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Musicality Meets Tonality: A Tonal Congruence Index (I_{TG}) for Chinese Vocal Music

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In this paper, I propose a mathematical method for evaluating Chinese vocal music in terms of the degree of tonal congruence, based upon three categories of tonal accommodation principles, i.e. tonal contour resemblance, register distinction and ad hoc grace notes. Based on previous studies, I first give a much-needed detailed description of how tone sandhi and the neutral tone are accommodated in Chinese vocal music, but more importantly I also introduce tonal register distinction and ad hoc grace notes as new principles to evaluate tonal accommodation. Then an index is created to take all these principles into consideration, which enables the comparison of different songs in terms of their degrees of tonal congruence. This index is not only theoretically innovative but also useful when it comes to selection of Chinese vocal music for teaching purposes in CFL classes.

0. Introduction

Chinese is a tonal language that uses pitch to distinguish meaning, while at the same time pitch is an essential component of music as well, especially in terms of melodic lines of vocal music. The basic four tones in Mandarin Chinese are usually described as in TABLE 1.

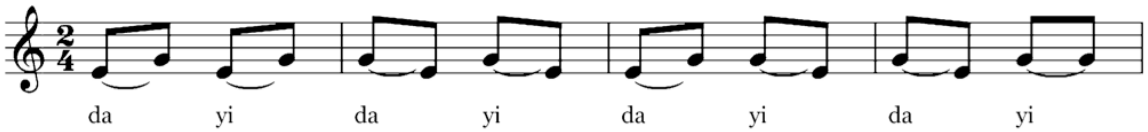
TABLE 1. Four tones in Mandarin Chinese

	1st tone	**2nd tone**	**3rd tone**	**4th tone**
Description	High level	Mid-rising	Low dip-rise	High falling
Tonal numerals	55	35	214	51

Because both linguistic tones in Chinese and melodic lines in music use the same property of sounds, i.e. pitch, there could be conflicts in works of vocal music between the need to convey the meaning of the lyrics clearly and the need to be musically creative. In theory if the melodic lines somehow imitate the tonal shapes of the words in the lyrics well enough, then the song should sound quite similar to how the words are spoken and hence it will be easier for listeners to understand the lyrics. However if music is composed in such a way as to focus on the musicality only without regard to how the

lyrics are perceived by listeners, there will definitely be cases when the words in the lyrics are misunderstood. In the musical EXAMPLE 1 shown here, we notice that the same syllables *da-yi* can be associated with different primary interpretations because the melodic contours correspond to different tones in each bar. Take the first bar for example, the first syllable is sung with a rising contour, which corresponds well to the 2nd tone in Chinese. Thus it sounds more like dá than dā, dǎ or dà. The first syllable da in the second bar is sung with a falling contour, which corresponds well to the 4th tone in Chinese. Thus it sounds more like dà than dā, dá, dǎ. Suppose the words associated with the first bar actually mean "rough idea", and then misunderstanding is very likely, unless contextual information can help to decide that it makes more sense to understand the words as "rough idea". Note that there are also other possible interpretations due to homophones in the language, e.g. "careless" for the second bar, and "1st year in college" for the fourth bar. But such interpretations are related to the language per se, but not tonal accommodation issues.

EXAMPLE 1 Primary interpretations of lyrics



The study of the interaction between melodies and tones has been approached from two different fields: linguistics and musicology. In linguistics, previous studies focus on the perceptions of tones in vocal music, especially in Cantopop (e.g. Schellenberg 2013). On the other hand, in traditional Chinese music, there are various methods to accommodate tones. In music conservatories in China, there are courses called *linguistic musicology.* For example, there is such a course for students of musicology and other interested students at the Central Conservatory of Music in Beijing, China. Composers of Chinese vocal music, especially in traditional genres, are well aware of the conflict between melodies and tones. They can choose to accommodate the linguistic tones to the degree that they consider appropriate musically. Thus different songs can be evaluated in terms of how well they accommodate the tones of the words in the lyrics. This is the main focus of my study here.

Previous studies in both fields mostly focus on the citation forms of tones. However in actual connected speech, tones can change forms easily, e.g. in tone sandhi. Although Zhang (1998, p. 10 and p. 27) discusses neutral tones and tone sandhi, especially half-3rd and half-4th tones, he does not give a detailed description based on linguistic research of these phenomena. Therefore there is more of a need to study the degree of tonal accommodation in terms of actual tonal shapes, instead of only

considering citation forms. On the other hand, although musical examples have been studied to show how the melodies imitate tones, there has not been any specific method to compare vocal music works and judge which one preserves the tones more faithfully. Thus in this article I will present my solution to these issues.

In section 2 of this paper, I will first talk about how tones are accommodated in traditional Chinese music, based on Zhang's (1998) studies. Different principles of tonal accommodation will be discussed with musical examples. Moreover I will propose register distinction and ad hoc grace notes as further methods to accommodate tones. I will also study in much detail how actual tonal shapes in connected speech, e.g. in tone sandhi and neutral tones, can be added to the principles of tonal accommodation to broaden the coverage of these principles. Then in section 3, I will propose a mathematical method called the Tonal Congruence Index (I_{TG}) to compare different works of vocal music in terms of their degrees of conforming to the tones of the lyrics. Examples of comparisons will be given based on application of this method to both sample snippets of songs and complete songs. In section 4, to conclude the proposal made in this paper, some pedagogical applications of this index will be made to show how it can be used to teach singing in Chinese language education.

1. Principles of tonal accommodation

In traditional Chinese music, two major requirements are very important, i.e. clear enunciation of words and tonal accommodation.[1] Zhang (1998) gives an excellent description of such requirements. In this section, I will first present Zhang's (1998) description of the methods, and then I will make two new suggestions, i.e. register distinction, and ad hoc grace notes. I will also discuss tone sandhi and the neutral tone.

1.1 Tonal contour resemblance

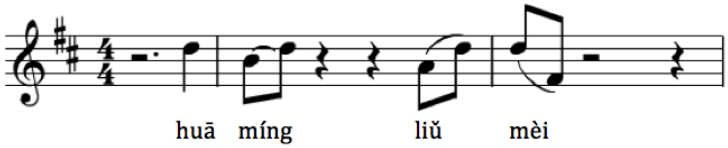
In the *Jīngyùn Dàgǔ*, a traditional Beijing-style musical genre, the four tones of Mandarin Chinese can be imitated according to the following methods (Zhang 1998). I will name these methods "Tonal Contour Resemblance".

(1) Tonal Contour Resemblance (Zhang 1998)
- 1st tone: use high notes mostly, can use a single note or a downward succession of single notes, but not upward succession;
- 2nd tone: use upward successions of two notes for one 2nd tone, or for two 2nd tones;
- 3rd tone: use low notes in a sharp upward progression;
- 4th tone: use high notes in a downward progression

[1] 吐字 and 依字行腔.

An immediate comment on these tonal contour resemblance principles is that they have the citation tones as their basis. However as is more common in connected speech, variations of the tonal shapes are more often used. Therefore even if a composer does not completely abide by these principles, the tones can still be imitated in terms of their sandhi forms. I will come back to this issue later in section 2.2. But for now, to show how these principles are used in actual works of vocal music, let's see an example from *Jīngyùn Dàgǔ*, as shown in EXAMPLE 2.

EXAMPLE 2 Jīngyùn Dàgǔ: Bā Ài[2] (source: Zhang 1998)



The second word "míng" is a 2nd tone realized in music by the notes B-D. The melody and the tone both have a rising contour, and they match pretty well. The third word "liǔ" is a 3rd tone realized by A-D. The note A is the lowest note in the first two bars, and the A-D progression is sharper than the B-D progression for the word "míng". Linguistically, the 3rd tone has both a low dip component and a low rising component. Thus the low note A followed by a higher note D conforms to the rising component of the 3rd tone, and also the sharper progression and the lower starting note in the case of the melody contour for "liǔ" makes it possible to be distinguished from the 2nd tone. The fact that the 2nd tone and the 3rd tone share a similar rising component, albeit with different starting point, can be shown in two aspects. First, in tone sandhi environments where a 3rd tone is followed by another 3rd tone, the first 3rd tone is realized as the 2nd tone in terms of its tonal shape. Second, for students of the Chinese language, the 2nd tone and the 3rd tone can be easily confusable. As for the other two words, i.e. "huā" with the 1st tone and "mèi" with the 2nd tone, the melodic line obviously conforms to the tonal shapes.

1.2 Register distinction

Zhang (1998) does not mention the notion of pitch register as a separate method of tonal accommodation, although it is indirectly referred to in many places, e.g. the 3rd tone should use low notes as the starting point while the 4th tone should use a high note as the starting point. He also presented an example where two 3rd tones are together and the first 3rd-tone syllable was realized as a single high note, apparently because it is actually a 2nd tone as a result of tone sandhi. But register distinction is not used by Zhang (1998) consistently as a principle for all four tones. Of course this is only to be expected since Zhang's (1998) main purpose of describing those tonal contour resemblance principles is

[2] 京韵大鼓《八爱》:"花明柳媚。"

to illustrate traditional practice in musical composition, rather than linguistic research on the relation between tones and music.

In linguistics, the tonal property can be further analyzed as two separate but related properties: register and tonal contour (also see Bao 1999 and Yip 1989). Therefore to accommodate tones in musical composition also means to preserve the register distinction. Such an approach has been proposed for Cantonese vocal music. Wong and Diehl (2002) argue that the 6 tones in Cantonese (i.e., not including the entering tones; also see, e.g. Dong 2014, p. 166 for further explanations.) can be grouped into high-pitch (55 and 35), mid-pitch (33 and 23) and low-pitch (21 and 22) categories. Although the exact contour of the tones might not be wholly preserved, the register distinction can narrow the possible interpretations to one of two tones in each register.

Now let's give a parallel analysis of the register distinction in Mandarin Chinese. First the only non-controversial one would be the 1st tone as a high-pitch tone. Then in the same fashion as in Cantonese tones mentioned above, we can treat the 2nd tone as a high-pitch tone as well. For the 4th tone, the starting point is a high pitch, and moreover in many cases the falling contour does not often reach the level 1 as in citation tones. In connected speech the 4th tone is often realized as 53 especially if the following tone starts with a 5. Therefore the 4th tone can be considered a high-pitch tone as well.

The 3rd tone is often realized as 211 (half-3rd tone)[3] if it followed by the 1st, 2nd or 4th tones. In this case it is a low-pitch tone. If the 3rd tone is followed by another 3rd tone, it is realized as 35, thus a high-pitch tone. Therefore a register distinction in Mandarin Chinese would be as in TABLE 2 (also see Wang 1967 for a similar register distinction):

TABLE 2. Tonal register distinction

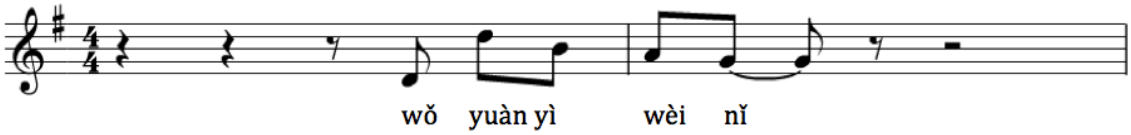
Register	**Tones**
High	1st, 2nd, 4th. If 3rd is followed by another 3rd, then yes.
Low	3rd in most cases (half-3rd)

Now let's see an example that uses register distinction. The EXAMPLE 3 is taken from a popular song by the famous singer Faye Wong. Therefore the genre of this song is very different from the traditional *Jīngyùn Dàgǔ* as shown in EXAMPLE 2. Presumably, musical composition of pop songs is not constrained by the tonal contour resemblance principles as much as traditional music is. However we will see that even if such tonal accommodation principles are not a primary concern for pop songs, the lyrics nonetheless conform to the tonal shapes to varying degrees. This is a reasonable argument if we

[3] This is a standard description of the half-3rd tone, e.g. as given in 《现代汉语》(北京大学中文系现代汉语教研室编，商务印书馆出版，2006). There is however debate whether the actual shape is indeed 211 or rather just a low even tone. For the purpose of this paper, both shapes are acceptable, as long as it is a low register tone.

assume the following two facts. First composers are well aware of the tonal properties of the language, and they seldom totally ignore such factors in composing. Second, lyricists are even more aware of the tonal properties of the language, and they have the liberty to choose a word that has a tonal contour similar to the melodic lines. This can be seen in the traditional Chinese poetic genre called the *cí*, where tonal properties are a primary concern while filling in the words for the musical patterns. Modern lyricists can choose words according to the melodic lines as well if they want to.

EXAMPLE 3 Faye Wong: Wǒ Yuànyì[4]



In this selection, both 3rd tone characters, i.e. wǒ and nǐ, are realized by one low note with no contour. Note that here the word "low" is relative to the adjacent notes, i.e. the environment in which it occurs. Thus in this EXAMPLE 3, the register distinction is preserved, no matter the contour is a low dip or a low flat contour. If we consider the half-3rd tone to be a low even tone, then the contour is preserved as well in this example.

Now let's focus on the third syllable in EXAMPLE 3, i.e. yi. In colloquial speech, the word "yuànyì" can be optionally pronounced as "yuànyi", with the syllable "yi" being a neutral tone. Although the neutral tone is primarily an unstressed syllable, its tonal properties are nonetheless present. In general the neutral tone is realized as a short falling tone when it is followed by the 1st, 2nd, or 4th tone, and it is a high short even tone if it is followed by the 3rd tone. The actual tonal values are 2 after a 1st tone; 3 after a 2nd tone; 1 after a 4th tone and 4 after a 3rd tone.[5] Thus it can be argued that the tonal register of the neutral tone is the opposite of the tonal register of the preceding syllable. If the preceding syllable is a high-register tone, the neutral tone is realized as a short low register tone, i.e. 2, 3, and 1. If the preceding syllable is a low-register tone, then the neutral tone is realized as a short high-register tone, i.e. 4. Now let's look back at the word "yuànyi" in EXAMPLE 3, the neutral-tone syllable "yi" is realized by a much lower note than the preceding high-register tone, i.e. the 4th tone. This is a good instance of how the neutral tone can be accommodated in singing.

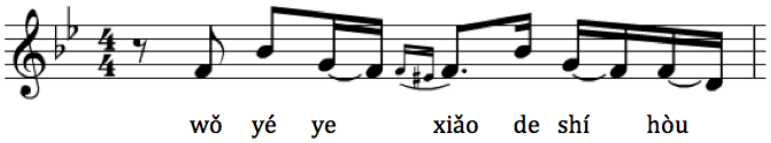
Now let's look at another example with more clear cases of the neutral tone. This one is taken from a Beijing-style pop song by the renowned singer Lǐ Gǔyī. If the pop song in the EXAMPLE 3 mentioned above cannot be argued to be written with Beijing Mandarin in mind, then the song in EXAMPLE 4 is definitely written with a distinct Beijing

[4] 王菲《我愿意》: "我愿意为你。"

[5] The description and tonal values are from pp.118-119 of《现代汉语》(北京大学中文系现代汉语教研室编，商务印书馆出版，2006).

Mandarin flavor. Thus we would expect to see a higher degree of tonal accommodation in this song.

EXAMPLE 4 Lǐ Gǔyī: Qiánmén Qíngsī Dàwǎnchá[6]



Let's first look at the word "yéye". The second syllable here, i.e. "ye", has a lexical neutral tone. It is always pronounced with a neutral tone. It is realized by the melodic line of G-F, which can be said to be a short falling tone, and it is lower than the preceding 2nd-tone syllable which is realized by a single note B-flat. Now let's look at the word "de", which is a grammatical particle always pronounced with a neutral tone. The preceding 3rd tone is realized by the note F with the grace notes FE-sharp, and the "de" is realized by a single high note B-flat. This is a perfect accommodation of both the tonal register and tonal contour of the neutral tone after a 3rd tone.

Note that in my analysis here I am not suggesting that the composer deliberately used such methods to preserve the tonal shapes. But rather I mean that the composition, as is, can be analyzed in such a fashion as to facilitate the understanding by the listener. The two neutral tones in the EXAMPLE 4 clearly show that the melodic lines conform to the tonal contours very well, no matter the composer and lyricists wanted to have this effect or not.

1.3 Ad hoc grace notes

In this section I will argue that the initial contour of a sung syllable is enough to realize a tonal contour, as shown in FIGURE 1.

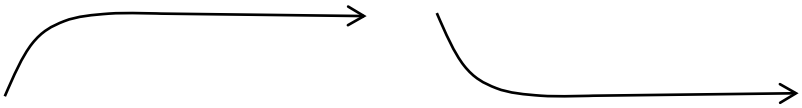


FIGURE 1. Initial contours of the 2nd tone and 4th tone in singing

Since the 2nd tone is a rising tone, and it is not possible to keep the pitch rising to ever higher levels in singing, it is thus very natural to hold the note flat after an initial rising section if a 2nd-tone word needs to be sung with a long melodic line, as shown in the first line graph in FIGURE 1. The same goes with a prolonged 4th tone in singing as shown in the second line graph in FIGURE 1. In terms of the dip-rising contour of the 3rd tone, an initial contour is also efficient, because the contour cannot be repeated unless in

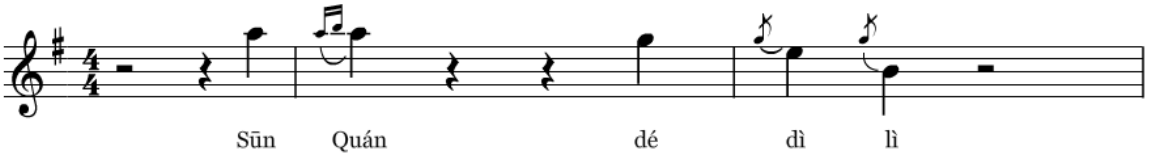
[6] 李谷一《前门情思大碗茶》: "我爷爷小的时候。"

a wave-like fashion if a 3rd-tone word is to be sung for a prolonged time. For the 1st tone, it is of course ok to just hold the same note as long as needed. But as also observed in the traditional principles shown in (1) in section 2.1, it is not necessary to hold the note all the time in order to keep the flat tonal contour in singing. It is ok to repeat the same flat contour in a downward succession of single notes.[7] Thus an initial contour would suffice to accommodate the tonal contour. Actually after the tone has been correctly perceived via the initial contour, the remaining melodic line on the same word does not matter that much anymore, and it can be whatever shapes the composer wants it to be, flat lines or waves or any other form.

According to the definition given on Wikipedia, "in music, ornaments or embellishments are musical flourishes that are not necessary to carry the overall line of the melody (or harmony), but serve instead to decorate or 'ornament' that line."[8] "A grace note is a kind of music notation used to denote several kinds of musical ornaments, usually printed smaller to indicate that it is melodically and harmonically nonessential."[9] In musical composition, grace notes are often written on the scores. But during performances, singers can add grace notes which are not part of the original score. I call these added notes by the singer "ad hoc grace notes". In Chinese vocal music, grace notes and especially ad hoc grace notes are very important in terms of tonal accommodation. The short initial contour as realized by the added grace notes is sufficient to preserve the tonal contrasts, as has been argued above.

Thus by looking at the original scores we can definitely find many grace notes and other types of ornaments. Actually we have seen one instance of grace notes in EXAMPLE 4. The word "xiǎo" has a 3rd tone, and the grace notes create an initial dipping and rising contour in conjunction with the main note, i.e. the mini contour FE#-F. I will give a few more examples here.

EXAMPLE 5 Jīngyùn Dàgǔ: Cǎochuán Jièjiàn[10] (source: Zhang 1998)



[7] Only downward succession of single notes is allowed. This might be related to the fact that the even tone tends to become slight lower in pitch as it progresses. Also see p. 82 of 《现代汉语》(北京大学中文系现代汉语教研室编，商务印书馆出版，2006).

[8] Ornament (music). (2015, June 22). In *Wikipedia, The Free Encyclopedia*. Retrieved 23:06, August 4, 2015, from https://en.wikipedia.org/w/index.php?title=Ornament_(music)&oldid=668058432

[9] Grace note. (2015, March 26). In *Wikipedia, The Free Encyclopedia*. Retrieved 23:04, August 4, 2015, from https://en.wikipedia.org/w/index.php?title=Grace_note&oldid=653662323

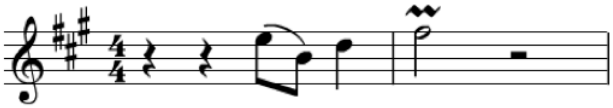
[10] 京韵大鼓《草船借箭》: "孙权得地利。"

In EXAMPLE 5, let's focus on the last two syllables first, i.e. dì and lì. Both have the 4th tone. With the grace notes added, the initial melodic lines of both words become very similar to the tonal contours, i.e. the falling tonal shape. Although the grace notes are very short compared to the main notes that they are attached to, the initial contour is sufficient to show the tonal contrast. In Zhang's (1998) original analysis, he treats these two syllables by using the tonal contour resemblance principles. He does not use "grace notes" or "ad hoc grace notes" as a separate method for tonal accommodation.[11]

Now let's take a look at the second syllable "Quán", which is a 2nd-tone word with a rising tonal shape. Without the grace notes, the single note A cannot preserve the contour of the tone, but with the grace notes, it has an initial rising contour, which corresponds well to the 2nd tone. Although these three notes taken together, i.e. AB-A, resemble a rising-falling contour, there is no such a tonal contour in Mandarin Chinese. Thus it will not create confusion in this case.

Besides the usual grace notes, there are other types of musical ornaments that can be used to create a mini-contour to accommodate the tones. In EXAMPLE 6, the upper mordent is used on the word with the 2nd tone, i.e. láng. The actual contour of $F^{\#}G^{\#}$-$F^{\#}$ is very similar to the contour of the word "Quán" in EXAMPLE 5 as described above.

EXAMPLE 6 Jīngyùn Dàgǔ: Dà Xīxiāng[12] (source: Zhang 1998)



Also note that in EXAMPLE 6, the tonal shapes and registers of the other two syllables, i.e. pàn and Zhāng, are completely preserved, which shows how traditional Chinese music, especially in a genre such as the *Jīngyù Dàgǔ*, which uses a semi-speaking tone, can accommodate the tones to a very high degree.

Although the examples with grace notes and other ornaments given here are not exactly ad hoc, these examples can still show how adding grace notes during performance can help accommodate the tonal contours, and this does happen very often, and every singer might have their unique ways of "fine-tuning" the song. These finer adjustments to the melodic lines can be easily spotted by listening to a recording of a song and comparing it to the original score. Thus actual performances usually accommodate the tones even better than the scores. But since they are not written in the score, in this paper

[11] Zhang (1998) also uses this example to show how tone sandhi is realized in musical composition. The words "dì" and "lì" are both 4th-tone words, but the first 4th tone is realized as half-4th, i.e. 53 instead of 51, while the second 4th tone is realized as a full 4th tone, i.e. 51. This distinction is almost completely perfectly shown in the melodic line.

[12] 京韵大鼓《大西厢》: "盼张郎。"

here, I will not take into consideration those ad hoc grace notes in actual performances, although by adding this factor into our calculations, it will yield better results.

So far I have introduced three major methods of accommodating tones in Mandarin Chinese. The best method to preserve the tonal contrasts in musical composition is the tonal contour resemblance principles described by Zhang (1998). But it is worth noting here that in these traditional principles the registers of the tones are also referred to, although the focus seems to be on the contour. Based upon a register distinction in Cantonese songs proposed by Wong and Diehl (2002), I also argue that a similar tonal register distinction can be made for Mandarin Chinese, and in singing, the tonal register distinction can be used to partially preserve the tonal contrast. Thirdly, I also argue that in Chinese singing performances, the singer can add ad hoc grace notes or other ornaments that are not written in the scores to enhance the accommodation of tones.

But before going to the next section, I want to emphasize that these methods of tonal accommodation are not meant to be followed straightly for musical composition. As Zhang (1998) points out, these principles should be used flexibly, and in practice, rather than to accommodate each and every word in music, the composer and lyricists can focus on the first one or two words and other key words only and be more flexible with the remaining words in the phrase.

Now the question is how we can quantify the degree of tonal accommodation in different works of vocal music. In the next section, I propose a simple mathematical index to quantify tonal congruence.

2. Tonal congruence index (I_{TG})

In order to calculate how well a song accommodates the tones of the words in the lyrics, I will propose the following scoring method, as shown in TABLE 3.

TABLE 3. Tonal congruence values

Tones	Register 0.5	Shape 0.5
1st	High register	Flat contour
2nd	High register	Rising contour; Grace notes.
3nd	Low register;	Flat or slight dipping contour (half-3rd); Rising contour (full 3rd); Grace notes.
4th	High register	Falling contour; Grace notes
Neutral	High after 3rd; Low otherwise	Short flat after 3rd; Short flat or falling otherwise.

The total score of tonal congruence for one specific syllable is 1. Of this one point, accommodation of the register and the tonal shape each counts as 0.5 point. For example, for the 1st tone, if the note is a high note, relatively speaking, then it gets 0.5 point for accommodating the register of the 1st tone. If the melodic line is a flat line, then it gets an additional 0.5 point for accommodating the tonal shape. Thus the total score of tonal congruence for this one syllable is 1. If in this case the note is a low note, relatively speaking, then it gets 0 for register accommodation. If the melodic line is still flat, it will get 0.5 point. Thus the total score of tonal congruence is 0.5. If the melodic line is not flat but the notes are high, then the score will also be 0.5. It will be 0 otherwise. Now for the 2nd tone, if the starting note is a high note, it will get 0.5 for register distinction, and if the melodic line, sometimes with grace notes, imitates the rising contour, then it will get an additional 0.5 point. For the 3rd tone, if the starting point is a low note, then it will get 0.5 for register distinction; if the melodic line, sometimes with grace notes, imitates the flat or slight dipping contour, i.e. the half-3rd tone, or the sharp rising contour, i.e. the full 3rd tone, then it will get an additional 0.5 point. Note that here if the 3rd tone is followed by another 3rd tone, the first 3rd tone becomes the 2nd tone and then it should just be treated in the same fashion as according to the scoring rules for the 2nd tone. For the 4th tone, if the starting note is a high note, it will get 0.5 for register distinction; if the melodic line, sometimes with grace notes, imitates the falling contour of the tone, then it will get an additional 0.5 point. In terms of the neutral tone, the calculation has to be done in comparison to the preceding syllable. If the preceding syllable is the 3rd tone, then the notes for the neutral tone should be higher in order to get 0.5 for register distinction. Otherwise, it should be lower. For tonal shapes, if the preceding syllable is a 3rd tone, then the melodic line of the neutral tone should be short and flat in order to get the additional 0.5 point. Otherwise it should be short flat or falling.

Now with these scoring rules ready, I propose the following formula for the Tonal Congruence Index (I_{TG}):

(2) Tonal Congruence Index

$$I_{TG} = \frac{\sum_{i=1}^{n} x_i}{n}$$

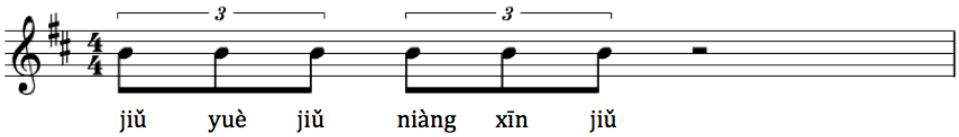
where n is the total number of tones, x_i is the tonal congruence value at tone i

According to the formula in (2), the scores of tonal congruence for each syllable in a song are summed up and then divided by the number of syllables. Thus the maximum possible value for I_{TG} is 1, meaning that the whole melodic line of the song accommodates the tones of each and every word in the lyrics both in terms of register and tonal shapes. The minimum possible value for I_{TG} is 0, meaning that the no part of the melodic line of the song accommodates the tones of any word in the lyrics either in terms of register or tonal shapes. Obviously in actuality no song ever written will get either 1 or 0. A song that gets 0 would definitely be very difficult to understand, and this is a very

unlikely real song at any rate. On the other hand, a song that gets 1 would sound almost the same as speaking, which would turn out to be less of a real song. Note that a potentially interesting case would be rap songs. I have not studied Chinese rap songs in terms of their tonal accommodation. But intuitively, it seems to me that although rap songs will definitely have a pretty high tonal congruence index score, they are nonetheless not the same as speaking. They are more "free-styling" than other genres of pop songs, but the rhythmic and melodic variations are greater than speaking. Actually some musicians, e.g. Cuī Jiàn, are still trying to figure out how to do rapping while not being constrained by the tones in Mandarin Chinese. The experimental rapping that tries to break away from the tonal constraints sounds more like some sort of Chinese dialects, although it might not be any real dialect at all. For more discussions on rap and hip-hop in Chinese vocal music, please see Liu (2013). Therefore for most songs in Chinese vocal music, their scores of I_{TG} should be between 0 and 1. A lower score means that overall, the song has more words that are not accommodated well in the melodic line. A higher score means that overall, the melodic line of the song accommodates the tones of more words. To illustrate how this method works, I will give a few examples here.

In the EXAMPLE 7, since all of the six notes here are the same, with no differentiation of pitch levels, we cannot decide which one is relatively higher or lower than the other ones. Therefore we need to assign 0 to all of the six syllables in terms of the register distinction. Now let's look at the tonal shapes. For the first syllable, it is a 3rd tone and is realized as a single note. Thus it can be argued to be a flat shape. Since the 3rd tone can be a low flat tone, we may assign 0.5 here. For the second syllable, it is the 2nd tone, and is realized by a single note. Therefore it is assigned 0 here for tonal shape accommodation. For the remaining words, the calculation is based upon the same reasoning, and we get the value of the index as 0.33.

EXAMPLE 7 Sample I_{TG} Jiǔshén Qǔ[13]



Here to show how the index is calculated, we first count how many syllables there are in this example here, i.e. n=6. Then for each word, we calculate the values for each of the 0.5 point. For example for word 1, the values are x_1=0+0.5. We do this for all of the words and get x_1=0+0.5; x_2=0+0; x_3=0+0.5; x_4=0+0; x_5=0+0.5; x_6=0+0.5. Then we add up all the numbers in the second step, which gives us 2. Then we divide it by the total number of syllables to get the overall index: I_{TG} = 2/6 = 0.33. I list the steps here in (3) for clear reference.

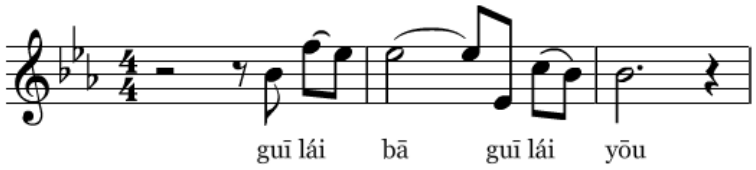
[13] 电影歌曲《酒神曲》:"九月九，酿新酒。"

(3) Step-by-step calculation of I_{TG} for EXAMPLE 7

- n=6
- x_1=0+0.5; x_2=0+0; x_3=0+0.5; x_4=0+0; x_5=0+0.5; x_6=0+0.5.
- I_{TG} = 2/6 = 0.33

Now let's take a look at another example, and make some comparisons.

EXAMPLE 8 Sample I_{TG} Kris Phillips: Gùxiāng de Yún[14]



In EXAMPLE 8, there are six syllables as well. The first syllable has a 1st tone, and it is realized by the note B-flat, which is the lowest in the first bar. Therefore we have to assign 0 here for its lack of register distinction. But the melodic line here is flat, thus preserving the flat contour of the 1st tone very well and we assign 0.5 here. Then for the first syllable, it gets 0.5 total. The second syllable has a 2nd tone. In terms of its register, it should be a high register tone. Here we see that it starts with F, which is the highest note in all three bars shown here. Thus we can assign 0.5 here. But the melodic line is a falling shape, which contradicts the rising tonal shape. Thus it gets 0 here. The total score for the second syllable is 0.5. The third syllable is a sentence-final particle, which is always pronounced with the neutral tone in actual speech. However they do have an emphatic tonal form, which is usually the first tone. Thus in singing, if such a particle is to be on the downbeat or emphasized by prolonging, it can be considered to be using the non-neutral tone form. Thus here the high single note would get 0.5 for register distinction and 0.5 for tonal shape. The tonal congruence value of the remaining three syllables can be calculated similarly, and I will just list the complete steps of calculation here in (4).

(4) Step-by-step calculation of I_{TG} for EXAMPLE 8

- n=6
- x_1=0+0.5; x_2=0.5+0; x_3=0.5+0.5; x_4=0+0.5; x_5=0+0; x_7=0.5+0.5
- I_{TG} = 3.5/6 = 0.58

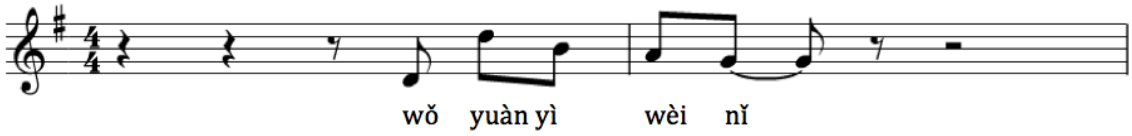
We can compare the I_{TG} for EXAMPLE 7 and EXAMPLE 8. The I_{TG} of EXAMPLE 8 is almost twice as high as that of EXAMPLE 7. Let's suppose that the examples shown here are representative of the whole songs respectively, and then based upon such a

[14] 费翔《故乡的云》:"归来吧，归来哟。"

comparison we can draw a further conclusion that the song in EXAMPLE 8 is much easier to be understood by the listener than the song in EXAMPLE 7. This could be confirmed by the general auditory perception upon hearing these two songs. But since contextual cues can also be used to further disambiguate the meanings of the lyrics, the degree of being easily understood cannot just be simply the same as the relative scores of the indices of these two examples. Nonetheless the scores of the indices are an important factor in determining the relative easiness of perception here.

Now let's look at another example of pop songs. This is the same example as EXAMPLE 3 we have seen above. Note here that for the third syllable, if it is treated as a 4th tone, then it will get a total of 0. However, as mentioned before, the word "yuànyì" can be optionally pronounced as "yuànyi" in colloquial speech, with the second syllable being neutral. Thus here we can treat it as a neutral syllable and assign a total value of 1 to it. The steps are listed in (5). It shows that the I_{TG} is 0.7, which is the highest score so far among the examples given.

EXAMPLE 9 Sample I_{TG} Faye Wong: Wǒ Yuànyì[15]

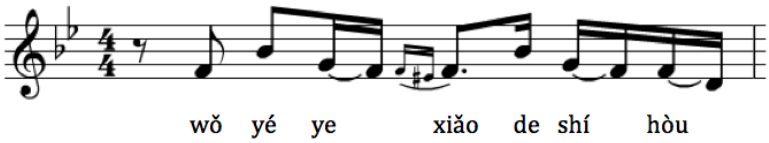


(5) Step-by-step calculation of I_{TG} for EXAMPLE 9

- n=5
- x_1=0.5+0.5; x_2=0.5+0; x_3=0.5+0.5; x_4=0+0; x_5=0.5+0.5
- I_{TG} = 3.5/5 = 0.7

The examples given so far are, however, not written specifically in a style that is close to the traditional Beijing folk songs. If we look at songs with more Beijing flavor or even traditional music genres, we might expect the I_{TG} score to be quite different from pop songs. Let's use the same EXAMPLE 4, repeated here as EXAMPLE 10. The steps are listed in (6).

EXAMPLE 10 Sample I_{TG} Lǐ Gǔyī: Qiánmén Qíngsī Dàwǎnchá[16]



[15] Same as EXAMPLE 3

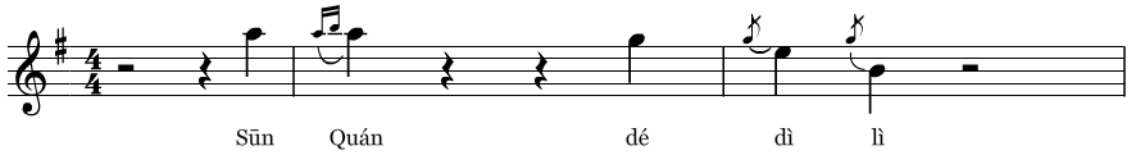
[16] Same as EXAMPLE 4.

(6) Step-by-step calculation of I_{TG} for EXAMPLE 10

- n=7
- x_1=0.5+0.5; x_2=0.5+0.5; x_3=0.5+0.5; x_4=0.5+0.5; x_5=0.5+0.5; x_6=0+0; x_7=0.5+0.5
- I_{TG}=6/7=0.86

The I_{TG} is 0.86, which is a lot higher than all the previous examples of pop songs. This is true to our original assumptions, and it suggests that the index can indeed capture our intuitions and how our perceptions of different songs are. Now let's see one more example from the traditional genre *Jīngyùn Dàgǔ*, which is not only infused with lots of Beijing dialect flavors but also has a semi-speaking style of singing. Thus we expect this type of songs to have the highest I_{TG} score so far. Indeed this is so, as shown by the EXAMPLE 11, which is actually the same as EXAMPLE 5 that we discussed earlier. The steps are listed in (7). We see that the I_{TG} score is 0.9, the highest so far.

EXAMPLE 11 Sample I_{TG} Jīngyùn Dàgǔ: Cǎochuán Jièjiàn[17]



(7) Step-by-step calculation of I_{TG} for EXAMPLE 11

- n=5
- x_1=0.5+0.5; x_2=0.5+0.5; x_3=0.5+0; x_4=0.5+0.5; x_5=0.5+0.5
- I_{TG} = 4.5/5 = 0.9

So now we can actually order all of these examples in terms of their I_{TG} scores from the lowest to the highest as shown in (8).

(8) Ordering of I_{TG} scores

Jiǔshén Qǔ<Gùxiāng de Yún<Wǒ Yuànyì<Qiánmén Qíngsī Dàwǎnchá<Jīngyùn Dàgǔ

So far we only presented snippets of songs to show how the I_{TG} is calculated. But to really compare two whole songs, we need to calculate the I_{TG} for complete songs. If there are multiple paragraphs with the same melody, we need to calculate all of the paragraphs for the same melody and add everything up in the same way. I did a calculation of the first paragraph of the lyrics for Faye Wong's Wǒ Yuànyì and Lǐ Gǔyī's

[17] Same as EXAMPLE 6.

Qiánmén Qíngsī Dàwǎnchá, and the I_{TG} for the former is 0.54 and the I_{TG} for the latter is 0.68. This is consistent with the I_{TG} scores based on the examples shown earlier.

There is still one more clarification here. Note that in some cases, the assignment of the scores for the register distinction or the tonal shapes can be debatable. However such differences will not change the overall value of the index, as long as the same considerations are kept consistent throughout all the calculations and comparisons.

Thus this section on the I_{TG} shows that the scores are consistent with our intuitions. Traditional music tends to have higher I_{TG} scores, while pop songs tend to have relatively lower scores to varying degrees. One possible exception would be rap songs. They would probably have very high I_{TG} scores. Although previous research can tell us how tones are accommodated in songs, we still need this mathematical method to quantify the degree of tonal accommodation, and it makes it possible to compare different songs to determine which one has a higher I_{TG} score, thus having a better perception result by the listeners, if other factors, e.g. contextual cues, do not play a decisive role.

3. Conclusions

In this paper, I have proposed new methods of tonal accommodation, i.e. register distinction and ad hoc grace notes. I have also given a detailed account of how tone sandhi and the neutral tone can be accounted for by the tonal accommodation principles. Based upon such principles, I create an index with its corresponding scoring rules to quantify the degree of tonal accommodation of different works of vocal music. It has been shown that traditional genres tend to have a higher I_{TG} score than most pop songs.

The new I_{TG} has both theoretical and pedagogical implications. First, theoretically it is the first attempt at quantifying tonal accommodation in vocal music. This is admittedly not the only way to quantify tonal accommodation. Moreover there could be modifications and improvements to be made on the formula given in (2). A further development would be to see whether such a method can be programmed, hence being automatically done, if the music scores in the proper format are given to a certain computer program. This would definitely make it much easier to compare songs, which would make the pedagogical application much more plausible.

In terms of the pedagogical applications, there has been an increased interest in recent years to teach singing to CFL (*Chinese as a Foreign Language*) students. One common concern for many researchers and instructors is that teaching singing might affect students' acquisition of tones because tonal shapes and contrasts can be ignored easily in many songs. Such concerns are not completely correct, as has been shown in this paper. Many songs, especially the more traditional genres, preserve the tonal shapes and contrasts very well. On the other hand, it is true that no song can preserve the tones 100%, and hence the concerns over tonal acquisition are still valid to some extent. Therefore to minimize the negative effect on tonal acquisition, songs can be taught to students at a higher level, say the ACTFL proficiency level Intermediate-High and above, and selections of songs should be based on the I_{TG} scores, whenever possible. For

example, teaching songs such as Lǐ Gǔyī's Qiánmén Qíngsī Dàwǎnchá can be an excellent way to engage students' interest while at the same time training accuracy of tonal production. Even for students at a lower proficiency level, say Novice-High, teaching songs with a high I_{TG} score can be beneficial, because tonal shapes and contrasts are usually very well accommodated in such songs.

However, some scholars might object to the assumption that singing tones or hearing tones sung are connected to speaking with correct tones or hearing spoken tones correctly. Since the debate is still not completely settled, for the time being, it is still more reasonable to choose songs with a higher I_{TG} score to teach CFL students to sing in Chinese. For one thing, teaching singing is a great method to engage and motivate students. Students welcome such courses. If we do see the benefit of teaching singing, then it is reasonable to try to minimize any potential negative effects on tonal acquisition, real or imaginary, by choosing songs that have a higher I_{TG} score, meaning that they accommodate tones better than other songs.

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