THE EVOLUTION OF SYNCOPATION IN 20TH-CENTURY POPULAR MUSIC

PROPOSAL OF PhD DISSERTATION

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1 Introduction

Has the amount of syncopation in popular music changed over time? Several studies have addressed this question. In popular songs recorded between 1890 and 1939, Huron & Ommen (2006) find that melodies "exhibited an increase in the proportion of syncopations over time," a result that is "consistent with the general idea that the amount of syncopation increases over the years from 1890 to 1939" (224). Volk & w. Bas de Haas (2013) likewise find an increase in syncopations among ragtime tunes recorded between 1890 and 1919. Among several prominent rock bands of the mid to late 20th century, Biamonte (2014) writes on "a general trend of increasing metric dissonance over time within the work of each band, as well as a generally increasing trend throughout the latter half of the twentieth century." In a collection of songs taken from Rolling Stone magazine's list of the "500 Greatest Songs of all Time," Tan et al. (2018) find that a song's year of release is a significant predictor of its degree of syncopation: syncopation increases significantly over time. In a corpus of rap verses, Waller (2016) finds "a noticeable tendency toward increasing [metric] complexity, beginning at the latest in the mid-1980s (and perhaps earlier) and continuing through all of the 1990s" (127).

These studies address different musical phenomena—syncopation, metric dissonance, and metric complexity. They also address different musical styles from different decades—Ragtime and early Jazz, Rock, and Rap. A point that these studies share in common is one of the starting points for this dissertation: that rhythm in popular music has changed significantly in its complexity over time. I suspect that this change is rooted, at least in part, on changing uses of *syncopation* across the 20th century. Although my hunch is that popular music has grown more syncopated over time, as the studies above suggest, I will proceed with the premise only that there is measurable change in the amount of syncopation over time. My main aim in the dissertation is to explore ways of quantifying and testing this premise.

The evolution of syncopation in popular music over the 20th century has not been the topic of rigorous theoretical study. One could argue that such a large body of music is not unified enough for a century-wide study to be meaningful: what do the rhythms of Tin Pan

Alley have to do with the rhythms of Rap? Figures 1–4 present the opening melodic fragments of four hit songs from different decades of the 20th century. Syncopations of the sort appearing at the words "Come all" and "story" of the song "Casey Jones" (figure 1) are common in classical music. Syncopations of the sort appearing at the words "hear" and the last syllable of "engineer" in the same song, however, are very uncommon in classical music (Tan et al., 2018). These relatively stressed syllables fall on weak beats, creating a mismatch between lexical and metrical stress. The lexical stress is heightened further by the rhyme. Consequently, "hear" and "-eer" seem to *anticipate* the following strong beats (beat 3). Work by Temperley (1999) and Tan et al. (2018) highlights this kind of syncopation in rock music, but it appears in many 20th-century popular styles—styles as diverse as Ragtime, swing, Rock, and Rap. Additional examples are marked with asterisks in figures 2, 3, and 4. This interpretation suggests that the rhythms of these popular styles, despite their differences, are unified by a common set of principles: Tin Pan Alley and Rap are not apples and oranges, at least as far as rhythm is concerned.

The central thrust of the dissertation is summarized in the opening question: has the amount of syncopation changed in popular music over the 20th century? This is a very challenging question to address, and it leads to four additional questions. First, what exactly is syncopation? The initial tasks of the dissertation are to evaluate and compare previous definitions, and to propose a model of syncopation that reconciles their differences. Second, what exactly constitutes a change in syncopation? Listeners generally have intuitions about syncopation that extend across styles. For example, most listeners would agree that figure 4 is more syncopated than figure 3, which is more syncopated than figure 1. But quantifying these intuitions proves to be quite challenging. Third, can complexity theory offer a means of quantifying syncopation? Studies of rhythm and meter sometimes address syncopation and complexity interchangeably (Smith & Honing, 2006), making complexity theory a promising starting point for the questions posed above. Fourth, how does one make such an exceedingly large volume of music—20th-century popular music—the topic of *any* study? This last question concerns the creation of a representative corpus of songs, which will serve as the basis for the investigation. I will address each of these four questions in turn over the remainder of the proposal, using popular songs from most decades of the century to illustrate my points. At the conclusion, I will summarize the anticipated organization of the dissertation, chapter by chapter.

2 Defining syncopation

Definitions of syncopation vary considerably between authors and genres. Wynton Marsalis (1995), writing on Jazz, conceives it most broadly as "doing the unexpected." *Oxford Music Online*, concerning art music, offers a much narrower definition: "The regular shifting of each beat in a measured pattern by the same amount ahead of or behind its normal position in that pattern." In general, most studies define syncopation in terms of a conflict between accents and the underlying meter.

While these definitions capture essential qualities of syncopation, they are not formulated in a way that is rigorous and measurable. More relevant to this dissertation are studies that quantify syncopation. Longuet-Higgens & Lee (1984) proposed the first widely accepted computational definition of syncopation. Inspired by theoretical linguistics, they regard rhythm as a structure that is "generated" by the grammar associated with a particular meter, and use tree structures to represent this generative relationship. Every event in a meter is weighted according to its distance from the "root" of the tree structure (figure 5). The hierarchical system of weights that results is essentially identical to the "metrical structure" of Lerdahl, Fred and Ray Jackendoff (1983).

With this system of weights, Longuet-Higgens & Lee define syncopation as an ordered pair (N, R) involving an event N followed by a non-event R of greater metrical weight. (A non-event is a rest, or continuation such as a tied note.) The strength of a syncopation is the difference between the weight of the non-event and the weight of the event that precedes it. According to this definition there are two syncopations in the opening melody of "Every

Breath You Take" by the Police: a stronger syncopation across the downbeat, and a weaker syncopation across the following beat (figure 5).

Longuet-Higgens & Lee (1984) identify a syncopation solely by the position of N and R within the metrical structure. Recent studies of popular music propose models of syncopation that incorporate lexical stress. Tan et al. (2018) adapt Longuet-Higgens & Lee's original model to account for the critical role that lexical stress plays in the rhythms of popular song. Tan defines syncopation as a stressed syllable on a weak beat that is not following by another syllable on or before the following beat. This definition is more restrictive: like Longuet-Higgens & Lee (1984) it requires that a weak beat event is followed by a non-event, but with the added condition that the weak beat event is a stressed syllable. According to Longuet-Higgens & Lee (1984), the weak beat event receives stress simply because there is no event on the following strong beat. According to Tan et al. (2018), however, the weak beat receives additional stress because it occurs with a stressed syllable, and the following beat does not. We can distinguish between these two kinds of stress as follows:

Positional stress: Stress that arises from the presence of an event.

Lexical stress: Stress that arises from the syllables of a language.

Both types of stress are more likely to occur on strong beats than weak ones. Syncopation results when one or both types of stress occur instead on a *weak beat*. I propose that these two types of stress give rise to two corresponding types of syncopation:

Positional syncopation: an event on a weak beat that is not followed by an event up to and including the following strong beat; a mismatch between positional stress and metrical stress.

Lexical syncopation: a stressed syllable on a weak beat, where all syllables up to and including the following strong beat are less stressed; a mismatch between lexical stress and metrical stress.

Figures 6 and 7 illustrate the difference between these two types of syncopation. In "Kokomo," the syllable "-ba" of "Aruba" is a positional syncopation but not a lexical one:

it is positional because the following strong beat does not contain an event. However it is not lexical because "-ba" is weak in relation to the preceding syllable "-ru-." In "Billie Jean," the syllable "beau-" of "beauty" is a lexical syncopation but not a positional one: it is lexical because it is stronger than the surrounding syllables. However it is not positional because it is followed by an event. Figures 6 and 7 show that these syncopations are not isolated events, but rather reappear at parallel points in the songs (the chorus in "Kokomo," and between the verses in "Billie Jean"). In popular music, positional and lexical syncopations often occur together, such as those marked with asterisks in figures 1–4.

Figure 8 summarizes the distinction between positional and lexical syncopation. The term "positional" as it applies to syncopation was first used by Tan et al. (2018), and corresponds to the view proposed by Longuet-Higgens & Lee (1984). Lexical syncopation corresponds to the view proposed by Condit-Schultz (2016). He notes that "it is possible for a passage to be unsyncopated on the surface (all syllables), but have syncopations between stressed syllables." Condit-Schultz only considers syncopations between stressed syllables, ignoring unstressed syllables altogether. Tan et al. (2018) defines syncopation both on positional as well as lexical terms. I will adopt a broader view here that encompasses figure 8 in its entirety: syncopation must, at a minimum, exhibit a mismatch between positional or lexical stress.

Defining syncopation as a mismatch—in terms of stress that is offset from its normal location—bears some resemblance to Krebs' "displacement dissonance" (Krebs, 1999). I have neglected to discuss an additional kind of syncopation, one that corresponds to Krebs' "grouping dissonance." In figure 9, the notes at "I," "can't," and "no" are normal syncopations on their own. As a whole, however, these notes establish a new dotted-quarter pulse, which in turn sets up an expectation for a new event at every dotted quarter. This type of syncopation in figure 9 is very common in popular rhythm, and it sounds qualitatively different than the sum of its parts. This example suggests that syncopation cannot be defined solely in terms of a mismatch involving lexical or positional stress. One challenge of the dissertation will be to incorporate these different types of syncopation into a single overarching model.

3 Measuring syncopation

To suggest that syncopation has changed in popular music over time presupposes some way of *measuring* it. One simple way to measure the syncopation of a song is to divide the number of syncopations by some linear variable, such as the number of offbeat notes at a given beat level (16th, 8th, or quarter), or some unit of time. A song with a larger quotient would be more "syncopation dense," so to speak. We might call this quotient the "syncopation density" of a span of music. This is a good first step. It is a rather rudimentary approach by itself, however, as it implies that all syncopations are equal in their strength. But syncopation is not a uniform musical phenomenon: the relative strengths of two syncopations can vary considerably. If a syncopation is defined as the mismatch between metrical stress and some other kind of stress—as I have defined it above—then the degree of this mismatch can be taken as a measure of syncopation strength. A fairly weak beat with a moderate degree of stress is less syncopated than a very weak beat with a large degree of stress. Figure 10 lists four types of stress that appear to affect the strength of a syncopation. While some of these factors are accounted for in recent theories of syncopation, others are not.

Metrical stress: syncopations right before a downbeat are stronger than syncopations in the middle of the measure. Longuet-Higgens & Lee (1984) were the first to argue that the strength of a syncopation depends on its location within the measure. This is now a commonly accepted view. A syncopation at the very least must be less metrically stressed than the following note.

Durational stress: syncopations involving a continuation are stronger than syncopations involving a rest. Leong (2011) notes that the distinction between continuations and rests—or what she calls "syncopes" and "upbeats" respectively—has been all but lost in contemporary scholarship on syncopation. But for 19th-century theorists like Riemann, the continuation was synonymous with syncopation (Leong, 2011). This distinction has not been explored in studies of popular music. Continuations exhibit what I will call "durational stress," whereas rests do not.

Lexical stress: lexical syncopations are stronger than non-lexical syncopations. It seems reasonable to assume that the different types of syncopation in figure 8 are not equal in their strength. Both Condit-Schultz (2016) and Tan et al. (2018) disregard non-lexical syncopations entirely, suggesting at the very least that lexical syncopations are stronger.

Primacy stress: syncopations that are not preceded by a note are stronger than syncopations that are. All previous theories of syncopation, at least to my knowledge, disregard the note immediately *prior* to the syncopation. Yet the presence or absence of a note before the syncopation appears to affect the strength of the syncopation itself. An un-preceded syncopation exhibits what I will call "primacy stress."

I have omitted positional stress from figure 10 because it is not clear whether its presence unconditionally strengthens a syncopation. For example, purely lexical syncopations may be stronger than lexical-positional syncopations because the former involves a conflict between stressed and unstressed syllables. In this case, positional stress would actually *weaken* the overall syncopated effect, rather than strengthen it.

Can these four types of stress be aggregated to produce some overall measure of syncopation? It is not immediately clear how such a measure could be created in a rigorous way. For example, what is the effect of metrical stress in relation to the effect of lexical stress? Is one greater than the other? Modeling the relative strengths of these stress types is one of the core challenges of this dissertation. The challenge is complicated further by the likely possibility of interdependence among these factors. For example, Tan et al. (2018) find that lexical-positional syncopations occur most often immediately before downbeats and before the middle of the bar. They use this placement as evidence of what they call "anticipatory syncopation." At the very least, this observation is evidence that lexical-positional syncopations occur in some parts of the measure more than others: that is to say, that the frequency with which lexical stress occurs appears to vary between different positions in the measure.

I suspect that there is also a significant relationship between lexical stress and continuations. At the 8th-note position immediately before the downbeat, lexical-positional syncopations frequently involve continuations; such is the case with "Cheek To Cheek" (figure 2) and "Love Will Keep Us Together" (figure 3). The continuations here heighten the "anticipatory" nature of the syncopations, the sense that these syncopations "belong" to the following downbeats. Non-lexical syncopations located at the same 8th-note position, by contrast, frequently involve rests; such is the case with "Heartbreak Hotel" and "Canary in a Coalmine" (figure 11). In these examples there is little sense of anticipation. The rests instead create exactly the opposite effect: these syncopations seem to "belong" to the notes that precede them.

The rise of syncopation over the past century does not necessarily entail a change in the *number* of syncopations: it could rather entail a change in syncopation *strength*, of one form or another. For example, if lexical syncopations are indeed stronger than positional syncopations, we might see a change over time in the number of lexical syncopations in proportion to the number of positional syncopations.

4 Syncopation and complexity

Syncopation is closely related to the idea of complexity: a rhythm that is more syncopated tends to be heard as more complex. This assumption has empirical support: Smith & Honing (2006) found that judgments of complexity in short rhythms correlated significantly with their degree of syncopation, as measured by the Longuet-Higgens & Lee (1984) algorithm. The connection with complexity is also musically intuitive: the melody of figure 2 would likely sound simpler (less complex) if Astaire had instead sung unsyncopated quarter notes, as the original melody is notated.

For the purposes of the dissertation, there are at least two reasons why it is useful to construe syncopation as complexity. First, doing so offers a promising means of addressing the issues raised earlier concerning the quantification of syncopation. Complexity in music can be modeled in terms of probability: an event that is low in probability is more complex. And probability theory provides a mathematical framework for quantifying the relationship between the various stress types mentioned above.

Second, construing syncopation as complexity brings syncopation into dialog with more general theories of complexity in art. One theory, proposed by Berlyne (1960), is that people tend to prefer a moderate amount of complexity, not so little as to bore, not so much as to overwhelm. The distribution resembles an "inverted U" shape, with preference tapering off at the extremes. Several studies have tested this prediction with music. For example, Witek et al. (2015) found that people are the most inclined to move when music exhibits a moderate amount of syncopation. Another related theory, proposed recently by Temperley (2018), is that composers often distribute complexity uniformly across musical space and time. High complexity in rhythm, for example, is often balanced with low complexity elsewhere. Temperley uses information theory to model this intuition across several musical styles and parameters.

Some recent studies suggest that popular music has become less complex over time. In popular music from 1955 through 2010, Serra et al. (2012) found a decline in the variety of timbres and pitch sequences. Within a similar time frame, Morris (2017) found evidence that popular lyrics have become increasingly repetitive. If syncopation is to be understood in terms of complexity, its increase over the years would counter these findings. It would also reflect Temperley's principle of uniform complexity at a very large scale. Listeners demand a certain threshold of complexity, and different popular styles across the century meet this demand with certain musical parameters more than others. If syncopation increases over time, we would expect a corresponding loss of complexity in other parameters, and vice versa.

Syncopation and complexity are closely related, but they are not synonymous. In certain musical contexts, in fact, they may be quite opposed. Figure 12a reproduces the opening of "Love Will Keep Us Together," which consists of a repeated melodic idea. The syncopation at the word "think" raises complexity because it arrives earlier than expected. Now consider the same word in figure 12b, which instead syncopates the initial statement: does "think" arrive where we expect it to now? Without considering any other context, the answer is "yes," since we generally expect stressed syllables to fall on strong beats. However, this note is actually *delayed* if we hear it in relation to the analogous note on "love," since we generally expect patterns to repeat. Huron (2006) has suggested that uncertainty (i.e., complexity) increases when an expected event is delayed. We might conclude, therefore, that the word "think" in figure 12b has greater complexity precisely because it is *not* syncopated. What was unexpected has become expected, and vice versa. Syncopation is not merely "doing the unexpected," as Wynton Marsalis (1995) suggests. Rather, there are certain musical contexts in which a syncopation may be more probable than a non-syncopation.

5 Corpus methodology

5.1 Source

The studies cited at the beginning of this proposal are based on corpora, each selected from a different source, and each spanning several decades of the 20th century. Volk & w. Bas de Haas (2013) use 1,000 MIDI files of ragtime tunes recorded between 1890 and 1919. Huron & Ommen (2006) use 1,131 selections from popular songs recorded between 1890 and 1939. Tan et al. (2018) use a subset of Rolling Stone magazine's "500 Greatest Songs of all Time," which consists of songs recorded between 1950 and 1999. Waller (2016) uses 45 rap verses recorded between 1979 and 2009.

There are no published corpus-based studies that include popular music from all decades of the 20th century. It is not clear, first of all, what would be the best way to sample music consistently from all decades. There is no single chart that spans the entire century: the *Billboard Hot 100*—today's definitive chart for top hits—only extends back to 1955. To account for pre-1955 music, Krumhansl (2017) combines the *Billboard Hot 100* with a collection of songs taken from Joel Whitburn's *A Century of Pop Music*. Whitburn (1991) aggregates data across multiple charts to produce rankings for each year from 1890–1954. Krumhansl achieves a corpus of popular music spanning 1910 through 2009 by combining Whitburn's pre-1955 collection with *Billboard's* post-1955 charts. I will adopt this approach in the dissertation. To reduce these collections down to a manageable size, I have chosen to select the top song from each year of the century. This produces the table included in the appendix below. The objects of analysis in this corpus are recordings, not sheet music. Although sheet music sales influenced the rankings in the early decades, all songs in the table are associated with the success of a particular recording, measured by a combination of record sales, radio airplay, jukebox sales, and later, cassette and CD sales.

5.2 Encoding

The way a corpus is encoded depends on the questions it is designed to address. To summarize, those questions are:

1. Has syncopation changed in frequency or strength over the century?
2. To what extent do various types of stress (metrical, durational, lexical, primacy) affect syncopation strength?
3. How does syncopation relate to complexity? Are there any trade-offs between syncopation and complexity in other parameters?

At a minimum, then, the notes of the corpus should be encoded to reflect their lexical stress, their location in the meter, and their duration. Several corpora exist that encode lexical stress and metrical position (Tan et al., 2018; Waller, 2016; Condit-Schultz, 2016). None of these corpora encode information about a note's duration, however. This exclusion is in part due to the practical limitations of sound recording, and the acoustics of the voice: while the location of a note's onset is typically clear, the location of its release is sometimes blurred by the decay in the note's sound envelope. In short, it is harder to hear offsets than onsets. This poses a challenge for the study of durational stress (figure 10).

Figure 13a presents one possible encoding for "It's A Long Way To Tipperary" (1915). The first column lists the timepoint of each note relative to the very beginning of the song. The measure is the basic unit, with decimals representing divisions of the measure. For example, "5.2500" means the second quarter note of the fifth measure. The second column lists the duration of each note. The whole note is the basic unit here, with decimals representing fractions of the whole note. The fourth column lists the syllable of each note. For example, MIGHTY[2] refers to the second syllable of the word "mighty." Finally, the third column lists the lexical stress of the syllable, with "1" being stressed, and "0" being unstressed. With the exception of the second column (the durations), the encoding procedure here is taken from Tan et al. (2018). Tan also encodes pitch and scale degree information. Although pitch is not a central concern of this dissertation, there are at least three reasons to include pitch in the present corpus. First, doing so will make the corpus more useful to future studies. Second, doing so will make it possible to study trade-offs in complexity between syncopation and pitch, if there are any. Finally, it is possible that syncopation strength may be affected by pitch in some way. Figure 13b adds two more columns to account for pitch: the third column is the MIDI number of the note and the fourth column is its chromatic scale degree integer (tonic=0; leading tone=11). Figure 13b captures all of the data that is necessary to address the central research questions posed above.

The coding proposed here only accounts for melody, ignoring cases where syncopation arises in non-melodic parts. This decision limits the scope of the dissertation, simplifies the corpus, and aligns the corpus with the studies cited above, each of which codes for melody exclusively.

6 Chapter overview

Figure 14 is a chapter overview of the dissertation. The first four chapters are theoretical, and the fifth chapter is analytical.

Chapter 1 will introduce the main questions of the dissertation, and justify the importance of these questions. This chapter will also make a case for the study of syncopation in popular music in general.

Chapter 2 will introduce the relevant literature, beginning with general approaches to syncopation. The chapter will make a distinction between models of metric complexity and models of syncopation. Models of metric complexity measure the alignment between a rhythm and the underlying meter. Models of syncopation are concerned with particular events, and whether or not those events qualify as syncopations under some definition. I will conclude chapter 2 with a review of recent studies that address syncopation in popular music.

Chapter 3 will set about modeling syncopation. The discussion surrounding figures 8 and 10 is a good theoretical starting point. I have defined syncopation generally as a mismatch between metrical stress and some other kind of stress. I have also suggested several types of stress that can participate in this mismatch, some of which have not appeared in previous work. One challenge will be to incorporate these stress types into a single multivariate model. If syncopation is construed continuously rather than categorically—if syncopation is "fuzzy" rather than "crisp", to borrow from the terminology of pitch-class set theory—then probability theory offers a promising way forward. Formulating syncopation in terms of probability would also lay the groundwork for the study of complexity in chapter 4.

Chapter 4 will explore the relationship between syncopation and complexity, beginning with a brief survey of the literature on this topic. Following the ideas of Berlyne and Temperley, I will consider several trading relationships between complexity in rhythm and complexity in other musical parameters, such as pitch. This will lead to a set of predictions that I will test in chapter 5. Another aim of chapter 4 is to demonstrate that the relationship between syncopation and complexity is more nuanced than previous studies have acknowledged. In reference to figure 12 I suggested that syncopation and complexity may conflict in some cases, despite the common view that they are synonymous. While we usually expect events to fall on strong beats, a repeated pattern may lead us to instead expect a syncopation. An additional example of this point is figure 9. Here, the word "no" occurs right where we expect it to, despite being syncopated. If "no" had instead occurred an 8th note later, on beat three, it would sound delayed, and therefore, unexpected. Previous studies of popular rhythm have not explored this nuance in detail.

Chapter 5 will introduce the corpus, which I will use to test the main questions of the dissertation. Following a description of the corpus itself, I will use the multivariate model from chapter 3 to test the assumption that syncopation has changed significantly over the century. I have mentioned that there are several ways in which syncopation could be understood to have "changed" over time. Like Huron & Ommen (2006), I will consider each of these in turn. I will also use the model to study complexity trade-offs between syncopation and other musical parameters. A discussion will follow that revisits the main questions in light of the results of the corpus analysis.

Chapter 6 will summarize the contributions of the dissertation, and propose directions for future work. I will recommend ways in which the model described in chapter 3 might be extended to include other styles, such as Western art music. The corpus is a valuable contribution in and of itself. Because the corpus extends across such a large range of music, it naturally invites larger questions of style and genre, and of historical changes in text setting, and pitch relations.

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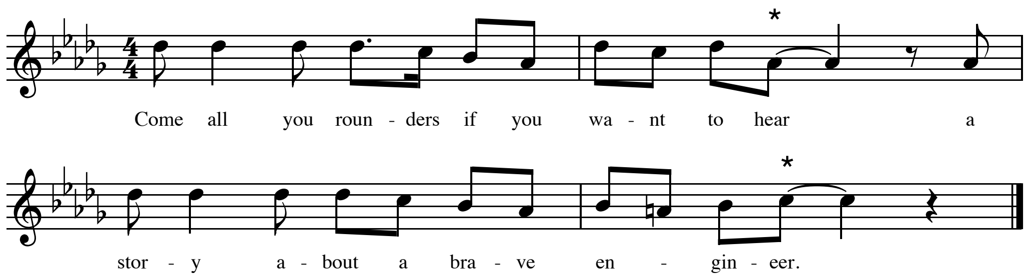


Figure 1: "Casey Jones" by Billy Murray (1910).

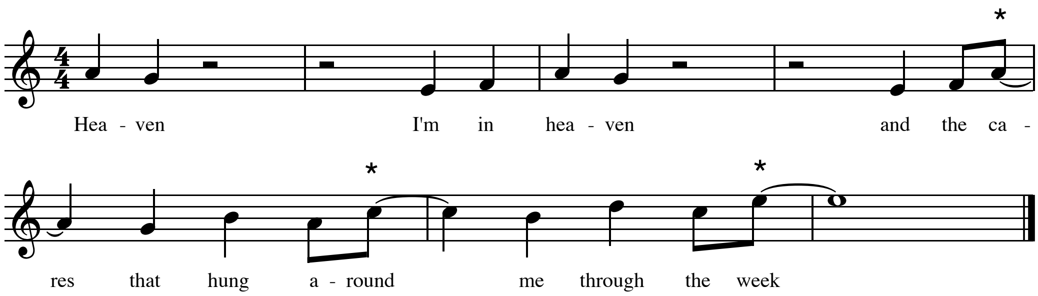


Figure 2: "Cheek To Cheek" by Fred Astaire (1935).

Figure 3: "Love Will Keep Us Together" by Captain & Tennille (1975).

Figure 4: "Gangsta's Paradise" by Coolio (1995).

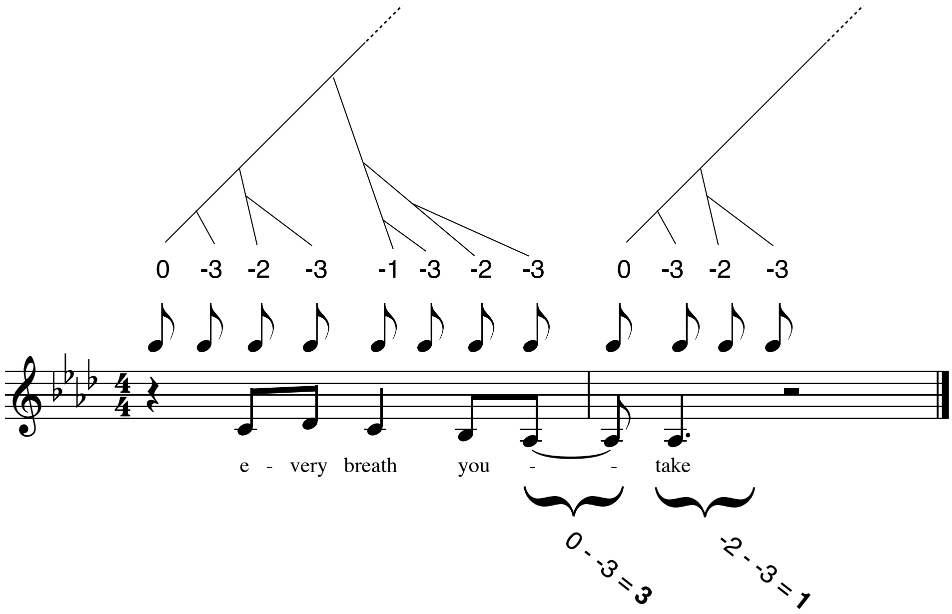


Figure 5: The model proposed by Longuet-Higgens & Lee (1984), demonstrated with the opening melody of "Every Breath You Take" by the Police.

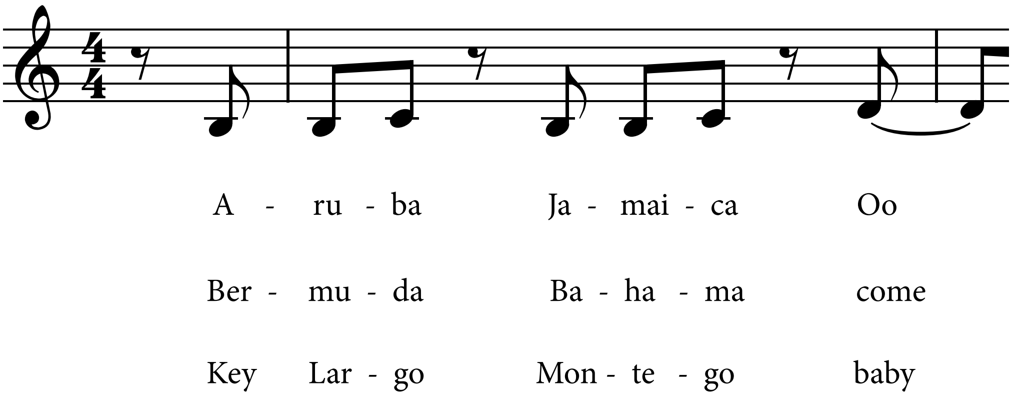


Figure 6: Positional syncopations in "Kokomo" by the Beach Boys (1988).

Figure 7: Lexical syncopations in "Billie Jean" by Michael Jackson (1982).

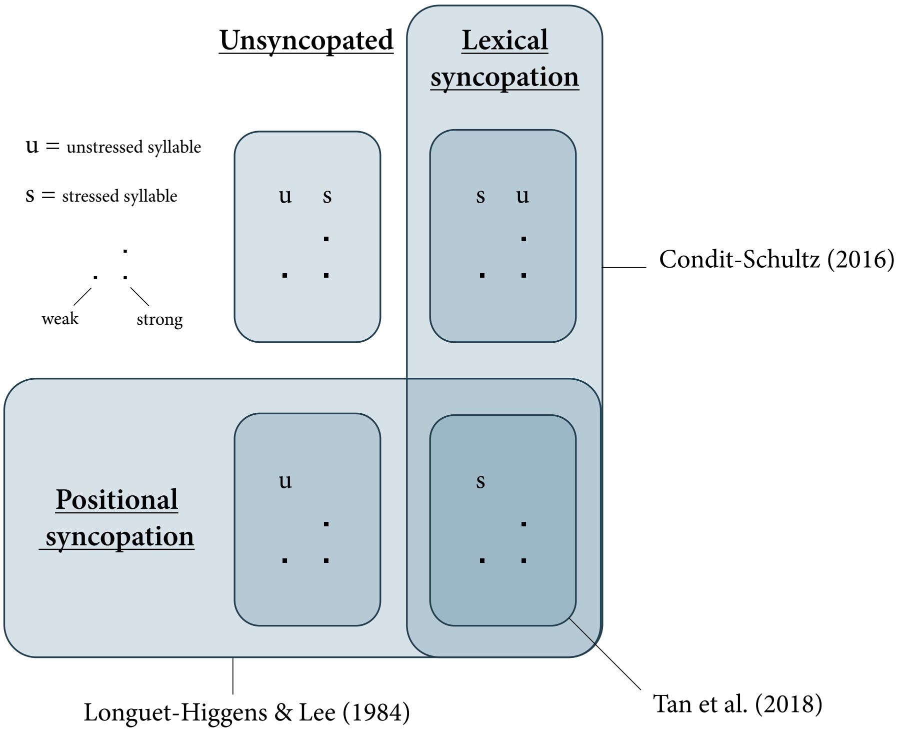


Figure 8: Positional and lexical syncopation.

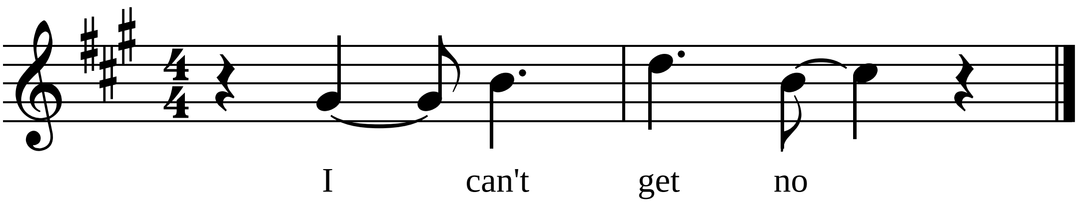


Figure 9: Syncopation in "(I Can't Get No) Satisfaction" by the Rolling Stones (1965).

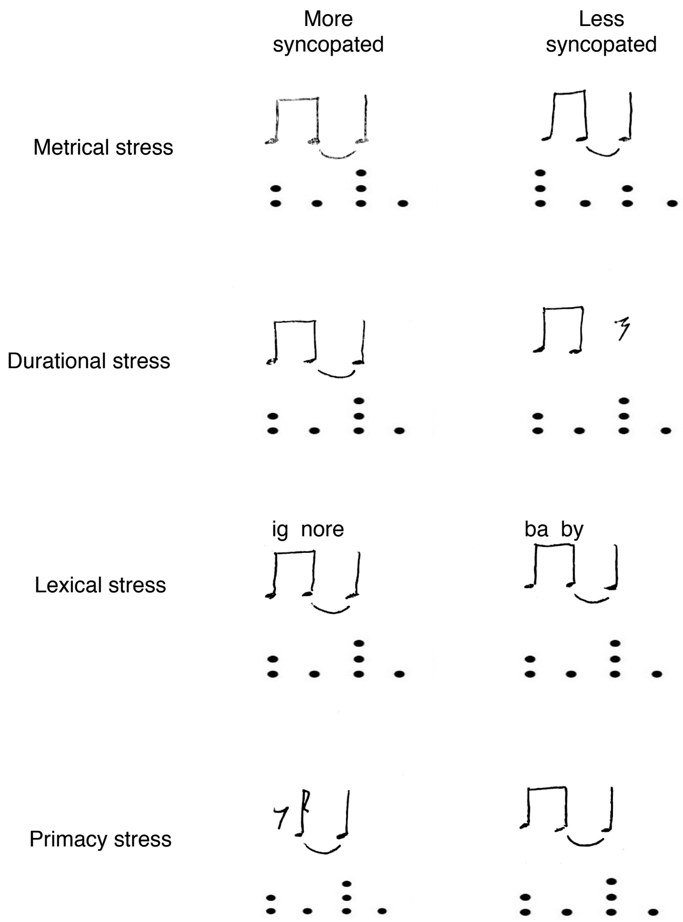


Figure 10: Four factors that affect the strength of a syncopation.

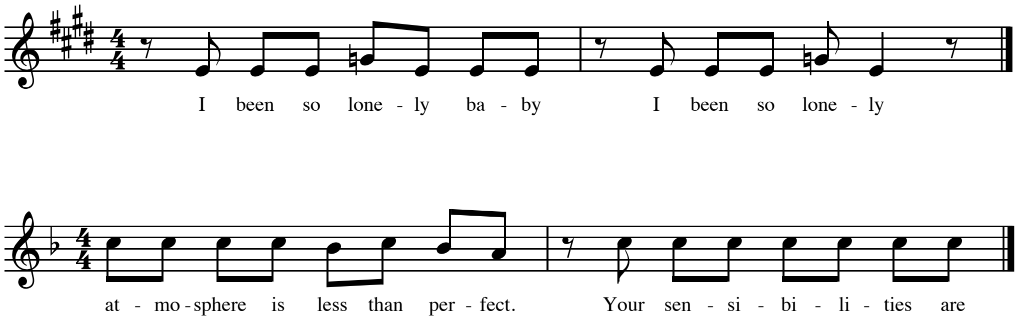


Figure 11: Positional syncopations with a rest in "Heartbreak Hotel" by Elvis Presley (1956), and "Canary in a Coalmine" by the Police (1980).

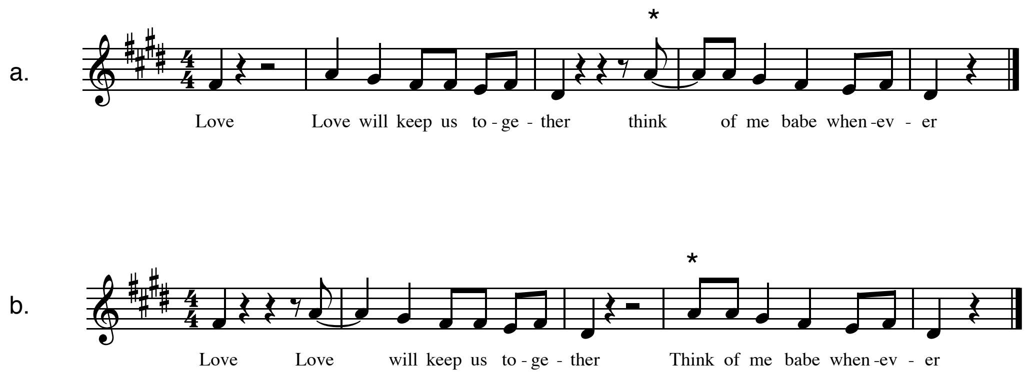
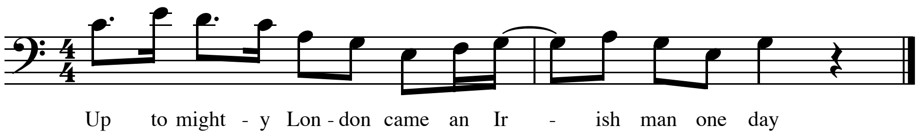


Figure 12: Recomposition of "Love Will Keep Us Together" (1975), illustrating a conflict between syncopation and complexity.



a.

```
5.0000 0.1875 1 UP[1]
5.1875 0.0625 1 TO[1]
5.2500 0.1875 1 MIGHTY[1]
5.4375 0.0625 0 MIGHTY[2]
5.5000 0.1250 1 LONDON[1]
5.6250 0.1250 0 LONDON[2]
5.7500 0.1250 1 CAME[1]
5.8750 0.0625 1 AN[1]
5.9375 0.1850 1 IRISH[1]
6.1250 0.1250 0 IRISH[2]
6.2500 0.1250 1 MAN[1]
6.3750 0.1250 1 ONE[1]
6.5000 0.2500 1 DAY[1]
```

b.

```
5.0000 0.1875 60 0 1 UP[1]
5.1875 0.0625 64 4 1 TO[1]
5.2500 0.1875 62 2 1 MIGHTY[1]
5.4375 0.0625 60 0 0 MIGHTY[2]
5.5000 0.1250 57 9 1 LONDON[1]
5.6250 0.1250 55 7 0 LONDON[2]
5.7500 0.1250 52 4 1 CAME[1]
5.8750 0.0625 53 5 1 AN[1]
5.9375 0.1850 55 7 1 IRISH[1]
6.1250 0.1250 57 9 0 IRISH[2]
6.2500 0.1250 55 7 1 MAN[1]
6.3750 0.1250 52 4 1 ONE[1]
6.5000 0.2500 55 7 1 DAY[1]
```

Figure 13: Possible encodings of "It's A Long Way To Tipperary" (1915).

1. Introduction
    - Has popular music grown more syncopated?

2. Background
    - General definitions of syncopation
    - Computational models of metric complexity
    - Computational models of syncopation
    - Syncopation in popular music

3. Modeling syncopation
    - Measuring syncopation strength and density
    - Stress types

4. Syncopation & complexity
    - Complexity in music
    - Complexity trade-offs
    - Conflicts between syncopation and complexity

5. Corpus analysis
    - Source
    - Encoding
    - Tests and results
        - Syncopation over time
        - Complexity trade-offs
    - Discussion

6. Conclusion & future directions

Figure 14: Chapter outline of the dissertation.