Rhythm in the Speech and Music of Jazz and Riddim Musicians

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Previous research has demonstrated similarities in the rhythmic characteristics of the speech and instrumental music within individual languages, such as French or English, but clear differences in these rhythmic patterns between languages. A recent finding has shown a comparable result for the rhythmic patterns of the spontaneous speech and instrumental music of musicians who speak different dialects of English, such that within-dialect speech and music rhythms are more similar to one another than are across-dialect rhythms. We extend the latter finding by comparing the rhythmic characteristics of the spontaneous speech and jazz productions of jazz musicians who speak American English with those of the spontaneous speech and riddim productions of Jamaican musicians, who speak Jamaican English. We found that the speech and music rhythmic patterns were similar within each dialect but different across dialects. Though scholars have suggested a link between speech prosody and jazz in the past, this is the first study known to us to demonstrate a link between the rhythmic properties of the speech and music of jazz musicians.

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In the past, researchers often speculated that national music rhythms reflected the linguistic rhythms of the composers' native languages. Because French and English have been described as having very different rhythmic patterns (Pike, 1945), the speech and music of English and French would appear to be good candidates for investigation of this question. Wenk (1987) was able to provide some initial support for the expected rhythmic differences in French and English instrumental and vocal music, but it was the application of new tools — for example, the normalized Pairwise Variability Index (nPVI) (Low, Grabe & Nolan, 2000) used in investigations by Huron and Ollen (2003), Patel and Daniele (2003), and Patel, Iversen, and Rosenberg (2006) — for assessing rhythm that has revealed considerable evidence in support of the link between the speech and instrumental music rhythms in individual languages. With such tools, researchers have found similarities in the rhythms of speech and music within French, as well as similarities in those rhythms within English, but differences in both music and speech rhythms when French and English are compared (e.g., Patel et al., 2003). Listeners have also been able to classify instrumental music correctly as either French or English using rhythmic information (Hannon, 2009).

The nPVI allows researchers to provide a global index of the rhythmic patterns of music and language in terms of their tendency to use either relatively similar durations from one note or one vowel to another, as in French, or to show greater note-to-note or vowel-to-vowel durational contrast, as in English. A recent study of particular interest (Temperley & Temperley, 2011) demonstrated an even tighter link between a specific music pattern known as the Scotch Snap, in which the beat falls on a sixteenth note followed by a dotted eighth note, and a specific linguistic rhythmic pattern, the prevalence of very brief, stressed, short vowels in English. This speech pattern was not found in Italian and was very rare in German, both of whose music traditions lack the Scotch Snap.

The nPVI and similar durational metrics have been used to distinguish not only between languages, but among dialects of the same language, including English dialects (Deterding, 2001; Ferragne & Pellegrino, 2004a, 2004b; Low et al., 2000; Thomas & Carter, 2006; Thomas & Coggshall, 2006; Coggshall, 2008), as well as dialects of Arabic (Ghazali, Hamdi & Barkat, 2002) and European and Brazilian Portuguese (Frota & Vigario, 2001). McGowan and Levitt (2011) used nPVI measures to explore the question of whether regional music rhythms reflected the linguistic rhythms of the composers' native dialects. They compared the speech and music rhythms of musicians who spoke three different dialects of English, with three musicians per group, and again found that the speech and music rhythmic patterns were correlated in each area. Unlike most previous studies, they analyzed spontaneous speech rather than read speech, since the two are often different (e.g., Deterding, 2001; Silverman, Blaauw, Spitz, & Pitrelli, 1992), and unscored instrumental music; in this case, fiddled reels, rather than music notation.

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The present study extends the investigation of rhythmic patterns in instrumental music and spontaneous speech to the speech and music of jazz musicians who are all speakers of American English and riddim musicians who are all speakers of Jamaican English. Previous research (Thomas & Carter, 2006) using nPVI with spontaneous speech has shown that American speakers of both African and European descent tend to produce English utterances with a higher median nPVI (between 51-52), whereas Jamaican English speakers tend to produce utterances with a lower median nPVI (around 40), which is in fact more typical of creole-based varieties of English than those without any creole history (Wells, 1982).[1]

Although it is an instrumental music genre, the riddim is nonetheless created to accommodate the rhythms of Jamaican English. A riddim forms the base of all dancehall tunes. The dancehall song is most often made up of a riddim with its own melody plus a vocalist singing over the riddim with a different melody (Manuel & Marshall, 2006). A producer creates the riddim, nowadays almost always digitally, with an underlying drumbeat that is then overlaid with other synthesized rhythms to which are added one or more melodies of varying complexity. Producers want their riddims used widely to accompany many different vocalists, each with a different song, so the underlying rhythmic patterns of the music need to be compatible with those of Jamaican speech. Indeed, when a performer's timing is in sync with that of the riddim, it is called "riding the riddim" (Stolzoff, 2000, p. 126.) An example of a very widely used riddim is the "Sleng Teng" riddim, produced by King Jammy and Wayne Smith, which is reported to have been used in over 380 different reggae and dancehall tunes (http://riddims.frenkieh.com/show/riddims/18/page_10/).

As in the case of riddims, jazz vocalists have often provided lyrics for instrumental jazz solos, a practice called vocalese (Berliner, 1994, p. 99). It has also been suggested that instrumental jazz as a music genre is influenced by the speech patterns of the musicians (Bauer, 2014; Berliner, 1994). Although one publically available study (McDonough, Danko, & Zentz, 2007) provided some measures of rhythm in the speech and music of two jazz musicians, the authors did not find a match in the rhythmic patterns. However, there was only one small speech sample and one small music sample for each musician.

Although ideally we would have liked to use the same music genres, as was the case for McGowan and Levitt (2011), speakers of different languages or dialects often do not share the same instrumental music traditions, making such a choice difficult. Although the genres we chose are different, we felt we had good reasons for predicting that both the rhythmic patterns of instrumental jazz and riddim music would reflect the different speech rhythms of their producers.

Method

MATERIALS

We used online sources to collect materials. Since our study was designed to compare the spontaneous speech and instrumental performances from individual musicians, in order to be able to collect speech samples, we had to first look for recorded interviews of prominent jazz and riddim musicians.[2] The jazz musicians we selected are famous and very familiar to American audiences, and the riddim producers selected for study are well known to Jamaicans. Each musician has produced riddims used by multiple artists, and several have produced songs that made it to the Billboard charts. We then chose several riddims and jazz improvisations from each musician, downloaded both interviews and instrumental music from YouTube.com, and converted all samples to MP3 files using a free online conversion software program (youtube-mp3.org). Appendix A contains a complete list of the speech and music sources. As can be seen from the Appendix, the music samples from the jazz musicians range from 1926 to 2000 and for the riddim producers from 1998 to 2013, and the speech samples from the jazz musicians range from 1956 to 2012 and from the riddim producers from 2008 to 2013. The narrower range for the Jamaican musicians is due to the fact that the dancehall riddim is a relatively new genre, dating from the late 1980s (Manuel & Marshall, 2006). However, our choice of particular musicians was made based on their reputations and the availability online of samples of their speech.

[1] Creole-based varieties of English have been described as syllable timed, a term that — along with stress timed — was developed to characterize the impressions researchers originally had of the rhythmic differences between languages such as French and English. Researchers first thought the rhythmic differences were based either on isochrony of syllables (syllable timed) or of stressed syllables (stress timed). More recent research has shown that differences are better attributed to patterns of full and reduced vowels, syllable types, and the lengthening effects of stress (Dauer, 1983, 1987). Languages that are described as syllable timed typically have lower nPVIs.

[2] The first author of this paper is a native of Jamaica and is familiar with its dancehall traditions.

TABLE 1. *Speech and Music Characteristics*

	Speech			Music		
	Utterances *N*	Vowels per utterance *M* (range)	*M* nPVI (*SD*)	Phrases *N* (%Head)	Notes per phrase *M* (range)	*M* nPVI (*SD*)
Group						
American						
LA	23	12.70 (4-24)	56.20 (11.76)	22 (100)	11.05 (8-20)	50.62 (14.66)
JC	21	9.43 (4-21)	49.64 (23.83)	22 (52)	13.91 (8-31)	53.77 (21.94)
HH	30	7.60 (4-13)	53.71 (16.45)	20 (49)	13.20 (8-23)	53.76 (23.84)
MD	24	9.34 (4-23)	55.17 (13.41)	20 (86)	12.45 (8-24)	61.09 (21.63)
WM	23	10.30 (4-16)	60.37 (15.17)	22 (85)	16.91 (8-67)	43.31 (11.14)
M	24.2	9.87	55.03 (16.12)	21.2	13.50	52.51 (18.64)
Jamaican						
DC	24	11.42 (4-22)	49.90 (12.58)	20	11.05 (8-17)	41.39 (12.84)
TK	25	7.20 (4-12)	44.27 (14.54)	20	12.35 (8-15)	38.47 (11.26)
SM	24	9.54 (4-17)	43.36 (15.64)	20	11.95 (8-17)	42.06 (20.70)
ER	22	8.41 (4-16)	49.32 (17.91)	20	11.45 (8-14)	35.05 (9.83)
PS	22	11.18 (4-22)	51.89 (12.33)	18	9.22 (5-14)	28.67 (14.85)
M	23.4	9.67	47.75 (14.60)	19.6	11.20	37.13 (13.90)

PHRASE SELECTION

Speech. In keeping with the methodology developed by Grabe and colleagues (Grabe, Post, & Watson, 1999), we selected phrases from the interviews with our jazz and riddim musicians that were at least four syllables in length with no hesitations or filled pauses. All phrases typically had lengthened final syllables — phrase-final intonation — which we verified by auditorily and visually examining their F0 contour, and were followed by unfilled pauses of at least 50 ms. We did not analyze phrases that contained quotations from another speaker. All speakers had at least 20 phrases (see Table 1).

Music. Using the definitions developed by Love (2012), we selected segments from our music compositions. Love considers the segment to be the smallest unit of music phrasing. According to Love, it is "chiefly defined through surface features like rests and relatively long notes" (p. 5). This definition was very compatible with our criteria for segmenting speech phrases. Determination of the end boundary of the music segment was often also made in light of the downbeat of the following segment.

From the instrumental jazz and riddim productions, working from the beginning of the piece, we chose all the music phrases that had no internal rests and were at least eight notes in length. When phrases were repeated, we used no more than one repeat. Previous work (McGowan & Levitt, 2011; Patel & Daniele, 2003) had selected music phrases of longer length – at least 12 notes each. However, we found that many of the jazz pieces and, in particular, many of the riddim productions had relatively short music phrases, so we chose phrases that were at least eight notes in length. The only exception was in the case of the music phrases for the riddim musician PS, who had both fewer available riddims and whose music phrases tended to be very short. In his case, the minimum number of notes in a phrase was five. For each riddim we chose the predominant melody, which usually consisted of eight bars, and divided it into phrases and subphrases of approximately two bars, based on the location of rests and transitions. Although the phrases range in length from one to eight bars with an average bar length of 2.19, the overwhelming majority were two bars. Jazz phrases were chosen similarly, with phrase lengths also ranging from one to eight bars and an average phrase length of 2.97 bars. Jazz phrases came either from the head or improvisation sections. The percent of phrases that came from the head varied from a low of 49% to a high of 100% (see Table 1).

SEGMENTATION

With the aid of Praat software (Boersma & Weenink, 2009), we measured the durations of the vowels and notes, after marking their boundaries using interactive playback. These durations were then used to calculate the nPVI for each speech utterance or music phrase. To identify vowel boundaries, we used the criteria from Peterson and Lehiste (1960). In order to determine boundaries for sounds such as /l/, /r/, /w/ and /j/, we considered in addition both perceptual information and rapid spectral changes in formants. Following Patel et al. (2006), we segmented individual vowels rather than vocalic intervals, and following Ferragne and Pellegrino

(2004a) we also counted syllabic consonants as vowels. Segmentation of the music phrases was a bit simpler. Since there were no pauses between notes, the duration of a note started with its onset and ended with the onset of the next note, which is equivalent to the interonset interval (IOI), often used in studies of music rhythm. Ornaments such as slides or grace notes were counted as part of the note that they preceded because they serve to articulate the note that follows (Gainza, Lawlor, & Coyle, 2004).

In Figure 1 we provide a sample phrase from each musician in music notation, which was generated using the program Noteflight (noteflight.com). The translation into notes suggests a greater regularity in their duration for notes of a particular metrical value (e.g., a quarter note) than we often found in the actual measurement of the music. Indeed, even the notes produced by musicians who play scored music can show substantial variability in duration, when compared to the score. (e.g., Repp, 1998)

nPVI

The nPVI equation is shown below, where m is the number of vowels or music notes and d_k is the duration of the k^{th} vowel or music note. The equation is sensitive to the lengths of adjacent notes or vowels. Patterns in which a series of vowels or notes of similar length occur would have lower nPVI values than those in which long and short vowels or notes alternate. After computing the difference between successive vowel durations, the nPVI measure normalizes for changes in rate by dividing by the mean duration of the two vowels. For utterances or music phrases of length m (vowels or notes), the nPVI computes the degree of contrastiveness between successive vowels or notes, takes the mean of these scores and then multiplies it by 100 (Low et al., 2000).

$$nPVI = \frac{100}{(m-1)} * \sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(\frac{d_k + d_{k+1}}{2})} \right| \qquad (1)$$

Results

Table 1 displays, for each jazz or riddim musician, information about the number of speech and music phrases analyzed, the mean number and range of the notes or vowels in a phrase, and the mean nPVI and standard deviation for his speech and music phrases.

Because the data from the music phrases were not normally distributed and the sample sizes for both the music and the speech were small, we used nonparametric tests to evaluate the significance of our findings. We conducted a Mann-Whitney between groups test for the speech data and found a highly significant difference between the nPVI values for the American and Jamaican musicians' speech, $U = 5178.00$, $p < .001$, $r = -.23$. In order to determine whether there were significant differences in the speech data from musicians within each group, we did separate Kruskal-Wallis analyses of the Jamaican speech and the American speech, which revealed no significant differences among speakers of either group: Americans, $H(4) = 6.68$, $p = .15$, Jamaicans, $H(4) = 4.38$, $p = .36$ (see Figure 2).

For the music phrases, the between-group comparison was also highly significant, $U = (2814.00$, $p < .001$, $r = -.37$. In order to determine whether there were significant differences in the music data from musicians within each group, we did separate analyses of the American and Jamaican music: Americans, $H(4) = 8.29$, $p = .08$, Jamaicans, $H(4) = 7.93$, $p = .09$ (see Figure 3) .

Figure 4 plots the speech nPVI against the rhythm nPVI of each of the American and Jamaican composers and includes the regression line. For both groups, the overall correlation between the speech and music nPVIs, though positive, was not significant, $r = .43$, $N = 10$, $p = .21$. Separate correlations run on just the Jamaican data and just the American data revealed a nonsignificant negative correlation, $r = -.70$, $N = 5$, $p = .19$ in both cases.

Discussion

Our American jazz musicians produced music that—like their speech—has a higher nPVI, while our Jamaican musicians produced music that—like their speech—has a lower nPVI. Thus, our results show that English-speaking musicians whose dialects differ in terms of their linguistic rhythms produce instrumental music with similarly different rhythms, even when the instrumental productions are very different in style. Given that riddims are produced so that multiple singers can create lyrics to accompany them and that jazz instrumentals often have lyrics added to them once they have become popular, it makes sense that the underlying rhythms of the speech and music should be comparable. As far as we can tell, our study is the first to find empirical evidence to support a link between the rhythmic patterns of the speech and music of jazz musicians.

As was the case in McGowan and Levitt (2011), the difference between the mean values for the American and Jamaican speech nPVIs was less than the difference

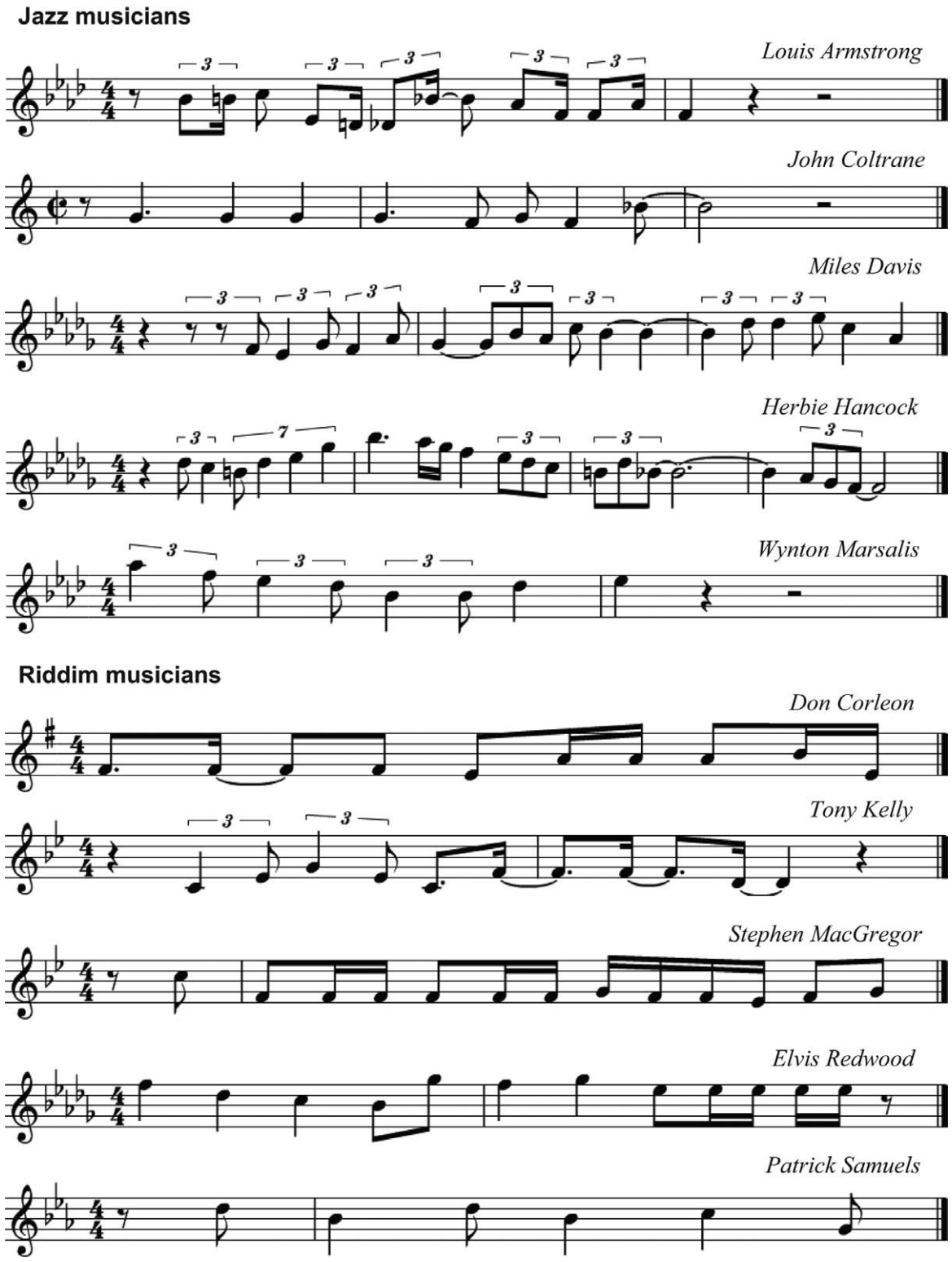

FIGURE 1. A sample music phrase from each musician in music notation. The pieces from which the phrases were taken are listed here. Armstrong: *Weather Bird;* Coltrane: *Moment's Notice*; Davis: *So What*; Hancock: *Cantaloupe Island*; Marsalis: *Soon All Will Know;* Corleon: *Dropleaf;* Kelly: *Blaze*; MacGregor: *Mad World*; Redwood: *Steppa*; Samuels: *Overproof*.

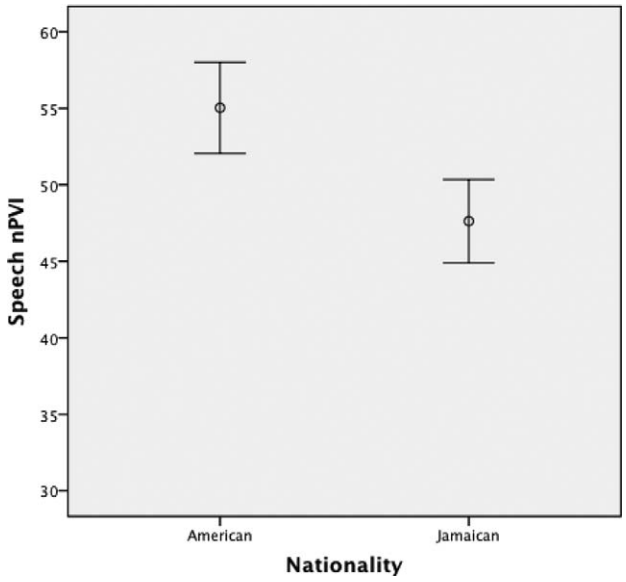

FIGURE 2. Mean nPVI scores and 95% confidence intervals for American and Jamaican speech.

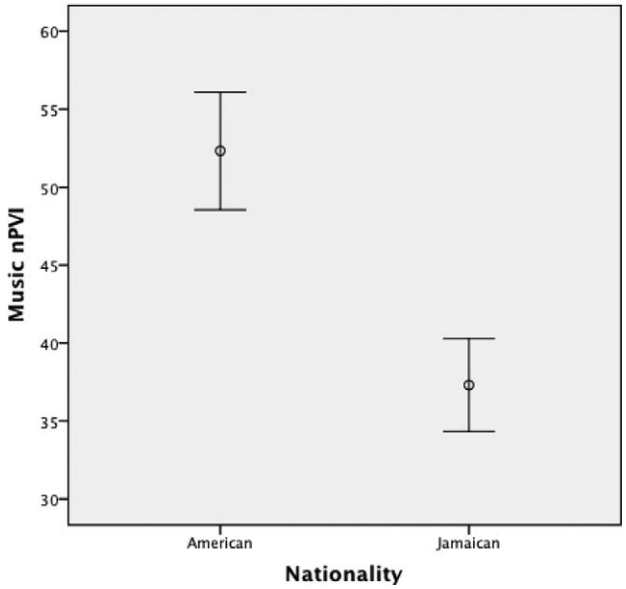

FIGURE 3. Mean nPVI scores and 95% confidence intervals for American and Jamaican music.

between those for the Jamaican and American music nPVIs (see Table 1), even though the difference was highly significant in both cases. Why might the rhythmic patterns appear somewhat closer in the speech than in the music of the musicians? In the current study, the spontaneous speech was all collected from interviews, and in the case of McGowan and Levitt (2011), it was

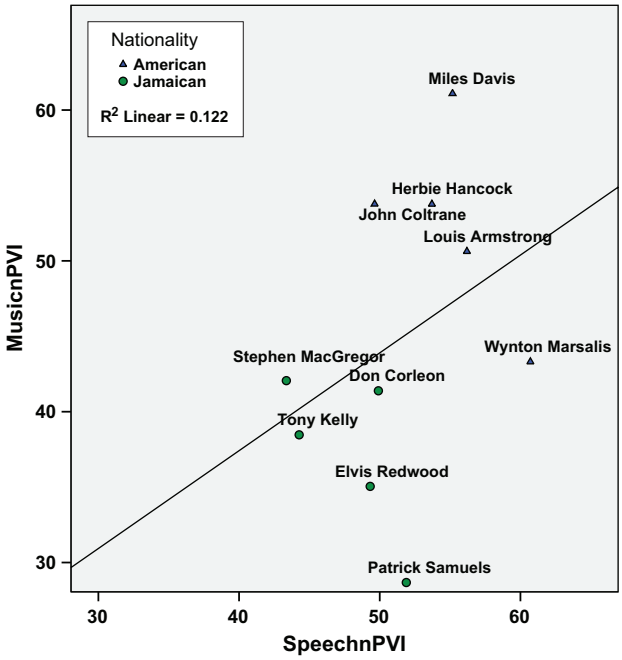

FIGURE 4. Each musician's mean nPVI for speech rhythm plotted against his mean nPVI for music rhythm.

collected from interviews and story telling. Such situations are considered more formal and are designed to be heard by a wider audience, so they often elicit more standard speech forms (Labov, 1972). Since the Jamaican speech nPVIs are generally lower than those of the standard dialects (Thomas & Carter, 2006), the interview situation may have elicited from some of the Jamaican musicians speech that conformed to more standard English and its rhythmic patterns. The riddims, on the other hand, are designed to work with the lyrics of popular music, which more likely reflect the speech patterns of the less formal versions of the Jamaican English dialect.

This explanation for why the difference between our two groups for the speech nPVIs is smaller than the difference between their music nPVIs suggests a reason for the discrepancy between the results of Patel and Daniele (2003) and our findings. They found that there was a greater difference between the speech nPVIs for the two languages that they examined (French and English) than between the nPVIs for the French and English music themes that they studied, whereas in our case the nPVI difference was bigger for our music samples. In the case of Patel and Daniele's (2003) speech samples, the authors examined differences in read speech between languages where style shifts are less likely to lead to a greater convergence in rhythmic

patterns. In the case of their music samples, they were examining music themes, which had been chosen from a compendium of music themes on the basis of a number of restrictions. These selection restrictions seem to have contributed to there being a greater difference in the music nPVIs for those themes, because in Huron and Ollen's (2003) replication and extension of Patel and Danielle (2003), where the restrictions were eliminated, the difference between the French and English music nPVIs was reduced, though still significant. Huron and Ollen wrote: "The less stringent sampling criterion suggests, but does not establish, that the differences between English and French music apply more broadly" (p. 270). In this context, it's possible that selection of a less eclectic collection of jazz musicians might have resulted in a larger difference between our jazz and riddim nPVIs.

Neither the positive correlation between the two groups of musicians nor the negative correlations within each group was significant, which, with so few data points involved, is perhaps to be expected, given the lack of statistical power. Future research might examine the rhythmic patterns in the spontaneous speech and music of a greater number of musicians from each group to see if a significant positive correlation emerges. But if our above reasoning for closer values in the spontaneous speech nPVIs than in the music nPVIs of the American and Jamaican musicians is correct, it might also be of interest to look at the rhythmic properties of lyrics developed for riddims and jazz instrumentals, as Temperley and Temperley (2013) have done for French lyrics and music, to see if lyrics set to riddims and jazz instrumentals more closely reflect the music rhythms of their respective genres than does spontaneous speech from interviews or other formal situations.

Our results provide support for Patel's (2008) suggestion that learning the prosodic patterns of a particular language can affect the production of rhythmic patterns in music, even in the case of instrumental music, which is not created with specific lyrics in mind. With respect to linguistic and music rhythm perception, we have already noted that listeners are able to identify music as either French or English, based on its rhythmic patterns (Hannon, 2009). It would be interesting to see whether listeners could also match music rhythms and speech patterns across dialects.

Although a number of studies have suggested some improvements to the nPVI measure for the analysis of music (see, for example, Toussaint, 2012) this study points to its usefulness as a measure that can be applied to the analysis of rhythm in both speech and music and is sensitive as well to rhythmic differences among dialects of the same language. Thus, it contributes to a small body of literature that finds an influence of dialectal rhythm on music rhythm. Furthermore, like McGowan and Levitt (2011), this study used spontaneous speech and recorded music to calculate the nPVI values, rather than read speech and music notation, which shows that data from spontaneous speech and recorded music support the more extensive findings in the literature showing that the linguistic rhythms of languages can be echoed in the music rhythms of their instrumental music.

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