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FUNDAMENTAL RHYTHMIC CHARACTERISTICS OF IMPROVISED STRAIGHT-AHEAD JAZZ

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FUNDAMENTAL RHYTHMIC CHARACTERISTICS OF IMPROVISED STRAIGHT-AHEAD JAZZ

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The purpose of this investigation is to delineate the characteristics of the jazz rhythmic quality known as swing, and to illustrate these characteristics through transcription and analysis of improvisatory musical examples from model jazz recordings. The meaning of the term swing is explored through examination of publications addressing jazz rhythm, resulting in a compiled list of the characteristics of swing. Two studies follow which investigate the rhythmic techniques of jazz performance in relation to these characteristics. In the first study, five improvisations by jazz masters Oscar Peterson, Wynton Kelly, Wynton Marsalis, and Marcus Roberts are transcribed and analyzed. In the second study, excerpts from a contemporary jazz recording by the University of Texas Faculty Jazz (*On The Cusp*, 2007) are transcribed and analyzed for the purposes of measuring timing features, including steadiness of beat, rhythmic asynchronies between instruments, and swing ratios.

Findings support the compiled characteristics of swing rhythm, and also suggest generalities regarding how jazz musicians interpret time feel, such as accompanying instrumentalists exhibiting a closely synchronized time feel, soloists frequently playing

behind the beat of accompanying rhythm sections, and soloists performing eighth notes that are often more even than the eighth notes of accompanying ride-cymbal patterns.

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CHAPTER ONE: INTRODUCTION

When asked to define *swing*, trumpeter Louis Armstrong's legendary response was: "If you have to ask, you'll never know" (Collier & Collier, 1997; *Jazz*, 2007, in *Encyclopaedia Brittanica*; Lawn & Hellmer, 1996). Armstrong's sentiment seems to imply that swing cannot be expressed with mere words, but rather is only fully understood through involvement with jazz music making. The assertion is credible; many aspects of artistry are best learned through experience, and are difficult to express in words. Yet, if swing cannot be defined, this presents major problems for jazz educators. How can educators teach jazz rhythm if they are unable to define swing?

In his influential book, *The Process of Education*, Bruner (1977) emphasized the importance of understanding the fundamental principles of a subject, and illustrated the benefits of such understanding in teaching and learning processes. This paper aims to develop fundamental understanding of jazz rhythm by investigating the quality known as swing. Swing has been identified as one of the most important aspects (the second being improvisation) that distinguish jazz from other types of music (Gridley, 1988). In fact, many authors and jazz musicians have described swing as a central element of jazz rhythm (e.g., Berliner, 1994; Collier & Collier, 1996; Erskine, 2005; Friberg & Sundström, 2002; Liebman, 1997; Schuller, 1968). It may be argued that swing is the "heart" or "essence" of jazz rhythm, as it is declared in the famous song title: "It Don't Mean a Thing If It Ain't Got that Swing," composed by Duke Ellington and Irving Mills. To better understand jazz rhythm, it is indispensable to examine the fundamental quality of swing in performances by jazz experts. This process of examining the work or behavior of experts leads to a deeper understanding of their subjects of expertise, often providing clarity regarding the core principles of a subject, and ultimately leading to the ability to explain these principles to students (Duke, 2005; Lehmann & Ericsson, 1997; Woody, 2001).

Rhythm is a very important element of jazz, yet it may be the least discussed element in jazz education because of the difficulty of describing it in concrete terms (Lawn, 1981; Liebman, 1997). In fact, a vast amount of jazz pedagogical resources are focused on the melodic and harmonic aspects of jazz, but very few are focused on rhythm (Witmer & Robbins, 1988). College jazz programs require courses such as harmony, theory, and piano; whereas, they rarely, if ever, require courses in rhythm, percussion, or dance. In addition, jazz education texts often state the importance of rhythm in jazz, but tend to focus only briefly on rhythmic techniques. For example, in *Creative Jazz Improvisation*, Reeves (2007) wrote: "Rhythm is the most important element in jazz" (p. 26). Despite this statement, very few pages in the text are dedicated to the topic of rhythm, whereas subjects like chords and scales are covered extensively (see also Benward & Wildman, 1984). This is a common problem in jazz education: The importance of rhythm is asserted strongly, yet relatively few materials are devoted to the topic.

One of the most effective resources on jazz rhythm, particularly swing, is an instructional DVD by jazz saxophonist David Liebman titled *Understanding Jazz Rhythm: The Concept of Swing* (1997). In this DVD, Liebman describes the characteristics of swing, demonstrates them with performances on his saxophone, and provides practice exercises for students. Another more recent contribution to jazz pedagogy focused on rhythm is the text *Time Awareness for all Musicians* by drummer Peter Erskine (2005), which eloquently discusses time and rhythm in jazz performance, and includes beneficial rhythmic exercises.

Jazz history texts and ethnomusicological studies also impart valuable information about swing, often supporting the ideas expressed with quotations from jazz musicians (Berliner, 1994; Dance, 1974; Gioia, 1997; Kernfeld, 1995; Monson, 1996; Schuller, 1968; Ward, 2000). However, because these sources focus mainly on what has been spoken and written about swing, they include few efforts to examine jazz rhythm in musical examples (i.e., authentic jazz performances).

A few researchers have investigated the concept of swing in jazz performances by measuring aspects of timing such as swing ratios and asynchronies. The swing ratio is the difference in duration between *downbeats*[1] and *off-beats*[2] when swing subdivision is applied to eighth-note rhythms. For example, the swing ratio of a precisely executed triplet-based subdivision (i.e., ) is 2:1. Asynchronies refer to the difference in onset or attack times of two or more instruments that appear to play simultaneously. Asynchronies are usually measured in milliseconds.

Research that has analyzed these aspects of timing in jazz performance includes studies by Rose (1989), Collier and Collier (2002), and Friberg and Sundström (2002).

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[1] In this paper, the term downbeats refers to the beats in a musical measure that are normally counted, for example, beats 1, 2, 3, and 4 in a measure of 4/4 meter.

Rose investigated timing in the performance of an accompanying rhythm section (no soloist), and Collier and Collier measured the timing of two solos by Louis Armstrong. Friberg and Sundström analyzed the timing of improvised solos and rhythm-section accompaniments using highly regarded, well known jazz recordings. However, none of these researchers used audio files representing isolated instruments when measuring timing, such as the files available in multi-track studio recordings. Instead they used recordings representing the total ensemble.

In summary, the study of jazz rhythm lacks a clear definition of swing that is supported by analysis of musical examples representing authentic jazz performances. Liebman (1997) has contributed the most complete definition of swing, which he supports effectively with a few demonstrations using his saxophone and a ride cymbal on his instructional DVD. However, only a few studies have examined swing in recorded performances of jazz artists, and more investigation of existing recordings is needed to support the ideas of Liebman and others. Such investigation can provide increased understanding of the rhythmic techniques used by jazz artists to achieve a quality of swing in their performances.

The present investigation addresses this question: What is swing, and how are the characteristics of swing demonstrated in performances by jazz experts? Initially, the meaning of the term swing is explored and the characteristics of swing are defined, and then musical examples are analyzed in two different studies to illustrate these characteristics.

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[2] In this paper, the term off-beats refers to beats that occur between downbeats.

In the first study, five improvised solos are transcribed and analyzed, representing four well known jazz masters: Oscar Peterson (two examples), Wynton Kelly, Wynton Marsalis, and Marcus Roberts. The analyses focus on the rhythmic techniques of these soloists with particular emphasis on how their improvisations demonstrate the characteristics of swing. In the second study, excerpts from a contemporary jazz recording (*On the Cusp*, 2007) are examined through transcriptions and timing measurements of *ride patterns*[3], *walking bass lines*[4], piano *comping*[5], and improvised solos. This study provides a more precise and objective examination than the first study by measuring timing at the micro level and calculating asynchronies and swing ratios. Specifically, it examines a multi-track studio recording, allowing for isolation of individual instruments and thereby overcoming problems associated with identifying an individual instrument in the spectrograms or waveforms representing recordings of ensembles. This use of a multi-track recording increases the certainty and accuracy of timing measurements when it is desirable to extract single-instrument tones from ensemble recordings.

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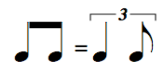
[3] In this paper, the term ride patterns refers to the rhythmic patterns performed by drummers on ride cymbals providing the basic pulse or beat of the music along with the subdivisions of the beat.
[4] Walking bass lines are bass lines idiomatic to the swing style based on quarter-note rhythms.
[5] Comping is an informal word for "accompanying" or "complementing" used in jazz performance. Comping often consists of the playing of chords behind soloists, but the term can be used to describe the function of any accompanying instrument.

The Characteristics of Swing

The term swing has multiple definitions. In musical performance, swing means to apply an uneven or triplet-based subdivision to eighth-note rhythms (i.e., 
).
The term *swing subdivision* is used in this paper to describe this occurrence. Swing is also a term for a musical style in which swing subdivision occurs and a number of other features may be found such as 4/4 meter, walking bass lines, and idiomatic ride patterns. The label *swing style* is used herein for this particular application of the term. Throughout this document, the term swing is used in the general sense, referring to the spirit of jazz music and the rhythmic qualities that are fundamental and/or distinct to jazz.

Although swing is sometimes considered to be a subjective phenomenon dependent on the experience of listeners, there is great agreement in literature about jazz regarding the rhythmic characteristics that define swing. I investigated the topic of swing in many publications from the last 50 years, including jazz education texts, jazz history texts, ethnomusicological studies, and research papers (Aebersold, 1992; Benward & Wildman, 1984; Berliner, 1994; Collier & Collier, 2002, 1997, 1996; Crook, 1991; Dance, 1974; Ellis, 1991; Erskine, 2005; Friberg & Sundström, 2002, 1997; Galper, 2005; Gioia, 1997; Gridley, 1988; Kernfeld, 1995; Lawn, 1981; Lawn & Hellmer, 1996; Liebman, 1997; McLaughlin, 1983; Monson, 1996; Prögler, 1995; Reeves, 2007; Robinson & Kernfeld, 2007; Rose, 1989; Schuller, 1968; Ward, 2000; Yoshizawa, 1999). Within these sources, I found the recurrence of a number of specific rhythmic aspects associated with the quality of swing, which I used to compile a list of 12 characteristics.

Not all of these 12 facets of swing were discussed in every source investigated, but the DVD by Liebman (1997) was the most comprehensive, discussing each of the characteristics to some extent. The list presented here was strongly influenced by Liebman's lecture and demonstration. The characteristics of swing are: beat, rhythmic accuracy, democratization of the beat, relaxed-flowing-effortless quality, forward motion, rhythmic variety, idiomatic articulation, polyrhythm, phrasing flexibility, tension and release, interpretation of subdivision, and interpretation of beat placement.

Beat is a regular pulse that is perceived in music. Music that "swings" has an underlying beat that is obvious to the listener. The swing beat is energetic, infectious, and, in many cases, quite steady (Kernfeld, 2007a; Monson, 1996).

Rhythmic accuracy means that rhythms are executed with precision and good timekeeping. Rhythmic accuracy is essential for a successful jazz performance, and can be difficult to achieve given the improvisatory nature and complexity of jazz music.

Democratization of the beat occurs when "weak" beats are emphasized as much or more than "strong" beats[6], as when a *backbeat* (i.e., emphasis on beats 2 and 4) is imposed upon a 4/4 structure, or when a sequence of consecutive off-beats are accented. Gridley (1988) described this phenomenon as "tugging at opposite sides of the beat" (p. 7). Some authors have suggested that this technique contributes to the forward motion characteristic of swing (e.g., Berliner, 1994; Schuller, 1968).

The **relaxed-flowing-effortless quality** of swing is somewhat intangible, and difficult to express in a written paper, but far too important to be omitted. Berliner (1994) wrote: "Praised for their swing, effective improvisations are 'natural, flowing, uncontrived, and spontaneous'" (p. 147). Erskine (2005) summed up his definition of swing: "I think we could generalize that a feeling of swing has a drive or momentum in balance with a feeling of relaxation and effortlessness" (p. 21). To create a feeling of swing, musicians must overcome unwanted tension or anxiety.

Forward motion refers to the buoyant quality of swing. Some have suggested that emphasizing off-beats creates a sense of pull toward successive downbeats, (e.g., Berliner, 1994; Schuller, 1968). In addition, starting phrases with *pick-up notes* (i.e., one or more notes preceding and leading into a new phrase or measure) and creating phrases that extend across bar lines can create a sense of forward motion (Galper, 2005). In a unique description, Kernfeld (1995) emphasized the role of the triplet in forward motion:

> The essential properties of a simple swing rhythm can be summarized by [saxophonist] Lester Young's concise definition, the rhythmic phrase "tinkety boom." Simple swing should meet three criteria:
>
> 1. Some beats are explicitly subdivided into three parts (tin ke ty).
> 2. The first and third parts receive emphasis (TIN ke TY).
> 3. The third part sounds as if it were connected more to the following beat than to its own (TIN ke TY-BOOM) and thus pushes the rhythm forward. (p. 14)

Rhythmic variety alludes to the diversity, complexity, and unpredictability of rhythmic content that are often characteristic of jazz music.

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[6] See "Extending the Principles of Musical Meter," Chapter Two, for a discussion of strong and weak beats.

Idiomatic articulation refers to the various articulation devices that are prevalent in swing such as accents, *ghost notes* (i.e., notes played so lightly that they are barely audible), pitch inflections, and differing degrees of staccato and legato. Abrupt dynamic contrast, achieved with the use of accented notes and ghost notes, is a clear example of idiomatic articulation (Liebman, 1997; Schuller, 1968; Yoshizawa, 1999). In his doctoral dissertation, Yoshizawa (1999) conducted a study of bebop pianists' phrasing, and found that accents tended to be placed in the following places: on the off-beats in syncopated figures, at the beginnings of phrases or groupings, on the anticipatory first note of a phrase when it is tied across a downbeat, on the highest note in a phrase, and on the final note in a phrase when it is short and occurs on an off-beat. Besides these examples, there are many other possibilities in articulation, allowing for highly personalized approaches to jazz performance.

Polyrhythm is perceived when at least one musical part is regular and/or metrical, while concurrent parts are irregular, or imply a different meter from the first part.

Phrasing flexibility relates to the independence of phrasing in relation to formal structures. In many cases, compositional structures in jazz consist of four-bar sections, and harmonic changes tend to occur every two or four beats. Jazz phrasing, particularly the phrasing of soloists, frequently diverges from these regular structures, crossing over boundaries and creating a sense of unpredictability. Also, diversity in phrase lengths is often desirable in jazz improvisations. Berliner (1994) wrote effectively about this idea:

> Because the foundational harmonic blocks of many pieces are square, made up of regular repeating two-, four-, and eight-bar phrases, improvisers evaluate solos as being square, in a pejorative sense, when their patterns consistently coincide with the composition's harmonic blocks. By altering the design of phrases within a progression, varying their spans, and, at times superimposing secondary meters on those of the piece, mature artists can obscure the formal elements that guide their inventions in much the same way as the architect, in designing an impressive structure, obscures its underpinnings. "Great jazz players start and end in different places as they go from chorus to chorus," Chuck Israels explains…Barry Harris similarly appraises solos of uniform phrase length to be as "monotonous as the drone of a dull speaker." (pp. 245-246)

Tension and release refers to the technique of creating rhythmic conflict, and resolving the conflict with a rhythmic coming together. Frequently the soloist does this by playing rhythms that seem to go against the underlying beat of the rhythm section to generate tension, and then resolving the tension by playing rhythms that align with the beat. Alternating passages of rhythmic tension and release are common in jazz, and can generate great excitement.

Interpretation of subdivision is most apparent with regard to swing subdivision. When swing subdivision is applied to eighth-note rhythms, the difference in duration between downbeats and off-beats is the swing ratio. The swing ratio varies greatly due to different tempos, styles, and personal preferences of musicians. Interpretation of swing subdivision in the swing style is particularly important because the effects of these interpretations are relatively easy for the listener to perceive. Performers may also interpret subdivision in non-swing styles, such as straight-eighth or sixteenth-note styles, but there is less room for interpretation in these styles, so slight differences in subdivision are barely noticeable to the listener.

Interpretation of beat placement refers to the temporal placement of rhythmic figures against the underlying beat. The beat in jazz is often described as a "wide" beat indicating that there is room for manipulation of temporal placement within a range that is considered accurate (e.g., Benward & Wildman, 1984; Berliner, 1994; Prögler, 1995). According to Benward and Wildman (1984):

> A beat can either be wide or narrow. For example, although each beat occurs as a "point" in time, try to envision the difference between the "point" made by an ultrafine-line pen and a magic marker. The ultrafine-line pen demonstrates the center of a beat, while the magic marker widens the possibilities, allowing a loose, swinging, personal approach to time on many different structural levels. A wide-beat concept is not just a haphazard reaction, however; it is idiomatic to the jazz style. (p. 127)

Some soloists may choose to play slightly behind the beat of accompanying rhythm sections for expressive purposes (Ellis, 1991; Liebman, 1997), whereas rhythm sections generally try to play together closely (Berliner, 1994; Rose, 1989). Individual musicians demonstrate unique interpretations of where to place sounds in relation to the beat.

Although the preceding 12 characteristics are helpful in defining swing, it is necessary to point out that swing is more than just a collection of technical features. Many musicians express that swing is mostly about attitude or spirit. Gridley (1988) used the term "group spirit" in defining swing. Bassist Red Mitchell used a poem to express his sentiments of swing: "It isn't really rigid metronomic time that counts. It's sound and soul, communication, love, support and bounce" (Prögler, 1995, p. 47).

Limitations of the Study

This investigation is limited to the analysis of just a few musical examples, each of which represents the *straight-ahead*[7] style performed at a moderate tempo (about 124 to 181 bpm). Moderate tempos were chosen because they are commonly performed, and in this style, moderate tempos allow for performers' interpretations of time feel. The observations made apply only to the examples analyzed, although it is assumed that generalizations developed from these studies would likely be applicable to other musical examples of the same rhythmic style and tempo range. It is less likely that these generalizations would be applicable to jazz music of different rhythmic styles and/or tempos.

Further limitations regarding the first study are that the inquiry is limited to four jazz masters (Peterson, Kelly, Roberts, and Marsalis), two historical periods (1960's and 1980's), and two instruments (piano and trumpet). Findings may or may not generalize to recordings by other jazz masters, from other historical periods, or in performances representing additional instruments.

In the second study, the analysis is limited to short excerpts from a full-length CD recording, and the musical parts transcribed and analyzed are restricted to ride patterns, walking bass lines, piano accompaniment, and piano solo. Thus, not all aspects of the ensemble performance are considered, and findings may or may not generalize to other excerpts and musical parts in this CD recording. Timing is measured on the micro level;

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[7] In this paper, the term straight-ahead refers to a conventional jazz rhythmic style that features walking bass lines and idiomatic ride patterns.

there is no examination of long-range tempo fluctuation. Additionally, the calculation of *perceptual attack time*[8] in this study is problematic because there is a range of time at which listeners may perceive the attack of a musical tone, and different instruments have contrasting acoustical properties that affect this perception. In fact, no existing method for calculating perceptual attack time is ideal, because perceptual attack time cannot be pinpointed to the exact millisecond. The method for determining perceptual attack time used in this study must be taken into account when interpreting the results regarding asynchronies between instruments. The problem of perceptual attack time is discussed in greater detail in Chapters Two and Four.

[8] In this study, perceptual attack time refers to the moment at which the listener perceives the rhythmic impact of a musical tone.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

"I just think swing is a matter of some good things put together that you can tap your foot by." Count Basie, 1972[9]

The main goal of this dissertation is to gain a fundamental understanding of rhythm in jazz performance. The two studies herein use different approaches to this problem: The first study provides musical analysis, and the second study measures ensemble timing. Therefore, the literature reviewed in the present chapter covers a broad range of topics, addressing musical, psychological, and perceptual issues. The first section discusses the impact of *African music*[10] on the development of jazz rhythm. This is followed by an exploration of the psychological foundations of rhythmic performance, particularly beat perception and synchronization. The next section reviews perceptual studies that are important for understanding how to interpret findings in research on ensemble timing. And the final section summarizes existing studies that have analyzed ensemble timing in jazz performance.

The Historical Impact of African Culture

Between 1451 and 1870, a staggering total of about 10 million Africans arrived in the New World as slaves (Kaufman & Guckin, 1979; A History of Western Africa, in *Encylopaedia Britannica*, 2007). The Africans who were forcibly transported to the New

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[9] From *The World of Swing* (Dance, 1979).

[10] In this paper, the term African music refers to music of West African tribal cultures as described by Jones (1959), Kauffman (1980), Kaufman and Guckin (1979), and Nketia (1974).

World hailed from various regions of West and Central Africa. Initially brought to the Caribbean islands, many were transferred to South America or New Orleans. The majority of slaves who landed in North America were from West African regions such as Dahomey (Benin), Togo, Nigeria, and Ghana (Kaufman & Guckin, 1979). According to Gioia (1997):

> Forcibly taken away from their homeland, deprived of their freedom, and torn from the social fabric that had given structure to their lives, these transplanted Americans clung with even greater fervor to those elements of their culture that they could carry with them from Africa. Music and folk tales were among the most resilient of these. Even after family, home, and possessions were taken away, they remained. (p. 7)

African music and culture contrasted greatly with the music and culture of the European colonizers. Yet in spite of the oppression that slaves suffered, they adapted their ways of life to their new environments, transforming European musical traditions to meet their needs for artistic expression. The transplanted Africans clung to their own musical traditions, but they also heard European classical music, looked at musical scores, and played European instruments. The African heritage began to emerge among European musical conventions, and the Africans' affinity for rhythmic complexity was not lost. The folk music of the slaves – ring shouts, blues, spirituals, work songs, funeral marches, banjo music – were the early products of this cultural fusion, which eventually produced jazz and strongly influenced 20th-century music throughout the world (Gioia, 1997; Jenkins, 1945; Kaufman & Guckin, 1979).

RHYTHM IN AFRICAN CULTURE

Rhythm in African culture and music had a strong impact on the development of jazz, distinguishing it from European classical music. In general, music in West African tribal societies fulfilled the specific function of initiating physical movement such as dance, work, or play. Hence, beat and rhythm were often the most prominent musical elements. More specifically, the polyrhythms of African ensemble music were extremely complex, and frequently did not conform to the principles of European musical notation. In a fascinating development, jazz musicians managed to retain aspects of African rhythm, such as the strong emphasis on beat and a tendency to create complex polyrhythms, while adapting African rhythmic techniques to the frameworks of relatively simple European metrical structures (Gioia, 1997; Kaufman & Guckin, 1979; Schuller, 1968).

In indigenous African cultures, virtually all music is integrated with societal activities like ceremony, work, and play. Whether it is hand clapping and dancing at a wedding ceremony, or the paddling of oars accompanying a rowing song, music and movement go hand in hand. Nketia (1974) described the integration of music and work by the Frafra tribe of Ghana:

> In this society, a player of the one-string fiddle and a rattle player accompany teams of men who cut grass. As they play, the workers swing their cutlasses in a concerted manner to the rhythms of their music, causing the slashing sounds of the blades to fall regularly on the main beats. This has a remarkable effect on the speed as well as the efficiency of grass cutting, for rhythmic movements that are properly organized on some regular basis appear to be less fatiguing than movements in which exertion and release of effort do not form an ordered sequence. (pp. 28-29)

The European ideal of "absolute music" (i.e., music existing solely for musical, aesthetic purposes) is foreign to indigenous African cultures, as is the idea of a motionless, non-participating audience sitting quietly at a concert. According to Kaufman and Guckin (1979):

> In contrast to European "art music," both African traditional music and early jazz are an integral part of a complete societal structure. The word "art" has no counterpart in African languages. Whenever the word is used it is done so in the form of some European language. The African musician deals with dance, music, folklore and costumes as a completely integrated entity involved in all phases of life including religion, work, war, birth, death, etc. Similarly, American jazz has emerged from work songs, field hollers, religious music, folklore and the funeral brass bands of the 19th century black society. (p. 75)

Jones (1959) explained that African music is incomplete without dancing and hand clapping:

> The norm of African music is the full ensemble of the dance: all other forms of music are secondary. If an African wants to explain his music to the outsider, it is the full dance which he will take as his example. If the drums are beating but there is no singing or dancing Africans will think 'there is nothing happening': so too, if there is music and the performers 'really mean business' it is essential to have the full ensemble. This consists of the instruments of the orchestra, the hand-clapping, the song, and the dance. All these four ingredients combine to form the central act of African music-making, the equivalent of our Western symphonies. (p. 51)

The widespread incorporation of percussion instruments and body movement of African music contrasts with the traditions of European classical music. For example, audience members customarily sit still when attending a classical concert, and much classical repertoire is performed without percussion instruments.

In contemporary jazz, audience behavior seems to be a working compromise between the European tradition of non-participation and the African tradition of total involvement (Storb, 2001). At jazz concerts, audience members frequently applaud or shout in the middle of a performance, movement is tolerated, and dancing or clapping hands may be observed. Spontaneous interaction between audience and performers is expected, even encouraged in some situations (Monson, 1996). Audience response is often of a rhythmic nature: swaying, clapping, or dancing. Notably, in the heyday of jazz as popular music – the Swing Era – jazz was primarily dance music (Dance, 1974; Gioia, 1997; Ward, 2000).

Naturally, music that emphasizes percussion instruments and synchronized movement is often characterized by a steady beat. The emphasis on a strict beat in most music for jazz band is an aspect that contrasts with many classical works for orchestra or band, in which the expressive quality known as *rubato*[11] is preferable. The prominence of an explicit, steady beat in jazz is a factor that can be attributed, in large part, to African roots.

African music's emphasis on rhythm, movement, and percussion influenced the evolution of the drum set and the rhythm section, now fixtures in jazz and popular music. In fact, a central function of the rhythm section – to provide a stable rhythmic underpinning to support improvisation – is a direct outgrowth of the African tradition. In African music, it is common for a host of musicians to provide recurring rhythmic patterns while the master drummer performs elaborate improvisations (Jones, 1959;

[11] Rubato is the expressive alteration of rhythm or tempo, literally "robbed or stolen time" (Hudson, 2007).

Kaufmann, 1980; Kaufman & Guckin, 1979). The modern-day jazz rhythm section fulfills a similar foundational and supportive role. Jazz soloists and bandleaders appreciate fine rhythm sections, which provide inspiring environments for improvisation. The rhythm section is often viewed as the foundation of the jazz band, strongly influencing important musical aspects such as time, sound, and expression (Berliner, 1994; Monson, 1996).

EXTENDING THE PRINCIPLES OF MUSICAL METER

The Western musical notational system likely evolved out of a need to create written representation of already existing music. However, because the written score gained central importance in the European classical tradition, it is possible that the rhythmic characteristics of classical music were affected, at least to some extent, by developments in notational practice. Notation is predicated on the idea that the time value of individual notes can be measured in beats, and that notated rhythms are organized by a system of counting. The time signature, provided at the beginning of a musical score, indicates how rhythms are to be counted, and establishes the duration of measures. Notated rhythms must conform to the rules of time signature; that is, when the values of individual notes within a measure are added, the total must equal the duration of the measure. Measure length often remains constant throughout large sections of a piece, if not the entire piece. Thus, the time signature establishes a structure of regularly occurring, isometric measures – a phenomenon known as meter. Meter is discussed in greater detail below.

In the African tradition, musicians do not count measures or read rhythms from a score. Instead, rhythmic patterns represent words, sayings, or tunes; musicians must memorize patterns based solely on their sound (as opposed to thinking of notation, or calculating values of note durations). Therefore, rhythm is not restricted by measures or notation. What unifies the musical parts in an African ensemble is the smallest pulse level, not larger units like measures. This is a fundamental difference between the approach to rhythm in African music and European classical music (Jones, 1959; Kaufman & Guckin, 1979; Schuller, 1968).

In fact, it might seem to Western listeners that the different musical parts in an African ensemble are not unified or related; and when Western notation is applied to African music, bar lines among parts rarely coincide. Yet, African musicians know exactly how their parts fit within the framework of the ensemble, because they know from experience how the *composite rhythm*[12] should sound (Jones, 1959: Kauffman, 1980; Kaufman & Guckin, 1979; Koetting & Knight, 1986; Schuller, 1968). According to Schuller (1968):

> When the European thinks of polyrhythm, he generally conceives of it as two or more rhythmic strands occurring simultaneously, retaining, however, vertical coincidence at phrase beginnings and endings, at bar lines, and at other focal points. The African, on the other hand, conceives his polyrhythms on a much more extended, more complex, polymetrically organized basis, where phrases rarely, and sometimes never, coincide vertically. In fact, his overriding interest is in cross-rhythms, the more subtle and complex the better…Indeed, two of the drummers may play at cross-rhythms to each other for entire performances, which often continue for hours. (pp. 11-12)

Early jazz evolved predominantly through an aural/imitation process; efforts to notate jazz occurred later. Notation of jazz is difficult because some aspects of rhythm in jazz challenge or extend conventional principles of notation and meter in a manner that reveals the influence of African music.

Meter is characterized by the existence of multiple pulse layers or periodicities, at least two, but preferably three or more (London, 2002; Parncutt, 1994). Whenever a pulse is apparent there is the possibility of subdividing it into faster values (lower levels) or grouping it into larger groupings (higher levels), a principle that can be applied to all beat-based music. However, the definition of meter in Western music theory goes further. Every pulse level is isometric, the pulse levels are related by simple integer ratios, and a resulting pattern of strong and weak beats exists (Lerdahl & Jackendoff, 1983; London, 2002; Martens, 2005). In jazz, these three principles are challenged or extended.

In Western music theory, a given meter is thought to have an intrinsic pattern of strong and weak beats (e.g., Lerdahl & Jackendoff, 1983). This notion can be explained simply with the aid of Figure 2.1, in which four pulse levels commonly existing in music of 4/4 meter are shown: whole notes, half notes, quarter notes, and eighth notes.

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[12] The composite rhythm is the integrated rhythm (or surface rhythm) that occurs when different musical parts are simultaneously performed (London, 2007).

Figure 2.1: Illustration of pulse levels in 4/4 meter

In 4/4 meter, the quarter note equals one beat, therefore beats 1 through 4 are represented by the quarter notes in each measure. Beat 1 is the strongest beat, because all pulse levels are synchronized at beat 1 (i.e., in the illustration, all levels coincide vertically at beat 1 of each measure). Likewise, beats 1 and 3 are stronger than beats 2 and 4, because fewer pulse levels are synchronized at beats 2 and 4. The off-beats (those between the quarter notes) are the weakest because only the eighth-note pulse level occurs at these points.

One of the most obvious and frequently discussed rhythmic features of jazz is its stress on beats 2 and 4, as opposed to 1 and 3, the traditionally “strong” beats. The backbeat in jazz (a beat regularly occurring on beats 2 and 4) is often emphasized by the drummer, normally with the hi-hat cymbals when playing in the swing style or with the snare drum when playing styles such as rock or funk. In jazz and classical music in 4/4 meter, *structural accents* (e.g., musical events such as harmonic changes or beginnings/endings of formal sections) tend to frequently occur on beats 1 and 3. Yet the addition of a backbeat in jazz creates *dynamic accents* (i.e., notes that are attacked more strongly) on beats 2 and 4. Schuller (1968) described this phenomenon as “democratization of the beat” (p. 6). In Figure 2.2, the addition of a backbeat (represented by the second line from the top) increases the number of events occurring on beats 2 and 4. Thus, the "strength" of beats 1 through 4 is somewhat equalized.

Figure 2.2: A basic 4/4 structure with a backbeat added

Berliner (1994) described the importance of a backbeat, emphasizing the feeling of forward motion that is often linked to the idea of "democratization of the beat" (e.g., Galper, 2005; Lawn & Hellmer, 1996; Liebman, 1997; Schuller, 1968):

> In many African American musical genres, the accents of the drummer's hi-hat cymbal, together with the audience's complementary handclapping and finger snapping, reinforce patterns that fall on the backbeats and intensify the backbeat's pull away from the strong beats. This, in turn, maximizes the force of the subsequent swing back toward the strong beats. (pp. 148-149)

This tendency to emphasize beats that are traditionally considered weak in metrical structures is also apparent in the abundance of *syncopation* (i.e., emphasis on off-beats) in jazz. For example, jazz soloists seem to frequently place dynamic accents on notes that occur on off-beats, and/or emphasize off-beats by avoiding playing on downbeats. Figures 2.3 and 2.4 illustrate these common ways to achieve syncopation.

Figure 2.3: Syncopation by avoiding downbeats

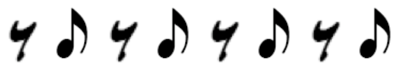


Figure 2.4: Syncopation by accenting off-beats

Syncopation can be a variation from what is rhythmically obvious or expected, and subtle manipulation of the obvious is an important aesthetic quality of African music (Jones, 1959; Kaufman & Guckin, 1979). Some authors claim that syncopation in jazz is an outgrowth of African influences (e.g., Schuller, 1968; Galper, 2005). Galper wrote:

> It was the African invention of syncopation that transformed western music into jazz. It was a rhythmic innovation. Yet, rhythmic syncopation, the musical element that makes jazz, jazz, is the least understood aspect of jazz. Syncopation is the life-blood of the music…I learned syncopation at the feet of the masters, hearing how it should go night after night, by trying my best to emulate it. (p. 58)

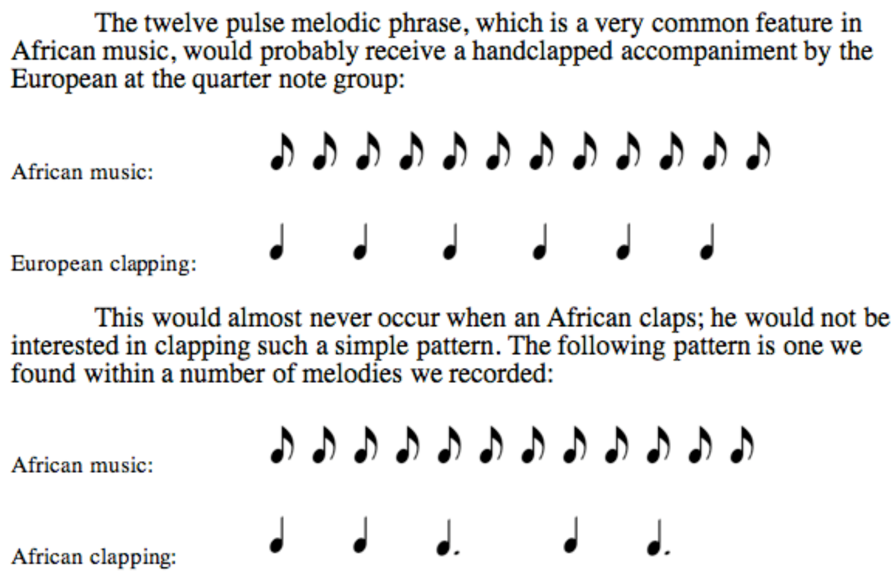
The emphasis on backbeat and syncopation in African-influenced music raises questions about the idea of intrinsic strong and weak beats. Western music theory indicates that “stronger” beats receive greater emphasis and/or are felt more strongly in the majority of instances. However, much jazz music seems to go against this principle by frequently emphasizing so-called weak beats. This phenomenon occurs at both the quarter-note level (i.e., backbeat) and eighth-note level (i.e., syncopation). Because the so-called weak beats are often played and felt most strongly, the nomenclature "strong" and "weak" is problematic when applied to jazz.

Another characteristic of jazz not easily explained by metrical principles is the liberal use of *additive rhythms* (Jones, 1959; Kauffman, 1980; Kaufman & Guckin, 1979; Nketia, 1974; Schuller, 1968). Additive rhythms are irregular rhythms that do not align with the internal divisions of a metrical structure. Prior to the 20th century, additive rhythms were infrequently found in European classical music, yet they were widespread in African music (Jones, 1959; Schuller, 1968). The opposite of additive rhythms, *divisive rhythms*, are rhythms that align with the internal divisions of a metrical structure (Nketia, 1974), for example consecutive half notes or quarter notes in 4/4 meter.

Without the concept of meter in an African ensemble, it is unnecessary for musical parts to be aligned consistently at higher-level periodicities such as the measure. Instead, African music tends to be unified by the fastest underlying pulse. This pulse is called the *density referent*[13] (Jones, 1959: Kauffman, 1980; Kaufman & Guckin, 1979; Koetting & Knight, 1986; Schuller, 1968). The authors Kaufman and Guckin (1979) illustrated the idea of density referent while suggesting that Europeans would have a tendency to use this pulse to create divisive rhythms, whereas Africans would be more inclined to create additive rhythms (see Figure 2.5).

[13] Interestingly, several jazz educators have claimed that in jazz the eighth note is the primary rhythmic unit, whereas in classical music it is the quarter note (e.g., Erskine, 2005; Lawn & Hellmer, 1996; Liebman, 1997). Following this idea, the jazz eighth note seems to fulfill a similar role as the density referent.

Figure 2.5: From *The African Roots of Jazz* (Kaufman & Guckin, 1979, pp. 89-90)



The twelve pulse melodic phrase, which is a very common feature in African music, would probably receive a handclapped accompaniment by the European at the quarter note group:

African music:

European clapping:

This would almost never occur when an African claps; he would not be interested in clapping such a simple pattern. The following pattern is one we found within a number of melodies we recorded:

African music:

African clapping:

The pattern called "African clapping" in Figure 2.5 is one of the most common *ground patterns* or *time lines* in African music. Such a pattern functions as a guideline for timekeeping and the coordination of the ensemble, and is often performed with handclaps or bells. Nketia (1974) explained:

> Because the time line is sounded as part of the music, it is regarded as an accompanying rhythm and a means by which rhythmic motion is sustained. Hence, instead of a time line that represents simple regular beats reflecting the basic pulse, a more complex form may be used. (p. 132)

This concept of irregular ground patterns is used frequently in jazz, particularly in *Latin jazz*[14]. One of the most common ground patterns in both African music and jazz is widely

[14] Latin jazz is a blanket term for the styles of jazz in which elements of Afro-Hispanic music, particularly its rhythms are prominent (Kernfeld, 2007c).

known as *habanera*: . This pattern, an additive rhythm, is easily integrated by Western musicians because it fits in a 4/4 measure, hence it is a good example of the blending of rhythmic traditions. Two approaches are possible in performing habanera: the additive approach of feeling it as three beats (i.e., long, long, short - with an underlying pulse of 3+3+2), or the metrical approach of understanding the pattern in the context of a 4/4 measure (i.e., the first note occurs on “one”, the second note on “the and of two”, the third note on “four”). Not only is this pattern prominent in Latin music of many different regions (e.g., Cuba, Brazil, Argentina), it is also common in ragtime, swing style, and rock-n-roll (Brewer, 1999).

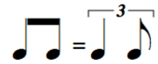
The clavé rhythms (see Figures 2.6 and 2.7) of Afro-Cuban jazz are similar examples of irregular ground patterns. According to Campos (1996):

> We can think of *Clave* as a two bar repetitive rhythmic pattern. This pattern is sometimes not even heard but just felt behind the complex polyrhythmic structure of Afro-Cuban music. This pattern is played by two round sticks, also called *clavés*. The *Clave* works like a “*rhythmic cell*” or building block at the most basic level…In Afro-Cuban music everything has to fit with this “*rhythmic cell*.” …So, we could say that *Clave* is the foundation of Afro-Cuban Music and that it serves as an organizing force that holds the polyrhythmic complexity of such music together. (p. 3)

Figure 2.6: Two/three clavé

Figure 2.7: Three/two clavé

The ground pattern concept, illustrated for example by habanera and clavé, is quite different than rhythmic organization based on metrical structures. In the metrical approach, all pulse levels are *isochronous sequences* (i.e., simple series of evenly spaced beats); but in the ground-pattern approach, it is possible to have non-isochronous "beats." Some specific ground patterns that occur frequently in jazz are also found in the older tradition of African music, attesting to the assumption that this rhythmic aspect of jazz can be traced to African origins (Kaufman & Guckin, 1979).

Finally, the swing subdivision feature of jazz extends the metrical principle of simple integer ratios among pulse levels. Early jazz musicians learned popular tunes (e.g., marches, ragtime tunes, sentimental songs) by ear, and performed them in highly personalized ways. Rather than conforming to the written music, they often interpreted songs by making the rhythms more syncopated and applying a "lilt" or "triplet feel" to the subdivision of the beat. With this approach, eighth notes are played unevenly by lengthening the downbeat and shortening the off-beat. The downbeat receives approximately two triplet partials, and the off-beat receives approximately one triplet partial. However, the ratio between downbeat and off-beat is not fixed; it can be affected by tempo, style, and the interpretation of the performer. Efforts to notate swing subdivision have evolved over the years, and have included using dotted rhythms or expressing rhythms in 12/8 meter. In current practice, swing-style eighth notes are notated as standard eighth notes, but a score may contain the guideline  to instruct performers to apply swing subdivision throughout a piece. Bear in mind that jazz performers may not approach this triplet rhythm strictly, but instead will produce approximations of it.

The phenomenon of uneven, triplet-based subdivision that is not interpreted strictly is found in styles other than jazz, such as European folk music and European classical music (Donington, 1982; Gabrielsson, Bengsston, & Gabrielsson, 1983). In Baroque music, it is known as “inequality” (Donington, 1982). However, there are some important differences between the swing subdivision in jazz and the “lilting” subdivision of these other styles. In European classical and folk music, this approach to subdivision generally occurs in the context of compound meter (e.g., 6/8, 9/8, or 12/8): Beats are subdivided into three equal partials, and the rhythms tend to be downbeat-oriented (Donington, 1982; Gabrielsson, Bengsston, & Gabrielsson, 1983). In jazz, swing subdivision is often an aspect of performers’ personalized renderings of songs originally written in 4/4 meter, thus it is unclear whether the end result is best understood in compound or simple meter. In addition, the idiomatic articulation and syncopation of jazz creates a rhythmic quality that is quite different than the lilting feeling of Baroque dances in compound meter, for example.

Jazz musicians acknowledge that swing subdivision is open to interpretation. Jazz soloists vary their approach to swing subdivision for expressive purposes, and many prefer a more even subdivision than the triplet-based ratio of 2:1 (Collier & Collier, 2002;

Ellis, 1991; Friberg & Sundström, 1997; Gridley, 1988; Lawn & Hellmer, 1996; Liebman, 1997). European metrical principles do not account for complex ratios such as 1.7:1, and there is no conventional notation to express the many subtle variations in swing subdivision that occur in jazz music. Thus, swing subdivision is another rhythmic aspect of jazz that complicates its representation by metrical structure and notation.

In review, many rhythmic characteristics of African music, which often contrasted with those of European classical music, were integrated into jazz. These characteristics included: integration of music with other social activities, emphasis on percussion instruments, improvisation juxtaposed against ground patterns, and abundance of polyrhythms. In addition, the metrical approach to rhythm is an inadequate system for understanding some of the rhythmic complexities of jazz and its African antecedents. Syncopation, additive rhythms, irregular ground patterns, and swing subdivision are elements of jazz rhythm that are not effectively represented by Western metrical concepts such as: strong and weak beats, regular groupings, alignment of musical parts at larger time spans like the measure, and pulses related strictly by simple integer ratios.

Foundations of Rhythmic Performance: Beat, Movement, and Tempo

The characteristics of swing discussed in Chapter One could not have evolved without the first item listed, that is, *beat*. The idea of rhythmic synchronization, or "locking in," as a jazz musician might say, is predicated upon the human ability to perceive a beat (i.e., a steady pulse) and coordinate one's movements with it. These basic behaviors – beat perception and rhythmic movement – are foundational to musical performance and dance. The roles of beat perception and movement in human timing have been topics of interest in psychological research for many years. Some of the main ideas from this research and their implications for musical performance and pedagogy are discussed in this section.

BEAT PERCEPTION AND SYNCHRONIZATION

Rhythmic music, or music with a beat, is a universal phenomenon. In fact, all known cultures have some form of rhythmic music that is accompanied by body movement such as dancing, clapping, tapping, or swaying (Brown, 2003; Nettl, 2000). The presence of a steady beat enables musicians to synchronize sounds, unites dancers with musicians, and often engages the attention of listeners. Beat and rhythm are a central part of musical experience.

In psychological terms, a beat is a regular pulse that is perceived in a sequence of stimuli. This pulse can function as a unit for human timing, facilitating the estimation of temporal intervals or durations. A beat provides predictability, allowing motor responses to be planned in anticipation of expected future events. Beat-based timing makes possible the precise synchronization of movements, exemplified in the performance of music and dance. (Drake, Penel, & Bigand, 2000; Fraisse, 1982; Jones & Boltz, 1989; Patel, Iversen, Chenn, & Repp; 2005; Repp, 2005).

The process of perceiving a beat and coordinating movements with it, known as *beat perception and synchronization* (BPS), entrainment, or sensorimotor synchronization, seems to be an innate proclivity distinct to humans. Some non-human species demonstrate synchronous behavior (e.g., the synchronous “chorusing” of some insect and frog species), but *Homo sapiens* is the only species known to demonstrate BPS, that is, to perceive a beat in external stimuli and adapt one’s movements to correspond with it (Merker, 2000; Patel, *et al.*, 2005). Because BPS is an innate, distinctly human behavior, and a fundamental aspect of rhythmic performance, BPS may have been an important factor in the origins and evolution of music (Brown, 2003; Merker, 2000; Repp & Penel, 2003).

BPS occurs quickly and with apparent effortlessness. In fact, listeners can perceive a beat in a regular auditory sequence by the third pulse and coordinate a movement response accordingly (Fraisse, 1982). Despite the simplicity of this task, the adaptability of BPS suggests complex neural processes (Patel, *et al.*, 2005). A beat can be perceived in elaborate as well as simple stimuli; and movement responses, such as tapping, are voluntary and flexible. For example, humans are able to tap with different body parts, tap with beats or between beats, tap various subdivisions and groupings of a beat, adapt to tempo changes, perceive a beat in complex music, and maintain steady tapping after the stimulus is muted (Repp, 2005).

Researchers have investigated the role of sensory modality in BPS by presenting subjects with visual and auditory stimuli. Interestingly, a beat can be perceived in a series of visual stimuli, but the auditory modality is far more conducive to BPS. This fact is exemplified in everyday behavior. For example, Repp and Penel (2003) pointed out that people are unlikely to tap their feet when observing musicians or dancers on a muted television set, and visual rhythmic sequences are less often encountered in daily life than are auditory rhythmic sequences. The authors suggested: "Sound rather than light is the preferred medium for rhythmic stimulation. One reason why music has evolved in the auditory rather than the visual modality may be that auditory rhythms inevitably engage our body more than visual rhythms do" (p. 252).

To investigate the role of sensory modality in BPS tasks, Repp and Penel (2003) asked subjects to coordinate taps with an auditory or visual metronome (flashing light) while a distractor sequence was present in the other sensory modality. Visual distractors had no effect on subjects' ability to synchronize with the auditory metronome; whereas, auditory distractors strongly attracted participants' taps, disrupting their ability to synchronize with the visual metronome.

In another study that explored the effects of auditory and visual stimuli, Patel and colleagues (2005) presented subjects with rhythmic sequences in auditory and visual modalities. In the auditory modality, subjects were able to synchronize with fast and moderately paced isochronous sequences, as well as with more complex rhythmic patterns. Subjects could perceive a beat in the complex auditory rhythmic patterns and synchronize taps, but were unable to do so when the same patterns were presented visually. In the visual modality, subjects were able to synchronize only with isochronous sequences that were of moderate tempo. The idea that sound is the preferred means for perception of beat in rhythmic stimuli is supported by the findings of these studies.

In summary, when a regular beat is evident in aural stimuli, humans are adept at using that beat as a temporal unit to regulate the timing of movements. Music, dance, and tapping tasks associated with BPS are examples of activities that rely on this beat-based timing. The rate or tempo of a beat plays a crucial role in this ability.

TEMPO

> *"Swing can be thought about tempo-wise. So far as I'm concerned, the best for swinging would be medium tempo. Like Basie says, something you can pat your foot to comfortably, more or less."* Freddie Green, 1972[15]

BPS is dependent on certain tempo constraints. At extremely slow tempos, long lapses of time between events make it difficult to perceive the events as being related or connected; and at extremely fast tempos, the speed limits of motor and perceptual processes restrict BPS behavior (Fraisse, 1983). Tempos that are most effective for BPS correspond to widely used musical tempos that are considered moderate. Furthermore, moderate tempos are common in the spontaneous rhythmic movements of humans (discussed below), suggesting a relationship between beat-based timing and motor systems.

Musicians have long recognized that choosing a moderate tempo allows one to easily subdivide the main beat into smaller beats (subdivisions) and group it into larger beats (groupings). In Western music, there are several beats or pulses that occur simultaneously and are related by simple integer ratios. Among the layers of pulses within a given piece of music, there is usually a particular layer that stands out or is perceived as fundamental, the *tactus*. To define tactus, Lerdahl and Jackson (1983) made

[15] From *The World of Swing* (Dance, 1979).

references to physical movement: “Metrical intuitions about music clearly include one specially designated level, which we are calling the *tactus*. This is the level of beats that is conducted and with which one most naturally coordinates foot-tapping and dance steps” (p.71). The tactus is a highly salient beat, usually of moderate tempo, which can be easily divided to form subdivisions or multiplied to form groupings.

Spontaneous human movement behaviors like rocking, walking, and chanting suggest an innate proclivity toward beat-oriented behavior, and also tend to occur at moderate tempos. Fraisse (1982) reported tempos of spontaneous rhythmic movements like the sucking of an infant, which occurs at intervals of 600 to 1200 milliseconds (ms) or 100 to 50 beats per minute (bpm)[16], and walking, which occurs on average at about 550 ms per step (109 bpm).

Fraisse also determined ranges for *spontaneous tempo* (i.e., rate at which subjects tap a natural or comfortable beat) and *preferred tempo* (i.e., rate that, when heard is considered neither too fast nor too slow, or feels comfortable). Spontaneous tempos varied from 380 to 880 ms (158 to 68 bpm), with 600 ms (100 bpm) most representative. Preferred tempos existed on average at about 500 to 600 ms (120 to 100 bpm). Fraisse noted:

> It is striking that the rhythm of the heart, of walking, of spontaneous and of preferred tempo are of the same order of magnitude (intervals of from 500 to 700 msec)…There is only a narrow range of frequencies of natural or voluntary rhythms and of preferred tempo. (p. 154)

[16] For convenience, millisecond values of temporal intervals are converted to metronome values of tempos (beats per minute).

In addition, Fraisse determined that accuracy in BPS tasks like tapping along with metronome clicks was best at intervals of 400 to 800 ms (150 to 75 bpm), and that BPS was possible within the range of 200 to 1800 ms (300 to 33 bpm).

Parncutt (1994) explored the role of tempo in the *pulse salience* of music (i.e., the perceptual strength or prominence of beat in music) by reviewing prior studies and conducting his own studies in which subjects were asked to tap along with musical excerpts. He determined that the most effective tempo ranges for beat perception in music corresponded closely to the most effective ranges for BPS reported by Fraisse (1982). Parncutt defined the range of 200 to 1800 ms (300 to 33 bpm) as the *existence region*: "a range of periods within which isochronous sequences are perceived to be musically rhythmic (or to imply movement)" (p. 436). Within this region, there is a *dominance region*, the region of greatest pulse salience, of 400 to 900 ms (150 to 67 bpm). Subjects were most likely to perceive a beat and synchronize taps accurately within this range, suggesting that the moderate tempos of music are well suited to human timing processes.

The outer numbers of Parncutt's existence region suggest rate limits for BPS. Repp (2005) noted that upper tempo limits tend to match the maximum frequency at which the effector can move. For finger tapping, this corresponds to intervals of about 150 to 200 ms. Overcoming such a biomechanical limit is possible by tapping with alternating hands. In this case, the upper limit or synchronization threshold is about 100 to 125 ms. Using alternating hands, a highly trained musician was able to synchronize accurately with stimuli that occurred at 100 ms intervals (Pressing & Jolley-Rogers, *cited in* Repp, 2005). This example represents the fastest tempo reported at which synchronized tapping was achieved in Repp's comprehensive review of sensorimotor synchronization studies.

The threshold of approximately 100 ms not only applies to limits in the speed of movement, but also applies to the perception of beat. For example, subjects have difficulty perceiving a pulse if the rate of events in a sound stimulus is too fast. A method for testing this idea of perceptual limit is to change the synchronization task to tapping with one out of every two, three, or four clicks. By reducing the speed of tapping, the motor limit is no longer a factor; therefore, difficulties in this task are attributed to perceptual limits. In fact, subjects cannot precisely synchronize with stimuli when the intervals between metronome clicks are about 100 to 125 ms or less, even when asked to tap with every two, three, or four clicks (Repp, 2005). Thresholds in the auditory/perceptual system seem to correspond closely to those in the motor system. Tempos that are too fast to be synchronized accurately with movements may also be too fast to be perceived accurately with the ear.

Additional studies (e.g., Friberg & Sundström, 2002; London, 2002) have suggested that the 100 ms value approximately represents the maximum pace at which sounds are perceived as rhythmic, and at which musicians execute rhythms. According to London, although musical durations less than 100 ms do exist, they are normally not assigned rhythmic values, but instead occur in ornamental contexts such as trills and grace notes. London also made the distinction that the upper threshold for tactus is about 200 to 250 ms (400 to 300 bpm), whereas the fastest practical subdivision of a tactus is about 100 ms. Friberg and Sundström (2002) measured the timing of jazz drummers' ride patterns, and found that the smallest interval between the strokes of drum sticks was about 80 to 100 ms, supporting the idea that durations approximately equal to 100 ms may represent the fastest practical subdivision of beats in musical performance.

The lower rate limit for BPS is less sharply defined than the upper limit. As intervals increase beyond about 700 ms, an increase in variability (i.e., error) in synchronization tasks is sometimes observed. However, trained individuals can compensate for this effect by internally subdividing the beat (e.g., subjects can divide an interval of 1000 ms into two intervals of 500 ms). Starting at around 1800 ms, predictability becomes increasingly difficult. In this range, subjects may stop trying to predict the occurrence of each click, but will instead tap in response to clicks. Thus, responses may lag behind stimuli (Repp, 2005).

These data regarding rate limits confirm what musicians already know instinctively. Extreme tempos, fast or slow, tend to be the most difficult tempos to execute. Yet, the difficulty can be overcome by choosing to focus on a beat of moderate duration. In the case of slow tempos, musicians can focus on smaller subdivisions of the beat; and in the case of fast tempos, larger groupings of the beat.

Jones's dynamic attending theory (Drake, Penel & Bigand, 2000; Jones & Boltz, 1989; Martens, 2000), which has been strongly influential in psychological and computational modeling of rhythm perception, presents the intuitively appealing concept of *attunement*. This theory suggests that there exists within each individual a *referent period*, an internal mechanism for timing. Unlike a mechanical timekeeper, the referent period is adaptive, gravitating toward moderate tempos. Stimuli such as music cause the individual's timekeeper to become entrained with an external beat, a process called attunement. This pulse then becomes the *reference level,* the temporal unit allowing the listener to attend to all existing pulses in the music, thereby facilitating perception of beat, meter, and rhythm. Thus, the human "clock" is not only adaptive, but it also functions in a manner in which multiple periodicities and their relationships can be perceived spontaneously.

In review, auditory perception and motor production of beat is an inherent timing skill, fundamental to humans' experience of music and perception of musical time. Auditory stimuli with beat characteristics tend to stimulate internal timing processes, and the auditory system is the preferred sensory medium for rhythm perception. Sound patterns that are effective in providing regularity or predictability are conducive to the coordination of movements such as those that occur in music and dance. Regarding tempo, many spontaneous rhythmic movements of humans occur at tempos that are common to music, and tempo limitations or constraints are similar in perceptual and motor tasks. The fundamental nature of BPS as a skill, along with the fact that music and dance are culturally ubiquitous, suggest that BPS may have been central to the evolution of music. Music and dance engage timing, movement, and perceptual behaviors simultaneously in a single activity.

PERCEPTION AND MOVEMENT IN HUMAN TIMING

The coordination of movement with a beat relies on both perceptual and motor skills; it involves perceiving a beat correctly along with producing accurately timed movements. Research in BPS suggests that motor and perceptual skill may be correlated. This idea has intuitive appeal for musicians. Anecdotally, many musicians would agree that high-quality practice leads to incremental improvement of both listening (perception) and technique (motor skill). It is plausible that, in rhythmic performance, motor and perceptual learning are intrinsically related.

Human timing studies have shown that skill in perception (e.g., of brief temporal intervals) and skill in motor production (e.g., of a steady beat) are correlated, suggesting that these behaviors may share common neural mechanisms (Aschersleben, 2002; Hecht, Vogt, & Prinz, 2001; Ivry & Hazeltine, 1995; Keele, Pokorny, Corcos, & Ivry, 1985; Repp, 2005). Keele and colleagues (1985) asked subjects to produce a series of taps and attempt to maintain constant temporal intervals between the taps. Timing accuracy in this task was compared with subjects' accuracy in judging durations of brief perceptual events (e.g., temporal intervals between clicks), and a moderately strong, statistically significant correlation of .53 was found. In a second experiment, the researchers investigated the effects of musical training on these tasks. Subjects who were skilled pianists were significantly better at both timing judgment and motor timing than were control subjects with little or no musical training. The fact that musical training affected both perceptual and motor skills gives further credence to the idea that these skills are correlated.

Ivry and Hazeltine (1995) also tested subjects on similar tapping and judgment tasks, corroborating the existence of significant positive correlations ($r = .52$) between motor and perceptual accuracy. Unlike Keele and colleagues (1985) who tested only one tempo (400 ms intervals), Ivry and Hazeltine (1995) tested a range of tempos. In both perceptual and motor tasks, variability increased linearly as temporal intervals increased from 325 to 550 ms. Perceptual acuity and motor timing were both made more difficult as temporal intervals increased. The observation that tempo had the same effect on both types of skill supports the idea of correlation between perceptual and motor timing.

Along with correlation studies, a discovery of BPS research known as the "negative asynchrony" highlights the importance of perception in motor timing tasks. This phenomenon has been observed for more than 100 years, and has been replicated in numerous studies (see Aschersleben, 2002 for a review). When performing the seemingly easy task of coordinating taps with a metronome, subjects frequently place taps 20 to 80 ms early in relation to metronome clicks. This seems to be a perceptual error because subjects consistently place their taps early, yet they remain unaware of the discrepancy.

Musically trained individuals exhibit less negative asynchrony (and in some cases, none at all) than non-musicians. Aschersleben (1994, *cited in* Aschersleben, 2002) found mean negative asynchronies of 40 to 50 ms for non-musicians, 30 to 40 ms for subjects who played musical instruments, and just 14 ms for subjects enrolled as students in a music academy. Repp (2004, 1999) found that professional musicians were sometimes able to tap in exact synchrony with metronome clicks. In addition, Aschersleben (2002) reported that 10 training sessions, in which subjects were informed about the size and direction of asynchronies, enabled subjects to correct negative-asynchrony tendencies. Training in synchronization tasks as well as musical training can help subjects to overcome the tendency to tap ahead of metronome clicks.

One possible explanation for the negative-asynchrony effect is that subjects may rely on tactile feedback when judging the timing of taps. It has been shown that tactile afferent processes take longer than aural afferent processes (Aschersleben, Gehrke, & Prinz, 2004; Gescheider, 1966). In other words, a tactile stimulus requires more time than an aural stimulus to be perceived. Therefore, if clicks and taps were to occur at precisely the same moment, the click sound would be perceived slightly earlier than the sensation in the finger as it strikes a surface. If subjects estimate the timing of a tap based on tactile stimuli, they would have to place taps early in order to perceive them as occurring simultaneously with audible clicks. It makes sense that musicians and trained individuals would be adept at compensating for the slight delay in tactile stimulation by focusing on a result of taps other than tactile feedback, such as the sound of the finger as it strikes a surface. In fact, researchers have designed tasks in which an aural signal is electronically generated when a computer key is tapped, and the additional auditory feedback has the effect of reducing negative asynchronies (Aschersleben, 2002). Correct rhythmic learning in music may also rely on this principle: Musicians must learn to perceive the *when* of their actions based on the sound produced, not based on tactile or kinesthetic feedback.

BPS and Jazz Rhythm

Throughout the history of jazz, the principle method of learning the art form has been through hearing and imitation (Berliner, 1994; Galper, 2005; Gioia, 1997; Monson, 1996; Pickens, 2004; Reeves, 2007; Ward, 2000; Yoshizawa, 1999). Prior to the advent of recording technology, aspiring jazz players gained the opportunity to listen and imitate only during live performances. It was difficult for people to hear jazz music unless they lived in an area where early jazz was a part of the culture – New Orleans and Chicago, among other places. But when the first jazz phonograph record was produced in 1917, "Livery Stable Blues" by the Original Dixieland "Jass"[17] Band (ODJB), possibilities for learning jazz extended far beyond its traditional geographical hubs. A new kind of pedagogy was born – the method of playing along with recordings. In fact, Bix Beiderbecke, the legendary cornetist who was raised in Davenport, Iowa, likely had not been exposed to any jazz music before acquiring an ODJB record in 1919. At the age of 15, Beiderbecke painstakingly learned the cornet parts performed by Nick LaRocca (the band's cornetist and leader), through a trial-and-error process until he was able to play the piece "Tiger Rag" in its entirety (Gioia, 1997; Ward, 2000).

ODJB records were commercially successful, paving the way for more jazz bands to record and sell their music. Another noteworthy group was King Oliver's Creole Jazz Band, featuring Joe "King" Oliver on lead cornet and Louis Armstrong on second cornet. Oliver's recordings influenced countless aspiring jazz musicians. Later, Armstrong would lead his own bands and receive far greater acclaim for his recordings than Oliver. Historians maintain that modern jazz trumpet playing can be traced backed to this basic lineage of Oliver, Armstrong, followed by Roy Eldridge, and then Dizzy Gillespie (Berliner, 1994; Gioia, 1997; Ward, 2000).

The passing on of the music through aural means such as recordings and live performance has been a central part of jazz's evolution for all musicians, regardless of

[17] The name was later changed to the Original Dixieland Jazz Band.

their instruments of choice. This aural/imitation process remains one of the most important aspects of jazz education in the present day (Berliner, 1994; Galper, 2005; Gioia, 1997; Monson, 1996; Pickens, 2004; Reeves, 2007; Ward, 2007; Yoshizawa, 1999).

Many well known jazz masters have reported that playing or singing along with recordings was an important part of their practice strategy (Berliner, 1994; Reeves, 2007; Yoshizawa, 1999). Interestingly, this practice method is a type of synchronization task: Musicians practice coordinating their movements with recorded music. For example, some musicians advocate singing along with recorded improvised solos as an initial procedure for learning jazz rhythm and phrasing. Artists such as Bud Freeman, Melba Liston, Tommy Flanagan, Kenny Barron, Barry Harris, and Fred Hersch have testified to using this method in the early stages of their learning jazz (Berliner, 1994; Yoshizawa, 1999). After learning to sing a solo, the next step is often to play the solo note for note on one's instrument.

In many cases, jazz students not only learn solos for content, but they also strive to match every nuance of the solo: timing, articulation, dynamics, inflection, and timbre (Berliner, 1994). In essence, this task involves precise synchronization, matching the recording so closely that it sounds as if the recorded instrument and the live instrument were one and the same. This is a very effective procedure for learning jazz rhythm (Berliner, 1994; Yoshizawa, 1999). By synchronizing with the recorded jazz performances that they wish to emulate, musicians may learn how to convey the sounds and rhythms that are distinctive to jazz.

There are obvious similarities between playing along with recordings and BPS tasks like tapping along with music or a metronome. In both cases, movements are coordinated with an external time source, and perceptual and motor skills are engaged. For jazz musicians to match every nuance of a recording, they must know the sound of the music (perceptual skill), and be able to produce accurately timed movements to match the sound (motor skill).

In addition to playing along with recordings, jazz musicians have been known to use devices such as metronomes in their practice (Berliner, 1994; Crook, 1991; Erskine, 2005; Laverne, 1993; Liebman, 1997). By providing a stable time source with which to synchronize, metronomes used during practice may be beneficial in developing good habits with regards to rhythmic accuracy and steady timekeeping. However, this assumption has not received adequate empirical investigation.

Besides metronomes, "play-along recordings" have sustained long lasting popularity in jazz pedagogy. Examples of these are the recordings that accompany method books by Jamey Aebersold, such as *How to Play Jazz and Improvise* (1992), which was originally published in 1967 and is still used in the present day. These recordings feature rhythm sections performing in an accompanying style, and are created to provide soloists with accompaniment for their personal practice. In addition, recordings of drum/percussion tracks are available (e.g., Campos 1996), as well as software programs that simulate rhythm sections, such as Band in A Box (PG Music). The availability and popularity of these materials for jazz practice in addition to the history of playing along with recordings support the idea that synchronization-based tasks provide an effective approach to learning jazz rhythm.

Body movement may be another important tool in rhythm pedagogy. As described earlier, BPS research has shown that there is a close relationship between movement and perception of beat or time. Activities like dancing and clapping are often associated with musical rhythm, and jazz educators have promoted the idea of dance as a beneficial tool for students to improve rhythmic skills. Pickens (2004) wrote: "Get the beat in your feet. Let the music move you. Feel the music with your body. Jazz started out as dance music" (p.1). Similarly, Campos (1996) gave an account of how Salsa dancing improved his students' rhythmic execution when playing Latin jazz on the keyboard. Berliner (1994) emphasized the importance of African-American social dance:

> In addition to metaphorizing swing in terms of dance, many performers also emphasize the importance in their upbringing of black social dance, which sensitized them to the subtleties of rhythmic expression, training them to interpret time and to absorb varied rhythms through corresponding dance steps and other patterns of physical motion. Practices mentioned earlier in which drummers actually reproduce and play off of patterns emanating from the intricate footwork of tap dancers, and vice versa, epitomize the influence of body movement upon rhythmic conception in jazz. (p. 152)

Clearly, there is interconnectedness between musical rhythm and movement. Dance and other movement techniques seem to be valuable tools for the teaching of rhythm in jazz.

Temporal Perception in the Auditory Modality

Before examining the data of jazz timing studies, it is helpful to have an understanding of the perceptibility of micro nuances in timing. In other words, at what point do temporal deviations or asynchronies become noticeable to the listener? This would seem to be an important question for interpreting the results of musical timing studies for practical purposes. For example, can a listener hear the difference between swing ratios of 2:1 and 1.5:1? Or, if a soloist plays 10 ms behind the beat of the drummer, is it enough to create a noticeably "laid-back" feeling? Experiments that have tested auditory perception of temporal characteristics provide some insight into these questions. Studies exploring the perception of swing ratios, asynchrony, and temporal order are reviewed in this section.

In addition to the matter of aural detection of timing nuances, the issue of perceptual attack time is pertinent to studies in musical timing. The ability to determine the moment at which a musical tone has rhythmic impact is necessary for measuring asynchronies between musical tones. This matter is problematic because different musical instruments produce contrasting acoustical properties that affect when rhythmic emphasis is perceived. Basic information about perceptual attack time and the "percent of max" method of Vos and Rasch (1981) is also included in this section.

PERCEPTION OF SWING RATIOS

Friberg and Sundberg (1994, see also Friberg & Sundström, 2002, 1997) investigated the just noticeable difference (JND) of swing ratios by presenting listeners with musical examples generated by a synthesizer. Subjects initially listened to eighth notes (ratio=1:1) at the tempo 170 bpm. By incrementally altering this ratio in either direction, the researchers found that it had to change by 20% on average to be noticed by listeners. In a second experiment, conducted similarly but using a much slower tempo (63 bpm), subjects initially heard triplet-based swing eighth notes (ratio=2:1), which were gradually altered. As was the case in the first experiment, ratios had to change by about 20% to be noticed. Findings suggest that deviations of 20% may be a good "rule of thumb" for JND's in swing ratios, however more research on the perceptibility of swing ratios is needed to support this idea. Only two tempos were tested in this study, and the researchers pointed out that differences among individual listeners were quite large.

Perception of Asynchrony and Temporal Order

When two sounds are presented to a listener separated by just a few milliseconds, they may be perceived as simultaneous. The ability to detect that two distinct sound events occur successively as opposed to simultaneously is called *perception of asynchrony* in this paper. The ability to correctly report which of two different sound events occurs first, a somewhat more difficult task than simply noticing two distinct events, is called *temporal order judgment* (Hirsh & Sherrick, 1961; Kanabus, Szelag, Rojek, & Pöppel, 2002). As Hirsh and Sherrick (1961) pointed out, perception of asynchrony is a prerequisite for temporal order judgment, because the determination that two events are successive as opposed to simultaneous is necessary to detect which event occurs first.

The ear is a powerful tool for the perception of asynchrony. Under the most favorable conditions, sound events separated by less than 2 ms are perceived as distinct. This is possible when extremely short, identical sounds are used, such as 1 ms clicks

(Gescheider, 1966: Hirsh & Sherrick, 1961). However, a number of factors affect the perception of asynchrony, most notably the duration and the amplitude of the stimuli. As the duration of stimuli increases, the threshold for perception of asynchrony also increases. In addition, when two sounds have different durations or different amplitudes, the threshold for perception of asynchrony increases (Gescheider, 1966; Hirsh & Sherrick, 1961; Kanabus, *et al*. 2002), with the exception of cases in which the difference in amplitude is 5 to 10 decibels and the first event has the lower amplitude (Gescheider, 1966).

Although it is fascinating that the ear can detect asynchronies as small as 2 ms, this ability does not seem to be useful in a musical context. In music, sounds with durations as brief as clicks synthesized in a laboratory generally do not exist. Furthermore, musical tones have complex acoustical properties that interact with perception of asynchrony such as: pitch, timbre, duration, amplitude, and acoustical rise time.

Rasch (1978) used quasi-musical stimuli (i.e., electronically produced musical tones) in a study investigating the effects of timbre and amplitude on perception of asynchrony. Acoustical factors that adversely affected temporal perception were: slow rise times of tones, equal amplitudes between tones, and a high coincidence of harmonics between tones. Under the most favorable conditions, subjects were able to perceive temporally distinct events when onset difference times were 10 ms. Under the least favorable conditions, events separated by as much as 30 ms were perceived as simultaneous.

Other studies have investigated temporal order judgment, which is the ability to not only perceive two distinct events, but also to correctly report which event occurred first. Hirsch and Sherrick (1961) conducted experiments in which subjects listened with headphones to pairs of electronic tones that differed only in pitch, and were separated by 10, 20, or 30 ms intervals. The average threshold for temporal order judgment was found to be 20 ms, defined as the condition in which at least 75% of subject responses were correct. In a more recent experiment, Kanabus and colleagues (2002) presented subjects with pairs of electronic tones that differed only in pitch, and were separated by 5, 10, 20, 40, 80, 150, 300, or 500 ms intervals. They found an average threshold for temporal order judgment just above 40 ms, also based on the qualification of 75% correct responses. It is unclear why this finding is different than the previous finding of 20 ms by Hirsch and Sherrick (1961). Perhaps differences in subject training and durations of tones impacted results. Hirsh and Sherrick used trained subjects[18], whereas Kanabus and colleagues did not. The durations of stimuli were not disclosed in the study of Hirsh and Sherrick[19]; Kanabus and colleagues used tones of 15 ms duration.

To summarize, a number of factors influence perception of asynchrony and temporal order judgment, including experimental conditions, listener differences, and differences among sound characteristics. Experiments in temporal order judgment have determined perceptual thresholds in the range of about 20 to 40 ms, but conditions in the laboratory clearly can be made to be more favorable for perceptual judgments than most

[18] The nature of the training was not described.

real-life experience with music. Musical examples are rich with complex variations in duration, pitch, timbre, amplitude, and acoustical rise time, all factors influencing temporal perception. Furthermore, music generally flows forward in time, allowing few opportunities to isolate events for temporal judgment.

PERCEPTUAL ATTACK TIME OF MUSICAL TONES

The moment at which a listener perceives the rhythmic impact of a musical sound is the perceptual attack time. To measure asynchronies between musical sounds, a reliable method for determining the perceptual attack time of each sound is needed.

Computer-generated waveforms (i.e., graphic representations of sound waves such as those offered in sequencing programs) may be used to measure timing, offering powerful magnification in which one can "zoom in" to observe timing at the level of milliseconds. However, it is problematic to pinpoint perceptual attack time, because there is a range of time at which a musical attack may be perceived. This range corresponds to the area of the waveform known as the *attack transient*. The attack transient is the portion of the waveform beginning at physical onset, the moment at which the waveform begins to rise, and continuing through amplitude peak. The acoustical rise time is the temporal interval between physical onset and amplitude peak.

"Impulsive" sounds, such as the sound of a drumstick striking a ride cymbal, are characterized by miniscule rise times. For example, ride cymbal transients have rise times

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[19] Hirsch and Sherrick (1961) sent 1 ms electrical pulses through "electrical tuned circuits," resulting in tones that sounded like "brief xylophone notes," but the duration of the "xylophone notes" was not reported.

of about 1 ms[20]. When working with ride cymbal tones, choosing either physical onset or amplitude peak is appropriate for estimating perceptual attack time if they are separated by 1 ms, a negligible amount of time in terms of human perception. Other musical tones are characterized by longer rise times. For example, the rise times of pizzicato bass transients range from about 15 to 85 ms. In these transients, the perceptual attack time occurs at some hypothetical point between physical onset and signal peak, and the longer rise times result in a greater range at which individuals might perceive the attack. Thus, rise time is a critical component affecting the perception of attack, and longer rise times make it problematic to pinpoint perceptual attack time.

The question of perceptual attack time has been of interest in computer music for many years. In the 1970's, composers interested in programming music computationally discovered the problem of perceptual attack time (see Gordon, 1984). For example, programmers organized musical tones by aligning the physical onsets of their waveforms only to find that this resulted in uneven, unmusical rhythms. Aligning the tones according to amplitude peak produced the same unsatisfactory effect. Neither the physical onset nor the amplitude peak provided an accurate representation of perceptual attack time. At physical onset the level of the signal is too low for the listener to perceive, and amplitude peak may occur well after the listener first perceives the beginning of the tone, particularly if the tone has a long rise time. To produce musical rhythms computationally,

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[20] The observations regarding ride-cymbal and bass tones were made while examining waveforms using Pro Tools, described in Chapter Four. The ride cymbal was struck with a drumstick, and the bass was played pizzicato or "plucked."

programmers, like researchers working on musical timing, needed a method for determining perceptual attack time.

Theoretical models for calculating perceptual attack time are problematic, because there is a range of human perception. In perceptual studies, experimental conditions and different acoustical qualities of musical tones affect listeners' perception of attack. Furthermore, listener responses are not completely consistent even when experimental parameters are stable. Nevertheless, effective methods have been developed to predict perceptual attack time in a manner that is acceptably similar to how attacks are perceived by humans. Such methods are useful when a mathematical and objective means of determining the perceived attack time of musical tones is needed.

A number of computational methods and algorithms have been developed to address the problem of perceptual attack time in computer music, the details of which are beyond the scope of this paper. A method for determining perceptual attack time by looking at waveform displays in sequencing programs was needed for the present study, and the *percent of max* model developed by Vos and Rasch (1981) was found to be optimal for my purposes.

In the experiments of Vos and Rasch (1981), subjects were presented with complex synthetic tones. The tones were identical except for two independent variables: amplitude and rise time. Subjects listened to a sequence of tones and attempted to make the sequence perceptually isochronous by adjusting the temporal placement of the tones.

The researchers posited that *perceptual onset*[21] occurs when a threshold in amplitude is reached. They found that thresholds were best expressed relative to the amplitude peak of a given signal, and determined that perceptual onsets were estimated to occur at the moment a waveform crossed an amplitude threshold existing at 17.8% of maximum amplitude.

Following Vos and Rasch (1981), Gordon (1987, 1984) conducted similar experiments using 16 different musical tones, which were recordings of orchestral instruments played by live musicians, and in some cases performed with different musical articulations. The instruments included: English horn, bassoon, trumpet, French horn, cello (with different bowed attacks), muted trombone, oboe (different instruments played by different players), flute, E-flat clarinet, B-flat clarinet, soprano saxophone, and alto saxophone (played at contrasting dynamic levels).

Gordon used two distinct experimental methods to determine perceptual attack times. The first method followed the experiments of Vos and Rasch: Subjects arranged tones to form isochronous sequences. In the second method, subjects arranged tones to occur in synchrony with other set tones. After compiling data from the subjects who were most consistent in their responses, Gordon tested several models designed to predict perceptual attack time. The results from these models were compared to the data from the human subjects. A few models performed quite similarly to humans, including the

[21] For the purposes of this discussion, perceptual onset and perceptual attack time are synonymous. Gordon (1987, 1984) made a distinction between perceptual attack time and perceptual onset, pointing out that wind instruments and bowed string instruments may produce sounds that are audible prior to the moment of rhythmic impact. According to Gordon's definition, perceptual onset is the moment at which the listener perceives the tone's beginning, and perceptual attack time is the moment at which the tone's rhythmic emphasis is perceived.

percent of max model, with which Gordon found the optimal percentage to be 5.8% of maximum amplitude. When the percent of max model was applied at 5.8%, there was a significant correlation of .952 between data predicted by the model and data from human subjects.

In a more recent study (Collins, 2006), eight different models (including percent of max) for predicting perceptual attack time were compared to data from human subjects, in a similar manner as Gordon's study. In the first experiment, stimuli consisted of 25 synthetic sine wave tones of various pitches and rise times. The percent of max model performed as the best of the predictors when optimized at 97% of maximum amplitude. In other words, the attack times predicted by the percent of max model at 97% most closely matched the perceived attack times of human subjects. In a second experiment, a database of 100 sounds was used, including synthetic sounds, recordings of the human voice, recordings of solo instruments, and recordings of full ensembles: jazz band, orchestra, choir, and percussion. None of the models performed as well in this experiment as they did in the first experiment. The greater diversity of sounds in the second experiment resulted in greater variety of human responses, making attack times more difficult to predict consistently. The percent of max model was the third most effective of the eight models, optimized at 32% of maximum amplitude.

To review, in three studies that used data from the perception of human subjects, four different optimal percentages were generated for predicting perceptual attack time using the percent of max model: 17.8% (Vos & Rasch, 1981), 5.8% (Gordon, 1984), 97% (Collins, 2002), and 32% (Collins, 2002). Clearly, the optimal percentages vary widely, influenced by factors such as experimental method, differences among subjects, and differences in the acoustical characteristics of stimuli. Nevertheless, when compared to other models, the percent of max model was among the most effective predictors of perceptual attack time.

A final important point about perceptual attack time is that the ear is more "forgiving" when listening to tones with relatively long rise times. In other words, when musical tones with slow rise times occur on the same beat of the measure, listeners perceive them as acceptably synchronous even if the attacks of the tones are not precisely aligned. In contrast, when impulsive or percussive sounds are not precisely synchronized, it is more easily noticeable to the listener (Gordon, 1984; Rasch, 1978). Perceptual attack times are more difficult to predict when working with tones with relatively slow rise times, but this problem is made less consequential by the fact that there is a greater range of acceptable accuracy when calculating perceptual attack times of such tones.

In summary, interpreting the results of musical timing studies that measure asynchronies between instruments is problematic for two reasons. The first is that there are unanswered questions about the perceptibility of asynchronies in musical examples. In laboratory experiments, thresholds for temporal order judgment exist in the range of about 20 to 40 ms, and it is possible that a similar threshold could be relevant to music listening activities, but this idea has not been sufficiently investigated. The other problem has to do with measurement of asynchronies. Researchers have used different methods to determine the attacks or onsets of musical notes, and in each method there is an unknown margin of error in the estimations of attack. This is due to the problems associated with pinpointing the attack at the millisecond level discussed previously. Thus, if asynchronies of 40 ms between instruments were reported, it would be unclear how much of the 40 ms discrepancy could be attributed to method of measurement.

Considering the following factors – differences in individuals, differences in acoustical qualities of musical examples, and differences in methods of measurement – it is suggested here, that under most conditions it is unlikely that listeners could consistently make accurate temporal order judgments for reported asynchronies occurring less than 40 ms apart in musical examples. This hypothetical threshold would likely be lower if the instruments used were percussion instruments characterized by rapid attacks.

Analysis of Jazz Timing

An important aspect of jazz rhythm is known as *time feel*. Throughout this paper, time feel refers to the manner in which individual performers interpret swing subdivision and beat placement.

There are many terms within the spoken vernacular of jazz musicians that describe interpretations of time feel. When referring to swing subdivision, "more triplety" and "straighter" may be used to describe the range of possibilities between the 2:1 and 1:1 ratios (i.e., triplet-based subdivision and even subdivision), and "corny" to describe subdivisions that are more uneven than the triplet (e.g., a dotted eighth note followed by a sixteenth note). Regarding beat placement, the terms "laid-back," "relaxed," and "on the back edge," describe a desirable behind-the-beat approach, but "dragging" normally has negative connotations. Similarly, the phrases "on top" or "on the front edge" are used to describe playing that is slightly ahead of the beat, but if playing is too far ahead, it may be described as “uptight” or “rushing.” The reality of this language and its use illustrates the fact that jazz musicians are highly aware of subtle differences in timing, and that these nuances are an important part of their art (Berliner, 1994; Monson, 1996; Prögler, 1995).

Deviation from the norm (or from a mechanical standard) is an important aspect of artistic expression, and for jazz musicians, time feel presents opportunities for subtle, individualistic deviation. Liebman (1997) pointed out that jazz players’ approaches to time feel are distinguishing aspects of their personal styles. According to Liebman, saxophonists Dexter Gordon and Hank Mobley had very behind-the-beat approaches, trumpeter Clifford Brown’s approach was “exact and on top,” and trumpeter Miles Davis had a “fantastic middle-of-the-beat” approach. When listening to recordings, jazz musicians can identify their favorite players based on time feel, an important feature of a performer’s unique sound.

The notion of time feel introduces major difficulties for educators. Nuances such as manipulation of subdivision and beat placement occur at the micro level of timing. This presents problems: Micro deviations of timing can be difficult to perceive accurately, and musical notation cannot sufficiently represent such subtleties. Studies in jazz timing have begun to address some of the elusive aspects of time feel, providing valuable data through measurement of timing in jazz performance.

Timing variations discovered at the micro level inevitably raise the question of whether these variations were intended by the performer or were merely a result of random error. Although there is no doubt that random error exists in human motor processes, there is ample evidence that jazz performers have a degree of control over subtle timing nuances. Liebman (1997) pointed out that musical style impacts how swing subdivision and beat placement should be interpreted, and stated, “a good musician can do it all,” indicating that it is appropriate for musicians to adjust their interpretations based on the style of music. Liebman effectively demonstrated stylistic manipulations of time feel on his instructional DVD. In separate studies, Reinholdsson (1987) and Prögler (1995) asked jazz bassists to perform bass lines ahead of or behind the beat of a metronome. The bass lines were recorded and measured computationally, and in all cases the bassists effectively performed the techniques as instructed. A drummer in Prögler’s study had two different approaches for playing a ride pattern based on his interpretations of drummers Kenny Clarke and Elvin Jones. Ride patterns were recorded and analyzed, and systematic variations pertaining to each interpretation were revealed. There are many additional examples in studies focused on classical musicians showing that performers have control over micro variations in timing (e.g., Repp, 1999).

Accurate data about jazz timing with regard to individual players, tempo, style, or instrument played can potentially serve educators and students by providing clear knowledge of rhythmic techniques. The studies reviewed below have begun to fulfill that need by providing valuable information about two important aspects of jazz rhythm: swing subdivision and beat placement.

SWING SUBDIVISION

Swing subdivision in jazz has been analyzed in a number of studies since 1985. A well known fact is that swing ratios decrease as tempos increase from moderate to fast (Collier & Collier, 1996; Collier & Wright, 1995; Friberg & Sundström, 2002, 1997; Gridley, 1988; Rose, 1989). The point at which swing subdivision ceases to be "triplety" and becomes "straighter" varies depending on individual players and context, but the following theoretical illustration provides a general idea about the role of tempo in determining swing ratios.

The triplet-based ratio of 2:1 is practical at the tempo 200 bpm, which corresponds to 300 ms intervals between beats. At this tempo and ratio, long/short durations of downbeat/off-beat equal 200/100 ms. As the tempo increases beyond 200 bpm, it becomes necessary to straighten the eighth notes incrementally, because it is difficult to perform rhythmic durations less than 100 ms[22]. If the off-beat duration remains constant at about 100 ms, then the ratio gradually becomes more even until the tempo 300 bpm is reached. At 300 bpm, which corresponds to 200 ms intervals between beats, the subdivision necessarily becomes even (ratio=1:1), producing downbeat/off-beat durations of 100/100 ms. Thus, the tempo range 200 to 300 bpm corresponds approximately to a linear decrease in swing ratios from 2:1 to 1:1.

Of course this illustration is conjectural. The 100 ms limit may vary greatly depending on one's instrument and technical facility, and many jazz soloists prefer a straighter approach to eighth notes at tempos slower than 200 bpm. The important point

[22] See "Tempo" in this chapter for a discussion of the motor and perceptual limits associated with 100 ms.

is that the swing ratio cannot simply be “transposed” to different tempos; it must be adjusted as tempos change.

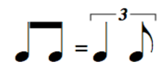
Studies measuring swing ratios have focused on eighth-note passages of soloists and/or the ride patterns of drummers. The typical ride pattern is a repeated pattern of a quarter note followed by two eighth notes, the classic “ching, ching-a-ching, ching-a” sound associated with the swing style. However, drummers liberally alter the pattern, creating individualistic renderings.

In existing research, many swing ratios in improvised solos fall between 2:1 and 1:1. Rose (1985, *cited in* Ellis, 1991; Rose, 1989) found mean ratios of 1.5:1 in unaccompanied improvised solos from jazz recordings. Reinholdsson (1987), in an analysis of a drum solo by Roy Haynes, found ratios between 1.48:1 and 1.82:1. Ellis (1991) analyzed the timing of three jazz saxophonists, and reported an average ratio of 1.7:1. In an analysis of two Louis Armstrong solos, Collier and Collier (2002) determined an average ratio of about 1.6:1.

There are instances in which performers exceed the 2:1 ratio at moderate and slow tempos, and this seems to be characteristic of rhythm section performance, particularly the ride patterns of drummers. Rose (1989) analyzed a recording of “September Song” from a widely used pedagogy method by Jamey Aebersold. In a recording consisting of piano, bass, and drums, (no soloist), he found an average swing ratio among all instruments of 2.38:1 for the tempo 132 bpm. Collier and Collier (1996) asked drummers to perform ride patterns for a wide range of tempos between 25 and 280 bpm, and average ratios that exceeded 2:1 were frequently produced in some of the slow and intermediate tempos. The average ratios of the individual drummers across all tempos were: 1.85:1, 2.23:1, and 3.01:1. Using three well known, highly regarded jazz recordings and one play-along recording, Friberg and Sundström (2002) analyzed the ride patterns of drummers Adam Nussbaum, Tony Williams, Jack DeJohnette, and Jeff "Tain" Watts. Across a range of tempos from about 110 bpm to 330 bpm, average swing ratios ranging from 3.5:1 to 1:1 were found. At tempos 200 bpm and slower, average ratios produced by each drummer exceeded 2:1. In some of the performances by Tony Williams, average ratios exceeded the dotted-eighth/sixteenth ratio of 3:1 (tempos of about 120 to 140 bpm).

Friberg and Sundström (2002) provided evidence of important systematic differences in how drummers approach swing subdivision when playing a ride pattern as compared to soloists when improvising melodies. The swing ratios of the soloists (George Coleman, Herbie Hancock, Keith Jarrett, Marcus Roberts, Miles Davis, and Wynton Marsalis) were analyzed and compared to the ratios of drummers' ride patterns. The authors reported:

> For medium tempi, it is clear that the soloists' swing ratios are considerably lower than the drummers' swing ratios and that all means are below 2, that is, they are all more even than a strict triplet feel. Interestingly, this finding is in agreement with the previous statement that the swing ratio is between 1 and 2 (1:1 and 2:1). Also, it shows that it is important to distinguish between different instruments and function (solo/accompaniment) when discussing swing ratios. (p. 341)

These studies show that interpretation and context are factors affecting swing subdivision. Personal preference, tempo, instrument played, technical ability, performance function (accompaniment vs. solo), and musical style can have considerable impact on swing ratios. Triplet-based subdivision (i.e., ) may be a good initial explanation of swing subdivision, however the nuances of subdivision in the recordings of jazz masters have revealed complexities beyond the basic triplet-based approach.

BEAT PLACEMENT

Beat placement in jazz can be explored by measuring the asynchronies between musical parts in an ensemble. It is well known that when ensemble performance is analyzed at the micro level, there are asynchronies among musical parts. In some cases, these asynchronies are intentional for aesthetic reasons; in other cases, they are the result of random error. The classic example of the former in jazz is the soloist who plays behind the beat of the rhythm section to express a "laid-back" feeling (Ellis, 1991; Liebman, 1997).

In studies of jazz timing, beat placement has been examined in two distinct contexts: relationships among the instruments of the rhythm section, and relationships between soloist and rhythm section[23]. Generally speaking, rhythm sections strive to portray a unified concept of beat placement, providing cohesion and groove in a performance (Berliner, 1994; Monson, 1996; Rose, 1989). In contrast, soloists often manipulate beat placement for expressive purposes, creating tension and release, or achieving a time feel that is stylistically desirable (Ellis, 1991; Liebman, 1997).

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[23] An example of a context that has not been studied is sectional playing in a big band.

Rose (1989) analyzed rhythm-section performances in three musical styles: swing style, ballad, and Latin jazz. Because a play-along recording was used, the rhythm section only performed the function of accompanying. Rose converted cassette recordings to digital audio signals and used different stereo channels and audio equalization to achieve a degree of separation among piano, bass, and drum signals. The study reported a tendency for the drums to sound first, the piano second, and the bass last. Note that this order may be reflective of the acoustical rise times of each instrument, and not necessarily the intentions of the musicians. Rose determined perceptual attack times at the point in which waveforms reached 85% of maximum amplitude, frequently resulting in a measurement closer to amplitude peak than physical onset. It is natural that bass tones would reach amplitude peak later than piano and drum tones, because in general, bass tones have the longest rise times, followed by piano tones, and then drum tones. Rose also found that the onsets of the three instruments consistently occurred within a window of about 6 to 35 ms, revealing impressive cohesion in the ensemble.

Ellis (1991) asked three jazz saxophonists to perform written melodic patterns using a digital (MIDI) saxophone device, accompanied by a computer-generated bass line. A software program was used to determine onsets of the synthetic saxophone and bass tones (personal communication, January 12, 2008). Ellis analyzed the timing of the performances, and found that each saxophonist played behind the beat of the accompaniment. The average lag time was 60, 94, 133, 163, and 221 ms for the respective tempos of 90, 120, 150, 180, and 210 bpm. Interestingly and unexpectedly, the values of lag time showed a tendency to increase with tempo. Findings seemed to be in agreement with the historical tradition of jazz saxophonists preferring a "laid-back" feeling (see also Liebman, 1997).

Using highly regarded jazz recordings Friberg and Sundström (2002) measured the timing of soloists George Coleman, Herbie Hancock, Keith Jarrett, Marcus Roberts, Miles Davis, and Wynton Marsalis. The researchers measured asynchronies between soloists' attacks and ride-cymbal attacks using spectrograms[24] to determine note onsets. An important finding of this study was that soloists' beat placement was different for downbeats than it was for off-beats. They found that all soloists tended to place downbeats behind the downbeats of the accompanying ride patterns. For tempos in the range of about 120 to 200 bpm, average delays ranged from about 30 to 90 ms. Opposite to Ellis's findings, the absolute values in lag time tended to decrease as tempos increased. Interestingly, the behind-the-beat effect was not observed when the timing of off-beats was analyzed. The average placement of soloists' off-beats was remarkably close to the off-beats of the ride patterns, ranging from about -20 to 20 ms. The soloists showed a tendency to perform downbeats a little late and off-beats on time in relation to ride patterns, resulting in a more even subdivision than the subdivision of the accompanying ride patterns.

In summary, research has focused on two main aspects of jazz timing: swing subdivision and beat placement. These aspects are essential techniques of swing, though

[24] A spectrogram is a computer-generated visual display representing sound, in which the horizontal axis represents time and the vertical axis represents frequency. Amplitude is represented only approximately by the intensity or shade of the image. The spectrograms used in this study represented recordings of the ensemble; there was no separation of instruments. Signals corresponding to individual instruments were estimated based primarily on pitch frequency. Like waveform analysis, spectrogram analysis is problematic, but the details of spectrogram analysis are beyond the scope of this paper.

they cannot be adequately notated, and listeners' experiences of these phenomena are somewhat subjective. Therefore, jazz timing studies provide clarity regarding time feel in jazz performance by means of objective measurement and analysis. The following conclusions about time feel were drawn from the studies reviewed.

Swing subdivision is not only a matter of personal or stylistic preference, but is also impacted by tempo, function (melody vs. accompaniment), and instrument played. For soloists, swing subdivision is straighter than the 2:1 ratio at moderate to fast tempos. For drummers' ride patterns, more uneven subdivision than that of soloists is frequently used, particularly at slower tempos. At times, ride pattern ratios exceed the dotted-eighth/sixteenth ratio of 3:1 at moderate to slow tempos. In all cases, swing ratios decrease as tempos increase from moderate to fast, and tempos in the vicinity of 300 bpm necessitate abandoning swing subdivision in favor of even subdivision.

Beat placement is manipulated within a range of about 90 ms, that is, average asynchronies do not exceed 90 ms[25]. Asynchronies between soloists and rhythm section are in the range of about 30 to 90 ms for downbeats. Off-beats tend to be more closely synchronized. Soloists generally play behind the beat of rhythm sections. In fact, none of the soloists in the studies reviewed showed a tendency to perform ahead of the accompanying rhythm section's beat when tempos under 250 bpm were performed. In contrast to soloists, accompanists achieve greater accuracy in synchronization. Average

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[25] However, Ellis (1991) reported much larger average asynchronies in a study that did not analyze authentic jazz performances, but instead analyzed jazz saxophonists' performances on an electronic instrument in relation to a computer-generated bass line.

asynchronies among rhythm-section instruments performing an accompaniment function are low, about 6 to 35 ms.

CHAPTER THREE: SOLO TRANSCRIPTION AND ANALYSIS

In this study, five improvised solos from commercially produced recordings are selected for transcription and analysis. The recordings chosen exemplify the straight-ahead style as performed by recognized jazz masters. Two historical periods are represented: the early 1960's and the 1980's. In addition, performances by the same artist and improvisations based on the same composition are included so that relevant comparisons can be drawn between particular examples. The soloists are: Oscar Peterson (two selections), Wynton Kelly, Wynton Marsalis, and Marcus Roberts; and the compositions are: "Autumn Leaves" (two selections), "Days of Wine and Roses," and "April in Paris" (two selections). Each soloist is a highly regarded jazz master, and the compositions are well known standards. The commonalities of each composition are: 32-bar song form, medium tempo (about 135 to 180 bpm), and straight-ahead rhythmic style.

Literature about jazz rhythm has described the characteristics of swing, but these qualities cannot be actualized in the absence of musical examples. The improvised solos analyzed in this study serve as such examples. Each solo is investigated for rhythmic techniques related to the characteristics of swing: emphasis on off-beats, rhythmic variety, use of articulation devices, polyrhythmic effects, flexibility of phrasing, and time feel. Full appreciation for the selections is possible only through listening to the recordings; the musical scores and analyses herein are merely representations of each performance.

Method

I used a transcription/performance process to notate and study selected improvised solos by Oscar Peterson (pianist), Wynton Kelly (pianist), Wynton Marsalis (trumpeter), and Marcus Roberts (pianist). Initially, I listened to a given recording and transcribed the music with pencil and paper, while periodically playing along with passages on the piano to check my work. After completing a draft of a transcription, I used the program Transcribe (2007, Seventh String Software) to check for accuracy. This is excellent software for examining audio data, providing the ability to slow down playback without changing pitch. Passages that are difficult to transcribe become much easier when played at slower speeds. In addition, the software allows for adjustment of audio equalization (EQ), tuning, and stereo balance, facilitating easier aural detection of musical parts that are somewhat obscured in the basic recording (e.g., the left-hand of the piano part).

Using Transcribe and high quality Sony headphones, I listened many times to each solo, section by section, adjusting the speed of playback to various values while using the EQ, stereo, and tuning features as needed. During this process, I learned how to play each solo on the piano at various tempos. With Transcribe, I created audio files of the performances at tempos slower than the original, and then played the solos along with the recordings, gradually increasing the speed until I was able to perform each solo at the actual tempo of the original recording. To verify that I perceived the music accurately and could execute it in close synchrony with the recordings, I recorded my playing along with each solo. I then listened to playback of these performances, in which my playing was audible simultaneously with the original recording. The purpose of listening in this manner was to reveal errors that might have been missed while I was engaged in performing the solos. Whereas I made every effort to produce highly accurate transcriptions, I acknowledge that the process of transcribing music by ear is a subjective one, as evidenced by the likelihood that two individuals will transcribe the same music differently.

Using the software Finale (2005, MakeMusic, Inc.), I created scores for each transcription. An important goal of the scores was to provide the ideal notation to represent the rhythms and articulation devices of each solo. In addition, the scores included details related to subtleties of timing such as and variations in subdivision and beat placement. Approximate metronome markings were also provided, which I determined manually with a Dr. Beat DB-66 metronome (manufactured by Roland).

Chord symbols were omitted from the notation for the following reasons: 1) the analyses focused on rhythm, thus there were few references to harmonic aspects, 2) extra space was needed above the staves for special instructions regarding timing, and 3) the chord progressions of these songs are well known and easily accessed elsewhere. In lieu of chord symbols and conventional bar lines, I used a system of double bar lines to illustrate the four-, eight-, and 16-measure sections intrinsic in the structure of each composition. Double bar lines (sectional boundaries) were placed at the end of each formal section (i.e., the eight- or 16-measure sections labeled A or B). Dashed double bar lines (sub-sectional boundaries) were placed every four measures within the A or B sections. The illustration of measure groupings in this manner proved useful when phrasing was analyzed. The complete transcriptions are provided in Appendix A.

The analyses focus on specific rhythmic aspects related to the characteristics of swing presented in Chapter One. These include emphasis on off-beats, rhythmic variety, use of articulation, use of polyrhythmic effects, phrasing, and time feel (swing subdivision and beat placement). Many aspects of the analyses are subjective, particularly articulation, phrasing, and time feel. My experience listening to and performing the solos informed these subjective aspects. Also included in the analyses are comparisons between solos. Improvisations based on the same composition are compared (Peterson's and Kelly's renditions of "Autumn Leaves," Marsalis's and Roberts's performances of "April in Paris"), and improvisations by the same artist are compared ("Autumn Leaves" and "Days of Wine and Roses" by Peterson).

Analyses

ANALYSIS OF OSCAR PETERSON'S IMPROVISATION ON "AUTUMN LEAVES"

Overview

"Autumn Leaves" was composed by Joseph Kosma, with lyrics by Jacques Prevert and Johnny Mercer. This performance is by the Oscar Peterson Trio, featuring Peterson on piano, along with Ray Brown on bass, and Ed Thigpen on drums. The album is titled *Live at CBC Studios 1960*, recorded in 1960 and released by Just a Memory

Records. The song is performed in the key of F minor, with a tempo of approximately 172 to 181 bpm during Peterson's solo.

"Autumn Leaves" has a 32-measure formal structure. In this transcription, the composition is divided into three formal sections: A (the first eight measures), A1 (the subsequent eight measures), and B (the final 16 measures). In addition, the melodic and harmonic structure of the composition establishes four-measure sub-sections within the A and B sections.

Peterson's solo begins with a two-measure *solo break*[26] followed by two choruses of continued improvisation. The final measure of the second chorus is omitted from the transcription because it contains the pick-up notes of the composed melody, thus it is no longer improvised material. The score consists of 65 measures (see Appendix A, pp. 217-222).

Off-beats

In this solo, Peterson shows a strong tendency to favor off-beats for dynamic accent placement. In the right-hand part, a total of 29 accents are notated, 23 of which occur on off-beats, compared to just six on downbeats. In the left-hand part, a total of nine accents are notated, all of which occur on off-beats. The percentage of written accents that occur on off-beats is 84%.

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[26] The term solo break refers to a brief period in which a soloist plays without the accompaniment of the rhythm section, often occurring at the beginning of a solo.

Off-beats are also strongly favored for the rhythmic placement of *left-hand comps*[27]. A total of 135 left-hand comps are notated, 129 occurring on off-beats, compared to just six on downbeats. The percentage of left-hand comps that occur on off-beats is 96%.

A noteworthy technique in which Peterson utilizes syncopation is to frequently conclude phrases by placing the final note on an off-beat. This pattern seems to be a personal tendency and/or an important unifying theme of the solo, occurring repeatedly throughout (mm. 3, 5, 8, 35-36, 37-38, 41, 44-45, 50, 60, 62-63, 65). Example 3.1 illustrates phrases that end on off-beats.

Example 3.1: Peterson's improvisation on "Autumn Leaves" (mm. 1-8): Vertical arrows indicate phrase endings occurring on off-beats.

[27] The term left-hand comps refers to the accompanying interjections during a piano solo played by the

Rhythmic Variety

Peterson uses a variety of rhythmic values with particular emphasis on faster note values. No note values greater than a half note are found (occurring just once, in mm. 37-38), but all practical faster values are used: dotted quarter notes, quarter notes, quarter-note triplets, dotted eighth notes, eighth notes, eighth-note triplets, sixteenth notes, quintuplets, and sextuplets. Quintuplets and sextuplets are extremely fast at this tempo, and they tend to be interspersed within phrases, as opposed to being used consistently throughout the length of a phrase.

It is very common for Peterson to use several different note values within the same phrase. In fact, the vast majority of phrases contain notes of at least three different values (mm. 1-3, 11-13, 14-17, 18-20, 20-23, 23-26, 26-31, 32-33, 34-36, 36-38, 38-41, 47-50, 50-53, 54-55, 57-60, 61-65). A representative example of a phrase that uses varied rhythmic values begins just before measure 51. In this phrase, Peterson uses quintuplets, eighth-note triplets, tied eighth-note triplets, eighth notes, and quarter notes (see Example 3.2).

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pianist’s left hand to support right-hand melodies, often consisting of short chords.

Example 3.2: Peterson's improvisation on "Autumn Leaves" (mm. 50-54): an example of rhythmic variety within a phrase (mm. 50-53)

Articulation

The term "jazz legato" can be used to describe Peterson's general articulation, meaning a type of legato in which the notes are connected but attacks are distinct or slightly percussive, resulting in a legato style that is less smooth than a true classical legato (Liebman, 1997). Throughout the performance, articulation devices are interspersed such as accents, staccatos, tenutos[28], grace notes[29], and ghost notes[30].

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[28] The tenuto marking is a horizontal line above or below a given note, indicating that the note is sustained for its full duration.

[29] Because the piano is a fixed pitch instrument, it is impossible to "bend" a pitch on the piano, yet pitch bending is an important type of inflection in jazz. The addition of a grace note a step below the main note produces the effect of bending into the main pitch. Grace notes are included as articulation devices because when used in this manner, they are a variation on how notes are attacked.

[30] Ghost notes are indicated by parentheses surrounding the notes.

Peterson frequently uses more than one type of articulation device within the same phrase (mm. 1-3, 8-10, 11-13, 14-17, 20-23, 23-26, 30-33, 46-50, 50-53, 57-60, 61-65). He also varies the articulation in the left-hand comping throughout, utilizing tenutos, staccatos, accents, and ghost notes.

As discussed previously, accents are frequently placed on off-beats. Furthermore, melodic content plays a role in accent placement. Many accents occur on an off-beat when the given note is a melodic upper neighbor, that is, the accented note is followed by a note one melodic step below (mm. 2, 8, 21, 34, 52). In addition, accents frequently occur at the highest pitch within a given phrase (mm. 2, 8, 22, 32, 34, 46, 60).

Ghost notes are particularly prevalent in the left-hand comps (mm. 9, 11, 15, 25, 29, 39, 42-44, 47-49, 53-54, 57, 63) but are also found in the right-hand phrases on four occasions (mm. 9, 15, 30, 58). In general, Peterson keeps the dynamic level of the accompanying left-hand part much softer than the level of the melodic right-hand part.

Polyrhythms

In measures 46 to 48, Peterson creates an interesting polyrhythmic effect by utilizing quarter-note triplets (notated as tied eighth-note triplets), creating three-against-two polyrhythms, in which the three-note groupings of the triplets are superimposed over the two-note (quarter-note) groupings intrinsic to the metrical structure. Interestingly, Peterson starts this idea on beat 2 of the measure, creating “over-the-bar-line” phrasing (i.e., notes within the phrase are tied over measure lines). Thus, the note attacks do not align with the strong beats of the measure. Peterson resolves the rhythmic tension in measure 49, using sixteenth notes and eighth notes that do align with the strong beats (see Example 3.3).

Example 3.3: Peterson's improvisation on "Autumn Leaves" (mm. 46-49): Polyrhythms are created by juxtaposing quarter-note triplet values against 4/4 meter (mm. 46-48). The polyrhythmic effect is resolved in measure 49 through the use of rhythms that align with the metrical structure.

Phrasing

Throughout this solo, Peterson consistently phrases across sectional boundaries and sub-sectional boundaries[31]. In fact, there are 16 instances of sectional and sub-sectional boundaries indicated by different types of double bar lines on the score, and

Peterson's phrases clearly continue across these boundaries in every instance with the possible exception of measure 11, in which the material on beat 1 could be interpreted as the beginning of a phrase. A good example of crossing a sectional boundary occurs in measure 1. This phrase, which begins as an unaccompanied solo break, continues across the double bar line at section A (m. 3). In addition, a subsequent phrase crosses over a sub-sectional boundary at measure 7 (see Example 3.4).

Example 3.4: Peterson's improvisation on "Autumn Leaves" (mm. 1-8): Examples of phrases continuing across sectional and sub-sectional boundaries are indicated by horizontal arrows (mm. 2-3 and 6-7).

[31] Phrasing across "boundaries", as defined here, occurs in each and every instance in which the notes of a given phrase continue across a double bar line. This includes the use of pick-up notes preceding a double bar line.

At each sectional and sub-sectional boundary, there is an important change in the chord progression, which is fundamental to the structure of the composition. Peterson often anticipates these harmonic changes prior to reaching the point at which the new harmony occurs, a technique that shows flexibility with chord placement in relation to the underlying *harmonic rhythm* (i.e., the rhythm at which harmonies change in the composition), as well as creating a sense of forward motion by propelling the music forward as the new harmonies unfold. He frequently does this by playing the upcoming chord in the left hand a half beat early, that is, on the off-beat just prior to beat 1 (mm. 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 50, 62). Example 3.5 provides two clear illustrations of this technique. Peterson plays D-flat dominant seventh with the left hand just prior to reaching measure 31, and B-flat minor with the left hand just prior to reaching measure 35, the start of his second chorus.

Example 3.5: Peterson's improvisation on "Autumn Leaves" (mm. 30-35): Anticipations of upcoming harmonic changes with left-hand comps are indicated by vertical arrows below the score (mm. 30 and 34).

There are also a few instances in which Peterson seems to anticipate upcoming harmonic changes with the material he plays in the right hand (mm. 22, 42, 50, 54, 58).

Peterson uses much variety of phrase lengths throughout this improvisation. An analysis of phrase lengths yields the following approximate values (in measures) from the beginning to the end of the solo: 2.5, 1, 2, 1.5, <1, 2.5, 4, 3, 3, 1, 1, 5.5, 1.5, 2, 2, 3.5, 1, 1, 1.5, 1.5, 2.5, 3, 2, 1, 3.5, 5. Figures 3.1 and 3.2 illustrate the phrase lengths for each chorus.

Figure 3.1: Phrase lengths in Peterson's first chorus of "Autumn Leaves": For convenience, values less than 1 are assigned the value .5.

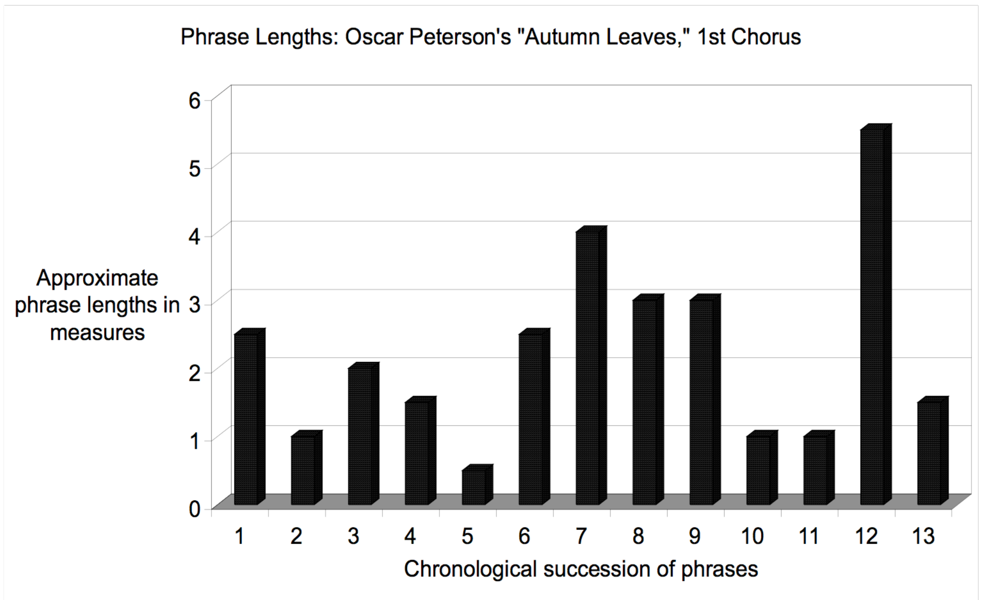
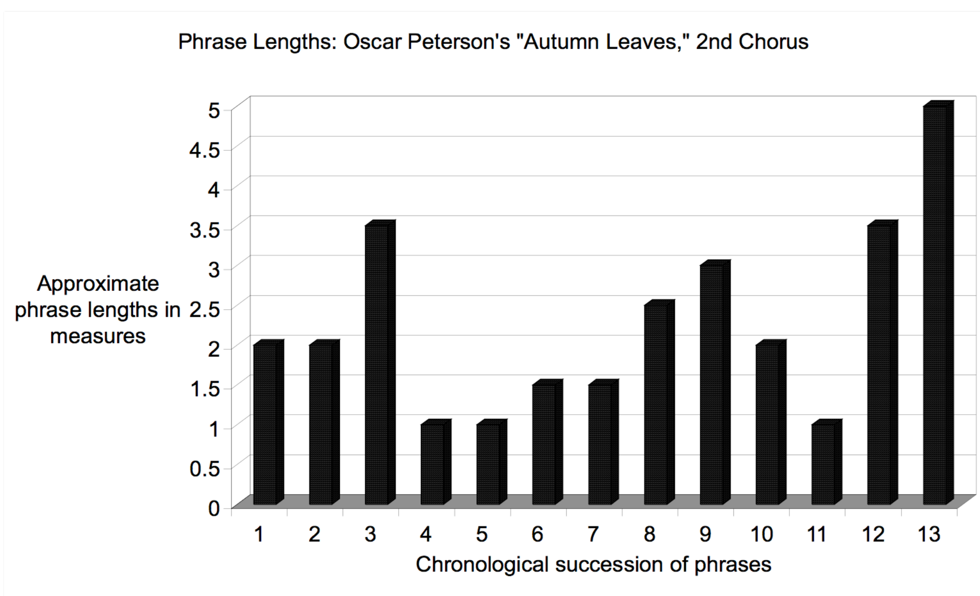


Figure 3.2: Phrase lengths in Peterson's second chorus of "Autumn Leaves": For convenience, values less than 1 are assigned the value .5.



Peterson sometimes plays two adjacent phrases of the same length, but not more than two. He shows a tendency to play shorter phrases at the beginning of each chorus, and the longest phrases occur towards the end of the B sections, creating the effect of increased momentum as each chorus progresses.

Time Feel

Because of the relatively fast tempo of this performance, one might expect Peterson's approach to swing subdivision to be more even than triplet-based. I tested this idea, in a subjective manner, by choosing eighth-note passages, slowing down the recording, and tapping triplets while listening to the passages. I found it to be quite easy to coordinate my triplet taps with Peterson's eighth-notes, indicating a general triplet-based approach to swing subdivision throughout. This was also evident when I performed the solo accompanied by the recording at different playback speeds. In particular, when triplets are interspersed within eighth-note lines, the triplet-based approach to eighth notes is clear, particularly when an eighth note precedes the triplet, as in 

(mm. 2, 9, 17, 21, 32, 34, 40, 50, 51, 53, 59). However, there are some passages in which Peterson plays eighth notes that are straighter than the 2:1 triplet ratio, but not as even as strict eighth notes. These are indicated in the score by the term "straighter" or "straight" (mm. 14, 26-29, 31, 44, 63).

Regarding beat placement, Peterson generally uses a straightforward approach to timing in this performance, emphasizing rhythmic accuracy; deviations are used sparingly. In two instances, a behind-the-beat approach is indicated on the score by the term “lay back,” and in these passages a straighter approach to subdivision is also evident (mm. 14, 31). There are also two instances in which Peterson delays the attack of a single high note for expressive purposes, indicated by the term “late” (mm. 43, 60).

Summary

Peterson strongly favors off-beats over downbeats for the placement of dynamic accents and left-hand comps: 84% of dynamic accents occur on off-beats, and 96% of left-hand comps occur on off-beats. He uses much rhythmic variety, favoring notes faster than quarter notes, and frequently uses three or more different note values within a single phrase. Similarly, he also uses variety in articulation, and tends to incorporate more than one type of articulation device within a phrase. Polyrhythmic effects are utilized sparingly: There is just one clear example of a polyrhythmic passage, created with quarter-note triplet values that are displaced in relation to the strong beats of the measures (mm. 46-48). Peterson exhibits much flexibility in phrase placement and phrase length. Phrases are consistently played across formal boundaries, and phrase lengths are varied: No more than two consecutive phrases of the same length are found. Peterson tends to play shorter phrases at the beginning of each chorus, and the longest phrases toward the end of each chorus. In general, Peterson’s approach to time feel is characterized by triplet-based swing subdivision, and accurate placement of notes in relation to the underlying beat. At times, Peterson manipulates his basic approach by incorporating a more even approach to swing subdivision, and playing slightly behind the beat of the rhythm section. These last two techniques, which tend to occur simultaneously, are used sparingly.

ANALYSIS OF WYNTON KELLY'S IMPROVISATION ON "AUTUMN LEAVES" AND COMPARISON TO PETERSON'S IMPROVISATION ON "AUTUMN LEAVES"

Overview

This rendition of "Autumn Leaves" is by the Wynton Kelly Trio, featuring Kelly on piano, along with Paul Chambers on bass, and Jimmy Cobb on drums. The album is titled *Someday My Prince Will Come*, recorded in 1961, and released by Vee-Jay Records. The song is performed in the key of G minor, and the tempo during Kelly's improvisation is approximately 130 to 137 bpm, much slower than Peterson's version. Kelly's improvised solo begins with two beats of pick-up notes followed by three complete choruses, for a total of 96.5 measures (see Appendix A, pp. 223-230).

Off-beats

In this solo, Kelly, like Peterson, shows a strong tendency to favor off-beats for dynamic accent placement. In the right-hand part, a total of 57 accents are notated, 40 of which occur on off-beats, compared to 17 on downbeats. In the left-hand part, a total of 10 accents are notated, seven of which are on off-beats, compared to three on downbeats. The overall percentage of written accents that occur on off-beats is 71%.

Like Peterson, Kelly strongly favors off-beats for the rhythmic placement of left-hand comps. A total of 238 left-hand comps are notated, 192 occurring on off-beats, compared to just 46 on downbeats. The percentage of left-hand comps that occur on off-beats is 81%.

Rhythmic Variety

Similar to Peterson, Kelly uses a variety of rhythmic values with particular emphasis on faster note values. Unlike Peterson, Kelly uses some longer note values in the right-hand part, including a dotted half note (m. 89) and a whole note (m. 95). The left-hand part also includes dotted half notes and longer values (mm. 5, 8-9, 13-14, 16-17). Throughout the solo, the note values utilized include: whole note, dotted half notes, half notes tied to eighth notes, half notes, dotted quarter notes, quarter notes, quarter-note triplets, dotted eighth notes, eighth notes, eighth-note triplets, sixteenth notes, quintuplets, and sextuplets. Quintuplets and sextuplets are not used consistently, but instead are interspersed within phrases. In addition to streams of sixteenth notes (i.e., runs), Kelly also utilizes sixteenth-note-based patterns such as: , , and  (mm. 28, 34-35, 42, 44, 47-48, 52-54, 62, 71-72, 75-76, 79-80). The slower tempo of Kelly's rendition of "Autumn Leaves" makes these types of rhythmic patterns more practical than they would be in the faster version by Peterson; nevertheless, it is worth noting that Peterson rarely uses these patterns, whereas Kelly uses them often.

Like Peterson, Kelly frequently uses at least three different rhythmic values within a single phrase (mm. 2-3, 6-7, 9-10, 11-12, 12-13, 13-15, 15-16, 17-19, 19-20, 20-22, 23-24, 26-27, 28-29, 29-31, 33-34, 35, 41-43, 46-48, 49-50, 51-52, 53-54, 55-56, 58, 60, 62-63, 68-72, 74-75, 76-77, 77-80, 82-84, 88-90, 90-92, 92-93). Unlike Peterson, Kelly plays a few phrases in which only one rhythmic value is used (mm. 4, 26, 40, 57, 59, 61, 66, 96). In these instances, phrases are short, occurring within one measure.

Articulation

Kelly's general articulation is similar to Peterson's, but at times slightly more detached, particularly when playing faster note values. Of course it is virtually impossible to play detached sixteenth notes on the piano at the faster tempo of Peterson's version, and relatively easy at the tempo of Kelly's. Kelly varies the articulation throughout the solo in a similar manner as Peterson, utilizing accents, staccatos, tenutos, grace notes, and ghost notes. He uses staccato or detached articulation frequently when playing faster note values like eighth-note triplets and sixteenth notes (mm. 2, 11, 17, 20, 23, 26, 33, 38-39, 64, 85-87). Kelly also uses tremolos on two occasions (mm. 82-83). Like Peterson, Kelly frequently incorporates more than one type of articulation device within a single phrase (mm. 2-3, 4, 5-6, 6-7, 11-12, 12-13, 13-16, 17-20, 20-22, 23-24, 26-27, 27-28, 28-29, 29-31, 32, 33-34, 35, 38-39, 46-48, 49-50, 51-52, 53-54, 55-56, 62-63, 64-65, 67-68, 68-72, 77-80, 81-84, 84-88, 88-90, 90-92).

Melodic content is a determining factor in accent placement. Like Peterson, Kelly frequently accents melodic upper neighbors when they occur on off-beats (mm. 4, 5, 8, 19, 21-22, 33, 53-54, 68-69, 83). In the left-hand part, there are relatively few accents, just eight in 96 measures of music, but ghost notes are found frequently (mm. 2, 4, 5-7, 10, 15-16, 17-18, 23-24, 30, 32-36, 38, 44, 47-51, 54-57, 61-64, 66, 68, 75-78, 81-82, 85, 87-89, 92). Like Peterson, Kelly keeps the dynamic level of the accompanying left-hand part much softer than the right-hand part.

Polyrhythms

In two instances, Kelly briefly uses quarter-note triplets (notated as tied eighth-note triplets), creating a polyrhythmic effect against the intrinsic quarter-note structure of the meter (mm. 11-12, 20-21). Kelly begins these triplet ideas in somewhat unpredictable places in the measure, on beat 4 and on the off-beat of 4. The resulting phrases extend across bar lines, as was the case in Peterson's use of quarter-note triplets.

At one point in the solo, Kelly creates a polyrhythmic effect by implying 3/4 meter over the 4/4 meter of the composition. He does this by playing four consecutive phrases that span three beats (see Example 3.6)

Example 3.6: Kelly's improvisation on "Autumn Leaves" (mm. 24-31): Horizontal arrows illustrate the three-beat time spans, suggesting the superimposition of 3/4 meter (mm. 25-28).

Phrasing

Kelly extends his phrases across the majority of sectional and sub-sectional boundaries, but not the vast majority like Peterson. In Kelly's case, phrases cross 14 of 24 boundaries. Like Peterson, Kelly frequently uses left-hand comps to anticipate harmonic changes that occur at boundaries (mm. 8, 12, 16, 20, 24, 32, 36, 44, 52, 60, 64, 68, 72, 76, 80, 84, 88, 96).

Kelly shows a strong preference for short phrases when compared to Peterson. None of Kelly's phrases are longer than four measures, and twenty-two of his phrases are shorter than one measure. Because rests occur between many of these short phrases, Kelly's solo emphasizes the use of space more than Peterson's solo. Kelly frequently uses adjacent phrases of the same or similar length, often creating an imitative or call-and-response quality, in which a similar rhythm is applied to different sequences of pitches (mm. 1-3, 25-28, 57-60, 65-68). An analysis of phrase lengths in Kelly's solo yields the following approximate values (in measures) from the beginning to the end of the solo: <1, <1, <1, 1, 2, <1, 1.5, 1, 1, 2, 1.5, 2, <1, 2.5, 1.5, <1, <1, <1, <1, 1.5, 2, <1, 1.5, 2, <1, 2.5, <1, <1, 1, 3, 2, 2, 2, 2, <1, <1, <1, <1, <1, 2, 1, <1, <1, 4, 1, 2, 1, 4, 1.5, 2.5, 3, 2, 2.5, 1, 1, 1.5, 1. Figures 3.3, 3.4, and 3.5 illustrate the phrase lengths in each chorus of Kelly's improvisation.

Figure 3.3: Phrase lengths in Kelly's first chorus of "Autumn Leaves": For convenience, values less than 1 are assigned the value .5.

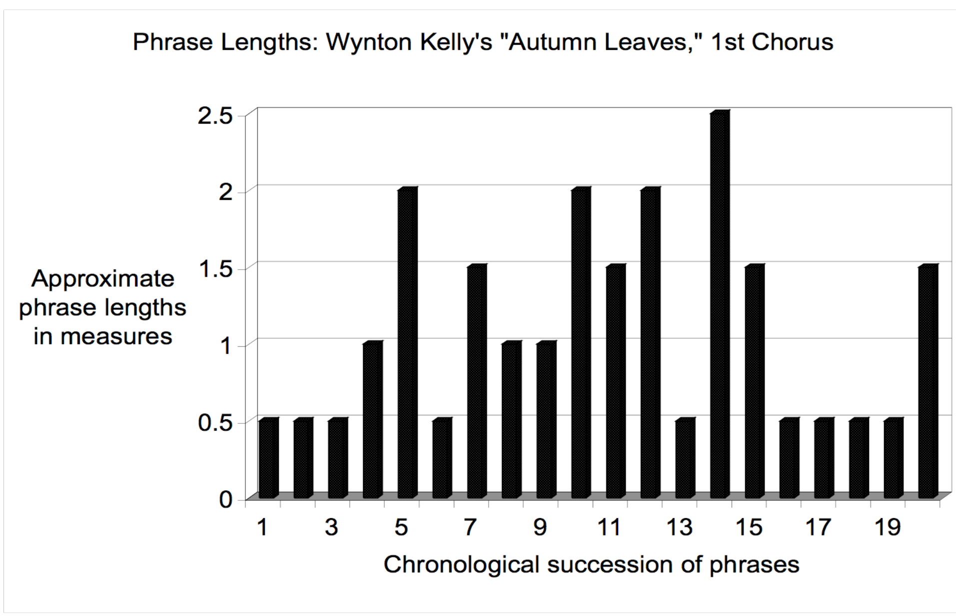


Figure 3.4: Phrase lengths in Kelly's second chorus of "Autumn Leaves": For convenience, values less than 1 are assigned the value .5.

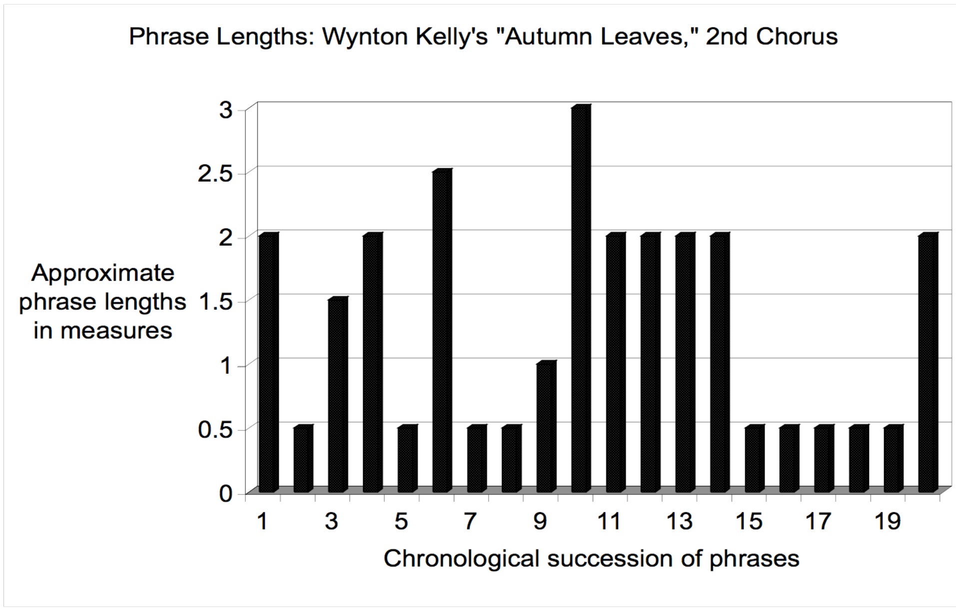
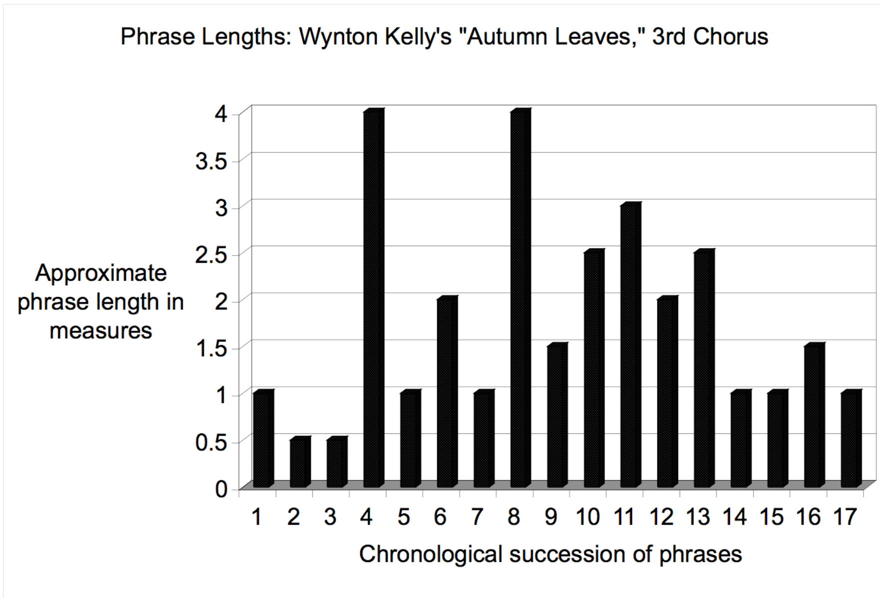


Figure 3.5: Phrase lengths in Kelly's third chorus of "Autumn Leaves": For convenience, values less than 1 are assigned the value .5.



Time Feel

Tapping triplets along with this recording at slower playback revealed that Kelly's general approach to swing subdivision is triplet-based like Peterson's. However, Kelly's eighth notes are generally more elastic than Peterson's, that is, they are slightly less precise and it is more difficult to synchronize taps with them. This could be due to differences in personal styles, but tempo likely plays an important role. At slower tempos, there is more room for timing deviations. Unlike Peterson, Kelly does not play passages of eighth notes that are noticeably straighter than his general triplet-based approach to subdivision. In fact, on a few occasions, he includes subdivisions (dotted-eighth/sixteenth notes) that are more uneven than his general swing subdivision (mm. 9, 25, 28, 58, 60, 62). Again, this contrast is likely attributable to stylistic differences as well as differences in tempo between the two recordings.

There are a few instances where Kelly plays behind the beat for expressive purposes (mm. 8-9, 17-18, 30-31, 43, 53-54). In addition, Kelly's frequent use of grace notes creates a behind-the-beat feeling, because the grace notes delay the main notes (pick-up notes of m. 1, mm. 5, 7, 14, 21, 24, 27, 31, 49, 51-52, 81-82, 84). Also noteworthy is that when Kelly plays streams of sixteenth notes, the overall tempo tends to decrease slightly, whereas the opposite tendency is evident in Peterson's performance. In general, Kelly displays a behind-the-beat approach more than Peterson.

Summary

A number of similarities and differences are evident in Kelly's and Peterson's improvised solos over "Autumn Leaves." Both pianists show a strong tendency to emphasize off-beats with dynamic accentuation, as well as with placement of left-hand comps. Both use a great amount of rhythmic variety, generally emphasizing rhythmic values faster than the quarter note. At least three different rhythmic values are used within a given phrase for the majority of phrases; exceptions to this occur at times during Kelly's solo, in which short phrases that utilize only one rhythmic value are occasionally used. Similarly, both soloists use much variety of articulation, often within a single phrase. In each example, accents are frequently placed on melodic upper neighbors occurring on off-beats. Also, the dynamic level of the left-hand parts is kept under that of the right-hand parts, and the majority of ghost notes occur in the left-hand parts. Kelly and Peterson utilize quarter-note triplets to create polyrhythmic effects, and in each instance the quarter-note-triplet groupings are displaced (not aligned) with the strong beats of the measure. Kelly uses an additional polyrhythmic technique of juxtaposing phrases that imply 3/4 meter against the underlying 4/4 meter. Both pianists tend to create phrases that extend across formal boundaries, but the technique is less pronounced in Kelly's solo than in Peterson's. In general, shorter phrase lengths are used more frequently in Kelly's solo when compared to Peterson's, and Kelly shows a greater inclination to work with phrases of the same length for a longer period of time than Peterson. Unlike Peterson, Kelly plays many phrases that are shorter than one measure, and also plays more than two consecutive phrases of the same length in a few instances. Kelly leaves more space between phrases than Peterson. Both pianists generally exhibit a triplet-based approach to swing subdivision, with some deviations. Kelly uses subdivisions that are more uneven than his basic approach (notated as dotted eighth/sixteenth rhythms), and Peterson incorporates subdivisions that are more even than his basic approach (straighter eighth notes). Regarding beat placement, Kelly favors a behind-the beat interpretation more than Peterson.

ANALYSIS OF OSCAR PETERSON'S IMPROVISATION ON "DAYS OF WINE AND ROSES" AND COMPARISON TO PETERSON'S IMPROVISATION ON "AUTUMN LEAVES"

Overview

"Days of Wine and Roses" was composed by Henry Mancini. This performance is by the Oscar Peterson Trio, featuring Peterson on piano, Ray Brown on bass, and Ed Thigpen on drums. The album is titled *We Get Requests*, recorded in 1965, and released by M. G. M. Records. The song is performed in the key of F major, with a tempo of approximately 155 bpm during Peterson's solo.

"Days of Wine and Roses" has a 32-measure formal structure. In this transcription, the composition is divided into two sections: A (the first 16 measures) and A1 (the subsequent 16 measures). In addition, the melodic and harmonic structure of the composition establishes four-measure sub-sections within the A sections. Peterson's solo begins with a two-measure solo break followed by one and a half choruses of continued improvisation. The half chorus extends into the first measure of A1. The score consists of 51 measures (see Appendix A, pp. 231-234).

Off-beats

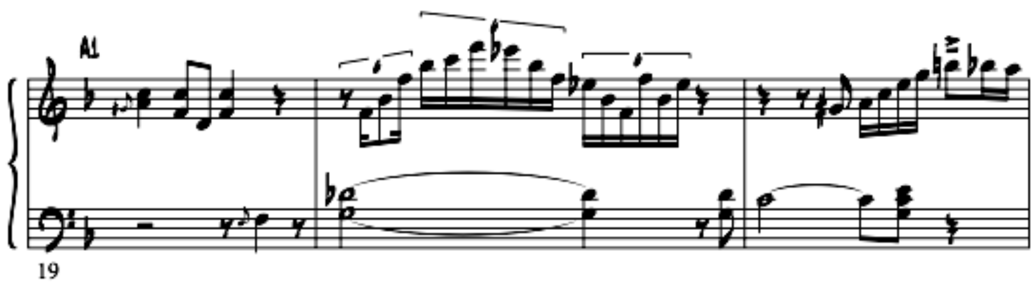
In this solo, Peterson shows a tendency to favor off-beats for dynamic accent placement, but the tendency is less pronounced than in his performance of "Autumn Leaves." In the right-hand part, a total of 30 accents are notated, 20 of which occur on off-beats, compared to 10 on downbeats. In the left-hand part, just two accents are notated, one occurring on a downbeat and one on an off-beat. The overall percentage of dynamic accents occurring on off-beats is 67%.

Similar to the improvisation on "Autumn Leaves," off-beats are strongly favored for the rhythmic placement of left-hand comps. A total of 99 left-hand comps are notated, 84 occurring on off-beats, compared to just 15 on downbeats. The percentage of left-hand comps occurring on off-beats is 85%. On two occasions, it was difficult to determine if left-hand comps were placed on downbeats or off-beats. These were interpreted as being played on off-beats, but slightly late (mm. 7, 33). In the "Autumn Leaves" improvisation, Peterson frequently ends phrases with notes occurring on off-beats, but this pattern is not strongly apparent in this solo.

Rhythmic Variety

In this solo and in "Autumn Leaves," Peterson uses a variety of rhythmic values with particular emphasis on faster note values, and no note values greater than a half note are found in the right-hand part. In the left-hand part, there are some instances of note values greater than a half note (mm. 20-21, 28-30, 36, 46-47). Peterson uses dotted quarter notes, quarter-note triplets, and all conceivable subdivisions of the quarter note at this tempo: eighth notes, sixteenth notes, quintuplets, and sextuplets. His use of quintuplets and sextuplets is very impressive given the tempo, displaying his exceptional command of technique. Whereas in the "Autumn Leaves" performance he intersperses sextuplets and quintuplets in an ornamental fashion, in this performance he creates passages in which these faster values are used somewhat consistently within phrases (see Examples 3.7 and 3.8).

Example 3.7: Peterson's improvisation on "Days of Wine and Roses" (mm. 19-21): Peterson constructs a short phrase in which the sextuplet is the primary rhythmic unit (m. 20).



Example 3.8: Peterson's improvisation on "Days of Wine and Roses" (mm. 25-27): Peterson incorporates five-note groupings throughout a phrase, utilizing quintuplets and sixteenth-note-triplet/sixteenth-note combinations.

The tendency to incorporate several different rhythmic values within a single phrase is slightly less pronounced than it was in "Autumn Leaves," although the majority of phrases do consist of at least three different rhythmic values (mm. 8-13, 14-19, 21-24, 25-30, 31, 32, 33-37, 43-46).

Articulation

Peterson uses "jazz legato" throughout this solo, except triplets are notably detached throughout, and more detached than in the performance of "Autumn Leaves," a factor likely due to tempo. It is very difficult to play detached triplets on the piano at the faster tempo of the "Autumn Leaves" performance. As in the "Autumn Leaves" improvisation, Peterson uses articulation devices such as accents, staccatos, tenutos, grace notes, and ghost notes. He frequently uses more than one type of articulation device within the same phrase (mm. 1-3, 4-5, 6-7, 8-13, 14-19, 21-24, 33-37, 43-46). He also varies the articulation in the left-hand comping throughout. Ghost notes are particularly prevalent in the left-hand comps (mm. 4, 7, 13, 16-18, 22, 24-27, 32, 43), but are also found in the right-hand phrases on three occasions (mm. 11, 23, 43). In general, Peterson keeps the dynamic level of the accompanying left-hand part much softer than the level of the melodic right-hand part.

Polyrhythms

Peterson creates polyrhythms by using quarter-note triplet values, as he did in "Autumn Leaves," but the technique is slightly different in this solo. In two instances, Peterson *implies* quarter-note triplets (mm. 2, 17). In both cases, these triplet ideas begin on beat 2 of the measure, and Peterson creates the quarter-note-triplet feeling in the context of eighth-note-triplet passages. Peterson emphasizes every other eighth-note triplet through the use of "double stops"[32] (See Examples 3.9 and 3.10).

Example 3.9: Peterson's improvisation on "Days of Wine and Roses" (mm. 1-3): "Double stops" in measure 2 imply quarter-note triplets.

Example 3.10: Peterson's improvisation on "Days of Wine and Roses" (mm. 16-18): "Double stops" (octaves) in measure 17 imply quarter-note triplets.

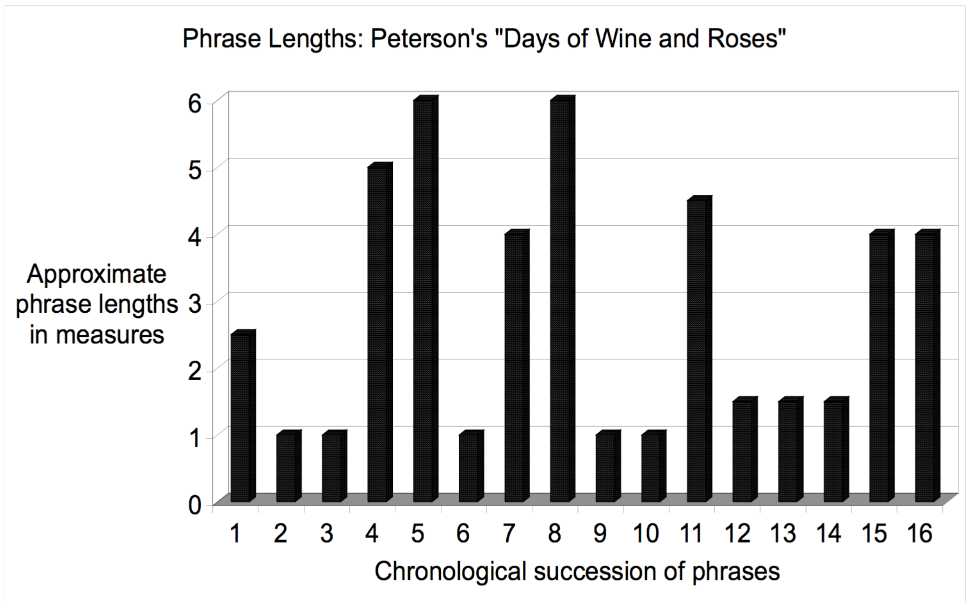
[32] "Double stop" is a term often used by players of string instruments, indicating two notes played together, or *harmonic interval.*

Phrasing

Peterson extends his phrases across the majority of sectional and sub-sectional boundaries, about 10 of 13, a slightly less pronounced tendency than in "Autumn Leaves." In measure 39, the question of phrasing is debatable, but in this analysis beat 1 of measure 39 is interpreted as the beginning of a new phrase. As in the performance of "Autumn Leaves," Peterson frequently anticipates harmonic changes that occur at boundaries with left-hand comps played just before beat 1 (mm. 6, 10, 22, 26, 30, 34, 46).

This solo is characterized by contrasting phrase lengths, that is, phrases tend to be either quite short or quite long. Some of the short, adjacent phrases have an imitative or call-and-response quality, in which rhythmic content is repeated using different melodic pitches (mm. 31-32, 39-42). An analysis of phrase lengths yields the following approximate values (in measures) from the beginning to the end of the solo: 2.5, 1, 1, 5, 6, 1, 4, 6, 1, 1, 4.5, 1.5, 1.5, 1.5, 4, 4. Figure 3.6 illustrates the phrase lengths used throughout the length of the solo.

Figure 3.6: Phrase lengths in Peterson's "Days of Wine and Roses": For convenience, values less than 1 are assigned the value .5.



In each 16-measure formal section, Peterson shows a tendency to begin with shorter phrase lengths and increase phrase lengths as the section progresses, creating a feeling of building momentum. This is similar to the tendency he showed in "Autumn Leaves" over the longer time span of each 32-measure chorus.

Time Feel

In this performance, Peterson's time feel is similar to that in the "Autumn Leaves" solo, but rhythmic accuracy is even more apparent in "Days of Wine and Roses." The underlying triplet feel is more consistent than in "Autumn Leaves": Passages of noticeably straighter eighth notes are not used in this solo.

Regarding beat placement, this performance is characterized by greater accuracy and steadiness than “Autumn Leaves.” In fact, the tempo is stable at 155 bpm. There are three instances of a behind-the-beat approach indicated in the score with “lay back” (mm. 6, 37, 46). Interestingly, two of these occurrences share the same melodic shape and articulation characteristics (See Examples 3.11 and 3.12).

Example 3.11: Peterson’s improvisation on “Days of Wine and Roses” (mm. 4-7): A behind-the-beat approach is evident briefly, indicated by “lay back” (m. 6).

Example 3.12: Peterson’s improvisation on “Days of Wine and Roses” (mm. 44-47): A behind-the-beat approach is evident briefly, indicated by “lay back” (m. 46). Notice the similarity in melodic shape to the case in Example 3.11.

Summary

In both performances, “Autumn Leaves” and “Days of Wine and Roses,” Peterson emphasizes off-beats with dynamic accents and placement of left-hand comps. In “Days of Wine and Roses,” the tendency for accents to occur on off-beats is less pronounced: 67% compared to 84% in “Autumn Leaves.” In each improvisation, Peterson uses much rhythmic variety, favoring notes faster than quarter notes, and often uses three or more different note values within a single phrase. He uses the fastest conceivable rhythmic values (e.g., quintuplets and sextuplets) at some point during each solo. Throughout both performances, he uses much variety in articulation, and frequently incorporates more than one type of articulation device within a single phrase. In each piece, polyrhythms are created by the use of quarter-note triplets or implied quarter-note triplets that do not align with the strong beats of the measure. Peterson exhibits much flexibility in phrase placement and phrase length throughout the improvisations. Phrases are consistently played across formal boundaries. Shorter phrases tend to occur at the beginning of formal sections or choruses, and longer phrases toward the end of them. Adjacent phrases of the same length are used sparingly. When they are used, they sometimes have an imitative quality in which the same rhythmic sequence is repeated using different melodic pitches. Peterson’s general time feel is characterized by triplet-based swing subdivision, and an emphasis on rhythmic accuracy in relation to the underlying beat. At times, Peterson manipulates his basic approach to time feel by using straighter subdivision and/or a behind-the-beat approach. The straighter subdivision technique is apparent only in the solo on “Autumn Leaves.” The behind-the-beat approach is used sparingly in both solos.

ANALYSIS OF WYNTON MARSALIS'S IMPROVISATION ON "APRIL IN PARIS"

Overview

"April in Paris" was composed by Vernon Duke, with lyrics by Edgar "Yip" Harburg. This performance is by the Wynton Marsalis Quartet, featuring Marsalis on trumpet, Marcus Roberts on piano, Robert Hurst on bass, and Jeff "Tain" Watts on drums. The album is titled *Standard Time Volume One*, recorded in 1987, and released by Columbia. The song is performed in the key of C major, and the tempo during Marsalis's improvisation is about 152 to 157 bpm.

"April in Paris" has a 32-measure formal structure. In this transcription, the composition is divided into four eight-measure sections: A, A1, B, and A2. In addition, the melodic and harmonic structure of the composition establishes four-measure sub-sections within the A and B sections.

This performance features a noteworthy arrangement, which incorporates a metric modulation during the *head* (i.e., the theme or melody on which the performance is based). The metric modulation occurs at section B, at which point the underlying beat of sections A and A1, referred to as the quarter note in this analysis, modulates to a slower tempo. The quarter note of the original meter approximately equals the quarter-note triplet of the new meter. At section A2, the meter modulates back to the initial tempo. The solos take place in the slower tempo of section B. Marsalis's solo begins with a two-measure solo break followed by two choruses of continued improvisation. The second chorus extends two measures into the first chorus of the piano solo that follows. The transcription consists of 68 measures (see Appendix A, pp. 235-237).

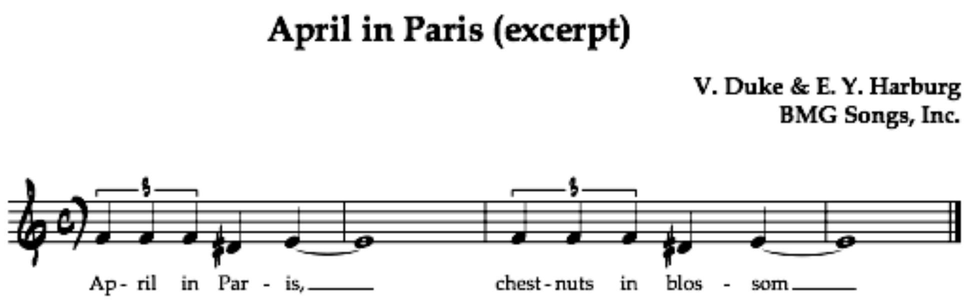
Off-beats

For significant portions of this solo, Marsalis uses an unconventional, non-metrical rhythmic approach, which is problematic to express in terms of downbeats and off-beats (mm. 1-4, 23-33, 56-63). Within the remainder of the solo, 12 accents occur on off-beats, and just three accents occur on downbeats, demonstrating a tendency to favor off-beats for dynamic accent placement. In addition, there are three passages in which Marsalis creates syncopation by playing sequences of consecutive off-beats (mm. 34, 40, 67).

Rhythmic Variety

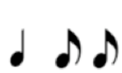
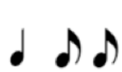
Marsalis demonstrates a great amount of rhythmic variety, some of which is problematic to represent with notation. Marsalis performs with much rhythmic freedom, choosing rhythmic values and note groupings that do not conform to the metrical structure of the piece. At times Marsalis "floats above" the beat of the rhythm section, taking risks rhythmically while the rhythm section provides stability of tempo and formal structure. This is very similar to an idea discussed in Chapter Two regarding African music. African master drummers, in their improvisations, create rhythms that may represent words or tunes. These rhythms do not necessarily have a specific mathematical relationship to the stable ground patterns that accompany the improvisations. For example, to begin his solo, Marsalis clearly borrows from the melody of "April in Paris," creating a phrase based on the opening melodic idea of the composition (see Example 3.13).

Example 3.13: "April in Paris" (mm. 1-4), composed by Duke and Harburg



Marsalis utilizes the melodic shape of the opening phrases of Duke's composition at the beginning of his solo. In the transcription, quarter-note triplets, the notation that most closely resembles what is played, are used in this passage. However, the rhythms are played very freely, without any explicit relationship to the metrical structure provided by the rhythm section; the notation is an approximation. In measure 5, Marsalis resolves the rhythmic tension created by these non-metrical rhythms, and "joins" the rhythm section by playing a phrase that is metrical (see Example 3.14).

Example 3.14: Marsalis's improvisation on "April in Paris" (mm. 1-6): Marsalis borrows a melodic shape from the composition and uses it in his solo break (mm. 1-2). Rhythmic content (mm.1-4) is represented with quarter-note triplet groupings, but is actually played very freely, not conforming to the metrical structure. In measures 5 to 6, Marsalis resolves the rhythmic tension with a passage that clearly aligns with the metrical structure, indicated by "in time."

In measures 8 to 9, Marsalis utilizes another rhythmic technique that cannot be notated adequately, but can be described with the verb "morph." The melodic sequence – E, E, D – is repeated three times. The sequence in its first occurrence is notated as . In the next two occurrences of this sequence, the rhythm takes the form of a pattern that falls between  and , a pattern for which no conventional notation exists. It gradually changes to the true quarter-note rhythm in measure 10. Thus, the rhythmic pattern morphs from  to  (see Example 3.15).

Example 3.15: Marsalis's improvisation on "April in Paris" (mm. 7-12): The rhythmic pattern of the melodic sequence – E, E, D – morphs in a manner that cannot be notated (mm. 8-9), gradually changing to the quarter-note-triplet rhythm of measure 10, indicated by "in time."

There are two passages in this solo, indicated by "somewhat freely," that were so problematic to notate that it was necessary to include a paragraph of instructions pertaining to these areas on the last page of the score (mm. 23-33, 56-63). In these passages, Marsalis seems to choose a rhythmic unit that cannot be linked mathematically to the metrical structure provided in the accompaniment. The closest approximation of this unit is the eighth-note triplet, but Marsalis "plays" with the rhythmic value, accelerating and decelerating slightly. The notations that most closely resemble the rhythms played are used in the score, but they are not to be interpreted literally because they do not align precisely with the metrical beat. Marsalis performs a rhythmic pulse that is not specifically related to the underlying beat, and creates unpredictable groupings of this pulse through the use of articulation (indicated by slurs and accents). In addition, he slightly varies the tempo in these sequences, creating even greater rhythmic complexity. An excerpt from one of these passages is shown in Example 3.16.

Example 3.16: Marsalis's improvisation on "April in Paris" (mm. 22-26): Marsalis uses a rhythmic unit approximately equal to the eighth-note triplet, and creates irregular groupings with this unit through the use of slurs and accents (mm. 23-26).

The fastest rhythmic values notated in this transcription are thirty-second notes (m. 38), although, once again, the notation is merely the closest approximation of what is audible, and should not be taken literally. The acoustical effect of this passage is like a "sheet of sound" or a continuation of the glissando that precedes it; however, at slower playback, the notated pitches are evident albeit they seem to smear into each other. To create this effect, it seems that Marsalis rapidly moved his fingers over the valves of the trumpet, approximating the notes indicated while continuing to blow air through the instrument (see Example 3.17).

Example 3.17: Marsalis's improvisation on "April in Paris" (mm. 35-38): Marsalis continues the acoustical effect of the glissando in measure 37 with an approximation of the notation in measure 38.

Regarding the conventional rhythmic values that are possible to notate, the longest duration is a dotted half note tied to an eighth note (m.11), and the fastest values, besides the thirty-second notes described above, are sixteenth notes (mm. 64-66). Marsalis frequently uses at least three different rhythmic values within a single phrase (mm. 1-6, 7-12, 13-14, 15-17, 18-22, 34-35, 39-42, 44-46, 47-51, 55-56, 56-63, 65, 66-68). Additionally, the use of space is a noteworthy characteristic of this solo. Marsalis frequently rests for three to five beats between phrases (mm. 6-7, 17-18, 22-23, 38-39, 44, 52-53, 54-55). The longest rest is 5.5 beats (mm. 36-37).

Articulation

Marsalis's general articulation is quite legato, and "slurring" is more prominent than "tonguing" throughout[33]. Many of the notated accents are in the context of slurred passages, created by rapidly increasing the speed of the air stream through the trumpet.

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[33] On the trumpet, attacks can be created by the flow of air through the lips while moving the valves (slurring), or by articulating the tongue against the back of the upper teeth, similar to speaking the consonant "t" or "d" (tonguing). It can be difficult, when listening, to discriminate between soft tonguing and slurring at times. There are no indications of slurring or tonguing on the score.

Marsalis shows a tendency to accent every other note (those that occur on off-beats) when playing eighth-note-based, descending, stepwise passages (mm. 20-21, 45, 53). In addition to accents, he incorporates devices such as staccatos, grace notes, tenutos, ghost notes, bending pitches, and a glissando. Marsalis frequently uses at least two of these devices within a single phrase (mm. 7-12, 13-17, 18-22, 39-43, 44-46, 47-51, 53-54, 55-56, 64-65, 65, 66, 66-68).

Polyrhythms

In this improvisation, there are a number of examples of Marsalis creating polyrhythmic effects. As described previously, Marsalis begins the solo with a quarter-note-triplet idea, referencing the melody of this composition. The opening lyric of the song is: "April in Paris, chestnuts in blossom." Each of these short grammatical phrases contains five syllables, each syllable corresponding to a melodic pitch (See Example 3.13). Hence, there is an intrinsic five-note grouping in each melodic phrase. By using this five-note grouping and applying it to quarter-note-triplet values, Marsalis creates at least two distinct layers of polyrhythm: the three-against-two effect of quarter-note triplets in 4/4 meter, as well as the five-note groupings juxtaposed against the already polyrhythmic structure. Not only is this technique evident in measures 1 to 4 (Example 3.14), but Marsalis also uses the idea again in measures 47 to 49 (see Example 3.18).

Example 3.18: Marsalis's improvisation on "April in Paris" (mm. 47-49): Quarter-note triplets are presented in five-note groupings (indicated by slurs) that correspond to the melodic shape and lyric of the opening phrases of the composition.

In addition to these quarter-note-triplet sequences, Marsalis also creates multiple layers of polyrhythm in two very striking passages (mm. 23-33, 56-63). The basic rhythmic unit utilized (i.e., the unit that cannot be defined by notation) creates a polyrhythmic effect against the meter and beat of the rhythm section. Furthermore, the groupings indicated by slurs create another layer of rhythmic complexity, and the placement of accents yet another layer (see Example 3.19).

Example 3.19: Marsalis's improvisation on "April in Paris" (mm. 22-26): Notice the multiple layers of rhythmic complexity created by the rhythmic values, the groupings indicated by slurs, and the placement of accents.

Phrasing

Interestingly, Marsalis extends his phrases across all sectional boundaries (double bar lines in the score), but just three of eight sub-sectional boundaries (dashed double bar lines in the score). Perhaps Marsalis consciously strives to create momentum when crossing into new formal sections, indicated by the consistency with which his phrases cross the sectional boundaries. His lack of tendency to cross sub-sectional boundaries seems to be a natural byproduct of his inclination to use space between phrases; he often rests at the sub-sectional boundaries (mm. 6-7, 22-23, 38-39, 54-55).

Marsalis's choice of phrase lengths has an unpredictable quality. An analysis of phrase lengths yields the following approximate values (in measures) from the beginning to the end of the solo: 5, 6, 2, 3, 5, 10.5, <1, 2, 1, 4.5, 2, 5, 1, 1, 8, 1, <1, <1, <1, <1, 1.5. Figures 3.7 and 3.8 illustrate the phrase lengths in each of the two choruses.

Figure 3.7: Phrase lengths in Marsalis's first chorus of "April in Paris": For convenience, values less than 1 are assigned the value .5.

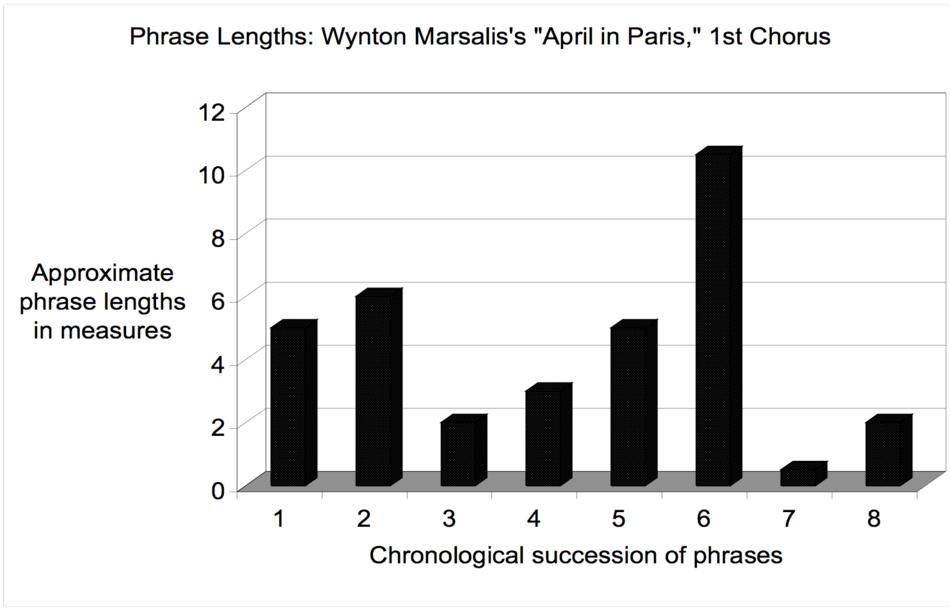
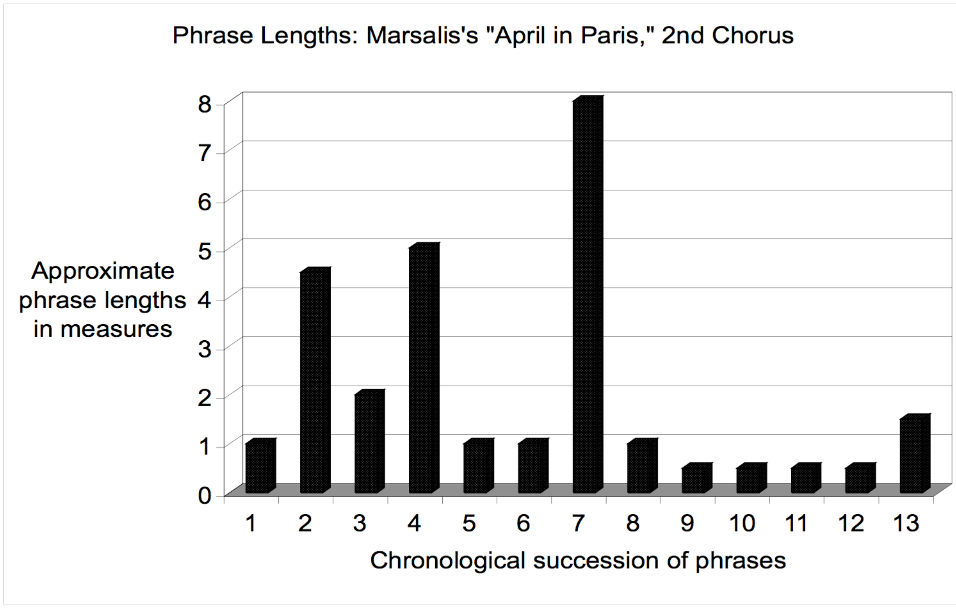


Figure 3.8: Phrase lengths in Marsalis's second chorus of "April in Paris": For convenience, values less than 1 are assigned the value .5.



The longest phrases are strikingly long (10.5 and 8 measures) and occur at moments of great rhythmic tension (mm. 23-33, 56-63). To conclude the solo (mm. 65-68), Marsalis creates the effect of "winding down," by playing a sequence of short phrases that have a stuttering quality, and using a decrescendo (see Example 3.20).

Example 3.20: Marsalis's improvisation on "April in Paris" (mm. 65-68): Marsalis "winds down" his solo with a sequence of short phrases and a decrescendo. Horizontal arrows indicate the interpretation of phrase lengths.

Time Feel

Marsalis plays relatively few eighth-note sequences in this solo. However, when he does play eighth notes, they are clearly more even than a triplet-based approach (i.e., 2:1 swing ratio). Eighth notes are generally played very legato, but with consistent dynamic emphasis on the off-beats. In some cases, these accents are too slight to warrant including them in the notation (mm. 5, 7-10, 13-14). In other cases, accents are included because the given notes were attacked considerably louder than the surrounding notes (mm. 20-21, 42-43, 45, 53). The consistent emphasis on off-beats gives the eighth-notes an uneven quality, idiomatic to jazz eighth notes, but without the temporal 2:1 ratio resulting from triplet-based subdivision.

Regarding beat placement, Marsalis shows a general tendency to play behind the beat, indicated by "lay back" or "behind the beat." In some passages, this is very noticeable, indicating that it is likely a technique that he uses to create rhythmic tension (mm. 7-9, 19, 39-40, 44-45). Marsalis also frequently slides into pitches using grace notes (mm. 11, 31, 45, 51, 55, 60-64, 67) or bending pitches (mm. 15, 35, 46). These devices contribute to the behind-the-beat effect by causing the main pitch to arrive slightly later than where notated.

Summary

In this solo, Marsalis frequently emphasizes off-beats with dynamic accents, and on a few occasions plays phrases consisting of consecutive off-beats. Marsalis achieves a great amount of rhythmic variety through the use of notes and rests of various durations. In addition, he uses triplets and unconventional rhythmic units to create irregular and unpredictable groupings. He uses much variety in articulation, and tends to incorporate more than one type of articulation device within a single phrase. He also employs "special effects" like glissandos and bending pitches. Polyrhythms are created with triplets and unconventional rhythmic values, which Marsalis groups in interesting ways, notably in five-note groupings referring to the melody of "April in Paris." In addition, the polyrhythmic effect of these passages is increased by the use of dynamic accents that are unaligned with the melodic groupings. This creates an added layer of rhythmic complexity, as opposed to reinforcing the complexity that already exists due to the note values and melodic groupings. Marsalis exhibits much flexibility in phrase placement and phrase length: Phrases are consistently played across formal boundaries, phrase lengths are quite unpredictable, and there is no symmetry between adjacent phrases. Marsalis's general time feel is characterized by a quite even approach to swing subdivision and a behind-the beat feeling.

ANALYSIS OF MARCUS ROBERTS'S IMPROVISATION ON "APRIL IN PARIS" AND COMPARISON TO MARSALIS'S IMPROVISATION ON "APRIL IN PARIS"

Overview

This improvisation by Marcus Roberts is also from *Standard Time Volume One* by the Wynton Marsalis Quartet. In fact, Roberts's solo immediately follows the trumpet solo by Marsalis. The tempo during Roberts's solo is approximately 146 to 151 bpm. The transcription begins in the third measure of the compositional structure because the preceding trumpet solo extends about two measures beyond the length of a chorus. Roberts improvises for roughly two choruses, and stops his solo one measure before the end of the second chorus, at which point there is a break before the final presentation of the head. The length of the transcription is 62 measures (see Appendix A, pp. 238-242).

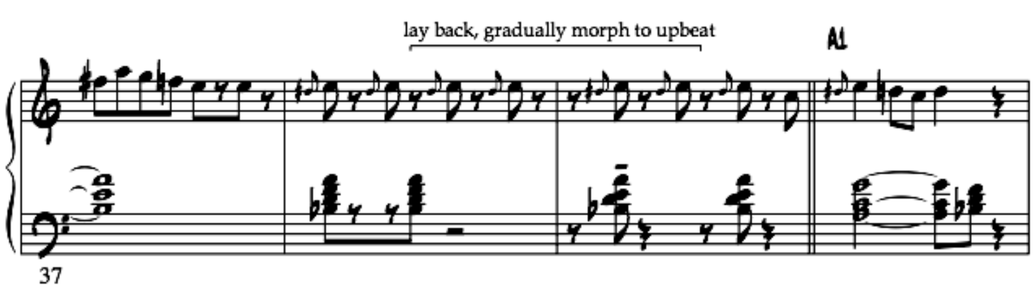
Off-beats

In this solo, Roberts achieves balance between emphasizing off-beats and downbeats in his melodic ideas. There are 18 notated accents, nine of which occur on off-beats, and nine on downbeats. Roberts does not show the tendency that was apparent in Marsalis's solo of consistently accenting off-beats when playing eighth-note sequences.

In addition to accent placement, Roberts uses another technique that creates balance between off-beat and downbeat emphasis, in which successive rhythmic patterns are presented, one of which emphasizes off-beats while the other emphasizes downbeats. See Examples 3.21 and 3.22 (see also mm. 1-2, 44-47, 52-54).

Example 3.21: Roberts's improvisation on "April in Paris" (mm. 8-11): an example of alternating off-beat and downbeat emphasis. Roberts plays a sequence of consecutive off-beats using the pitch C-sharp (m. 9), followed by two measures in which downbeats are prominent and off-beats are "ghosted" (mm. 10-11).

Example 3.22: Roberts's improvisation on "April in Paris" (mm. 37-40): an example of alternating downbeat and off-beat emphasis. Roberts plays repetitions of the pitch E. Initially, the E's are played on downbeats (mm. 37-38), gradually shifting to off-beats (m. 39), and finally resolving again on a downbeat (m. 40).



Regarding left-hand comps, Roberts places more comps on off-beats than on downbeats[34]: 37 of 47 left-hand comps occur on off-beats, for a percentage of 79%. This tendency is similar to the approaches of Peterson and Kelly, but the percentage is slightly lower in this case.

Rhythmic Variety

Roberts demonstrates a great amount of rhythmic variety in this solo, and like Marsalis, uses some unconventional rhythmic techniques that are problematic to notate. On two occasions, Roberts uses the same "morph" technique discussed previously in the analysis of Marsalis's solo. Roberts presents the rhythmic pattern , and plays two repetitions of this pattern, each successively slower until the pattern is approximately transformed to an identical rhythm pattern of twice the duration:  (see Example 3.23).

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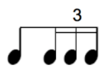
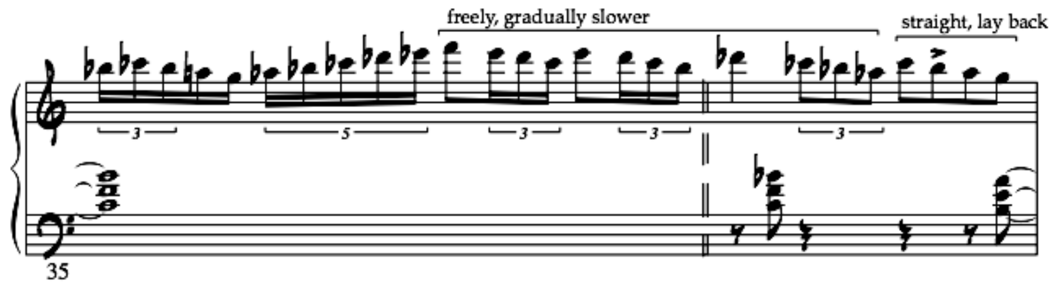
[34] Passages in which the two hands play chordal figures in unison are not included in this analysis (mm. 13-15, 27-31, 45-46, 55-62), because the left-hand part in these passages is not interpreted as having an accompaniment role distinct from right-hand melodies.

Example 3.23: Roberts's improvisation on "April in Paris" (mm. 35-36): The pattern  morphs into an approximation of , indicated by "freely, gradually slower."



A similar "morph" technique is found in measures 37 to 40, in which Roberts plays repetitions of the pitch E. The E's are initially presented on downbeats, but Roberts gradually places the notes more behind the beat, until they shift completely to off-beats. He then resolves the tension by arriving on E again at the downbeat of measure 40 (see Example 3.24).

Example 3.24: Roberts's improvisation on "April in Paris" (mm. 37-40): The placement of the pitch E gradually shifts from downbeats (mm. 37-38) to off-beats (m. 39).

As was the case in Marsalis's solo, a passage in this solo is extremely problematic to notate (mm. 27-30). Roberts plays a sequence of staccato chords, the placement of which is difficult to pinpoint in relation to the beat of the rhythm section. The notation should not be taken literally, but it does provide an effective visual representation that when used in conjunction with the recording can be successfully realized. Roberts may have been striving for unpredictability in this passage (see Example 3.25).

Example 3.25: Roberts's improvisation on "April in Paris" (mm. 27-31): The section marked "freely" (mm. 27-30) is very problematic to notate because it is not directly related to the beat of the accompanying rhythm section.

In this solo, Roberts uses a variety of rhythmic values[35] with particular emphasis on faster note values, a characteristic that was evident in the analyses of the other piano solos, but not as much in Marsalis's solo. In the right-hand part, Roberts uses a dotted half note, a half note tied to an eighth note, dotted quarter notes, quarter-note triplets, eighth notes, sixteenth notes, quintuplets, and sextuplets. Some longer values are used in the left-hand part (mm. 1-2, 11-12, 32-35, 53). Like all of the soloists analyzed in this

[35] Measures 28-31 and 55-62 are omitted from this part of the analysis, because mm. 28-31 contain undefined rhythmic values, and mm. 55-62 represent a different meter.

study, Roberts often incorporates three or more different rhythmic values within a phrase (mm. 1-7, 11-12, 16-17, 18-24, 24-25, 33-34, 34-37, 41-42, 42-43, 44-45, 48-51, 51-54). In contrast to Marsalis, Roberts uses space very sparingly in this solo. Phrases have little silence between them, if any, and the longest duration of a rest in the right-hand part is 1.5 beats (mm. 14, 18, 40-41, 47).

Articulation

Roberts's general articulation is quite legato, but he does intersperse staccato chordal passages (mm. 27-31, 57-62). Regarding accent placement, Roberts demonstrates an interesting technique of utilizing dynamic accents to highlight particular groupings or melodic lines. For example, in two instances (mm. 8, 25) he highlights three-note groupings by stressing the first note of each group, resulting in an alternating downbeat/off-beat emphasis. Example 3.26 illustrates this technique.

Example 3.26: Roberts's improvisation on "April in Paris" (mm. 8-11): Notice the accent placement emphasizing the first note of the three-note, chromatic descending motifs (m. 8). The first accent occurs on a downbeat, and the second occurs on an off-beat.

In a different passage, Roberts selectively places his accents in a manner that brings out a particular melodic line (see Example 3.27).

Example 3.27: Roberts's improvisation on "April in Paris" (mm. 46-50): Notice the accent placement bringing out the melodic line – E, B, B-flat, A, G-sharp – (mm. 48-49).

In addition to accents, Roberts incorporates devices such as staccatos, grace notes, tenutos, and ghost notes. Unlike Marsalis, he does not show a tendency to frequently use at least two of these devices within a single phrase. Roberts uses gradual dynamics (crescendos and diminuendos) more than any of the soloists analyzed previously (mm. 14-15, 20, 22-23, 31, 42-43, 61). Like the other pianists, Roberts keeps the volume of the accompanying left-hand part much lower than that of the melodic right-hand part.

Polyrhythms

A previously described section (mm. 27-31, see Example 3.25) has a polyrhythmic effect, but it is difficult to define the polyrhythm because the rhythms used are undefined. Another polyrhythmic technique occurs in measures 52 to 56, in which Roberts utilizes quarter-note triplet values to initiate a metric modulation: The quarter-note triplet becomes the quarter note of the new meter. Roberts begins this quarter-note-triplet idea on the off-beat of 3, creating over-the-bar-line phrasing and a sense of unpredictability. The sense of unpredictability is enhanced by the unusual melodic intervals, which alternate between large intervals (octaves and sevenths) and small intervals (minor seconds). See Example 3.28.

Example 3.28: Roberts's improvisation on "April in Paris" (mm. 51-56): Quarter-note triplet values beginning in measure 51 (notated as tied eighth-note triplets or eighth-note triplet/eighth-note-triplet rests) initiate a metric modulation in measure 55.

Phrasing

Roberts's phrases cross all but three of the sectional and sub-sectional boundaries (mm.15-16, 31-32, 43-44), showing an inclination to obscure the symmetrical quality of the formal structure like Marsalis and the other soloists discussed previously. An analysis of phrase lengths yields the following approximate values (in measures) from the beginning to the end of the solo: 7, <1, <1, 2, 1.5, <1, 1.5, 2, 5.5, 2, 2, 4, 1, 1.5, 3, 3, 1, 1.5, 1, 1.5, <1, 3.5, 3.5, 2, <1, <1, <1, <1, <1, <1, <1, <1. Figures 3.9 and 3.10 illustrate the phrase lengths in each of the two choruses.

Figure 3.9: Phrase lengths in Roberts's first chorus of "April in Paris": For convenience, values less than 1 are assigned the value .5.

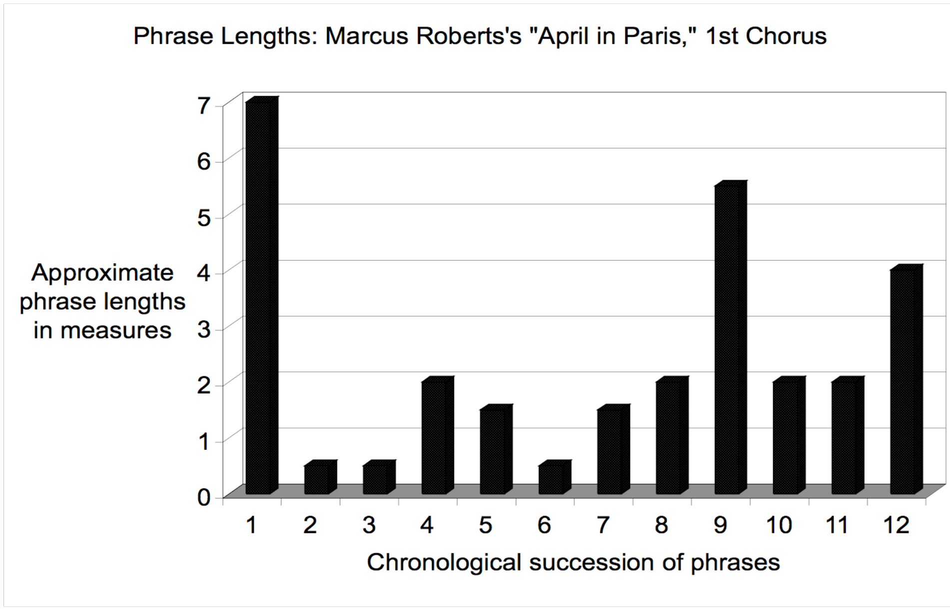
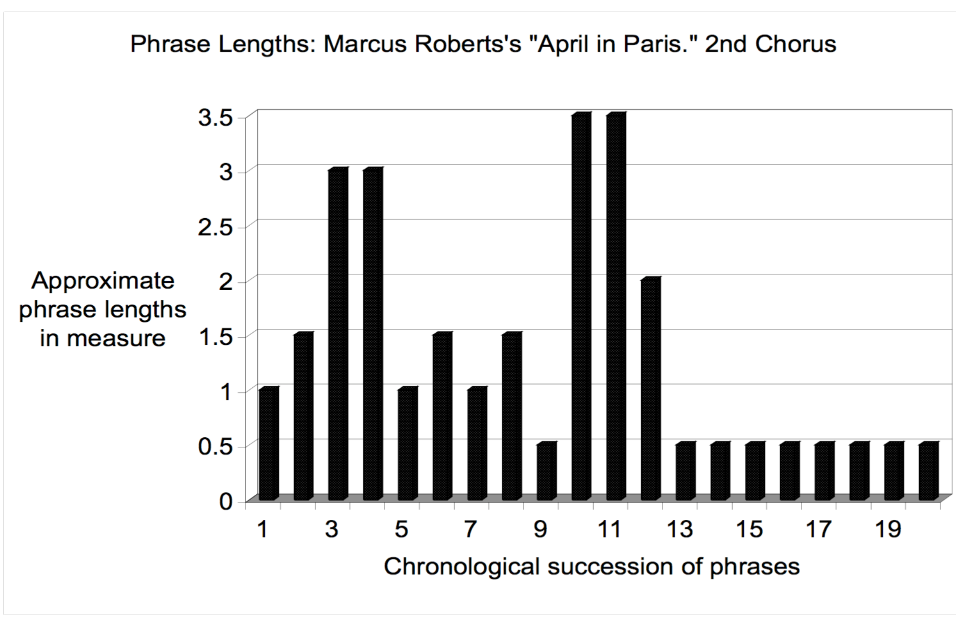


Figure 3.10: Phrase lengths in Roberts's second chorus of "April in Paris": For convenience, values less than 1 are assigned the value .5.



Roberts's phrasing has a similar unpredictable quality like Marsalis's, but he does not utilize space as extensively. Although there are many short phrases, there is little space between the phrases and some phrases overlap, so the solo has a continuous quality, not a fragmented quality that would be evident in the case of many short phrases separated by rests. The series of <1 values at the end of the improvisation might not be considered as melodic phrases, but instead short rhythmic interjections (mm. 57-62). This brief section of the solo does have a fragmented quality, percussive rather than melodic, contrasting with much of Roberts's other material, but reminiscent of measures 27 to 31 (Example 3.25). See Example 3.29.

Example 3.29: Roberts's improvisation on "April in Paris" (mm. 57-62): Roberts plays a series of short, percussive figures to conclude his solo. Horizontal arrows indicate the interpretation of phrase lengths.

Time Feel

It is difficult to make generalizations about Roberts's swing subdivision, because his time feel is quite elastic throughout this solo, and there are few passages of consistent eighth notes. When triplets are interspersed among eighth-note lines, the swing subdivision is triplet-based (mm. 1-12, 41, 44). But there are also a few instances when eighth notes are straighter, and these occur in passages when a behind-the-beat approach is also evident (mm. 22, 36). The previously discussed technique of Marsalis, in which eighth notes are quite even while off-beats are accented, is evident only briefly in Robert's solo (m. 36).

Roberts demonstrates a behind-the-beat approach at times for brief passages (mm. 21-23, 35-36, 38-39), and at times by delaying just one or two notes for expressive purposes (mm. 6, 7, 21, 48). In the latter case, the delayed notes are often among the highest melodic pitches in the phrase. Both Roberts and Marsalis incorporate behind-the-beat passages in their solos, but the technique is slightly more prominent in Marsalis's improvisation.

Summary

In this solo, Roberts, in contrast to Marsalis, is not inclined to emphasize off-beats with accent placement more than downbeats, but instead achieves a degree of balance between accentuation of off-beats and downbeats. Both soloists create a great amount of rhythmic variety through the use of notes of various durations. Roberts plays faster note values more consistently than Marsalis, and Marsalis incorporates rests more than Roberts. Both improvisers produce rhythms that are unconventional and therefore difficult to notate, creating a sense of unpredictability and risk-taking. The use of special articulation devices is slightly more prominent in Marsalis's solo, but both performers use much variety in articulation. Polyrhythms are created by the use of triplets and other rhythmic values that are difficult to define. Marsalis uses polyrhythmic techniques more extensively than Roberts, and creates some very striking passages discussed above (Examples 3.18, 3.19). Roberts uses a polyrhythmic technique to initiate a metric modulation (Example 3.28). Both soloists exhibit much flexibility in phrase placement and phrase length. Phrases are consistently played across formal boundaries, and phrase lengths are quite unpredictable. Marsalis's general time feel is characterized by a straighter approach to eighth notes and a rather prominent behind-the beat feeling. Roberts often uses a triplet-based approach, but also incorporates a straighter and behind-the-beat approach at times.

Discussion

The five improvised solos analyzed in this study provide much credibility to the list of swing characteristics presented in Chapter One. In fact, none of the transcribed solos lack any of the swing characteristics. Regarding the characteristics that can be illustrated in this written study, each solo demonstrates the techniques selected for analysis: emphasis on off-beats, use of rhythmic variety, use of idiomatic articulation, polyrhythmic effects, flexibility of phrasing, and interpretation of swing subdivision and beat placement. There are a number of interesting similarities and differences among the examples.

Each soloist favors off-beats over downbeats for placement of dynamic accents, with the exception of Roberts who balances his placement of dynamic accents between off-beats and downbeats. None of the soloists favor accent placement on downbeats or strong beats. A specific accent technique found in all of the solos is to accent melodic upper neighbors when they occur on off-beats. In addition, each of the pianists strongly favors placement of left-hand comps on off-beats as opposed to downbeats. This is noteworthy because the compositions feature harmonic changes on the strong beats. By placing left-hand comps on the off-beat prior to expected harmonic changes, pianists create syncopation and a sense of forward motion. These observations support Schuller's idea of "democratization of the beat" (Liebman, 1997; Schuller, 1968), in which jazz musicians "democratize" rhythmic emphasis by stressing beats other than the beats that already have intrinsic emphasis (i.e., strong beats). One of the most fundamental ways in which jazz musicians make Western musical structures "swing" is to create accents at points other than the obvious points of structural emphasis. Because downbeats, strong beats, four-measure groupings, and formal "boundaries" already have *intrinsic* emphasis, jazz soloists often find alternative points in the structure, such as the off-beat, to create additional emphasis. This technique transforms the rhythmic quality of the music, giving it an additional layer or dimension of rhythmic emphasis for listeners to experience. Interestingly, this idea of an additional layer is also achieved through techniques of polyrhythm and phrasing, discussed below.

All soloists use a striking amount of rhythmic variety in their improvised melodies, an interesting point considering that the melodies of the compositions are not characterized by much rhythmic variety. All soloists use at least three different rhythmic values in the majority of phrases. All soloists, except Marsalis, use all practical rhythmic values faster than the quarter note in a relatively short period of time such as within one chorus of improvisation. In addition, Marsalis and Roberts use rhythmic values that are impossible to notate adequately because they are beyond the scope of conventional notation. Rhythmic variety is clearly an important aspect of swing, and demonstrating facility with a large range of rhythmic techniques is desirable for jazz performers.

Each soloist tends to use more than one articulation device in many of their phrases, and all use "special effects" such as grace notes, bending pitches, glissandos, and tremolos at some point in their solos. Dynamic contrast between ghost notes and accented notes is very important in all of the improvisations. These observations suggest that idiomatic jazz articulation in the swing style contrasts with the smooth, even articulation that characterizes much music of other styles, particularly European classical music prior to the 20th Century. Also noteworthy in the piano solos are the clear differences between articulation in the right-hand and left-hand parts. Left-hand comps are often "ghosted," and the dynamic level of the right-hand parts is generally much louder than the left-hand parts. This helps the listener to perceive the difference in melody versus accompaniment function of the two hands.

In each example, there is at least one passage in which a polyrhythmic effect is created, and these effects are most often created with triplets (eighth-note and/or quarter-note triplets). Triplets occurring in 4/4 meter naturally result in a polyrhythm in which three-note groupings are superimposed over the two- or four-note groupings intrinsic to the meter. In addition, the soloists use triplets in interesting ways such as: displacing the triplet in relation to the strong beats of the measure, presenting triplets in unusual melodic groupings (e.g., the five-note groupings in Marsalis's solo), and incorporating irregular placement of accents in the triplet sequences. All of these polyrhythmic techniques have the effect of creating additional layers or dimensions of rhythmic complexity that are frequently absent in simple music in 4/4 meter. The fact that each soloist in this study uses polyrhythmic techniques attests to the importance of polyrhythm as a characteristic of swing.

Each soloist exhibits flexibility of phrasing in relation to the underlying structure of the meter and formal composition of each piece. In fact, none of the soloists show a tendency to consistently create phrases that reinforce the underlying structure. This flexibility of phrasing is similar to the "democratization of the beat" idea, but it occurs at a larger time scale. Whereas democratization of the beat (or syncopation) occurs at the divisions of a measure, phrasing flexibility occurs at the larger groupings of measures. In the examples of this study, each composition is characterized by symmetrical melodic phrases that align with the harmonic rhythm and formal structure, yet the improvised solos show few indications of regular, symmetrical phrasing. The bar graphs presented in the analyses (Figures 3.1 – 3.10) illustrate this fact: None of the soloists repeatedly use two- or four-measure phrases on a consistent basis. By frequently creating phrases that do not align with the harmonic rhythm and formal structure of a composition, jazz soloists create an additional layer of rhythmic complexity that contrasts with the predictable two- and four-measure time spans established in the composition. This is a very important characteristic of swing, similar to the "democratization of the beat" idea, but occurring at larger time spans.

A commonality in the improvisations related to time feel is the accentuation of off-beats during eighth-note passages. When this occurs, the swing subdivision tends to be less triplet-based and more even. In addition, a behind-the beat approach is often evident in these passages as well. These three techniques tend to occur simultaneously: accented off-beats, straighter eighth-notes, and a behind-the-beat feeling.

There are also a number of interesting contrasts among the examples in this study. One of the most striking differences is that the solos by Marsalis and Roberts are far more difficult to notate than the other solos. This is a result of the unconventional rhythmic approach in the recording of “April in Paris” evident in the arrangement, which features a metric modulation. Both Marsalis and Roberts seem to take risks during their improvisations, producing very unusual rhythmic ideas and creating a sense of adventurousness. Because “April in Paris” was recorded in 1987, more than two decades after the recordings of Peterson and Kelly, it may appear that rhythmic “risk-taking” is characteristic of a more modern approach to straight-ahead jazz than the approach during the 1960’s. However, in the case of the album *Standard Time Volume One*, from which the track “April in Paris” was selected, unconventional rhythmic approaches to frequently played jazz standards are a theme throughout. Almost every selection from the album features an adventurous arrangement highlighted by striking rhythmic techniques. It is suggested here that the unconventional rhythmic techniques in the solos by Marsalis and Roberts are mainly attributed to the nature of the recording project, not necessarily to historical context. A much larger study than the present study would be necessary to compare historical periods.

Also striking are some of the differences in rhythmic content in the trumpet solo by Marsalis compared to the four piano solos. Each of the pianists frequently performs “runs,” incorporating sixteenth notes, quintuplets, and sextuplets; whereas, Marsalis uses sixteenth notes only very briefly in the closing phrases of his solo. Marsalis is the only soloist who uses the technique of choosing a rhythmic unit unrelated to the beat of the rhythmic section and creating melodic lines with that unit (mm. 23-33, 56-63, see Example 3.16). Also, Marsalis tends to leave far more space between phrases than pianists Roberts or Peterson. Kelly, however, is similar to Marsalis in this aspect, also tending to leave space between phrases.

Regarding time feel, Marsalis's approach to swing subdivision is noticeably more even than the subdivision of the pianists, particularly Kelly and Peterson whose swing subdivision is generally triplet-based. Marsalis emphasizes a behind-the-beat feeling more than the pianists. In general, Marsalis takes more liberties in his approach to time feel than the pianists, although Roberts exhibits much freedom in his approach as well.

It is notable that Peterson's "Days of Wine and Roses" and Marsalis's "April in Paris" are performed at approximately the same tempo. Yet, the difference in time feel between the two solos is quite dramatic. Peterson's "Days of Wine and Roses" is the most triplet-based and exact of all the examples, whereas Marsalis's "April in Paris" is the solo in which the most rhythmic liberties are evident. The two performances are of the same tempo, based on the same type of composition, and performed in the same straight-ahead style; yet, the rhythmic techniques of each soloist are markedly different. The compelling point is that, in spite of the differences in the approaches to time feel, both solos are highly effective in creating a feeling of swing.

An important observation regarding time feel is that each example presented here exhibits different approaches to time feel. This is true even for the two examples by the same artist, Oscar Peterson. In the “Autumn Leaves” performance, Peterson incorporates passages of relatively straight eighth notes, and there is some fluctuation in beat placement and tempo throughout. In “Days of Wine and Roses,” Peterson’s approach to rhythm is more exact: Subdivision is triplet-based throughout, and the tempo is stable. Regarding the other examples, Kelly’s solo shows more “elasticity” and behind-the-beat playing than either of Peterson’s solos; and the solos by Marsalis and Roberts show the most deviation or interpretation of time feel. The fact that the description of time feel is somewhat different in each of the analyses suggests that many possibilities exist regarding time feel in jazz performance. Not only do different artists have different approaches to time feel, but the same artist may change their approach to time feel depending on musical context. It is suggested here that a strictly defined, dogmatic approach to time feel in jazz is probably inappropriate. Perhaps the fundamental principle underlying time feel in jazz is that freedom of interpretation exists. Jazz artists can use this freedom as an opportunity to develop rhythmic techniques beyond just playing correctly, thereby expanding their range of musical expression.

CHAPTER FOUR: GROUP TRANSCRIPTION AND TIMING ANALYSIS

In the first study, improvised solos were analyzed to illustrate rhythmic characteristics such as emphasis on off-beats, rhythmic variety, use of articulation, use of polyrhythmic effects, phrasing, and time feel. In the present study, the analysis is extended beyond the work of soloists to include an analysis of ensemble playing. The study examines excerpts from the performances of a small jazz group, providing transcriptions of material played by the accompanying instrumentalists (drummer, bassist, pianist) as well as by the soloist (pianist). The timing of the transcribed parts is measured and analyzed. The study focuses on rhythmic techniques that are fundamental to the straight-ahead style and to the quality of swing. These include: 1) the coordination of ride patterns and walking bass lines, and their roles in establishing an underlying beat, 2) the temporal relationship of the soloist with the underlying beat, and 3) the interpretations of swing subdivision in the ride-cymbal and soloist parts.

Initially, I examined the ride-cymbal and bass material because idiomatic ride patterns and walking bass lines are basic distinguishing features of the straight-ahead style, and musicians and scholars agree that the synchronization of ride patterns and bass lines is a very important attribute of swing (Berliner, 1994; Chor & Ashley, 2006; Dance, 1974; Gridley, 1988; Lawn, 1981; Monson, 1996, Prögler, 1995). Furthermore, the bass line and ride pattern fulfill important musical roles related to timekeeping such as establishing the tempo, meter, and formal structure of a piece, and providing a foundation upon which the ensemble achieves a feeling of groove or rhythmic excitement (Berliner, 1994; Dance, 1974; Gridley, 1988; Lawn, 1981; Monson, 1996, Prögler, 1995).

I also explored the soloist's approach to beat placement, that is, the temporal relationship between the improvised solo and the underlying beat of the accompanying rhythm section. As discussed in the first study, multiple approaches to beat placement are evident in jazz recordings, revealing historical precedents and individual stylistic preferences (Benward & Wildman, 1984; Berliner, 1994; Collier & Collier, 2002; Ellis, 1991; Gridley, 1988; Liebman, 1997; Prögler, 1995). In addition, there is some evidence that soloists approach beat placement in a different manner than accompanying instrumentalists, that is, soloists may intentionally perform slightly out of sync with the beat of the rhythm section for expressive purposes, whereas the accompanying players generally try to synchronize their parts closely (Berliner, 1994; Ellis, 1991; Friberg and Sundström, 2002; Laverne, 1993; Liebman, 1997; Monson, 1996; Rose, 1989).

Finally, I investigated the soloist's and drummer's approaches to swing subdivision. As discussed previously, swing subdivision is influenced by tempo, stylistic preferences, performance function (melody vs. accompaniment), and performance medium (i.e., instrument). Faster tempos necessitate a more even subdivision than the triplet-based 2:1 ratio, whereas slower tempos leave more room for variation in subdivision (Collier & Collier, 1997, 1996; Collier & Wright, 1995; Friberg & Sundström, 2002, 1997). Individual players exhibit stylistic preferences regarding swing subdivision, and differing approaches to swing subdivision have evolved throughout jazz's history (Ellis, 1991; Lawn & Hellmer, 1996; Liebman, 1997). Lastly, swing subdivision may vary depending on performance function and instrument played (Ellis, 1991; Friberg & Sundström, 2002; Rose, 1989).

The specific features I examined are: 1) synchronization between ride-cymbal attacks and a theoretical steady beat, 2) synchronization between bass and ride-cymbal attacks, 3) synchronization between piano and ride-cymbal attacks when the pianist is improvising a solo, 4) synchronization between piano and ride-cymbal attacks when the pianist is performing an accompaniment function, 5) swing ratios in the ride patterns, and 6) swing ratios in the improvised piano solo.

The study poses the following questions: 1) How closely are musical parts synchronized? 2) How is synchronization affected by instrument played and musical context? 3) What do the observed asynchronies reveal about performers' general approaches to beat placement? 4) What swing ratios are produced in the drummers' ride patterns and the improvised solo? 5) How are swing ratios affected by instrument played and musical context? 6) What do the observed swing ratios reveal about performers' general approaches to swing subdivision?

Similar to the first study, this study is limited to just a few musical examples. Each example is an illustration of swing in jazz performance, and the timing measurements provide additional insight into how the quality of swing is achieved. Full appreciation for the written analysis is made possible through listening to the excerpts analyzed[36].

[36] Readers are invited to contact the author for assistance in acquiring the audio files.

Method

MUSICAL SELECTIONS

The musical examples in the present study were drawn from a recording entitled *On the Cusp* (2007) by the University of Texas Faculty Jazz. This CD recording features highly regarded expert performers who serve on the jazz department faculty at the University of Texas at Austin. The selections were recorded live in a studio without the use of click tracks, overdubbing, or any other device that could influence the natural timing of the ensemble during a spontaneous performance. A primary reason for choosing this recording is that I was granted access to the Pro Tools files from the recording session. With these files I was able to isolate audio tracks and take accurate timing measurements for individual instruments.

Because of the focus on rhythmic characteristics of straight-ahead jazz performed at moderate tempos, I chose the compositions “Easy Green” and “Swan Gaze” by Ron Westray, which feature the straight-ahead style at moderate tempos. “Easy Green” is a composition in which sections featuring a bass ostinato (i.e., repeated pattern) in 7/4 meter alternate with sections in 4/4 meter. The tempo ranges from about 163 to 175 bpm in the excerpts analyzed. “Swan Gaze” is a composition in 3/4 meter, a jazz waltz. The tempo ranges from about 124 to 131 bpm throughout the excerpts analyzed. Both pieces feature swing-style ride patterns and walking bass lines. Drummer Brannen Temple performed the ride patterns, and bassist John Fremgen played the bass lines.

Along with examining bass and ride cymbal, it was also desirable to include an analysis of improvised-solo material. I chose the piano over other solo instruments because determining the attack time for piano tones is less problematic than for the tones of wind instruments or electric guitar. In addition, I wanted to investigate the role of performance function in the pianist's approach to timing by comparing piano-solo excerpts with piano-accompaniment excerpts. Pianist Jeff Hellmer performed the piano parts.

It was impractical to transcribe and analyze an entire piece because of the tremendous amount of data in the audio files. Therefore, I listened to each performance and selected representative excerpts in which idiomatic ride patterns and bass lines were particularly prominent. There were fewer of these sections in "Swan Gaze" than in "Easy Green" because Temple played the drums with brushes throughout much of "Swan Gaze." In addition, I chose excerpts from different parts of the arrangements to determine if the approach to ride patterns and bass lines changed in different contexts. For example, from "Easy Green" I selected excerpts occurring during the head, the trombone solo, the saxophone solo, and the piano solo. From "Swan Gaze" I selected excerpts occurring during the trombone solo and the piano solo.

TRANSCRIPTION AND TIMING ANALYSIS

Once I selected the musical excerpts I transcribed the ride-cymbal, bass, and piano parts. I used the same method of transcription as that described in Chapter Three, however the process of transcribing was made easier with the use of Pro Tools. With the

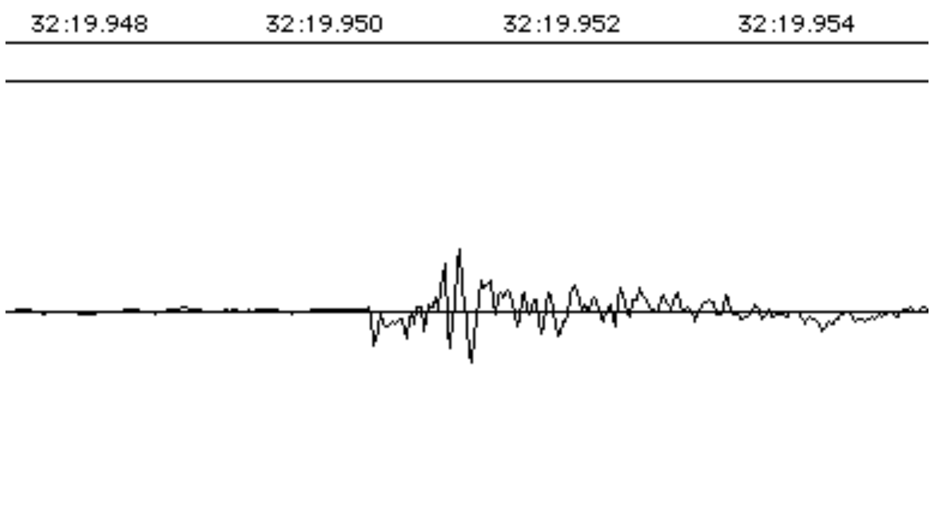
Pro Tools files, I was able to isolate the tracks corresponding to particular microphones. When working with these individual tracks, the sounds of the chosen instruments were very clear while other instruments could be heard only faintly or not at all.

To analyze the timing of each transcribed note I referred to the edit window in Pro Tools, in which the waveforms were displayed along with a timeline (ruler) marked in milliseconds. Because multiple microphones were used, I had to first determine which track to use for each instrument. For example, two microphones were used to record the bass, and several microphones were used to record the piano and the drum set. There was a slight difference between the attack times of each track due to the placement of each microphone. Therefore, I communicated with Mark Sarisky, the recording engineer, to determine which microphones were placed closest to each instrument. I then used the track corresponding to the microphone placed closest to the bass when analyzing the bass part, and the track corresponding to the microphone placed closest to the ride-cymbal when analyzing the ride-cymbal part. For the piano solo, I used the track corresponding to the microphone placed closest to the hammers of the piano in the area played by the right hand. For the piano accompaniment, I used two tracks: "left" and "right," because accompaniment excerpts involved chords that were spread apart using two hands. In the recording studio, the piano and drums were set up in the same room, separated by barriers, and the bass was isolated in a different room.

I used listening and visual techniques to locate attack transients in the waveforms. Three features of Pro Tools were particularly useful in facilitating this process. One feature was the zoom tool, which allowed me to look at waveforms at different time scales. Another feature was the selection tool, which allowed me to highlight events. And the third feature was a function of playback: By pressing the control key simultaneously with the left bracket key, I was able to hear just the "snippets" that were highlighted with the selection tool. I used this function for each and every transcribed note, highlighting the part of the waveform that appeared to correspond to a particular note and listening to the snippet to confirm that it represented the note that it appeared to represent.

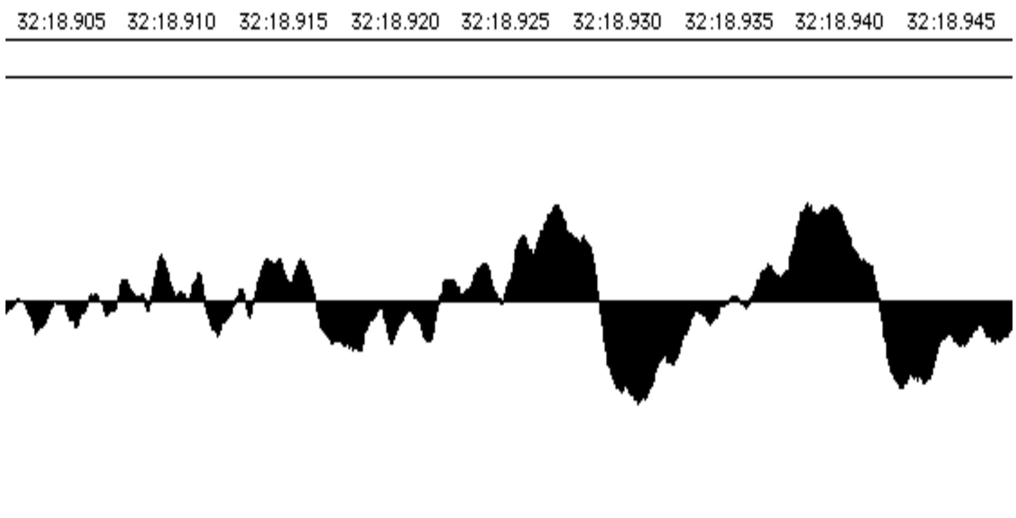
The attack transients of ride-cymbal tones were characterized by miniscule rise times, about 1 ms, and the amplitude peaks were well defined and easy to locate. See Figure 4.1 for a representative ride cymbal waveform.

Figure 4.1: A representative ride cymbal waveform shown at a 2 ms time scale



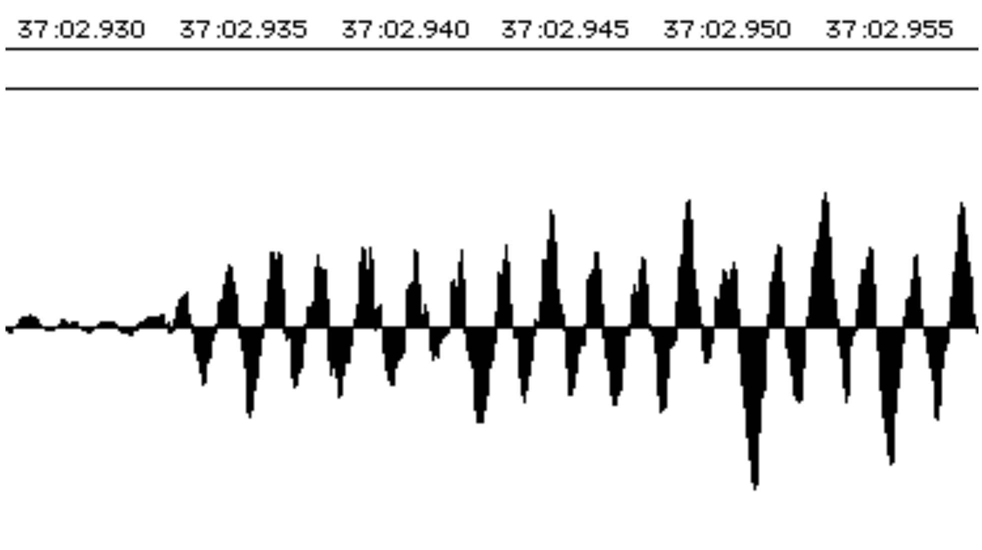
The rise times of bass tones ranged from about 15 to 85 ms, varying much depending upon pitch register and articulation. Figure 4.2 shows a representative bass waveform.

Figure 4.2: A representative bass waveform shown at a 5 ms time scale



Piano tones generally had shorter rise times than bass tones, about 5 to 50 ms, and a relatively slow decay. Figure 4.3 shows a representative piano waveform.

Figure 4.3: A representative piano waveform, shown at a 5 ms time scale



I examined attack times only for the notes needed to calculate asynchronies and swing ratios (discussed below). For the majority of these notes in the ride-cymbal, bass, and piano parts, transients and amplitude peaks could be located with certainty. However, at times extraneous audio content appearing in the waveform made it difficult to decipher the transient or amplitude peak of a given note. Examples of extraneous audio content were the rattling of the metallic bass string against the fingerboard of the bass or residual noise from the crash cymbals of the drum set. If there was any uncertainty about a particular note, I simply did not take a measurement. Only notes that could be measured with confidence were included in the data. Measurements were available for approximately 92% of notes needed.

After locating the transients, I determined perceptual attack times. Because acoustical rise times of cymbal tones were about 1 ms, a negligible amount of time in terms of human perception, I simply measured the attack time for ride cymbal tones at amplitude peak. For piano and bass tones, which have relatively long rise times, I used the 85% of max method to calculate perceptual attack time. This method, the *percent of max* method developed by Vos and Rasch (1981), was chosen because a mathematical, objective, and consistent means of measurement was desirable. The validity of this method has been proven empirically (Collins, 2006; Gordon, 1984; Vos and Rasch, 1981); however, the optimal percentage varies widely depending on experimental conditions and differences among musical tones. Following Rose (1989), I applied the value 85% to the method.

According to the percent of max method, the attack of a musical tone is perceived at the point at which the tone's waveform crosses an amplitude threshold, which is best expressed relative to the tone's amplitude peak. Therefore, I took a relative decibel measurement of each tone at amplitude peak, multiplied this value by .15, and subtracted the amount from the value at peak. The resulting amplitude value (85% of maximum amplitude) represented the threshold for perceptual attack. The moment at which the waveform crossed the threshold was determined to be the perceptual attack time.

I also used a listening technique to informally test the validity of the 85% of max method. After calculating the attack time of two consecutive notes, I used the selection tool in Pro Tools to highlight the area in the edit window that corresponded to the notes. The highlighted area began at the millisecond marker corresponding to the attack of the first note and continued from left to right across the timeline to the millisecond marker at the attack of the second note. I then listened to the snippet that was highlighted. Of course the first note was audible for its complete duration, but only the very beginning of the second note could be heard because playback stopped abruptly at the point of its attack. For piano tones, the attack of the second note sounded like an extremely brief, percussive sound in which the pitch was barely perceptible. For bass tones, only the percussive noise of the attack could be heard; the pitch was not perceptible. This occurs because most bass pitches have a lower frequency than most piano pitches, thus it takes more time for bass pitches to develop. I used this listening technique for each and every piano and bass note measured. On one or two occasions, listening revealed a possible problem, because the attack did not sound similar to other attacks. In these instances, I assumed that interference in the audio signal caused an error, and omitted the measurement from the data. In addition, there were a few occurrences in which it was evident that notes in a piano chord had slightly different attack times. When it was possible to clearly distinguish between different notes in a chord, I measured the attack transient corresponding to the note that sounded first.

I used the perceptual attack times of each note to measure asynchronies and swing ratios. For asynchronies, I measured bass and piano attacks in relation to ride-cymbal attacks. I chose ride-cymbal attacks as points of reference because ride patterns fulfill the role of timekeeping in jazz performances[37], ride-cymbal attacks were clear and definite in the waveforms, and there is a precedent for using the ride-cymbal beat as a point of reference (Friberg & Sundström, 2002). Thus, I calculated asynchronies by determining the difference in milliseconds between the attack times of bass and ride cymbal, or piano and ride cymbal.

Because the ride-cymbal beat was the point of reference for the calculation of asynchronies, it was desirable to also examine the steadiness of the ride-cymbal beat. Therefore, ride-cymbal attacks[38] were measured in relation to a theoretical metronomic beat. I followed the method of Collier and Collier (2002) to calculate the theoretical beat. However, Collier and Collier used one-measure segments to calculate the beat, whereas I chose to use two-measure segments so that a greater number of measurements could be included (discussed below). Choosing longer segments, such as an entire excerpt, would

[37] Walking bass lines are also very important in the role of timekeeping, but I chose the ride cymbal mainly because their attack times can be pinpointed with greater certainty than the attack times of bass tones.

have been problematic due to the natural tendency for tempo fluctuation to occur over longer periods of time.

To calculate the theoretical beat, I selected consecutive two-measure segments starting at the beginning of each excerpt and continuing to the end of each excerpt. I calculated the length of each segment in milliseconds by measuring the duration between ride-cymbal attacks occurring on the first beat of each two-measure section. I divided the millisecond value by the appropriate number of beats to determine the duration of a single beat. A timeline was then created, in which the initial ride-cymbal attack represented the "zero point" or beginning of the timeline, and single beat durations determined successive points along the timeline. The points along the time line, separated by equal durations, defined the theoretical beat. I then measured asynchronies between cymbal attacks and the theoretical beat. Because the initial cymbal attack of each two-measure segment defined the time line, there was not an asynchrony to be measured at this point, thus the initial cymbal attack of each two-measure segment is not included in the data. By choosing two-measure segments as opposed to one-measure segments (as in Collier & Collier, 2002), I was able to include a greater percentage of ride-cymbal attacks in the data.

In a few instances, there was no ride-cymbal attack on beat 1 of a two-measure segment, so I used the attack in the closest proximity of beat 1 (usually beat 2 or beat 4) to define the timeline. Therefore, the lengths of some timelines were shorter than eight beats, but timelines shorter than five beats were not used. By limiting the range of the

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[38] Only attacks occurring on downbeats were measured here because downbeats were sufficient to establish

timelines to five to eight beats in length, I kept the method of measurement consistent while allowing for the inclusion of the large majority of theoretical-beat measurements. In total, the excerpts consisted of 57 two-measure segments, and I was able to determine the theoretical beat for all but four of these segments.

Swing ratios in this study were determined when two consecutive eighth notes were followed by an attack on the downbeat. I calculated durations between attacks and divided the downbeat duration by the off-beat duration. Eighth-note sequences occurred consistently in only the ride patterns and improvised solo, thus measurement of swing ratios was limited to the ride-cymbal and piano-solo parts.

MUSICAL SCORES

Using Finale, I created musical scores for each excerpt. Table 4.1 lists the musical scores representing the "Easy Green" excerpts, and Table 4.2 lists the musical scores representing the "Swan Gaze" excerpts. The tables show the score titles including the time markers (minute: second) of each excerpt, the types of measurements provided in each score, the part of the arrangement from which the excerpt was taken, and the length in measures of each score.

a pulse. Off-beat attacks were measured later to determine swing ratios.

Table 4.1: List of scores representing the "Easy Green" excerpts

Score title	Measurements provided	Part of the arrangement	Length in measures
Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 32:17-32:35)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Head	13
Easy Green: Ride Cymbal and Bass (excerpt 32:17-32:35)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Head	13
Easy Green: Ride Cymbal and Piano Accompaniment (excerpt 32:17-32:35)	1) Piano-accompaniment and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Head	13
Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 33:15-33:38)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Trombone solo	14
Easy Green: Ride Cymbal and Bass (excerpt 33:15-33:38)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Trombone solo	14
Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 35:12-35:33)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Saxophone solo	14
Easy Green: Ride Cymbal and Bass (excerpt 35:12-35:33)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Saxophone solo	14
Easy Green: Ride Cymbal and Piano Accompaniment (excerpt 35:12-35:30)	1) Piano-accompaniment and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Saxophone solo	13
Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 36:30-36:52)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Piano solo	14
Easy Green: Ride Cymbal and Bass (excerpt 36:30-36:52)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Piano solo	14
Easy Green: Ride Cymbal and Right-Hand Piano Solo (excerpt 36:30-36:52)	1) Piano-solo and ride-cymbal asynchronies 2) Piano-solo swing ratios 3) Ride-cymbal swing ratios	Piano solo	14
Easy Green: Ride Cymbal and Right-Hand Piano Solo (excerpt 36:59-37:21)	1) Piano-solo and ride-cymbal asynchronies 2) Piano-solo swing ratios 3) Ride-cymbal swing ratios	Piano solo	14

Table 4.2: List of scores representing the "Swan Gaze" excerpts

Score title	Measurements provided	Part of the arrangement	Length in measures
Swan Gaze: Ride Cymbal/Theoretical Beat and Bass (excerpt 84:50-85:35)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Piano solo	30
Swan Gaze: Ride Cymbal and Bass (excerpt 84:50-85:35)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Piano solo	30
Swan Gaze: Ride Cymbal and Right-Hand Piano Solo (excerpt 84:50-85:21)	1) Piano-solo and ride-cymbal asynchronies 2) Piano-solo swing ratios 3) Ride-cymbal swing ratios	Piano solo	18
Swan Gaze: Ride Cymbal/Theoretical Beat and Bass (excerpt 87:10-87:54)	1) Ride-cymbal and theoretical-beat asynchronies 2) Theoretical-beat durations 3) Bass and ride-cymbal asynchronies	Trombone solo	30
Swan Gaze: Ride Cymbal and Bass (excerpt 87:10-87:54)	1) Bass and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Trombone solo	30
Swan Gaze: Ride Cymbal and Piano Accompaniment (excerpt 87:10-87:43)	1) Piano-accompaniment and ride-cymbal asynchronies 2) Ride-cymbal swing ratios	Trombone solo	22

Results: Asynchronies

Complete results are shown in the musical scores (see Appendix B), which include the transcribed musical parts along with the timing measurements: asynchronies, swing ratios, and theoretical beat durations. In places where a measurement was unavailable, the abbreviation "NA" is used. As discussed earlier, this occurred in cases in which the attack transient of a note could not be located with certainty. Data pertaining to asynchronies are summarized in this section.

Ride-cymbal attacks were measured in reference to a theoretical beat, and bass and piano attacks were measured in reference to ride-cymbal attacks (or the ride-cymbal beat). Positive asynchrony values indicate that instruments were late in relation to the beat or point of reference against which they were measured. For example, positive values of bass/ride-cymbal asynchronies indicate that bass attacks occurred after ride-cymbal attacks. Negative values indicate that instruments were early in relation to the beat or point of reference.

Means and standard deviations of the asynchrony values are provided in this section. The mean can be interpreted as a measure of the player's general approach to synchronization. Because signed values (as opposed to absolute values) were used to measure asynchronies, the mean shows the performer's tendency to be early or late in relation to the frame of reference. The standard deviation is a measure of the consistency of a performer's approach.

The idiomatic walking bass lines and ride patterns in these excerpts are quarter-note-oriented, which results in bass and ride-cymbal notes occurring on almost every beat and producing a large number of bass/ride-cymbal asynchrony measurements (n=283). In contrast, the idiomatic piano parts are characterized by greater rhythmic variety and greater use of rests, thus there are fewer measurements of piano/ride-cymbal asynchronies (n=140).

RIDE-CYMBAL/THEORETICAL-BEAT ASYNCHRONIES IN "EASY GREEN"

Complete results are shown in the scores titled "Easy Green: Ride Cymbal/Theoretical Beat and Bass" (see Appendix B). Ride-cymbal/theoretical-beat asynchronies in the "Easy Green" excerpts are generally small as indicated by the means, which are close to zero. The proportions of positive and negative asynchronies are almost equal. Table 4.3 shows the number of measurements, ranges, means, and standard deviations of ride-cymbal/theoretical-beat asynchronies, and Figure 4.4 illustrates the means and standard deviations in a graph.

Table 4.3: Summary of ride-cymbal/theoretical-beat asynchronies in "Easy Green"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
32:17	36	-38 to 25 ms	-5 ms	16 ms
33:15	39	-25 to 33 ms	-4 ms	12 ms
35:12	36	-11 to 20 ms	2 ms	9 ms
36:30	36	-14 to 35 ms	4 ms	12 ms
TOTAL	147	-38 to 35 ms	-1 ms	13 ms

Figure 4.4: Ride-cymbal/theoretical-beat asynchronies in “Easy Green”: means and standard deviations

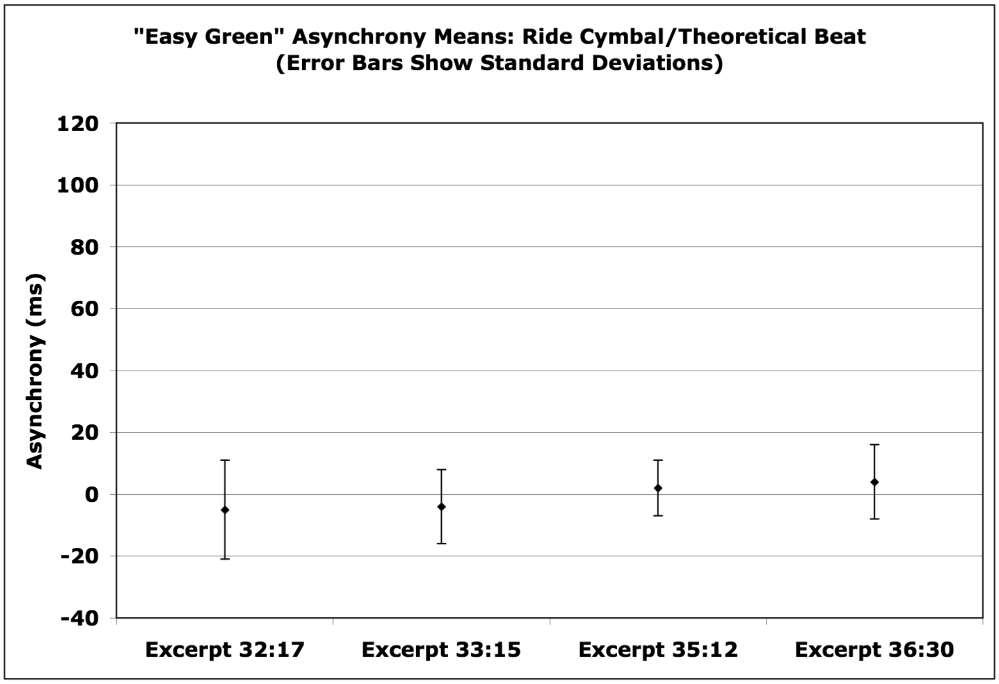


Table 4.4 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.4: Proportion of ride-cymbal/bass synchronies and asynchronies in "Easy Green"

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
32:17	36	56%	0%	44%
33:15	39	64%	5%	31%
35:12	36	50%	0%	50%
36:30	36	39%	5.5%	55.5%
TOTAL	147	52%	3%	45%

Table 4.5 shows the standard deviations of ride cymbal/theoretical beat durations expressed as a percentage of the average beat durations.

Table 4.5: Standard deviations of ride-cymbal/theoretical-beat asynchronies and average beat durations in "Easy Green"

Excerpt	Average Beat Duration	Standard Deviation	*SD* as Percentage of Beat Duration
32:17	345 ms	16 ms	5%
33:15	358 ms	12 ms	3%
35:12	347 ms	9 ms	3%
36:30	347 ms	12 ms	3%
TOTAL	347 ms	12 ms	3%

RIDE-CYMBAL/THEORETICAL-BEAT ASYNCHRONIES IN "SWAN GAZE"

Complete results are shown in the scores titled "Swan Gaze: Ride Cymbal/Theoretical Beat and Bass" (see Appendix B). Ride-cymbal/theoretical-beat asynchronies in the "Swan Gaze" excerpts are generally small as indicated by the means, which are close to zero. There is a slight majority of positive asynchronies compared to negative asynchronies. Table 4.6 shows the number of measurements, ranges, means, and standard deviations of ride-cymbal/theoretical-beat asynchronies, and Figure 4.5 illustrates the means and standard deviations in a graph.

Table 4.6: Summary of ride-cymbal/theoretical-beat asynchronies in “Swan Gaze”

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
84:50	71	-39 to 39 ms	1 ms	15 ms
87:10	59	-26 to 28 ms	5 ms	11 ms
TOTAL	130	-39 to 39 ms	3 ms	13 ms

Figure 4.5: Ride-cymbal/theoretical-beat asynchronies in “Swan Gaze”: means and standard deviations

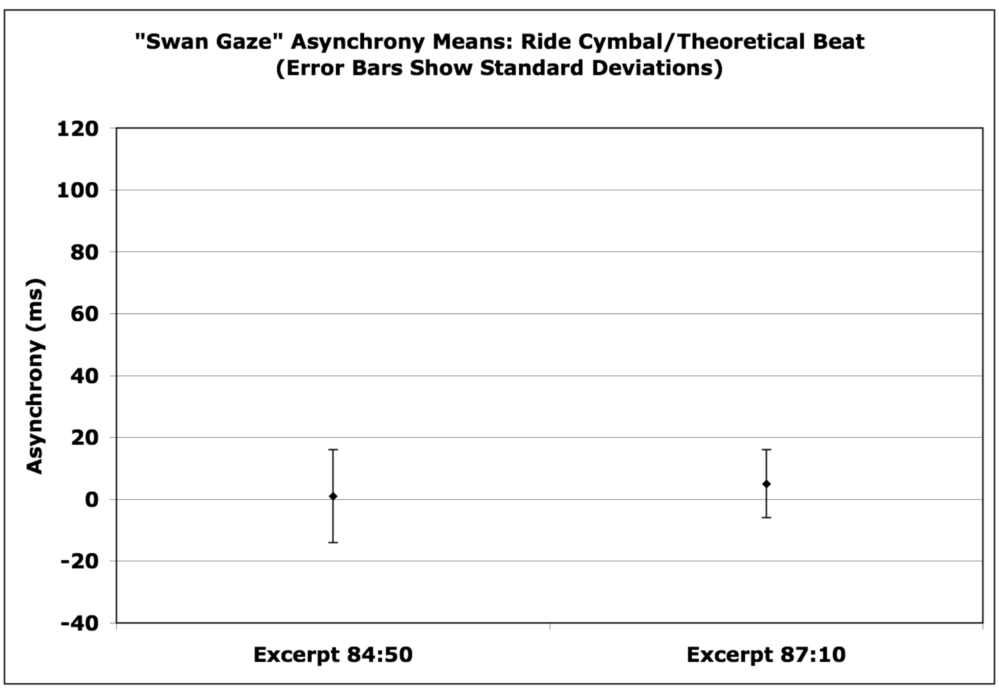


Table 4.7 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.7: Proportion of ride-cymbal/theoretical-beat synchronies and asynchronies in "Swan Gaze"

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
84:50	71	42%	3%	55%
87:10	59	25%	12%	63%
TOTAL	130	35%	7%	58%

Table 4.8 shows the standard deviations of ride-cymbal/theoretical-beat asynchronies expressed as a percentage of the average beat durations.

Table 4.8: Standard deviations of ride-cymbal/theoretical-beat asynchronies and average beat durations in "Swan Gaze"

Excerpt	Average Beat Duration	Standard Deviation	*SD* as Percentage of Beat Duration
84:50	481 ms	15 ms	3%
87:10	469 ms	11 ms	2%
TOTAL	475 ms	13 ms	3%

BASS/RIDE-CYMBAL ASYNCHRONIES IN "EASY GREEN"

Complete results are shown in the scores titled "Easy Green: Ride Cymbal and Bass" (see Appendix B). The large majority of bass/ride-cymbal asynchronies in the "Easy Green" excerpts are positive, indicating that most bass attacks occur slightly after ride-cymbal attacks. Table 4.9 shows the number of measurements, ranges, means, and standard deviations of bass/ride-cymbal asynchronies, and Figure 4.6 illustrates means and standard deviations in a graph.

Table 4.9: Summary of bass/ride-cymbal asynchronies in "Easy Green"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
32:17	36	-17 to 77 ms	30 ms	18 ms
33:15	46	-52 to 68 ms	24 ms	21 ms
35:12	39	-16 to 67 ms	22 ms	17 ms
36:30	42	-27 to 65 ms	30 ms	19 ms
TOTAL	163	-52 to 77 ms	25 ms	19 ms

Figure 4.6: Bass/ride-cymbal asynchronies in "Easy Green": means and standard deviations

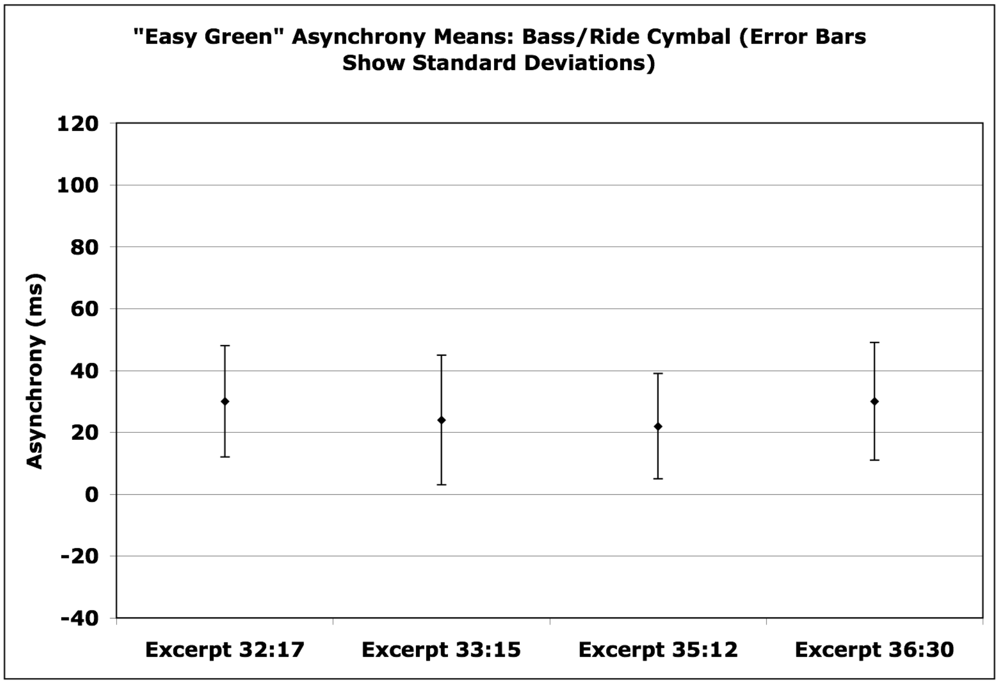


Table 4.10 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.10: Proportion of bass/ride-cymbal synchronies and asynchronies in "Easy Green"

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
32:17	36	5.5%	3%	91.5%
33:15	46	7%	0%	93%
35:12	39	8%	0%	92%
36:30	42	5%	0%	95%
TOTAL	163	6%	1%	93%

BASS/RIDE-CYMBAL ASYNCHRONIES IN "SWAN GAZE"

Complete results are shown in the scores titled "Swan Gaze: Ride Cymbal and Bass" (see Appendix B). The large majority of bass/ride-cymbal asynchronies in the "Swan Gaze" excerpts are positive, indicating that most bass attacks occur slightly after ride-cymbal attacks. Table 4.11 shows the number of measurements, ranges, means, and standard deviations of bass/ride-cymbal asynchronies, and Figure 4.7 illustrates means and standard deviations in a graph.

Table 4.11: Summary of bass/ride-cymbal asynchronies in "Swan Gaze"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
84:50	56	-6 to 95 ms	48 ms	23 ms
87:10	64	-37 to 120 ms	39 ms	26 ms
TOTAL	120	-37 to 120 ms	43 ms	25 ms

Figure 4.7: Bass/ride-cymbal asynchronies in “Swan Gaze”: means and standard deviations

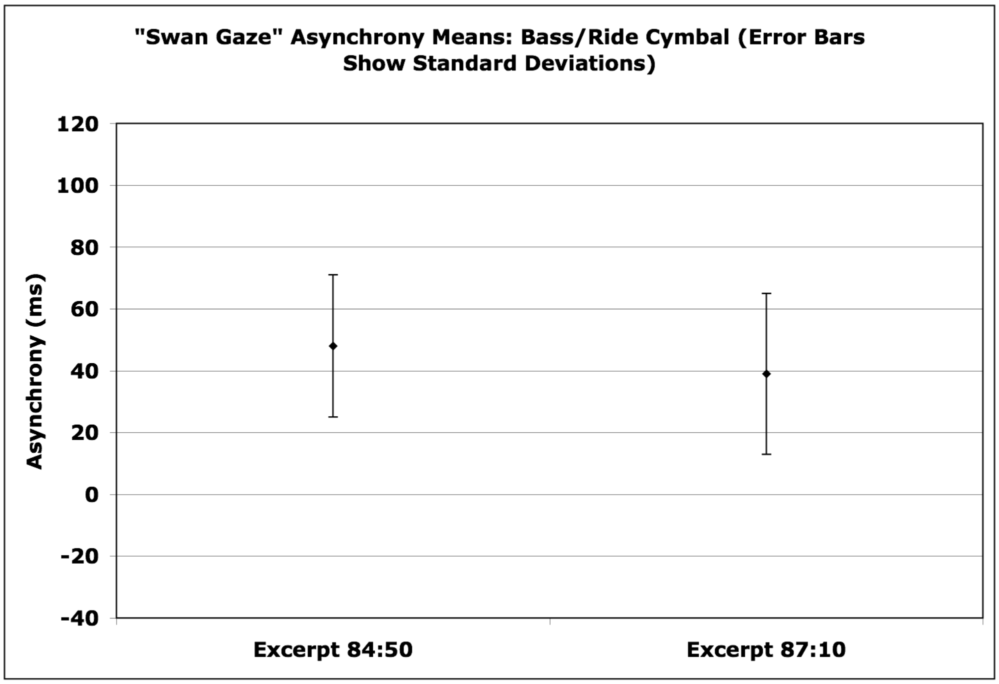


Table 4.12 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.12: Proportion of bass/ride-cymbal synchronies and asynchronies in "Swan Gaze"

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
84:50	56	4%	0%	96%
87:10	64	5%	0%	95%
TOTAL	120	4%	0%	96%

PIANO/RIDE-CYMBAL ASYNCHRONIES IN "EASY GREEN"

Piano solo

Complete results are shown in the scores titled "Easy Green: Ride Cymbal and Right-Hand Piano Solo" (see Appendix B). The vast majority of piano-solo/ride-cymbal asynchronies in the "Easy Green" excerpts are positive, indicating that most piano-solo attacks occur after ride-cymbal attacks. Many of the asynchronies are quite large and therefore highly perceptible. Table 4.13 shows the number of measurements, ranges, means, and standard deviations of piano-solo/ride-cymbal asynchronies.

Table 4.13: Summary of piano-solo/ride-cymbal asynchronies in "Easy Green"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
36:30	26	-2 to 182 ms	73 ms	43 ms
36:59	39	6 to 194 ms	70 ms	48 ms
TOTAL	65	-2 to 194 ms	71 ms	46 ms

Table 4.14 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.14: Proportion of piano-solo/ride-cymbal synchronies and asynchronies in "Easy Green"

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
36:30	26	4%	0%	96%
36:59	39	0%	0%	100%
TOTAL	65	1.5%	0%	98.5%

Piano accompaniment

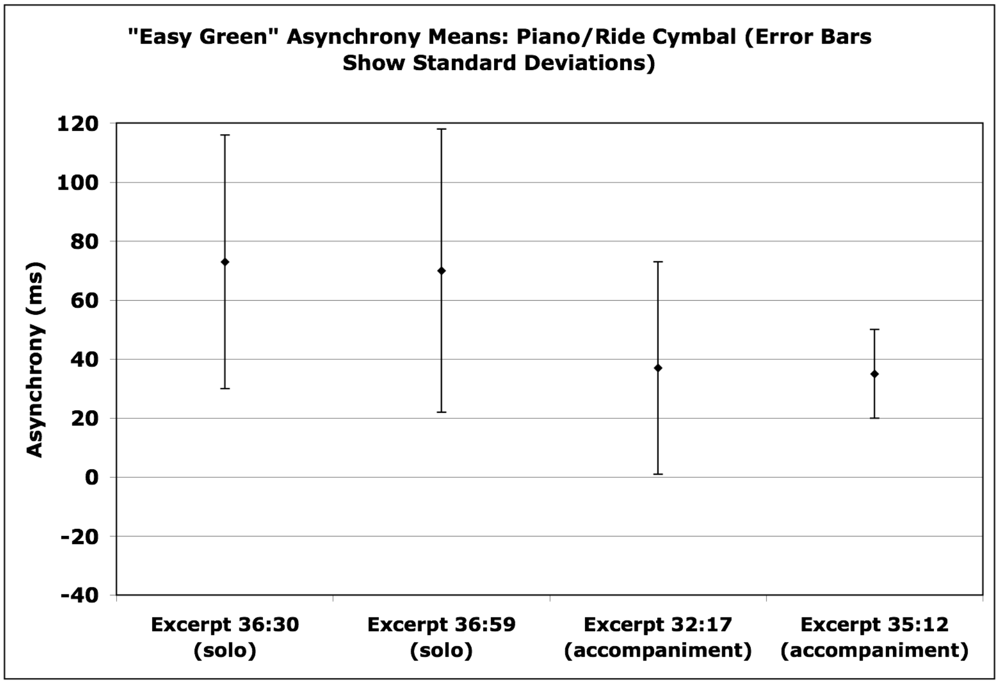
Complete results are shown in the scores titled "Easy Green: Ride Cymbal and Piano Accompaniment" (see Appendix B). All of the piano-accompaniment/ride-cymbal asynchronies in the "Easy Green" excerpts are positive, indicating that all piano-accompaniment attacks occur slightly after ride-cymbal attacks. Table 4.15 shows the number of measurements, ranges, means, and standard deviations of piano-accompaniment/ride-cymbal asynchronies.

Table 4.15: Summary of piano-accompaniment/ride-cymbal asynchronies in "Easy Green"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
32:17	7	12 to 111 ms	37 ms	36 ms
35:12	12	4 to 55 ms	35 ms	15 ms
TOTAL	19	4 to 111 ms	36 ms	24 ms

Figure 4.8 illustrates the differences between piano solo and piano accompaniment, showing the means and standard deviations of all piano/ride-cymbal asynchronies in "Easy Green."

Figure 4.8: Piano/ride-cymbal asynchronies in "Easy Green": means and standard deviations



PIANO/RIDE-CYMBAL ASYNCHRONIES IN "SWAN GAZE"

Piano solo

Complete results are shown in the scores titled "Swan Gaze: Ride Cymbal and Right-Hand Piano Solo" (see Appendix B). The vast majority of piano-solo/ride-cymbal asynchronies in the "Swan Gaze" excerpts are positive, indicating that most piano-solo attacks occur after ride-cymbal attacks. Many of the asynchronies are quite large and therefore highly perceptible. Table 4.16 shows the number of measurements, ranges, means, and standard deviations of piano-solo/ride-cymbal asynchronies.

Table 4.16: Summary of piano-solo/ride-cymbal asynchronies in “Swan Gaze”

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
84:50	39	-8 to 167 ms	60 ms	42 ms

Table 4.17 shows the distribution of negative and positive asynchronies, as well as asynchronies equaling zero (i.e., synchronies).

Table 4.17: Proportion of piano-solo/ride-cymbal synchronies and asynchronies in “Swan Gaze”

Excerpt	Number of measurements	Negative asynchrony	Synchrony (asynchrony=0)	Positive asynchrony
85:50	39	2.5%	0%	97.5%

Piano accompaniment

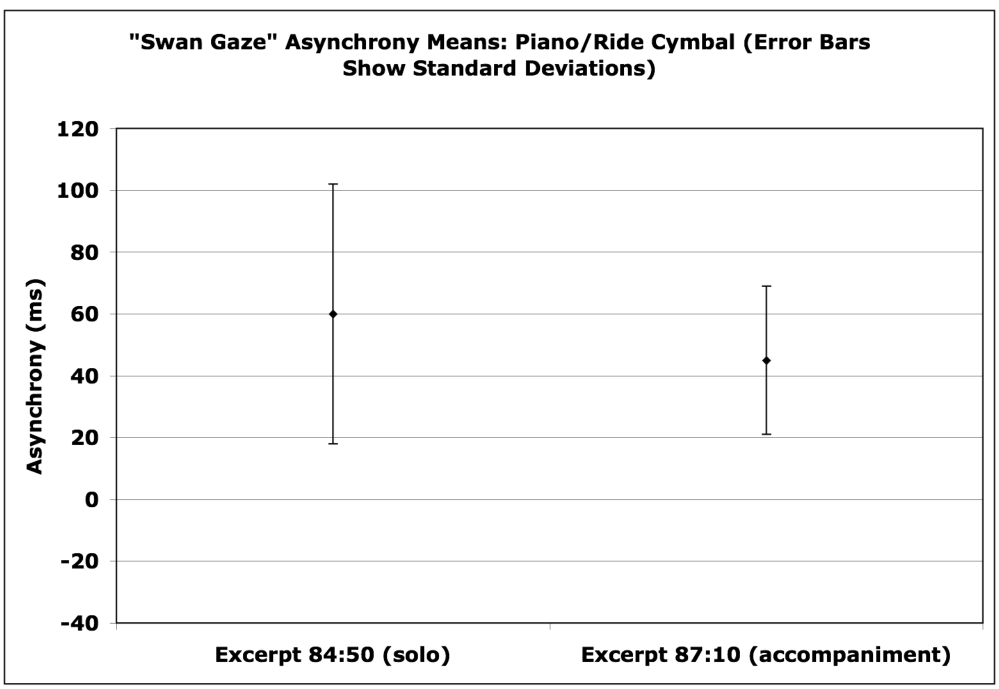
Complete results are shown in the scores titled “Swan Gaze: Ride Cymbal and Piano Accompaniment” (see Appendix B). All of the piano-accompaniment/ride-cymbal asynchronies in the “Swan Gaze” excerpts are positive, indicating that all piano-accompaniment attacks occur slightly after ride-cymbal attacks. Table 4.18 shows the number of measurements, ranges, means, and standard deviations of piano-accompaniment/ride-cymbal asynchronies.

Table 4.18: Summary of piano-accompaniment/ride-cymbal asynchronies in "Swan Gaze"

Excerpt	Number of measurements	Range of asynchrony	Mean	Standard deviation
87:10	17	19 to 88 ms	45 ms	24 ms

Figure 4.9 illustrates the differences between piano solo and piano accompaniment, showing the means and standard deviations of all piano/ride-cymbal asynchronies in "Swan Gaze."

Figure 4.9: Piano/ride-cymbal asynchronies in "Swan Gaze": means and standard deviations



Discussion: Asynchronies

RIDE-CYMBAL/THEORETICAL-BEAT ASYNCHRONIES

Results pertaining to ride-cymbal/theoretical beat asynchronies are very consistent in all excerpts: Asynchrony means are close to 0 ms, and standard deviations are extremely small. Drummer Brannen Temple demonstrates exceptional accuracy, which is remarkable given that there is no aural feedback from a metronomic beat (i.e., the recording was done without a “click track”). It is assumed that Temple has developed timekeeping skills that are not dependent on an external metronome; in musicians’ jargon, he demonstrates a great “internal clock.” However, it is also notable that the other musicians in the ensemble likely contribute to the steadiness; particularly the bassist who plays on almost every beat.

The standard deviations of ride cymbal/theoretical beat asynchronies are very low, ranging from 9 to 16 ms. This striking consistency is even more pronounced when the standard deviation is expressed as a percentage of the beat duration: about 3% in “Easy Green” and “Swan Gaze.” It is notable that despite the slower tempo of “Swan Gaze,” the standard deviations are about the same for both pieces. This is somewhat surprising, because in timekeeping tasks, greater deviations are frequently observed as tempos become slower (Allan, 1979; Aschersleben, 2002; Drake, *et al.*, 2000; Fraisse, 1982; Ivry & Hazeltine, 1995; Keele, *et al.*, 1985; Repp, 2005). As an expert jazz drummer, it is likely that Temple has developed skill in timekeeping that can be transferred to different tempos.

The only notable contrast in ride-cymbal/theoretical-beat asynchronies between "Easy Green" and "Swan Gaze" is that there are fewer negative asynchronies and more positive asynchronies in "Swan Gaze." However, this difference is very slight. Perhaps it can be attributed to the relatively slow tempo and 3/4 meter of "Swan Gaze." For many musicians, there may be a tendency to rush when performing a jazz waltz at the tempo of "Swan Gaze." Perhaps Temple intuitively plays a shade behind the beat in "Swan Gaze" to prevent the piece from rushing.

There are some interesting observations regarding how musical context relates to ride-cymbal/theoretical-beat asynchronies. For example, in "Easy Green" the position in the excerpt seems to have a slight relationship with the direction of asynchronies. In three of the four "Easy Green" excerpts, the large majority of negative asynchronies occur towards the beginning of the excerpts. A possible explanation for this observation has to do with compositional structure. "Easy Green" features two main formal sections that alternate: a section consisting of a bass ostinato in 7/4 meter, and a straight-ahead section in 4/4 meter. The excerpts occur just after the ostinato sections. It is sometimes difficult to maintain steadiness when rhythmic styles and meter change. Perhaps Temple plays "on top of the beat" in the initial measures of the excerpts in an effort to firmly reestablish the straight-ahead style and 4/4 meter as the music transitions from the contrasting section in 7/4 meter.

In addition, the tempo of the ensemble performance drops noticeably in excerpt 33:15 (around mm. 3-8), at which time there are a large majority of negative ride-cymbal/theoretical-beat asynchronies. It is possible that Temple sensed this drop in tempo, and played ahead of the beat in this passage to avoid an undesirable dragging effect.

It is also noticeable in both pieces that asynchronies of a particular type (i.e., positive or negative, large or small) tend to occur in compact groups or bunches. This may be a natural result of musicians listening closely to the tempo. Skilled musicians are able to avoid undesirable, abrupt changes of tempo. The occurrence of similar types of asynchronies in groups reflects consistency of tempo. In contrast, if large changes in asynchronies occurred from note to note or measure to measure, then this would be a reflection of abrupt tempo changes.

In summary, Temple's approach to timekeeping in ride patterns is highly accurate in relation to the theoretical beat. Similar types of asynchronies tend to occur in compact groups because there are no abrupt tempo changes. There is some indication that Temple tends to play slightly ahead of the beat at particular times in Easy Green, for example immediately after the sections in 7/4 meter, or when the music shows signs of dragging. Perhaps the slight ahead-of-the-beat approach gives the music a quality of forward motion. In contrast, in "Swan Gaze" perhaps the slight behind-the-beat approach helps to avoid rushing. If there is any validity to these speculations, it is likely that these adjustments occur intuitively, as opposed to being conscious thought processes that occur while playing. The main point is that Temple's timekeeping is remarkably accurate.

A prior study (Collier & Collier, 2002) used a method similar to the present study to analyze the timing of two trumpet solos by Louis Armstrong. Trumpet attacks were measured in relation to a theoretical beat, which was calculated using one-measure groups. Similar to the present study, Collier and Collier found very low mean asynchronies (for downbeats): about -1 ms in "Cornet Chop Suey," and about -10 ms in "Potato Head Blues." (Figure 5, p. 472) In addition, similar types of asynchronies tended to occur in compact groups. However, the standard deviations (for downbeats) were much higher in the analysis of the trumpet solos than in the ride patterns of the present study, about 60 ms in "Cornet Chop Suey" and about 80 ms in "Potato Head Blues" (Figure 5, p. 472). This is likely due to the fact that Armstrong was improvising melodically in a soloist's role and manipulating timing for expressive purposes. It is not surprising that he demonstrated greater flexibility in beat placement than what is observed in Temple's ride patterns when performing an accompanying function. The tempos of the musical examples in the study by Collier and Collier were similar to the tempos of the "Easy Green" excerpts: about 174 bpm in "Cornet Chop Suey," and about 182 bpm in "Potato Head Blues."

BASS/RIDE-CYMBAL ASYNCHRONIES

It is notable that differences in arrangement features among the excerpts (head, trombone solo, saxophone solo, piano solo) do not affect Fremgen and Temple's approach to synchronizing bass lines and ride patterns. Bass/ride-cymbal asynchronies are very consistent among excerpts from the same piece, as indicated by the similar means and standard deviations. These similar measurements show that Fremgen and Temple are consistent in their approach to synchronization when performing the same piece, even when accompanying different soloists or accompanying the performance of the head.

In both "Easy Green" and "Swan Gaze," there is a strong tendency for bass attacks to occur slightly later than ride-cymbal attacks: The majority of bass/ride-cymbal asynchronies are positive: 93% in "Easy Green," and 96% in "Swan Gaze." However, asynchronies are larger in "Swan Gaze" than in "Easy Green" ("Swan Gaze" total: *m*=43 ms; "Easy Green" total: *m*=25 ms), indicating that bass attacks are placed further behind ride-cymbal attacks in "Swan Gaze" than in "Easy Green." This may be attributed to the slower tempo and different meter of "Swan Gaze." Perhaps Fremgen and Temple prefer a more "laid-back" feeling in the bass lines when playing a slow jazz waltz compared to a faster piece in 4/4 meter.

A likely cause of the positive bass/ride-cymbal asynchronies is the difference in rise times between bass and ride-cymbal tones. Ride-cymbal tones have a miniscule rise time of about 1 ms. In contrast, bass tones have rise times of about 15 to 85 ms. Perceptual studies have shown that attacks of musical tones with short rise times are perceived considerably closer to physical onset compared to attacks of musical tones with long rise times (Collins, 2006; Gordon, 1987, 1984; Rasch, 1978; Vos & Rasch, 1981). Theoretically speaking, if bass and ride-cymbal physical onsets were synchronized, the perceptual attack times of bass tones would occur later than those of ride-cymbal tones, and the size of the asynchrony would be directly related to the rise time of each bass tone[39]. Stated in musical terms, if bass and ride cymbal were played at the exact same moment, the impulsive quality of the ride-cymbal sound compared to the slow-to-develop bass sound would naturally result in ride-cymbal attacks being perceived slightly before bass attacks.

An explanation for the larger bass/ride-cymbal asynchronies in "Swan Gaze" compared to "Easy Green" is the effect of tempo on the bassist's articulation. Fremgen's articulation (or the force of his attacks) varies slightly from note to note. Notes in which the articulation is "pointed" (i.e., the highest volume occurs at the beginning of the tone followed by an immediate decay) have shorter rise times than "elongated" notes (i.e., there is a slight swell in volume at the beginning of the tone). The slower tempo of "Swan Gaze" requires that bass tones be sustained longer to connect the notes in a legato manner, resulting in more elongated than pointed notes when compared to "Easy Green." The elongated notes produce relatively late measurements of perceptual attack times, contributing to the larger asynchronies. This tempo-dependent difference in articulation between the two pieces is perceptible, and one could argue that the elongated notes create a somewhat more "laid-back" feeling than the pointed notes.

The delay of bass attacks in relation to ride-cymbal attacks has also been found in previous studies that analyzed jazz recordings. Friberg and Sundström (2002) analyzed recordings on which the following bassist/drummers performed: Ron Carter/Adam Nussbaum, Ron Carter/Tony Williams, Robert Hurst/Jeff "Tain" Watts, and Gary

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[39] The reader might ask at this point why physical onsets were not measured. The reason is because physical onsets cannot be located by looking at waveforms unless each tone is preceded by silence, which rarely happened in these performances.

Peacock/Jack DeJohnette. The researchers found that bass attacks were on average later than ride-cymbal attacks in the excerpts of moderate tempo. For tempos between 120 and 210 bpm, average bass/ride-cymbal asynchronies ranged from about 2 to 30 ms, and standard deviations ranged from about 30 to 50 ms (Figure 8, p. 343). Prögler analyzed a recording on which bassist Steve Rodby and drummer Mike Hyman performed, and found that Rodby generally placed his attacks slightly late in relation to Hyman's ride patterns; calculations of asynchronies were not reported. Rose analyzed performances of a rhythm section[40] performing an accompanying function (no soloist), and found a tendency for drum tones to occur first followed by piano tones and then bass tones. Rose did not analyze the ride cymbal separately, but rather combined the instruments of the drum set in his analysis. On average, the size of the asynchronies among piano, bass, and drums ranged from 6 to 35 ms.

The idea that bass tones are slightly delayed in relation to ride patterns is contrary to the often-stated idea that bassists should play "on top of the beat" to make the music swing (see Lawn, 1981; Rose, 1989). However, bass tones have much longer rise times than ride-cymbal tones, and it may be argued that the physical motion required to pull the string of the bass is more strenuous than tapping a cymbal with a drum stick. At times it may seem to bassists that they are placing attacks slightly ahead of drummers' attacks to achieve an acceptable degree of cohesiveness, while the measurement of perceptual attack time reveals that bass attacks are slightly late. Hence, in some cases it may be good

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[40] The recordings are from *A New Approach to Jazz Improvisation* (Jamey Aebersold, Inc.). Rose does not disclose the names of the performers.

advice for educators to tell student bassists to play "on top of the beat" to avoid an undesirable dragging effect.

Standard deviations of bass/ride-cymbal asynchronies are very low throughout both pieces ("Swan Gaze" total: *sd*=19 ms; "Easy Green" total: *sd*=25 ms), indicating that Fremgen and Temple maintain the temporal coordination of their bass lines and ride patterns with consistency. The slightly greater standard deviation in "Swan Gaze" may be a byproduct of its slower tempo. In synchronization tasks, greater deviation is frequently observed as tempos become slower because longer intervals between beats can make the estimation of timing more difficult (Allan, 1979; Aschersleben, 2004; Fraisse, 1982; Ivry & Hazeltine, 1995; Rasch, 1988; Repp, 2005).

Regarding the interaction between ride-cymbal/theoretical-beat asynchronies and bass/ride-cymbal asynchronies (see the scores titled "Ride Cymbal/Theoretical Beat and Bass," Appendix B), there are no strong connections or patterns between the two types of asynchronies. It is notable that there are frequent occurrences of negative asynchronies in the ride-cymbal part coinciding with large positive asynchronies in the bass part. This is logical because if Temple were playing slightly ahead of the theoretical beat while Fremgen played slightly behind the theoretical beat, the resulting bass/ride-cymbal asynchronies would naturally be relatively large positive values. However, this observation is weakened by the fact that there are also frequent occurrences of positive asynchronies in the ride-cymbal part coinciding with large positive asynchronies in the bass part. As noted previously, the vast majority of bass/ride-cymbal asynchronies are positive, hence bass attacks tend to be late in relation to ride-cymbal attacks regardless of the ride cymbal's relationship to the theoretical beat. Therefore, deviations in the timing of the ride patterns may have contributed in *isolated instances* to bass/ride-cymbal asynchronies for individual notes, but the ride patterns are very accurate in relation to the theoretical beat. It cannot be concluded that *general tendencies* in ride-cymbal/theoretical-beat asynchronies contribute strongly to the general tendency for bass attacks to be behind ride-cymbal attacks.

In summary, bass attacks usually occur slightly after ride-cymbal attacks, and the asynchronies are smaller in "Easy Green" (*m*=25 ms) than in "Swan Gaze" (*m*=43 ms). The temporal relationship between bass and ride cymbal is very consistent in each piece, as indicated by the low standard deviations. The most plausible explanation for the positive bass/ride-cymbal asynchronies is the relatively slow acoustical rise time of bass tones. The consistency of Fremgen's and Temple's approach to synchronization may indicate that they are comfortable with the perceived synchronization of their musical parts, that is, the slightly late perceptual attack time of the bass is aesthetically desirable, or it sounds "right" to the performers.

PIANO/RIDE-CYMBAL ASYNCHRONIES

Results pertaining to piano and ride-cymbal asynchronies show a clear contrast in Hellmer's approach to synchronization depending on whether he is performing as soloist or accompanist. As the soloist Hellmer's general approach is very behind-the-beat and flexible, but as the accompanist his approach is just slightly behind-the-beat and consistent.

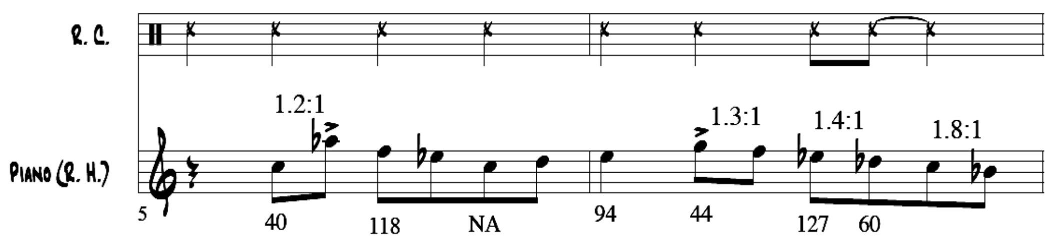
In the piano-solo excerpts, all but two of the asynchronies are positive, and many of the asynchronies are large enough to be easily perceptible, yielding means that are quite high ("Easy Green" total: *m*=71 ms; "Swan Gaze" total: *m*=60 ms). Results indicate that Hellmer's approach to beat placement as the soloist is behind-the-beat in relation to ride patterns, a finding that supports the idea that soloists often play behind the beat of accompanying rhythm sections to create a "laid-back" feeling (Ellis, 1991; Friberg & Sundström, 2002; Liebman, 2007). In addition, standard deviations are quite high ("Easy Green" total: *sd*=46 ms; "Swan Gaze" total: *sd*=42 ms), indicating much flexibility in Hellmer's approach as the soloist. This flexibility is indeed perceptible when listening to the excerpts.

In the piano-accompaniment excerpts, all piano/ride-cymbal asynchronies are positive. However, compared to piano-solo data, piano-accompaniment/ride-cymbal asynchronies are generally smaller, as indicated by the lower means ("Easy Green" total: *m*=36 ms; "Swan Gaze" total: *m*=45 ms). This shows that, when accompanying, Hellmer synchronizes attacks more closely with ride patterns than when performing as the soloist. In addition, standard deviations in the piano-accompaniment excerpts are low ("Easy Green" total: *sd*=24 ms; "Swan Gaze" total: *sd*=24 ms), indicating that Hellmer's approach, as the accompanist to beat placement is quite consistent.

There are a number of interesting relationships between melodic and rhythmic elements of the improvised solos and the size of asynchronies in the piano-solo excerpts. For example, asynchronies tend to be larger for notes occurring on downbeats than for notes occurring on off-beats. In "Easy Green," the mean of piano-solo/ride-cymbal asynchronies on downbeats is 79 ms, compared to 31 ms on off-beats. In "Swan Gaze," the mean of piano-solo/ride-cymbal asynchronies on downbeats is 71 ms, compared to 30 ms on off-beats. Interestingly, this downbeat/off-beat effect is not observed in the piano-accompaniment excerpts. In the piano-accompaniment excerpts, asynchronies are similar for downbeats and off-beats, although there are few measurements on off-beats because piano-accompaniment and ride-cymbal attacks rarely coincided on off-beats. In "Easy Green," the mean of piano-accompaniment/ride-cymbal asynchronies on downbeats is 38 ms, compared to 30 ms for off-beats. In "Swan Gaze," the mean of piano-accompaniment/ride-cymbal asynchronies on downbeats is 46 ms, compared to 43 ms on off-beats.

Another example of musical elements relating to asynchronies in the piano solo is observed in eighth-note passages throughout the piano-solo excerpts. In these passages, attacks on downbeats tend to be quite late when preceded by either a melodic upper neighbor or an accented note ("Easy Green": excerpt 36:30, mm. 5-6, 10, 12; excerpt 36:59, mm. 3, 5-6, 12; "Swan Gaze": excerpt 84:50, mm. 7, 12, 17-18). Example 4.1 illustrates this technique.

Example 4.1: "Easy Green," excerpt 36:30 (mm. 5-6): Note the large asynchronies (118 and 127 ms) indicated under piano notes occurring on downbeats just after an accented note or a melodic upper neighbor.

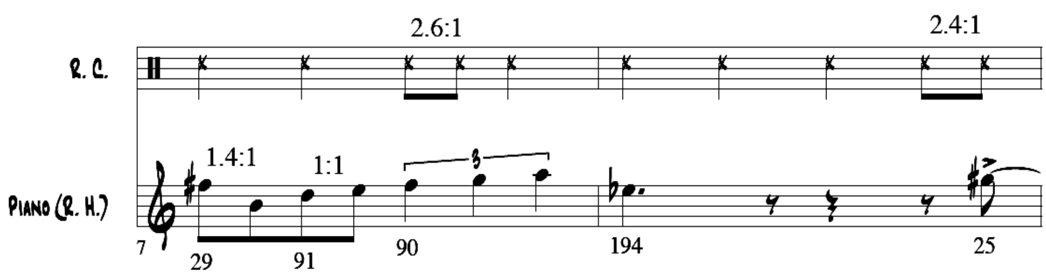


Another case of musical elements relating to asynchronies is apparent in "Easy Green" when chromatic lower melodic neighbors are used. There is a tendency for downbeat attacks immediately preceded by a chromatic lower neighbor to be quite late (excerpt 36:30, mm. 9, 11; excerpt 36:59, mm. 10, 14). Example 4.2 illustrates this technique.

Example 4.2: "Easy Green," excerpt 36:59 (mm. 9-10): Note the large asynchrony on the pitch C-sharp (m.10) occurring just after a chromatic lower neighbor.

It is of interest to point out the context in which the largest piano-solo asynchrony occurs. In excerpt 36:59, the E-flat in measure 8 is 194 ms late in relation to the ride-cymbal attack. This note is preceded by a quarter-note triplet pattern and a descending melodic interval of a tritone. Perhaps Hellmer elongates the triplet for expressive reasons to highlight the triplet idea and the angular melodic shape. See Example 4.3.

Example 4.3: "Easy Green," excerpt 36:59 (mm. 7-8): The largest piano asynchrony (194 ms) occurs in measure 8 after a quarter-note triplet (m.7).



In review, piano-solo attacks on downbeats are delayed to a larger degree than are those on off-beats. In addition, in eighth-note passages downbeat attacks tend to be especially late when preceded by an accented note, a melodic upper neighbor, or a chromatic lower neighbor. Lastly, there is just one instance of a quarter-note triplet followed by an attack on the downbeat, and this attack represents the largest asynchrony in the data.

In summary, Hellmer demonstrates contrasting approaches to beat placement depending on performance function (solo vs. accompaniment). As the soloist, he places many attacks considerably behind the beat of ride patterns, and is very flexible in his approach to synchronization. As the accompanist, he places attacks just slightly behind the beat of ride patterns, and is consistent in his approach to synchronization. In addition, musical elements relate to asynchronies in the piano solo. For example, rhythmic context relates to asynchronies: Asynchronies occurring on downbeats are greater than those occurring on off-beats. This effect of downbeat/off-beat context is not evident in the piano-accompaniment. Also in the piano solo, downbeat attacks that are preceded by an upper melodic neighbor, an accented note, a chromatic lower neighbor, or a quarter-note triplet tend to be especially delayed in relation to ride-cymbal attacks.

The finding that the soloist plays behind the beat of ride patterns is in agreement with existing studies that have measured soloists' beat placement in relation to accompanying rhythm sections. In an experimental study by Ellis (1991), jazz saxophonists consistently placed attacks behind the beat of computer-generated accompanying bass lines. For tempos between 90 and 210 bpm, average saxophone/bass asynchronies ranged from 24 to 251 ms, and standard deviations ranged from 36 to 106 ms. In the study by Friberg and Sundström (2002), all soloists tended to place attacks behind the attacks of ride cymbals when playing moderate tempos. The soloists were George Coleman, Herbie Hancock, Keith Jarrett, Marcus Roberts, Miles Davis, and Wynton Marsalis. The study also found that downbeat/off-beat context related to soloists' asynchronies. For tempos between 120 and 210 bpm, average asynchronies for soloist/ride-cymbal asynchronies on downbeats ranged from about 30 to 90 ms, and standard deviations were about 25 to 90 ms. On off-beats, average asynchronies ranged from about -5 to 15 ms, and standard deviations from about 25 to 50 ms (Figures 6-7, p. 342).

Moreover, in the first study of this document, musical elements such as melodic shape and accent placement were related to behind-the-beat playing in the analysis of solos by Peterson, Kelly, Roberts, and Marsalis. Specifically, behind-the-beat passages tended to occur in the context of eighth-note descending lines in which off-beats were accented. This concurs directly with the observations of the present study, in which the larger asynchronies tend to occur in eighth-note passages when notes on downbeats are preceded by either a melodic upper neighbor or an accented off-beat.

Conclusions: Beat Placement

The following conclusions related to beat placement are based on the present and previous studies on timing features of straight-ahead jazz performed at moderate tempos. Accompanying instrumentalists (pianists, bassists, and drummers) generally synchronize their parts closely and consistently when performing conventional idiomatic comping such as piano chords, walking bass lines, and ride patterns. Synchronization is not always perfect, however. There is a tendency for drums to sound first, followed by bass, and then piano. On average, the attacks of the three instruments occur within in a window of about 2 to 45 ms (Friberg & Sundström, 2002; Rose, 1989; this dissertation). In addition, the timekeeping of rhythm sections is very steady when small sections of music are examined, standard deviations in beat durations equaling about 3 to 5 percent of metronomic beat durations (this dissertation).

Soloists tend to play behind the beat of accompanying rhythm sections, and in some cases this behind-the-beat approach is very noticeable. On average, soloists delay their attacks by about 30 to 90 ms[41] (Friberg & Sundström, 2002; this dissertation). Musical elements relate to soloist/rhythm-section asynchronies. Notes on downbeats are played further behind the beat than notes on off-beats (Friberg & Sundström, 2002; this dissertation). In addition, notes on downbeats are played especially late when they occur in eighth-note passages and are preceded by a melodic upper neighbor or accented note (this dissertation).

Results: Swing Ratios

Complete results are shown in the musical scores (see Appendix B), which include the transcribed musical parts along with the timing measurements: asynchronies, swing ratios, and theoretical beat durations. In places where a measurement was unavailable, the abbreviation "NA" is used. As discussed earlier, this occurred in cases in which the attack transient of a note could not be located with certainty. Data pertaining to swing ratios are summarized in this section.

Swing ratios were measured only in the ride-cymbal and piano-solo parts because these were the parts that featured sequences of eighth notes. To measure the ratio, it was necessary to locate three consecutive attacks: downbeat, off-beat, downbeat. The duration of the first half of the beat was then compared to the duration of the second half of the beat to determine the ratio. Therefore, ratios were available exclusively in instances in which two consecutive eighth notes were immediately followed by an attack on the downbeat.

[41] This excludes the data from Ellis (1991), because Ellis did not analyze authentic jazz performances.

Means and standard deviations of the ratio values are provided in this section. The mean can be interpreted as a measure of the player's general approach to swing subdivision, and the standard deviation as a measure of the consistency of this approach.

RIDE-CYMBAL SWING RATIOS IN "EASY GREEN"

Complete results are shown in the scores titled "Easy Green: Ride Cymbal and Bass" and "Easy Green: Ride Cymbal and Right-Hand Piano Solo" (see Appendix B). Ride-cymbal swing ratios in the "Easy Green" excerpts generally fall between the triplet-based ratio of 2:1 and the sixteenth-note based ratio of 3:1; the total average ratio is 2.6:1. Standard deviations are very low. Table 4.19 shows the number of measurements, ranges, means, and standard deviations.

Table 4.19: Summary of ride-cymbal swing ratios in "Easy Green"

Excerpt	Number of measurements	Range of ratio	Mean	Standard deviation
32:17	7	1.9:1 to 2.7:1	2.3	0.3
33:15	18	2.2:1 to 3:1	2.5	0.2
35:12	13	2.1:1 to 3.1:1	2.6	0.3
36:30	4	2.4:1 to 3.2:1	2.8	0.4
36:59	12	2.3:1 to 3.2:1	2.7	0.3
TOTAL	53	1.9:1 to 3.2:1	2.6	0.3

RIDE-CYMBAL SWING RATIOS IN "SWAN GAZE"

Complete results are shown in the scores titled "Swan Gaze: Ride Cymbal and Bass" and "Swan Gaze: Ride Cymbal and Right-Hand Piano Solo" (see Appendix B). Like the ride-cymbal swing ratios in "Easy Green," those in the "Swan Gaze" excerpts generally fall between 2:1 and 3:1. However, there are a number of ratios in "Swan Gaze" that exceed 3:1, resulting in a relatively high average of 2.8:1. Standard deviations are very low. Table 4.20 shows the number of measurements, ranges, means, and standard deviations.

Table 4.20: Summary of ride-cymbal swing ratios in "Swan Gaze"

Excerpt	Number of measurements	Range of ratio	Mean	Standard deviation
32:17	25	1.9:1 to 3.6:1	2.9	0.4
33:15	34	2.1:1 to 3.2:1	2.6	0.3
TOTAL	59	1.9:1 to 3.6:1	2.8	0.4

PIANO-SOLO SWING RATIOS IN "EASY GREEN"

Complete results are shown in the scores titled "Easy Green: Ride Cymbal and Right-Hand Piano Solo" (see Appendix B). In the "Easy Green" excerpts, piano-solo swing ratios are lower than ride-cymbal swing ratios; in fact, the overall average is 1.2:1, a value closer to strict eighth-note subdivision (1:1) than triplet-based subdivision (2:1). However, there is much variability in the piano-solo ratios, resulting in larger ranges and standard deviations than in the ride-cymbal ratios. Table 4.21 shows the number of measurements, ranges, means, and standard deviations.

Table 4.21: Summary of piano-solo swing ratios in “Easy Green”

Excerpt	Number of measurements	Range	Mean	Standard deviation
36:30	10	0.9:1 to 1.8:1	1.2:1	0.3
36:59	14	0.5:1 to 3.2:1	1.2:1	0.6
TOTAL	24	0.9:1 to 3.2:1	1.2:1	0.5

PIANO-SOLO SWING RATIOS IN “SWAN GAZE”

Complete results are shown in the score titled “Swan Gaze: Ride Cymbal and Right-Hand Piano Solo” (see Appendix B). In the “Swan Gaze” excerpt, the average piano-solo swing ratio is 2.1:1, close to an exact triplet-based ratio. However, there is much variability in the piano-solo ratios, resulting in a very large range and standard deviation. Table 4.22 shows the number of measurements, range, mean, and standard deviation.

Table 4.22: Summary of piano-solo swing ratios in “Swan Gaze”

Excerpt	Number of measurements	Range	Mean	Standard deviation
84:50	12	1.1:1 to 5.7:1	2.1	1.3

Discussion: Swing Ratios

RIDE-CYMBAL SWING RATIOS

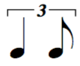
Results pertaining to swing ratios in the ride patterns indicate that Temple's general approach to swing subdivision is quite consistent across excerpts. Means and standard deviations are very similar, although they are slightly larger in "Swan Gaze" than in "Easy Green." This is likely a byproduct of the slower tempo of "Swan Gaze." It is well known that slower tempos often relate to larger swing ratios and greater variability in the ratios (e.g., Collier & Collier, 1996; Collier & Wright, 1995; Friberg & Sundström, 2002, 1997). It is also notable that "Easy Green" is in 4/4 meter, whereas "Swan Gaze" is in 3/4 meter. The difference in meter may also have affected the slight differences in ratios.

The total means (2.6:1 in "Easy Green" and 2.8:1 in "Swan Gaze") are greater than the 2:1 ratio implied by the notation , indicating that Temple's subdivision is generally more uneven than an exact triplet-based subdivision. The total standard deviations (0.3 in "Easy Green" and 0.4 in "Swan Gaze") indicate that Temple's swing subdivision is quite consistent throughout the excerpts. This consistency is highlighted by expressing the standard deviation of ratios as a percentage of the mean ratio: 12% in "Easy Green, and 14% in "Swan Gaze."

The average swing ratios of ride patterns found in this study are similar to findings of other studies. In the study by Friberg and Sundström (2002), the average swing ratios of each of the four drummers were greater than 2:1 for tempos between 100 and 200 bpm. Collier and Collier (1996), in a study that compared swing ratios of drummers' ride patterns when playing in a "strict triplet feel" versus a "swing feel," determined that in the swing-feel condition, ratios tended to be "slightly greater than the strict triplets" (p.284) when moderate tempos were performed. Rose (1989) found an average swing ratio of 2.38:1 among instruments of a rhythm section (piano, bass, and drums) performing at the tempo 132 bpm.

The notion that swing subdivision in ride patterns is triplet-based is challenged by these findings, at least in the case of moderate tempos. There is some evidence that the tempo 200 bpm is associated with ride-pattern ratios being triplet-based (2:1), and that the ratio decreases as tempos increase beyond 200 bpm, and increases as tempos decrease from 200 bpm (Collier & Collier, 1996; Friberg & Sundström, 2002). Thus tempos greater than 200 bpm should frequently yield ride-pattern ratios less than 2:1, and tempos less than 200 bpm should frequently yield ratios greater than 2:1. The present study confirms this hypothesis regarding the slower tempos.

PIANO-SOLO SWING RATIOS

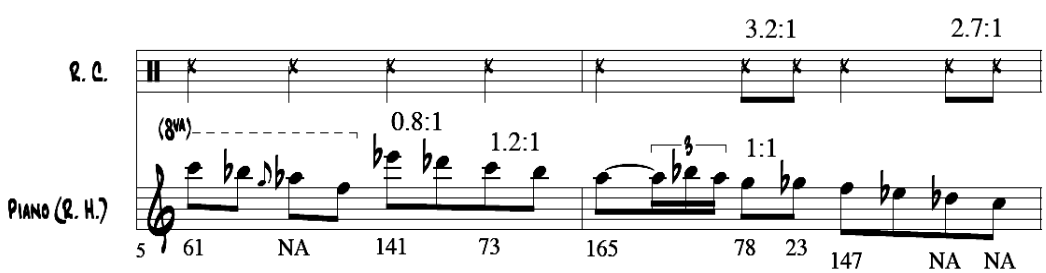
In "Easy Green," Hellmer exhibits a quite even approach to swing subdivision compared to the subdivision in the ride patterns performed by Temple in the same piece. The mean of piano-solo ratios is 1.2:1, a value less than the 2:1 ratio implied by the notation , and considerably less than the mean ratio of 2.6:1 found in the ride patterns. In this piece, Hellmer clearly prefers a quite even approach to eighth notes. This observation is in accord with the idea that jazz soloists often play eighth notes more evenly than a triplet-based approach, and more evenly than the eighth notes found in ride patterns (e.g., Ellis, 1991; Friberg & Sundström, 2002; Laverne, 1993; Liebman, 1997).

Whereas the means of piano-solo ratios are the same in the two "Easy Green" excerpts, the standard deviations are different. This is due to a few rather large ratios produced in excerpt 36:59 (discussed below). The overall standard deviation of piano-solo ratios is very high, 42% of the overall mean. This contrasts strongly with the analysis of ride-cymbal ratios, in which the standard deviation was just 12% of the mean throughout "Easy Green" excerpts. The large standard deviation in the piano solo indicates much flexibility in Hellmer's approach to swing subdivision as the soloist. It is assumed that this variability in subdivision is intentional for expressive purposes, an idea that is supported by the facts that deviations are highly perceptible and musical elements relate to deviations.

In "Swan Gaze," both the mean and standard deviation are considerably greater than in "Easy Green," indicating that Hellmer plays more uneven eighth notes and varies the subdivision more in "Swan Gaze." This is likely a byproduct of the slower tempo of "Swan Gaze," and may also be attributed to the fact that "Swan Gaze" is in 3/4 meter. The range of ratios in "Swan Gaze" (1.1:1 to 5.7:1) is strikingly large, as is the standard deviation (1.3, or 62% of the mean). This illustrates a great amount of flexibility in Hellmer's approach to swing subdivision. In fact, this flexibility is easily noticeable when listening to the excerpt.

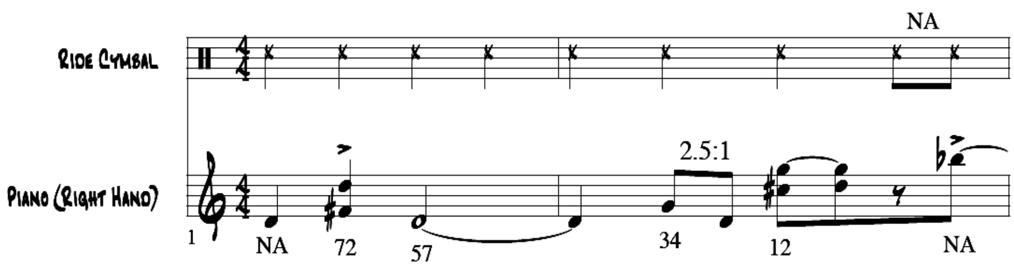
Regarding the relationship between melodic and rhythmic elements of the improvised solo and swing ratios, swing subdivision tends to be particularly even in the piano-solo excerpts during behind-the-beat passages, as evidenced by the simultaneous occurrence of low swing ratios and large positive asynchronies. As discussed previously, the behind-the-beat approach often occurs in eighth-note passages, particularly descending passages and passages in which off-beats are accented. In these passages, relatively low swing ratios are also prevalent ("Easy Green": excerpt 36:30, mm. 5-6, 10, 14; excerpt 36:59, mm. 3, 5-6, 12; "Swan Gaze": excerpt 84:50, mm. 11, 14, 16-18). This finding is in agreement with the analyses of the solos in the first study, in which straighter subdivision and a "laid-back" quality often occurred simultaneously in the context of descending eighth-note lines and/or eighth-note lines characterized by accented off-beats. Example 4.4 is a representative example in which low ratios occur in this context.

Example 4.4: "Easy Green," excerpt 36:59 (mm. 5-6): Note the low swing ratios (0.8:1, 1.2:1, and 1:1) indicated above piano notes in the context of a descending eighth-note line. Also note the large asynchronies (141, 73, 165, 78, and 147 ms) occurring on downbeats indicated below piano notes.



When there is an ascending melodic interval larger than a wholestep between the off-beat and the downbeat, swing ratios tend to be higher than usual ("Easy Green": excerpt 36:30, mm. 13-14; excerpt 36:59, mm. 2, 7; "Swan Gaze": excerpt 84:50, mm. 9-10, 14-15). Example 4.5 illustrates this technique.

Example 4.5: "Easy Green," excerpt 36:59 (mm. 1-2): Note the relatively large ratio of 2.5:1 above piano notes in measure 2, and its occurrence in the context of a wide ascending melodic interval (D to C-sharp).

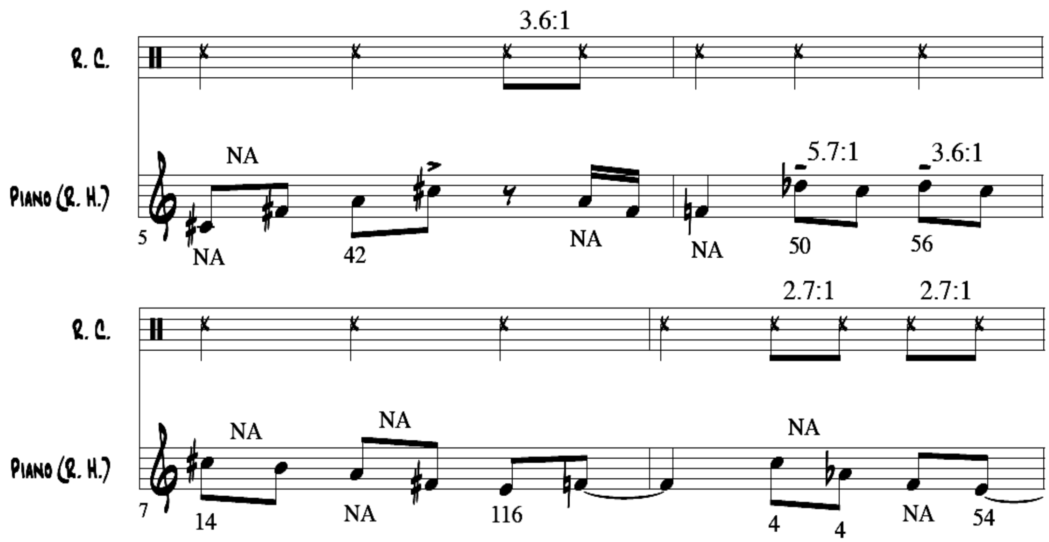


The largest swing ratio in the piano-solo excerpts of "Easy Green" takes place in a phrase in which the highest pitch occurs on a downbeat, progresses to the lower melodic neighbor on the off-beat, and returns to the high pitch on the downbeat (similar to the classical *mordent*). See Example 4.6.

Example 4.6: "Easy Green," excerpt 36:59 (mm. 3-6): The ratio of 2.7:1 indicated above piano notes (m. 4) is the largest of the ratios found in the piano-solo excerpts of "Easy Green." Note the melodic shape: The phrase begins on C, progresses to its lower neighbor, and returns to C (mm. 4-5).

Interestingly, the largest ratios in the piano-solo excerpt of "Swan Gaze" occur in the same melodic context as the largest ratio in "Easy Green": The highest pitch of a phrase occurs on a downbeat, progresses to the lower neighbor on the off-beat, and returns to the high pitch on the downbeat. See Example 4.7.

Example 4.7: "Swan Gaze," excerpt 84:50 (mm. 5-8): Note the large swing ratios (5.7:1 and 3.6:1) indicated above piano notes (m. 6), and the similarity in melodic context to the occurrence of the largest ratio in "Easy Green" (Example 4.6).



In summary, Hellmer's approach to swing subdivision is different in the two pieces because the ratios and deviations are noticeably larger in "Swan Gaze" compared to "Easy Green." However, musical elements have the same effect on ratios in both pieces. Melodic direction, melodic intervals, and placement of accents relate to the size of swing ratios in the piano solo as discussed above. In addition, smaller ratios frequently occur simultaneously with a "laid-back" approach to beat placement.

Average swing ratios less than 2:1 in the eighth notes of soloists performing at moderate tempos have been reported in other studies (Collier & Collier, 2002; Ellis, 1991; Friberg and Sundström, 2002; Reinholdsson, 1987; Rose, 1985, *cited in* Ellis, 1991). Findings indicate that at moderate tempos, soloists frequently perform swing subdivision more evenly than an exact triplet-based ratio. Furthermore, the approach of soloists is different than the approach evidenced in ride patterns: Soloists tend to play subdivision more evenly and with more variation (Friberg & Sundström, 2002).

Conclusions: Swing Subdivision

The present study suggests that the soloist approaches swing subdivision differently than the approach evident in the drummer's ride patterns. Ratios produced by the soloist are more even and exhibit greater variation than those found in the accompanying ride patterns. These findings give strength to the ideas that soloists tend to interpret swing subdivision more evenly than the swing subdivision of accompanying ride patterns, and that soloists approach swing subdivision with greater flexibility than accompanying instruments, ideas in agreement with the findings of Friberg and Sundström (2002).

In addition, musical elements relate to the swing ratios in the improvised melodies of the soloist, suggesting that variations in the subdivision occur as a part of musical expression. Specifically, the subdivision tends to be more even than usual in eighth-note passages that have a descending melodic shape and in passages in which off-beats are accented. In contrast, subdivision tends to be more uneven than usual when there is a large ascending melodic interval between the downbeat and off-beat, and in melodies in which a main pitch proceeds to its lower neighbor and returns again to the main pitch.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

The purposes of this dissertation were: 1) to delineate the characteristics of the rhythmic quality known as swing, and 2) to illustrate these characteristics through transcription and analysis of improvisatory musical examples from model recordings of straight-ahead jazz. First, the characteristics of swing, compiled from existing writings about jazz rhythm, were listed and defined (beat, rhythmic accuracy, democratization of the beat, relaxed-flowing-effortless quality, forward motion, rhythmic variety, idiomatic articulation, polyrhythm, phrasing flexibility, tension and release, interpretation of subdivision, and interpretation of beat placement). Then, two studies were conducted to explore the rhythmic techniques related to these characteristics in improvised solos and ensemble performances. The first study analyzed improvisations by master jazz soloists based on my transcribing and playing along with their recorded solos. In the second study, excerpts from a contemporary ensemble performance were transcribed and the micro timing of these excerpts was measured with the aid of software.

Each improvised solo in the first study effectively demonstrated all of the techniques investigated. Soloists emphasized off-beats primarily by placing dynamic accents on off-beats, and in the case of pianists left-hand comps on off-beats. Much rhythmic variety was evident throughout the solos and often within phrases. Soloists used idiomatic articulation devices throughout their improvisations. Polyrhythms were created mainly with triplets and irregular groupings of triplets. The performers showed a strong tendency to improvise phrases that were displaced in relation to the structural features of each piece, and used much variety in phrase lengths. Finally, soloists showed individualistic interpretations of beat placement and swing subdivision: This frequently involved straighter subdivision and a behind-the-beat approach, two techniques that tended to occur simultaneously.

In the excerpts of the second study, the timing of ride patterns was generally accurate and steady, and bass and piano-accompaniment attacks were slightly late in relation to ride-cymbal attacks. The temporal coordination of these three accompanying instruments was very consistent. In addition, the average swing ratios of the ride patterns were 2.6:1 and 2.8:1, more uneven than a precise triplet-based ratio, and swing subdivision was consistent in the ride patterns. In the piano solos, the interpretation of time feel contrasted with the approach to time feel in the accompanying parts. Piano-solo attacks were frequently placed very late in relation to ride-cymbal attacks, and the range of these asynchronies was relatively large. In addition, average piano-solo swing ratios were 1.2:1 and 2.1:1, more even than the ratios of the accompanying ride patterns, and the piano-solo ratios varied greatly throughout the short excerpts. Manipulations of swing subdivision and beat placement in the piano solos were often very perceptible, and seemed to be related to the melodic and rhythmic elements of the improvisations.

Discussion

The musical examples analyzed in both studies demonstrated the quality of swing very effectively. For instance, all of the examples exhibited a strong feeling of beat, that is, it was easy to perceive a pulse and tap along when listening to the recordings.

Accurate timekeeping is an important technique for generating a strong sense of beat, and there were some impressive indications of steady time in these performances. For example, in "Days of Wine and Roses" the tempo was stable at 155 bpm for the entire 51-measure piano solo. Another example of accurate timekeeping was found in the analysis of Brannen Temple's ride patterns. Temple's steadiness was clear when comparing his ride-cymbal attacks in relation to a theoretical metronomic beat. Average asynchronies between the ride cymbal and theoretical beat were as low as 1 ms, and standard deviations of the asynchronies were as low as 9 ms. The rhythmic accuracy of these excerpts was also apparent in the analysis of bass and piano-accompaniment parts, which were synchronized very consistently with the ride patterns as indicated by the low standard deviations of bass/ride-cymbal asynchronies and piano-accompaniment/ride-cymbal asynchronies. In a previous study, Collier and Collier (2002) analyzed the steadiness of trumpet solos performed by Louis Armstrong, and determined that Armstrong kept a remarkably steady beat during his unaccompanied solo breaks as well as when he performed with the ensemble. The results of these studies support the concept that accurate timekeeping is an important skill for jazz musicians and a strong factor in creating a feeling of swing. Monson (1996) emphasized this idea with remarks from jazz musicians, highlighting the connection between jazz rhythm and movement:

> A jazz musician is said to have good time if his or her underlying pulse is steady, strong, and infectious, with emphasis on the latter. Good time should make you want to "pat your feet," as Count Basie remarked, or make you want to "march along with it," as drummer Michael Carvin (1990) explained. The idea that good time should inspire movement remains fundamental. (p. 28)

The present studies provide several interesting observations regarding time feel in jazz performance, and particularly how factors such as tempo, instrument played, and performance function relate to time feel. The general effect of tempo on swing subdivision in jazz performance is clear and well documented (e.g., Collier & Collier, 1996; Collier & Wright, 1995; Friberg & Sundström, 1997). It is known that the swing ratio is not fixed, but instead the ratio generally increases as tempos decrease and vice versa. This tendency for swing ratios to be affected by tempo was observed in the analysis of improvised solos in the first study. For example, in the two solos by Oscar Peterson swing subdivision was generally triplet-based, but passages of straighter subdivision (i.e., ratios lower than 2:1) were frequently found in the faster tempo of "Autumn Leaves." Also, in Wynton Kelly's performance of "Autumn Leaves," which represented the slowest tempo of any of the transcriptions, there was frequent of use of subdivision more uneven than triplet-based subdivision (i.e., ratios greater than 2:1). This effect of tempo on swing ratios was also evident in the analysis of excerpts from *On the Cusp*, in which the two selections "Easy Green" and "Swan Gaze" represented contrasting tempos. The lower average swing ratios were found in the faster tempo of "Easy Green." Previous studies of jazz timing have reported this same effect of tempo on swing ratios (Collier & Collier, 1996; Ellis, 1991; Friberg & Sundström, 2002, 1997). In summary, faster tempos generally produce smaller ratios, and slower tempos generally produce larger ratios.

The relationship between tempo and beat placement is less clear than the relationship between tempo and swing subdivision. In many beat-based timing tasks, such as those used in the study of BPS, slower tempos are associated with greater variability in synchronization accuracy because these tasks are generally more difficult at slower tempos (Allan, 1979; Aschersleben, 2002; Fraisse, 1982; Ivry & Hazeltine, 1995; Keele, *et al*., 1985; Parncutt, 1994; Repp, 2005). This idea might lead to the hypothesis that asynchronies between musical parts should be greater when slower tempos are performed. However, musicians often demonstrate exceptional skills in synchronization, including the ability to coordinate their parts accurately within a broad range of tempos. In these studies, there was no strong evidence that tempo had an effect on beat placement, although some of the differences among the examples might be related to differences in tempo.

For example, tempo may have played a role in the differences in beat placement between the two performances of "Autumn Leaves" by Oscar Peterson and Wynton Kelly. In the slower tempo of Kelly's rendition, a behind-the-beat approach was much more apparent than in Peterson's version, hence the slower tempo was associated with the greater manipulation of beat placement. However, in comparing the two performances by Peterson: "Autumn Leaves" and "Days of Wine and Roses," the opposite effect of tempo was observed: There was slightly more variation of beat placement in the faster tempo of "Autumn Leaves."

Similarly, in the analysis of excerpts from *On the Cusp*, comparisons between the average asynchronies in the two pieces "Easy Green" and "Swan Gaze" showed that the slower tempo of "Swan Gaze" resulted in greater bass/ride-cymbal asynchronies and piano-accompaniment/ride-cymbal asynchronies. Thus, the slower tempo resulted in greater asynchronies in the accompanying rhythm section. However, the opposite effect was observed when the piano solo was analyzed. Average piano-solo/ride-cymbal asynchronies were slightly lower in the slower tempo of “Swan Gaze.” Bear in mind that differences between the average asynchronies in “Easy Green” and “Swan Gaze” were often very slight. In addition, there were minimal differences in ride-cymbal/theoretical-beat asynchronies between “Swan Gaze” and “Easy Green.” These minimal differences show that Temple’s timekeeping was highly accurate in both tempos. Furthermore, the synchronization of the accompanying piano and bass in both pieces was quite consistent despite the contrasting tempos. In summary, there were no compelling effects of tempo on beat placement in the examples analyzed.

Other factors that may have affected time feel are performance medium (i.e., instrument) and function (melody vs. accompaniment). For example, the study of improvised solos revealed differences in Marsalis’s swing subdivision compared to the other soloists, which may be attributed to instrument played. Marsalis performed on the trumpet, whereas the other soloists were pianists. Marsalis consistently exhibited a quite even approach to eighth notes with a strong tendency to regularly accent off-beats. The piano soloists tended to use a more triplet-based approach to subdivision, however straighter subdivision with accented off-beats was used by the pianists at times. Perhaps straighter subdivision is more idiomatic in jazz trumpet improvisations than in jazz piano improvisations, however many more solos would have to be compared before drawing such a conclusion.

The analyses of excerpts from *On the Cusp* revealed that there were strong differences in swing subdivision between the accompanying ride-cymbal part and the piano solo. Ride-pattern swing ratios were more uneven and more consistent than piano-solo swing ratios. The average ride-cymbal ratios exceeded the triplet-based 2:1 ratio in "Easy Green" and "Swan Gaze" while average piano-solo ratios were less than or almost equal to 2:1. In addition, standard deviations showed that ride-cymbal ratios were much more consistent than piano-solo ratios. This contrast in consistency becomes even more striking when standard deviations are expressed as a percentage of the average ratio. Standard deviations in the piano ratios were as high as 62% of the mean, whereas standard deviations in the ride-cymbal ratios were as low as 12% of the mean. Similar differences between swing ratios in improvised solos compared to swing ratios in accompanying ride patterns have also been observed in previous studies. Friberg and Sundström (2002) analyzed the swing ratios in solos and accompanying ride patterns of the same performances, and found that the subdivision of ride patterns was more uneven (larger ratios) and more consistent (smaller standard deviations) than the subdivision of soloists. No additional research has directly compared the subdivision of soloists with accompanying ride patterns, but a number of studies have reported swing ratios lower than 2:1 in the improvisations of soloists (Collier & Collier, 2002; Ellis, 1991; Friberg & Sundström, 2002; Reinholdsson, 1987; Rose, 1985, *cited in* Ellis, 1991), and a number of studies have reported swing ratios greater than 2:1 in accompanying rhythm sections (Collier & Collier, 1996; Friberg & Sundström, 2002, 1997; Rose, 1989). In summary, the results of the present and previous studies indicate that swing subdivision in accompanying ride patterns differs from swing subdivision in improvised solos when moderate tempos are performed. Soloists generally gravitate toward ratios less than 2:1 and may vary the ratio greatly for expressive purposes, while ride-pattern ratios are generally greater than 2:1 and consistent.

Performance medium (i.e., instrument) and function (solo vs. accompaniment) are also important in the interpretation of beat placement. Musicians performing on instruments fulfilling an accompaniment function generally exhibit accurate and consistent approaches to synchronization, whereas improvising soloists may exhibit large asynchronies and very flexible interpretations of beat placement. In fact, all of the soloists in the first study demonstrated some flexibility of beat placement. This often involved delaying one or two notes for expressive purposes or playing passages in which a behind-the-beat approach was noticeable. For example, Peterson and Roberts delayed the timing of the highest note in a phrase, and Kelly, Marsalis, and Roberts frequently performed sequences of notes that were noticeably behind the beat. Marsalis, the only non-pianist in the study, displayed the most flexible approach to time feel, and his instrument, the trumpet, is rarely used in accompanying roles compared to the piano.

In the analysis of excerpts from *On the Cusp*, accompanying instrumentalists approached beat placement with an emphasis on accuracy and consistency while the soloist often played very much behind the beat and demonstrated much flexibility in his approach to beat placement. These differences related to performing function were observed when pianist Jeff Hellmer's playing was analyzed in accompaniment and solo contexts. As accompanist, Hellmer synchronized his parts closely and consistently with the ride patterns. In fact, piano-accompaniment/ride-cymbal asynchronies were very similar to bass/ride-cymbal asynchronies, as the bassist was also performing an accompanying function. In contrast, Hellmer as the soloist frequently played far behind the beat of the ride patterns and exhibited much flexibility in his approach to synchronization, as evidenced by the high means and standard deviations in piano-solo/ride-cymbal asynchronies. Thus, contrasting approaches to beat placement related to performance function were found even in the case of the same performer playing the same instrument and the same piece.

These results are in agreement with previous studies. Friberg and Sundström (2002) showed that accompanying bassists synchronized their parts more closely and consistently with ride patterns than did soloists, and soloists often demonstrated much flexibility in synchronization and played very behind the beat of ride patterns. No additional studies directly compared accompaniment function to solo function, but Rose (1989) found that the players in a rhythm section performing an accompaniment function synchronized their parts with great accuracy and consistency. In contrast, Ellis (1991) observed jazz saxophonists placing their attacks very behind the beat of accompanying rhythm-section tracks. In summary, musicians performing an accompaniment function tend to synchronize their parts closely and consistently, whereas musicians performing a solo function often play behind the beat of accompanying rhythm sections and vary beat placement greatly for expressive purposes.

When jazz musicians perform as soloists, the interpretation of time feel presents opportunities for musical expression. It may be argued that soloists' ways of interpreting time feel are important distinguishing aspects of their individualistic “sounds” or “voices” (see Liebman, 1997). This concept that personal stylistic preferences are expressed through time feel is supported by the observation that different soloists exhibit distinct approaches to time feel. In fact, the examples in the present investigation represented the straight-ahead rhythmic style performed at similar tempos with similar instrumentation, and in the case of the first study were based on standard 32-bar compositions. Despite these commonalities, differences in time feel were evident among the improvised solos. For example, Peterson’s performance of “Days of Wine and Roses” was characterized by precise beat placement and consistent swing subdivision, whereas there was more variation of beat placement and passages of straighter subdivision in his performance of “Autumn Leaves.” Additionally, in another performance of “Autumn Leaves,” Kelly often used a behind-the-beat approach and subdivisions resembling dotted-eighth/sixteenth-note rhythms. In the second study, aspects of Hellmer’s unique approach to time feel were observed, including a behind-the-beat approach when performing a quarter-note-triplet rhythm and very uneven subdivision when executing melodies in which a main pitch descended to a lower neighbor and returned to the main pitch.

Previous studies of jazz timing have also revealed distinct approaches to time feel in various performances. Friberg and Sundström (2002) used famous jazz recordings to document differences in the time feel of six soloists as well as four bassist/drummer pairs. Prögler (1995) recorded bassists playing walking bass lines along with recordings of drummers performing ride patterns, and reported differences in the time feel of individual musicians. And Ellis (1991) instructed jazz saxophonists to perform simple notated musical examples along with an accompaniment track, and found differences among the individuals' approaches to time feel even when playing the same material with the same equipment and the same accompaniment track. Hence, the findings of individualistic approaches to time feel are important because they show that jazz musicians go beyond just playing rhythms correctly. Experienced jazz musicians use interpretation of beat placement and swing subdivision as tools for musical expression. As such, these tools are a significant aspect in the development of a personal "sound" or "voice," and are also important elements contributing to the feeling of swing in improvised solos.

Although there were distinctions in the individual approaches to time feel among soloists, there were also some striking commonalities in soloists' approaches to time feel. These commonalities suggest some basic principles related to how expert jazz soloists use time feel. Interestingly, a number of these commonalities are associated with the interaction of melodic and rhythmic elements with timing. For example, swing ratios in all improvised solos were influenced by specific melodic and rhythmic elements. Straighter subdivision was often found in sequences of eighth notes that had a descending melodic direction and frequent accents on off-beats. A behind-the-beat approach was also evident in these passages. This phenomenon was observed in solos by Peterson, Kelly, Marsalis, Roberts and Hellmer. In addition, the beat placement of single notes was sometimes delayed when notes represented the highest pitch in a given phrase (Peterson and Roberts), and when notes were preceded by a melodic upper neighbor or accented note (all soloists).

The rhythmic context of off-beat versus downbeat related strongly to beat placement. The behind-the-beat approach of soloists was markedly evident for notes occurring on downbeats, whereas notes occurring on off-beats tended to be more closely synchronized with ride patterns. For example, in Hellmer's solos the means of piano-solo/ride-cymbal asynchronies on downbeats were 79 and 71 ms, compared to 31 and 30 ms on off-beats. Friberg and Sundström (2002) found similar results: Mean asynchronies for soloist/ride-cymbal asynchronies on downbeats ranged from about 30 to 90 ms, and about -5 to 15 ms for off-beats (moderate tempos).

In general, behind-the-beat playing seems to be the preference of experienced soloists. All of the soloists in the present and previous studies tended to play behind the beat of accompanying rhythm sections. Some soloists played more consistently behind the beat than others, but none of the soloists showed a tendency to play ahead of the beat when moderate tempos were performed[42]. Similarly, in the study by Ellis (1991), all of the jazz saxophonists placed attacks behind the beat of the accompaniment. In addition, many authors refer to the tradition of jazz soloists creating a "laid-back" feeling by playing behind the beat of rhythm sections (e.g., Berliner, 1994; Ellis, 1991; Friberg and Sundström, 2002; Liebman, 1997), suggesting that this "laid-back" approach is an important aspect of swing. The findings of this dissertation and previous studies indicate

[42] In the study by Friberg and Sundström (2002), there were some occurrences of soloists playing slightly ahead of the beat at tempos greater than 250 bpm.

that it is idiomatically appropriate for jazz soloists to play behind the beat of accompanying rhythm sections.

In review, similarities among soloists' interpretations of time feel suggest some general principles. Straighter subdivision and behind-the-beat playing frequently occur in sequences of eighth notes that have a melodic descending direction and in which off-beats are regularly accented. This simultaneous use of behind-the-beat attacks, straighter subdivision, and accentuation of off-beats is likely an effective technique for generating an idiomatic time feel for jazz soloists. Interestingly, this technique results in an uneven quality of eighth notes, which is suitable to the jazz style, but in this case achieved with accentuation of off-beats as opposed to being achieved with the use of triplet-based subdivision (i.e., 2:1 swing ratios). In addition, single notes are frequently performed behind the beat when preceded by an accented off-beat or melodic upper neighbor, or when a note represents the highest pitch in a given phrase. Furthermore, in relation to ride patterns, soloists delay the placement of notes on downbeats to a greater degree than notes on off-beats, naturally resulting in a more even swing subdivision than the subdivision in the accompanying ride patterns. Lastly, experienced soloists rarely play ahead of the beat of accompanying rhythm sections.

In the examples analyzed, many of the timing manipulations of the soloists were highly perceptible. In contrast, the timing differences demonstrated by the accompanying instrumentalists were imperceptible or barely perceptible at best. This suggests that accompanying instrumentalists generally try to play with accuracy and cohesiveness, while soloists may choose to manipulate timing for expressive purposes. In addition, the fact that specific musical elements are related to soloists' manipulations gives further support to the idea that these manipulations are intentional for musical expression. If deviations of timing were a result of random error, they would not frequently occur in the same musical context. Jeff Hellmer agreed that the timing variations in his solos were intentional for expressive purposes, although he pointed out that this occurred on an intuitive level as opposed to being a conscious thought process (personal communication, April 15, 2008). In the musical examples of this paper, the basic approach to ensemble timing is one in which rhythm sections provide stability while soloists frequently use timing deviations to create tension or other expressive qualities.

There is an interesting parallel between the effect of performance function (solo vs. accompaniment) on time feel and the idea of syncopation. Syncopation, in the broadest sense, can be defined as juxtaposition of irregularity against regularity. Generally speaking, in straight-ahead jazz the rhythm section provides regularity while the soloist creates irregularity. This is evident when soloists emphasize off-beats, use irregular phrase placement, and create polyrhythms as illustrated in the first study, while accompanying rhythm sections provide a stable underpinning in which rhythmic patterns are often repetitive. Comparably, the results of the second study show that the micro timing of rhythm sections tends to be quite accurate and therefore stable while the micro timing of soloists is flexible and creates a degree of tension. Therefore, both *timing* and *content* contribute to the phenomenon of irregularity juxtaposed against regularity. This quality – irregularity against regularity (or tension against stability) – is one of the most fundamental principles of rhythm in straight-ahead jazz performance.

Recommendations for Practice and Performance

One of the objectives of this paper was to contribute an in-depth examination of jazz rhythm that would ideally have practical applications for students and educators. For example, practice methods that incorporate the rhythmic techniques of master improvisers, such as these practice suggestions listed below, may be beneficial for aspiring jazz musicians. Each of the following practice ideas is related to the rhythmic techniques demonstrated by the master soloists analyzed in the first study.

1. Practice incorporating more syncopation into improvised solos by accenting off-beats or avoiding downbeats. Pianists can practice placing left-hand comps on off-beats.
2. Develop rhythmic variety by mastering the use of every conceivable rhythmic value in improvisational playing. Practice creating phrases that use at least three different rhythmic values. Experiment with unconventional rhythmic approaches by playing rhythms that cannot be represented by conventional notation.
3. Develop idiomatic articulation by playing solos that use all possible articulation devices. Practice creating phrases that use more than one articulation device. Practice accenting melodic upper neighbors that occur on off-beats. Imitate the most striking articulation devices of admired jazz soloists. Practice increasing the use of ghost notes and dynamic accents, thereby creating more dynamic contrast. Incorporate other dynamic devices such as crescendos and diminuendos. Pianists can strive for dynamic contrast between accompaniment and solo parts.

4. Develop phrasing flexibility by practicing improvisations in which irregular phrase lengths are predetermined or phrase lengths are consciously varied. Practice starting and ending phrases in different places in the formal structure. Consciously avoid "square" phrasing, that is, phrasing that consistently aligns with the two- and four-measure structures of many jazz standards.
5. Master the triplet-based ratio of 2:1 by practicing with a metronome that subdivides the beat into three equal partials. Mastery of the 2:1 ratio should provide a frame of reference for deviation from the 2:1 ratio. Practice playing eighth notes at moderate tempos that are slightly more even than 2:1. Practice varying swing subdivision throughout improvisations. Imitate the swing subdivision of admired soloists by learning their solos and practicing them accompanied by the recordings.
6. Practice accurate (middle-of-the-beat) rhythmic placement in relation to accompanying metronomes, rhythm tracks, or rhythm sections. Also practice playing slightly behind the beat of the accompaniment. Practice phrases in which behind-the-beat playing occurs simultaneously with straighter subdivision and accented off-beats.

Along with the practice techniques listed above for soloists, the following concepts derived from the second study can be applied to ensemble performance. Each of these practice ideas are related to the rhythmic techniques demonstrated in the excerpts from *On the Cusp*.

1. Accompanying instrumentalists can strive to coordinate parts with great accuracy. For example, bassists and drummers can strive to synchronize their bass lines and ride patterns as precisely as possible, and pianists when comping can place their chords in close synchrony with the attacks of the ride cymbal and bass. Bassists can be aware of the fact that their instrument produces tones with longer rise times than ride-cymbal tones, therefore the physical motion required to play the bass may have to occur a shade earlier than the striking of the cymbal for perceptual attack times to be synchronized. Drummers can place cymbal attacks "on top of the beat," avoiding the tendency to let the tempo drag when bassists or soloists play slightly behind the beat.
2. At medium tempos, drummers can become comfortable with ride pattern ratios slightly greater than 2:1, and adjust the ratio appropriately as different tempos are performed (i.e., incrementally reduce the ratio as tempos increase). Drummers can aim for consistency in the swing subdivision of ride patterns within a given tempo. Drummers can imitate the ride patterns of the expert drummers whom they most admire.
3. Soloists can strive to either play in precise synchrony with the beat of the rhythm section, or slightly behind the beat. An ahead-of-the-beat approach may not be desirable in the straight-ahead style. Soloists can explore flexibility in beat placement and swing subdivision, particularly at slower tempos. Soloists can incorporate idiomatic approaches to time feel, such as the simultaneous incorporation of behind-the-beat playing with straighter subdivision and

accentuation of off-beats. Soloists can imitate the time feel of expert soloists whom they admire.

A few observations in this document were somewhat surprising or striking, and it is recommended that educators consider these particular observations and how they may impact the teaching of jazz rhythm. First, the bass played behind the beat of the ride cymbal, not "on top of the beat." Second, there were different approaches to swing subdivision in the same performances; thus, not all members of an ensemble are required to interpret subdivision in the same manner. Lastly, soloists often played behind the beat of rhythm sections, and this behind-the-beat approach was particularly strong in passages that had a descending melodic direction. This is notable because many students tend to rush when improvising, and the problem of rushing is often increased when playing descending passages.

Suggestions for Further Research

To date the amount of research in jazz rhythm and timing is relatively small, particularly when compared to the vast body of existing jazz recordings. In fact, the present contribution to this research is limited to just five improvised solos and several short excerpts from two ensemble pieces. Future research might investigate additional historical periods, performers, instrumentations, tempos, and rhythmic styles.

For example, jazz rhythm has changed historically, and the exploration of recordings from different periods could provide insight into how and why time feel in jazz may have evolved. In addition, the recorded work of many well-known jazz masters has not been investigated scrupulously for rhythmic features. Such investigation might lead to increased understanding of the performance styles of the music's preeminent artists. It would also be valuable to investigate more rhythmic styles, including genres that are outgrowths of jazz, such as rock-n-roll, rhythm and blues, and funk, to determine the extent to which the characteristics of swing are evident in various styles.

In the present investigation, the recordings of experts were used to gain knowledge about the characteristics of jazz rhythm. Additional research related to the practice and pedagogy of experts could potentially elucidate how rhythmic skills are taught and learned. The documentation of techniques that benefit the development of rhythmic skills would aid educators who strive to teach jazz rhythm successfully.

The second study in this paper observed differences in time feel that seemed to be related to tempo, instrument played, and performance function. Additional research is needed to draw strong conclusions about the effects of these variables. For example, more tempos and a greater variety of instruments could be examined. Also, it was particularly compelling that the same performer (Jeff Hellmer) demonstrated contrasting approaches to time feel based on solo versus accompaniment function. It would be interesting to analyze other performers in these two contexts to determine if the same relationships between time feel and performance function would be observed. Lastly, melodic and rhythmic elements in the improvised solos interacted with particular manipulations of time feel in the examples studied. Further research examining the effect of these elements on time feel in more performances is needed.

Additional perceptual studies would be beneficial for the interpretation of research on jazz timing. At present, it is largely unknown how listeners perceive timing deviations in jazz performances. For example, is playing 40 ms behind the beat of a ride pattern enough to generate a “laid-back” feeling? Studies could explore how much deviation of swing subdivision and beat placement must occur for listeners to perceive a difference in “feel.” Also, researchers could present to experienced listeners musical examples representing different approaches to time feel, and inquire about their opinions regarding the timing of each example.

There have been relatively few empirical studies investigating the perceptual attack time of musical tones, and more information about this subject is needed to better understand and more effectively measure the perception of asynchrony in musical contexts. In fact, no research has explored the perceived synchronization of ride cymbal and bass. Because ride-cymbal and bass tones have contrasting acoustical characteristics, factors that affect perceptual attack time may vary greatly between the two types of musical sounds. The optimal conditions for perceptual synchrony of bass and ride-cymbal attacks are unknown. Investigation into this matter could potentially offer increased understanding of how bass and ride-cymbal parts are coordinated in performance and perceived by the listener, an important concept because the synchronization of walking bass lines and ride patterns is one of the most fundamental techniques of straight-ahead jazz.

APPENDIX A: SOLO TRANSCRIPTIONS

Autumn Leaves

Kosma, Prevert, & Mercer
Solo by Oscar Peterson, trans. by A. Belfiglio


straighter, lay back
13
16
19
21
24


(8va)
straighter 8ths
27
straighter, lay back
30
A
33
36
39


4
A1
late
straight
42
44
46
48


8
5
50
53
55
57


6
late
60
straighter
63

Autumn Leaves

Kosma, Prevert, & Mercer
Solo by Wynton Kelly, trans. by A. Belfiglio


14
lay back
17
21
24
28
lay back


A
32
35
16ths detached
38
A1
40


4
(8va)
lay back
42
8va
as written
44
46
48
8


lay back
52
55
58
61


A
early
A1
65
68
71
74


76
78
80
84
86


8
88
92
96

Days of Wine and Roses

Henry Mancini
Solo by Oscar Peterson, trans. by A. Belfiglio


2
16
A1
19
22
25
26


28
31
late
34
more straight
lay back
36
40


4
lay back
cresc.
44
8va
48
(8va)
A1
50

April in Paris

Duke & Harburg
Solo by Wynton Marsalis, trans. by Anthony Belfiglio


2
A2
lay back
push ahead
freely
A
in time
very behind the beat
A1
behind the beat and straighter
B

* In the "somewhat freely" sections, the notation is not interpreted strictly because this passage is problematic to notate conventionally.
Establish a pulse approximately equal to the 8th-note triplet, but not necessarily related to the beat of the rhythm section, and apply the groupings as indicated by the slurs.
Sextuplets and septuplets are not clearly distinguishable, instead the pulse accelerates slightly at the septuplets.
Measure lines do not coincide precisely with the beats of the rhythm section.
Listen to the recording to get the feel.

April in Paris

Duke & Harburg
Solo by Marcus Roberts, trans. by A. Belfiglio


2
B
16
19
late
very behind the beat
straight
21
A2
24
freely
27


3
29
A
32
freely, gradually slower
straight, lay back
35
lay back, gradually morph to off-beat
A1
37
41


43
46
late
49
51

* the quarter-note triplet becomes the new quarter note

APPENDIX B: GROUP TRANSCRIPTIONS AND TIMING MEASUREMENTS

Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 32:17-32:35)

Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
bass line by John Fremgen


NA 1 9 12 25 6
R. C.
345 ms
NA 28 11 24 -6 NA
Bass
7
NA 3 -20 9 18 14 10
R. C.
346 ms
-17 25 77 62 24 8 15
Bass
9
NA 22 -5 7 2 -9 5
R. C.
344 ms
23 2 NA NA 1 13 NA
Bass
11
NA
R. C.
18
Bass
13

Easy Green: Ride Cymbal and Bass (excerpt 32:17-32:35)

Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


R. C.
Bass
2.3:1
2.6:1
NA
28
11
24
-6
NA
7
2:1
2.3:1
NA
-17
25
77
62
24
8
15
9
1.9:1
23
2
NA
NA
1
13
NA
11
18
13

Easy Green: Ride Cymbal and Piano Accompaniment (excerpt 32:17-32:35)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown below piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


2.3:1
2.6:1
R. C.
Piano
7
2:1
2.3:1
NA
R. C.
Piano
9
111
1.9:1
R. C.
Piano
11
60
19
R. C.
Piano
13
NA

Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 33:15-33:38)

Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
bass line by John Fremgen


R. C.
Bass
NA -14 -22 -8 -11 -6 8 -4
361 ms
-52 43 37 12 36 11 7 36
7
NA 2 -3 -6 -8 6 6
353 ms
37 20 24 NA 25 19 23 NA
9
NA -1 33 26 11 -6 1 5
358 ms
38 61 1 -3 7 56 43 22
11
NA 0 4 NA 0 NA NA NA
351 ms
1 15 26 NA 29 30 NA NA
13

Easy Green: Ride Cymbal and Bass (excerpt 33:15-33:38)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


Easy Green
R. C.
Bass
2.2:1
2.6:1
2.5:1
2.2:1
-52 43 37 12
36 11 7 36
7
2.5:1
2.3:1
2.7:1
2.7:1
2.5:1
3:1
37 20 24 NA
25 19 23 NA
9
2.5:1
2.5:1
2.6:1
38 61 1 -3
7 56 43 22
11
NA NA
NA NA
1 15 26 NA
29 30 NA NA
13

Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 35:12-35:33)

Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


2
Easy Green
R. C.
NA NA NA 15 6 3 13
344 ms
Bass
NA 40 NA 20 13 36 19
7
R. C.
NA 18 4 -6 20 15 14 10
347 ms
Bass
46 28 18 NA 11 29 11 11
9
R. C.
NA -7 3 -5 6 7 5
345 ms
Bass
19 26 38 29 41 11 21
11
R. C.
NA NA NA NA NA
Bass
12 NA NA NA NA
13

Easy Green: Ride Cymbal and Bass (excerpt 35:12-35:33)

Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
bass line by John Fremgen


R. C.
Bass
2.5:1
2.7:1
2.7:1
NA
40
NA
20
13
36
19
7
2.1:1
2.6:1
2.7:1
46
28
18
NA
11
29
11
11
9
2.7:1
2.1:1
19
26
38
29
41
11
21
11
NA
3:1
12
NA
NA
NA
NA
13

<u>Easy Green: Ride Cymbal and Piano Accompaniment (excerpt 35:12-35:30)</u>

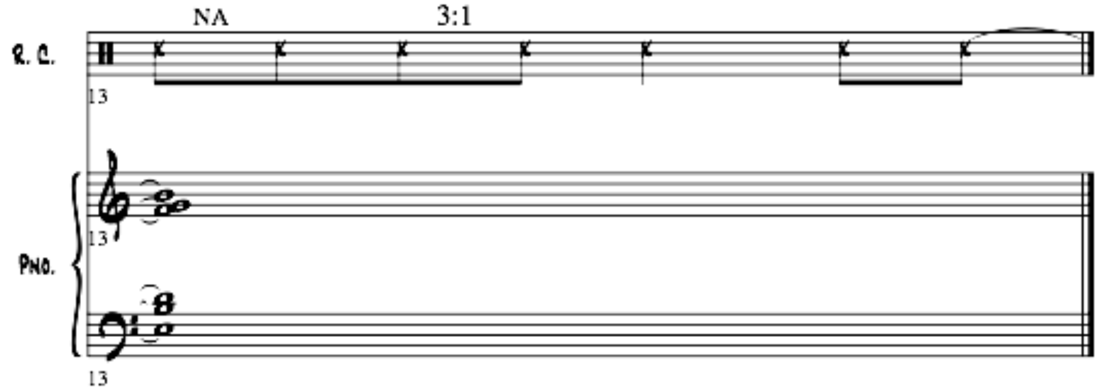
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown below piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


R. C.
Pno.
5
44
27
NA
2.5:1
2.7:1
2.7:1
7
55
15
NA
45


2.1:1
2.6:1
2.7:1
R. C.
Pno.
9
39
2.7:1
2.1:1
R. C.
Pno.
11
41
53
29


NA
3:1
R. C.
13
Pno.
13
13

Easy Green: Ride Cymbal/Theoretical Beat and Bass (excerpt 36:30-36:52)

Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
bass line by John Fremgen

R. C.
Bass
NA -14 21 4 -5 17 21 -8
347 ms
42 42 12 25 57 12 26 42
7
NA -1 14 -12 7 0 -10 -2
351 ms
-27 25 -15 47 33 31 24 49
9
NA 2 -11 -11 -3 -9 1 12
342 ms
25 35 36 52 45 43 41 16
11
NA 4 -8 -9 NA
346 ms
NA 32 NA 35 4
13

Easy Green: Ride Cymbal and Bass (excerpt 36:30-36:52)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


3.2:1
3.1:1
R. C.
42
42
12
25
57
12
26
42
Bass
7
R. C.
-27
25
-15
47
33
31
24
49
Bass
9
2.6:1
2.4:1
R. C.
25
35
36
52
45
43
41
16
Bass
11
R. C.
NA
32
NA
35
4
Bass
13

Easy Green: Ride Cymbal and Right-Hand Piano Solo (excerpt 36:30-36:52)
Swing ratios are shown over eighth-note pairs. Asynchronies (in ms) are shown under piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


3.2:1
3.1:1
R. C.
Piano (R. H.)
7
59
35
23
46
23
R. C.
Piano (R. H.)
1.1:1
1:1
1:1
1.1:1
9
133
73
182
NA
81
123
2.6:1
2.4:1
R. C.
Piano (R. H.)
11
46
NA
115
NA
80
NA
R. C.
Piano (R. H.)
1.3:1
0.9:1
NA
13
38
79
49
37
-2

Easy Green: Ride Cymbal and Right-Hand Piano Solo (excerpt 36:59-37:21)
Swing ratios are shown over eighth-note pairs. Asynchronies (in ms) are shown under piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Easy Green

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


R. C.
Piano (R. H.)
2.6:1
2.4:1
1.4:1
1:1
7
29 91 90 194 25
2.8:1
2.4:1
2.6:1
0.9:1
9
74 116 NA 39 179
2.5:1
8va
0.9:1
0.5:1
11
52 22 70 56 145 58
2.8:1
2.3:1
3:1
(8va)
1.6:1
0.7:1
13
26 41 18 72 108 44 34 6 44

Swan Gaze: Ride Cymbal/Theoretical Beat and Bass (excerpt 84:50-85:35)

Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


R. C.
Bass
NA 12 1 5 14 5
484 ms
43 37 59 32 26 NA
7
NA -6 -7 -6 22 14
474 ms
24 102 NA 70 NA NA
9
NA -16 3 -15 1 6
478 ms
NA 73 65 80 NA 46
11
NA 35 39 35 13 22
471 ms
NA NA 53 NA 47 57
13

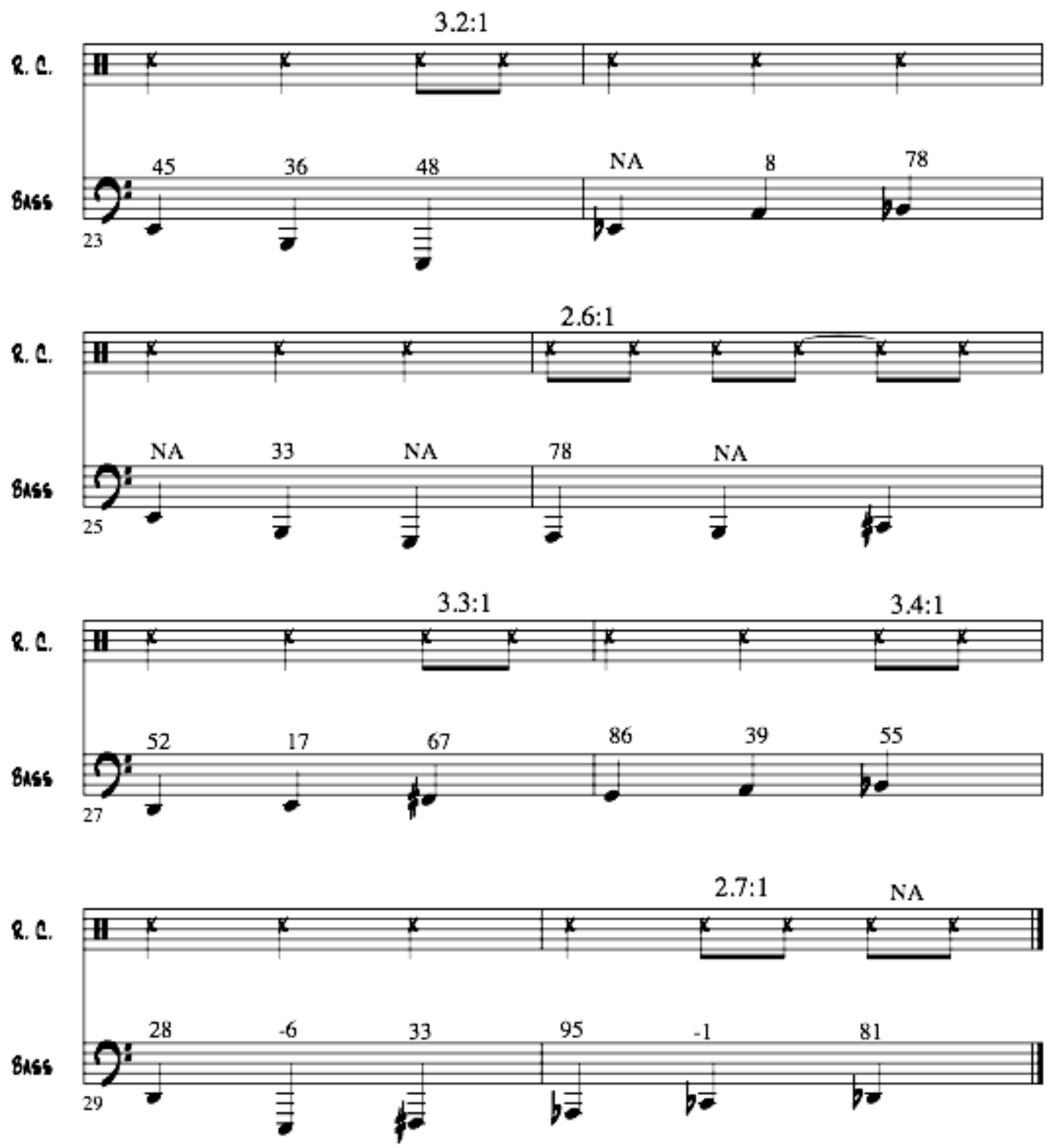

R. C.
Bass
NA 14 14 17 -1 3
482 ms
NA 36 36 36 35
15
NA -18 -23 3 -15 -12
484 ms
36 NA NA NA 28 55
17
NA -27 -25 -23 -18 -11
475 ms
NA 66 61 49 75 49
19
NA 8 3 4 -2 NA
479 ms
NA 43 27 NA 49 NA
21


NA 6 -13 -7 -10 -39
R. C.
483 ms
45 36 48 NA 8 78
Bass
23
NA 4 -6 5 11
R. C.
482 ms
NA 33 NA 78 NA
Bass
25
NA 13 -14 -9 -13 -11
R. C.
485 ms
52 17 67 86 39 55
Bass
27
NA 7 0 -4 11 NA
R. C.
480 ms
28 -6 33 95 -1 81
Bass
29

Swan Gaze: Ride Cymbal and Bass (excerpt 84:50-85:35)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


R. C.
BASS
2.7:1 2.7:1
43 37 59 32 26 NA
7
2.5:1 NA 2.9:1
24 102 NA 70 NA NA
9
2.8:1 3.6:1 3.1:1 3:1
NA 73 65 80 NA 46
11
3.1:1 3:1 3:1 3.4:1
NA NA 53 NA 47 57
13


R. C.
Bass
2.9:1
3
NA
36
36
36
35
15
2.8:1
2.5:1
NA
2:1
1.9:1
36
NA
NA
NA
28
55
17
3:1
NA
66
61
49
75
49
19
NA
NA
43
27
NA
49
NA
21

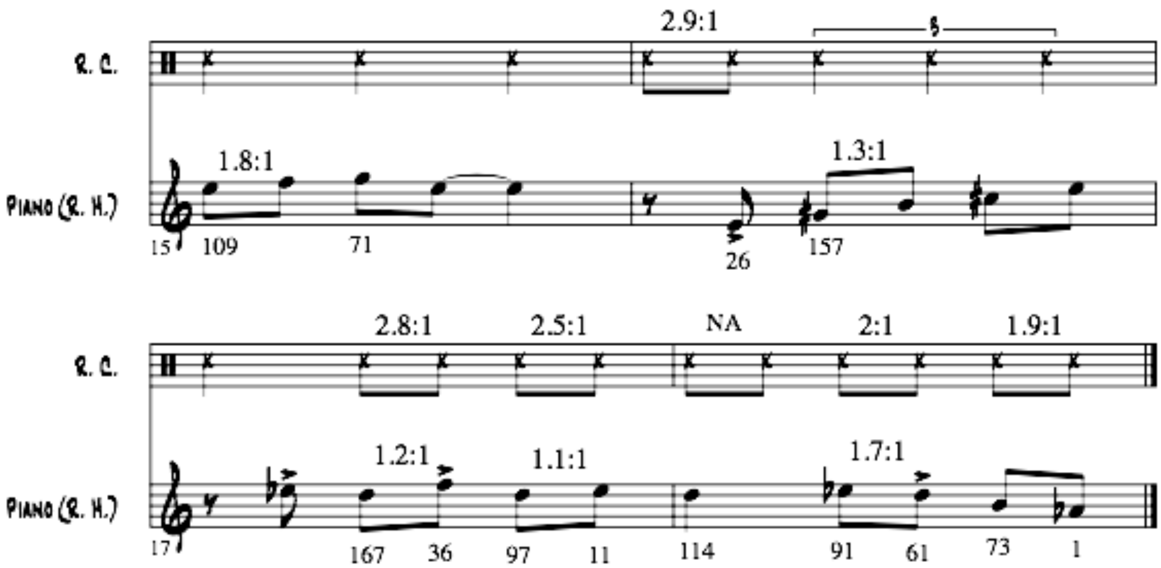

3.2:1
R. C.
Bass
45
36
48
NA
8
78
23
2.6:1
NA
33
NA
78
NA
25
3.3:1
3.4:1
52
17
67
86
39
55
27
2.7:1
NA
28
-6
33
95
-1
81
29

Swan Gaze: Ride Cymbal and Right-Hand Piano Solo (excerpt 84:50-85:21)
Swing ratios are shown over eighth-note pairs. Asynchronies (in ms) are shown under piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Swan Gaze

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


R. C.
Piano (R. H.)
2.7:1
2.7:1
NA
NA
NA
7
14
NA
116
4
4
NA
54
2.5:1
NA
2.9:1
2.3:1
9
57
56
NA
2.8:1
3.6:1
3.1:1
3:1
NA
1.4:1
11
46
59
NA
NA
67
12
110
46
42
3.1:1
3:1
3:1
3.4:1
NA
1.2:1
2.1:1
13
-8
NA
NA
102
3
94
62


R. C.
Piano (R. H.)
2.9:1
3
1.8:1
1.3:1
15
109
71
26
157
2.8:1
2.5:1
NA
2:1
1.9:1
1.2:1
1.1:1
1.7:1
17
167
36
97
11
114
91
61
73
1

Swan Gaze: Ride Cymbal/Theoretical Beat and Bass (excerpt 87:10-87:54)
Asynchronies (in ms) between ride cymbal and theoretical beat are shown above ride-cymbal notes; positive values indicate that cymbal attacks occur after the theoretical beat, and negative values indicate that cymbal attacks occur before the theoretical beat. Theoretical beat durations (in ms) for two-measure segments are shown below the ride-cymbal notes. Asynchronies (in ms) between bass and ride cymbal are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


R. C.
BASS
NA 6 23 20 18 10
472 ms
64 39 47 56 60 48
7
NA NA 20 -6 6 8
473 ms
54 NA 36 65 3 28 52
9
NA 11 -4 0 22 NA
466 ms
66 76 54 NA 3 53
11
NA 0 -10 13 13
466 ms
24 NA 24 NA 56
13


R. C.
Bass
NA 20 8 NA 13 12
472 ms
77 54 17 NA 23 65
15
NA 2 1 10 11
457 ms
42 NA 66 55 50
17
NA 21 25 28 9 5
470 ms
NA 16 18 51 66 NA
19
NA 9 5 NA -2 NA
467 ms
NA 17 1 NA 13 NA
21


R. C.
Bass
NA
-26
-12
18
0
465 ms
16
80
60
8
120
23
NA
17
6
2
0
-10
467 ms
54
12
21
32
NA
77
25
NA
-3
-8
-11
-15
-14
465 ms
36
33
51
52
50
NA
27
NA
NA
NA
NA
NA
31
49
27
NA
NA
29

Swan Gaze: Ride Cymbal and Bass (excerpt 87:10-87:54)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown above bass notes; positive values indicate that bass attacks occur after cymbal attacks, and negative values indicate that bass attacks occur before cymbal attacks. NA=not available.


2.9:1 2.5:1 2.4:1 2.6:1 2.7:1 2.6:1
R. C.
64 39 47 56 60 48
Bass
7
NA 2.6:1 3.2:1 2.7:1 2.5:1
R. C.
54 NA 36 65 28 52
Bass
9
2.7:1 NA
R. C.
66 76 54 NA 3 53
Bass
11
2.7:1 2.7:1 2.9:1
R. C.
24 NA 24 NA 56
Bass
13


R. C.
Bass
77 54 17 NA 23 65
15
NA 2.1:1 2:1 2.3:1
R. C.
42 NA 66 55 50
Bass
17
3:1 3:1 2.9:1
R. C.
NA 16 18 51 66 NA
Bass
19
R. C.
NA 17 1 NA 13 NA
Bass
21


R. C.
Bass
2.8:1
3.2:1
3.2:1
3:1
16
80
60
8
120
23
54
12
21
32
3
NA
77
25
2.4:1
2.3:1
2.4:1
2.4:1
2.1:1
36
33
51
52
50
NA
27
2.6:1
2.5:1
2.2:1
3
31
49
3
27
NA
NA
3
29

Swan Gaze: Ride-Cymbal and Piano Accompaniment (excerpt 87:10-87:43)
Swing ratios are shown above eighth-note pairs. Asynchronies (in ms) are shown below piano notes; positive values indicate that piano attacks occur after cymbal attacks, and negative values indicate that piano attacks occur before cymbal attacks. NA=not available.

Swan Gaze

composed by Ron Westray
ride cymbal by Brannen Temple
piano by Jeff Hellmer


2.6:1
NA
2.5:1
R. C.
Piano
5
NA
87
2.9:1
2.5:1
2.4:1
2.6:1
2.7:1
2.6:1
R. C.
Piano
7
66
NA


NA
2.6:1
3.2:1
2.7:1
2.5:1
R. C.
Piano
9
82
40
58
2.7:1
NA
R. C.
Piano
11
88
28


2.7:1
2.7:1
2.9:1
R. C.
Piano
13
13
R. C.
Piano
15
15


NA
2.1:1
2:1
2.3:1
R. C.
Piano
17
17
NA
31
3:1
3:1
2.9:1
R. C.
Piano
19
19
19
25
26
29

Swan Gaze

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Mr. Belfiglio has had the opportunity to perform with jazz artists such as Kenny Garrett, Dave Douglas, Branford Marsalis, Delfeayo Marsalis, Jason Marsalis, Steve Turré, and Eddie Gomez. He has released two CD recordings: *First Time Only* (2001) and *Project Escape* (2006), and has performed in live radio broadcasts on Nashville Public Radio, Austin Public Radio, and WFLN Philadelphia.

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