

Comparing the Rhythm of Instrumental Music and Vocal Music in Mandarin and English

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Abstract

This paper reports a study comparing the rhythm of instrumental music and vocal music in both the tonal language Mandarin Chinese and the non-tonal language British English. The widely accepted normalized pairwise variability index (nPVI) was adopted to measure the rhythm of language and music in these two cultures. Current findings validate that instrumental music in both cultures reflects the rhythmic characteristics of their corresponding languages. The rhythmic contrast of Chinese instrumental music is much lower than that of the British instrumental music. When language becomes part of the music, however, the rhythmic contrasts in Chinese vocal music is unexpectedly more variable than that in the British vocal music. Nevertheless, despite the high rhythmic contrasts in Chinese vocal music, the prominently lower rhythmic contrasts in Chinese children's songs compared to Chinese folk songs confirms the universality of the increased regularity in the rhythm of children's songs, which demonstrates the impact of language habit on music rhythm.

Index Terms: instrumental music, vocal music, nPVI, language rhythm

1. Introduction

Rhythm is one of the central features of both the music [1] and languages [2], carrying abundant cultural-specific information. Different interconnections between music rhythm and language rhythm have been widely discussed in past research. In the early research concerning language and music, a parallel of the rhythmic structure has been found between language and instrumental music in many cultures [3, 4, 5]. These studies intentionally include only instrumental music, claiming that vocal music will bring in the influence of language, and thus it is obvious that language will influence vocal music's rhythm. However, later research came out with different conclusions concerning vocal music. The rhythmic pattern of language does not necessarily predict the rhythmic pattern of its music. While some research found that vocal music is in accordance with its language in rhythmic variation [6], others found no correlation between the rhythmic pattern of language and that of music [7]. Nevertheless, past research mainly focused on the non-tone western language and their music, very few studies looked into the eastern tonal language such as Chinese. Since in the past, tonal language's rhythmic characteristic was believed to be bounded to the support of the prosodic properties of tones, thus the rhythm of tonal language was once considered as a vague appendix with no specific features. What determines their

rhythmic groups are the general prosodic rules that impact tonal languages' specific syllable compression patterns, vowel reduction and vowel lengthening strategies [8, 9]. As the central parts of a tonal language's prosody, tone influences such language's rhythmic representation and rhythmic reflection in music. However, past research mainly focused on the non-tone language, while the studies concerning tonal languages with great lexical pitch variation were rather limited. Therefore, this study put an emphasis on the tone-language Chinese to discover the correlation between tonal language's rhythm and the musical rhythm. In addition to that, most of the past research analyzed only one type of music genre, instrumental music or vocal music. With different calculation standards and different source materials, it is hard to compare instrumental music with vocal music to find out how the participation of language may influence the rhythmic pattern of the music. Considering the great variation among different musical genres, the current study will include both instrumental music and vocal music in our investigation.

Besides language's prosodic elements like tone, the functional change of language can also make a difference to its rhythmic variation. For example, when language is child-oriented motherese specialized for children tends to have a different rhythmic pattern compared to the speech targeted on adults [10]. As one of the most important rhythmic input for children, children's songs have been an important focus in children's language development. When it comes to music input and language acquisition, music rhythm can better help children's acquisition of aural discrimination [11]. It can assist children to have a higher sense of rhythm, which is crucial for the development of reading ability [12] since the musical rhythm can influence children's perception and acquisition of language rhythm. For babies who have not yet get in touch with a dictionary, they can organize their speech according to the intuitions which were similar to the composition of their music input [13]. Apart from rhythm, music can go beyond prosody: it delivers the pedagogical content of the songs to motivate kids to learn life skills such as eating and washing [11, 14]. Hannon (2006) found that children's song differs from folk music in that it has an exaggerated rhythmic pattern. The rhythmic contrast in the children's music of a syllable-timed language French is much lower than that of the folk music, while the children's song of a stressed-timed language English has a larger rhythmic contrast than its folk songs. Such exaggeration can be attributed to the function of children's songs as to facilitating children's language learning. Nevertheless, very few studies before have looked into the music of tonal language like Chinese.

The current study pursued a hypothesis that since language rhythm can leave an imprint on instrumental music, we

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hypothesized that Chinese instrumental music also resembles Mandarin Chinese as having a low rhythmic variation. When it comes to vocal music, including children's music and folk music, we hypothesized that language's influence will be more prominent. Therefore, Chinese folk music was expected to have a lower rhythmic variation than Chinese children's music.

2. Method

2.1. Material

The music database for the current study contained 296 songs with Chinese and English lyrics. 155 songs are for children (Chinese N=74, English N=69), and 141 songs are folk songs mainly for adults (Chinese N=70, English N=71), 120 instrumental music (Chinese N=60, English N=60). Table 1 demonstrates the content of the music corpus.

In the early history of Chinese children's songs (late nineteenth century to early twentieth century), many Chinese children's music pieces were deeply influenced by foreign children's music, such as those from German, America, and Japan. To rule out the potential foreign influences in this study, all the musical pieces were divided into two historic groups: songs composed before 1950 and after 1950, since 1950 witnessed a transformation of Chinese children's songs to more original compositions, and the theme of nationalism started its development in Chinese children's songs at about 1950 [15]. In its early age of development, Chinese children's music was widely adapted from foreign children's songs of German, America, and Japan. To rule out the potential influence of these foreign songs, this study excluded all the adapted songs with the same tunes as the original foreign children's songs. Since the adapted music took hold of a large proportion of Chinese children's music, the original compositions were rather limited. This corpus includes 17 pieces of Chinese original children's songs before the 1950s and 57 pieces after the 1950s. We calculated the nPVI in these two groups separately.

Table 1: *Corpus of Music samples*

		Before 1950	After 1950	Total
Children's songs	Chinese	17	57	74
	English	15	55	69
Folk songs	Chinese	38	32	70
	English	37	34	71
Instrumental music	Chinese	28	32	60
	English	29	31	60

All these materials came from Internet sources and were collected after careful examination based on two standards. Firstly, Chinese songs were written by Chinese natives, and English songs were written by English natives (American and British). All these songs have a specified age orientation (child-oriented or adult-oriented) which can be judged based on the song's introduction and its content of lyrics. Secondly, according to the research focusing on language's rhythmic examination, the uncertain intersentential pauses in language must be ruled out in the calculation of its nPVI [3]. In music, the interval pauses or uncertain prolongations resemble the uncertain pauses in language, and to prevent their influence on our calculation, the songs in our corpus must have at least 20 consecutive notes without any interval pauses or uncertain prolongations, facilitating the standard measurements of nPVI. Such restrictions were in reference to past studies concerning music and language (such as in [3, 4, 5]).

This corpus included songs with 6 types of meters, 2/4 (71 Chinese, 22 English), 3/4 (7 Chinese, 23 English), 3/8 (0 Chinese, 3 English), 6/8 (1 Chinese, 18 English), and 4/4 (65 Chinese, 71 English), and 12/8 (0 Chinese, 1 English), 3/2 (0 Chinese, 1 English). The most common meters were 2/4, 3/4, and 4/4. The songs in this corpus involve 8 major keys and 6 minor keys, C major (38 Chinese, 36 English), F major (28 Chinese, 17 English), and G major (16 Chinese, 41 English), D major (20 Chinese, 23 English) took the dominant place.

2.2. nPVI

The rhythm of the music was measured by nPVI [16, 17], a widely adopted calculation formula in past research concerning the comparison between the rhythmic variation of language and music. nPVI was first introduced to examine the rhythmic type of languages [16]. Language with low nPVI was categorized as the syllable-timed language, while the languages with high nPVI are categorized as the stress-timed language [18, 19]. d_k in language represents the duration of the k^{th} vowel intervals, while m is the overall number of the vowel intervals. Referring to past research (such as [3, 4, 5]), since the music note resembles vowel-interval in the way that they are both the core of their sound system, d_k in music stands for the duration of the k^{th} notes, and m is the total number of the notes.

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

When quantifying the music score, the quarter note was quantified as 1, and the rest of the notes were calculated based on their ratio to the quarter note. For example, the eighth note is about half of the quarter note, then it gets the value of zero points five. Below are examples of score quantification. Figure 1 and Figure 2 demonstrate the quantification of the simplified scores and musical staff. The scores we collected as Chinese children's songs are mostly simplified scores. This kind of score is just another kind of notation, rendering no impact on the music itself. Pure numbers with no dots or lines underneath represent quarter notes. A dot at the right of the number means the prolong of the value of the note by half (for example: 6· is quantified as 1.5). A line below a number cut the value to half.

(for example: $\underline{1}$ was quantified as 0.5; $\underline{\underline{3}}$ was quantified as 0.25). Figure 2 shows the quantification of the music score written in the staff. Quarter note such as $\underline{\underline{\underline{1}}}$ was quantified as 1, and the eighth note takes half of a quarter note's value. For example, $\underline{\underline{\underline{\underline{1}}}}$ was quantified as 0.5. The quantification focuses only on the main melody, therefore in this selection, only the line led by treble clef is considered.

original score	2. <u>1</u> 2 3 6. <u>3</u> 5 - 2. <u>3</u> 5 6 3 2
	哎 呀呀, 哎 呀呀, 活 像一 只 蚬 蟔
quantification	1.5 0.5 1 1 1.5 0.5 2 0.75 0.25 0.5 0.5 1 1

Figure 1: *The original score extracted from Chinese children's song I am Learning Calligraphy from My Grandpa and the corresponding quantification of each musical note. (for this piece of selection: nPVI = 62.58)*



Figure 2: *The original score of English children's song Happy New Year and the quantification of each note. For this selection, only the notes describing the main melody led by treble clef was included. (for this piece of selection: nPVI = 37.14)*

Despite the different sources of music scores and different ways of music notation, the measurement of nPVI value in the current study strictly referred to the past authoritative research for example [3, 4]. The duration of the k^{th} note in music measurement resembles the duration of the k^{th} interval in speech, which makes the nPVI applicable both to music and language [3] to facilitate the comparison between music and language.

nPVI is by far a reliable quantitative measurement for music. Although past research has pointed out that speech rate changes may make nPVI fluctuated [16, 20], the current study focuses only on musical pieces whose rhythmic pattern remains stable as it is written on the scores. Thus, it is safe to claim that nPVI serves as a valid method for measuring music's rhythmic pattern. Although other variables such as rPVI and IOI (onset interval) have been used in past rhythmic measurement, for research specifying on instrumental music or research specify on tonal language, nPVI is the most widely used variable, which helps ensure the validity of the study outcomes.

2.3. Data analysis

nPVI values of all the 296 musical pieces were carefully collected. No extreme value was found in this corpus; therefore, all the samples were included in the analysis. All statistical analysis was performed in SPSS 25.0.0. The average values of the nPVI of each group were calculated and compared to each other through ANOVA test.

3. Result

Result showed that Chinese instrumental music (mean nPVI = 25.15, $sd = 8.07$) had a low rhythmic variation, paralleling the low nPVI of Chinese language, while English instrumental music (mean nPVI = 49.79, $sd = 15.88$) had a significantly higher rhythmic variation ($t = -10.71$, $p < 0.001$). Nevertheless, Chinese songs (mean nPVI = 47.954146, $sd = 14.86$), including children's songs and folk songs, had a much higher nPVI than Chinese instrumental music. The nPVI of English songs (mean nPVI = 41.017851, $sd = 17.75$), on the contrary, was relatively lower than that of the nPVI of the English instrumental music. Figure 3 demonstrates the average nPVI difference between vocal music and instrumental music in both Chinese and English cultures.

Before analyzing vocal music, we first examined the impact of historical change on Chinese children's music since 1950 marked the point of sharp transformation of themes of Chinese children's songs: before 1950, Chinese children's songs were greatly influenced by foreign children's songs, while after 1950, nationalism raised and Chinese children's songs embraced more originality. The result demonstrated no significant difference between Chinese children's music before and after 1950 ($F = 3.305$, $p = 0.073 > 0.05$, $t = -0.38$, $\text{sig.} = 0.705 > 0.5$).

Since there are no vital differences in two historical groups, we mixed them to form one group of Chinese children's songs and compared the combined group of Chinese children's music

with other categories of music. The result showed that although Mandarin is categorized as a syllable-timed language and English as a stress-timed language [16], the rhythmic contrast was larger for Chinese children's music (mean nPVI = 43.996, $sd = 1.42$) than English Children's music (mean nPVI = 41.018, $sd = 1.50$), but such difference was not statistically prominent ($t=1.401$, $p = 0.163 > 0.05$).

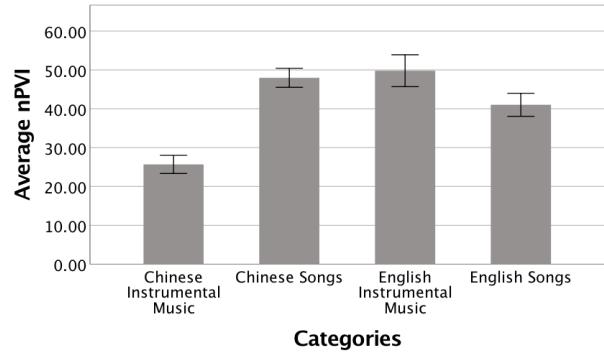


Figure 3: *Average nPVI values as a function of four music categories (Chinese instrumental music, Chinese songs, English instrumental music, English songs.)*

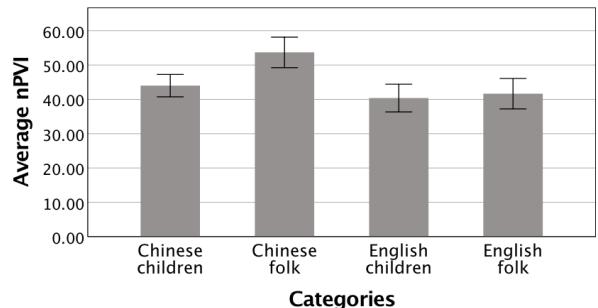


Figure 4: *Average nPVI values as a function of four music categories (Chinese children's songs, Chinese folk songs, English children's songs, English folk songs). Confidence interval = 95%*

The nPVI of Chinese folk songs also had a high degree of rhythmic variation (mean nPVI= 53.681, $sd = 1.71$). Its rhythmic variation was much greater than that of the Chinese children's songs ($t=3.502 p = 0.001 < 0.05$). English folk songs (mean nPVI = 41.641, $sd = 2.22$) also had a higher nPVI value compared with that of the English children's songs, though the difference was not statistically significant ($t=-.421$, $p = 0.675 > 0.05$). The gap between Chinese children's nPVI and Chinese folk songs' nPVI was prominently larger than that between English children's songs and English folk songs. In addition to that, the difference between the rhythmic variation of Chinese folk songs and English folk song was greater than the difference between Chinese children's songs and English children's songs. Chinese folk songs have a much higher mean nPVI than English folk songs ($t = 3.77$, $p<0.001$), while Chinese children's songs did not differ much from English children's songs in rhythmic variation ($t=1.84$, $p=0.068>0.05$), Figure 4 shows the average nPVI values of each category.

4. Discussion and Conclusion

The low rhythmic variety of Chinese instrumental music confirms our hypothesis and reproves the conclusion of past research. Chinese instrumental music paralleled with Mandarin Chinese in having low rhythmic contrast and low nPVI. However, the high rhythmic varieties of Chinese children's and folk songs disprove our hypothesis. Despite Mandarin's low rhythmic variation, the nPVI values of Chinese children's and folk songs are relatively high, and they are even higher than those of the English vocal music.

Though unexpected, the high rhythmic variation in Chinese vocal music found in this study is in line with Nguyễn (2017) who compared Vietnamese, a tonal language, with English and discovered a relatively high rhythmic variation in Vietnamese folk music despite Vietnamese is also a syllable-timed language like Chinese [21]. Nevertheless, these studies did not specify the potential causes of these differences. The main aim of this study is to examine how the participation of language may influence the rhythmic variation of music. Since the difference between Vietnamese and English is not significant, Nguyễn considers the high rhythmic variation in Vietnamese vocal music as inconclusive. However, in this study, it is not only between vocal music and instrumental music but also between children's music and folk music that the differences in rhythmic variation are prominent. These results demonstrate that a piece of music is accompanied by lyrics, the prosodic features of language impact variance of musical rhythm, which is in accordance with the results of the past research. Moreover, when the function of the language alters, and the prosodic features of language changes, the corresponding music also changes in its rhythmic variation. Considering such prominent differences across genres in Chinese music found in the current study, we would like to propose two possible explanations.

First of all, the limitation of nPVI measurement also gives us a clue. The measurement of nPVI only focuses on the timing of the segmentations. Nevertheless, timing is not the only contributor to the formation of rhythm [22]. Other factors such as tone and intonation can also have a substantial impact on the language's rhythm [23, 24, 25]. Moreover, such an impact may become more prominent in the tonal language. Unlike non-tonal language, the lexical pitch changes in tone language are determinant to the meaning of the words [26, 27]. And the duration is one of the determinant factors of the correct pronunciation of tone [23]. For example, the third tone (the falling-rising tone) in Mandarin Chinese has a longer lexical duration compared to the other three tones in Chinese [28]. When lyrics enter in music, the vocal music may reflect the characteristics of language which are missed in the language nPVI measurement.

Another possible explanation is that music does not resemble language in having a consonant-vowel structure [3]. Unlike language which depends mainly on sonority to segment vowels from consonants [29, 30, 31], it is the pitch and sonority difference between two musical notes that give a natural boundary for segmentation [5]. Languages' nPVI measurement is based on the duration of vowel intervals [16], while music's nPVI measurement takes the duration of the musical notes as its core. Considering the limitation of nPVI, future studies should consider using other quantitative measurements focusing on aspects other than this segmentation, such as the IOI measurement to reassure the outcome [32].

Despite their high rhythmic contrast, Chinese children's songs share the same tendency as the Chinese folk songs, which confirm that children-oriented rhythmic input is in parallel with the adult-oriented input. Moreover, the significantly lower rhythmic contrast of Chinese children's songs compared to Chinese folk songs suggests that the exaggeration in children's music found in the previous research (such as [4]) also works on Chinese children's music. In addition to that, Chinese children's music still shares some common features of increased rhythmic regularity with children's songs in other cultures. Child-oriented speech was believed to have a lower rhythm variation rate compared to adult-oriented speech [33]. Such a decrease in rhythmic variation also exists in children's music: the rhythmic variation of children's song was relatively low compared to the songs for adults in the same culture [2]. The current study further confirms this finding: The increased repetitive structure in Chinese and English children's songs demonstrates a universal need of children's songs for language learning and nursery. when a language has a relatively low rhythmic contrast (Chinese), its children's song will have a more prominent decrease in rhythmic contrast compared to the children's songs based on a language with high rhythmic contrast (such as English).

This study provides novel insight into how different languages and different language functions may influence the rhythmic variance of music. The complex interrelationship between the rhythm of spoken language and the musical pieces has been looked into by measuring the rhythm of not only vocal music, but also instrumental music. Although the instrumental music in two cultures both reflect the rhythmic variation of their corresponding languages, music with lyrics does not necessarily reflect language's rhythm in that the rhythmic variations in Chinese vocal music are unexpectedly higher than those in English vocal music, which led to further concern about the cross-domain rhythmic measurement. Despite the high rhythmic variation in Chinese vocal music, the inner relationship between folk music and children's music confirms the outcomes of past research. Chinese children's songs share the universal increase of rhythmic regularity with children's songs in other cultures, and that decrease of rhythmic variation in Chinese children's songs is more prominent than that in the English children's songs. suiting the needs of children's caregiving and children's language development.

Nevertheless, this study also has limitations. Although the sample size of this study is relatively larger than some studies of the same kinds, it is still smaller than some others [3, 7]. Besides, we only included strict notations in the corpus, omitting the variants in live performance. Future research should also take real-life singing into consideration. Moreover, since instrumental music and vocal music in different cultures may reflect language prosody in different ways, researchers are encouraged to compare these two types of music in other different languages in the future. As for methodology, future research may consider referring to various other ways of rhythmic measurements. Besides, since children's songs provide vital support for children's development, more investigations should be encouraged to look into different aspects of children's songs in other cultures.

5. Acknowledgements

This study was supported by Chun-Tsung Scholarship (2019-03-05) and the Major Programs of National Social Science Foundation of China (18ZDA293).

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