

Toward a Pedagogy of “Swing”: The Microstructure of Jazz Rhythm— A Literature Review

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Abstract

The purpose of this literature review was to critically examine the empirical investigations that have been conducted on the mechanical microstructure of jazz rhythm. First, the philosophical foundations of musical meaning, expression, and structure in jazz performance are discussed. Second, a performer-centered perspective of expression in jazz rhythm is reviewed. Third, the complexities of defining and measuring swing rhythm are outlined. Included in this literature review are the research studies pertaining to the empirical measurement of jazz rhythm. The focus of the selected studies is on empirically measured, mechanical occurrences. These studies are critiqued in terms of statistical reliability and validity. Lastly, the pedagogical implications in the field of music education are discussed along with suggested future research.

The study of microstructure in music stems from the cognitive psychological research of the 1950s and 1960s. Expressive microstructure is an integral part of musical structure that accounts for the varied, subtle, and distinctive forms of tone and rhythm. The principal features of microstructure include the characteristic amplitude shapes for individual tones as well as duration deviations from specific note values indicated in the score (Clynes, 2000, p. 77). Psychological interest in the microstructure of jazz performance began in the mid-1960s with specific consideration to the rhythmic relationships of eighth note pairs inherent in the swing style (Keil, 1966). Beginning in the late 1970s and 1980s, empirical investigation into the microstructural elements of a performer's eighth note treatment began to demystify some of the properties and subtle nuances of jazz rhythm (Owens, 1977; Reinholdsson, 1987; Rose, 1989). These investigations initially sought to break down the swing component of jazz time feel into more concrete, tangible means through methods of linear (eighth note duration) and vertical (ensemble timing) measurement. The relevance of such quantitative inquiry laid in the nuance of a performer's rhythmic discrepancies from the mechanical norm. In a jazz performance, these discrepancies were considered to be an additional layer of musical expression and interpretation inherent in jazz performance (Collier, 1996). In addition, investigation

into the microstructural analysis of jazz rhythm aimed to approach the allusive question, “What makes jazz swing?”

The purpose of this literature review was to critically examine the empirical investigations that have been conducted on the mechanical microstructure of jazz rhythm. Specifically, I identified significant findings, critiqued elements of statistical reliability and validity, offered suggestions for future research in the field, and discussed the pedagogical implications of such research in the field of music education. The context of the selected empirical investigations was established through a discussion of the philosophical foundations of meaning and expression in jazz performance. Furthermore, performer-centered views of musical expression inherent in jazz rhythm and the characteristic difficulties in defining and measuring swing were examined. Included in this literature review were the research studies pertaining to the empirical measurement of jazz rhythm. The focus of the selected studies was on measured, mechanical occurrences. Any studies discussing the perception of jazz rhythm were excluded in this literature review. The searched databases utilized to begin the initial review process included the *Music Education Search System (MESS)*, *Education Resources Information Center (ERIC)*, *Music Index*, *Proquest Dissertations and Theses*, *International Index to Music Periodicals (IIMP)*, and *Répertoire International*

de Littérature Musicale (RILM). Database search terms included *jazz*, *rhythm*, *swing*, *structure*, *microstructure*, *timing*, and *feel* in various combinations. Article abstracts were scanned for relevance. In addition, the reference lists for each selected study were used to locate any additionally relevant studies. The interdisciplinary nature of the field of jazz studies provided relevant research studies in the fields of music education, musicology, music theory, music perception, and music psychology. A narrative approach was better suited to this review of literature because the absence of quantitative data based upon statistical techniques in the selected research studies prevents the utilization of meta-analysis techniques.

Philosophical Foundations of Musical Meaning, Expression, and Structure in Jazz Performance

Psychological interest in the microstructure of jazz performance began in the mid-1960s with specific consideration to the rhythmic relationships inherent in the swing style. In 1966, Charles Keil developed a paradigm for understanding the rhythmic quality of swing (Keil, 1966, p. 339). His theory of "Engendered Feeling," a direct contradiction to Leonard Meyer's theory of "Embodied Meaning" from ten years earlier, sought to describe the innate emotion and meaning found in the production of jazz rhythm (Meyer, 1956). More specifically, it was an early attempt to describe the perception of time-feel inherent in a jazz performance that could not be captured through notation. He argued that a new processual methodology needed to be developed in order to analyze jazz rhythm and time-feel with significant results and connotations relevant to the field of jazz.

Keil's opposition of Meyer's theory laid in its application to musical systems outside of the Western compositional tradition. He claimed that deficiencies occur in applying Meyer's theory to the processual, improvised, and

spontaneous nature of jazz improvisation. Expression, he claimed, was not found in the syntax of the music alone:

This procedure assumes that for analytic purposes music can be fixed or frozen as an object in a score or recording, and it implies not only a one-on-one relationship between syntactic form and expression but a weighting in favor of the former factor to the detriment of the latter. (Keil, 1966, p. 337)

In addition to syntax, modes of presentation, understanding, and response have to be taken into consideration in order to comprehend the intricacies of a jazz performance. It was not only the syntactic, structural relationships that demonstrate embodied meaning, but also the rhythmic drive, groove, timing, and texture that interact equally and in a complex way to yield a Gestalt.

Keil's concept of engendered feeling merely referred to the swing feel or forward-moving rhythmic propulsion inherent in jazz rhythm. It stemmed from the asynchronous manipulation of timing and beat placement between ensemble members. This microstructural push and pull, or deviations from the fundamental metronomicity, conveyed information about musical structure. Furthermore, it was what gave jazz its fundamental swing feel. This push and pull, or "participatory discrepancy" (PD), could be categorized in two ways: processual and textural:

For "participatory discrepancies" one could substitute "inflection," "articulation," "creative tensions," "relaxed dynamisms," "semiconscious or unconscious slightly out of syncnesses." For "process" one could substitute "beat," "drive," "groove," "swing," "push," etc., and for "texture," one could substitute "timbre," "sound," "tone qualities,"... etc. (Keil, 1987, p. 275)

Figure 1 organizes and compares the major tenants of both Meyer and Keil's philosophical approach to musical meaning and expression.

Figure 1. Embodied meaning versus engendered feeling. Reprinted from Music Grooves: Essays and Dialogues, by C. Keil and S. Feld, 1994, Chicago: University of Chicago Press.

	Embodied Meaning	Engendered Feeling
1. Mode of construction	Composed	Improvised
2. Mode of presentation	Repeated performance	Single performance
3. Mode of understanding	Syntactic	Processual
4. Mode of response	Mental	Motor
5. Guiding principals	Architectonical (retentive)	"Vital drive" (cumulative)
6. Technical emphases	Harmony/melody/embellishment (vertical)	Groove/meter(s)/rhythm (horizontal)
7. Basic unit	"Sound term" (phrase)	Gesture (phrasing)
8. Communication	Linguistic	Paralinguistic (kinetic/proxemic)
9. Gratifications	Deferred	Immediate
10. Relevant criteria	Coherence	Spontaneity

Performer-Centered Views on the Elements of Jazz Rhythm

The subtle nuance of processural and textural participatory discrepancies has a substantial implication on a performer's personalized sense of time-feel in jazz performance. "Time-feel" was an important performance characteristic that expresses the unique interpretation of a performance in the jazz genre (Liebman, 2003, p. 21). The degree of rhythmic phrasing a performer expressed could be even more revealing than any type of melodic or harmonic expression. This expression, or "groove," was most obviously expressed to the listener in a string of eighth note patterns. When defining time feel, Liebman wrote:

I am not discussing aspects of syncopation, rhythmical augmentation and diminution, hemiola, etc., which describe actual rhythmical constructs themselves. No matter what rhythms are employed, be they eighths, sixteenths or whatever, it is the way these rhythms are played which determine the ambiance or feel of the music. I would venture to say that the emotional aspect of the music is greatly affected by how rhythm is played, maybe more so than what the rhythms themselves are made up of. A plausible definition of a good jazz rhythmic feel should involve words like "accurate" (meaning as close as possible to the original and ongoing pulse), "even" (connotating a smooth rather than choppy or awkward flow), "variable" (meaning not entirely predictable using a variety of rhythms) and of course our original word "swinging." (Liebman, 2003, p. 22)

Liebman described five elements that constitute time feel and phrasing: (a) articulation, (b) dynamics, (c) "the space between," (d) nuance, and (e) beat placement. Articulation was referred to the way in which a note was attacked. He suggested that when discussing articulation, consideration should be given to the specific jazz style being performed: "As a generalization we could say that the vast majority of articulations heard in jazz fall somewhere between staccato and legato with an incredibly vast palette of variety" (p. 23). Liebman referred to dynamics in terms of articulation and accent placement within the melodic line. He suggested that the soft spectrum of dynamics in a jazz performance include a ghost note, swallowed note, or muffled tone. Similar to articulation, the degree in which accents are used is spontaneous and is subject to variability. "The space between" was referred to the swing-ratio, or the ratio between the time duration of an eighth note on the up beat to the time duration of the eighth note on the subsequent down beat. This aspect of performance was directly related to the performers' conceptualization and expressivity of swing and time feel. Nuance, according to Liebman, was the most individualized aspect of time feel, as it encompassed common devices that were specific

to the instrument and control of the performer: vibrato, smears, portamento, grace notes, use of harmonics, bent tones, vocalizations, etc. Lastly, Liebman referred to beat placement as the subtlest of all time feel characteristics:

This is where the musician places his pulse in relation to the ongoing accompaniment. Because there is a reference point (or several depending upon the number of accompanists) this is a very subjective area and totally affected by the improviser's concept in the moment If we conceive of a beat not as a point in time but an area or measurement of a distance, then we have an entire "space" to play with as far as available choices where one can place their down and subsequent upbeats. (Liebman, 2003, p. 23)

Problems with Defining and Measuring Swing Rhythm

The obstacles with perceptual and cognitive definitions of swing. With such rhythmic complexity inherent in music performance, Gabrielsson (1985) suggested that musical expression between the performer and listener "is meant to be realized by the sounding music, not by reading of a score" (p. 28). The engagement of an aural approach to the realization of rhythmic deviation introduced to the listener an experience in which perception and conceptualization was freed from the limitations of rhythmic categories. Berliner (1994) explained that the jazz community has formulated aural descriptors as a means for describing their perception of jazz rhythm:

Imagining the beat as an "elliptical figure," the drummer or bass player can play either "ahead of the beat" (that is, on the front part of the elliptical figure), "behind the beat" (that is, on the very end of the elliptical figure or in varying degrees toward the center of the figure), or "on the beat" [that is, the center of the Figure 2]. (p. 151)

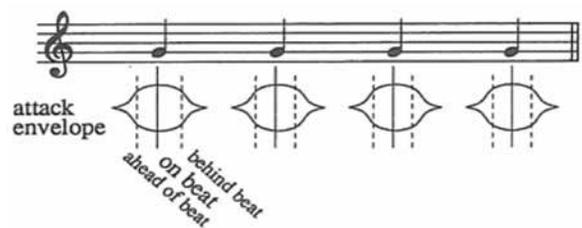


Figure 2. The beat as an elliptical figure. Reprinted from Jazz: The Infinite Art of Improvisation, by P. F. Berliner, 1994, Chicago: The University of Chicago Press.

Pianist Fred Herch further developed this notion:

... there should be ten, fifteen different kinds of time. There's a kind of time that has an edge on it for a while and then lays back for a while. Sometimes it rolls over the bar, and sometimes it sits more on the beats. That's what makes it interesting. (as cited in Berliner, 1994, p. 151)

Perception of music versus actual acoustical events.

The convoluted nature of the timing relationships within an ensemble performance could cause discrepancies between one's perception of music and the actual acoustical events. Contrary to Gabriellson's (1985) stance on the benefits of realizing music's communicative value through aural understanding, Collier and Collier (1994) believed that assigning aural descriptors of timing relations was problematic for two reasons: (a) the listener's preconceptions might influence their perception, and (b) incorrect preconceptions became engrained within the standard narrative of jazz history. Collier and Collier (2002) substantiated their claims with evidence that the perception of Louis Armstrong's rhythmic timing was not in agreement with the actual acoustical events in two of his recorded solos.

These discrepancies not only occurred with the listener, but they also occurred with the actively participating musician. Research has established that performer intention did not always equal performer execution. Prögler (1995) demonstrated that a drummer who perceived himself to be playing "behind the beat" actually was playing "ahead of the beat." Due to the possibility of discrepancies occurring between listeners' and performers' timing perceptions, the empirical analysis of timing relations was essential in understanding the true nature of jazz improvisation. Due to these discrepancies, all research studies pertaining to the perception of jazz rhythm have been excluded from this literature review. A concrete understanding of the mechanical underpinnings of jazz rhythm must first be realized before one could speculate on its relationship to perception.

Limitations of musical notation. In jazz performance, musical notation has been problematic. The accepted convention has been the categorization of successive swing eighth note into a default value of a quarter note-eighth note triplet (Gridley, 1988). However, conventional methods of "swing notation" could not account for the subtle variations in the subdivisions of the swing eighth note. Notation, in this case, was merely an approximation and did not accurately express the performance. The approximation and representation of jazz time-feel into triplet notation might stem from the psychological principle of parsimony as well as the theory of categorization (Bruner, Goodnow, & Austin, 1956). Human perception and cognition strived to interpret and simplify complex information through a coding system of hierarchical arrangement. It was Bruner's (1960) contention that "to perceive is to categorize, to conceptualize is to categorize, to learn is to form categories, to make decisions is to categorize." However, this might be seen as a limitation because the process of simplifying input caused a certain degree of imprecision (Kroll, Rieger, & Vogt, 2010, p. 201).

Benadon (2006) explained the problematic nature of this over-simplistic paradigm:

Adhering to any fixed ratio constitutes a misrepresentation of the rich variety of expressive microstructures found in jazz. Rather than replacing the triplet paradigm, our aim as jazz scholars should be to emphasize the absurdity of ascribing to any rigid formula whatsoever. (p. 91)

Three attempts have been made to formulate an alternate notation system in order to adequately account for microstructural deviations in jazz performance. Stewart (1982) created a grid notation system that "represents the time value of each beat as the distance between two adjacent, vertical lines on the grid" (p. 3). Haywood (1993) suggested an adaptation to standard notation by adding arrows beneath the notes in order to define anticipations and delays. Benadon (2007) suggested using a cyclical graphing method to visually represent and organize expressive timing data. Although these experimental notation conventions offered innovative approaches to representing rhythmic deviations, a more sophisticated explanation was needed to explain all three constructs of swing: eighth note duration, beat placement, and beat emphasis.

Personalization of swing rhythm. Deviations from the mechanical norm served as an expressive feature that defined the stylistic profiles of jazz artists (Bauer, 1993; Benadon, 2003; Benadon, 2006; Cholakis & Parsons, 1995; Collier & Collier 2002; Ellis 1991; Huang & Huang, 1994). This expressive feature of rhythm feel was engrained in each performer's unique treatment of the eighth note triplet and could serve as a basis for perceptual differentiation between individual jazz performers and jazz ensembles. American jazz critic Martin Williams (1970) commented on the use of rhythmic expression as a means of personalization: "... developing a personally-articulated triplet not only has been an identifying mark for the great players, it has been an expression of the high individuality on which this music depends and which it celebrates" (p. 208).

These subtle nuances of a performer's treatment of the eighth note differed not just stylistically, but also in terms of specific distinctions between groups and individuals.

...each of the great players has found his own way of pronouncing the [swing] triplet, expressed or implied.... Roy Eldridge's triplet doesn't sound like Louis Armstrong's; Miles Davis' didn't sound like Dizzy Gillespie's; Lester Young's triplet was unlike Coleman Hawkins'; and Stan Getz's is unlike Lester Young's. (Williams, 1970, p. 208)

Even though musicians perform with rhythmic approaches that could be perceptually unique and

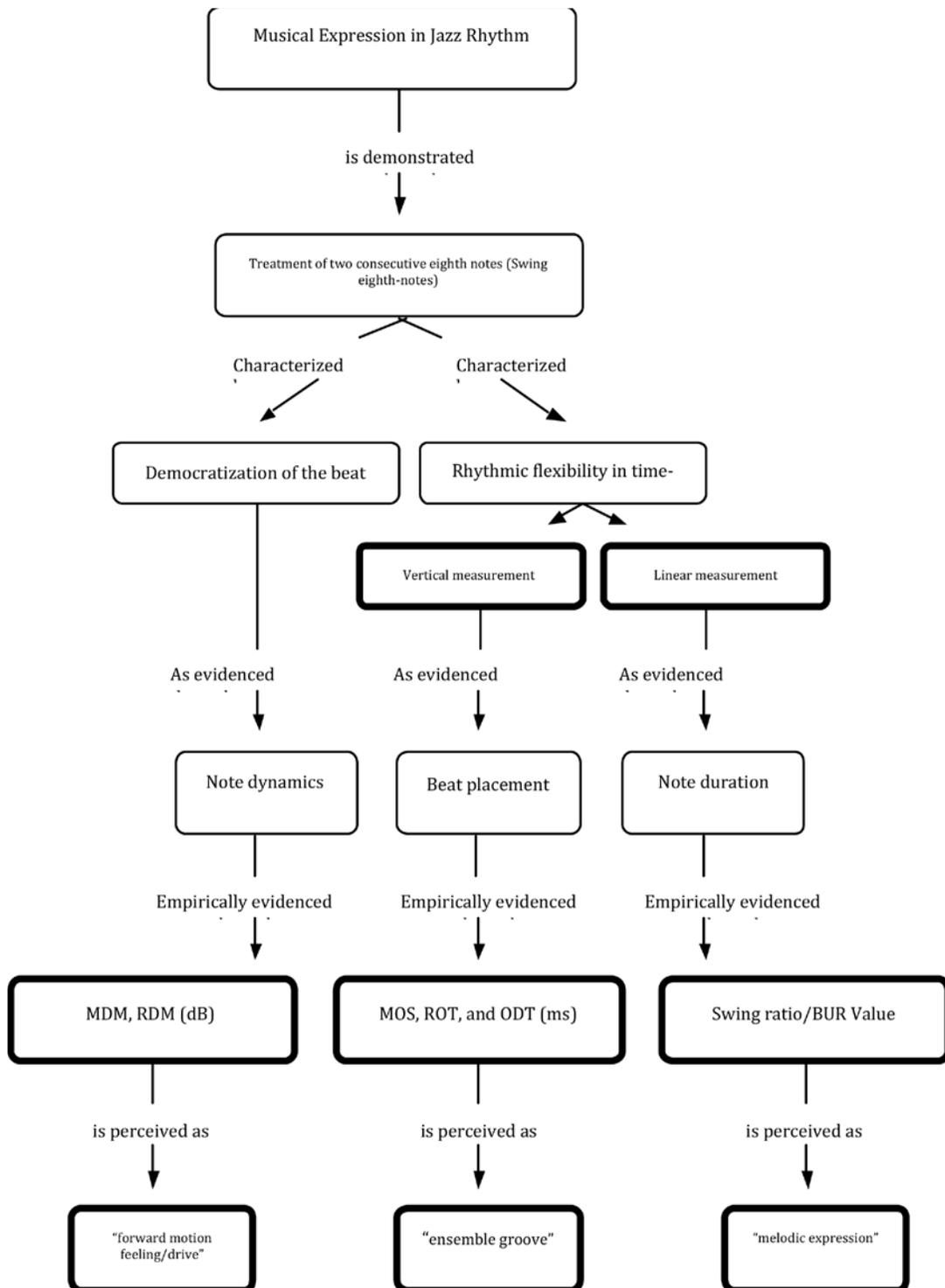


Figure 3. Constructs of musical expression as displayed through jazz rhythm with supporting perceptual and empirical evidence.

recognizable, the rhythmic manipulation in their performances was restricted to a point of perceptual “acceptance” or “correctness” within the particular performance context. Sterns (1970) noted, “When one jazzman confides to that another ‘has no beat’—and there is no harsher criticism—he is impugning his metronomic sense” (p. 4). Disparities among this perceptual “correctness” could even cause a hindrance in the overall musical performance: “... discrepancies in the way players interpret rhythm ... are especially serious when they affect the rhythm section’s fundamental interaction” (Berliner, 1994, p. 395). A wide range of rhythmic variety existed between what was perceptually considered to be “swinging” and what was perceptually considered to be “not swinging.”

The underpinnings of these perceptual judgments seemed to be linked by three common factors: (a) note duration of consecutive eighth notes, (b) placement of the beat in relation to the perceived pulse, and (c) note dynamics. Because the wide range of rhythmic variety in jazz performance often existed at the microstructural level, neither notation nor categorization was specific enough to capture this. In addition, human perception and hearing was more selective than what notation could capture (Hirsch, 1959). However, perception alone was not reliable enough to comprehend the exact measures of rhythmic deviation (Collier & Collier, 2002). A need existed to further explore these factors and their relationship to how swing functioned.

Empirically Testing the Constructs of Jazz Rhythm

The linear measurement of time-feel (i.e., eighth note duration) quantified the durational relationships between two consecutive eighth notes (the *crusis* and *anacrusis*) contained within one full beat. The empirical output of this linear measurement has been traditionally labeled as “swing ratio” (Collier & Collier, 2002; Friberg & Sundström, 2002). There were two problems with using a “swing ratio” (i.e., 1.47 sec : 1.48 sec) as a quantitative descriptor for eighth note durational relationships: (a) it was hard to compare relationships between eighth note pairs because a ratio did not provide a clear visual data point on a continuum, and (b) the ratio was redundant because it would have to be calculated into its quotient for use in statistical analysis and processes. In order to compensate for these inadequacies, Benadon (2006) suggested the use of the number derived from this quotient as a means to compare the relationships. This value was perceptually associated with the expressive quality of the soloist’s melodic style (Benadon, 2006; Collier & Collier, 2002; Friberg & Sundström, 2002).

The vertical measurement of time-feel (i.e., beat

placement) quantified the asynchronous timing between ensemble members relative to the underlying perceptual pulse of the music. The empirical output of vertical measurement was quantified by marked deviations from the perceived pulse measured in milliseconds. In particular, the beat placement relationships between performing members of the ensemble would be empirically defined by statistical methods. These methods included Mean Onset Time (MOS), Relative Onset Time (ROT), and Onset Difference Times (ODT) (Rasch, 1979, p. 122). The MOS was the average onset of times played simultaneously by players, measured in milliseconds. It was defined by the formula: $w = (w_1 + w_2 + \dots w_n) / n$. The ROS was the difference between the mean onset time (MOS) and actual onset time of a performer, measured in milliseconds. It was defined by the formula: $v_1 = w_1 - w, v_2 = w_2 - w, \dots v_n = w_n - w$. The ODT included the relationships of relative onset times (ROTs) between instruments, measured in milliseconds. It was defined by the formula: $d_{1,2} = v_2 - v_1, d_{1,3} = v_3 - v_1 \dots d_{n-1,n} = v_n - v_{n-1}$. These values were linked to the perceptual “quality” of the ensemble groove created by the rhythmic tension and release between ensemble members (Keil, 1966).

Empirical testing of the “democratization of the beat” paradigm (i.e., note dynamics) has yet to be published in research literature. Democratization of the beat was the broad generalization referring to the amount of emphasis in which specific notes were performed. The acoustical loudness of each eighth note performed could potentially be measured and quantified in decibels (dB). These values could be linked to the perceptual “forward motion” or “vital drive” feeling in jazz performance (Hodier, 1956, pp. 207-209). Figure 3 characterizes the relationships of the three constructs related to jazz rhythm.

Empirical Research in Microstructure, Rhythm, and Expression in Jazz Performance

Researchers have used a variety of techniques for quantitatively examining the microstructure of jazz rhythm. Owens (1977) conducted one of the earliest observational research studies in the microstructure of jazz performance. He used a melograph to transcribe a recording of Charlie Parker’s solo on “Parker’s Mood.” In using this method, Owens singled out the improvised solo from the accompaniment by using the loudness curve of the graphing procedure. The results from the graph allowed Owens the opportunity to empirically examine the details of Charlie Parker’s performance style in terms of his phrase shaping, vibrato, and overall melodic-improvisational approach. This technique was a small offshoot of a comprehensive study that deconstructed, documented, organized, and catalogued Parker’s motivic

vocabulary. Although informative, this study lacked the systematic or experimental type of research of more recent studies. In addition, instrument and measurement reliability were a factor.

Reinholdsson (1987) conducted a methodological pilot study on an eight-measure drum solo performed by Roy Haynes on the tune “*Everytime We Say Goodbye*.” The purpose of the study was to contribute strategies to scholarship by displaying a particular methodology for analyzing aspects of rhythm in live jazz performances. Reinholdsson questioned the validity and accuracy heavily based on his use of psychological and empirical observations as well as the relationship of the notational-based approach to transcription (aurally perceived) versus the direct and objective registrations of the physical sound. The recording of a drum solo was put into an analog sound analysis program called Mona. The durations of the measurements had an accuracy of ± 10 ms and were plotted in terms of amplitude. Reinholdsson performed a total of nine registrations (R1-R9) by varying the bandwidth and center frequency. The framework for mechanical performance and mechanical deviations were recorded as ratio-mechanical norms and compared to the duration of the measurements notated by the aurally conceived transcription. Reinholdsson’s results stressed the complications of the empirical analysis process. These included (a) problems with perception of sound in the transcription process (particularly the discrepancies with aural perception and the recorded readings from Mona) and (b) discrepancies in performance analysis (the physical manifestations of rhythm-as-intended versus rhythm-as-perceived). Reinholdsson called for future research into rhythm to include the full jazz ensemble with multi-channel recording. Specifically, researchers should investigate “the feasible changes and adaptations in the timing of the musicians as a result of interactive processes within the ensemble context” (p. 121). He also advised to employ methodological pluralism, in which an analysis should begin in broad terms and progressively shift to an analysis in a more defined, microstructural scope.

Rose (1989) measured the eighth note timing relationships of all notes played by the drums, piano, and bass in a play-along recording in three different mediums: swing-style, ballad, and Latin-style. In measuring asynchronization, Rose used deviations from the mean differences in onset times between piano, bass, and drums. Results showed that in the swing-style example, the order of beat placement from first to last included the drums, followed by the piano, and lastly the bass. The irony in this data is the placement order of the bass. In swing styles, the bass was perceptually considered to play “on top of the beat” in anticipation of the beat (Lawn, 1981) and it was considered to be the prominent timekeeper (Gridley, 1988). In order to analyze the long-short

eighth note beat divisions (swing ratio), Rose used two performance conditions: (a) three recorded performances of the piano, bass, and drums collectively and (b) fifteen unaccompanied, solo performances from recorded jazz literature. His measurement tool was an ISQ Spectrum Analyzer. Rose found that in the unaccompanied, solo performances, the mean swing ratio was 2.38:1. In the collective performances, Rose’s reported mean swing ratio was 1.43:1. The mean swing ratio of all three instruments was 2.4 and all performed with approximately the same swing ratio. The results of this study were interesting at face value; however, this study did not address any type of statistical significance that can be generalized to the overall population.

Ellis (1991) designed an experimental research study that measured the swing ratio of three professional saxophonists. The study sought to describe the asynchronizations and long-short eighth note beat divisions (swing-ratio) that occurred while playing with a prerecorded rhythm section tracks. The saxophonists were asked to perform various notated patterns based upon the blues form, using a Casio DH-100 MIDI wind controller. Each saxophonist performed three trials at 90, 120, 150, 180, and 210 bpm, totaling 15 trials total. Ellis found that all three players delayed the onset relative to the bass in all cases. A two-way repeated measures ANOVA indicated significant differences among the means of the delays of attack with subjects ($p < .007$), tempo ($p < .0001$), and interaction between subjects and tempo ($p < .0001$). Test statistics, degrees of freedom, and power were not reported. In addition, a two-way repeated measures ANOVA indicated significant differences among the means of the swing ratio with subjects ($p < .007$), tempo ($p < .0001$), and interaction between subjects and tempo ($p < .0001$). Test statistics, degrees of freedom, and power were once again not reported. Overall, it was found that the asynchronization between saxophonist and bass was in large part due to the performer delaying the onset attack (playing “behind the beat”). The swing ratio ranged between 1.474:1 and 1.871:1, averaging 1.701:1.

Collier and Collier (1994) took the full ensemble into account by observing the expressivity of jazz performances through the variance of tempo. This study examined and challenged the preconceived notions pertaining to the rhythmic relationships and beat placement of rhythm section instruments. Investigation into the understanding of the global nature of tempo provided insight into the more defined and subtle aspects of rhythmic performance. Five data sets were collected to provide insight into the question: Did jazz musicians prefer particular tempos? The data sets were organized by five categories: (a) band, (b) solo pianists, (c) alternative takes, (d) Teddy Wilson, and (e) tempo doubling. Audio segments were recorded using a stopwatch with the resolution of 1/100 of a second.

Replicating the recording process two to four times checked reliability. The root squared mean between replications was 48.75 ms. One hundred and eighty six tunes or alternate takes were recorded and spanned a range of dates from 1917-1985. The recordings were classified into four stylistic periods in accordance with the standard narrative of jazz history: New Orleans, swing, bebop, and avant-garde. All recordings were in 4/4 time. Using Spearman's rank order correlation, the durations of the recording segments were converted to standard metronome markings. The results showed that jazz rhythm was particularly stable and appeared to be an important factor in defining swing. Overall, the tempo variability was a product of precise control. Sixty five percent of the tunes never varied more than 5 percent. Overall, Collier and Collier concluded, "Rhythm is organized hierarchically... [and] timing preferences are tied to beat level, which is consistent with models of rhythm that give this level a fundamental priority" (Collier & Collier, 1994, p. 241).

Cholakis and Parson's (1995) observational study evaluated the ride cymbal patterns of 15 drummers. Until this research study, the common assumption was that drummers play in a strict triplet eighth note pattern at medium swing tempos. As the tempo increased, the triplet feel would approach a straight eighth note pattern and the distance between the two eighth notes became closer. As the tempo decreased, the distance between the two eighth notes increased. Fifteen drummers' cymbal patterns were analyzed from recorded performances ranging in tempi from 200-251 beats per minute. A total of two 4/4 measures were recorded and divided into equal eighth note subdivisions. Measurements of the test included the number of swing points (the number of off beats followed by on beats), tempo, velocity (reported in decibels), duration (the size of the beat), and swing points range of variability. The idealized perfect quantized time (a triplet quarter note followed by a triplet eighth note in the time span of one beat) was notated numerically as 1000 for the downbeat and 1000+667 as the upbeat. Time measured from 1000 to 8667 on the graph. The range of variability was measured by calculating the difference between the idealized time and the executed time. Measurements of test reliability were not reported. The overall results demonstrated two points: (a) the overall tendency of the drummers was to play closer to straight eighth notes as the tempo increased and (b) only three of fifteen drummers played behind the beat. By looking specifically at Art Blakey's results, Parsons and Cholakis drew three generalizations: (a) backbeats occurred significantly earlier than downbeats, (b) backbeats (beats 2 and 4) were generally louder than downbeats (beats 1 and 3), and (c) backbeat durations were longer than downbeat durations.

Prögler's (1995) quasi-experimental research analyzed the participatory discrepancies in the jazz rhythm section. His look into the three rhythm section instruments (piano, bass, and drums) as a whole in a jazz performance provided additional insight into the rhythmical relationships that define swing. His systematic methodology for measuring the

degrees of discrepancy provided tangible ways of describing and quantifying swing conceptualization. His study was both qualitative and quantitative in nature. Data for his study were gathered from three sources: (a) a recording session of a bass and ride cymbal (specifically for the experiment), (b) recording sessions and interviews with two drummers and one bassists, and (c) a "music-minus-one" recording. The foundation for his study was two recordings by bass players playing a twelve-bar blues in B flat along with a metronome at various tempi (60, 120, and 240 beats per minute). One was asked to play as close to the beat as possible. The second was asked to play "around" the beat. These two recordings then became the basis for overdubbed recordings of drummers playing the ride cymbal. The bassists were then asked to re-record ride taps to the bass lines for comparative purposes. Prögler's generalizations of the overall results of the study included the following: (a) participatory discrepancies occurred in jazz performances and could be accounted for syntactically, (b) these discrepancies could be quantified precisely, (c) the amount of discrepancy was contextual, and (d) recognition and quantification of these discrepancies could lead to a tangible way of realizing and describing rhythm in jazz performances.

Collier and Collier (1996) conducted an experimental research investigation in order to provide analysis of the relationships between tempo and three drummers' swing ratio. Using a MIDI drum pad, the three drummers were asked to perform a swing triplet feel and a straight triple feel at various tempi ranging from a beat duration of 2400 ms (extremely slow) to 214 ms (extremely fast). The results displayed divergent data from the three drummers. One drummer's data demonstrated a negative correlation between tempo and swing ratio while performing a swing pattern. As the tempo increased, the ratio between eighth notes became smaller. The other two drummers demonstrated higher swing ratio data in mid-tempo ranges. The results of this experiment were inconclusive as to the specificity of tempo direction in swing ratio data results. However, the study did demonstrate a tempo-dependent swing ratio. Lack of variability reporting and small sample size might have hindering the results of this study.

Abel (1996) conducted experimental research to answer the question, "How does swing work?" It was Abel's strategy to demystify the vagueness associated with the description of the term "swing." The purpose of the study was to quantify the degree in which metrical displacement, swing ratio, beat placement, and attack velocity interact to create an agreeable listening experience based upon expectation from prior qualitative studies. Abel's hypothesis was that: (a) well-formed performance would be preferred over the straight and perverse performance, and (b) metrical displacement would be preferred, with specific preference to direction and amount. Abel chose and tested 20 Cambridge University students with an average of 12.95 years of listening and playing experience. The only criterion for selection was having performing for listening experience. To prepare the recorded selections, Abel used Unicorn's Performer (5.02) sequencing program

on a Power Macintosh 7500-100 computer, a Yamaha SY99 digital synthesizer with an E-MU Proteus FX sound module. A 16-measure sample of a Bill Evans piano solo was used as the listening stimuli. A total of 15 permutations of the melody was played and the listeners responded to their preference to level of “swing” on a seven item Likert scale, ranging from 1= absolutely no swing to 7= swinging very much. Reliability of the performances included performance mode ($p < .0001$), metrical displacement ($p < .0033$), and interaction between performance mode and metrical displacement ($p < .0005$). The results showed that there was no significance between the straight and perverse performances. However, there was a significant difference for straight versus well formed ($p < .0009$) and for well formed versus perverse ($p < .0001$). The statistical significance of the least square means table showed that the only significance lies in the ahead-2 attack shift, showing that the listener threshold for agreeability was somewhere in the 10ms to 30ms delay range. Overall, at a tempo of 120 beats per minute, it seemed that swing rating was more dependent on the amount and direction of metrical displacement

The weakness in the research of quantifiable measures of jazz performance prompted Busse’s (2002) evaluative and experimental research. He set out to objectively measure and analyze performance deviations (microstructures) from mechanical regularity and measure how experts rated the musical examples as being representative of the “swing style.” Busse developed four performance models based on 281 one-measure performance samples using the Performer 5.02 sequencing program by Mark of the Unicorn, Inc. The 281 samples were produced by 33 solo performances by three jazz pianists. The performances were imputed via MIDI input. The specific microstructure variables measured were note placement, note duration, and note velocity at discrete beat subdivisions. Averaging the data values of the performances and mathematical ratios representative of traditional jazz notation developed the performance models. Forty-two jazz performers and educators were asked to evaluate the swing representativeness in the performance models once they were developed. In addition to the four derived performance models, they were asked to evaluate three additional models contrived from mathematical ratios.

The statistical results showed differences in each of the measured variables of the performers: downbeat note placement ($p < .001$), downbeat duration means ($p = .02$), upbeat note placement means ($p < .001$), and upbeat velocity means ($p = .02$). There was no reported statistical significance for the performers’ upbeat duration means ($p = .48$). No significant relationships were shown between performance tempo and beat placement, but there was a positive correlation between downbeat placement and upbeat placement ($r = .65$). Other positive correlations occurred between tempo and downbeat duration ($r = .30$), tempo and upbeat duration ($r = .57$), and downbeat duration and upbeat duration ($r = .52$). The judges found that the jazz swing style was represented

more by the derived performance models than the mechanical performance models. Overall, the following seven conclusions were drawn: (a) each performer demonstrated a personal approach to time feel, (b) downbeat note placement were generally performed behind the beat at all tempi, (c) upbeat note placements were generally performed later than the traditional triplet swing feel (swing > 66.7%), (d) there was no relationship between upbeat note placement and tempo, (e) notes on the downbeats tended to be performed with longer duration than notes on the upbeat, (f) as tempo increased, performers elongated note durations, and (g) there was only a slight tendency of upbeats to be accented.

Friberg and Sundström (2002) examined two aspects of swing ratio in two studies. First, they studied the variation of four drummers’ swing ratios on their ride cymbals. Second, they measured and compared the relationships of the swing ratios of a drummer’s cymbal accompaniment to a soloist’s swing ratio in a given performance. The study was descriptive, in that it gathered swing ratio data of the drummers, and it was correlational, since it compared the relationship of swing ratio to tempo. Friberg and Sundström claimed that there was a lack of documented evidence of the relationship between consecutive eighth notes with particular regard to tempo variance. The implications of this lack of evidence hindered pedagogical advancement in music expressivity and stylistic consideration. The purpose of this study had two intentions: (a) to measure the variation of ratios measured on the ride cymbal of drummers with varying styles and (b) to measure the variation of ratios between the soloist and cymbal accompaniment. The underlying variable in both studies was tempo. The only delimitation of the study was that the measurements were based on consecutive eighth note patterns. Operational definitions were offered for swing eighth note pattern and swing ratio. Swing eighth note pattern was defined as the lengthening of the odd eighth notes (eighth notes on the beat) and the shortening of the even eighth notes (eighth notes between the beat) to produce consecutive long-short patterns. The swing ratio was the relationship between these two notes. The relationships between two eighth notes that had the standard “triplet-feel” had the relationship of 2:1. The first part of the study measured the variation of ratios on the ride cymbal of four drummers from six recordings. All musical examples were commercially available and all examples were swing style where the ride cymbal was used. A 10-26 second clip from the beginning of a melodic solo was used. The ratio was measured using a spectrograph. A tempo was established by ascertaining a downbeat and measuring 10-16 downbeats following the initial downbeat. The results of the first method showed a linear decrease in swing ratio with increasing tempo. The largest ratio is approximately 3.5:1 (beyond the length of a dotted eighth and sixteenth-note pattern) and the slowest ratio is approximately 1:1 (even eighth notes). The four drummers had similar swing ratios regardless of diverse drumming styles. There was also little variation of ratios contained in the same song sample. The second method

measured the swing ratios of all instruments in various audio segments. All musical examples were commercially available and all examples were swing style where the ride cymbal was used. The audio clip was selected on the basis of the soloist playing consecutive eighth note strings. The results of the second method showed that at a medium tempo, soloists' swing ratios were considerably lower than drummers' swing ratios. All soloists' means were below 2, which was closer to straight eighth notes. The drummers' values were upwards of 4 for slow tempi. The soloists' smaller swing ratios could be accounted for by the delay in the downbeat and their synchronized upbeats with the drummers. The primary findings of both methods led to discussions of approaches to pedagogical applications. Friberg and Sundström found three applications for the findings: (a) Understanding the relationship between tempo and swing ratio helped the teacher to give constructive criticism and advice to a student in regards to swing style (particularly a beginning student), (b) feedback on parameters could improve advice on musical expressivity, and (c) awareness of swing ratio patterns allowed the teacher and performer to prescribe a diagnosis for time and swing feel to avoid common pitfalls typically associated with inexperienced players. The study dispelled and clarified the discrepancy between common belief and the physical reality of time and swing feel. Suggestions for further research included revealing characteristics of musicians' personal time and feel using the same research methods and analyzing musicians' preferred timing characteristics in their approach to improvisation.

Collier and Collier (2002) quantified parts of two Louis Armstrong solos in order to analyze two key elements of swing: placement of the downbeats and the placement of the swing or triplet ratio (the swing ratio). The selection for the two tunes (*Potato Head Blues* and *Cornet Chop Suey*) was based on the inclusion of Armstrong solos over stop-time passages. Isolating the solo sections over stop-time passages allowed Collier and Collier the ease of capturing Armstrong's solo with clarity. The solo segments were captured and transferred to waveform using Cool Edit 96. The coding was agreeable to approximately two or three cycles of a waveform (2ms or less). With this level of reliability, the variance was deemed as less likely to have an effect on the measurement outcomes. Timing was reset to the beginning of each measure. Reference points for the stop-time sections were cued by the ensemble hits on beat one. Reference points for the non-stop-time sections were cued by Armstrong's emphasis of the downbeats. If downbeats did not exist, markers were interpolated using analogous eighth notes. Dependent variables included discrepancy scores and proportional discrepancy. Results showed that Armstrong's mean was 2 ms ahead of the beat. Autocorrelational analysis of *Cornet Chop Suey* showed positive correlations among the eighth notes in each particular measure. This means that the deviations from the mean occurred in groups. In terms of swing ratio, 72 percent of the eighth note groupings in *Cornet Chop Suey*

displayed longer durations of the first note. In *Potato Head Blues*, 95 percent of the groupings contained uneven eighth note durations in the same way. Collier and Collier noted that the relationships of these groups appear to be closer to 2:1 than originally hypothesized (typical swing eighth notes appear to range between 1.4:1 and 1.7:1). The mean of the ratios of the two songs were almost identical: 1.61:1 (30-40 ms later than even eighth notes would indicate). Collier and Collier's conclusion was that the details of jazz rhythm should always be reviewed critically if it was discussed in terms of the unaided ear.

Ashley (2002) examined the nature of the expressive timing in ballad performance through two studies. The first study included the analysis of three interpretations of the Richard Rodgers and Lorenz Hart song, *My Funny Valentine*, by three performers: Chet Baker, Art Farmer, and Miles Davis. The three recordings were chosen for three reasons: (a) the proximity of their recording dates, (b) the performance skill of the artists, and (c) the diverse musical characteristics of the instrumental accompaniment. Ashley measured the note onset attack points using SoundEdit 16 software on a Macintosh computer. The onsets of the tones were defined as the amplitude zero crossing most immediately preceding the beginning of the (quasi) periodic portion of the tone. Using this definition in addition to taking the mean of three separate measurement periods, the error measurement was considered to be 3-5 milliseconds. The onset times of the solo performances were compared to the onset times of bass. Furthermore, the attack-time displacement (AD) was measured against the nominal performance of the original print notation of the melody to *My Funny Valentine*. The results of the first study indicated that tempo was non metronomic, yet extremely well controlled. The tempo was calculated for the first 16 measures of each performance by measuring the interonset interval of the bass from one downbeat to the following downbeat. The range of standard deviation from the mean tempo was 0.8-3.0 beats per minute (bpm). This small range supported the use of tempo as a controlled underlying pulse against the melody for measurement purposes. Ashley found that the deviations in tempo were extreme, ranging from -.38-1.4%. In addition, a noticeable motivic contour was exhibited. This was related to a "delay-accelerate" strategy in which the soloists would delay the beginning of the phrase and accelerate the end of the phrase in order to compensate for time lost. Lastly, there seemed to be a sense of "cadential anchoring," in which the soloist would align with the accompaniment at important cadential positions. Ashley's second study was the analysis of expressive timing in two takes of the song *Naima*, as recorded by John Coltrane. The same method of measurement was used in this study. Ashley found that the range of standard deviation from the mean tempo was 0.4-0.7 (0.7-1.7% of tempo). This small range again supported the use of tempo as a controlled underlying pulse against the melody for measurement purposes. By comparing the two takes, Ashley found a relatively "straight playing

VARIABLE(S)	AUTHOR(S)	RELEVANT FINDINGS
Tempo	Collier & Collier (1994)	<ul style="list-style-type: none"> tempo varies according to the points in the piece and particular points in the performance tempo variations are generally particular systematic, unconscious, and deliberate Tempo variations do not vary more than 5 percent Tendency of tempos can be categorized into three groups: (a) slow, 117MM, (b) medium, 160MM, and (c) fast, 220-230MM
Note duration	Rose (1989)	<ul style="list-style-type: none"> beats 2 and 4 are generally lengthened and beats 1 and 3 are generally shortened.
Note duration	Cholakakis & Parsons (1995)	<ul style="list-style-type: none"> Drummer's undivided beats were played consistently shorter than the divided ones.
Note duration and underlying harmony	Benadon(2006)	<ul style="list-style-type: none"> shifts in harmony and melodic character sometimes correlate to changes in BUR (Beat-Upbeat ratio) values,
Note duration and metrical placement of the beat	Benadon (2006)	<ul style="list-style-type: none"> higher BUR values occur at cadential phrase endings BUR ratios are not uniform within a phrase. They oscillate considerably from beat to beat
Note duration	Benadon (2006)	<ul style="list-style-type: none"> BUR values increase through the bar where as quarter note durations decreases
Note duration	Busse (2002)	<ul style="list-style-type: none"> notes on the downbeats tended to be performed with longer duration than notes on the upbeat
Note duration and tempo	Busse (2002)	<ul style="list-style-type: none"> as tempo increases, performers elongate note durations
Note duration	Collier & Collier (2002):	<ul style="list-style-type: none"> The total mean of analyzed swing ratios of were almost 1.61:1 (30-40 ms later than even eighth notes would indicate) 83.5 percent of eighth note pairs displayed longer durations of the first note Swing ratio ranges between ranges between 1.4 to 1 and 1.7 to 1
Note duration	Rose (1989)	<ul style="list-style-type: none"> Average swing ratio in a ballad 2.38:1
Note duration	Reinholdsson (1987)	<ul style="list-style-type: none"> Average swing ratio ranged from 1.48:1 to 1.82:1
Note duration and tempo	Ellis (1991)	<ul style="list-style-type: none"> Average swing ratio was 1.7:1
Note duration and tempo	Ellis (1991) Cholakakis & Parsons (1995) Friberg & Sundström (2002)	<ul style="list-style-type: none"> Swing ratio and tempo are indirectly proportional. As tempo increases, the swing ratio decreases and becomes closer to straight eighth notes
Note duration and tempo	Collier and Collier (1996)	<ul style="list-style-type: none"> Swing ratio is tempo-dependent
Note duration and tempo	Collier and Collier (1996) Benadon (2006) Honig and de Haas (2008)	<ul style="list-style-type: none"> Swing ratio and tempo are not indirectly proportional
Note duration	Friberg & Sundström (2002)	<ul style="list-style-type: none"> Instrumental soloists generally have smaller (less triplet oriented) swing ratios than the rhythm section
Beat placement	Rose (1989)	<ul style="list-style-type: none"> Asynchronization of nominally simultaneous tones by different instruments occurred. Tendency was for the drums to hit first, the piano to hit second, bass to hit last
Beat placement	Reinholdsson (1987)	<ul style="list-style-type: none"> Deviations in the mechanical norm of the drums equals 5-30ms
Beat placement and tempo	Ellis (1991)	<ul style="list-style-type: none"> Beat placement is not proportional to tempo. As tempo increases, beat placement tends to become more behind the beat
Beat placement	Prögler (1995)	<ul style="list-style-type: none"> Discrepancies in ensemble beat placement is contextual
Beat placement and tempo	Busse (2002)	<ul style="list-style-type: none"> downbeat note placement were generally performed behind the beat at all tempi upbeat note placements were generally performed later than the traditional triplet swing feel, (swing > 66.7%) there was no relationship between upbeat note placement and tempo
Beat emphasis	Busse (2002)	<ul style="list-style-type: none"> there was only a slight tendency of upbeats to be accented

Figure 4. Content analysis of the review of related literature.

style," in which the flexibility of the beat placement was rigid and in time. The alternate take revealed that Coltrane's beat placement was on average, late in nature. Also, there was less overt rhythmic expression performed in the melody of *Naima* compared to *My Funny Valentine*. This indicated that the performer was less likely to take rhythmic liberties on a song less familiar to the audience.

Benadon (2006) conducted an observational study of the temporal relationships between subsequent eighth notes performed with a swing feel in the context of instrumental improvised jazz solos (Beat-Upbeat Ratio, or BUR). The BUR was calculated as the proportion between the durational values of the first eighth note to the durational value of the second eighth note. Previous microrhythm studies neglected the relationship of the swing eighth note to time and pitch collectively. Although aspects of time were prevalent in some studies (Busse, 2002; Collier and Collier, 1994; Friberg and Sundström, 2002; Prögler, 1995), discussion of pitch was excluded. Benadon examined the nature of the jazz eighth note with the intent to explain their relationships to melody, harmony, phrase structure, musical personality (personalization), and the "swing-triplet" concept. Benadon examined and recorded the BUR measurements of a total of thirty-eight recorded solo improvisations using the digital sound editor Sound Forge 4.0 on a home personal computer. There were four criteria for the recorded examples: (a) the example must be taken from a string of at least 8 eighth notes, (b) the eighth note pattern could not be from a double-time passage or non-swing style performance, (c) the tempo was under 250 beats per minute, (d) the example was taken from a 4/4 metered performance, and (e) the quality of the recording had to be clear enough for an unambiguous discrimination reading. Benadon's results suggested that expressive microrhythm aid in the articulation of phrase structure in three ways: (a) shifts in harmony and melodic character sometimes correlated to changes in BUR values, (b) higher BUR values occurred at cadential phrase endings, and (c) motivic repetition and sequencing correlated to repetitive BUR measurements. Personalizations of BUR measurements were represented by histograms. Although no specific test reliability was documented, one could draw parallels between players' distinct rhythmic styles and BUR measurements by outlining the central tendencies and distribution curve of the data provided. Results showed that there was not an adherence to the triplet feel paradigm as discussed in the cannon of jazz history and pedagogy. The divergence from this general rhythmic model demonstrated the abundant array of expressivity found in the rhythmic feel of jazz performance.

Honing and de Haas (2008) examined the relationship of swing ratio and tempo by analyzing three drummer performances on a full MIDI drum set. There were three improvements with this research design as opposed to previous designs: (a) swing ratios were systematically probed in the tempo ranges of 100-240 bpm in order to

compliment previous studies, particularly at slower tempi, (b) performances were repeated in order to check for variability, and (c) the use of a full MIDI drum kit, as opposed to one drum pad, mimicked real-life performance situations. The research questions for this study were (a) How much control did drummers actually have over their swing ratio? (b) Did swing ratio scale linearly with tempo? (c) Was there a threshold in note duration around 100 ms? Three professional musicians were asked to play a swing excerpt at nine different beat durations: 250, 300, 340, 380, 420, 460, 500, 540, and 580 ms with sixteen repetitions. The tempi were marked using a metronome. The drummers performed with a high consistency and low variability between their individual performance styles ($r = .49, p < .0001$; $r = .60, p < .0001$; $r = .66, p < .0001$). This demonstrated that the drummers performed with control. This was measured by comparing their standard deviations from the mean swing ratio in SPSS. Considerable differences were found in the performance style of the three drummers by running ANOVA with the drummer and tempo as factors: $F(8,3419) = 1113.82, p < .0001, \eta^2 = .72, F(2,3419) = 376.94, p < .0001, \eta^2 = .18, F(15,3419) = 117.65, p < .0001, \eta^2 = .45$. Results also showed that swing timing did not scale proportionally with tempo as was suggested in Friberg and Sundström (2002): $r = .20, p < .0001$. Lastly, it was found that in an eighth note pairing, the second note duration was linear in beat duration without support for a lower limit around 100 ms as found in Friberg and Sundström (2002): $r = .94, p < .0001$. Figure 4 outlines content analysis of results from the research literature reviewed.

Summary of jazz related research. The results of the research and literature pertaining to microrhythm lead to the following conclusions: (a) jazz rhythm can be analyzed and evaluated empirically with reliable results; (b) jazz rhythm is stable and is an important factor in defining swing; (c) the relationship between the space between swing eighth notes (swing ratio) and tempo are indirectly proportionate. As tempo increases, the triplet feel approaches a straight eighth note pattern and the distance between the two eighth notes becomes closer. Conversely, as tempo decreases the eighth notes take on more of a triplet feel and the distance between the two eighth notes increases; (d) as a generalization, drummers tend to play on the beat or ahead of the beat as opposed to behind the beat; (e) the relationship microrhythmic variation as a variable of interplay and ensemble members is contextual; (f) changes in harmony yield changes in swing ratio; and (g) each musician has a personal approach to time feel. The experimental research (Abel, 1996; Busse, 2002) particularly demonstrates several implications pertinent to the assessment and evaluation of jazz: (a) changes in microrhythm are audible to the natural ear, (b) as tempo increases, musicians elongate note durations, (c) notes on the downbeat tend to be longer than notes on the upbeat, and (d) there is only a slight tendency to accent upbeats.

Pedagogical Implications and Future Research Suggestions

One of the most fundamental elements in jazz performance is swing rhythm. However, it is one of the least discussed elements in jazz education because of its elusive nature. Instructional problems exist due to the difficulty of describing it in concrete terms (Lawn, 1981; Liebman, 1997). Although the conceptualization of an overarching model of the mechanics of jazz rhythm is far from completion, the results of this study provide insights into the relationships of variables pertaining to the operational functioning of jazz rhythm. The problem, however, is that not all results of the selected research studies are supported by statistically reliable data. The absence of statistically reliable data shows an obvious conflict in the findings of this research. Furthermore, the absence of quantitative data based upon statistical techniques prevents any type of meta-analysis techniques such as the examination of variance, effect size, frequency distributions, or the implementation of z-score transformations. Therefore, the statistical synthesis of the examined data cannot be achieved and can only be considered in a narrative fashion. Recommended future research includes the separate quantitative examination of each of the three constructs pertaining to jazz swing rhythm: eighth note duration, note dynamics, and beat placement. Specifically, each examination should include proper statistical analysis with reports of power, effect size, and variation. A deeper understanding of the relationships between these variables may provide insight into three specific pedagogical areas for student development: (a) prescription, (b) prevention, and (c) aesthetics.

Prescription. Insight into the mechanics of swing rhythm may aid the instructor in the application of constructive, verbal criticism and advice toward the development of students' rhythmic feel. An understanding of the mechanical constructs of note dynamics, beat placement, and eighth note duration from an instructional standpoint may result in more comprehensive and through explanations related to jazz rhythm, ultimately improving teaching and pedagogy. Furthermore, an improved definitional clarity of these three constructs may aid the instructor in developing a more informed pedagogical strategy for teaching the concept of swing rhythm.

Prevention. If an understanding can be achieved between the mechanical microstructure of jazz rhythm and the perception of "what swings" and what "does not swing" in jazz performance, instructors should be informed with tangible, concrete evidence that can be used to diagnose and prevent pitfalls typically associated with developing jazz improvisers and performers. By moving outside of the usual aural imitation method for teaching jazz style, nuance, and expression, instructors should have another means for teaching elements of jazz rhythm that are stylistically appropriate.

Aesthetics. According to Liebman (1997), the subactus metrical level of music expression in jazz performance is the treatment of the eighth note:

The eighth note is the substructure of jazz rhythm. It is the equivalent of the penny to the dollar ... Of course there are permutations ... there are longer rhythms and short rhythms, but it is essentially the eighth note that is the currency ... and to understand how to phrase the eighth notes is crucial to having a good sense of swing. (DVD interview, 1997)

A microstructural understanding of eighth note treatment in jazz performance may lead to the ability to discuss aspects of musical expressivity in jazz performance in more concrete terms. In a more advanced capacity, instructors should be able to differentiate elements of jazz rhythm between performers, ensembles, styles, and genres outlined in the standardized narrative of jazz history. Having the vocabulary available to discuss these subtle intricacies of jazz rhythm may increase the student's abilities to think critically about the aesthetics of jazz performance as well as broaden the student's level of learning.

The analysis of jazz rhythm from a microstructural standpoint is an important step in understanding the mechanics and function of swing in jazz performance. More importantly, it is an essential step in improving the pedagogy of jazz rhythm. A concrete answer to the definition of swing is far from conception; however, quantitative research in the field of music education has consistently been expanding. Future findings from this line of inquiry may aid in unraveling the elaborate nature of jazz performance and improvisation. Additional research of this nature should allow for the building of educational theory and provide a strong, well-grounded foundation in jazz pedagogy.

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