is encoded twice: once for the end of the previous emcee, once for the beginning of the next emcee. To identify these cases, the same barline number is used twice in the transcription. Thus, barlines in an overlapping passage might proceed like: /MC1: =6 =7 =8 MC2: =8 =9 =10/. Only four songs in the current MCFlow dataset feature overlapping flow which necessitates the double notation of bars: Dr. Dre's "Nuthin' but a 'G' Thang," Nelly's "Grillz," Snoop Dogg's "Young, Wild & Free," and Warren G's "Regulate."

Chapter 5: Descriptive Analyses

This chapter presents some descriptive summaries and preliminary analyses of the MCFlow dataset. These analyses are not exhaustive, but are rather a demonstration of how rap flow can be studied using MCFlow. In Section 4.1 three prospective uses of MCFlow were suggested: describing norms, comparing artists, and discovering historical trends. The analyses in this chapter will attempt to illustrate the usefulness of MCFlow for pursuing each of these avenues of inquiry. The statistical information presented throughout this chapter is entirely descriptive. Thus, the graphs and tables in this chapter are descriptive summaries of the *sample*, not inferential estimates of true population parameters that might generalize to other rap. More thorough statistical analysis will await future research.

5.1 Analyses

5.1.1 Speed

Flow Speed

A very basic feature of rap flow is simply the rate at which syllables are delivered. In Section 2.2.3 it was suggested that speed is part of what distinguishes rapping from "singing." To describe the speed of flow the pace at which syllables appear is all that matters; syllables' duration are not relevant. Therefore, syllable and rest duration

tokens in MCFlow were converted to *Inter Onset Intervals* (IOIs) between syllables. Thus, the rhythms /♪ 𝄾 ♪ 𝄾 / and /♩ ♩ / are considered equivalent in the following analysis.

One way to summarize the speed of rap flow is simply to consider a histogram of the 66,034 syllable IOIs in the corpus, as shown in the left half of Figure 5.2. This histogram is distinctly bimodal, with a tall peak at around 150ms and a secondary peak around 300ms. This reflects the tendency for flow to be dominated by two primary durational values, with a $\frac{2}{1}$ relationship between the durations (as mentioned in Section 3.2.1). The histogram shown in the left half of Figure 5.1 is a tally of syllables treated as isolated events. A more informative impression of flow speed is garnered from calculating syllable rate in context. Accordingly, for each syllable in the corpus the number of syllable onsets delivered in the previous one second were tallied. A histogram of the resulting values are shown in the right half of Figure 5.1. These values represent the distribution of the actual number of syllables to occur in a one-second window. Both histograms in Figure 5.1 are purely descriptive of the data in the current sample, so their generalizability is uncertain. However, based on the right panel of 5.1 it appears that the typical pace of rap flow is approximately 4.44 syllables per second.

Any casual rap listener will have observed that emcees vary in their typical speed. Indeed, the average flow rate among the 38 emcees with significant sample sizes (more than 400 syllables) in the corpus varies from 3.67 to 5.75 syllables per second. As an illustrative comparison we can contrast the speed of the fastest emcee in the corpus, Big Boi, with that of the slowest emcee with significant representation, Lil' Wayne. The left plot in Figure 5.2 replicates the right histogram from Figure 5.1 overlaid

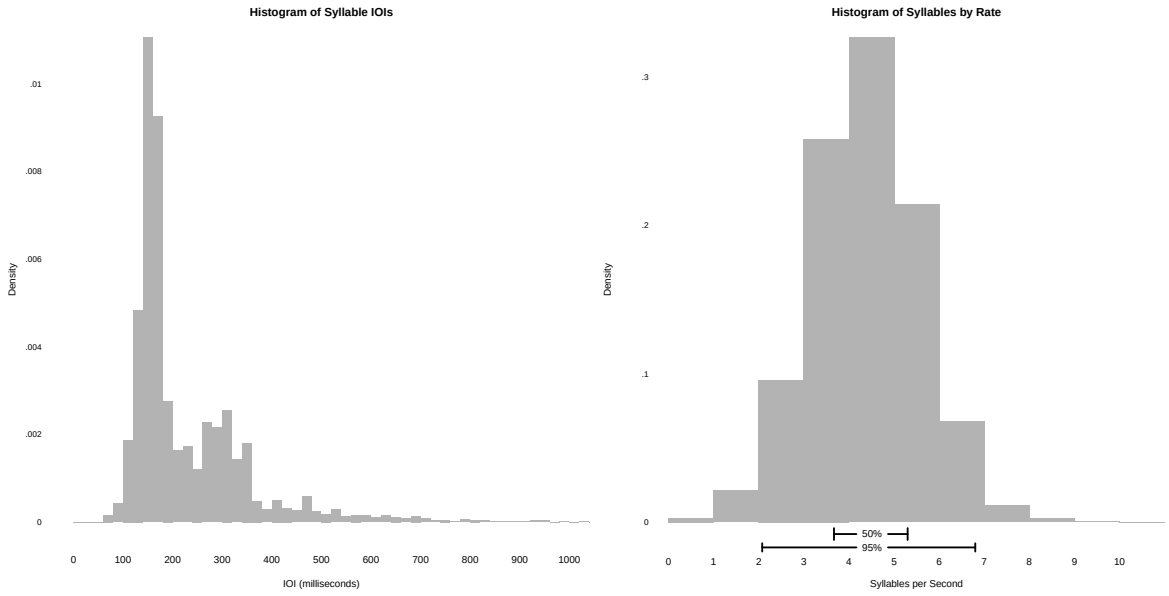

Figure 5.1: Distribution of rapped syllables by speed. The left panel shows a histogram of the 66,034 syllable Inter Onset Intervals (IOI) in MCFlow. The right panel (which is conceptually more meaningful) shows a histogram of the number of syllables delivered in a one-second window leading to each syllable in the corpus. Below the histogram the middle 50% and middle 95% inter-quantile ranges are indicated. Thus, 95% percent of rapped syllables are delivered in a one-second window containing between two and seven syllables.

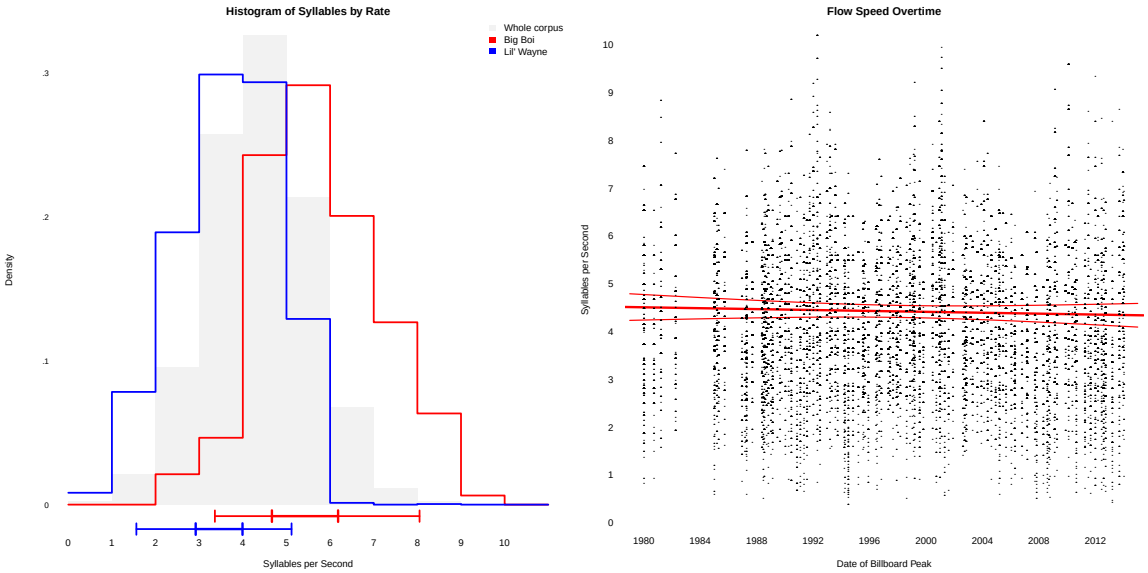

Figure 5.2: Left plot: a comparison of the rap speed of the slowest and fastest emcees in the MCFlow corpus, Lil' Wayne and Big Boi (not including emcees with fewer than 400 syllables in the corpus). The line below the plot indicate each emcee's 50% and 95% inter-quartile ranges. Right plot: rap syllable rate over time. The red regression line in the scatter plot was calculated using a multi-level linear model. The slight downward tip of the line is not significant at the 0.05 α-level.

with two additional histograms showing Big Boi and Lil' Wanye's distributions. As can be seen, the two emcees' middle 50% quantiles do not even overlap. We can also consider historical trends: has the average rate of rap flow changed over time? A priori, I know of no commentator, scholarly or otherwise, who has suggested that this is the case. The right panel of Figure 5.2 plots syllable rates by date of Billboard peak. As can be seen, there does not seem to be any indication of change over time.

Tactus Tempo

The lack of variation in rap speed across time becomes especially interesting in light of a clear change in hip-hop's tempos across time (Figure 5.3). Each point in Figure 5.3 represents the tempo of a song in the corpus (the variety of shapes

and colors are coded by artist). As can be seen, the typical tempo of hip-hop beats has gradually decreased over the three decades of rap history. It seems that emcees have tended to use slower and slower tempos over time, yet have continued to rap at roughly the same average speed. Though the overall trend is clear in the plot, the distribution of tempos remains skewed towards faster tempos.

5.1.2 Rhyme Frequency

Overall, 11,565 (30.4%) of the 38,000[37] stressed syllables in MCFlow corpus are involved in a rhyme. This is similar to the proportion observed by Hirjee and Brown in their text-based corpus research (2010, p.131). In the MCFlow dataset this proportion varies, again limited to emcees with more than 400 data points, from a low of 18.2% (Kurtis Blow) to a high of 47.8% (Eminem). Changes in the density of rhyme over time have been noted by rap scholars, such as Krims (2001, p. 49), and have also been empirically observed by Hirjee and Brown (2010). Figure 5.4 shows variation in rhyme density in MCFlow by date of song peak. Each point in the figure represents the proportion of rhymed stressed syllables in a particular song—select outliers are labeled. Historical changes in the density of rhyme, consistent with the observations Hirjee and Brown (2010, p. 132) do seem to be evident in Figure 5.4: There appears to be a continuous increase in the density of rhyme in the period 1980–2002. Interestingly, the trend observed through 2002 does not seem to continue; rather, rhyme density seems to plateau, or perhaps even recede, after 2002. Krims made his observations in 2001, and Hirjee and Brown's samples from after 2002 are few, so neither observed this later trend.

[37] This nice round number occurred purely by chance.

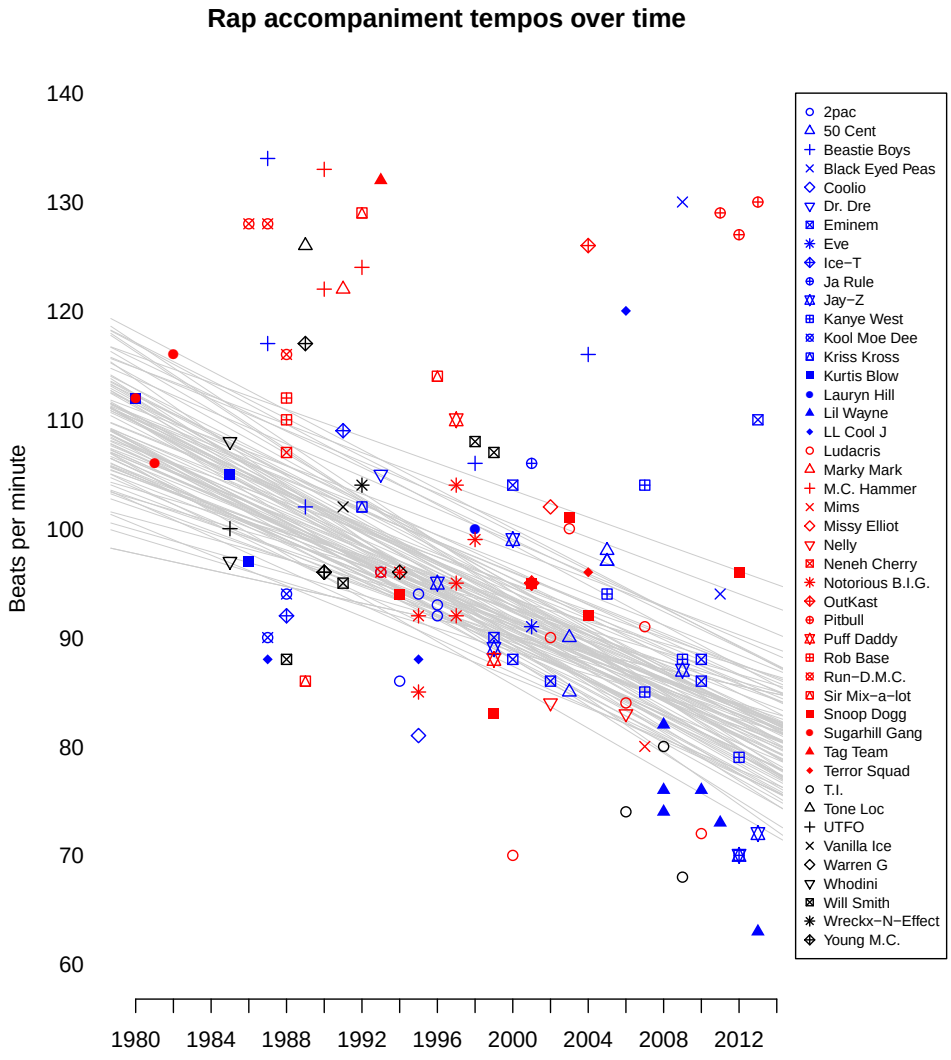

Figure 5.3: Distribution of (backbeat-defined) rap beat tempos over time. The grey lines show a "smattering" of plausible regression slopes randomly drawn from a Bayesian posterior distribution.

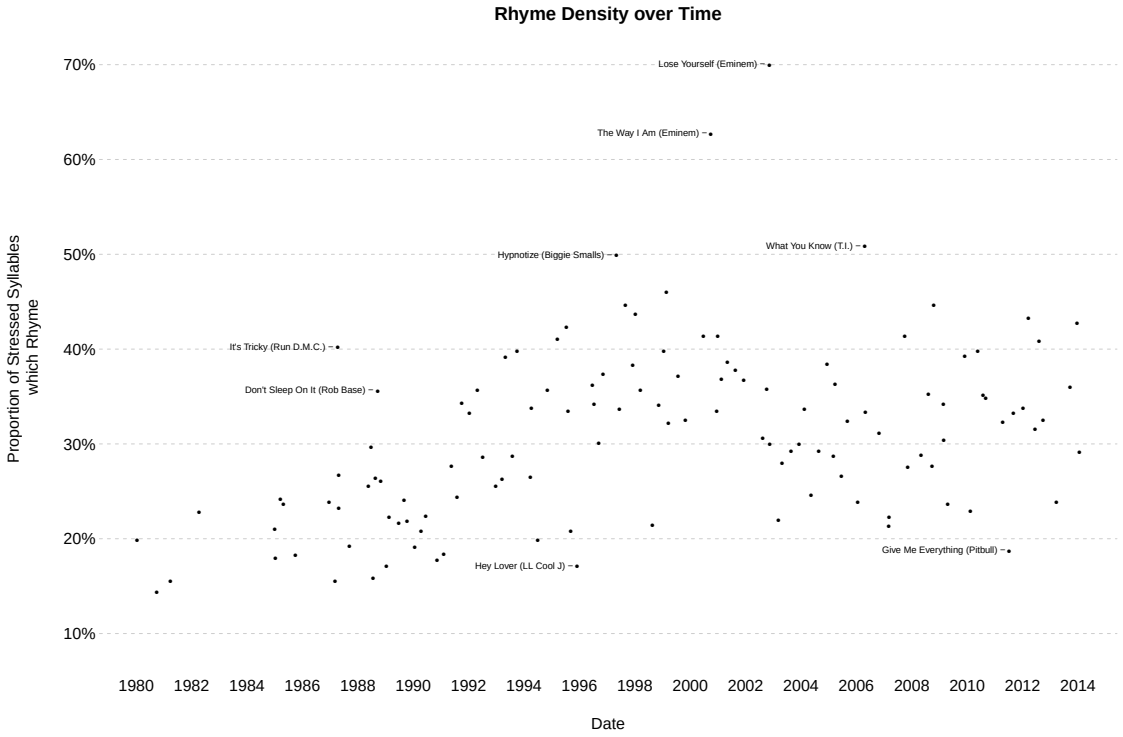

Figure 5.4: Density of rhymed syllables over time. Each point represents a song in the MCFlow dataset. The y-coordinate of each point indicates the proportion of rhymed stressed syllables in that song, while the x-coordinate represents the song's Billboard peak date. Select outliers are labeled.

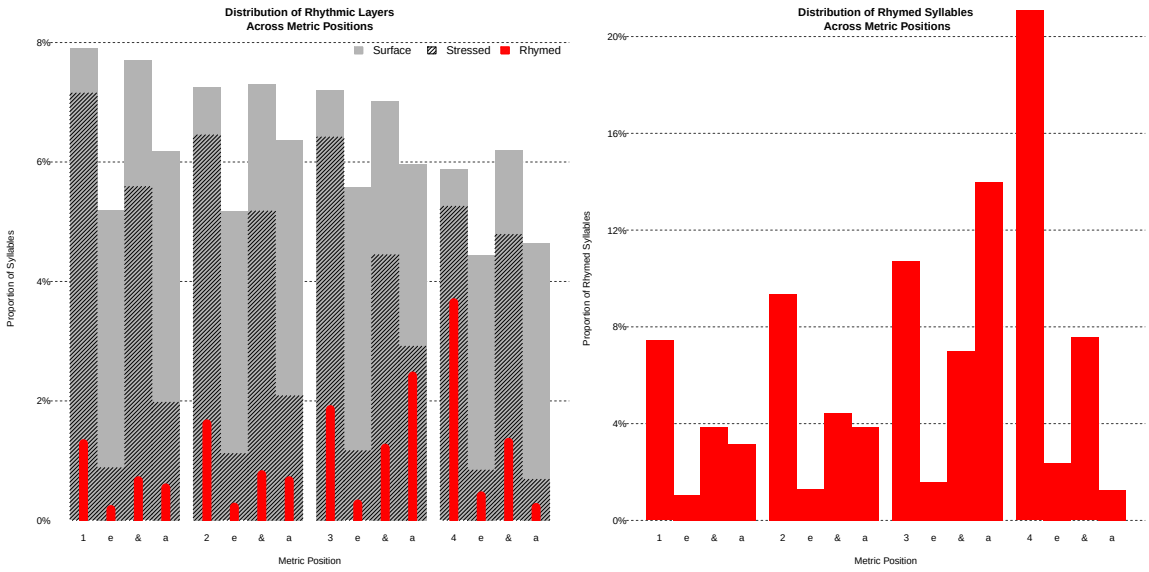

Figure 5.5: Left: Metric placement of three syllable layers: unstressed, stressed, rhymed. Right: Metric position of rhymed stressed syllables only.

5.1.3 Metric Placement of Rhythmic Layers

Consider now the placement of syllables in the meter. The left panel of Figure 5.5 shows the proportion of syllables in MCFlow delivered on each (of 16) metric positions—metric positions are rounded to the nearest 𝅘𝅥𝅯 position. The tendency for stressed syllables to be placed on relatively strong beats is clear. Note also the relatively few syllables landing in beat four, where phrase boundaries are likely to occur. Compared with unrhymed syllables, rhymed syllables represent a higher rhythmic layer, which is evident in their greater likelihood of landing on relatively strong beats. Nevertheless, the most striking feature of Figure 5.5 is that rhymes are much more likely to occur later in the measure, especially near beat four, where phrases often end. This is placement of rhymes on beat four is consistent with observations made by other rap scholars (Adams, 2009; Edwards, 2009, p. 107).

Recall from Section 3.1.1 (page 28) the discussion regarding the tactus pulse in hip-hop music. As noted in that discussion, up-tempo rap may be more appropriately notated at half the tempo in diminution, and conversely for down-tempo rap. This issue can be addressed empirically using the MCFlow data by asking: does the metric distribution of syllables across ♪ in up-tempo rap match the metric distribution of syllables across 𝅘𝅥𝅯 in mid-tempo rap? Conversely, does the metric distribution of syllables across 𝅘𝅥𝅰 in slow-tempo rap match the mid-tempo distribution of 𝅘𝅥𝅯? The greatest difficulty in answering these questions is classifying rap verses as up-tempo, mid-tempo, or down-tempo. After much exploration, the following operationalization was adopted: (1) any rap verse in which 𝅘𝅥𝅯 represent less than 20% of durations (favoring ♪ and ♩) is considered "up-tempo flow"; (2) any rap verse in which 𝅘𝅥𝅰 make up more than 25% of syllables is considered "down-tempo flow"; (3) all other verses are considered "mid-tempo." Based on these criteria only six songs in the current MCFlow dataset contain up-tempo flow, while seven evince down-tempo flow. The songs in question are listed in Table 5.1.

The metric distributions shown earlier in Figure 5.5 actually only represent data from "mid-tempo" MCFlow data (i.e. excluding the thirteen songs shown in Table 5.1). In comparison, Figures 5.6 and 5.7 show the metric distribution of syllables in up-tempo and down-tempo verses respectively. The left panel in each figure shows the metric distribution of syllables across ♪ and 𝅘𝅥𝅯 respectively, contrasted with the distribution across 𝅘𝅥𝅯 in the right panel of each figure. To understand these plots, pay close attention to the metric positions indicated on the x-axis. Regarding the up-tempo plot in Figure 5.6, the ♪-distributed left panel bears many resemblances to the 𝅘𝅥𝅯-distribution of mid-tempo flow shown in Figure 5.5, while the right plot

Table 5.1: Songs in MCFlow which contain "up-tempo" or "down-tempo" flow.

Song	**Section**	**Artist**	**Year**	**Timing**
"You Be Illin'"	All	Run DMC	1986	Up
"It's Tricky"	All	Run DMC	1987	Up
"Fight for Your Right"	All	the Beastie Boys	1987	Up
"Pray"	All	MC Hammer	1990	Up
"Woof"	All	Snoop Dogg	1998	Down
"What's Your Fantasy"	All	Ludacris	2000	Down
"Dead and Gone"	All	T.I.	2009	Down
"How Low"	All	Ludacris	2009	Down
"Just Can't Get Enough"	Verse 3	the Black Eyed Peas	2011	Up
"Niggas in Paris"	All	Jay-Z	2011	Down
"Mercy"	Verse 1–2	Kanye West	2012	Down
"Mercy"	Verse 3	Kanye West	2012	Up
"Holy Grail"	All	Jay-Z	2013	Down

does not. This supports the notion that up-tempo flow might be effectively renotated in diminution. Regarding the down-tempo plot in Figure 5.7, the 𝅘𝅥𝅯-distributed left panel also bears a resemblance to the mid-tempo 𝅘𝅥𝅰-distribution. However, the right panel of Figure 5.7 also shares some similar features with the mid-tempo distribution. Specifically, rhymes are more common around beat four than around beat two. This suggests that, though two-beat patterns are highly important in down-tempo flow, the complete four-beat measure remains metrically salient. Ultimately, the preliminary analysis here is obviously insufficient to resolve the issue of tactus definition in rap. Extensive research—perhaps combining behavioral experimentation and ethnographic interviews—will be necessary to advance our understanding of the hip-hop tactus.

We next can consider artist comparison and historical trends in metric distributions. For such a task, it can be useful to characterize the variability among discrete categories in a one-dimensional measure. A useful mathematical construct which can

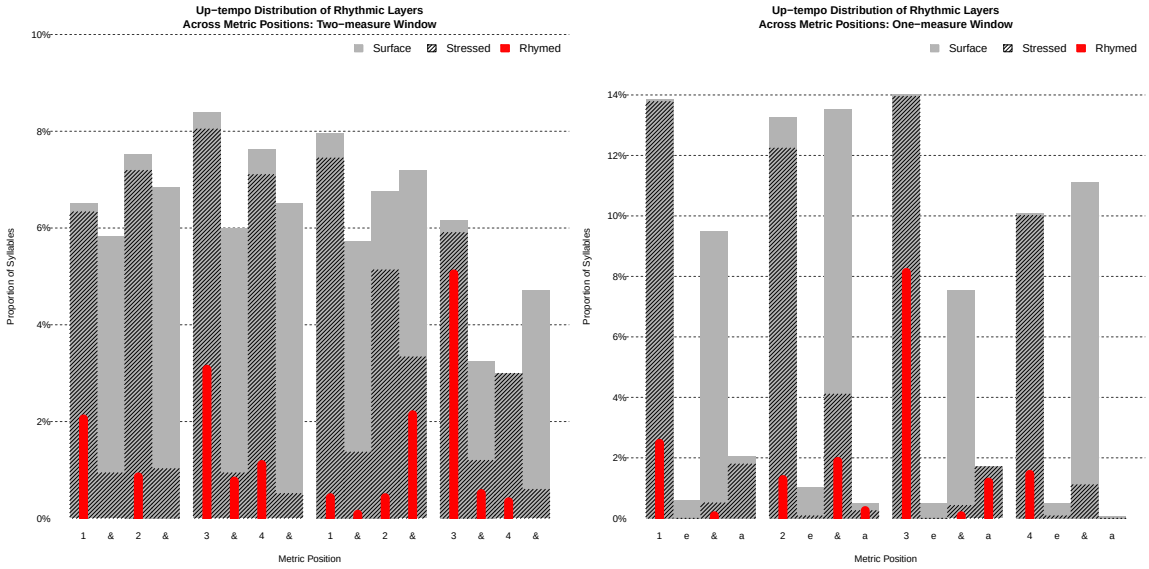

Figure 5.6: Both plots illustrate the metric placement of three syllable layers (unstressed, stressed, rhymed) in the six "up-tempo" rap songs in MCFlow. The left plot shows the distribution of syllables across two-measures of 𝅗𝅥 (with syllable positions rounded to the nearest ♪), while the right plot shows the distribution of syllables across one measure of 𝅗𝅥 (with syllable positions rounded to the nearest 𝅘𝅥𝅯). The question is: which interpretation more resembles the prototypical "mid-tempo" metric distribution shown in Figure 5.5?.

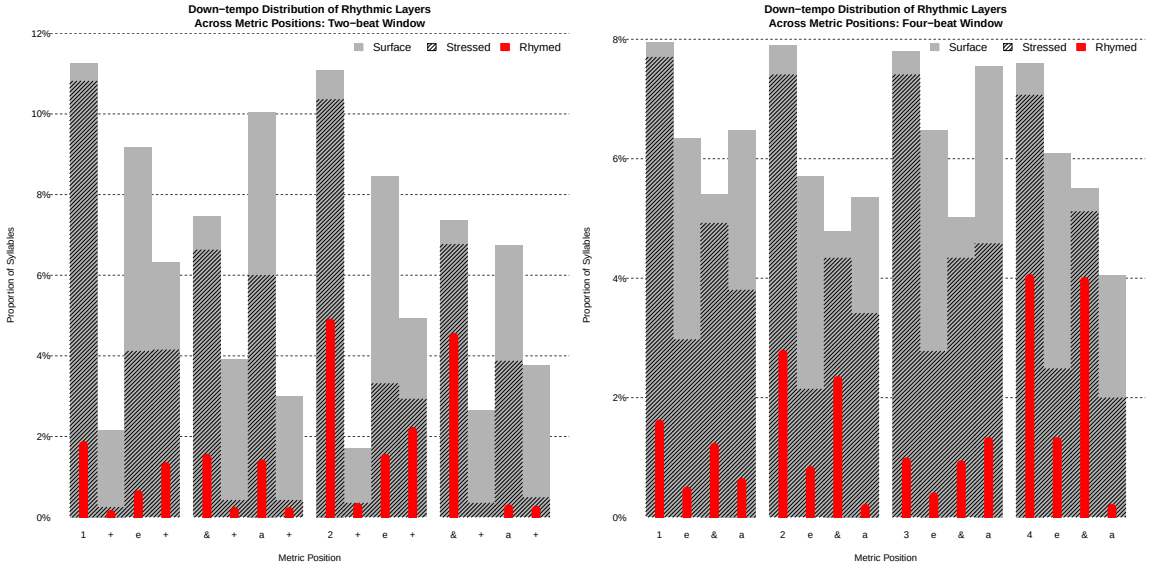

Figure 5.7: Both plots illustrate the metric placement of three syllable layers (unstressed, stressed, rhymed) in the seven "down-tempo" rap songs in MCFlow. The left plot shows the distribution of syllables across two-beats of 𝅗𝅥 (with syllable positions rounded to the nearest 𝅘𝅥𝅯), while the right plot shows the distribution of syllables across one measure of 𝅝 (with syllable positions rounded to the nearest 𝅗𝅥). The question is: which interpretation more resembles the prototypical "mid-tempo" metric distribution shown in Figure 5.5?.

be used for such a purpose is *entropy*—for a review of the application of entropy to music research see Margulis (2008). Though the literal information-theoretic meaning of entropy does not apply here, entropy provides a single summary value that captures the variability of choices in a set of discrete categories—such as 16 metric positions. In brief, the more probabilities are concentrated around a small number of values the lower the entropy score. Conversely, if probability is evenly distributed across all categories entropy is maximized. Thus, high entropy is indicative of lower predictability.

Here only the entropy of the highest rhythmic layer, stressed rhymed syllables, is considered. The overall entropy of rhymed syllables in the entire corpus (i.e. of the distribution shown in red in Figure 5.5) is 3.56. To compare entropy scores across artists, it is essential to apply the calculation to samples of equal sizes—larger samples ofter more opportunity for variation, which tends to increase entropy as sample size increases. Thus, one hundred rhymed syllables were sampled at random from the thirty emcees with at least 100 rhymed syllables in the corpus and the entropy was calculated for these samples. Between these thirty emcees, the entropy of the metric position of rhymes varies from a low of 2.08 (Kurtis Blow) to a high of 3.67 (Eminem). Though sample size has been accounted for, the variability in the metric position of rhymes clearly parallels variation in rhyme density—this is not surprising since packing more rhymes inevitably requires placing rhymes on more metric positions.[38] Given this parallel, it is not surprising that the entropy of metric positions of rhymes

[38]There is also a lack of data independence here which may affect the results. Eminem has more songs in the corpus than Kurtis Blow, so if significant variation occurs between songs, this may be falsely attributed to variation between emcees.

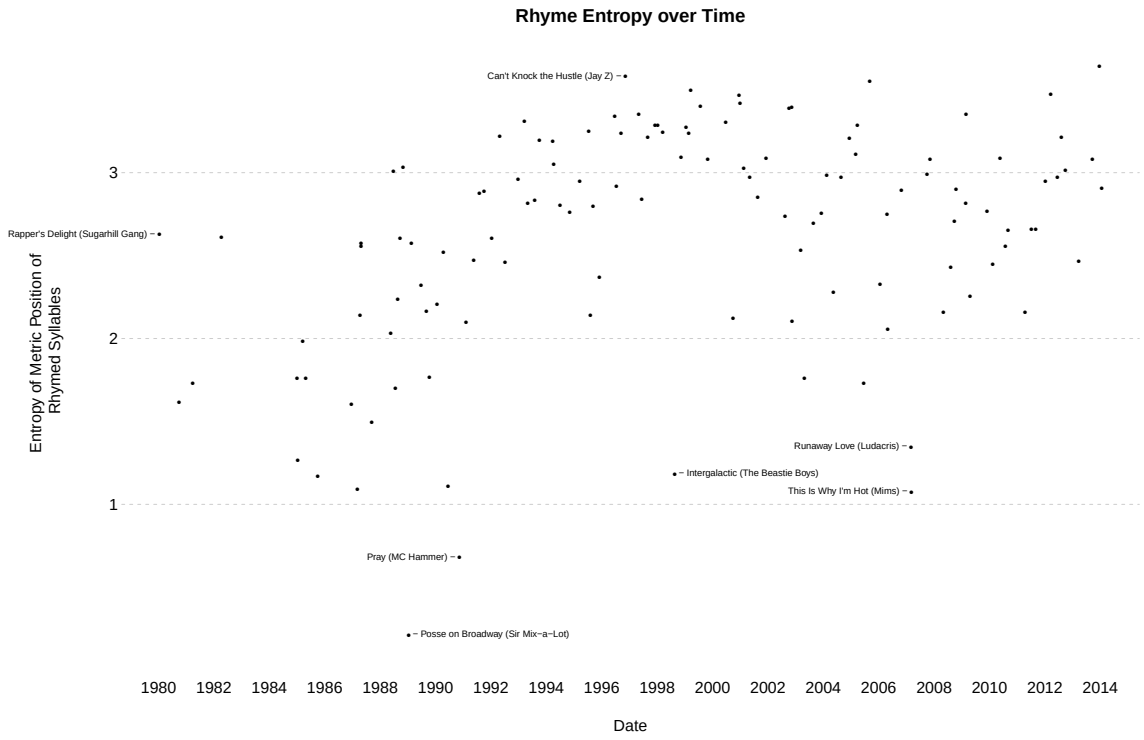

Figure 5.8: Entropy of rhyme metric positions over time. To base entropy calculations on equal sample sizes, 50 rhymed syllables were randomly sampled from each song to calculate the values shown here. Some songs had fewer than 50 rhymed syllables, which may depressed their entropy values compared to other songs.

over time is similar to rhyme density over time: Figure 5.8 shows the normalized ($n = 50$) entropy scores for each song in the corpus, plotted against their peak date.

Entropy scores are highly abstract; to give a conceptual impression of their meaning Figure 5.9 compares the distribution of rhymed syllables in Kurtis Blow (entropy = 2.08) with that of Ludacris (entropy = 3.56). As can be seen, Kurtis Blow concentrates more than half of his rhymes around beat four and the 𝅘𝅥𝅯 before beat four, with few rhymes on other locations. In contrast, Ludacris distributes far more of his rhymes on various weak subdivisions, leading to a much higher entropy score.

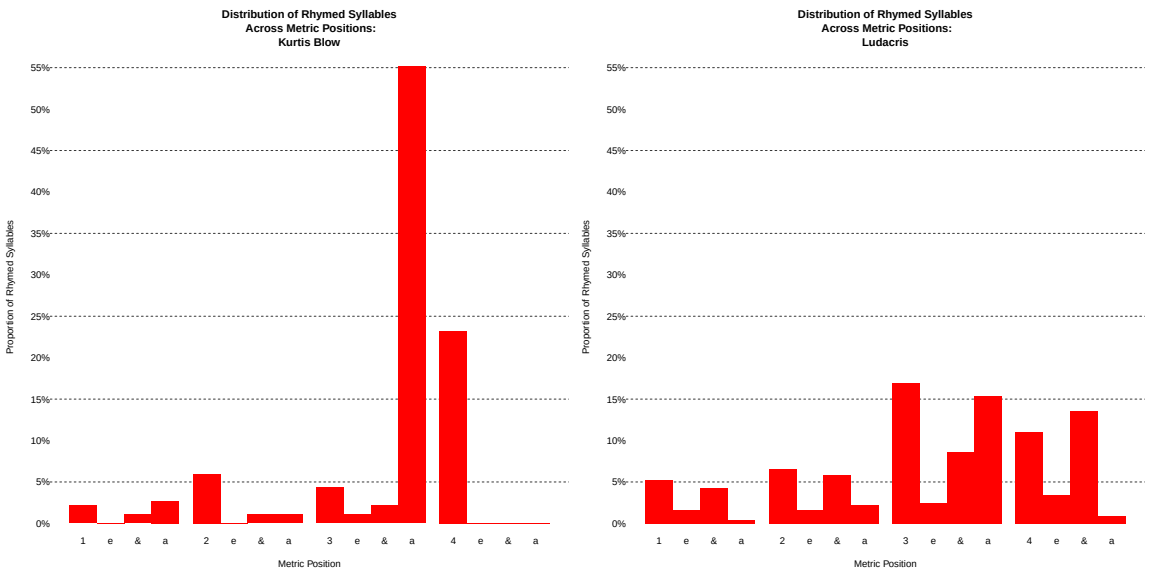

Figure 5.9: Comparison of metric distributions of rhyme from a low-entropy artist (Kurtis Blow), left panel, and a high-entropy artist (Ludacris), right panel.

1st-order Rhyme Patterns

Since music is experienced in real time, treating syllables or rhymes as independent events is unrealistic. Fortunately, it is a simple matter to condition entropy on a previous event—the probability of each consequent metric rhyme position given the metric position of the antecedent rhyme. In other words, given a marked syllable on a particular metric position, when is the rhyme likely to be clinched? We can visualize conditional rhyme-couplet relationships in a two dimensional figure, as in Figure 5.10. The left plot in Figure 5.10 shows the joint probability of each rhyme pair—each circle represents a proportion of the total. In the left plot it can be seen that, in MCFlow, the most common metric arrangement of an antecedent-consequent relationship is for a rhyme on beat four to be answered on beat four. The right plot shows the conditional probability given an antecedent rhyme—each circle represents the proportion of the

row it belongs in. All dots on the middle diagonal of these first-order figures represent rhymes separated by exactly one measure. A dot just above the middle diagonal represents a rhyme that appears one 𝅘𝅥𝅯 earlier than a measure—conversely, dots just below the middle diagonal represent rhymes that appear one 𝅘𝅥𝅯 "late."

The first-order conditional entropy of rhymes among MCFlow emcees (with sample sizes normalized to $n = 100$) ranges from a low of 0.74 (Nelly) to 2.19 (Will Smith). Nelly and Will Smith's conditional rhyme distributions are illustrated in Figure 5.11. The difference in conditional entropy between Nelly and Will Smith is starkly visible in this plot: for any given antecedent rhyme position, Nelly chooses from a far smaller, far more predictable, set of consequents. Conversely, the moments at which Will Smith clinches his rhymes are relatively unpredictable, often occuring later or earlier than one would expect given the "norms" of rap. This difference in rhyme predictability may reflect a stylistic difference between the two emcees' flow, giving them different aesthetic qualities or feels.

5.1.4 Phrasing

As a final illustrative analysis, consider the metric position of phrases in the metric grid. For this analysis, phrases are simply defined by the appearance of either a /3/ or a /4/ in the prosodic **break spine. Figure 5.12 illustrates the metric position of the 7,889 phrases in MCFlow: each phrase in the corpus is plotted as an arrow from left to right across the metric grid. The starting point of the arrows represent the metric position of the first syllable in the phrase—these starting points are staggered vertically to increase legibility. Each arrowhead represents the metric position of the last syllable in the phrase. The position of each arrows is randomly "jittered" slightly,

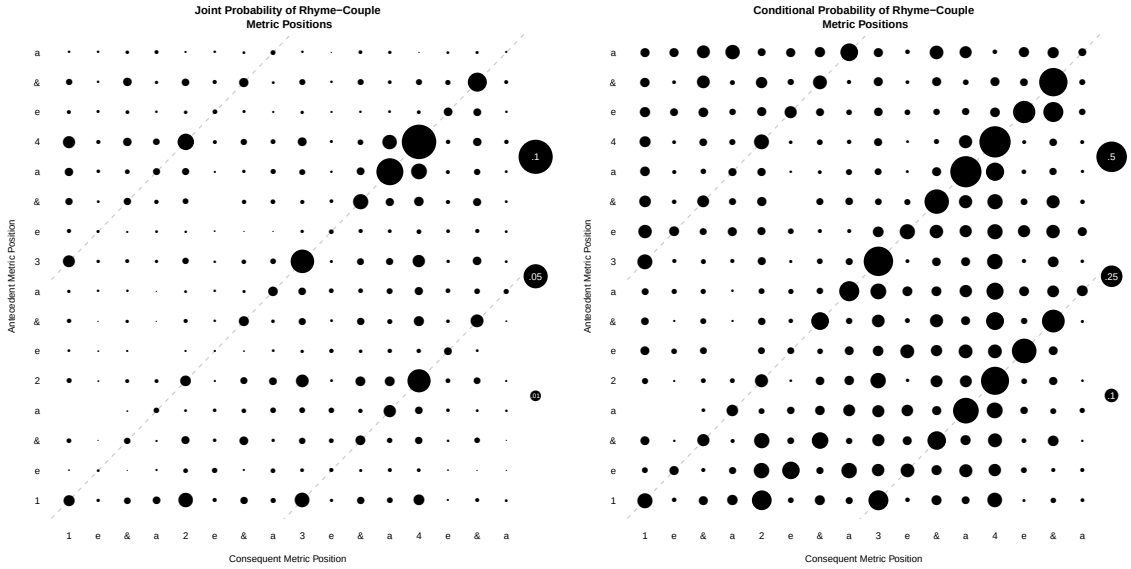

Figure 5.10: Joint (left) and conditional (right) probabilities of antecedent/consequent rhyme-pair metric positions. The middle diagonal marks rhymes separated by exactly one measure while the other two diagonals represent rhymes separated by two beats. The *area* of each circle represents the probability of that rhyme-couplet metric pairing—three circles to the right of each plot give a key to the sizes.

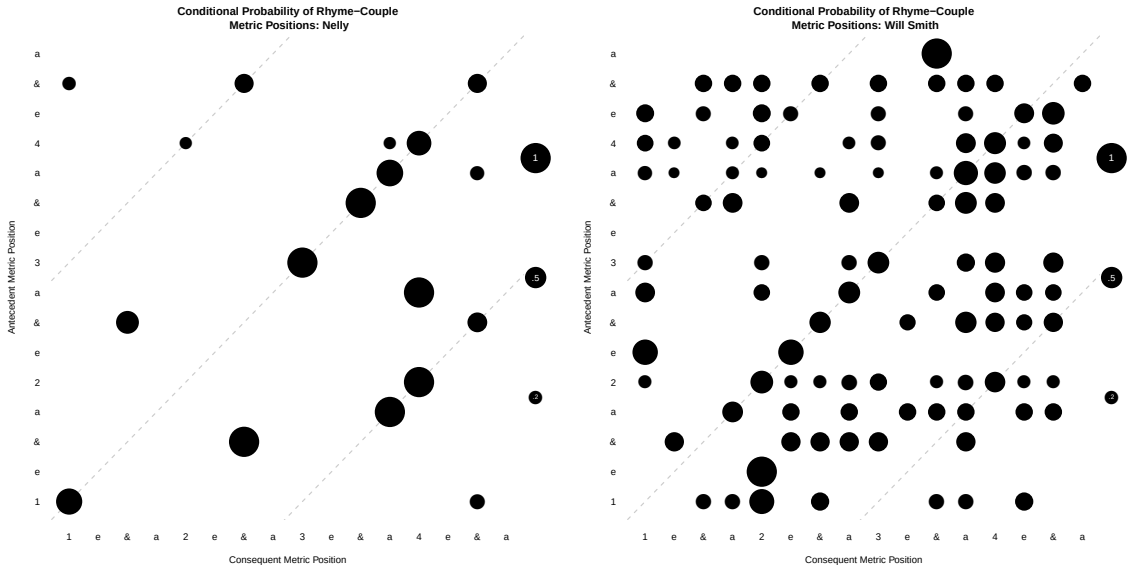

Figure 5.11: Conditional probabilities of antecedent/consequent rhyme-pair metric positions in performances by Nelly (left) and Will Smith (right). The middle diagonal marks rhymes separated by exactly one measure while the other two diagonals represent rhymes separated by two beats. The *area* of each circle represents the probability of that rhyme-couplet metric pairing—three circles to the right of each plot give a key to the sizes.

so that an overall impression of the density of arrows at all points can be roughly discerned—denser darker areas show more phrase density. From inspecting Figure 5.12 one can discern that the majority of phrases in MCFlow begin on, or immediately before, beat one and end around beat four. Two-beat phrases, either spanning beat one→beat two or beat three→beat four are also common. However, there is a huge number of other phrase arrangements. The metric position of phrases may reflect different qualitative "feels" for rap flow. More important may be how emcees arrange and vary consecutive phrases within a verse—a question not considered here, but which could be addressed using the MCFlow dataset.

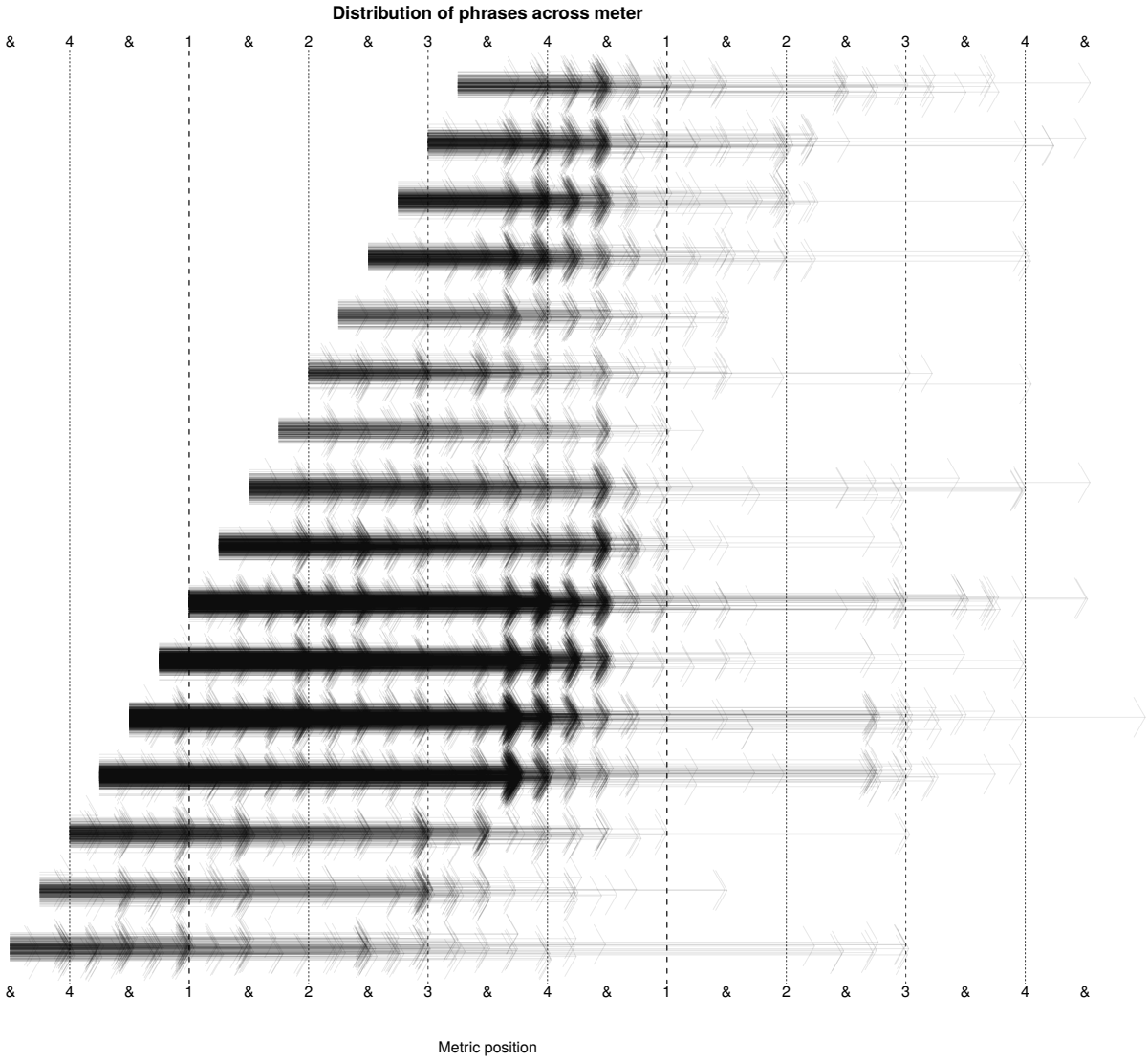

Figure 5.12: Each of the 7,889 phrases in MCFlow is plotted as an arrow starting at the metric position of the phrases' first syllable and ending at the metric position of the phrase's final syllable. The position of each arrow is slightly "jittered" so that the overall density of arrows at each location can be discerned.

Chapter 6: Sharing MCFlow

The goal of the MCFlow project is to promote and support a variety of research regarding the artistry of rap. Accordingly, the MCFlow dataset is freely available to any interested party, and can be downloaded at any time from the website www.rapscience.net. A limited toolkit of functions designed to afford the visualization and analysis of MCFlow data is also openly available at this site. Complete details for accessing the dataset and toolkit are presented in Appendix D.

Large datasets like MCFlow are primarily intended to support large-scale mass-analyses of the sort presented in Chapter 5. Unfortunately, this type of research requires significant computer-science experience and may appear daunting to many music scholars. To make MCFlow data more accessible to scholars with limited computer-science experience, a Graphical User Interface (GUI) was implemented and deployed at the www.rapscience.net site. This GUI allows users to create a variety of visualizations of MCFlow data, including recreating the various plots presented in Chapter 5 with various subsets of the MCFlow. For instance, a user can compare the metric position of rhymes between Ja Rule and 50 Cent. However, the most useful visualizations produced by the MCFlow GUI are *flow diagrams*. *Flow diagrams*

are highly intuitive visual "scores" of rap passages (described below). Many scholars, especially music theorists who engage extensively in score-based research, could potentially achieve much from thoughtful analysis of MCFlow flow diagrams.

Outside of the scholarly community, there is also a substantial number of lay hip-hop enthusiasts interested in discussing the artistic details of rap. Several popular websites exist which are dedicated to rap artistry and numerous blog-based discussions can be found. Notably, the website www.genius.com—a repository of "crowdsourced musical knowledge"—offers the community an area to discuss the interpretation of rap lyrics. Another interesting site is the page www.rapanalysis.com, which features a number of close-analyses of rap passages and outlines the basics of a "rap music theory." It seems possible that many of the users who visit these sites would be interested in exploring MCFlow, especially through the GUI. It is hoped that by engaging the wider non-academic community in theoretical discussion of rap, www.rapscience.net and MCflow can foster wider appreciation of rap's artistic value.

6.1 Flow Diagrams

A *flow diagram* is a graphical representation of rap which is optimized for viewing the structure of rap flow. In many cases, flow diagrams are more useful for visualizing rap than traditional notation. In a flow diagram, each measure of text is written above the next with syllables in all measures vertically aligned by metric position. Thus, all syllables that land on, for instance, beat two are aligned vertically. Figure 6.1 shows a flow diagram of the first eight measures of the first verse of the song "Money Maker" (2006) by Ludacris.

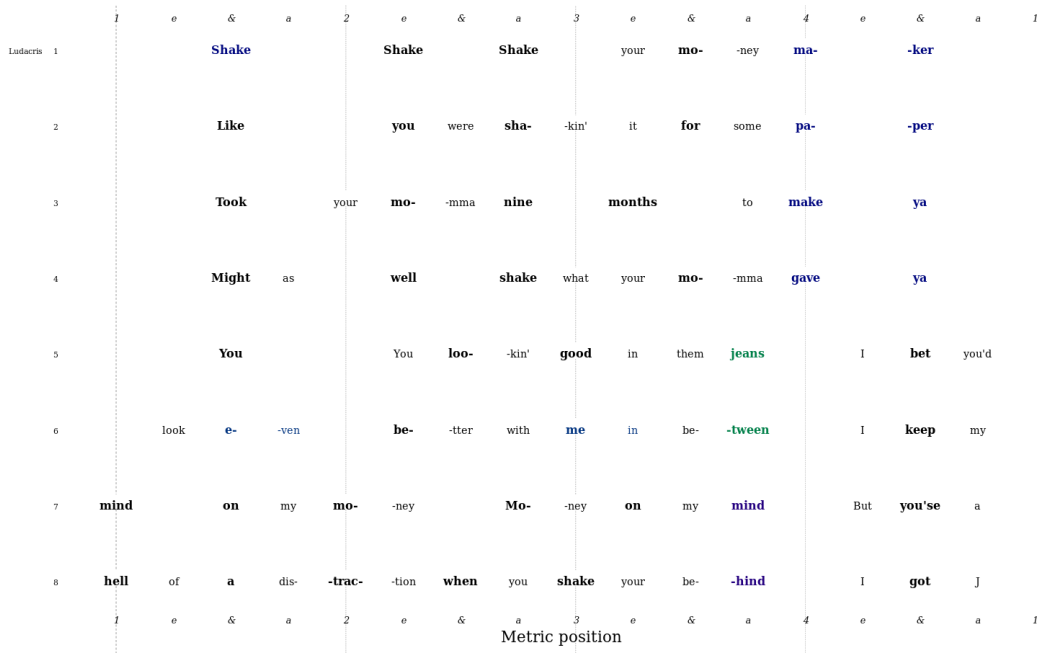

Figure 6.1: A traditional rap *flow diagram* of the first eight measures of the first verse of Ludacris' "Money Maker" (2006). Stressed syllables are shown in bold. Rhyme chains are color coded. This graphic is a screen-shot from the www.rapscience.net MCFlow GUI.

The flow diagram is a well-established approach to notating rap: some emcees themselves write their lyrics in flow diagram-like arrangements as part of their composition process (Edwards, 2009, p. 67), and several scholars have adopted flow diagrams for music theoretic use (Adams, 2008, 2009). However, the MCFlow GUI introduces a number of variations to the basic flow diagram that can afford more nuanced visual analysis of rap flow. (Full details of these options are presented in Appendix D.) One special option is the ability to filter flow diagrams by rhythmic layer—for instance plotting only stressed or rhymed syllables. Another option is to change the "metric wavelength" of flow diagram lines—for instance, creating flow diagrams in which each line is two measures or two beats instead of one measure. This option, allows more flexibility in representing flows with various styles. What's more, odd-numbered

wavelengths can be employed, which can be an effective means of visually searching for cross-rhythms.

Wrapping rap flow by a fixed metric size has the disadvantage of obscuring phrasing patterns. For instance, phrases that begin as pickups must cross lines from the right side of the page to the left. The most original feature of MCFlow flow diagrams is the option to wrap lines by phrase (determined as desired by the **break or **lyrics spine) instead of by a fixed metric unit, all the while keeping syllables in all phrases metrically aligned. Figure 6.2 shows the same passage from Ludacris' "Money Maker" plotted with one (prosody-defined) phrase per line. This approach can lead to some ambiguity and lack of clarity as a performance score, but has distinct advantages in analyzing musical structure. For instance, it can now be seen that beginning with phrase six, Ludacris shifts the metric position of his phrases. It also shows where Ludacris delivers two two-beat phrases in one measure /mind on my money... money on my mind/.

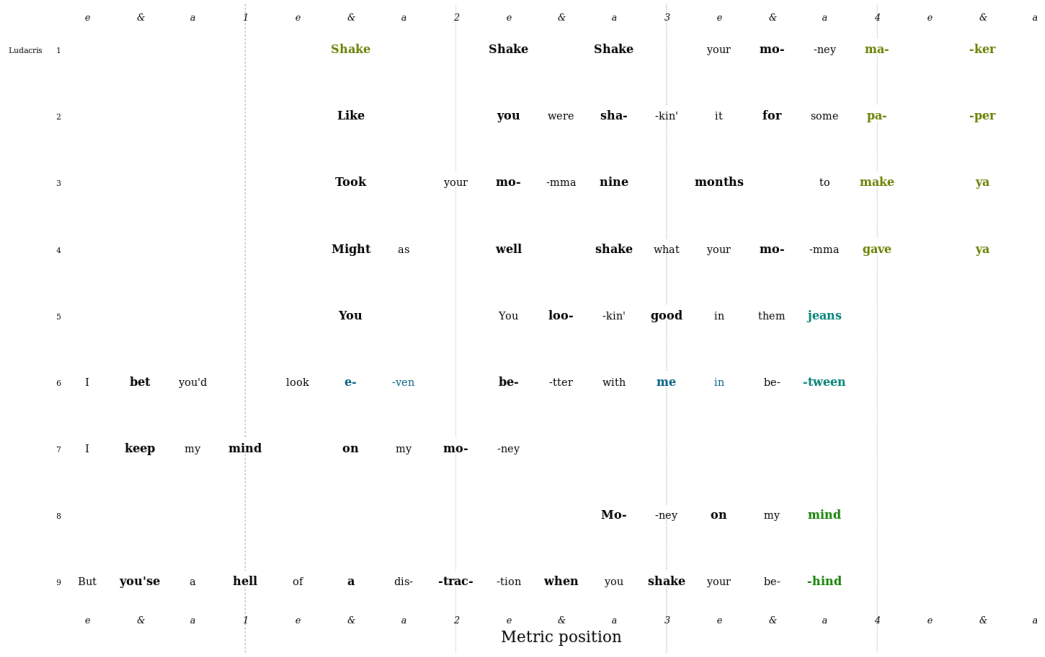

Figure 6.2: A phrase-wrapped *flow diagram* of the first eight measures of the first verse of Ludacris' "Money Maker" (2006). In this diagram, each prosodic phrase in the flow is plotted on it's own line, while still aligned metrically with the previous line. This makes it easier to see variation in the metric position of phrases. This graphic is a screen-shot from the www.rapscience.net MCFlow GUI.

Chapter 7: Conclusions

Summary

This dissertation had described the motivation, methodology, structure and content of a symbolic corpus of rap vocal transcriptions known as the Musical Corpus of Flow (MCFlow). MCFlow currently consists of 124 transcriptions of popular rap songs. However, MCFlow is a work in progress and, as explained in Chapter 4, the ultimate sampling target consists of over two hundred songs. Each MCFlow transcription contains information regarding rhythm, prosody, lyrics, syntax, pronunciation, and rhyme. Rhythmic information is encoded at a "syntactic level," similar to traditional music notation, which ignores "subsyntactic" rhythmic nuances. Encoded prosodic information (aside from rhythm) includes syllable stress and pitch accents, prosodic boundaries, and rhyme-like prosodic parallelisms (chymes). Two prosodic spines in MCFlow transcriptions mirror tiers from the well established ToBI prosodic encoding scheme. Lyrics are transcribed in standard-English orthography with all proper nouns identified and with syntactic and meaningful boundaries annotated. The actual pronunciation of lyrics are encoded in the International Phonetic Alphabet. A "two-dimensional" rhyme scheme encoding identifies the single and multi-syllable "rhyme units" and their relationships to other spoken events. Finally, a compressed

version of the encoding scheme is used to transcribe any secondary rapped voices (hype) in the music. The motivation of each element of this encoding scheme was explained as part of a theoretical outline of the "rudiments" of rap flow presented in Chapter 3.

This work has also presented some simple preliminary analyses of flow in the current MCFlow dataset (presented in Chapter 5). A number of possible historical trends were observed, including an increase in rhyme density through approximately 2002 (consistent with observation in other research), a decrease in the tempo of rap accompaniments through to the present, and an increase in the variability (specifically the entropy) of the metric placement of rhymes. In most analyses, it also appears that flow style varies between emcees—for instance, emcee Big Boi seems to rap much faster than emcee Lil' Wayne. However, these preliminary analyses are purely descriptions of the MCFlow sample. Inferential statistical models will be necessary to adequately test the generality of these observations in the "population" of rap as a whole.

MCFlow is intended to afford a variety of research programs, including ones that may have not occurred to the author. Thus, the scope of MCFlow is broad, with many pieces of information encoded in minimal, or moderate, detail. No part of the dataset's sampling or encoding scheme is optimized to address any particular line of inquiry in depth. For instance, the sampling scheme compromises between the demands of historical analysis and artist comparison, affording either line of research but not ideal for either. Due to these compromises, MCFlow will not be the best tool for testing very specific, precise, hypotheses. Rather, MCFlow will be most useful as a tool for exploratory analysis of rap flow, using thoughtful statistical modeling to

search for patterns but not to make strong conclusions. Any patterns discovered in MCFlow, even if they appear statistically sound, ought to be independently tested with more hypothesis-specific datasets. For instance, it appears that emcees vary considerably in the density of their rhyme usage. To precisely test this observation as a scientific hypothesis, the ideal dataset would maximize data independence and sample equal numbers of data points from a large number of emcees. One might select one hundred emcees at random (perhaps systematically by year) and randomly sample one syllable from each of fifty randomly selected verses by each emcee, only encoding whether or not that syllable was involved in a rhyme. Such a dataset would be significantly smaller and easier to assemble than MCFlow (5,000 data points instead of $500,000+$), but, by maximizing data independence and carefully controlling for confounding factors, would be more useful than MCFlow for testing this specific hypothesis. Of course, this hypothetical dataset would be useless for testing other hypotheses. In contrast, MCFlow serves as a flexible tool for a wide variety of exploratory analyses.

Future Work

Throughout the dissertation I have attempted to be clear about the weaknesses of MCFlow, including the lack of timbral information, lack of pitch detail, lack of information regarding accompanying beats, and lack of micro-timing information. In time I intend to incorporate this information, and more, into MCFlow transcriptions. Furthermore, once the current sampling plan is complete, I intend to supplement MCFlow with samples from a more diverse set of rap, including non-single tracks and relatively unpopular "underground" rap. Regarding historical trends, it seems likely

that many innovations in flow are first introduced "underground" and only gradually filter into the mainstream rap currently represented in MCFlow.

MCFlow is a means to an end. The interesting work has yet to be done. There are countless areas of inquiry which might be pursued, at least in their preliminary exploratory stages, using MCFlow. Many of these potential research programs have been hinted at or commented upon in this dissertation, such as the question raised in Section 3.3 regarding the relative scope of flow variation between emcees versus between songs. Myriad other somewhat obvious questions have not been stated: have rhyme-chains gotten longer over time? What proportion of rhymes are internal rhymes? What are the most common rhythmic motives? How often do emcees change the metric position of their phrases? In fact, historical trends in any of the data encoded in MCFlow may be of great interest. From the perspective of music cognition and perception, it has been suggested that MCFlow may be used as a tool for modelling the implicit knowledge of a "typical" rap listener. If this proposition is valid, MCFlow could be used as a resource for modelling the perception of rap in real time. Most of the descriptive analyses presented in Chapter 5 take an essentially static, out-of-time, approach to flow. However, Section 5.1.3 considered the probability of rhyme metric positions given a previous one, which (it could be argued) might parallel listeners' expectations regarding the "resolution" rhymed couplets. Higher-order conditional models could further expand upon this line of thought. There are no doubt many other interesting lines of inquiry which have not occurred to the author.

The methodology and motivation of MCFlow is clearly biased towards an empirical way of thinking. However, abstract "norms" or generalizations about flow are not necessarily interesting in themselves, but serve as a point of comparison for more

detailed analyses of individual musical passages. Thus, MCFlow can inform the sort of humanistic close-reading favored by many music theorists, and perhaps even contribute to critical discussion of rap and to general rap music appreciation. Questions regarding the music/text relationship may also be of interest to both musical and literary scholars. MCFlow might also be of interest regarding socio-cultural questions: does flow style reflect regional affiliation? How have changes in flow—for instance, increases in rhyme density—affected the cultural perception of hip-hop? Does complex, virtuosic, flow signal a desire to be taken seriously intellectually—if so, maybe complex flow will coincide with more "intellectual" vocabulary? Does simple laid-back flow signal authenticity and honesty?

It is my sincere hope that MCFlow will be of interest not only to scholars with significant empirical and/or computer-science backgrounds, but also to music theorists, musicologists, and other more traditionally humanistic scholars. What's more, I hope that lay rap enthusiasts will find MCFlow an intriguing new avenue for understanding appreciating their cherished music.

Rap is a sophisticated musical/poetic art form, overflowing with creative and beautiful displays of musical ingenuity. By affording the detailed analysis of a large sample of rap flow, I hope to contribute in some small way to a greater holistic understanding of rap musicality.

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Appendix A: List of Songs in Target Sample

The following table lists the songs in the sampling target, sorted by year.

Artist	Song	Peak	Year	Criteria	Sampled?
the Sugar Hill Gang	Rapper's Delight	36	1980	Yearly Top 5	Yes
Kurtis Blow	The Breaks - Part 1	87	1980	Yearly Top 5	Yes
the Sugar Hill Gang	8th Wonder	82	1981	Yearly Top 5	Yes
the Sugar Hill Gang	Apache	53	1982	Yearly Top 5	Yes
Kurtis Blow	Basketball	71	1985	Yearly Top 5	Yes
UTFO	Roxanne, Roxanne	77	1985	Yearly Top 5	Yes
Whodini	Friends	87	1985	Yearly Top 5	Yes
Whodini	Five Minutes Of Funk	NA	1985	Yearly Top 5	Yes
Run DMC	Walk This Way	4	1986	Yearly Top 5	
Run DMC	You Be Illin'	29	1986	Yearly Top 5	Yes
the Beastie Boys	(You Gotta) Fight For Your Right (To Party!)	7	1987	Yearly Top 5	Yes
LL Cool J	I Need Love	14	1987	Yearly Top 5	Yes
the Beastie Boys	Brass Monkey	48	1987	Yearly Top 5	Yes
Run DMC	It's Tricky	57	1987	Yearly Top 5	Yes
LL Cool J	I'm Bad	84	1987	Yearly Top 5	
Kool Moe Dee	Go See The Doctor	89	1987	Oldschool	Yes
Ron & The D.C. Crew	Ronnie's Rapp	93	1987	Oldschool	
Will Smith	Parents Just Don't Understand	12	1988	Yearly Top 5	Yes
Will Smith	A Nightmare On My Street	15	1988	Yearly Top 5	
Salt 'N Pepa	Push It	19	1988	Yearly Top 5	
J.J. Fad	Supersonic	30	1988	Yearly Top 5	
LL Cool J	Going Back To Cali	31	1988	Yearly Top 5	
Rob Base & D.J. E-Z Rock	It Takes Two	36	1988	Oldschool	Yes
Will Smith	Girls Ain't Nothing But Trouble	57	1988	Oldschool	
J.J. Fad	Way Out	61	1988	Oldschool	
Kool Moe Dee	Wild, Wild West	62	1988	Oldschool	Yes
Ice-T	Colors	70	1988	Oldschool	Yes
Run DMC	Mary, Mary	75	1988	Oldschool	Yes
World Class Wreckin' Cru	Turn Off The Lights	84	1988	Oldschool	
J.J. Fad	Is It Love	92	1988	Oldschool	
Tone Loc	Wild Thing	2	1989	Yearly Top 5	Yes
Neneh Cherry	Buffalo Stance	3	1989	Yearly Top 5	Yes
Tone Loc	Funky Cold Medina	3	1989	Yearly Top 5	
Young M.C.	Bust A Move	7	1989	Yearly Top 5	Yes
Neneh Cherry	Kisses On The Wind	8	1989	Yearly Top 5	
LL Cool J	I'm That Type Of Guy	15	1989	Oldschool	
2 Live Crew	Me So Horny	26	1989	Oldschool	
De La Soul	Me Myself And I	34	1989	Oldschool	
the Beastie Boys	Hey Ladies	36	1989	Oldschool	Yes
Rob Base & D.J. E-Z Rock	Joy And Pain	58	1989	Oldschool	
Will Smith	I Think I Can Beat Mike Tyson	58	1989	Oldschool	
House Of Lords	I Wanna Be Loved	58	1989	Oldschool	
Sir Mix-A-Lot	Posse On Broadway	70	1989	Oldschool	Yes
Vanilla Ice	Ice Ice Baby	1	1990	Yearly Top 5	
M.C. Hammer	Pray	2	1990	Yearly Top 5	Yes
M.C. Hammer	Have You Seen Her	4	1990	Yearly Top 5	
M.C. Hammer	U Can't Touch This	8	1990	Yearly Top 5	Yes
Candyman	Knockin' Boots	9	1990	Yearly Top 5	
Marky Mark & The Funky Bunch	Good Vibrations	1	1991	Yearly Top 5	Yes
Will Smith	Summertime	4	1991	Yearly Top 5	Yes
Vanilla Ice	Play That Funky Music	4	1991	Yearly Top 5	Yes
Naughty By Nature	O.P.P.	6	1991	Yearly Top 5	
Gerardo	Rico Suave	7	1991	Yearly Top 5	
LL Cool J	Around The Way Girl	9	1991	Top 32 Artist	
Salt 'N Pepa	Let's Talk About Sex	13	1991	Top 32 Artist	
Salt 'N Pepa	Do You Want Me	21	1991	Top 32 Artist	
Sir Mix-A-Lot	Baby Got Back	1	1992	Yearly Top 5	Yes
Kris Kross	Jump	1	1992	Yearly Top 5	Yes
Wreckx-N-Effect	Rump Shaker	2	1992	Yearly Top 5	Yes
M.C. Hammer	2 Legit 2 Quit	5	1992	Yearly Top 5	Yes
Arrested Development	Tennessee	6	1992	Yearly Top 5	

Snow	Informer	1	1993	Yearly Top 5	
Tag Team	Whoomp! There It Is	2	1993	Yearly Top 5	Yes
Dr. Dre	Nuthin' But A "G" Thang	2	1993	Yearly Top 5	Yes
Salt 'N Pepa	Shoop	4	1993	Yearly Top 5	
Onyx	Slam	4	1993	Yearly Top 5	
2Pac	I Get Around	11	1993	Top 32 Artist	Yes
Run DMC	Down With The King	21	1993	Top 32 Artist	Yes
Warren G	Regulate	2	1994	Yearly Top 5	Yes
Salt 'N Pepa	Whatta Man	3	1994	Yearly Top 5	
Coolio	Fantastic Voyage	3	1994	Yearly Top 5	
Da Brat	Funkdafied	6	1994	Yearly Top 5	
Domino	Getto Jam	7	1994	Yearly Top 5	
Snoop Dogg	Gin And Juice	8	1994	Top 32 Artist	Yes
2Pac	Keep Ya Head Up	12	1994	Top 32 Artist	
Coolio	Gangsta's Paradise	1	1995	Yearly Top 5	Yes
the Notorious B.I.G.	One More Chance/Stay With Me	2	1995	Yearly Top 5	Yes
LL Cool J	Hey Lover	3	1995	Yearly Top 5	Yes
Wu-Tang Clan	I'll Be There For You/You're All I Need To Get By	3	1995	Yearly Top 5	
the Notorious B.I.G.	Big Poppa	6	1995	Yearly Top 5	Yes
2Pac	Dear Mama	9	1995	Top 32 Artist	
the Notorious B.I.G.	Player's Anthem	13	1995	Top 32 Artist	
2Pac	How Do U Want It	1	1996	Yearly Top 5	Yes
Bone Thugs N Harmony	Tha Crossroads	1	1996	Yearly Top 5	
Quad City DJ's	C'Mon N' Ride It (The Train)	3	1996	Yearly Top 5	
LL Cool J	Loungin'	3	1996	Yearly Top 5	
Coolio	1,2,3,4 (Sumptin' New)	5	1996	Yearly Top 5	
2Pac	California Love	6	1996	Top 32 Artist	Yes
Busta Rhymes	Woo-Hah! Got You All In Check	8	1996	Top 32 Artist	
OutKast	Elevators (Me & You)	12	1996	Top 32 Artist	
Puff Daddy	I'll Be Missing You	1	1997	Yearly Top 5	Yes
the Notorious B.I.G.	Mo Money, Mo Problems	1	1997	Yearly Top 5	Yes
Puff Daddy	Can't Nobody Hold Me Down	1	1997	Yearly Top 5	
the Notorious B.I.G.	Hypnotize	1	1997	Yearly Top 5	Yes
Bone Thugs N Harmony	Look Into My Eyes	4	1997	Yearly Top 5	
Nas	Street Dreams	22	1997	Top 32 Artist	
Will Smith	Gettin' Jiggy Wit It	1	1998	Yearly Top 5	Yes
Lauryn Hill	Doo Wop (That Thing)	1	1998	Yearly Top 5	Yes
Puff Daddy	It's All About The Benjamin's	2	1998	Yearly Top 5	
Puff Daddy	Come With Me	4	1998	Yearly Top 5	
Puff Daddy	Been Around The World	4	1998	Yearly Top 5	
the Fugees	Gone Till November	7	1998	Top 32 Artist	
Busta Rhymes	Dangerous	9	1998	Top 32 Artist	
Busta Rhymes	Turn It Up (Remix)/Fire It Up'	10	1998	Top 32 Artist	
the Beastie Boys	Intergalactic	28	1998	Top 32 Artist	Yes
DMX	Get At Me Dog	39	1998	Top 32 Artist	
Will Smith	Wild Wild West	1	1999	Yearly Top 5	Yes
Puff Daddy	Satisfy You	2	1999	Yearly Top 5	Yes
Busta Rhymes	What's It Gonna Be?!	3	1999	Yearly Top 5	
JT Money	Who Dat	5	1999	Yearly Top 5	
Naughty By Nature	Jamboree	10	1999	Yearly Top 5	
the Fugees	Ex-Factor	21	1999	Top 32 Artist	
Eminem	The Real Slim Shady	4	2000	Yearly Top 5	Yes
Missy Elliott	Hot Boyz	5	2000	Yearly Top 5	
Nelly	(Hot Shit) Country Grammar	7	2000	Yearly Top 5	
Jay-Z	I Just Wanna Love U (Give It 2 Me)	11	2000	Yearly Top 5	Yes
Ja Rule	Between Me And You	11	2000	Yearly Top 5	
Bow Wow	Bounce With Me	20	2000	Top 32 Artist	
DMX	Party Up (Up In Here)	27	2000	Top 32 Artist	
DMX	What You Want	49	2000	Top 32 Artist	
OutKast	Ms. Jackson	1	2001	Yearly Top 5	Yes
Eve	Let Me Blow Ya Mind	2	2001	Yearly Top 5	Yes
Nelly	Ride Wit Me	3	2001	Yearly Top 5	
Lil' Romeo	My Baby	3	2001	Yearly Top 5	
Ja Rule	Livin' It Up	6	2001	Yearly Top 5	Yes
Missy Elliott	Get Ur Freak On	7	2001	Top 32 Artist	
Ja Rule	Put It On Me	8	2001	Top 32 Artist	
Missy Elliott	One Minute Man	15	2001	Top 32 Artist	
DMX	Who We Be	60	2001	Top 32 Artist	
Nelly	Dilemma	1	2002	Yearly Top 5	Yes
Nelly	Hot In Herre	1	2002	Yearly Top 5	
Ja Rule	Always On Time	1	2002	Yearly Top 5	
Eminem	Lose Yourself	1	2002	Yearly Top 5	Yes
Fat Joe	What's Luv?	2	2002	Yearly Top 5	
Missy Elliott	Work It	2	2002	Top 32 Artist	Yes
Puff Daddy	I Need A Girl (Part One)	2	2002	Top 32 Artist	
Jay-Z	'03 Bonnie & Clyde	4	2002	Top 32 Artist	
LL Cool J	Luv U Better	4	2002	Top 32 Artist	
Fat Joe	We Thuggin'	15	2002	Top 32 Artist	
the Fugees	Two Wrongs	28	2002	Top 32 Artist	
Nas	One Mic	43	2002	Top 32 Artist	
OutKast	Hey Ya!	1	2003	Yearly Top 5	
Nelly	Shake Ya Tailfeather	1	2003	Yearly Top 5	
50 Cent	In Da Club	1	2003	Yearly Top 5	Yes
Ludacris	Stand Up	1	2003	Yearly Top 5	Yes
50 Cent	21 Questions	1	2003	Yearly Top 5	
Ja Rule	Mesmerize	2	2003	Top 32 Artist	
Busta Rhymes	I Know What You Want	3	2003	Top 32 Artist	
Fabolous	Into You	4	2003	Top 32 Artist	

Fabolous	Into You	4	2003	Top 32 Artist	
Fabolous	Can't Let You Go	4	2003	Top 32 Artist	
Snoop Dogg	Beautiful	6	2003	Top 32 Artist	Yes
Nas	I Can	12	2003	Top 32 Artist	
Bow Wow	Let's Get Down	14	2003	Top 32 Artist	
Nas	Made You Look	32	2003	Top 32 Artist	
DMX	X Gon' Give It To Ya	60	2003	Top 32 Artist	
OutKast	The Way You Move	1	2004	Yearly Top 5	Yes
Snoop Dogg	Drop It Like It's Hot	1	2004	Yearly Top 5	Yes
Terror Squad	Lean Back	1	2004	Yearly Top 5	Yes
Juvenile	Slow Motion	1	2004	Yearly Top 5	
Twista	Slow Jamz	1	2004	Yearly Top 5	
Ja Rule	Wonderful	5	2004	Top 32 Artist	
Ludacris	Splash Waterfalls	6	2004	Top 32 Artist	
OutKast	Roses	9	2004	Top 32 Artist	
Fabolous	Breathe	10	2004	Top 32 Artist	
the Beastie Boys	Ch-Check It Out	68	2004	Top 32 Artist	Yes
Kanye West	Gold Digger	1	2005	Yearly Top 5	Yes
50 Cent	Candy Shop	1	2005	Yearly Top 5	Yes
the Game	Hate It Or Love It	2	2005	Yearly Top 5	
the Black Eyed Peas	My Humps	3	2005	Yearly Top 5	
50 Cent	Disco Inferno	3	2005	Yearly Top 5	Yes
Missy Elliott	Lose Control	3	2005	Top 32 Artist	
50 Cent	Just A Lil Bit	3	2005	Top 32 Artist	Yes
Bow Wow	Like You	3	2005	Top 32 Artist	
Young Jeezy	Soul Survivor	4	2005	Top 32 Artist	
Bow Wow	Let Me Hold You	4	2005	Top 32 Artist	
Will Smith	Switch	7	2005	Top 32 Artist	
T.I.	Bring Em Out	9	2005	Top 32 Artist	
Fat Joe	Get It Poppin'	9	2005	Top 32 Artist	
Nelly	Grillz	1	2006	Yearly Top 5	Yes
Ludacris	Money Maker	1	2006	Yearly Top 5	Yes
T.I.	What You Know	3	2006	Yearly Top 5	Yes
LL Cool J	Control Myself	4	2006	Yearly Top 5	Yes
Eminem	Shake That	6	2006	Yearly Top 5	
Bow Wow	Shortie Like Mine	9	2006	Top 32 Artist	
Young Jeezy	I Luv It	14	2006	Top 32 Artist	
Rick Ross	Hustlin'	54	2006	Top 32 Artist	
Kanye West	Stronger	1	2007	Yearly Top 5	Yes
Mims	This Is Why I'm Hot	1	2007	Yearly Top 5	Yes
Ludacris	Runaway Love	2	2007	Yearly Top 5	Yes
50 Cent	Ayo Technology	5	2007	Yearly Top 5	
Bone Thugs N Harmony	I Tried	6	2007	Yearly Top 5	
Kanye West	Good Life	7	2007	Top 32 Artist	Yes
Fabolous	Make Me Better	8	2007	Top 32 Artist	
Fat Joe	Make It Rain	13	2007	Top 32 Artist	
Young Jeezy	Go Getta	18	2007	Top 32 Artist	
Nas	Hip Hop Is Dead	41	2007	Top 32 Artist	
T.I.	Whatever You Like	1	2008	Yearly Top 5	
T.I.	Live Your Life	1	2008	Yearly Top 5	Yes
Lil Wayne	Lollipop	1	2008	Yearly Top 5	Yes
Ray J	Sexy Can I	3	2008	Yearly Top 5	
Kanye West	Love Lockdown	3	2008	Yearly Top 5	
Lil Wayne	A Milli	6	2008	Top 32 Artist	Yes
Snoop Dogg	Sensual Seduction	7	2008	Top 32 Artist	
the Fugees	Sweetest Girl (Dollar Bill)	12	2008	Top 32 Artist	
Young Jeezy	Put On	12	2008	Top 32 Artist	
Rick Ross	The Boss	17	2008	Top 32 Artist	
Fat Joe	I Won't Tell	37	2008	Top 32 Artist	
Rick Ross	Here I Am	41	2008	Top 32 Artist	
the Black Eyed Peas	I Gotta Feeling	1	2009	Yearly Top 5	
the Black Eyed Peas	Boom Boom Pow	1	2009	Yearly Top 5	Yes
Jay-Z	Empire State Of Mind	1	2009	Yearly Top 5	Yes
Eminem	Crack A Bottle	1	2009	Yearly Top 5	
Kanye West	Heartless	2	2009	Yearly Top 5	Yes
Pitbull	I Know You Want Me (Calle Ocho)	2	2009	Top 32 Artist	
T.I.	Dead And Gone	2	2009	Top 32 Artist	Yes
Jay-Z	Run This Town	2	2009	Top 32 Artist	
Eminem	Love The Way You Lie	1	2010	Yearly Top 5	Yes
Eminem	Not Afraid	1	2010	Yearly Top 5	Yes
the Black Eyed Peas	Imma Be	1	2010	Yearly Top 5	
Nelly	Just A Dream	3	2010	Yearly Top 5	
the Black Eyed Peas	The Time (Dirty Bit)	4	2010	Yearly Top 5	
Lil Wayne	Right Above It	6	2010	Top 32 Artist	Yes
Ludacris	How Low	6	2010	Top 32 Artist	Yes
Young Jeezy	Lose My Mind	35	2010	Top 32 Artist	
Pitbull	Give Me Everything	1	2011	Yearly Top 5	Yes
Wiz Khalifa	Black And Yellow	1	2011	Yearly Top 5	
the Black Eyed Peas	Just Can't Get Enough	3	2011	Yearly Top 5	Yes
Lil Wayne	She Will	3	2011	Yearly Top 5	Yes
Dr. Dre	I Need A Doctor	4	2011	Yearly Top 5	
Lil Wayne	How To Love	5	2011	Top 32 Artist	
Wiz Khalifa	No Sleep	6	2011	Top 32 Artist	
Pitbull	Hey Baby (Drop It To The Floor)	7	2011	Top 32 Artist	
Wiz Khalifa	Roll Up	13	2011	Top 32 Artist	
Rick Ross	Aston Martin Music	30	2011	Top 32 Artist	
Jay-Z	Niggas In Paris	5	2012	Yearly Top 5	Yes
Snoop Dogg	Young, Wild & Free	7	2012	Yearly Top 5	Yes

Pitbull	Back In Time	11	2012	Yearly Top 5	Yes
Kanye West	Clique	12	2012	Yearly Top 5	Yes
Kanye West	Mercy	13	2012	Yearly Top 5	Yes
Wiz Khalifa	Work Hard, Play Hard	17	2012	Top 32 Artist	
Eminem	The Monster	1	2013	Yearly Top 5	Yes
Eminem	Berzerk	3	2013	Yearly Top 5	
Jay-Z	Holy Grail	4	2013	Yearly Top 5	Yes
Eminem	Rap God	7	2013	Yearly Top 5	
Pitbull	Feel This Moment	8	2013	Yearly Top 5	
Pitbull	Timber	1	2014	Yearly Top 5	Yes
Eminem	Guts Over Fear	22	2014	Yearly Top 5	
Pitbull	Fireball	23	2014	Yearly Top 5	
Pharrell	Come Get It Bae	23	2014	Yearly Top 5	
Lil Wayne	Believe Me	26	2014	Yearly Top 5	
Wiz Khalifa	We Dem Boyz	43	2014	Top 32 Artist	

The following table lists the songs in the sampling target, sorted by artist.

Artist	Song	Peak	Year	Criteria	Sampled?
2 Live Crew	Me So Horny	26	1989	Oldschool	
2Pac	California Love	6	1996	Top 32 Artist	Yes
2Pac	Dear Mama	9	1995	Top 32 Artist	
2Pac	How Do U Want It	1	1996	Yearly Top 5	Yes
2Pac	I Get Around	11	1993	Top 32 Artist	Yes
2Pac	Keep Ya Head Up	12	1994	Top 32 Artist	
50 Cent	21 Questions	1	2003	Yearly Top 5	
50 Cent	Ayo Technology	5	2007	Yearly Top 5	
50 Cent	Candy Shop	1	2005	Yearly Top 5	Yes
50 Cent	Disco Inferno	3	2005	Yearly Top 5	Yes
50 Cent	In Da Club	1	2003	Yearly Top 5	Yes
50 Cent	Just A Lil Bit	3	2005	Top 32 Artist	Yes
Arrested Development	Tennessee	6	1992	Yearly Top 5	
the Beastie Boys	Brass Monkey	48	1987	Yearly Top 5	Yes
the Beastie Boys	Ch-Check It Out	68	2004	Top 32 Artist	Yes
the Beastie Boys	Hey Ladies	36	1989	Oldschool	Yes
the Beastie Boys	Intergalactic	28	1998	Top 32 Artist	Yes
the Beastie Boys	(You Gotta) Fight For Your Right (To Party!)	7	1987	Yearly Top 5	Yes
the Black Eyed Peas	Boom Boom Pow	1	2009	Yearly Top 5	Yes
the Black Eyed Peas	I Gotta Feeling	1	2009	Yearly Top 5	
the Black Eyed Peas	Imma Be	1	2010	Yearly Top 5	
the Black Eyed Peas	Just Can't Get Enough	3	2011	Yearly Top 5	Yes
the Black Eyed Peas	My Humps	3	2005	Yearly Top 5	
the Black Eyed Peas	The Time (Dirty Bit)	4	2010	Yearly Top 5	
Bone Thugs N Harmony	I Tried	6	2007	Yearly Top 5	
Bone Thugs N Harmony	Look Into My Eyes	4	1997	Yearly Top 5	
Bone Thugs N Harmony	Tha Crossroads	1	1996	Yearly Top 5	
Bow Wow	Bounce With Me	20	2000	Top 32 Artist	
Bow Wow	Let Me Hold You	4	2005	Top 32 Artist	
Bow Wow	Let's Get Down	14	2003	Top 32 Artist	
Bow Wow	Like You	3	2005	Top 32 Artist	
Bow Wow	Shortie Like Mine	9	2006	Top 32 Artist	
Busta Rhymes	Dangerous	9	1998	Top 32 Artist	
Busta Rhymes	I Know What You Want	3	2003	Top 32 Artist	
Busta Rhymes	Turn It Up (Remix)/Fire It Up'	10	1998	Top 32 Artist	
Busta Rhymes	What's It Gonna Be?!	3	1999	Yearly Top 5	
Busta Rhymes	Woo-Hah! Got You All In Check	8	1996	Top 32 Artist	
Candyman	Knockin' Boots	9	1990	Yearly Top 5	
Coolio	1,2,3,4 (Sumptin' New)	5	1996	Yearly Top 5	
Coolio	Fantastic Voyage	3	1994	Yearly Top 5	
Coolio	Gangsta's Paradise	1	1995	Yearly Top 5	Yes
DMX	Get At Me Dog	39	1998	Top 32 Artist	
DMX	Party Up (Up In Here)	27	2000	Top 32 Artist	
DMX	What You Want	49	2000	Top 32 Artist	
DMX	Who We Be	60	2001	Top 32 Artist	
DMX	X Gon' Give It To Ya	60	2003	Top 32 Artist	
Da Brat	Funkdafied	6	1994	Yearly Top 5	
De La Soul	Me Myself And I	34	1989	Oldschool	
Domino	Getto Jam	7	1994	Yearly Top 5	
Dr. Dre	I Need A Doctor	4	2011	Yearly Top 5	
Dr. Dre	Nuthin' But A "G" Thang	2	1993	Yearly Top 5	Yes
Eminem	Berzerk	3	2013	Yearly Top 5	
Eminem	Crack A Bottle	1	2009	Yearly Top 5	
Eminem	Guts Over Fear	22	2014	Yearly Top 5	
Eminem	Lose Yourself	1	2002	Yearly Top 5	Yes
Eminem	Love The Way You Lie	1	2010	Yearly Top 5	Yes
Eminem	Not Afraid	1	2010	Yearly Top 5	Yes
Eminem	Rap God	7	2013	Yearly Top 5	
Eminem	Shake That	6	2006	Yearly Top 5	
Eminem	The Monster	1	2013	Yearly Top 5	Yes
Eminem	The Real Slim Shady	4	2000	Yearly Top 5	Yes
Eve	Let Me Blow Ya Mind	2	2001	Yearly Top 5	Yes
Fabolous	Breathe	10	2004	Top 32 Artist	
Fabolous	Can't Let You Go	4	2003	Top 32 Artist	
Fabolous	Into You	4	2003	Top 32 Artist	
Fabolous	Make Me Better	8	2007	Top 32 Artist	
Fat Joe	Get It Poppin'	9	2005	Top 32 Artist	
Fat Joe	I Won't Tell	37	2008	Top 32 Artist	
Fat Joe	Make It Rain	13	2007	Top 32 Artist	
Fat Joe	We Thuggin'	15	2002	Top 32 Artist	
Fat Joe	What's Luv?	2	2002	Yearly Top 5	
the Fugees	Ex-Factor	21	1999	Top 32 Artist	
the Fugees	Gone Till November	7	1998	Top 32 Artist	
the Fugees	Sweetest Girl (Dollar Bill)	12	2008	Top 32 Artist	
the Fugees	Two Wrongs	28	2002	Top 32 Artist	
the Game	Hate It Or Love It	2	2005	Yearly Top 5	
Gerardo	Rico Suave	7	1991	Yearly Top 5	
House Of Lords	I Wanna Be Loved	58	1989	Oldschool	
Ice-T	Colors	70	1988	Oldschool	Yes
J.J. Fad	Is It Love	92	1988	Oldschool	
J.J. Fad	Supersonic	30	1988	Yearly Top 5	
J.J. Fad	Way Out	61	1988	Oldschool	
JT Money	Who Dat	5	1999	Yearly Top 5	
Ja Rule	Always On Time	1	2002	Yearly Top 5	
Ja Rule	Between Me And You	11	2000	Yearly Top 5	

Ja Rule	Livin' It Up	6	2001	Yearly Top 5	Yes
Ja Rule	Mesmerize	2	2003	Top 32 Artist	
Ja Rule	Put It On Me	8	2001	Top 32 Artist	
Ja Rule	Wonderful	5	2004	Top 32 Artist	
Jay-Z	'03 Bonnie & Clyde	4	2002	Top 32 Artist	
Jay-Z	Empire State Of Mind	1	2009	Yearly Top 5	Yes
Jay-Z	Holy Grail	4	2013	Yearly Top 5	Yes
Jay-Z	I Just Wanna Love U (Give It 2 Me)	11	2000	Yearly Top 5	Yes
Jay-Z	Niggas In Paris	5	2012	Yearly Top 5	Yes
Jay-Z	Run This Town	2	2009	Top 32 Artist	
Juvenile	Slow Motion	1	2004	Yearly Top 5	
Kanye West	Clique	12	2012	Yearly Top 5	Yes
Kanye West	Gold Digger	1	2005	Yearly Top 5	Yes
Kanye West	Good Life	7	2007	Top 32 Artist	Yes
Kanye West	Heartless	2	2009	Yearly Top 5	Yes
Kanye West	Love Lockdown	3	2008	Yearly Top 5	
Kanye West	Mercy	13	2012	Yearly Top 5	Yes
Kanye West	Stronger	1	2007	Yearly Top 5	Yes
Kool Moe Dee	Go See The Doctor	89	1987	Oldschool	Yes
Kool Moe Dee	Wild, Wild West	62	1988	Oldschool	Yes
Kris Kross	Jump	1	1992	Yearly Top 5	Yes
Kurtis Blow	Basketball	71	1985	Yearly Top 5	Yes
Kurtis Blow	The Breaks - Part 1	87	1980	Yearly Top 5	Yes
Lauryn Hill	Doo Wop (That Thing)	1	1998	Yearly Top 5	Yes
LL Cool J	Around The Way Girl	9	1991	Top 32 Artist	
LL Cool J	Control Myself	4	2006	Yearly Top 5	Yes
LL Cool J	Going Back To Cali	31	1988	Yearly Top 5	
LL Cool J	Hey Lover	3	1995	Yearly Top 5	Yes
LL Cool J	I Need Love	14	1987	Yearly Top 5	Yes
LL Cool J	I'm Bad	84	1987	Yearly Top 5	
LL Cool J	I'm That Type Of Guy	15	1989	Oldschool	
LL Cool J	Loungin'	3	1996	Yearly Top 5	
LL Cool J	Luv U Better	4	2002	Top 32 Artist	
Lil Wayne	A Milli	6	2008	Top 32 Artist	Yes
Lil Wayne	Believe Me	26	2014	Yearly Top 5	
Lil Wayne	How To Love	5	2011	Top 32 Artist	
Lil Wayne	Lollipop	1	2008	Yearly Top 5	Yes
Lil Wayne	Right Above It	6	2010	Top 32 Artist	Yes
Lil Wayne	She Will	3	2011	Yearly Top 5	Yes
Lil' Romeo	My Baby	3	2001	Yearly Top 5	
Ludacris	How Low	6	2010	Top 32 Artist	Yes
Ludacris	Money Maker	1	2006	Yearly Top 5	Yes
Ludacris	Runaway Love	2	2007	Yearly Top 5	Yes
Ludacris	Splash Waterfalls	6	2004	Top 32 Artist	
Ludacris	Stand Up	1	2003	Yearly Top 5	Yes
M.C. Hammer	2 Legit 2 Quit	5	1992	Yearly Top 5	Yes
M.C. Hammer	Have You Seen Her	4	1990	Yearly Top 5	
M.C. Hammer	Pray	2	1990	Yearly Top 5	Yes
M.C. Hammer	U Can't Touch This	8	1990	Yearly Top 5	Yes
Marky Mark & The Funky Bunch	Good Vibrations	1	1991	Yearly Top 5	Yes
Mims	This Is Why I'm Hot	1	2007	Yearly Top 5	Yes
Missy Elliott	Get Ur Freak On	7	2001	Top 32 Artist	
Missy Elliott	Hot Boyz	5	2000	Yearly Top 5	
Missy Elliott	Lose Control	3	2005	Top 32 Artist	
Missy Elliott	One Minute Man	15	2001	Top 32 Artist	
Missy Elliott	Work It	2	2002	Top 32 Artist	Yes
Nas	Hip Hop Is Dead	41	2007	Top 32 Artist	
Nas	I Can	12	2003	Top 32 Artist	
Nas	Made You Look	32	2003	Top 32 Artist	
Nas	One Mic	43	2002	Top 32 Artist	
Nas	Street Dreams	22	1997	Top 32 Artist	
Naughty By Nature	Jamboree	10	1999	Yearly Top 5	
Naughty By Nature	O.P.P.	6	1991	Yearly Top 5	
Nelly	(Hot Shit) Country Grammar	7	2000	Yearly Top 5	
Nelly	Dilemma	1	2002	Yearly Top 5	Yes
Nelly	Grillz	1	2006	Yearly Top 5	Yes
Nelly	Hot In Herre	1	2002	Yearly Top 5	
Nelly	Just A Dream	3	2010	Yearly Top 5	
Nelly	Ride Wit Me	3	2001	Yearly Top 5	
Nelly	Shake Ya Tailfeather	1	2003	Yearly Top 5	
Neneh Cherry	Buffalo Stance	3	1989	Yearly Top 5	Yes
Neneh Cherry	Kisses On The Wind	8	1989	Yearly Top 5	
the Notorious B.I.G.	Big Poppa	6	1995	Yearly Top 5	Yes
the Notorious B.I.G.	Hypnotize	1	1997	Yearly Top 5	Yes
the Notorious B.I.G.	Mo Money, Mo Problems	1	1997	Yearly Top 5	Yes
the Notorious B.I.G.	One More Chance/Stay With Me	2	1995	Yearly Top 5	Yes
the Notorious B.I.G.	Player's Anthem	13	1995	Top 32 Artist	
Onyx	Slam	4	1993	Yearly Top 5	
OutKast	Elevators (Me & You)	12	1996	Top 32 Artist	
OutKast	Hey Ya!	1	2003	Yearly Top 5	
OutKast	Ms. Jackson	1	2001	Yearly Top 5	Yes
OutKast	Roses	9	2004	Top 32 Artist	
OutKast	The Way You Move	1	2004	Yearly Top 5	Yes
Pharrell	Come Get It Bae	23	2014	Yearly Top 5	
Pitbull	Back In Time	11	2012	Yearly Top 5	Yes
Pitbull	Feel This Moment	8	2013	Yearly Top 5	
Pitbull	Fireball	23	2014	Yearly Top 5	
Pitbull	Give Me Everything	1	2011	Yearly Top 5	Yes

Pitbull	Hey Baby (Drop It To The Floor)	7	2011	Top 32 Artist	
Pitbull	I Know You Want Me (Calle Ocho)	2	2009	Top 32 Artist	
Pitbull	Timber	1	2014	Yearly Top 5	Yes
Puff Daddy	Been Around The World	4	1998	Yearly Top 5	
Puff Daddy	Can't Nobody Hold Me Down	1	1997	Yearly Top 5	
Puff Daddy	Come With Me	4	1998	Yearly Top 5	
Puff Daddy	I Need A Girl (Part One)	2	2002	Top 32 Artist	
Puff Daddy	I'll Be Missing You	1	1997	Yearly Top 5	Yes
Puff Daddy	It's All About The Benjamin's	2	1998	Yearly Top 5	
Puff Daddy	Satisfy You	2	1999	Yearly Top 5	Yes
Quad City DJ's	C'Mon N' Ride It (The Train)	3	1996	Yearly Top 5	
Ray J	Sexy Can I	3	2008	Yearly Top 5	
Rick Ross	Aston Martin Music	30	2011	Top 32 Artist	
Rick Ross	Here I Am	41	2008	Top 32 Artist	
Rick Ross	Hustlin'	54	2006	Top 32 Artist	
Rick Ross	The Boss	17	2008	Top 32 Artist	
Rob Base & D.J. E-Z Rock	It Takes Two	36	1988	Oldschool	Yes
Rob Base & D.J. E-Z Rock	Joy And Pain	58	1989	Oldschool	
Ron & The D.C. Crew	Ronnie's Rapp	93	1987	Oldschool	
Run DMC	Down With The King	21	1993	Top 32 Artist	Yes
Run DMC	It's Tricky	57	1987	Yearly Top 5	Yes
Run DMC	Mary, Mary	75	1988	Oldschool	Yes
Run DMC	Walk This Way	4	1986	Yearly Top 5	
Run DMC	You Be Illin'	29	1986	Yearly Top 5	Yes
Salt 'N Pepa	Do You Want Me	21	1991	Top 32 Artist	
Salt 'N Pepa	Let's Talk About Sex	13	1991	Top 32 Artist	
Salt 'N Pepa	Push It	19	1988	Yearly Top 5	
Salt 'N Pepa	Shoop	4	1993	Yearly Top 5	
Salt 'N Pepa	Whatta Man	3	1994	Yearly Top 5	
Sir Mix-A-Lot	Baby Got Back	1	1992	Yearly Top 5	Yes
Sir Mix-A-Lot	Posse On Broadway	70	1989	Oldschool	Yes
Snoop Dogg	Beautiful	6	2003	Top 32 Artist	Yes
Snoop Dogg	Drop It Like It's Hot	1	2004	Yearly Top 5	Yes
Snoop Dogg	Gin And Juice	8	1994	Top 32 Artist	Yes
Snoop Dogg	Sensual Seduction	7	2008	Top 32 Artist	
Snoop Dogg	Young, Wild & Free	7	2012	Yearly Top 5	Yes
Snow	Informer	1	1993	Yearly Top 5	
the Sugar Hill Gang	8th Wonder	82	1981	Yearly Top 5	Yes
the Sugar Hill Gang	Apache	53	1982	Yearly Top 5	Yes
the Sugar Hill Gang	Rapper's Delight	36	1980	Yearly Top 5	Yes
T.I.	Bring Em Out	9	2005	Top 32 Artist	
T.I.	Dead And Gone	2	2009	Top 32 Artist	Yes
T.I.	Live Your Life	1	2008	Yearly Top 5	Yes
T.I.	What You Know	3	2006	Yearly Top 5	Yes
T.I.	Whatever You Like	1	2008	Yearly Top 5	
Tag Team	Whoomp! There It Is	2	1993	Yearly Top 5	Yes
Terror Squad	Lean Back	1	2004	Yearly Top 5	Yes
Tone Loc	Funky Cold Medina	3	1989	Yearly Top 5	
Tone Loc	Wild Thing	2	1989	Yearly Top 5	Yes
Twista	Slow Jamz	1	2004	Yearly Top 5	
UTFO	Roxanne, Roxanne	77	1985	Yearly Top 5	Yes
Vanilla Ice	Ice Ice Baby	1	1990	Yearly Top 5	
Vanilla Ice	Play That Funky Music	4	1991	Yearly Top 5	Yes
Warren G	Regulate	2	1994	Yearly Top 5	Yes
Whodini	Five Minutes Of Funk	NA	1985	Yearly Top 5	Yes
Whodini	Friends	87	1985	Yearly Top 5	Yes
Will Smith	A Nightmare On My Street	15	1988	Yearly Top 5	
Will Smith	Gettin' Jiggy Wit It	1	1998	Yearly Top 5	Yes
Will Smith	Girls Ain't Nothing But Trouble	57	1988	Oldschool	
Will Smith	I Think I Can Beat Mike Tyson	58	1989	Oldschool	
Will Smith	Parents Just Don't Understand	12	1988	Yearly Top 5	Yes
Will Smith	Summertime	4	1991	Yearly Top 5	Yes
Will Smith	Switch	7	2005	Top 32 Artist	
Will Smith	Wild Wild West	1	1999	Yearly Top 5	Yes
Wiz Khalifa	Black And Yellow	1	2011	Yearly Top 5	
Wiz Khalifa	No Sleep	6	2011	Top 32 Artist	
Wiz Khalifa	Roll Up	13	2011	Top 32 Artist	
Wiz Khalifa	We Dem Boyz	43	2014	Top 32 Artist	
Wiz Khalifa	Work Hard, Play Hard	17	2012	Top 32 Artist	
World Class Wreckin' Cru	Turn Off The Lights	84	1988	Oldschool	
Wreckx-N-Effect	Rump Shaker	2	1992	Yearly Top 5	Yes
Wu-Tang Clan	I'll Be There For You/You're All I Need To Get By	3	1995	Yearly Top 5	
Young Jeezy	Go Getta	18	2007	Top 32 Artist	
Young Jeezy	I Luv It	14	2006	Top 32 Artist	
Young Jeezy	Lose My Mind	35	2010	Top 32 Artist	
Young Jeezy	Put On	12	2008	Top 32 Artist	
Young Jeezy	Soul Survivor	4	2005	Top 32 Artist	
Young M.C.	Bust A Move	7	1989	Yearly Top 5	Yes

Appendix B: List of Songs Already Transcribed in MCFlow Dataset

The following table lists the songs currently in the MCFlow dataset, sorted by artist.

Artist	Emcee(s)	Song	Peak	Year	Criteria[39]
2Pac	2Pac, Dr. Dre	California Love	6	1996	Top-Artist Top 5
2Pac	2Pac	How Do U Want It	1	1996	Yearly Top 5
2Pac	2Pac, Shock G, Money B	I Get Around	11	1993	Top-Artist Top 5
2Pac	2Pac, Wycked	Papa'z Song	87	1994	Top Artist*
2Pac	2Pac	So Many Tears	44	1995	Top Artist*
50 Cent	50 Cent	Candy Shop	1	2005	Yearly Top 5
50 Cent	50 Cent	Disco Inferno	3	2005	Yearly Top 5
50 Cent	50 Cent	In Da Club	1	2003	Yearly Top 5
50 Cent	50 Cent	Just A Lil Bit	3	2005	Top-Artist Top 5
50 Cent	50 Cent	P.I.M.P.	3	2003	Top Artist*
the Beastie Boys	Ad-Rock, MCA, Mike D	Brass Monkey	58	1987	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Ch-Check It Out	68	2004	Top-Artist Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	(You Gotta) Fight for Your Right (to Party!)	7	1987	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Hey Ladies	36	1989	Oldschool
the Beastie Boys	Ad-Rock, MCA, Mike D	Intergalactic	27	1998	Top-Artist Top 5
the Black Eyed Peas	Apl.De.Ap, Fergie, Taboo, Will.I.Am	Boom Boom Pow	1	2009	Yearly Top 5
the Black Eyed Peas	Apl.De.Ap, Fergie, Taboo, Will.I.Am	Just Can't Get Enough	3	2011	Yearly Top 5
Coolio	Coolio	Gangsta's Paradise	1	1995	Yearly Top 5
Dr. Dre	Dr. Dre, Snoop Dogg	Nuthin' But a 'G' Thang	2	1993	Yearly Top 5
Eminem	Eminem	Lose Yourself	1	2002	Yearly Top 5
Eminem	Eminem	Love the Way You Lie	1	2010	Yearly Top 5
Eminem	Eminem	Not Afraid	1	2010	Yearly Top 5
Eminem	Eminem	Rock Bottom	NA	1999	Top Artist*
Eminem	Eminem	The Monster	1	2013	Yearly Top 5
Eminem	Eminem	The Real Slim Shady	4	2000	Yearly Top 5
Eminem	Eminem	The Way I Am	58	2000	Top Artist*
Eve	Eve	Let Me Blow Ya Mind	2	2001	Yearly Top 5
Ice-T	Ice-T	Colors	70	1988	Oldschool
Ice-T	Ice-T	New Jack Hustler	67	1991	Oldschool
JaRule	JaRule	Livin' It Up	6	2001	Yearly Top 5
Jay-Z	Jay-Z	Can I Get A...	19	1999	Top-Artist Top 5
Jay-Z	Jay-Z	Can't Knock the Hustle	73	1996	Top Artist*
Jay-Z	Jay-Z	Empire State of Mind	1	2009	Yearly Top 5
Jay-Z	Jay-Z	Holy Grail	4	2013	Yearly Top 5
Jay-Z	Jay-Z	I Just Wanna Love U (Give It To Me)	11	2000	Yearly Top 5
Jay-Z and Kanye West	Jay-Z, Kanye West	Niggas In Paris	5	2012	Yearly Top 5
Kanye West, Jay-Z and Big Sean	Kanye West, Jay-Z, Big Sean	Clique	12	2012	Yearly Top 5
Kanye West	Kanye West	Gold Digger	1	2005	Yearly Top 5
Kanye West	Kanye West	Good Life	7	2007	Top-Artist Top 5
Kanye West	Kanye West	Heartless	2	2009	Yearly Top 5
Kanye West, Big Sean, Pusha T and 2 Chainz	Kanye West, Big Sean, Pusha T, 2 Chainz	Mercy	13	2012	Yearly Top 5
Kanye West	Kanye West	Stronger	1	2007	Yearly Top 5
Kool Moe Dee	Kool Moe Dee	Go See the Doctor	87	1987	Oldschool
Kool Moe Dee	Kool Moe Dee	Wild Wild West	62	1988	Oldschool
Kriss Kross	Mac Daddy, Daddy Mac	Jump	1	1992	Yearly Top 5
Kurtis Blow	Kurtis Blow	Basketball	71	1985	Yearly Top 5

[39]Criteria marked with * indicate an ad-hoc sampling decision, not entirely consistent with the final sampling plan described in Chapter 4.

Kurtis Blow	Kurtis Blow	If I Ruled the World	NA	1985	Yearly Top 5
Kurtis Blow	Kurtis Blow	The Breaks	87	1980	Yearly Top 5
Lauryn Hill	Lauryn Hill	Doo Wop (That Thing)	1	1998	Yearly Top 5
Lil Wayne	Lil Wayne	A Milli	6	2008	Top-Artist Top 5
Lil Wayne	Lil Wayne	Got Money	10	2008	Top Artist*
Lil Wayne	Lil Wayne	Lollipop	1	2008	Yearly Top 5
Lil Wayne	Lil Wayne	Love Me	9	2013	Top-Artist Top 5
Lil Wayne	Lil Wayne	Right Above It	6	2010	Top-Artist Top 5
Lil Wayne	Lil Wayne	She Will	3	2011	Yearly Top 5
LL Cool J	LL Cool J	Control Myself	4	2006	Yearly Top 5
LL Cool J	LL Cool J	Hey Lover	3	1995	Yearly Top 5
LL Cool J	LL Cool J	I Need Love	14	1987	Yearly Top 5
Ludacris	Ludacris	How Low	6	2010	Top-Artist Top 5
Ludacris	Ludacris	Money Maker	1	2006	Yearly Top 5
Ludacris	Ludacris, Mystikal, I-20	Move Bitch	10	2002	Top Artist*
Ludacris	Ludacris	Runaway Love	2	2007	Yearly Top 5
Ludacris	Ludacris	Stand Up	1	2003	Yearly Top 5
Ludacris	Ludacris	What's Your Fantasy?	21	2000	Top Artist*
Marky Mark and the Funky Bunch	Marky Mark	Good Vibrations	1	1991	Yearly Top 5
MC Hammer	MC Hammer	2 Legit 2 Quit	5	1992	Yearly Top 5
MC Hammer	MC Hammer	Pray	2	1990	Yearly Top 5
MC Hammer	MC Hammer	U Can't Touch This	8	1990	Yearly Top 5
Mims	Mims	This Is Why I'm Hot	1	2007	Yearly Top 5
Missy Elliott	Missy Elliott	Work It	2	2002	Top-Artist Top 5
Nelly	Nelly	Dilemma	1	2002	Yearly Top 5
Nelly	Nelly	Grillz	1	2006	Yearly Top 5
Neneh Cherry	Neneh Cherry	Buffalo Stance	3	1989	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Big Poppa	6	1995	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Going Back to Cali	26	1998	Top-Artist Top 5
the Notorious B.I.G.	Biggie Smalls	Hypnotize	1	1997	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Juicy	27	1994	Top Artist*
the Notorious B.I.G.	Biggie Smalls	Mo Money Mo Problems	1	1997	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	One More Chance/Stay With Me	2	1995	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Sky's the Limit	60	1997	Top-Artist Top 5
OutKast	Andre 3000, Big Boi	Ms. Jackson	1	2001	Yearly Top 5
OutKast	Big Boi	The Way You Move	1	2004	Yearly Top 5
Pitbull	Pitbull	Back In Time	11	2012	Yearly Top 5
Pitbull	Pitbull	Give Me Everything	1	2011	Yearly Top 5
Pitbull	Pitbull	Timber	1	2014	Yearly Top 5
Puff Daddy	Puff Daddy	I'll Be Missing You	1	1997	Yearly Top 5
Puff Daddy	Puff Daddy	Satisfy You	2	1999	Yearly Top 5
Rob Base and DJ E-Z Rock	Rob Base	Don't Sleep On It	NA	1988	Oldschool*
Rob Base and DJ E-Z Rock	Rob Base	It Takes Two	36	1988	Oldschool
Run-D.M.C.	Run, DMC	Down With the King	21	1993	Top-Artist Top 5
Run-D.M.C.	Run, DMC	It's Tricky	57	1987	Yearly Top 5
Run-D.M.C.	Run, DMC	Mary, Mary	75	1988	Oldschool
Run-D.M.C.	Run, DMC	You Be Illin'	29	1986	Yearly Top 5
Sir Mix-A-Lot	Sir Mix-A-Lot	Baby Got Back	1	1992	Yearly Top 5
Sir Mix-A-Lot	Sir Mix-A-Lot	Jump On It	97	1996	*
Sir Mix-A-Lot	Sir Mix-A-Lot	My Posses On Broadway	70	1989	Oldschool
Snoop Dogg	Snoop Dogg	Beautiful	6	2003	Top-Artist Top 5
Snoop Dogg	Snoop Dogg, Pharrell	Drop It Like It's Hot	1	2004	Yearly Top 5
Snoop Dogg	Snoop Dogg	Gin and Juice	8	1993	Top-Artist Top 5
Snoop Dogg	Snoop Dogg, Butch Cassidy, Goldie Loc, Tray Deee, Master P	Lay Low	50	2001	Top Artist*
Snoop Dogg	Snoop Dogg, Fiend, Mystikal	Woof	62	1999	Top Artist*
Snoop Dogg and Wiz Khalifa	Snoop Dogg, Wiz Khalifa	Young, Wild and Free	7	2012	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	8th Wonder	82	1981	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	Apache	53	1982	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	Rapper's Delight	36	1980	Yearly Top 5
Tag Team	D.C., Steve Roll'n	Whoomp! (There It Is)	2	1993	Yearly Top 5
Terror Squad	Fat Joe, Remy Martin	Lean Back	1	2004	Yearly Top 5
T.I.	T.I.	Dead and Gone	2	2009	Top-Artist Top 5
T.I.	T.I.	Live Your Life	1	2008	Yearly Top 5
T.I.	T.I.	What You Know	3	2006	Yearly Top 5
Tone Loc	Tone Loc	Wild Thing	2	1989	Yearly Top 5
UTFO	Kangol Kid, EMD, Doctor Ice	Roxanne, Roxanne	77	1985	Yearly Top 5
Vanilla Ice	Vanilla Ice	Play That Funky Music	4	1991	Yearly Top 5
Warren G	Warren G and Nate Dogg	Regulate	2	1994	Yearly Top 5
Whodini	Jalil Hutchins	Five Minutes of Funk	NA	1985	Yearly Top 5
Whodini	Jalil Hutchins	Friends	87	1985	Yearly Top 5
DJ Jazzy Jeff and the Fresh Prince	Will Smith	Parents Just Don't Understand	12	1988	Yearly Top 5
DJ Jazzy Jeff and the Fresh Prince	Will Smith	Summertime	4	1991	Yearly Top 5
Will Smith	Will Smith	Gettin' Jiggy Wit It	1	1998	Yearly Top 5
Will Smith	Will Smith	Wild Wild West	1	1999	Yearly Top 5

Wreckx-N-Effect	A Plus, Teddy Riley, Markell Riley	Rump Shaker	2	1992	Yearly Top 5
Young M.C.	Young M.C.	Bust A Move	7	1989	Yearly Top 5
Young M.C.	Young M.C.	I Come Off	75	1990	Oldschool*
Young M.C.	Young M.C.	Principal's Office	33	1990	Oldschool*

The following table lists the songs currently in the MCFlow dataset, sorted by year.

Artist	Emcee(s)	Song	Peak	Year	Criteria[40]
Kurtis Blow	Kurtis Blow	The Breaks	87	1980	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	Rapper's Delight	36	1980	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	8th Wonder	82	1981	Yearly Top 5
the Sugarhill Gang	Big Bank Hank, Master Gee, Wonder Mike	Apache	53	1982	Yearly Top 5
Kurtis Blow	Kurtis Blow	Basketball	71	1985	Yearly Top 5
Kurtis Blow	Kurtis Blow	If I Ruled the World	NA	1985	Yearly Top 5
UTFO	Kangol Kid, EMD, Doctor Ice	Roxanne, Roxanne	77	1985	Yearly Top 5
Whodini	Jalil Hutchins	Five Minutes of Funk	NA	1985	Yearly Top 5
Whodini	Jalil Hutchins	Friends	87	1985	Yearly Top 5
Run-D.M.C.	Run, DMC	You Be Illin'	29	1986	Yearly Top 5
Kool Moe Dee	Kool Moe Dee	Go See the Doctor	87	1987	Oldschool
LL Cool J	LL Cool J	I Need Love	14	1987	Yearly Top 5
Run-D.M.C.	Run, DMC	It's Tricky	57	1987	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Brass Monkey	58	1987	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	(You Gotta) Fight for Your Right (to Party!)	7	1987	Yearly Top 5
Ice-T	Ice-T	Colors	70	1988	Oldschool
Kool Moe Dee	Kool Moe Dee	Wild Wild West	62	1988	Oldschool
Run-D.M.C.	Run, DMC	Mary, Mary	75	1988	Oldschool
DJ Jazzy Jeff and the Fresh Prince	Will Smith	Parents Just Don't Understand	12	1988	Yearly Top 5
Rob Base and DJ E-Z Rock	Rob Base	Don't Sleep On It	NA	1988	Oldschool*
Rob Base and DJ E-Z Rock	Rob Base	It Takes Two	36	1988	Oldschool
Neneh Cherry	Neneh Cherry	Buffalo Stance	3	1989	Yearly Top 5
Sir Mix-A-Lot	Sir Mix-A-Lot	My Posses On Broadway	70	1989	Oldschool
Tone Loc	Tone Loc	Wild Thing	2	1989	Yearly Top 5
Young M.C.	Young M.C.	Bust A Move	7	1989	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Hey Ladies	36	1989	Oldschool
MC Hammer	MC Hammer	Pray	2	1990	Yearly Top 5
MC Hammer	MC Hammer	U Can't Touch This	8	1990	Yearly Top 5
Young M.C.	Young M.C.	I Come Off	75	1990	Oldschool*
Young M.C.	Young M.C.	Principal's Office	33	1990	Oldschool*
Ice-T	Ice-T	New Jack Hustler	67	1991	Oldschool
Vanilla Ice	Vanilla Ice	Play That Funky Music	4	1991	Yearly Top 5
DJ Jazzy Jeff and the Fresh Prince	Will Smith	Summertime	4	1991	Yearly Top 5
Marky Mark and the Funky Bunch	Marky Mark	Good Vibrations	1	1991	Yearly Top 5
Kriss Kross	Mac Daddy, Daddy Mac	Jump	1	1992	Yearly Top 5
MC Hammer	MC Hammer	2 Legit 2 Quit	5	1992	Yearly Top 5
Sir Mix-A-Lot	Sir Mix-A-Lot	Baby Got Back	1	1992	Yearly Top 5
Wreckx-N-Effect	A Plus, Teddy Riley, Markell Riley	Rump Shaker	2	1992	Yearly Top 5
2Pac	2Pac, Shock G, Money B	I Get Around	11	1993	Top-Artist Top 5
Dr. Dre	Dr. Dre, Snoop Dogg	Nuthin' But a 'G' Thang	2	1993	Yearly Top 5
Run-D.M.C.	Run, DMC	Down With the King	21	1993	Top-Artist Top 5
Snoop Dogg	Snoop Dogg	Gin and Juice	8	1993	Top-Artist Top 5
Tag Team	D.C., Steve Roll'n	Whoomp! (There It Is)	2	1993	Yearly Top 5
2Pac	2Pac, Wycked	Papa'z Song	87	1994	Top Artist*
Warren G	Warren G and Nate Dogg	Regulate	2	1994	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Juicy	27	1994	Top Artist*
2Pac	2Pac	So Many Tears	44	1995	Top Artist*
Coolio	Coolio	Gangsta's Paradise	1	1995	Yearly Top 5

[40]Criteria marked with * indicate an ad-hoc sampling decision, not entirely consistent with the final sampling plan described in Chapter 4.

LL Cool J	LL Cool J	Hey Lover	3	1995	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Big Poppa	6	1995	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	One More Chance/Stay With Me	2	1995	Yearly Top 5
2Pac	2Pac	How Do U Want It	1	1996	Yearly Top 5
2Pac	2Pac, Dr. Dre	California Love	6	1996	Top-Artist Top 5
Jay-Z	Jay-Z	Can't Knock the Hustle	73	1996	Top Artist*
Sir Mix-A-Lot	Sir Mix-A-Lot	Jump On It	97	1996	*
Puff Daddy	Puff Daddy	I'll Be Missing You	1	1997	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Hypnotize	1	1997	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Mo Money Mo Problems	1	1997	Yearly Top 5
the Notorious B.I.G.	Biggie Smalls	Sky's the Limit	60	1997	Top-Artist Top 5
Lauryn Hill	Lauryn Hill	Doo Wop (That Thing)	1	1998	Yearly Top 5
Will Smith	Will Smith	Gettin' Jiggy Wit It	1	1998	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Intergalactic	27	1998	Top-Artist Top 5
the Notorious B.I.G.	Biggie Smalls	Going Back to Cali	26	1998	Top-Artist Top 5
Eminem	Eminem	Rock Bottom	NA	1999	Top Artist*
Jay-Z	Jay-Z	Can I Get A...	19	1999	Top-Artist Top 5
Puff Daddy	Puff Daddy	Satisfy You	2	1999	Yearly Top 5
Snoop Dogg	Snoop Dogg, Fiend, Mystikal	Woof	62	1999	Top Artist*
Will Smith	Will Smith	Wild Wild West	1	1999	Yearly Top 5
Eminem	Eminem	The Real Slim Shady	4	2000	Yearly Top 5
Eminem	Eminem	The Way I Am	58	2000	Top Artist*
Jay-Z	Jay-Z	I Just Wanna Love U (Give It To Me)	11	2000	Yearly Top 5
Ludacris	Ludacris	What's Your Fantasy?	21	2000	Top Artist*
Eve	Eve	Let Me Blow Ya Mind	2	2001	Yearly Top 5
JaRule	JaRule	Livin' It Up	6	2001	Yearly Top 5
OutKast	Andre 3000, Big Boi	Ms. Jackson	1	2001	Yearly Top 5
Snoop Dogg	Snoop Dogg, Butch Cassidy, Goldie Loc, Tray Deee, Master P	Lay Low	50	2001	Top Artist*
Eminem	Eminem	Lose Yourself	1	2002	Yearly Top 5
Ludacris	Ludacris, Mystikal, I-20	Move Bitch	10	2002	Top Artist*
Missy Elliott	Missy Elliott	Work It	2	2002	Top-Artist Top 5
Nelly	Nelly	Dilemma	1	2002	Yearly Top 5
50 Cent	50 Cent	In Da Club	1	2003	Yearly Top 5
50 Cent	50 Cent	P.I.M.P.	3	2003	Top Artist*
Ludacris	Ludacris	Stand Up	1	2003	Yearly Top 5
Snoop Dogg	Snoop Dogg	Beautiful	6	2003	Top-Artist Top 5
OutKast	Big Boi	The Way You Move	1	2004	Yearly Top 5
Snoop Dogg	Snoop Dogg, Pharrell	Drop It Like It's Hot	1	2004	Yearly Top 5
Terror Squad	Fat Joe, Remy Martin	Lean Back	1	2004	Yearly Top 5
the Beastie Boys	Ad-Rock, MCA, Mike D	Ch-Check It Out	68	2004	Top-Artist Top 5
50 Cent	50 Cent	Candy Shop	1	2005	Yearly Top 5
50 Cent	50 Cent	Disco Inferno	3	2005	Yearly Top 5
50 Cent	50 Cent	Just A Lil Bit	3	2005	Top-Artist Top 5
Kanye West	Kanye West	Gold Digger	1	2005	Yearly Top 5
LL Cool J	LL Cool J	Control Myself	4	2006	Yearly Top 5
Ludacris	Ludacris	Money Maker	1	2006	Yearly Top 5
Nelly	Nelly	Grillz	1	2006	Yearly Top 5
T.I.	T.I.	What You Know	3	2006	Yearly Top 5
Kanye West	Kanye West	Good Life	7	2007	Top-Artist Top 5
Kanye West	Kanye West	Stronger	1	2007	Yearly Top 5
Ludacris	Ludacris	Runaway Love	2	2007	Yearly Top 5
Mims	Mims	This Is Why I'm Hot	1	2007	Yearly Top 5
Lil Wayne	Lil Wayne	A Milli	6	2008	Top-Artist Top 5
Lil Wayne	Lil Wayne	Got Money	10	2008	Top Artist*
Lil Wayne	Lil Wayne	Lollipop	1	2008	Yearly Top 5
T.I.	T.I.	Live Your Life	1	2008	Yearly Top 5
Jay-Z	Jay-Z	Empire State of Mind	1	2009	Yearly Top 5
Kanye West	Kanye West	Heartless	2	2009	Yearly Top 5
T.I.	T.I.	Dead and Gone	2	2009	Top-Artist Top 5
the Black Eyed Peas	Apl.De.Ap, Fergie, Taboo, Will.I.Am	Boom Boom Pow	1	2009	Yearly Top 5
Eminem	Eminem	Love the Way You Lie	1	2010	Yearly Top 5
Eminem	Eminem	Not Afraid	1	2010	Yearly Top 5
Lil Wayne	Lil Wayne	Right Above It	6	2010	Top-Artist Top 5
Ludacris	Ludacris	How Low	6	2010	Top-Artist Top 5
Lil Wayne	Lil Wayne	She Will	3	2011	Yearly Top 5
Pitbull	Pitbull	Give Me Everything	1	2011	Yearly Top 5
the Black Eyed Peas	Apl.De.Ap, Fergie, Taboo, Will.I.Am	Just Can't Get Enough	3	2011	Yearly Top 5
Jay-Z and Kanye West	Jay-Z, Kanye West	Niggas In Paris	5	2012	Yearly Top 5
Pitbull	Pitbull	Back In Time	11	2012	Yearly Top 5
Kanye West, Big Sean, Pusha T and 2 Chainz	Kanye West, Big Sean, Pusha T, 2 Chainz	Mercy	13	2012	Yearly Top 5
Kanye West, Jay-Z and Big Sean	Kanye West, Jay-Z, Big Sean	Clique	12	2012	Yearly Top 5
Snoop Dogg and Wiz Khalifa	Snoop Dogg, Wiz Khalifa	Young, Wild and Free	7	2012	Yearly Top 5
Eminem	Eminem	The Monster	1	2013	Yearly Top 5
Jay-Z	Jay-Z	Holy Grail	4	2013	Yearly Top 5
Lil Wayne	Lil Wayne	Love Me	9	2013	Top-Artist Top 5
Pitbull	Pitbull	Timber	1	2014	Yearly Top 5

Appendix C: Example Transcription

The following is an example of a complete MCFlow transcription. The transcription is of Biggie Smalls' "Big Poppa" (1995).

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16	.	.	.	.	R	.	.
16	1	^	4	.	hu	who	D
16	0	.	.	.	ju	you	D
8	1	+	.	.	bi	be	D
8	0	+	.	.	wIθ	with?.	D
=6	=6	=6	=6	=6	=6	=6	=6
16	1	v	4	.	θIŋz	things	.
16	0	.	.	.	ɾʊ	to	.
16	1	.	.	.	meIk	make	.
16	0	.	.	.	ju	you	.
8	1	+\	.	C	smaIl	smile.	.
8	.	.	.	.	R	.	.
16	1	.	4	.	wʌt	what	.
16	1	+	.	.	nʌm	num-	.
16	0	.	.	.	bɛ~z	-bers	.
16	0	.	.	.	tʊ	to	.
8	1	.	.	C	daIl	dial.}	.
16	1	+\	4	.	ju	{you	.
16	0	.	.	.	goʊn	gonna	.
=7	=7	=7	=7	=7	=7	=7	=7
16	1	.	.	.	bi	be	.

16	0	.	.	.	hir	here	.
16	1	.	.	.	foʊ	for	.
16	0	.	.	.	ə	a	.
8	1	.	.	C	waIl	while?.	.
16	1	+\	3	.	aIm	i'm	.
16	0	.	.	.	goʊn	gonna	.
16	1	.	.	.	kal	call	.
16	0	.	.	.	maI	my	.
8	1	+	.	D	kru	crew.	.
16	1	.	3	.	ju	you	.
16	0	.	.	.	goʊ	go	.
16	1	.	.	.	kal	call	.
16	0	.	.	.	joʊ	your	.
=8	=8	=8	=8	=8	=8	=8	=8
8	1	+	.	D	kru	crew.	.
16	1	.	3	.	wi	we	.
16	0	.	.	.	kæn	can	.
16	1	.	.	.	ran	ren-	.
16	0	.	.	.	deI	-dez-	.
8	1	+	.	D	vu	-vous	.
16	1	.	2	.	æt	at	D
16	0	.	.	.	ðə	the	D
16	1	.	.	.	bar	bar	D
16	0	.	.	.	ə	a-	D
8	1	.	.	.	raʊn	-round	D
8	1	_	.	D	tu	two.}	D
=9	=9	=9	=9	=9	=9	=9	=9
16	.	.	.	.	R	.	.
8	1	+	4	.	plænz	{plans	.
16	0	.	.	.	tʊ	to	.
8	1	+	.	E	liv	leave.	.
16	1	.	3	.	θroʊ	throw	.
16	0	.	.	.	ðə	the	.
16	1	+	.	E	kiz	keys	.
16	0	.	.	.	rə	to	.
16	1	.	.	.	lI	Li-	.
16	0	.	.	.	dl	-l'_	.
8	1	+	.	E	siz	_Cease.	.
16	1	.	4	.	pʊl	pull	.
16	0	.	.	.	ðə	the	.
=10	=10	=10	=10	=10	=10	=10	=10
16	1	+	.	[F	trʌk	truck	.
8	1	v	.	.	ʌp	up	.
8	1	+	.	G]	frənt	front,	.
16	1	.	2	.	æn	and	.
16	0	.	.	.	roʊl	roll	.
8	1	+	.	[F	ʌp	up	.
16	0	.	.	.	ðə	the	.
8	1	.	.	.	nɛkst	next	.
16	1	+	.	G]	blʌnt	blunt;	.
16	0	.	4	.	soʊ	so	D
16	1	.	.	.	wi	we	D
16	0	.	.	.	kIn	can	D
=11	=11	=11	=11	=11	=11	=11	=11
8	1	+	.	.	stim	steam	D
16	1	.	.	.	an	on	D
16	0	.	.	.	ðə	the	D
16	1	.	.	.	weI	way	D
16	0	.	.	.	tʊ	to	D
16	0	.	.	.	ðə	the	D
16	1	(+\	.	(H	tɛ	te-	D
16	0	-)	.	h)	li	-lly.	D
16	1	.	3	.	goʊ	go	D
16	1	.	.	.	fIl	fill	D
16	0	.	.	.	maI	my	D
16	1	(+\	.	(H	bɛ	be-	D
16	0	_)	.	h)	li	-lly.	D
16	.	.	.	.	R	.	.
16	0	.	4	.	ə	a	.
=12	=12	=12	=12	=12	=12	=12	=12
16	1	.	.	.	ti	t_	.
8	0	.	.	.	boun	_bone	.
8	1	+	.	I	steIk	steak	.
8	1	.	3	.	tʃiz	cheese	.
8	1	+	.	.	ɛgz	eggs	.
16	0	.	.	.	ɛn	and	.
16	1	.	.	.	wɛl	Wel-	.
16	0	.	.	.	tʃIz	-cher's	.
8	1	-	.	I	greIp	grape.	.
16	1	^	4	.	kan	con-	.
16	0	.	.	.	vɛ~	-ver-	.
=13	=13	=13	=13	=13	=13	=13	=13
8	1	.	.	I	seIt	-sate	.
16	1	.	.	.	foʊ	for	.
16	0	.	.	.	ə	a	.
8	1	/	.	J	fju	few	.
16	.	.	.	.	R	.	.
16	0	.	3	.	kəz	because	.

16	1	.	.	.	In	in	.
16	0	.	.	.	ə	a	.
8	1	/	.	J	fju	few	.
16	1	.	.	.	wi	we	.
16	0	.	.	.	goʊn	gonna	.
8	1	+	.	J	du	do	.
=14	=14	=14	=14	=14	=14	=14	=14
16	1	.	2	.	wʌt	what	.
16	0	.	.	.	wi	we	.
16	1	.	.	.	keIm	came	.
16	0	.	.	.	tʊ	to	.
8	1	+	.	J	du	do.	.
16	1	.	3	.	eInt	ain't	.
16	0	.	.	.	ðæt	that	.
8	1	.	.	.	raIt	right	.
8	1	/	.	J	bu	boo?.:	.
4	.	.	.	.	R	.	4tru 1 true.
=15	=15	=15	=15	=15	=15	=15	=15
16	.	.	.	.	R	.	.
16	0	.	4	.	fɛ~	for-	.
16	1	.	.	.	gIt	-get	.
16	0	.	.	.	ðə	the	.
16	1	+	.	.	tɛ	te-	.
16	0	.	.	.	li	-lly.	.
16	1	.	3	.	wi	:we	.
16	0	.	.	.	dʒəst	just	.
16	1	.	.	.	goʊ	go	.
16	0	.	.	.	tʊ	to	.
16	0	.	.	.	ðə	the	.
8	1	+\	.	.	krIb	crib	.
16	0	.	3	.	ɛn	and	.
16	1	.	.	.	watʃ	watch	.
16	0	.	.	.	ə	a	.
=16	=16	=16	=16	=16	=16	=16	=16
16	1	(\	.	(K	mu	mo-	.
16	0	-)	.	k)	vi	-vie	.
16	1	.	.	.	In	in	.
16	0	.	.	.	ðə	the	.
16	0	.	.	.	dʒə	ja-	.
16	1	(\	.	(K	ku	-cu-	.
16	0	-)	.	k)	zi	-zzi.	.
16	1	.	3	.	smoʊk	smoke	.
8	1	+	.	.	ɛlz	ls	.
16	1	.	.	.	waI	while	.
16	0	.	.	.	jə	you	.
16	1	(\	.	(K	du	do	.
16	0	_)	.	k)	mi	me.}}	.
8	.	.	.	.	R	.	.
*>Verse3	*>Verse3	*>Verse3	*>Verse3	*>Verse3	*>Verse3	*>Verse3	*>Verse3
=0	=0	=0	=0	=0	=0	=0	=0
1	.	.	.	.	R	.	2..R
.	.	.	4	.	.	({how	16haʊ 1
.	.	.	.	.	.	you	16jə 0
=1	=1	=1	=1	=1	=1	=1	=1
4.	.	.	.	.	R	li-	16lI 1
.	.	.	.	.	.	-ving	16vIn 0
.	.	.	.	.	.	Bi-	16bI 1
.	.	.	.	.	.	-ggie_	16gi 0
.	.	.	.	.	.	_Smalls?.:)	4.smalz 1
16	0	.	4	.	In	in	.
8	1	(+\	.	.	mæn	man-	.
16	0	-)	.	.	ʃIn	-sions	.
16	0	.	.	.	In	and	.
8	1	(+\	.	(A	bɛn	Ben-	.
16	0	-)	.	a)	zIz	-zs.	.
16	1	.	3	.	gI	gi-	.
16	0	.	.	.	vIn	-ving	.
=2	=2	=2	=2	=2	=2	=2	=2
8	1	+	.	A	ɛnz	ends	.
16	1	.	.	.	tʊ	to	.
16	0	.	.	.	maI	my	.
8	1	+	.	A	frɛnz	friends	.
16	1	.	2	.	ɛn	and	.
16	0	.	.	.	It	it	.
16	1	.	.	.	filz	feels	.
8	1	.	.	.	stu	stu-	.
8	1	(+	.	(A	pɛn	-pen-	.
16	0	_)	.	a)	dIs	-dous.	.
16	.	.	.	.	R	.	.
16	0	.	4	.	trə	tre-	D
=3	=3	=3	=3	=3	=3	=3	=3
16.	1	(+	.	(A	mɛn	-men-	D
16.	0	-)	.	a)	dIs	-dous	D
8	1	\-	.	C	krim	cream.	D
16	.	.	.	.	R	.	.
16	1	.	3	.	fʌk	fuck	D
16	0	.	.	.	ə	a	D
16	1	.	.	.	da	do-	D

16	0	.	.	.	lɛ~	-llar	D
16	1	.	.	.	æn	and	D
16	0	.	.	.	ə	a	D
8	1	_	.	C	drim	dream.	D
8	.	.	.	.	R	.	.
=4	=4	=4	=4	=4	=4	=4	=4
16	1	.	4	.	stIl	still	.
8	1	.	.	.	toʊt	tote	.
8	1	.	.	B	gæts	gats	.
8	1	+	.	B	stræpt	strapped	.
16	0	.	.	.	wIθ	with	.
16	1	.	.	.	In	in-	.
16	0	.	.	.	fə	-fra-	.
8	1	.	.	.	rɛd	-red	.
8	1	\	.	C	bimz	beams.	.
8	.	.	.	.	R	.	8wət 1 what?~
=5	=5	=5	=5	=5	=5	=5	=5
8	.	.	.	.	R	.	.
16	1	^	4	(D	tʃap	cho-	.
16	0	.	.	d	In	-pping	.
4	1	\	.	E)	oʊz	os.+	.
.	.	.	.	.	.	.	16ə 0 uh-
.	.	.	.	.	.	.	8hʌ 1 -huh?~
16	1	.	3	.	smoʊk	smo-	.
16	0	.	.	.	In	-king	.
16	1	.	.	.	laI	lah	.
16	0	.	.	.	n	in	.
16	1	+	.	(D	ap	Op-	.
16	0	.	.	d	ɾə	-ti-	.
4	1	\	.	E)	moʊz	-mos.	.
=6	=6	=6	=6	=6	=6	=6	=6
16	1	.	3	.	mə	mo-	.
16	0	.	.	.	ni	-ney	.
16	1	\	.	E	hoʊz	hoes	.
16	0	.	.	.	In	and	.
8	1	\	.	E	kloʊðz	clothes.	.
16	1	+	3	.	al	:all	D
16	0	.	.	.	ə	a	D
16	1	.	.	.	nI	ni-	D
16	0	.	.	.	gə	-gga	D
4	1	\	.	E	noʊz	knows.	D
=7	=7	=7	=7	=7	=7	=7	=7
16	.	.	.	.	R	.	.
16	0	.	4	.	ə	a	.
16	1	.	.	.	fu	foo-	.
16	0	.	.	.	lIʃ	-lish	.
16	1	(\	.	(F	plɛ	plea-	.
8	0	-)	.	f)	ʒə	-sure.	.
16	0	.	3	.	wət	what-	.
16	1	(+\	.	(F	ɛ	-e-	.
16	0	_)	.	f)	və	-ver.	.
16	.	.	.	.	R	.	.
16	0	.	4	.	aI	i	.
16	1	.	.	.	hæ	had	.
16	0	.	.	.	ɾə	to	.
16	1	.	.	.	faIn	find	.
16	0	.	.	.	ðə	the	.
=8	=8	=8	=8	=8	=8	=8	=8
16	1	.	.	.	bɛr	bur-	.
16	0	.	.	.	id	-ied	.
16	1	(\	.	(F	trɛ	trea-	.
16	0	_)	.	f)	ʒə	-sure.	16ðə 0 the~
8	.	.	.	.	R	.	8wʌt 1 what?~
16	0	.	3	.	soʊ	so	.
8	1	.	.	.	græmz	grams	.
16	0	.	.	.	aI	i	.
16	1	.	.	.	hæd	had	.
16	0	.	.	.	ɾə	to	.
16	1	(\	.	(F	mɛ	mea-	.
16	0	_)	.	f)	ʒə	-sure.	.
16	.	.	.	.	R	.	8ʌ 1 uh~
16	0	.	4	.	haʊ	how-	.
=9	=9	=9	=9	=9	=9	=9	=9
16	1	.	.	(F	ɛ	-e-	.
16	0	.	.	f)	və	-ver	.
16	1	.	2	.	lIv	li-	.
16	0	.	.	.	In	-ving	.
16	1	(+	.	(F	bɛ	be-	.
16	0	-	.	f	ɾɛ~	-tter	.
8	1	+)	.	G)	naʊ	now.	.
16	1	.	3	.	ku	Coo-	D
16	0	.	.	.	tʃi	-gi	D
16	1	(+	.	(F	swɛ	swea-	D
16	0	-	.	f	ɾɛ~	-ter	D
8	1	+)	.	G)	naʊ	now.	D
16	.	.	.	.	R	.	.
8	1	.	4	H	drap	drop	.
=10	=10	=10	=10	=10	=10	=10	=10

```
8               1               .               .               H               tap             top             .
16              0               .               .               .               bi              B_              .
8               1               \               .               I               ɛmz             _Ms.            .
16              1               .               3               .               aɪm             i'm             D
16              0               .               .               .               ðə              the             D
8               1               +               .               .               mæn             man             D
8               0               .               .               .               gɛ~l            girl-           D
8               1               +               .               I               frɛn            -friend.}       D
8               .               .               .               .               R               .               .
*-              *-              *-              *-              *-              *-              *-              *-
!!!OTL:Big Poppa
!!!RTL:Ready to Die
!!!RRD:1995/02/20
!!!RRM:Bad Boy
!!!RC#:7-9015
!!!BPP:6
!!!BPD:1995/03/18
!!!COC:The Notorious B.I.G.
!!!COL:Biggie Smalls
!!!COM:Christopher George Latore Wallace
!!!CDT:1972/05/21-1997/03/09
!!!ENC:Nathaniel Condit-Schultz
!!!EED:Nathaniel Condit-Schultz
!!!RDT:2014/-2016/04/
!!!EST:Complete
!!!RDF**recipx: **recip interpretation with complex-fractional, meter-insensitive, durations.
!!!RDF**stress: Syllable stress encoded as either 1 or 0.
!!!RDF**tone: Encoding of pitch peaks, nadirs, glides, and parallelism.
!!!RDF**break: Encoding of prosodic disjunctions as 0,1,2,3, or 4.
!!!RDF**rhyme: Two-dimensional encoding of rhyme relationships between syllables.
!!!RDF**ipa: 41-symbol IPA encoding of syllable pronunciation.
!!!RDF**lyrics: Encoding of word boundaries, meanings, and syntactic/semantic units.
!!!RDF**hype: **recipx, **ipa, **stress, and **lyrics encoding secondary vocal parts.
```

Appendix D: MCFlow Package Details

D.1 Accessing MCFlow Data

MCFlow data is available in two formats: (1) Humdrum text files; (2) R data objects. Both formats are available at www.rapscience.net/MCFlow/data.html.

D.1.1 Humdrum Data

The raw Humdrum-formatted text files (described in detail in Chapter 4) can be downloaded from www.rapscience.net/MCFlow/data.html in a single zip file. Once unzipped, the files can be inspected with any text editor application or even loaded into spreadsheet software. Thus, anyone with basic computer skills should be able to access them. However, to fruitfully process and analyze these files it is recommended that one install the *Humdrum Toolkit* as well as the *Humdrum Extras* package, both available at www.humdrum.org. As mentioned in Section 4.2.3, several important rhythm-related Humdrum functions—*timebase* and *dur*—do not recognize the unique features of **recipx. Accordingly, two modified functions—*timebasex* and *durx*—are also available at the www.rapscience.net/MCFlow/data.html page. Once downloaded these files must be transfered to the humdrum/bin directory where other humdrum

functions are stored, before being used. Their usage is identical to the native Humdrum *timebase* and *dur* functions. Fortunately, Craig Sapp's *Humdrum Extras*—for instance *beat*—are already preprogrammed to interpret **recipx's complex-fraction duration tokens (e.g. /16%5/).

The second data format in which MCFlow is available is as an *R* data object. R is a free-ware software environment for statistical computing and graphing, widely used in the sciences for data analysis. MCFlow can be loaded in as an R "package" on any computer with R installed; R can be downloaded from *www.r-project.org* and can be installed on all major operating systems. The MCFlow R-package files can be downloaded in a single zip file from www.rapscience.net/MCFlow/data. Once downloaded and unzipped, the package must be loaded into R. From within an R session, type

```
install.packages('xxx/FlowPackage.R')
```

with 'xxx/' replaced with the file path where the MCFlow package file was unzipped.[41] This command will unpack and install the MCFlow package in your R software, and will only need to be run once by each user. Once installed, the MCFlow package can then be loaded in any R session by typing `library(MCFlow)`. Once the package is loaded the entire MCFlow dataset and MCFlow package functions (described below) will be available in the R workspace.

[41] Windows users may need to use backslash (\) in place of forward slash (/) in their file path.

D.1.2 the MCFlow R Package

Data

When the MCFlow package is loaded in an R session the MCFlow data will exist in an R object called `FlowData`. The `FlowData` object consists of an R *list* object, with each item in the list being a song in the corpus, named with the format /ArtistName_SongTitle/, and stored as an object of the class *Rap*. Thus, the song "Buffalo Stance" by Neneh Cherry can be accessed with the command `FlowData[['NenehCherry_BuffaloStance']]`. Each *Rap* object in the `FlowData` list is itself a R list of transcriptions, one for each verse in the song. As an example, the second verse of Ja Rule's "Livin' It Up" can be accessed with the command `FlowData[['JaRule_LivinItUp']][[2]]`.

Each transcription of a rapped verse is encoded as a R *data.frame* object. The first eight columns of each verse data.frame contain the data from each of the eight MCFlow Humdrum spines (**recipx, **stress, **tone, etc.), with the appropriate column names.[42] All the data tokens in the Humdrum transcription appear in the data.frame's rows—e.g. one row = one syllable. Instead of interpretation records, interpretation information—as well as some reference information—is encoded in seven additional columns—Year, Song, Artist, Emcee, BPM, Measure, and Section. In addition, useful transformations of the **recipx data are encoded in an additional six columns: *dur.16* (numeric durations in 𝅘𝅥𝅯 units); *dur.ms* (numeric duration in milliseconds); *ioi.16* (numeric inter-onset-intervals in 𝅘𝅥𝅯 units); *ioi.ms* (numeric inter-onset-intervals in milliseconds); *syl.per.sec* (the numeric coding of syllables per second

[42]Since the word /break/ is a R keywords, the **break spine column is labelled /breaks/.

used in Section 5.1.1); and beat (the metric position, in ♪, of each syllable). The complete set of *reference record* metadata for each song is encoded in the attributes of the *Rap* object. Thus, the reference data for Jay-Z's "Empire State of Mind" can be accessed with the command `attributes(FlowData[['JayZ_EmpireStateOfMind']])`. Two more data objects (also data.frames) encode the metadata (reference records) for the entire corpus in one place: `CorpusInfo_bySong` and `CorpusInfo_byVerse`.

In many statistical analyses, it is preferable to have all data encoded in a single object. Thus, loading the MCFlow will also load a `FlowCorpus` object, which is simply all the MCFlow transcriptions combined in a single data.frame. The package also includes a special function `Corpus\_Subset` which can be used to draw subsets of the `FlowCorpus` object, by any number of criteria. For instance, if one wishes to draw all data in which Snoop Dogg or 2pac were the emcees, between the years 1992–1993, the `Corpus\_Subset` command can quickly and easily achieve this. See the `Corpus\_Subset` documentation (by typing `?Corpus\_Subset` in R) for more details.

Tools

Loading the MCFlow package will also load several visualization functions. One is the `plot.Rap` function, which plots rap flow diagrams: A *flow diagram* is a graphical representation of rap flow, which is generally more useful than traditional music notation (Section 6.1). If the R function `plot()` is called with a MCFlow *Rap* object, a flow diagram of the song in question will be plotted. The *Rap* plot function has a number of optional arguments which control the details of the flow diagram—some of these options are discussed in Section 6.1. In addition to flow diagrams, four other plot types are built into the MCFlow R package:

(1) `plot\_Speed()` plots distributions of syllable delivery speeds, as in Figure 5.1 (p. 127).

(2) `plot\_Metric()` plots metric distributions of syllables, as in Figure 5.5 (p. 132).

(3) `plot\_Rhyme()` plots 1st-order conditional rhyme distributions, as in Figure 5.10 (p. 141).

(4) `plot\_Phrase()` plots the metric position of phrases as arrows on the metric grid, as in Figure 5.12 (p. 143).

Combined with the `Corpus\_Subset` function, these plot functions can be easily applied to any subset of the MCFlow dataset. See the documentation of each function for details.

D.1.3 MCFlow's Graphical User Interface

The MCFlow Graphical User Interface can be accessed at the web url *www.rapscience.net/MCFlow/gui*. This GUI implements each plotting function in the MCFlow package (described in the previous section), with all function arguments appearing as user controls in the GUI. The select box marked "plot type" allows the user to select which type of plot. In addition, at the top of the page, a GUI control panel implements a limited version of the `Corpus\_Subset` function, allowing users to select subsets of the corpus by artist, or by year. Thus, if one wanted to compare, say, the metric distribution of rhymes in 1990 to that in 2004, one could easily achieve this. Instructions for the use of the MCFlow GUI are included in the website.