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The evolution of syncopation in twentieth-century American popular music

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ABSTRACT

Several studies have found increases in syncopation within genres of twentieth-century popular music, but its evolution across the entire century has not been explored. In this study we use a new corpus of vocal melodies to examine trends in the use of syncopation. We find an increasing trend over the entire century. We also consider three ways of categorising syncopations into 'strong' and 'weak' forms, and find that the strong forms increase more rapidly and later in the century than the weak forms. We consider the implications of these trends and discuss further issues that are illuminated by our corpus.

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Syncopation; popular music; melody; rhythm; lexical stress

1. Introduction

An important and distinctive aspect of twentieth-century (and twenty-first-century) American popular music is its high degree of syncopation. If we define syncopation informally as a conflict between accents and metre, then syncopation is present to some extent in many musical styles, and certainly in pre-twentieth-century Western music. But its very frequent and prominent use in twentieth-century popular styles – from ragtime to jazz to rock to rap – sets these styles apart from music of previous centuries. Indeed, syncopation is often the *primary* feature that distinguishes twentieth-century popular melodies from earlier ones. Compare Ella Fitzgerald's (1938) rendition of 'A-Tisket, A-Tasket' with the traditional children's song (Figure 1). While Fitzgerald alters both the pitches and rhythms of the original, it is the rhythms – the syncopations – in her performance that unmistakably mark it as a product of the twentieth century.

Several corpus studies have explored rhythm in twentieth-century popular music, all of them relating to syncopation in some way. A recurrent theme emerges from these studies. In popular songs recorded between 1890 and 1939, Huron and Ommen (2006) find that melodies 'exhibited an increase in the proportion of syncopations over time' (224). In a study of ragtime piano music, Volk and de Haas (2013) find an increase in the amount of syncopation between the ragtime era (1890-1919) and later decades. In music by prominent rock bands of the mid- to late-twentieth century, Biamonte (2014) observes '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' (8.1). (Biamonte's concept of 'metrical dissonance' includes syncopation as well as other rhythmic devices such as irregular time signatures.) And in a study of rap, 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' (p. 127). (The connection between syncopation and complexity will be discussed further below.)

All four of these studies point to increases in the amount of syncopation within specific styles of popular music: early twentieth-century popular song, ragtime, rock, and rap. It is natural to wonder, then, if this reflects a more general trend of increasing syncopation over the entire century. This is not necessarily the case; it might be that each style begins with a relatively low level of syncopation and increases from there. But the possibility of a general increase in syncopation across the century is, at least, a hypothesis worth considering. Testing this hypothesis is our primary aim in the current study. We should be clear about the motivation for this hypothesis. It is not based on any general theory that popular music tends to increase in rhythmic complexity (or complexity in general) over time; to our knowledge, no one has suggested this. Rather, it is a more specific, empirically motivated prediction. Localised historical trends sometimes turn out to be part of a larger trajectory, and it is

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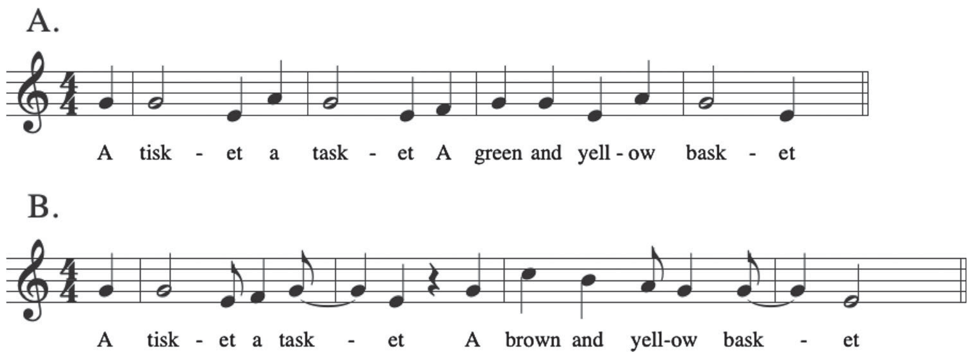

Figure 1. (A) 'A-Tisket A-Tasket' (children's song). (B) Ella Fitzgerald's rendition of 'A-Tisket A-Tasket' (1938) (transposed for comparison; the original is in Ab major).

reasonable to ask if that is the case here. As we will see, our study confirms the reality of this trajectory; at the end of the article we will consider its further implications for issues of music history and music cognition.

A secondary purpose of our study is to introduce a publicly available corpus of popular song melodies that spans the entire twentieth century, with one song from each year. (The corpus is available at *popcorpus.com*.) The corpus consists of transcriptions created by ear from recordings. While the corpus is relatively small, it is sufficient for our purpose of examining general trends in syncopation across the century. We hope it may be useful to other researchers as well, particularly with regard to early twentieth-century popular song – a repertoire that is not currently represented in any publicly available corpus, to our knowledge.

Our focus in this study is on American popular music (our corpus consists mostly of American songs, chosen for their popularity among American consumers). For simplicity, we will simply refer to this as 'popular music'. This seems justified, given the undisputed historical importance of American popular music and its impact around the world. Many styles of popular music worldwide show great American influence, in rhythm as in other domains; in Japanese and Korean popular music, for example, one hears syncopated patterns very similar to those of American music. On the other hand, there are undoubtedly distinctive and indigenous rhythmic features of non-American popular styles as well. We do not claim that our conclusions necessarily apply to popular musics of other nations, which are certainly deserving of study in their own right.

In section 2 of the paper, we present the theoretical framework for our study, and offer several concrete predictions regarding the evolution of syncopation in twentieth-century popular music. In section 3, we describe our corpus. In section 4, we use the corpus to test our predictions. In section 5, we discuss further implications of the increase in syncopation across the century. In section 6, we discuss some further issues in the rhythm of popular music that are illuminated by our corpus; in section 7, we offer some brief conclusions.

2. Theory and predictions

2.1. Theoretical framework

Our study assumes the well-known metrical theory of Lerdahl and Jackendoff (1983), in which metre is conceived as a framework of several levels of beats – a *metrical grid* (see Figure 2). Lerdahl and Jackendoff also introduce the concept of *phenomenal accent*, which is anything that gives emphasis to a point in time, such as a note-onset (relative to a rest), a loud or long note, a stressed syllable of text, or a change of harmony. A syncopation is then defined as a phenomenal accent occurring on a relatively weak beat. This definition accords well with the conventional understanding of syncopation as a conflict between accent and metre (e.g. Randel, 1986, p. 827). Defined in this way, syncopation is clearly a matter of degree: a syncopation could have greater or lesser 'strength' (i.e. degree of conflict with the metre), depending both on its metrical location and its degree of phenomenal accentuation. (The term 'strength' is not ideal, since this term also refers to the metrical accentuation of a beat – i.e. its height in the metrical grid – but its usage with regard to syncopation seems well-established; Longuet-Higgins & Lee, 1984; Sioros et al., 2014.) For our purposes, three factors influencing the strength of a syncopation are especially important: the source of phenomenal accent, the beat level at which the syncopation occurs, and its position relative to neighbouring stronger beats. Each of these factors is discussed below. We also consider the important concept of *anticipatory syncopation* – the possibility of a syncopated event anticipating its underlying position.

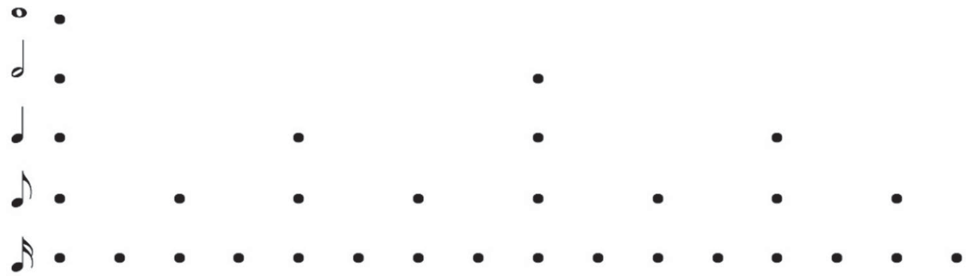

Figure 2. A metrical grid for 4/4 time.

2.2. Source of accent

In Lerdahl and Jackendoff's framework, any source of phenomenal accent could give rise to syncopation; this includes factors such as loudness or harmonic change. In the current study, however, we will be concerned only with two such factors: length and lexical stress. Length is the most commonly cited factor in discussions of syncopation. The well-known model of Longuet-Higgins and Lee (1984) defines syncopation purely in terms of length: in their model, a syncopation is simply a long note on a weak beat. Most other models of syncopation are similar in this regard, defining syncopation in terms of the metrical locations of events and their lengths, not considering other sources of accent (for a survey of syncopation models, see Gomez et al., 2007). Following these previous studies (and many studies of rhythm more generally), we define the 'length' of a note as its *inter-onset interval*, the time interval between the note's onset and that of the following note. More specifically, following Tan et al. (2019), we define a *positional syncopation* as a note on a weak beat that is not followed by another note on or before the following strong beat. Thus, in Figure 3, the second note in each of the four patterns is a positional syncopation. (The first note in each pattern is not essential to the definition.) It has also been suggested, however, that the literal duration of a note might affect its accentuation, and therefore, its degree of syncopation (Leong, 2011; Temperley, 2019a). For example, the second note in Figure 3(A) seems more accented (and therefore more syncopated) than it would be if it were an eighth-note followed by a rest. We define a *durational syncopation* as a positional syncopation whose literal note length extends beyond the following strong beat.

Lexical stress, otherwise known as syllabic stress, is another important source of phenomenal accent, at least in vocal melody (which is our focus in the current study). Several recent models of syncopation have incorporated lexical stress as a factor (Condit-Schultz, 2017; Tan et al., 2019; Waller, 2016). The linguistic phenomenon of syllabic stress is complex and multi-leveled, and sometimes depends on context (Hayes, 1995). To some extent, however, the stress level of a syllable can be determined out of context: for example, function words (such as articles, prepositions, and pronouns) are generally unstressed; content words (such as nouns, verbs, and adjectives) generally have at least one stressed syllable. Following other recent studies, we recognise just two levels of stress: stressed and unstressed. We then define a *lexical syncopation* as a stressed syllable on a weak beat. More detail about this aspect of our study is provided in section 3.

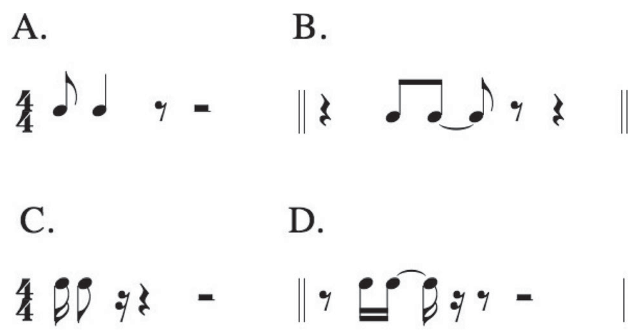

Figure 3. Syncopations.

2.3. Metrical level

In common-practice music, the probability of a note-onset occurring on a beat increases with the strength of the beat; longer notes are also more likely to occur at stronger beats (Palmer & Krumhansl, 1990; Temperley, 2010, pp. 365–366). If we view syncopation as challenging or conflicting with the metre, then, it follows that the strength (destabilising effect) of a syncopation should be inversely related to the strength of the beat on which it falls. For example, the second note in Figure 3(D), a note at the 16th-note level, is a stronger syncopation than the second note in Figure 3(B), a note at the 8th-note level (we will refer to these as '16th-level' and '8th-level' syncopations, respectively). Previous studies (Tan et al., 2019; Temperley, 2021) have confined their attention to 8th-level and 16th-level syncopations, and we will do so here. One problem is that, by this criterion, the amount of syncopation in a melody depends partly on the way that its metrical levels are mapped on to rhythmic values (quarter-note, eighth-note, and so on), which is not always obvious. One might also wonder if the strength of a syncopation at a certain level is more dependent on the absolute speed of that level than on how it is (or might be) notated. We will return to both of these points.

2.4. Metrical context

The strength of a syncopation depends not only on the strength of its own beat, but also on the larger metrical context. Patterns such as those in Figure 3 in fact create syncopation (conflict with the underlying metre) in two ways: partly because they feature long notes on weak beats (as discussed above), but also because they deny a note on the following strong beat (what Huron & Ommen [2006] call the 'lacuna'). For that reason, the strength of a syncopation should increase as the strength of the following beat increases. Thus Figure 3(B) should seem more strongly syncopated than Figure 3(A), as we believe it does: the weak-beat note in Figure 3(A) only denies a note on a quarter-note beat, whereas Figure 3(B) denies a note on a half-note beat. Similarly, Figure 3(D) is stronger than Figure 3(C). Both metrical level and metrical context are incorporated into Longuet-Higgins and Lee's (1984) syncopation model: in that model, the strength of a syncopation is negatively related to the strength of its own beat and positively related to the strength of the following beat. The distinction between Figures 3(A) and 3(B) (and between Figures 3(C) and 3(D)) is crucial to our study; following Temperley (2019a), we call the weak-beat notes in Figures 3(A) and 3(C) *2nd-position* syncopations (because they fall on the second quarter of a metrical segment – a half-note segment in Figure 3(A), a quarter-note segment in Figure 3(C)) and those in Figures 3(B) and 3(D) *4th-position* syncopations (falling on the fourth quarter of such segments). As another example, Figure 4 contains three 8th-level positional syncopations (marked with asterisks): the second syllable of 'yellow' and the second syllable of 'ribbon' are 2nd-position syncopations, and the word 'old' is a 4th-position syncopation. The historical importance of the distinction between 2nd- and 4th-position syncopations was first recognised by Berlin (1980), who called them untied and tied syncopations, respectively; the distinction has been further explored by Tan et al. (2019) and Temperley (2019a, 2021).

2.5. Anticipatory syncopation

In some cases, a syncopation is understood as anticipating the beat on which it 'belongs'; following previous work (Tan et al., 2019), we call these 'anticipatory syncopations'. In Figure 4, for example, the note of 'old' is heard as an anticipation of the following downbeat. Anticipatory syncopation interacts in complex ways with the factors of lexical stress and metrical context. In Figure 4, the stressed syllable 'old', a 4th-position syncopation, falls on a weaker beat than the previous unstressed syllable 'the', creating a direct conflict between stress and metre. Shifting 'old' to the following strong beat resolves the conflict, since 'old' is now on a stronger metrical position than 'the'. On the other hand, consider the word 'yellow' in the same example; in this case, the 2nd-position syncopation '-low' is an unstressed syllable, following the stressed syllable 'yel-'. Moreover, even if '-low' were shifted to the following quarter-note beat, it would still be on a weaker metrical position than 'yel-'. Thus, if the syncopated syllable were stressed, shifting it would not resolve the conflict. (One could possibly consider '-low' to be anticipatory for other reasons – since shifting it would yield a simpler, more stable rhythm; but this seems more debatable.) In general, then, a 4th-position lexical syncopation can be 'resolved' by shifting it, whereas a 2nd-position lexical syncopation cannot. We therefore predict that 4th-position (positional) syncopations will usually be lexically stressed, and 2nd-position (positional) syncopations will usually be unstressed. A further prediction follows from this reasoning as well. If 4th-position syncopations are typically anticipatory – strong-beat events that have been shifted to the previous weak beat – we would expect them to carry other forms of accentuation as well, such as durational emphasis. Thus we predict that 4th-position syncopations will tend to be durational syncopations (extending over the following empty beat) more often than 2nd-position syncopations.

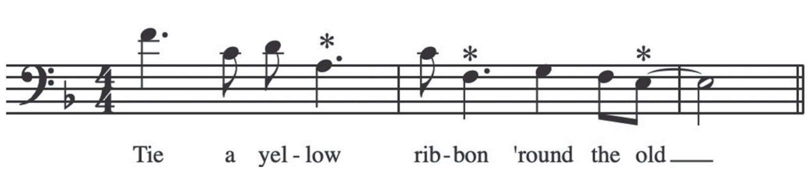

Figure 4. Tony Orlando & Dawn (1973), 'Tie A Yellow Ribbon "Round the Ole Oak Tree"'. Syncopations are marked with asterisks.

As has been observed elsewhere (Tan et al., 2019; Temperley, 1999), it is sometimes difficult to decide whether a specific syncopation is anticipatory, and it is not necessary to do so for our purposes here. The relationship between anticipatory syncopation and syncopation strength is also not obvious. On the one hand, one might say (as suggested above) that interpreting a syncopation as anticipatory 'resolves' it, in a sense, making it more compatible with the underlying metre. On the other hand, this anticipatory interpretation presumably requires some cognitive effort, and acknowledges a clash between the note's surface position and the underlying metre. We favour the latter view, though this is an unresolved issue, and not crucial to our argument. In terms of *surface* rhythm, it seems clear that 4th-position syncopations are stronger than 2nd-position syncopations, for reasons explained earlier. The importance of anticipatory syncopation, for present purposes, is that it motivates additional predictions about the correlation between metrical position and phenomenal accent: it suggests that 4th-position syncopations should tend to be lexically and durationally accented, more so than 2nd-position syncopations.

A final type of situation is shown in Figure 5. In the top staff (showing the performed rhythm), the second syllable of 'to-geth-er' is stressed, and falls on the fourth eighth of a half-note segment, making this a 4th-position lexical syncopation. It is not, however, a positional syncopation, since the following beat contains a syllable. We therefore refer to this type of syncopation as a *non-positional lexical* syncopation. (The same situation occurs at the end of the next phrase, on 'whenever'.) In a sense, one might say, the lack of positional syncopation here reduces the strength of the syncopation. In another sense, though, the juxtaposition of a stressed syllable on a weak beat and an unstressed syllable on the following strong beat heightens the sense of syncopation; there is a conflict between the 'strong-weak' stress pattern and the 'weak-strong' metrical pattern that does not arise with positional syncopations. Notice also that, due to the presence of a syllable on the strong beat, the stress/metre conflict cannot be resolved simply by shifting 'geth-' to that beat; an anticipatory interpretation requires shifting both syllables to the following beats, as shown in the bottom staff, and this presumably requires more cognitive effort. Therefore, we suggest that non-positional lexical syncopations (like 'to-geth-er' in Figure 5) are actually stronger than positional lexical syncopations (like 'think' at the end of the third bar).

2.6. Summary of assumptions about syncopation strength

We summarise our assumptions about syncopation strength as follows:

1. 16th-level syncopations are stronger than 8th-level syncopations (though tempo may be a factor here).
2. 4th-position syncopations are stronger than 2nd-position syncopations.
3. Non-positional lexical syncopations are stronger than positional lexical syncopations.

One could combine these three criteria to create a single numerical value representing a syncopation's overall strength. This seemed to us like a rather arbitrary exercise, however, since there is no objective way of deciding the weight of each factor relative to the others. Instead, as we explain below, we consider the three factors independently and form predictions for each one with regard to historical change.

2.7. Predictions

First, we have already stated two general predictions about relationships between syncopation types:

1. Among positional syncopations, 4th-position ones will generally be lexically stressed; 2nd-position ones will generally be unstressed.

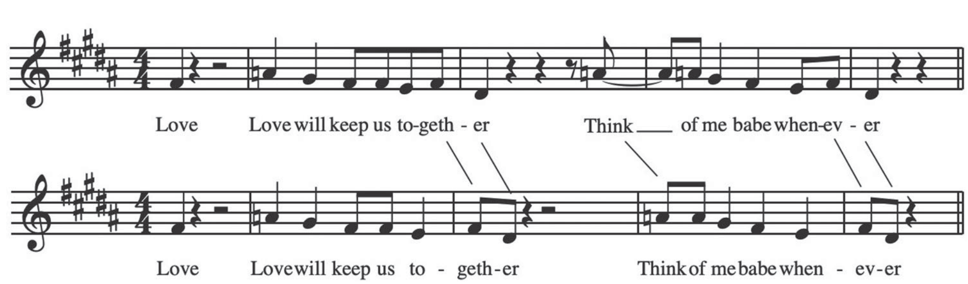

Figure 5. Captain and Tennille (1975), 'Love Will Keep Us Together'. The top staff shows the performed rhythm; the bottom staff shows the underlying rhythm.

2. Among positional syncopations, 4th-position ones will more often be durational syncopations than 2nd-position ones.

We now turn to predictions about historical change. Recall that our general prediction was that syncopation would increase over the course of the century. We thought that this might manifest itself in two ways. First, one might simply see an increase in the frequency of syncopations. (As we will explain, we normalise this as a proportion of the number of notes in each song.) Second, one might see an increase in the strength of the syncopations that did occur. Either of these trends on its own (an increase in frequency with no change in strength, or an increase in strength with no change in frequency) could be seen as an increase in syncopation. However, we also thought it likely that both trends would emerge: that syncopations would increase in both frequency and strength. This could be reflected in the data in various ways. One might find, for example, that a stronger type of syncopation increased at a faster rate than a weaker type (or perhaps the weaker type did not increase at all), thus giving rise to both an increase in overall frequency and an increase in average strength. One might also find that a broad category of syncopations increased in frequency, while within that category, a stronger subtype increased as a proportion of the category, relative to a weaker one; if both the larger category's increase and the strong subtype's increase within the category were linear, one would then see a quadratic trend in the increase of the strong subtype.

Applying linear or quadratic functions to proportions is admittedly somewhat problematic, since proportions are bounded by 0 and 1; still, such functions can capture historical trends over limited periods. Alternatively, one might expect to see a sigmoidal trend, in which an initial rise tapers off to a maximum value. A sigmoidal trend can be characterised by the point of maximum change. Suppose there were two types of syncopation, one stronger and one weaker, both increasing over time, as shown in Figure 6 (a hypothetical scenario); black dots mark the points of maximum change in each one. If the point of maximum change was later for the stronger type than for the weaker type, it can be seen that the frequency of the stronger type relative to the weaker type would gradually increase, thus increasing the average syncopation strength. We consider this possibility as well.

Combining these ideas about changes in syncopation over time with the assumptions about syncopation strength stated earlier yields the following specific predictions:

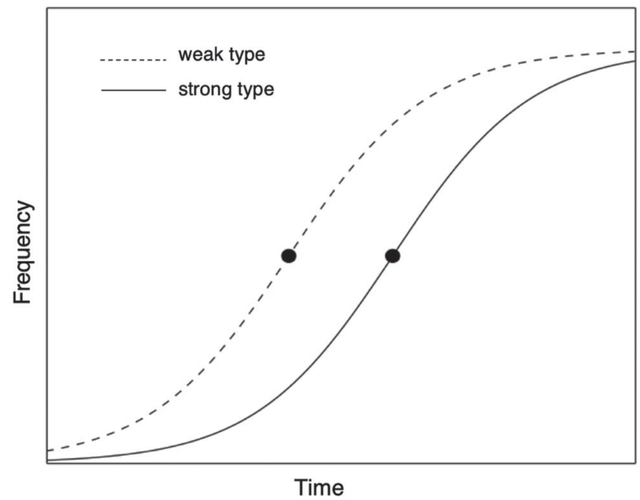

Figure 6. A hypothetical scenario in which two types of syncopation, one strong and one weak, both increase in a sigmoidal fashion. Black dots show points of maximum change.

3. Among positional syncopations, 4th-position syncopation will increase at a faster rate than 2nd-position syncopation, and its maximum change will be later in the century.
4. Among positional syncopations, 16th-level syncopation will increase at a faster rate than 8th-level syncopation, and its maximum change will be later in the century.
5. Non-positional lexical syncopation will increase at a faster rate than positional lexical syncopation, and its maximum change will be later in the century.

2.8. Syncopation and complexity

One theoretical issue that requires discussion is the relationship between syncopation and rhythmic complexity. It seems generally agreed that the two concepts are closely related. Experimental studies have found strong correlations between syncopation and perceived complexity (Fitch & Rosenfeld, 2007; Gomez et al., 2007; Smith & Honing, 2006). There are good theoretical reasons for drawing this connection. In information-theoretic terms, the rhythmic complexity of a piece could be defined in terms of its predictability as to where (in relation to the metre) events will occur. Generally speaking (in styles with a perceptible metre), notes (especially accented notes) tend to fall on stronger beats; it is widely assumed that this is what conveys the metre to the listener (Lerdahl & Jackendoff, 1983). This is presumably true in twentieth-century popular music as well, at least with respect to the accompaniment. If a song has a high degree of syncopation, this means that many events (and accented events) occur on weaker beats, thus lowering the song's rhythmic predictability. (One might say this increases the rhythmic entropy of the song.) Of course, if syncopations are common in a style, that will make them more predictable; but even so, there are presumably more events on strong beats than weak ones (otherwise the metre could not be correctly perceived), so syncopations can still be assumed to add a degree of complexity. To quantify the complexity (information content) of a melody would be a difficult undertaking and is beyond our scope here. We should note, also, that syncopation is not the only factor in rhythmic complexity; in particular, repetition of syncopated rhythms *within* a song could make them highly predictable. Even so, the general connection between syncopation and complexity seems valid; we return to this in later sections of the paper.

3. The corpus

In creating our corpus, we wanted to include a range of songs from across the twentieth century that were widely known and reflective of American popular taste. To this end, we set a goal of including the most popular song in the United States of each year of the century. Several challenges arose in achieving this goal. The means of music distribution have changed over time: sheet music was the primary format in 1900, but was exceeded by record sales by 1930 (Anonymous, 2014; Kernfeld, 2011); later decades saw the rise of other formats such as cassettes, CDs, and digital downloads. For the very early decades of the century, accurate sales data is lacking and recordings are sometimes difficult to obtain. There is no single sales chart that spans the entire century: the Billboard Hot 100 – today's definitive chart for American popular hits – only extends back to 1955. To solve this problem, we adopted the approach taken by Krumhansl (2017). Krumhansl combines the Billboard Hot 100 with a collection of songs taken from Joel Whitburn's *A Century of Pop Music* (1999). Whitburn aggregates data across multiple charts to produce rankings for each year from 1890 to 1954. Following Krumhansl, we combined Whitburn's chart data for the years up to 1955, with data from the Billboard Hot 100 chart for the years from 1955 onward. See the Appendix for a full list of songs included in the corpus. Most of the songs in the corpus are by American artists, though not all; a number of songs in later decades are by British artists, and a few come from other nations such as Canada and Sweden.

The corpus contains complete vocal melodies for each song. Our encodings of the melodies are based on our own transcriptions from recordings, rather than on sheet music. This is partly because both Whitburn's lists and the Billboard chart refer to recordings. In addition, Temperley (2021) shows that sheet music from the years around 1900 often omitted syncopations that occur in recorded performances. From the Whitburn and Billboard lists, we selected the highest-ranking recording from each year of the century (1900–1999) that (a) was in a simple duple metre (4/4, 2/4, or 2/2) throughout, (b) had a vocal melody that was clear with respect to both pitch (i.e. not spoken) and rhythm (the metrical positions of notes), and (c) had lyrics in English. There were some judgement calls here; a song could slightly violate one or more of these conditions and still qualify for inclusion in the corpus. For example, Vanessa Williams' 'Save The Best For Last' (1992) is primarily in 4/4 but includes a few 2/4 bars; the bridge of Blondie's 'Call Me' (1980) includes the title phrase of the song in French and Italian, but is otherwise entirely in English; Al Jolson's flexible timing in the song 'April Showers' (1922) obscures the beat in some moments**.** However, most songs clearly met or did not meet the above conditions for inclusion. The decision to include only songs in simple duple metre has precedents in previous studies of syncopation (Huron & Ommen, 2006; Tan et al., 2019; Volk & de Haas, 2013). Furthermore, the theoretical framework outlined in section 2 assumes an entirely duple metrical structure. One judgement call here involved songs with 'swung' tempo, in which the first half of the quarter-note beat is longer than the second. Such songs were generally included, unless they had frequent division of the beat into three, suggesting a 12/8 metre rather than 4/4; thus we included Rudy Vallee's 'The Stein Song' (1930) and Bill Haley & the Comets' 'Rock Around The Clock' (1955), but not Elvis Presley's 'Heartbreak Hotel' (1956) and Rod Stewart's 'Tonight's The Night' (1977).

One serious limitation of the corpus is its underrepresentation of music by African-American artists, especially in the first half of the century. Indeed, the earliest appearance of an African-American singer in the corpus is the Ella Fitzgerald song shown in Figure 1(B), from 1938. (The proportion of African-American artists gradually improves as time goes on; in the 1990s, four of the ten artists are African-American.) This underrepresentation is especially regrettable given the undisputed importance of African-American influences in shaping the syncopated rhythms of twentieth-century popular music (Berlin, 1980; Hamm, 1983; Temperley, 2021). Several of the songs in the early years of the century are also quite offensive, perpetuating negative stereotypes about African-Americans. However, it seemed important to have objective, consistent criteria for determining inclusion in the corpus, and using the Whitburn and Billboard lists seemed the best way to achieve this goal.

In creating our transcriptions, we used a modified version of a format used in previous studies (Tan et al.,

Onset	Offset	Pitch	SD	Stress	Syllable
4.0000	4.0625	60	0	0	UP[1]
4.1875	4.2500	64	4	0	TO[1]
4.2500	4.3750	62	2	1	MIGHTY[1]
4.3750	4.5000	60	0	0	MIGHTY[2]
4.5000	4.6250	57	9	1	LONDON[1]
4.6250	4.7500	55	7	0	LONDON[2]
4.7500	4.8750	52	4	1	CAME[1]
4.8750	4.9375	53	5	0	AN[1]
4.9375	5.1250	55	7	1	IRISH[1]
5.1250	5.2500	57	9	0	IRISH[2]
5.2500	5.3750	55	7	1	MAN[1]
5.3750	5.5000	52	4	0	ONE[1]
5.5000	5.7500	55	7	1	DAY[1]

Figure 7. The format of the corpus, for the opening of John McCormack's 'It's a Long Way to Tipperary' (1915).

2019; Temperley & de Clercq, 2013), which we do not describe here (see the corpus website for details). We then automatically converted this format into a second format which we used for the statistical corpus analysis reported below. An example of the latter format is shown in Figure 7. A melody is represented as a list of note statements; each statement contains six items. The first item is the timepoint of the note's onset relative to the beginning of the song, with bars (measures) as units. For example, '5.2500' means the second quarter-note beat of the fifth bar. The second item is the timepoint of the note offset. The third item is the pitch number of the note (following the usual convention of middle C = 60), and the fourth item is its chromatic scale degree integer (tonic = 0, #1/b2 = 1, etc.). The fifth item is the lexical stress of the syllable, with '1' being stressed and '0' being unstressed. Finally, the sixth item is the syllable itself. For example, MIGHTY[2] refers to the second syllable of the word 'mighty'. The first, third, and fourth items match the format used by Temperley and de Clercq (2013); Tan et al. (2019) extend this format to include the fifth and sixth items. The second item, the note offset, is included for the purpose of analysing durational syncopation, and is unique to this study. Notice that every note statement in the corpus is identified by a syllable; in the case of a melisma (where a syllable extends over multiple notes), only the first note of the melisma is included. This resulted in the exclusion of 2139 non-initial melisma notes contained in our original transcriptions. In its final format, the corpus contains 25,124 notes.

With regard to syllabic stress, we used the procedure described in Tan et al. (2019). After obtaining the lyrics for each song from multiple sources on the internet, we used the Carnegie Mellon University (CMU) Pronouncing Dictionary to map each syllable to one of three stress values: 0 for unstressed syllables (*to*-ma-to), 1 for stressed syllables (to-*ma*-to), and 2 for syllables with secondary stress (to-ma-*to*). Following Tan et al. (2019), all monosyllabic function words (such as articles, pronouns, and prepositions) were assigned an unstressed syllable, and 2's were converted to 1's, i.e. treated as stressed syllables. A small number of words were not found in the CMU dictionary, such as 'rum-tumming' (from the American Quartet's 'Over There' [1917]), or were pronounced with a different number of syllables than their dictionary entries. Such words were appended to the dictionary.

Transcription from recordings is a subjective activity, often demanding a considerable degree of interpretation. The exact pitch, metrical location, or duration of a note is sometimes ambiguous and difficult to discern. To reduce the degree of subjectivity in our transcriptions, the first author (VanderStel) first transcribed each song of the corpus; these transcriptions were then edited by the second author (Temperley), who suggested alternative transcriptions of certain segments; the transcriptions were then re-edited by the first author.

In the songs in our corpus, the metrical framework is usually conveyed clearly and unambiguously by the accompanying instruments. Some subjectivity arises, however, in the mapping of metrical levels onto notational values and bars. In general, we sought to choose a mapping such that each bar contained four 'tactus' beats, where the tactus is the primary beat level – the level at which one normally taps or moves to the music. The choice of tactus is consequential in our study, since we define the metrical level of a syncopation in relation to the tactus: the 8th-note level is one level below the tactus, the 16th-note level is two levels below. Psychological studies have shown a preference for tactus levels in a certain absolute range, roughly 80 to 120 BPM (London, 2012). However, other factors may influence the choice of tactus as well; in late twentieth-century popular music, by convention, the tactus is conveyed by the drumbeat – the alternation of kick and snare drum – which may vary across a wide absolute range. Most often in our transcriptions, the tactus corresponds to the notated quarter-note (in sheet music for the song), but not always. In some songs notated in 2/4, such as Albert Campbell's 'Ma Blushin Rosie' (1902), the (notated) 8th-note seemed like a better choice of tactus (so that our bars correspond to notated bars); in other 2/4 songs, such as the American Quartet's 'Over There' (1917), we chose a quarter-note tactus, thus grouping two notated bars into a single bar.

A few of the songs in the corpus are notated in 2/2, such as Al Jolson's 'California Here I Come' (1924), suggesting a half-note tactus. In such cases, we generally adopted a quarter-note tactus, thus respecting the barlines of the notation but not the choice of tactus. The songs notated in 2/2 contain some quarter-note syncopations – for example, in the title phrase of 'California Here I Come'. In terms of absolute tempo, however, the quarter-note level in such songs is closer to a typical 8th-note level. At slower tempos, positional quarter-note syncopations (i.e. notes on weak-quarter beats with no note on the following half-note beat) usually carry little sense of syncopation; consider the second syllable of 'Tasket' in Figure 1(B).

4. Testing the predictions

In this section, we test the predictions put forth in section 2. We begin with two predictions concerning the relationships between types of syncopation. We predicted first that, based on the logic of anticipatory syncopation, 4th-position positional syncopations will usually be stressed syllables, and 2nd-position positional syncopations will usually be unstressed. (Recall that a positional syncopation is a note onset on a weak beat with no note on or before the following strong beat. Hereafter we refer to 4th-position positional syncopations as 4p's, and 2nd-position positional syncopations as 2p's). Our corpus bears out this prediction: 1,855 out of 2,754 (67%) 4p syncopations are stressed; 629 out of 1,994 (31%) 2p syncopations are stressed ($\chi^2(1) = 593.2$, $p < 10^{-15}$). In fact, the association between lexical stress and metrical position may be stronger than these figures suggest. As noted earlier, the labelling of stress is complex and contextual (and somewhat subjective). Inspection of our corpus shows numerous cases where the automatic stress-labelling method used here produced incorrect results. Figure 8 shows three examples. In Figure 8(A), 'blue' (a 2p) is labelled as stressed syllable, but in speech it would probably be given less stress than the syllables on either side. More common is the reverse error, exemplified by the words 'me' in Figure 8(A) and 'on' in Figure 8(B); in these cases (both 4p's), function words that would normally be unstressed are stressed in context.

To obtain a more accurate measure of the correlation between syncopation position and stress, we did a further analysis considering only two-syllable words. The stress patterns of polysyllabic words tend to be highly consistent and are rarely affected by context. We looked only at cases where the second syllable of a two-syllable word was a 2p or 4p. In this case, we found that 21 out of 425 (5%) 2p's were stressed; 127 out of 183 (69%) 4p's were stressed ($\chi^2(1) = 285.1$, $p < 10^{-15}$). Thus, a much stronger difference now emerges between 4p's and 2p's. While there are some legitimate exceptions, it seems clear that 4p's are stressed and 2p's are unstressed in a large majority of cases. In some of the tests below, we compare 4p's and

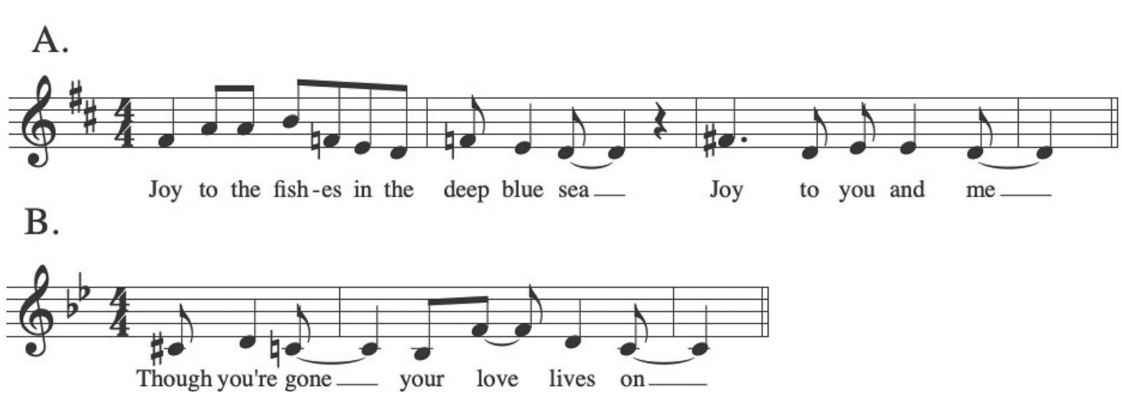

Figure 8. (A) Three Dog Night (1973), 'Joy to the World'; (B) Larry Clinton and his Orchestra (1939), 'Deep Purple'.

2p's without regard for lexical stress, but the strong correlation between metrical position and stress should be borne in mind.

We made a further prediction regarding the relationship between metrical position and durational syncopation. In general, it seems likely that longer note values, like stressed syllables, tend to fall on stronger beats – where length now refers to the *literal* duration of notes, not their inter-onset intervals. (This assumption has not been previously tested, to our knowledge.) If this is true, then it stands to reason that 4p syncopations – which are usually understood as anticipatory, belonging on the following strong beat – should coincide more with durational accents. Surprisingly, we found only a small difference between 2p's and 4p's, and in the opposite direction: 1,647 out of 1,994 (83%) 2p syncopations are also durational (extending beyond the following strong beat), while 2,192 out of 2,754 (80%) 4p syncopations are ($\chi^2(1) = 6.6$, $p < .05$). From this result, it would appear that durational accent, unlike lexical accent, is not strongly associated with the metrical context of a syncopation.

Our remaining three predictions concerned historical change in the use of syncopation. We test these predictions in the following manner. For any kind of syncopation, and for a given song, we can calculate a 'syncopation quotient', which is the number of tokens of that syncopation type as a proportion of the total number of syllables in the song. (Normalising by the number of syllables is not quite the same as normalising by the number of notes, due to melismas – syllables that span multiple notes. Since the items in our corpus correspond to syllables, not notes, this method of normalisation is more convenient.) For any syncopation type, the corpus gives us one value for each year; we can compare the trends in these values across the century, for different syncopation types.

Our first historical prediction concerns 2nd- and 4th-position positional syncopations. We suggested earlier that 4p's are a stronger form of syncopation than 2p's, due to the greater metrical strength of the 'lacuna' in the case of 4p's; 4p's are also much more likely than 2p's to be stressed syllables. Thus, we predicted that 4p's would increase at a faster rate than 2p's. This prediction is consistent with earlier work showing that 2nd-position syncopation was common in vocal and instrumental music before 1900, but 4th-position syncopation was nearly non-existent, at least until the very last years of the nineteenth century (Berlin, 1980; Temperley, 2021). Figure 9 shows, first, the syncopation quotients for the 100 songs in our corpus, combining 2p's and 4p's. (Unless otherwise noted, each graph combines syncopation data at

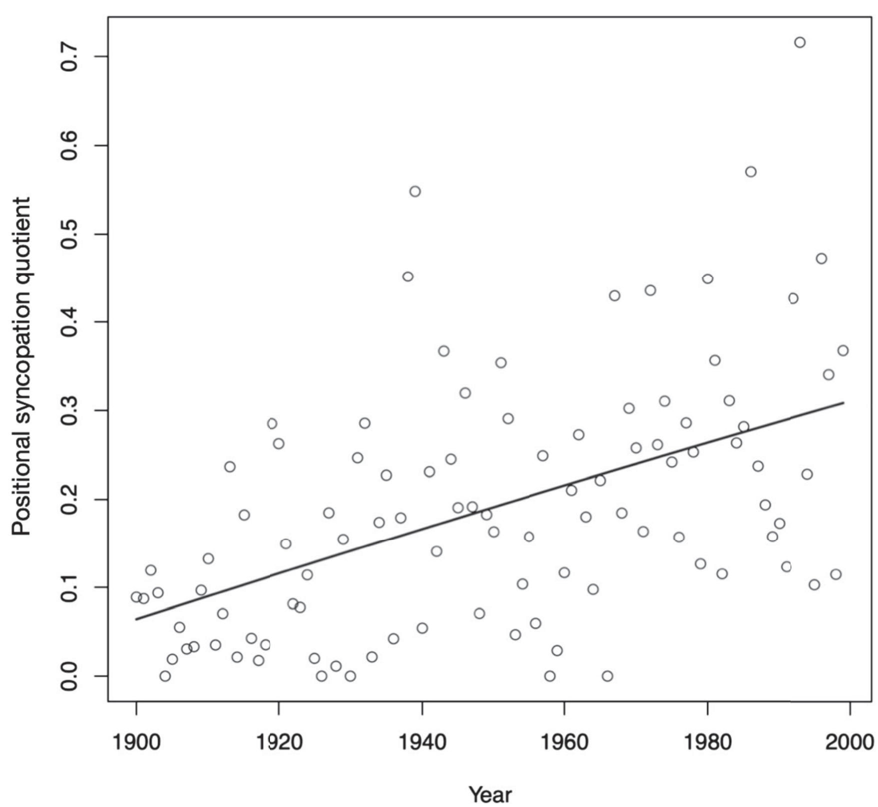

Figure 9. Positional syncopation quotients for each year of the century, including both 2p's and 4p's and both 8th- and 16th-level syncopations.

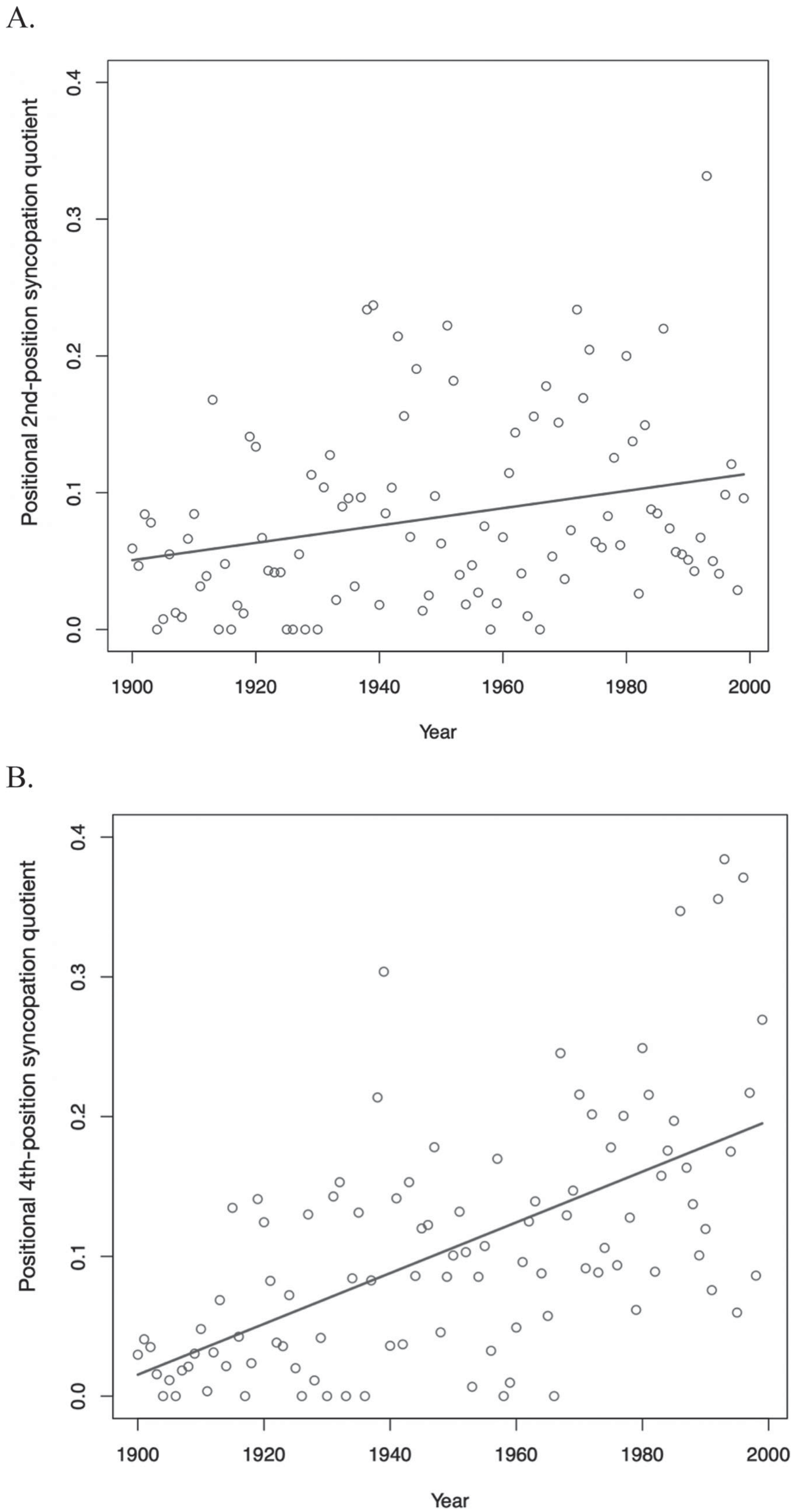

Figure 10. Positional syncopation, including 2p's only (A) and 4p's only (B).

both the 8th and 16th-level.) A regression showed a significant, positive linear trend ($r^2 = .25$, $p < .001$); the best-fitting line is shown. This indicates an increase in positional syncopation overall. Figure 10(A) shows this data for 2p's only ($r^2 = .07, p < .01$); Figure 10(B) shows it for 4p's ($r^2 = .36$, $p < .001$). It can be seen that the best-fitting line slopes more steeply for 4p's than for 2p's. While there are several ways of analysing this, the way we found to be most useful is as follows. We first examine both types of syncopation as proportions of the total number of events, and changes in these proportions over time, as predicted by the best-fitting line. For 2p's, the proportion increases from 5.0% (in 1900) to 10.9% (in 1999); 4p's increase from 1.5% to 19.3%. We can see, then, that 4p's increase at a much faster rate than 2p's. We can also express the 4p proportions as a portion of the sum of 2p's and 4p's (that is, all positional syncopations): In 1900, .015 / (.050 + .015) = .231; in 1999, .193 / (.109 + .193) = .639. Within the category of positional syncopations, then, the proportional weight of 4p's relative to 2p's increases greatly. Thus, if 4p's are viewed as stronger than 2p's, then not only does the overall number of syncopations increase over the century, but they increase in average strength as well.

One might posit a further distinction between syncopations on the fourth 8th-position of the measure and those at the eighth 8th-position (and analogously at the 16th-note level); we will call these 'weak 4p's' and 'strong 4p's', respectively. Strong 4p's could be seen as a stronger form of syncopation, since they deny an event on a whole-note beat rather than on a weak half-note beat, as weak 4p's do. Notably, also, Berlin (1980) claims that in ragtime, weak 4p's are much more common than strong 4p's. However, our data shows very little difference in historical trends between weak 4p's and strong 4p's; indeed, weak 4p's show a slightly greater increase across the century (from virtually 0% to 10.5%) than strong 4p's (from 1.6% to 9.3%).

Our second historical prediction addressed the relationship between 8th-level and 16th-level positional syncopation. Recall that we define the 8th- and 16th-note levels in relation to the tactus level indicated in the transcription: the 8th-note level is one level below the tactus, and the 16th-note level is two levels below. Since a 16th-level syncopation places the syncopated event on a lower (weaker) metrical level than an 8th-level one, it would seem to constitute a stronger form of syncopation; we predicted that this form of syncopation would increase faster or later in the century than 8th-level syncopation. Figure 11 shows the data for the two cases. (Note that Figure 9, showing all positional syncopations, sums these two sets of values.) Indeed, 8th-level syncopation (A) shows only a weak increasing trend ($r^2 = .05$, $p < .05$). By contrast, 16th-level syncopation (B) shows a very different pattern, though one that is poorly captured by a linear model: a very low value for most of the century and a marked increase in the last two decades. A quadratic model yields a significant fit to this distribution ($r^2 = .24$, $p < .01$); the best-fitting curve is shown on the figure. One could say, then, that the marked increase in positional syncopation in the latter part of the century, evident in Figure 9, is largely due to 16th-level syncopation.

One might take the relative increase in 16th-level syncopation to indicate an increase in syncopation strength in the later decades of the century. A complication, however, is the factor of tempo. Figure 12 shows the tempo of each song in the corpus. We see a clear decreasing trend ($r^2 = .11, p < 0.01$), with the best-fitting line going from 149 BPM at the beginning of the century (1900) to 102 BPM at the end (1999). (Again, it should be kept in mind that our identification of the tactus level in each song was somewhat subjective.) Thus, the increase in 16th-level syncopations may indicate that the preferred metrical range for syncopations remained relatively constant in terms of *absolute* time, but shifted towards the 16th-note level due to the slowing of the tempo. In that case, there is little reason to interpret the relative increase of 16th-note level syncopation as an increase in syncopation strength.

In some respects, our findings match those of Tan et al. (2019), who used a corpus of 80 songs from the latter half of the century. They, too, found a decrease in tempo over this period. However (summarising their rather complex results), they found little evidence of an overall increase in positional syncopation. This difference in results may be due to a difference between our corpus and theirs (their corpus was drawn from a list of songs specifically described as 'rock', whereas ours is not limited in that way), or to differences in the way syncopation is measured (Tan et al. counted positional lexical syncopations as a proportion of all stressed syllables). It may also be due to a difference in the time frame under consideration (the whole century in our study, the second half of the century in theirs); indeed, even in our data, the increase within the second half of the century is not very pronounced (see Figure 9). In both of these studies, the samples are relatively small; further data may provide a clearer picture with regard to changes in syncopation in the second half of the century.

Our third prediction focused on lexical syncopation – stressed syllables. Recall that non-positional lexical syncopations (like '(to)-geth-er' in Figure 5) are cases where a stressed syllable is directly followed by a metrically strong unstressed syllable. We suggested that non-positional lexical syncopations are actually stronger than

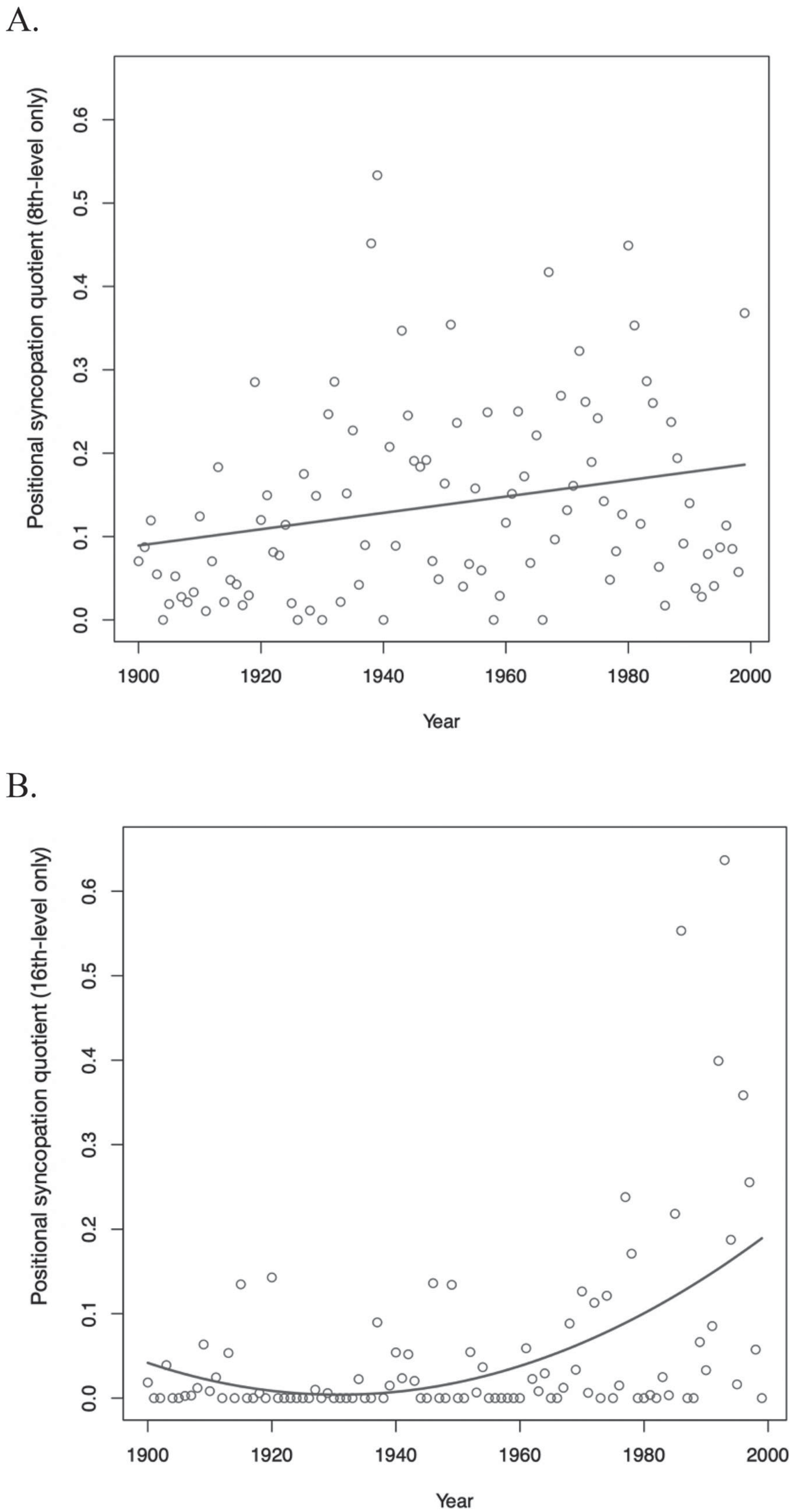

Figure 11. Positional syncopation (2p's and 4p's), 8th-level (A) and 16th-level (B).

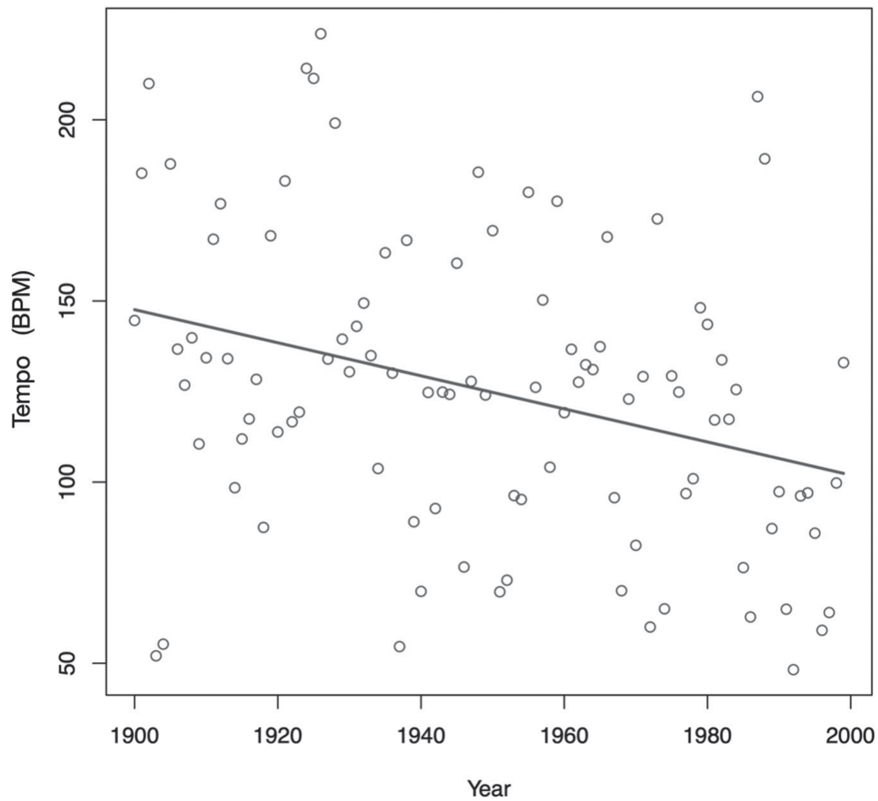

Figure 12. Tempo for each year of the century, determined by dividing the number of tactus beats (assuming four beats per bar) by the length of the song in minutes. This assumes a constant tempo within each song, which is a fair assumption for the vast majority of songs.

positional lexical ones (like 'think' in Figure 5); non-positional cases present a direct conflict between stress and metre, and cannot be resolved simply by shifting a single event. Figure 13 shows the syncopation quotients over time for positional lexical syncopation ($r^2 = .29, p < .001$) and non-positional lexical syncopation ($r^2 = .17, p < .001$). (Both categories include both 2p's and 4p's. Note that the y-axes in the two graphs are *not* scaled similarly, and that non-positional syncopation is far less common than positional syncopation overall.) According to the best-fitting lines, positional lexical syncopation increases from 1.8% in 1900 to 17.6% in 1999; non-positional lexical syncopation increases from 0.3% in 1900 to 3.1% in 1999. As a proportion of all lexical syncopations (positional and non-positional), non-positional syncopations increase only slightly: from 14.3% in 1900 to 15.0% in 1999. Again, we suspect that inaccuracies in the stress labelling conceal the true magnitude of the increase in non-positional lexical syncopation. Figure 13(B) shows a clear outlier in 1911, Arthur Collins and Bryon Harlan's 'Alexander's Ragtime Band'. This song contains 16 occurrences of the phrase 'come on' (see Figure 14). In our system, 'on' is treated as a preposition and therefore labelled as unstressed, making 'come' (which is stressed) a non-positional lexical syncopation; but in this context, 'on' is a particle, and therefore stressed relative to 'come', so in fact there is no syncopation here. To further explore this, we limited the count of non-positional lexical syncopations to those involving two adjacent syllables within a polysyllabic word (the first stressed, the second unstressed), since the stress patterns of these should rarely deviate from those in the dictionary. There were just 79 tokens of such words in the entire corpus (repetitions of a word within a song were not counted). Given such sparse data, a linear regression seemed inappropriate, and we chose to analyse the data in a different way: we divided the century into four quarters and counted syncopations as a proportion of notes within each quarter. A clear and distinctive pattern now emerges (see Figure 15(B)): the frequency is low in the first three quarters of the century and rises dramatically in the fourth quarter. Applying the same method to positional lexical syncopation (Figure 15(A)), we see a more gradual increase across the four quarters. This, then, is another factor contributing to the increase in strength of syncopations across the century.

We noted earlier that linear and quadratic models are problematic for modelling changes in proportions (though they may capture trends well in a localised way),

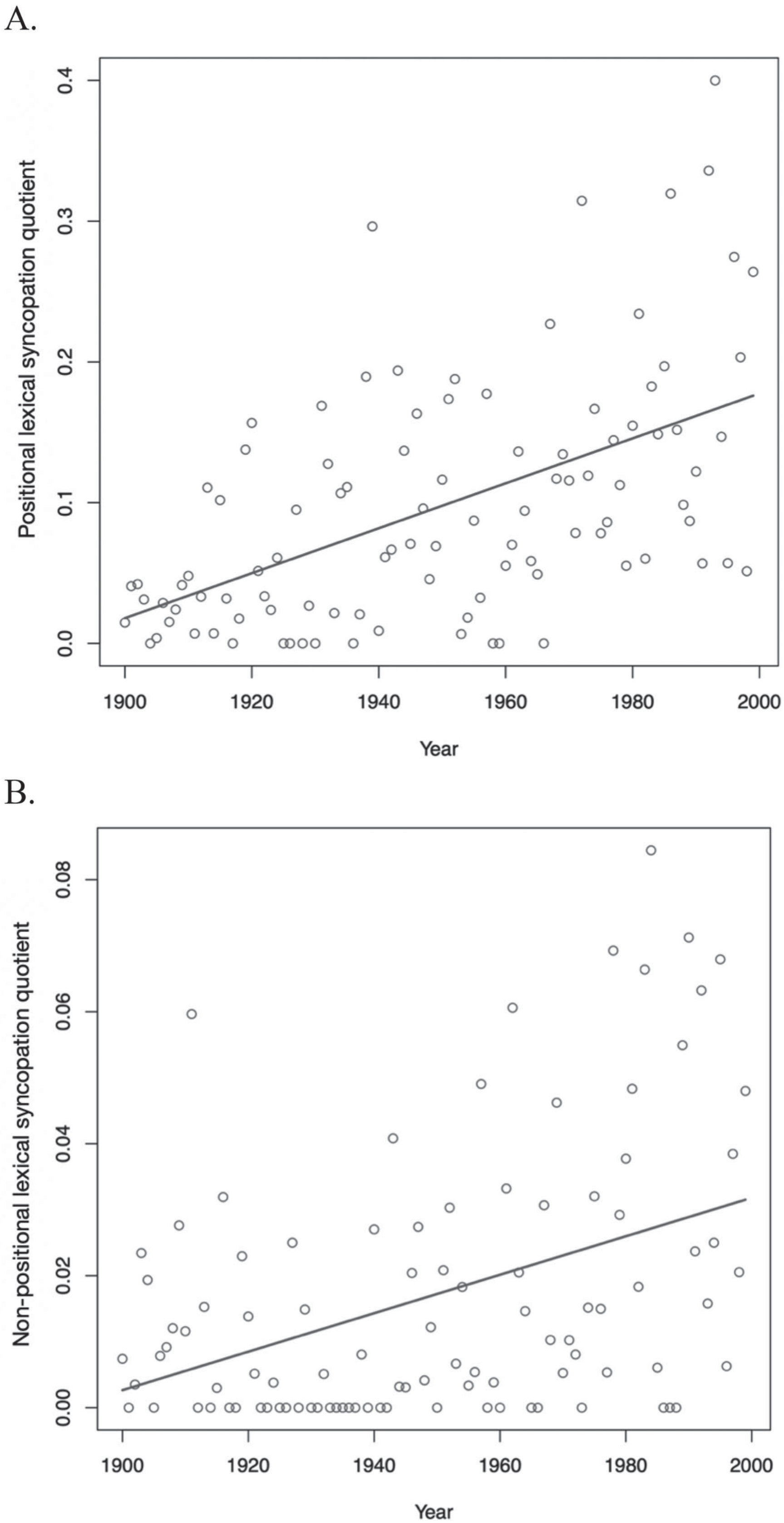

Figure 13. (A) Positional lexical syncopation. (B) Non-positional lexical syncopation.

Figure 14. Arthur Collins and Bryon Harlan (1911), 'Alexander's Ragtime Band'.

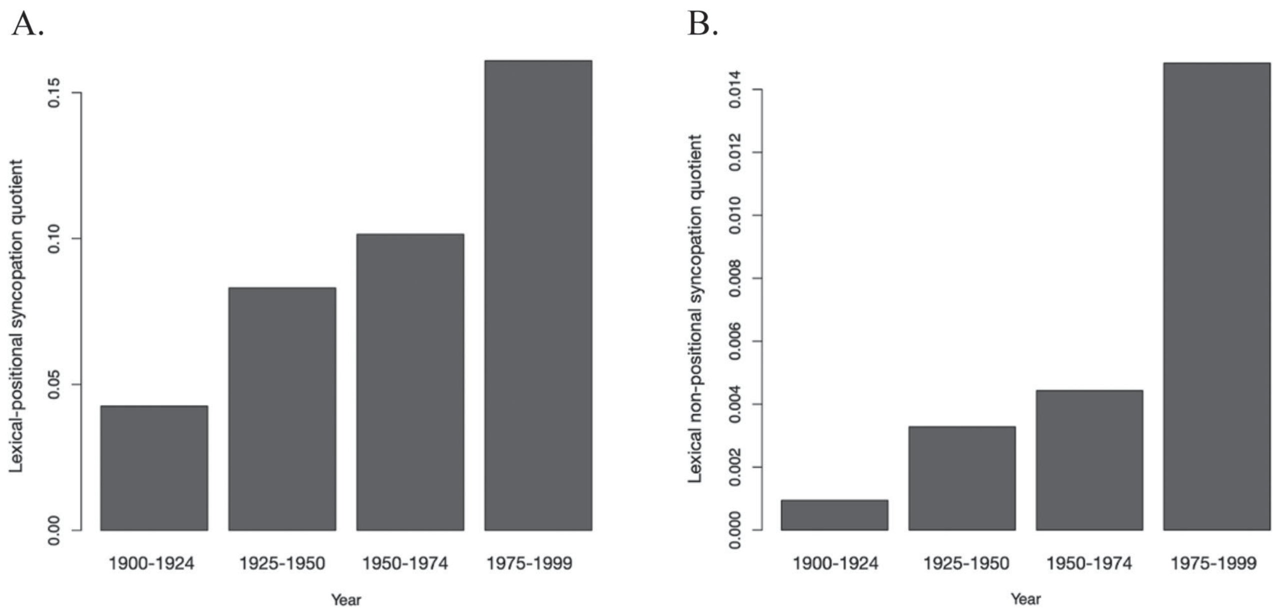

Figure 15. Positional lexical syncopation quotients (A) and single-word non-positional lexical syncopation quotients (B) for each quarter of the century.

and that sigmoidal models provide an alternative. Such a pattern might be found if a type of syncopation initially showed increasing growth, but then tapered off at some saturation value. One way to model sigmoidal patterns is with logistic regression; however, our attempts to use such models yielded non-significant results and failed to show sigmoidal patterns over the time span of interest. Here we adopt a simpler approach. As explained earlier, if there are two types of syncopation, both increasing in a sigmoidal way, we predict that the point of maximum change will occur later for the stronger type than for the weaker type. We examine this using the minimum sum of squared deviations, or MSSD. To calculate the MSSD, we consider ways of dividing the century into two 'halves' (not necessarily equal in size). For each half, we calculate the mean syncopation quotient across songs, and the sum of squared deviations (absolute differences) from this mean. We then add the sums of each half together. The MSSD corresponds to the year that minimises this sum. Essentially, this clusters the years of the century into two groups of consecutive years, in a way that maximises the similarity of values within each group and the differences between the groups; the boundary between the two groups should correspond roughly to the point of maximum change. The MSSD does not reflect the *direction* of change, but this can be seen from the graphs and statistics shown earlier. Below are the years that produce the MSSD for the types of syncopation discussed above:

2p syncopation: 1930

4p syncopation: 1966

8th-level positional syncopation: 1930

16th-level positional syncopation: 1984

Positional lexical syncopation: 1966

Non-positional lexical syncopation: 1977

In accord with our predictions, 4p syncopation increases later in the century than 2p syncopation, 16th-level positional syncopation increases later than 8th-level positional syncopation, and non-positional lexical syncopation increases later than positional lexical syncopation.

In summary, our predictions about historical change in syncopation are largely confirmed. Fourth-position syncopation increases at a faster rate than 2nd-position syncopation, and shows maximum increase later in the century; non-positional lexical syncopation increases faster than positional lexical syncopation, and shows maximum increase later. To characterise the evolution of syncopation in twentieth-century popular music in a general way, we might say that (a) it increases in frequency across the century, (b) this increase is due more to 4th-position syncopation than to 2nd-position syncopation, and (c) near the end of the century, a strong type of syncopation rare in earlier decades – non-positional lexical syncopation – becomes quite common. As for the distinction between 8th-level and 16th-level syncopation, the results are not so easy to interpret. Sixteenth-level syncopation does increase later in the century than 8th-level syncopation, but this may be partly or even entirely due to the decrease in tempo; it does not necessarily indicate a shift to faster metrical levels in an absolute sense, and therefore, it is not clear whether it contributes to the overall increase in syncopation strength.

5. Implications of the general trend

At least three patterns in our data – the overall increase in positional syncopation, the increase in 4th-position positional syncopation relative to 2nd-position positional syncopation, and the increase in non-positional lexical syncopation relative to positional lexical syncopation – indicate an increase in syncopation across the twentieth century. Seen from this perspective, earlier studies that show an increase in syncopation or rhythmic complexity within twentieth-century popular styles – ragtime (Volk & de Haas, 2013), early twentieth-century popular song (Huron & Ommen, 2006), rock (Biamonte, 2014), and rap (Waller, 2016) – are part of a larger-scale historical trend. In what follows, we discuss the implications of this trend. We do not claim to explain it, but we examine its parallels with other phenomena in musical history, and consider what further predictions might follow from it.

We suggested in section 1 that syncopation is closely related to rhythmic complexity. In information-theoretic terms, syncopation increases the variety of rhythmic patterns that may occur, thus lowering the overall predictability of the music. The trend of increasing syncopation over the twentieth century could thus be described as a trend of increasing rhythmic complexity. To our knowledge, it has not been proposed previously that popular music (or indeed, music in general) tends to become more complex, in rhythm or in any other domain. However, long-term increases in musical complexity are not without precedent. One interesting parallel that comes to mind is with pitch organisation in the nineteenth century. It seems to be generally agreed that Western music became more chromatic as the nineteenth century went on – that is, that the proportion of chromatic notes (notes outside of the operative major or minor scale) tended to increase. (The distinction between popular and art music may be relevant here; this distinction is more difficult to apply to the nineteenth century than to the 20th.) This has not been previously verified using corpus data, to our knowledge – perhaps because it is considered obvious – but there seems little doubt about it. One could say, then, that the complexity increase in the rhythmic domain in the twentieth century broadly mirrors that in the pitch domain in the nineteenth century. Though this is highly conjectural, we wonder if perhaps there is a certain self-perpetuating momentum to trends of this kind. For whatever reason, an increase in syncopation became associated with fresh, fashionable music; it then seemed natural that one could make music even more fresh and fashionable by making it even more syncopated (and similarly with chromaticism in the nineteenth century). It is not clear what would cause such a process to terminate. In the case of pitch organisation in the nineteenth century, it seems likely to be due to the fact that chromaticism beyond a certain level causes the tonal centre of a melody to become obscured. (Among more progressive composers, of course, this was considered acceptable or even desirable.) In the case of syncopation in the twentieth century, this account is less plausible, since the metrical structure is nearly always clearly conveyed by the accompaniment, no matter how syncopated the melody is. Perhaps more relevant is the fact that some late-twentieth-century melodies are practically saturated with syncopation; in Janet Jackson's 'That's the Way Love Goes' (1993), 71.6% of notes are 8th- or 16th-level positional syncopations (an excerpt is shown in Figure 16). It may be that, in recent years, positional syncopation has

Figure 16. Janet Jackson (1993), 'That's the Way Love Goes'.

been approaching its theoretical maximum. The question, then, is where popular music's rhythm will go next; we offer one tentative suggestion in the next section.

The most well-known theory with regard to musical complexity is Berlyne's (1960, 1971) 'inverted-U' theory, which states that a moderate degree of complexity is optimal for aesthetic enjoyment. Based on this theory, we might expect to see 'trade-offs' of complexity between musical dimensions; if complexity increases in one musical domain, it should decrease in others (see also Temperley, 2019b). One might expect, then, that the increase in rhythmic complexity over the twentieth century would be accompanied by decreases in other kinds of complexity. There is, in fact, some evidence for this. In popular music from 1955 through 2010, Serra et al. (2012) find a decline in the variety of timbres and pitch sequences; within a similar time frame, Morris (2017) finds that popular lyrics have become increasingly repetitive. The decrease in transduction noise, due to improvements in recording and playback technology, might also be regarded as a decrease in complexity (Link, 2001).

We explored the 'trade-off' hypothesis ourselves in two rather simple ways, using our corpus. First, we looked at the entropy of scale-degrees – pitch-classes in relation to the tonic. If a song stays entirely within a diatonic (major or minor) scale, its entropy should be lower than if it uses many chromatic tones; if it stays within a pentatonic scale, its entropy should be lower still. Rather than measuring each song's entropy individually, we grouped songs together by decade, and measured the overall scale-degree entropy of each decade. One could say that this defines each song's scale-degree complexity or unpredictability in relation to a style defined by the ten songs of that decade. (If songs were not grouped in this way, a song using a very limited pitch-class distribution – such as a whole-tone scale – might have very low entropy, though it was anomalous in relation to the style.) The results, shown in Table 1, show almost no change across the decades; by this measure, there does not appear to have been a significant decrease or increase in scale-degree complexity. Secondly, we examined melodic interval size: the average size of intervals from one melodic note to the next (see Table 1). Since large melodic intervals tend to be infrequent in nearly all styles (Huron, 2006), a style with a larger mean interval size could be considered more complex. Again, no significant trend is evident. In these respects, then, the prediction of trade-offs in complexity between rhythm and other melodic dimensions is not borne out.

Another musical dimension that is of interest in this regard is harmony. Intuitively, it seems to us that songs later in the century tend to be harmonically simpler than those of early decades. Early songs often feature fairly complex harmonic patterns, with different progressions in the different sections and usually with some use of chords outside of the key (such as secondary dominants). By contrast, songs like Janet Jackson's 'That's The Way Love Goes' (1993), TLC's 'Waterfalls' (1995), and Next's 'Too Close' (1998) consist entirely of two-bar or four-bar harmonic 'loops', repeated throughout the song. We suggest, then, that the increase in syncopation over the twentieth century may have been partly counterbalanced by a decrease in harmonic complexity. We know of no corpus that contains harmonic analyses of songs across the entire century, so it is not possible to test this conjecture in a systematic way, but it seems worthy of further study.

Table 1. Scale-degree entropy and interval size by decade.

Decade	Scale-degree entropy	Average interval size
1900s	3.008	2.475
1910s	3.076	2.274
1920s	3.052	2.807
1930s	3.052	2.363
1940s	3.092	2.328
1950s	2.768	2.215
1960s	2.856	2.323
1970s	3.091	2.243
1980s	2.983	2.100
1990s	2.802	2.239

Other recent research has examined syncopation and rhythmic complexity in relation to musical enjoyment. In particular, two experimental studies (Sioros et al., 2014; Witek et al., 2014), using rhythmic patterns typical of modern popular music, show that a moderate degree of syncopation is optimal for musical enjoyment and a sensation of 'groove'. This finding confirms both the link between syncopation and complexity and the applicability of Berlyne's 'inverted-U' theory. One complication that arises here (and throughout this discussion) is that predictability – and hence complexity – are affected by familiarity, and thus may change over time: as syncopations become more common, they may become more predictable and thus less 'complex'. Still, the fact remains that syncopation increases the variety and entropy of rhythmic patterns, and thus should increase complexity to some degree even when used in familiar ways.

6. Further issues

6.1. Other types of syncopation

We have focused so far on two rather specific types of syncopation: 2nd-position syncopations (on the second quarter of a quarter-note or half-note unit), usually unstressed, and 4th-position syncopations (on the fourth quarter of such a unit), usually stressed; we have further

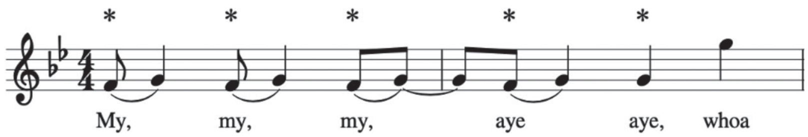

Figure 17. The Knack (1979), 'My Sharona'.

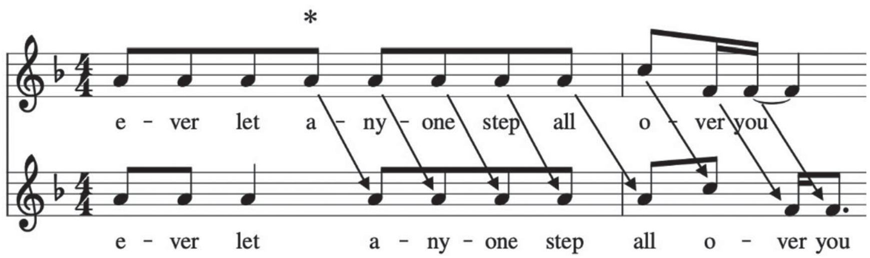

Figure 18. Wilson Phillips (1990), 'Hold On'. This a case of non-positional lexical syncopation that cannot be 'normalized' by shifting syllables to the right.

suggested that 4th-position syncopations generally have an anticipatory character. One might wonder whether all the syncopations in the corpus fall into one of these two categories. In fact there are some that do not, though they are relatively rare. One case is shown in Figure 16. The last syllable of the example, 'life', is on a weak sixteenth beat; it could be regarded as a 2nd-position syncopation, perhaps anticipating the following 8th-note beat. It seems more intuitive, however, to think of this note as being *delayed* from its underlying position, on the previous downbeat. Such 'retardative syncopations' have been observed elsewhere (Tan et al., 2019). Another type of syncopation that occurs occasionally in our corpus is cross-rhythm, the suggestion of a dotted-quarter or dotted-8th pulse in conflict with the underlying duple pulse. Figure 17 shows one instance. Cross-rhythms have been present in popular music throughout the century (Berlin, 1980; Traut, 2005); they have also been widely discussed from a theoretical perspective (Cohn, 2016; Toussaint, 2002). While many – perhaps most – syncopations could theoretically be explained as momentary cross-rhythms, there are only a few cases in our corpus, such as Figure 17, where the cross-rhythmic origin of the pattern seems beyond dispute.

Another type of syncopation is illustrated by Figure 18. In some ways, this example is similar to Figure 5. As in that case, a stressed syllable on a weak beat (the first syllable of 'an-y-one') is followed by a metrically strong unstressed syllable. In the case of Figure 5, we suggested that both the stressed and unstressed syllables ('-geth-er') were anticipating their underlying positions, as shown on the lower staff. The problem in Figure 18 is that the syllables cannot be shifted, because the positions to which they would be shifted are occupied by other syllables that resist shifting. If the entire phrase were shifted to the right – as shown on the second staff – the stressed syllables 'step' and 'o-(ver)' would be shifted from strong positions to weak ones, worsening the alignment of stress and metre rather than improving it. Unlike the other syncopation types discussed above, such 'blocked' syncopations cannot be explained in relation to a kind of unsyncopated 'deep structure'. Lee et al. (2017) find a number of examples of this type of syncopation in recent (post-2000) popular songs. Such *non*-anticipatory syncopations may indicate a new and growing trend in the rhythm of popular music – a way out of the stylistic 'dead end' that is reached when anticipatory syncopation reaches a saturation level, as in cases like Figure 16.

We suspect that the very intense forms of syncopation that emerge in the late 20th and early 21st centuries – lexical non-positional syncopation and blocked syncopation – may be partly due to the influence of rap. While our corpus contains no rap songs, rap has been an important part of popular music since the 1980s. Rap tends to feature a dense, rapid-fire delivery of syllables and complex interaction between stress and metre (Adams, 2009; Condit-Schultz, 2017; Ohriner, 2016; Waller, 2016); this may have influenced rhythm in melodic popular music as well. Comparison of rap and melodic popular music using the methods proposed here would be a natural area for further study.

6.2. Changing syncopation patterns within songs

If syncopation varies over the century, it stands to reason that it might also vary at smaller scales: over the course of a song, section, or phrase. Figure 19 compares the three choruses of the Larry Clinton Orchestra's 'Deep Purple' (1939), sung by Bea Wain. The top staff is the melody

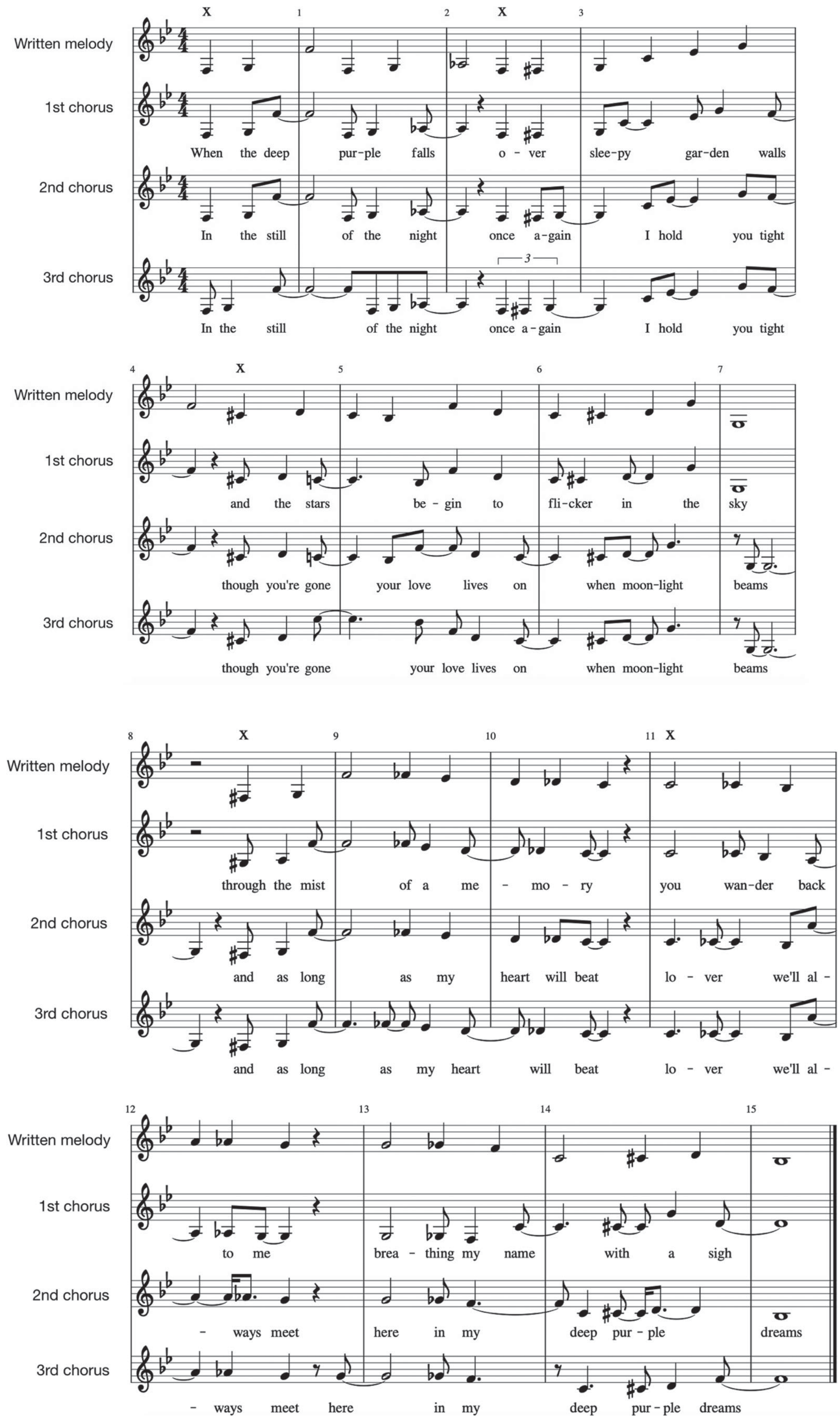

Figure 19. Larry Clinton Orchestra (1939), 'Deep Purple', showing the melody from the sheet music and the three choruses as sung by Bea Wain.

as it appears in the sheet music – 45 notes on quarter-note beats; the three choruses are shown below, with their performed rhythms. With the exception of some octave jumps (and some changes in the last two notes of the melody), the only difference between the three chorus melodies is the metrical placement of their notes. In each chorus, Wain syncopates the original melody by shifting some notes an eighth position to the left, or occasionally to the right. (The delay of the note in bar 7 in the second and third choruses could be viewed as retardative syncopation.) The locations of the syncopations vary from chorus to chorus, but the overall number of syncopations remains consistent: Wain does not syncopate one chorus much more than another. This seems to hold true in general. Over the entire corpus, we find that considering just the first half of each song (i.e. the first 50% of the notes), 19.4% of notes are positional syncopations (either 2p or 4p, 8th or 16th level); for the second half of each song, the proportion is 18.6%. This suggests that there is no strong tendency for syncopation to either increase or decrease as a song continues.

Does Wain syncopate some parts of the melody more than others? The melody consists of two eight-bar phrases, each of which can be broken down into sub-phrases of two, two, and four bars (similar to the classical 'sentence'). Only six notes of the original melody remain unchanged from chorus to chorus, and five of these (marked with x's) are the first note of a subphrase. (The sixth one is the *second* note of the final sub-phrase.) This suggests a strategy of avoiding syncopation at the beginning of a phrase. Testing this claim systematically would require annotating phrase boundaries in the corpus, which we have not done; however, our informal inspection of the data suggests that it may have general validity. Withholding syncopation at the beginning of a phrase serves a clear perceptual function, reasserting the metre so that events later in the phrase can be perceived *as* syncopations. Another example is 'Rock Around the Clock' (1955) by Bill Haley and his Comets (not shown here). The opening ' ^1-^3-^5' figure (e.g. 'when the *clock strikes one*') in the first and third bars of each verse is rendered with consistent, unsyncopated rhythm (though the lyrics change on each occurrence); syncopations appear only in the second and fourth bars. These examples are instructive in another way as well: the notes that Bea Wain and Bill Haley choose to syncopate in each chorus are not selected at random. Rather, the syncopations bring the melody closer to the natural rhythm of the lyrics. At the downbeat of bar 6 in the first chorus of 'Deep Purple', for example, the first syllable of 'flicker' feels most natural with a short duration; Wain shortens the note by moving the following note to the left, creating a 2p syncopation. Applying this rhythm to the parallel point in the second and third choruses – 'lives on when' – would feel quite unnatural. On the other hand, the second and third choruses have the same lyrics, but slightly different syncopations, showing that the syncopations are not entirely dictated by the lyrics; there is also, perhaps, a desire for rhythmic variety for its own sake.

6.3. *Syncopation in instrumental parts*

While our focus in this study has been entirely on vocal lines, syncopation certainly occurs in instrumental parts as well. Fourth-position syncopation, which first appeared in vocal lines in the years around 1900, seems to have emerged in solo instrumental parts and chordal accompaniment parts at about the same time (Berlin, 1980); in ragtime songs, right-hand piano parts show 4th-position syncopations even before vocal lines do (Temperley, 2021). Syncopation in drum parts and bass lines is another matter. In general, these parts of the texture tend to be unsyncopated in popular music, as they are responsible for conveying the metrical framework against which melodic syncopations are understood. However, there are cases where drum and bass parts are strongly syncopated as well (see Temperley, 2018, pp. 76–77, for discussion and examples). Our impression is that this, too, is a practice that emerges only in the later part of the century, and might therefore contribute to the general trend of increasing syncopation; this has not yet been systematically investigated, however.

7. Conclusions

Several prior studies have shown increases in syncopation within styles of twentieth-century popular music: ragtime (Volk & de Haas, 2013), early twentieth-century popular song (Huron & Ommen, 2006), rock (Biamonte, 2014), and rap (Waller, 2016). In this study, we have shown that these more localised increases are part of a broader trend. Syncopation in general increases in frequency across the century, and stronger forms increase faster and later than weaker forms. Our sample is relatively small, and offers a highly oversimplified picture of the rich landscape of popular music across the century, which included a wide variety of diverse styles. Still, combining our results with the studies of individual styles mentioned above, the overall trend seems clear.

Syncopation is a complex, multi-faceted musical device that contributes greatly to the rhythmic richness and appeal of twentieth-century American popular music. We hope our study has shed some light on the historical evolution of this device over the course of the twentieth century. We hope, also, that our corpus will facilitate further studies in this area, and studies of popular music more broadly.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Adams, K. (2009). On the metrical techniques of flow in rap music. *Music Theory Online*, *15*(5). https://doi.org/10.30535/mto.15.5.1

Anonymous. (2014). *History of the record industry, 1920s–1950s*. Retrieved May 5, 2021, from https://medium.com/@Vinylmint/history-of-the-record-industry-1920-1950s-6d491d7cb606

Berlin, E. (1980). *Ragtime: A musical and cultural history*. University of California Press.

Berlyne, D. (1960). *Conflict, arousal, and curiosity*. McGraw-Hill.

Berlyne, D. (1971). *Aesthetics and psychobiology*. Meredith Corporation.

Biamonte, N. (2014). Formal functions of metric dissonance in rock music. *Music Theory Online*, *20*(2). https://doi.org/10.30535/mto.20.2.1

Cohn, R. (2016). A platonic model of funky rhythms. *Music Theory Online*, *22*(2). https://doi.org/10.30535/mto.22.2.1

Condit-Schultz, N. (2017). A digital corpus of rap transcriptions. *Empirical Musicology Review*, *11*(2). https://doi.org/10.18061/emr.v11i2.4961

Fitch, W. T., & Rosenfeld, A. J. (2007). Perception and production of syncopated rhythms. *Music Perception*, *25*(1), 43–58. https://doi.org/10.1525/mp.2007.25.1.43

Gomez, F., Thul, E., & Toussaint, G. (2007). An experimental comparison of formal measures of rhythmic syncopation. In *Proceedings of the International Computer Music Conference* (pp. 101–104).

Hamm, C. (1983). *Music in the new world*. Norton.

Hayes, B. (1995). *Metrical stress theory*. University of Chicago Press.

Huron, D. (2006). *Sweet anticipation: Music and the psychology of expectation*. MIT Press.

Huron, D., & Ommen, A. (2006). An empirical study of syncopation in American popular music, 1890–1939. *Music Theory Spectrum*, *28*(2), 211–231. https://doi.org/10.1525/mts.2006.28.2.211

Kernfeld, B. (2011). *Pop song piracy: Disobedient music distribution since 1929*. University of Chicago Press.

Krumhansl, C. (2017). Listening niches across a century of popular music. *Frontiers in Psychology*, *8*, Article 431. https://doi.org/10.3389/fpsyg.2017.00431

Lee, C., Brown, L., & Müllensiefen, D. (2017). The musical impact of Multicultural London English (MLE) speech rhythm. *Music Perception*, *34*(4), 452–481. https://doi.org/10.1525/mp.2017.34.4.452

Leong, D. (2011). Generalizing syncopation: Contour, duration, and weight. *Theory and Practice*, *36*, 111–150.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. MIT Press.

Link, S. (2001). The work of reproduction in the mechanical aging of an art: Listening to noise. *Computer Music Journal*, *25*(1), 34–47. https://doi.org/10.1162/014892601300126098

London, J. (2012). *Hearing in time: Psychological aspects of musical meter* (2nd ed.). Oxford University Press.

Longuet-Higgins, H., & Lee, C. (1984). The rhythmic interpretation of monophonic music. *Music Perception*, *1*(4), 424–441. https://doi.org/10.2307/40285271

Morris, C. (2017, May). Are pop lyrics getting more repetitive? *The Pudding*. Retrieved April 5, 2021, from https://pudding.cool/2017/05/song-repetition/

Ohriner, M. (2016). Metric ambiguity and flow in rap music: A corpus-assisted study of Outkast's 'mainstream' (1996). *Empirical Musicology Review*, *11*(2), 153–179. https://doi.org/10.18061/emr.v11i2.4896

Palmer, C., & Krumhansl, C. (1990). Mental representations for musical meter. *Journal of Experimental Psychology: Human Perception and Performance*, *16*(4), 728–741. https://doi.org/10.1037/0096-1523.16.4.728

Randel, D. (Ed.). (1986). *The new Harvard dictionary of music*. Harvard University Press.

Serra, J., Corral, A., Boguna, M., Haro, M., & Arcos, J. (2012). Measuring the evolution of contemporary western popular music. *Scientific Reports*, *2*(521), 1–6. https://doi.org/10.1038/srep00521

Sioros, G., Miron, M., Davies, M., Gouyon, F., & Madison, G. (2014). Syncopation creates the sensation of groove in synthesized music examples. *Frontiers in Psychology*, *5*, Article 1036. https://doi.org/10.3389/fpsyg.2014.01036

Smith, L., & Honing, H. (2006). Evaluating and extending computational models of rhythmic syncopation in music. In *Proceedings of the International Computer Music Conference* (pp. 688–691).

Tan, I., Lustig, E., & Temperley, D. (2019). Anticipatory syncopation in rock: A corpus study. *Music Perception*, *36*(4), 353–370. https://doi.org/10.1525/mp.2019.36.4.353

Temperley, D. (1999). Syncopation in rock: A perceptual perspective. *Popular Music*, *18*(1), 19–40. https://doi.org/10.1017/S0261143000008710

Temperley, D. (2010). Modeling common-practice rhythm. *Music Perception*, *27*(5), 355–375. https://doi.org/10.1525/mp.2010.27.5.355

Temperley, D. (2018). *The musical language of rock*. Oxford University Press.

Temperley, D. (2019a). Second-position syncopation in European and American vocal music. *Empirical Musicology Review*, *14*(1–2). https://doi.org/10.18061/emr.v14i1-2.6986

Temperley, D. (2019b). Uniform information density in music. *Music Theory Online*, *25*(2). https://doi.org/10.30535/mto.25.2.5

Temperley, D. (2021). The origins of syncopation in American popular music. *Popular Music*, *40*(1), 18–41. https://doi.org/10.1017/S0261143021000283

Temperley, D., & de Clercq, T. (2013). Statistical analysis of harmony and melody in rock music. *Journal of New Music Research*, *42*(3), 187–204. https://doi.org/10.1080/09298215.2013.788039

Toussaint, G. (2002). A mathematical analysis of African, Brazilian, and Cuban clave rhythms. In *Proceedings of BRIDGES: Mathematical Connections in Art, Music and Science* (pp. 157–168).

Traut, D. (2005). 'Simply irresistible': Recurring accent patterns as hooks in mainstream 1980s music. *Popular Music*, *24*(1), 57–77. https://doi.org/10.1017/S0261143004000303

Volk, A., & de Haas, B. (2013). A corpus-based study of ragtime syncopation. In *Proceedings of the International Society for Music Information Retrieval* (pp. 163–168).

Waller, A. (2016). *Rhythm and flow in hip-hop music: A corpus study* [PhD thesis, University of Rochester, Eastman School of Music]. https://www.proquest.com/docview/1858816923

Whitburn, J. (1999). *A century of pop music*. Record Research Inc.

Witek, M., Clarke, E., Wallentin, M., Kringelbach, M., & Vuust, P. (2014). Syncopation, body-movement and pleasure in groove music. *PLoS ONE*, *9*(4). https://doi.org/10.1371/journal.pone.0094446

Appendix. List of songs in the corpus

Year	Song	Artist	Year	Song	Artist
1900	Tiger Lily	Arthur Collins	**1950**	If I Knew You Were Comin' I'd Have Baked a Cake	Eileen Barton
1901	Ma Blushin' Rosie	Albert Campbell	**1951**	Cry	Johnnie Ray
1902	Bill Bailey, Won't You Please Come Home	Arthur Collins	**1952**	You Belong To Me	Jo Stafford
1903	Come Down, Ma Evenin' Star	Lillian Russell	**1953**	You You You	The Ames Brothers
1904	Sweet Adeline (You're The Flower Of My Heart)	Haydn Quartet	**1954**	Oh! My PaPa	Eddie Fisher
1905	The Preacher And The Bear	Arthur Collins	**1955**	Rock Around the Clock	Bill Haley and His Comets
1906	The Grand Old Rag	Billy Murray	**1956**	The Wayward Wind	Gogi Grant
1907	Let's Take An Old Fashioned Walk	Ada Jones and Billy Murray	**1957**	All Shook Up	Elvis Presley
1908	Under Any Old Flag At All	Billy Murray	**1958**	All I Have To Do Is Dream / Claudette	Everly Brothers
1909	Put On Your Old Gray Bonnet	Haydn Quartet	**1959**	The Battle of New Orleans	Johnny Horton
1910	Casey Jones	Billy Murray & American Quartet	**1960**	Cathy's Clown	The Everly Brothers
1911	Alexander's Ragtime Band	Arthur Collins & Byron G. Harlan	**1961**	Tossin' and Turnin'	Bobby Lewis
1912	Ragtime Cowboy Joe	Bob Roberts	**1962**	Mashed Potato Time	Dee Dee Sharp
1913	You Made Me Love You (I Didn't Want to Do It)	Al Jolson	**1963**	Sugar Shack	Jimmy Gilmer & The Fireballs
1914	The Song That Stole My Heart Away	Henry Burr	**1964**	I Want To Hold Your Hand	The Beatles
1915	It's A Long Way To Tipperary	John McCormack	**1965**	Wooly Bully	Sam The Sham & The Pharaohs
1916	M-O-T-H-E-R (A Word That Means The World To Me)	Henry Burr	**1966**	The Ballad Of The Green Berets	Sgt. Barry Sadler
1917	Over There	American Quartet	**1967**	To Sir With Love	Lulu
1918	Just A Baby's Prayer At Twilight (For Her Daddy Over There)	Henry Burr	**1968**	Hey Jude	The Beatles
1919	I'll Say She Does	Al Jolson	**1969**	Sugar, Sugar	Archies
1920	Swanee	Al Jolson	**1970**	Bridge Over Troubled Water	Simon & Garfunkel
1921	Margie	Al Cantor	**1971**	Joy To The World	Three Dog Night
1922	April Showers	Al Jolson	**1972**	The First Time Ever I Saw Your Face	Roberta Flack
1923	That Old Gang Of Mine	Billy Murray & Ed Smalle	**1973**	Tie A Yellow Ribbon 'Round The Old Oak Tree	Tony Orlando
1924	California Here I Come	Al Jolson	**1974**	The Way We Were	Barbra Streisand
1925	I'll See You In My Dreams	Isham Jones with Ray Miller's Orchestra	**1975**	Love Will Keep Us Together	Captain & Tennille
1926	Who?	George Olsen	**1976**	Silly Love Songs	Wings
1927	My Blue Heaven	Gene Austin	**1977**	I Just Want to Be Your Everything	Andy Gibb
1928	My Angel (Angela Mia)	Paul Whitman	**1978**	Shadow Dancing	Andy Gibb
1929	Tip Toe Through The Tulips	Nick Lucas	**1979**	My Sharona	Knack
1930	Stein Song (University of Maine)	Rudy Vallee	**1980**	Call Me	Blondie
1931	Goodnight Sweetheart	Wayne King	**1981**	Bette Davis Eyes	Kim Carnes
1932	Night and Day	Fred Astaire with Leo Reisman	**1982**	Physical	Olivia Newton-John
1933	The Last Round-Up	George Olsen	**1983**	Every Breath You Take	The Police
1934	June In January	Bing Crosby	**1984**	When Doves Cry	Prince
1935	Cheek To Cheek	Fred Astaire	**1985**	Careless Whisper	Wham!
1936	Alone	Tommy Dorsey	**1986**	That's What Friends Are For	Dionne & Friends
1937	Sweet Leilani	Bing Crosby	**1987**	Walk LIke An Egyptian	Bangles
1938	A-Tisket A-Tasket	Ella Fitzgerald	**1988**	Faith	George Michael
1939	Deep Purple	Larry Clinton	**1989**	Look Away	Chicago
1940	I'll Never Smile Again	Tommy Dorsey	**1990**	Hold On	Wilson Phillips
1941	Amapola	Jimmy Dorsey	**1991**	(Everything I Do) I Do It For You	Bryan Adams
1942	White Christmas	Bing Crosby	**1992**	Save The Best For Last	Vanessa Williams
1943	I've Heard That Song Before	Harry James	**1993**	That's The Way Love Goes	Janet Jackson
1944	Shoo-shoo Baby	Andrews Sisters	**1994**	The Sign	Ace Of Base
1945	Rum And Coca-Cola	Andrews Sisters	**1995**	Waterfalls	TLC
1946	The Gypsy	Ink Spots	**1996**	Because You Loved Me	Celine Dion
1947	Near You	Francis Craig	**1997**	Candle In The Wind	Elton John
1948	Buttons And Bows	Dinah Shore	**1998**	Too Close	Next
1949	Riders In The Sky (A Cowboy Legend)	Vaughn Monroe	**1999**	Believe	Cher