

A Classroom-Centered Study of Third Tone in Mandarin Chinese

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Abstract—Phonological third tone sandhi studies in Mandarin Chinese will lead more often to a lab-centered research, whereas the incorporation of phonetic tone sandhi studies into phonological analyses will shed a light on a classroom-centered study. This incorporation suggests a revised approach to the third tone sandhi from an articulatory perspective. As a result, the study of pitch values and pitch contours of a third tone are taken over by the study of sound positions and jaw/chin movements. The well-known five-level tonal diagram is challenged and replaced by a seven-level tonal diagram with an application of only two forms of pronouncing a third tone ---pseudo third tone and pseudo second tone. All these aim to investigate a classroom-centered study of a third tone as an understudied area to provide practical guidance for Mandarin instructors and learners of Mandarin as second language.

Index Terms—phonological/phonetic third tone sandhi studies, classroom-centered study of third tone, seven-level tonal diagram, pseudo third tone and pseudo second tone, incompletely/completely neutralized pseudo second tone

I. INTRODUCTION

A third tone study of phonological nature has been performed for decades. Considerable progress has been made in our understanding of the processing of third tone sandhi from the phonological perspective. Advances in this literature have allowed many third tone sandhi problems to be addressed and solved. The outcomes which have been achieved through computer-generated data and computer-assisted analysis have provided valuable theoretical descriptions of Mandarin third tone sandhi mechanisms.

However, the successful application of these theoretical analyses to teaching of third tone sandhi for learners of Mandarin as second language has proven to be difficult. Their experimental results from a lab have been met with limited enthusiasm in classrooms, likely due to a combination of the following factors:

1. The main aims of their studies and analyses are primarily lab-centered in order to demonstrate that their outcomes are reliable, accurate and convincing.
2. The authors of these studies might forget that if these experimentally-based outcomes can only be measured and verified by a computer-assisted device such as PRAAT, WinPitch or EMA, these outcomes might paradoxically fail to be easily, accurately and reliably perceived by Mandarin teachers and learners in classroom.
3. Most of the experimental studies for theoretical analysis are based on a five-level numerical scale of pitch values or contours of F_0 (fundamental frequency, measured in the units of Hertz). The pitch values, pitch height and pitch contours are deterrent and not easily and accurately perceived by most Mandarin teachers and students without much phonological background.
4. The Mandarin teachers and learners in the classroom feel greatly challenged by the theoretical discourses and linguistic terms used by researchers, linguists and dissertation-writers in phonology, such as autosegmental phonology, optimality theory, constraint-based analyses, surface and underlying patterns, incomplete neutralization, derivational process, tonal domains and metrical domains, bimoraic syllables, etc.

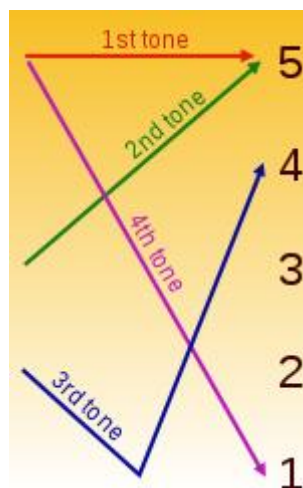
II. CLASSROOM-CENTERED STUDY OF THIRD TONE

A phonological tone sandhi study will lead more often to a lab-centered research, whereas the incorporation of phonetic tone sandhi studies into phonological analyses will shed light on a new approach to a classroom-centered study. This incorporation suggests a revised approach to the third tone sandhi from an articulatory perspective. As a result, the study of pitch values and pitch contours at labs will become a study of sound positions and jaw/chin movements in a classroom. The substantiated empirical findings from sound positions and jaw movements inside the mouth are easier for teachers and learners without much phonological background to comprehend and to apply to their teaching and learning experience. The learning process in the classrooms favors these perceptible properties with strong phonetic bases instead of patterns with abstract phonological features. Although the computer-assisted devices such as PRAAT and WinPitch are great tools to measure the values of Fundamental Frequency (F_0), human ears and mouths remain the final judge of any perceivable third tone sandhi behaviors and processes in teaching and learning experience. The evidence and data generated by computer-assisted devices do not efficiently solve the problem of how to teach the students to pronounce a sandhi third tone or how students know to correct or avoid their mistakes. At the same time, a

seven-level tonal diagram has been developed in order to provide a potentially better model for variable sandhi behaviors than the well-established five-level tonal diagram.

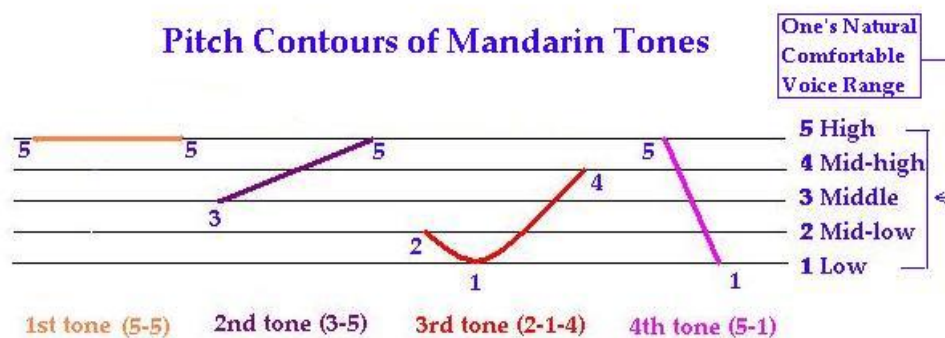
III. FIVE-LEVEL TONAL DIAGRAM

Most of previous Chinese tonal studies are based on or related to the five-level tonal diagram developed by Chao (1930). The five-level tonal diagram can be easily found in many studies of a third tone, even in *Tone (linguistics)* – Wikipedia:



Many researchers have quoted and used this five-point tonal scale in their discourses. The pitch values and pitch contours for four tones are transcribed in numbers. A general consensus has been reached in this literature that the pitch value of 214 on this five point scale is taken for the third tone or the full third tone. As a result, previous studies have consistently shown that the code of 214 represents the full third tone.

Jin (2018) said, “Chao (1930) designed a five-level numerical scale to represent the pitch height, ranging from 1 through 5 with the latter being the highest pitch level. In this representation system, the four basic tones are labeled as “55,” “35,” “214,” and “51” respectively.” (P. 68)



Yin (2003) states, “The numbers from 1 to 5 is used to designate these levels, where 1 represents the lowest comfortable pitch of the vocal range and 5 represents the highest. The first tone (tone 1) (55) is high and level. It is pitched near the top of the comfortable voice range. The second tone (tone 2) (35) starts around the middle of the voice range 3 and rises straight towards the level of the first tone 5. The third tone (tone 3) (214) begins near the bottom of the comfortable voice 2, proceeds to the bottom 1, and then upward to end above the middle 4. The fourth tone (tone 4) (51) begins at the top of the comfortable range 5 and falls quickly to the bottom 1 (Ch’en et al., 1994)” (P. 296).

The third tone as 214 in such a diagram is also introduced across the spectrum of textbooks such as in *Integrated Chinese* (2009). Many linguists and researchers still remain convinced that this five-level tonal diagram is a putative model for the pitch values and contours of the full four tones. If this putative model is challenged, the foundation for many third tone sandhi analyses will be compromised. For me, the number 214 does not represent the basic third tone or the full third tone or citation third tone. The third tone with the number 214 turns out to be only one of variable forms for a sandhi third tone both because the full third tone almost does not occur in our natural utterance and because a sandhi process for the third tone has already taken place even when four Mandarin lexical tones are pronounced one after another as a demonstration of teaching. This five-level scale is static in the sense that it represents only four full

tones and cannot be applied to the dynamic third tone sandhi process. This static five-level scale fails to explain the arbitrary nature of the third tone sandhi in natural utterances from both phonetic and phonological perspectives.

IV. SEVEN-LEVEL TONAL DIAGRAM

If the five-level tonal diagram as a foundation for many third tone sandhi studies is challenged, my seven-level tonal diagram may potentially provide a better model for four tones as well as for variable sandhi behaviors. In this seven-level tonal diagram, F_0 trajectory and pitch values are replaced by a sound's position inside the cavity of the mouth and by a trajectory of jaw/chin movements when a particular sound is pronounced. A dynamic peak of the sound position for the departure point of a third tone, a variable valley of sound positions for its falling and a different peak for its terminal rise within a third tone sandhi contour will be illustrated in the following diagrams instead of simply a static pitch value such as 214.

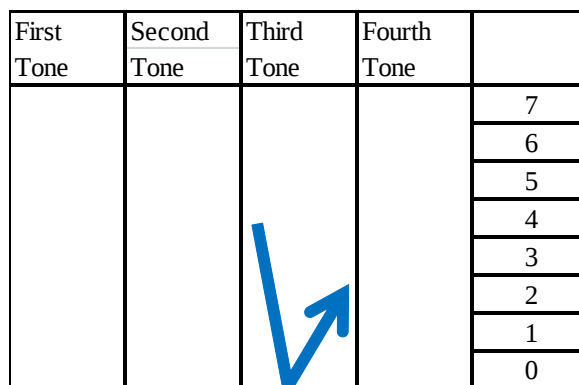


Figure 1 for ǎ as a **Full Third Tone (Third Tone or Citation Third Tone)**

Figure 1 is a static seven-level scale diagram. It is static in the sense that it represents the height of a sound position and the contour of the jaw/chin movement inside the mouth only for ǎ in its full third tone instead of its dynamic third tone sandhi process. In addition, it is static in the sense that it represents only the vowel “a” instead of any other vowels in a third tone or any sounds with the combination of a vowel with a consonant because different vowels have different sound positions inside the mouth. The number Zero is especially designated to illustrate the citation third tone or full third tone as a demonstration example when being pronounced in total separation from all the other three tones. The citation third tone or full third tone in this special case is assigned the number 402 instead of 214, and the number 402 indicates a deep falling with a moderate rise. However, the full third tone as 402 is not common in our natural utterance. It exists only as a demonstration or simply as a mistake.

The number Zero can only be applied in some very rare scenarios, when we want to show our great feelings or emotions by pronouncing the word 好 Hǎo ‘good’ as low as the number Zero in a long drawn-out sound H—ǎ—o in the same way as shouting the English word Yes: Y—e—s!. The number Zero is used in another rare scenario: 我的 Wǒ de ‘my/mine.’ The word 的 de is pronounced in a neutral tone which is relatively non-salient/non-significant in meaning. As a result, its duration is shortened. For the sake of compensation for the shortened duration of the neutral tone of 的 de, 我 Wǒ will get lengthened in duration instead. Therefore, 我 Wǒ in the phrase 我的 Wǒ de in a slow speech tempo can reach as low as the number Zero partially due to its extra long duration of the vowel “uo” and partially due to its derived duration from 的 de in neutral tone. The number for the trajectory of its jaw/chin movement will be 401. Although 好 hǎo in 好的 Hǎo de is followed also by 的 de, the vowel “ao” in 好 hǎo has a shorter duration than the vowel “uo” in 我 Wǒ. Therefore, the number for the trajectory of its jaw/chin movement will be 412 for 好 hǎo in a slow speech tempo instead of 401.

Anyhow, the number Zero is used for these three rare exceptions: full third tone, 好 hǎo pronounced with great feelings and 我 Wǒ in the phrase 我的 with slow speech tempo.

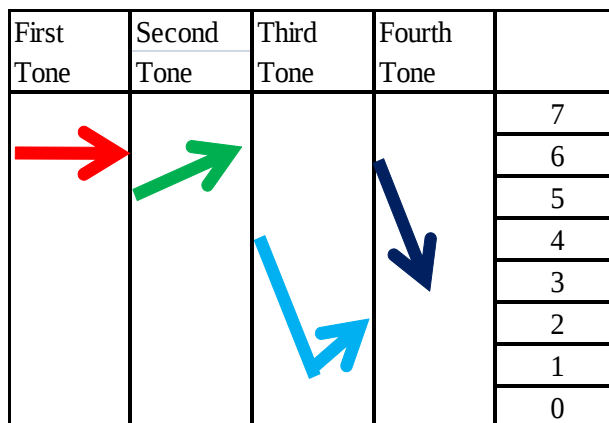


Figure 2 for ā, á, ǎ, à in a Slow or Regular Tempo Instead of a Quick Speech Tempo

In a slow or regular speech tempo, First Tone for “a” in this seven-level scale diagram is characterized by a high-level sound with the number 66; Second Tone is a rising tone with the number 56; Third Tone is a low-dipping and small rise tone with the number 412 instead of 214 (Note: if the third tone is pronounced in a quick speech tempo, its number will be 546), and Fourth Tone is a falling tone that begins at the top of the number 6 and falls only a half way to the bottom with the number 3. Here, “7” represents the highest possible sound position for any vowels or sounds, whereas “1” represents the lowest possible sound position for any vowels or sounds in a natural utterance.

In the five-level tonal system, the pitch values are divided into five levels: upper, upper middle, middle, lower middle, and lower, whereas in the seven-level tonal system, the sound positions are divided into seven levels: upper high, lower high, upper middle, middle, lower middle, upper low, and low. The seven-level scale does not aim to be completely accurate, but aims to be closer to accuracy and closer to fractions. (It would be better if fractions had been introduced in the seven-level scale diagram to describe a smaller terminal rise or a smaller initial fall in a sandhi third tone.)

Figure 2 is a partially static and partially dynamic seven-level scale diagram. It is static in the sense that it represents the sound positions and the contours of the jaw/chin movement inside the mouth only for the four tones ā, á, ǎ, à in a slow or regular utterance tempo instead of other vowels or in a quick tempo. In addition, it is static in the sense that it represents only the four tones with the same vowel “a” instead of any sounds with the different combination of a vowel with a consonant. However, as compared with ǎ with the number 402 in Figure 1, Figure 2 is dynamic in the sense that ǎ with the number 412 has already undergone a third tone sandhi process by shortening its falling distance to 1 instead of to 0, and by shortening the distance of its jaw/chin movement from a moderate rise to a small rise due to its interaction with the other three tones before the involvement of any other adjacent factors.

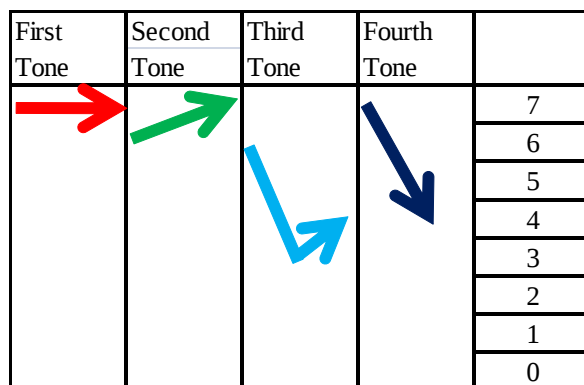


Figure 3 for qī, qí, qǐ, qì in a Slow or Regular Tempo

First Tone in qī is characterized by a top-level sound with the number 77; Second Tone in qí is a rising tone with the number 67; Third Tone in qǐ is marked by low-falling contour and followed by a small rise with the number 634 instead of 214, and Fourth Tone in qì is a falling tone that begins at the top of the number 7 and falls only a half way through with the number 4 instead of falling to the bottom with the number 1.

Figure 3 is also a partially static and partially dynamic seven-level scale diagram. It is static in the sense that it represents the sound positions and the contours of the jaw/chin movement inside the mouth only for qī with these four tones qī, qí, qǐ, qì in a slow or regular utterance tempo and cannot be applied to any other vowels or any sounds with a different combination of a vowel with a consonant.

However, it is dynamic in the sense that Figure 3 has taken some variables into consideration because the height of the sound position of “qī” shown in Figure 3 is different from the height of the sound position of “a” shown in Figure 2. These changes in sound height and contour of the jaw/chin movement are dynamic in the sense that a phonetic analysis

has been incorporated into a third tone sandhi analysis in this literature, and these differences and changes are clearly perceivable to a learner of Mandarin as a second language even without any phonological background. In addition, Figure 3 is dynamic in the sense that third tone in qǐ is marked by a higher departure point (6 instead of 4 as in mǎ), then by its falling (3 instead of 1 in mǎ) and followed by a small rise with its contour number 634, whereas third tone in mǎ is a low-dipping and small rise tone with a different number 412.

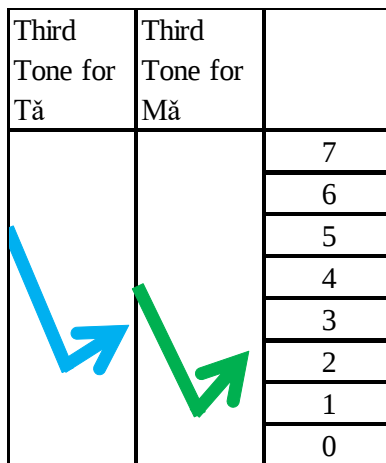


Figure. 4 for Tǎ and Mǎ in a Slow or Regular Tempo

Figure 4 is another partially static and partially dynamic seven-level scale diagram. It is static in the sense that it represents the sound positions and the contours of the jaw/chin movement inside the mouth only for these two sounds in a slow or regular speech tempo without a comprehensive consideration of all dynamic third tone sandhi processes. However, it is dynamic in the sense that Figure 4 has taken consonants into consideration such as “t” (called “initial” in Pinyin) in Tǎ and the consonant “m” in Mǎ even though they share the same vowel “ǎ.” The number assigned to Tǎ is 523, whereas the number assigned to Mǎ is 412, because the sound position of the consonant “t” is higher than that of the consonant “m.”

The seven-level tonal diagram outlines potential directions to which the studies of Chinese third tone can fruitfully proceed. Basing on this seven-level tonal scale, we are also equipped to bring new observations to the sound positions, jaw/chin movement and third tone sandhi behaviors.

V. FULL THIRD TONE AND THIRD TONE SANDHI

As it has been observed, the duration of tone 3 is longer than the other 3 tones in Mandarin. The number one factor which triggers a third tone sandhi is its extra long duration instead of some other factors. Then, the third tone sandhi is conditioned by a number of other factors such as syntactic structure, semantic structure, speech prosody, speaking rates, constituent strength/syntactic hierarchy, etc. Besides, the third tone sandhi is conditioned by its adjacent tones. The substantial duration of a full third tone cannot be maintained when a third tone is pronounced just with the other three tones such as in ā, á, ǎ, à even before the involvement of a syntactic, prosodic, lexical and semantic structure. It has to undertake a third tone sandhi process by compromising its duration, irrespective of any other factors.

So far, there exist only two kinds of full third tones: 1. a full falling and full rising third tone as pronounced like the shape of third tone graph “V”; 2. a full falling and half/moderate rising third tone with its number 402 as pronounced for a demo of ǎ with its total separation from any adjacent tones or syllables.

The third tone graph “V” represents the movement of a pendulum, starting with its left swing end and reaching its right swing end. However, the full third tone’s contour as a “V” shaped mark has never existed in natural language utterances because the jaw/chin movement starting from high falling will never rise to the same height as that of the pendulum-like third tone graph. It seems that you cannot make your physical jaw/chin perform a full falling and full rising as the shape of a third tone mark due to the principle of effort minimization. The principle of effort minimization will take advantage of its tonal faithfulness by being short of the full rising amplitude of a pendulum swing. Therefore, the first kind of full third tone never exists in our natural utterance. Nevertheless, although the “V” shaped mark for the 3rd tone is misleading, the third tone mark “V” will remain the same in writing in the future because no better tone mark can be found to replace it.

The second kind of full third tone is pronounced only as a demonstration example totally in separation with the other three tones or any sounds. In this case, the third tone is able to perform a deeper falling with a higher/moderate rise. That is why the number Zero in my seven-level scale diagram is designated to represent the full third tone with its number 402.

VI. PSEUDO THIRD TONE AND PSEUDO SECOND TONE

If having only two resulting sandhi forms for the third tone--- 1. Pseudo Third Tone; 2. Pseudo Second Tone---, the third tone sandhi will be much more simplified.

A. *Pseudo Third Tone*

The third tone is characterized by an initial falling and a terminal rise. The sandhi third tone is also a tone with an initial falling and a terminal rise. But the movement of the jaw/chin in Pseudo Third Tone has a deep initial falling with a small or smaller terminal rise instead of moderate or high terminal rise.

It has been observed in the article Hanyu Pinyin for Mandarin Speakers: Tones – MIT, “You will find that in these four words [好吃, 好人, 好看 and 好吧], “好” is pronounced in the half third tone -- there is no rising. Examples like this abound in speech: “每年” (měinián; every year), “老師” (lǎoshī; teacher), “眼睛” (yǎnjīng; eye) ...”

One of the reasons for the above description might be that a small rising is too small to be measured by the integers of five-level scale diagram due to a lack of fractions. If the contour of the jaw/chin movement is applied to this third tone sandhi process, you will definitely notice a small/smaller terminal rise with the jaw/chin for the third tone “好” in the above examples instead of no rising.

The so-called “half third tone” or “a low falling tone” with only a falling without a rise with its number 31 in the five-level scale is not the contour of a sandhi third tone. Although the terminal rise for this so-called “half third tone” or “a low falling tone” is not as pronounced as that of a full third tone, it is certainly perceivable with a small/smaller rise of the jaw/chin movement.

When a third tone is pronounced at a slow or regular speech rate instead of a fast tempo, it becomes a pseudo third tone with a deep falling and a small/smaller terminal rise or with a shorter falling and a very small terminal rise. (When third tone is pronounced at a fast speech rate, it becomes a pseudo second tone with a small initial fall and a high/long terminal rise instead as in **6.2. Pseudo Second Tone**).

Yin (2003) points out, “In a phonological phrase, the final syllable is lengthened and the non-final syllable(s) is shortened.” (P. 297)

Shi (2018) points out, “Cheng (1968) is an earlier phonological study of the Tone 3 sandhi in Mandarin. The author reports that the Mandarin Tone 3 maintains its full tone contour [214] only when it is produced in isolation or on the final syllable of an utterance followed by a pause.” (P. 4)

However, the picture presented here by the above authors is far from being complete. For me, whether the initial or final syllable, all the third tones undergo a tone sandhi to different extents because no syllable can be pronounced in its full third tone in natural utterances due to shortening their duration or to the principle of effort minimization. That means that not only will the initial Chinese character with a third tone in a phrase, a sense group or a domain undergo a tonal sandhi process if followed by another Chinese character, but the final syllable of an utterance or the last Chinese character of a phrase or a sense group will also undergo a third tone sandhi process if proceeded by another Chinese character or syllable. That means that the terminal full third tone in an utterance cannot be maintained due to its mutual interaction with the proceeding tone in the same way as the tone sandhi process experienced by a neutral tone in reduplication of syllables or Chinese characters. Although with no adjacent syllables following the final syllable, it will be pronounced with different amounts of articulatory effort when it appears at the end of a phrase or sense group or a domain, just as the original speed of a vehicle will determine its braking distance for its stop. Taking 你好 Nǐ hǎo for example, it is clearly perceivable that 好 hǎo can even sounds shorter than 你 Nǐ in a slow or regular speech tempo with the jaw moving down and up.

B. *Pseudo Second Tone*

Pseudo Second Tone is different from Pseudo Third Tone because Pseudo Second Tone is similar to a regular second tone. Although Pseudo Second Tone is similar to a regular second tone, the movement of the jaw/chin in pseudo second tone has a small initial fall with a high/long terminal rise. It is pseudo in the sense that Pseudo Second Tone still bears the distinguishing feature of a full third tone with an initial falling and a terminal rise. A third tone becomes a pseudo second tone when the speech tempo increases for an initial third tone in a disyllabic/trisyllabic domain (phrase or sense group) as well as for a non-initial/non-final third tone in a trisyllabic domain (phrase or sense group). In addition, Pseudo Second Tone is divided into two forms: 1. incompletely neutralized pseudo second tone; 2. completely neutralized pseudo second tone.

1. *Incompletely Neutralized Pseudo Second Tone*

Incompletely neutralized pseudo second tone is pseudo and incompletely neutralized (in a sense similar to but not totally identical to a second tone) in perception. When a third tone is changed from a pseudo third tone in a slow or regular speech tempo to a pseudo second tone (to be more accurate, an incompletely neutralized pseudo second tone) when the speech tempo increases, specially for an initial third tone in a disyllabic/trisyllabic domain (phrase or sense group) in a fast speech tempo. However, its initial small, though very small, falling movement can be clearly perceivable to the speaker. Most of the examples of pseudo second tone belong to an incompletely neutralized pseudo second tone.

2. *Completely Neutralized Pseudo Second Tone*

Linge (2012) says, “I’ve read numerous papers arguing that the rising tone resulting from two third tones in a row is identical to a normal second tone. However, I have also read papers which argue that there is a difference.” (2012-06-03 at 18:54)

So far, it seems that no resolution has been found to address these two above contradictory arguments identified by Olle Linge. The reason for this lies in two forms of Pseudo Second Tone: 1. incompletely neutralized pseudo second tone; 2. completely neutralized pseudo second tone. Many examples of an incompletely neutralized pseudo second tone support the argument “that there is a difference”, whereas the completely neutralized pseudo second tone explains why the researchers argue that “rising tone resulting from two third tones in a row is identical to a normal second tone.”

A completely neutralized pseudo second tone is realized in the sense that a sandhi third tone is extremely similar to a second tone. The difference between this sandhi third tone and the second tone is not clearly perceivable to a human being. This completely neutralized pseudo second tone is also realized in the sense that it is still pseudo instead of being 100% identical to the second tone. However, the difference, if any, between this completely neutralized pseudo second tone and the regular second tone can only be identified by a computer-assisted device.

Besides, a pseudo third tone in the initial syllable in a disyllabic or trisyllabic domain (phrase) is very susceptible to the changes of a speech tempo. It will be changed from a pseudo third tone in a slow or regular speech tempo to incompletely neutralized pseudo second tone in a fast speech tempo. The same holds true that an incompletely neutralized pseudo second tone in the initial syllable in a disyllabic or trisyllabic domain (phrase) will be changed back to a pseudo third tone in a slow or regular speech tempo. However, a completely neutralized pseudo second tone in the third tone sandhi process will be insusceptible to the increases or decreases of a speech tempo even when it is in the initial syllable of a disyllabic or trisyllabic domain.

Figure 5 represents a dynamic seven-level scale diagram for a pseudo third tone in a slow or regular speech tempo and an incompletely neutralized pseudo second tone in a fast speech tempo, and Figure 6 represents a completely neutralized pseudo second tone.

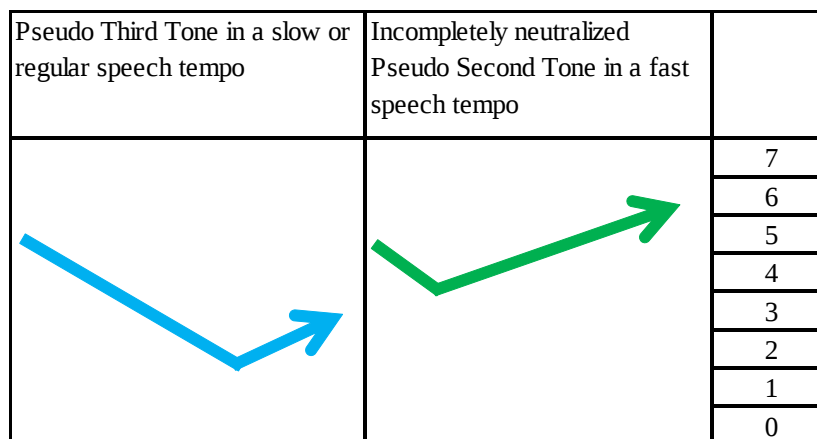


Figure. 5 for 起 Qǐ in 起点 Qǐdiǎn (starting point)

A third tone becomes a pseudo second tone when the speech tempo increases for an initial third tone in a disyllabic domain. 起 Qǐ in 起点 qǐdiǎn ‘starting point’ in a two third tone string is pronounced as a pseudo third tone with an initial moderate fall and a final small rise in a slow speech rate with the number of 523 due to the relative low sound position of the vowel “iǎn” in the final syllable 点 diǎn. 起 Qǐ in 起点 qǐdiǎn is changed to a pseudo second tone (to be more accurate, an incompletely neutralized pseudo second tone) with an initial small fall and a terminal high rise in a fast speech tempo with the number of 546.

Let’s take a well-known pair of 起码 Qǐmǎ ‘at least’ and 骑马 Qímǎ ‘horse riding’ for example.

Politzer-Ahles (2019) points out, “Liu (2013) tested six listeners’ explicit metalinguistic identification and discrimination of underlying and sandhi-derived Rising tones. In the identification task they heard ambiguous disyllables like [tɕʰi˥ ma˨], in which the first syllable was either underlyingly Rising or was changed to Rising via tone sandhi, and had to select the appropriate orthographic representation (for this example, either 起码 /tɕʰi˥ ma˨/ “at least” or 骑马 /tɕʰi˥ ma˨/ “ride a horse”). In the discrimination they heard disyllable pairs, where either both disyllables were the same, or one disyllable was a production with an underlying Rising and one a production with a sandhi-derived Rising tone. They then judged whether they were the same or different. The participants were not significantly more accurate than chance level in identifying the tones, but they were significantly above chance in discriminating them. Above-chance discrimination does not indicate that the tones were incompletely neutralized, though, because there are many other ways that different acoustic cues can allow participants to perform well on within-category discrimination (not just in tone perception and not just in incomplete neutralization contexts).”

Why does Liu in the above testing typically take this pair for examples instead of more common pairs? That is because the third tone sandhi of 起码 Qǐmǎ stands out to be an example of being maximally similar to a second tone

and can be classified as a completely neutralized pseudo second tone instead of an incompletely neutralized pseudo second tone. At the same time, they fail to find a solution from the phonetic perspective, namely, to figure out how the sounds of 起码 Qímǎ are phonetically produced so maximally similar to a second tone. Let's take the following seven-level scale diagram for illustration.

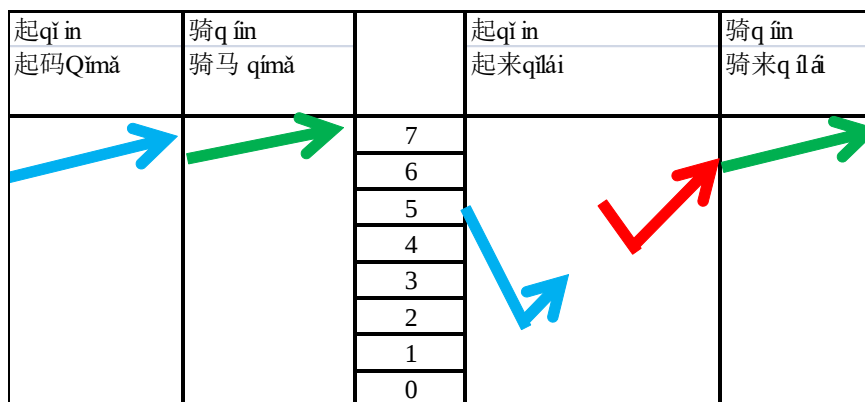


Figure. 6 for 起 qǐ in 起码 Qímǎ and 骑 q í in 骑马 qímǎ;
for 起 qǐ in 起来 qílái (get up) and 骑 q í in 骑来 q ílái (rode over).

起 qǐ in a string of two third tones 起码 qímǎ is pronounced as a pseudo second tone (to be more accurate, a completely neutralized pseudo second tone) with the number of 67 in a slow speech rate; it makes no change perceptible to a speaker even when the speech tempo is changed from slow to fast and it will still keep its number of 67 unchanged. It sounds almost exactly like 骑马 qímǎ. Their difference is so small that it can only be identified by a computer-assisted device.

It is important to know that the cases for a completely neutralized pseudo second tone are rare and can be considered as exceptions. They only exist with the four sounds “jǐ, qǐ, xǐ” and a sound with a vowel “ü,” and these four sounds must be followed by a syllable with the vowel “a.” “jǐ, qǐ, xǐ” and “ü” are located in an extremely high position inside the mouth and almost touch the roof (the hard palate or soft palate) of the mouth. In addition, the final syllable 码 mǎ with the vowel “a” in a disyllabic domain plays an essential role to make the initial small fall in a pseudo second tone almost disappear. The distinguishing feature of “a” in 起码 Qímǎ or 骑马 Qímǎ has been captured in the fact that the sound position for “a” will not follow along the contour of the jaw/chin movement when the jaw/chin has a deep falling, whereas “a” will go contrarily to a higher position and stay relatively high there instead. Generally speaking, when a sound position is extremely high and close to the roof of a mouth, the muscle of a mouth should get intense, and this intensity of the muscle will keep the upper jaw and lower jaw closed such as “jǐ, qǐ, xǐ” and “ü.” This rule applies to all sounds in Pinyin with the only exception of “a.” When “a” is pronounced, the upper jaw and the lower jaw will widely open with intense muscles, and the chin will move downward. However, when the muscle of a mouth stays intense, the sound position for “a” will go upward in a direction contrary to the movement of the chin. This movement of going upward will prevent 起 qǐ from making an initial small fall perceivable before its terminal rising.

If the final syllable mǎ is replaced by 来 lái in Figure 6, we will introduce a new pair of disyllables in 起来 qílái and 骑来 q ílái with the initial syllables 起 qǐ and 骑 q í. In this new case, the vowel in the final syllable is changed from “a” to “ai.” The difference between 起来 qílái and 骑来 q ílái is easily identified and clearly perceivable to the speaker. 起 qǐ in this case can make an initial moderate fall with a terminal small rise in a slow speed with the number 523 or an initial small fall with a terminal high rise in a fast speed with the number 546. However, 骑 q í in 骑来 q ílái is a second tone with the number 67.

Another example of a completely neutralized pseudo second tone can be found in 语法 yǔfǎ (grammar). “ü” is located in an extremely high position inside the mouth and almost touch the roof (soft palate) of the mouth. In addition, the final syllable 法 fǎ with the vowel “a” in a disyllabic domain (phrase) plays an essential role to make the initial small fall of the third tone in 语 yǔ almost disappear. It makes no change perceptible to a speaker even when the speech tempo is changed from slow to fast with its number of 67 unchanged.

If we just switch the sequence of the disyllable domain 语法 yǔfǎ ‘grammar’ to 法语 fǎyǔ ‘French’, it is important to find that 法 fǎ in 法语 fǎyǔ is capable of an initial deep fall and a final small rise in a slow speech tempo as well as of an initial small fall and a final high rise in a fast speech tempo. People might start to wonder why 法 fǎ in 法语 fǎyǔ is capable of an initial deep fall, whereas 语 yǔ in 语法 yǔfǎ is not capable of it without making a typical mistake. The reason for that is because the sound position of 法 fǎ in 法语 fǎyǔ is not extremely high and is relatively lower than 语 yǔ.

Figure 6 is dynamic in the sense that it has taken more variables into consideration because the height of the sound position of “qi” shown in Figure 6 is different from the height of the sound position of “qi” shown in Figure 5. This change in sound heights and contours of the jaw/chin movement even for the same sounds “qi” with the same third tone is dynamic. Besides, Figure 6 is dynamic in the sense that it has taken most variables into consideration not only because the tonal effect of the final syllable on the initial syllable “qi” in a disyllabic third tone sandhi process has been taken into consideration, but also because the effect of the vowel in the final syllable on the initial syllable “qi” in a disyllabic third tone sandhi process has been taken into consideration. These important phonetic changes failed to be incorporated into a phonological third tone sandhi analysis in most previous studies in this literature.

VII. CLASSROOM-CENTERED STUDY WITH VARIABLES OF THIRD TONE SANDHI

A dynamic mapping of a third tone sandhi should include numerous elements of arbitrary and variable nature.

A. Dynamic Seven-Level Tonal Diagram with Variables

Some dynamic features of a third tone sandhi process also have been captured in this diagram when various sound positions inside the mouth have been taken into consideration to indicate the arbitrary nature of a third tone sandhi. The sound position inside the mouth for the same syllable with a third tone should not have one single or same starting height position in a different sandhi environment. At the same time, the sound position inside the mouth for the same syllable with a third tone should not have one single or same lowest position. Furthermore, the sound position inside the mouth for the same syllable with a third tone should not have one single or same final ending height position in a different sandhi environment.

Not only should the whole contour of the jaw/chin movement be illustrated, but different versions of the contour of the jaw/chin movement in different speech speeds should also be mapped out. For example, the gradient differences in number should be delineated in a slow, regular or fast articulatory rate.

Taking Figure 1 for example, the full third tone “ǎ” with its contour value of 402 can be pronounced as 412, 423 or 435 in a different sandhi environment of slow, regular or fast articulatory rate. These productions are still perceived as gradient differences in a third tone sandhi process.

Taking Figure 3 for example, the contour value of 634 for the sandhi third tone “qǐ” indicates that its starting height is higher than the contour value of 412 for “ǎ” in Figure 2. The contour value of 634 for “qǐ” is realized in a slow or regular articulatory rate, and 657 in a fast articulatory rate in Figure 5. Even the asymptotic approximation value of 67 in Figure 6 for “qǐ” is actualized if followed by the vowel “a” in the final syllable in a disyllabic third tone sandhi.

Taking 语法 yǔfǎ (grammar) again for example, the third tone 语 yǔ takes an extremely high sound position close to the soft palate with the contour value of 67. The dynamic nature of third tone sandhi process in this case is constrained by a threshold of minimum and maximum range. It is important to point out that the number of 67 for 语 yǔ is not as significant as the contour values which run beyond this range for a classroom-centred study. For a teacher to know how a mistake has been made by a Mandarin student or for a Mandarin learner to know how to avoid such a mistake to happen, it is crucial to have a practical understanding of the potential contour values going beyond the range of limits which will lead to an error. The potential mistakes in coarticulation of 语法 yǔfǎ are materialized in the contour values with the number of either 624, 635, 647, 657 or 424. The numbers 624, 635, 647, 657 or 424 all indicate that their falling point is too low.

Students often make mistakes when pronouncing 我 wǒ in 我们 Wǒmen ‘we.’ The number of 412 for 我 wǒ in a pseudo third tone with a slow or regular tempo and 436 for 我 wǒ in a pseudo second tone with a fast tempo are both within the range of limits. However, the number of 413 with a higher rise in a pseudo third tone is a typical mistake which goes beyond the range of limits for 我 wǒ in 我们 Wǒmen. One of the most frequent/typical mistakes made by Mandarin learners is to change **a small rise to a moderate rise or high rise** in a pseudo third tone, namely **a wrong terminal rise from the number 1 to 3 or 2 to 4 or 3 to 5 in a pseudo third tone with a slow or regular speech tempo** such as in 413, 524 or 635 instead of 412, 523 or 634. Taking 你好 nǐ hǎo for another example, the contour value of 524 for 你 nǐ is only for the full third tone which should be avoided in a third tone sandhi. The contour values of 523 or 534 are realized in a slow or regular articulatory rate or 546 in a fast articulatory rate. When you say 你好 nǐ hǎo with a strong feeling, it should be pronounced as pseudo third tone; if it just serves as a response to somebody’s greeting, you will pronounce it as a pseudo second tone. It is crucial for a teacher and for a learner to know which potential contour values might go beyond the range of limits and lead to a mistake. The potential mistakes in coarticulation of 你好 nǐ hǎo are realized with the contour values of 66 in a fast speech rate. The number 66 indicates that the starting point with the number of 6 is too high with intense muscles for the third tone 你 “nǐ” especially in a fast speech tempo, as high as for the first tone. As a result, “nǐ” will actually sound like “nǐ” with intense muscles instead of relaxed muscles, a typical mistake made by many learners of Mandarin as second language. Taking 很忙 hěn máng for another example, the typical mistake for a Mandarin student is to pronounce 很 hěn with the number of 74 in a fast tempo instead of 546. Because 忙 máng is neither in a fourth tone nor with intense muscles, the muscle of his/her mouth will easily get intense

in a fast speech tempo if the number for the starting point of 很 hěn is too high. All these contribute to make 很 hěn sound like a fourth tone. As a result, 很忙 hěn máng tends to be changed to hèn máng according to the T-POLARITY constraint, which requires an initial tone to be followed by an opposite tone (Duanmu, 1999). That means that second or third tone tends to be changed to first or fourth tone or vice versa, and the relaxed muscles tends to be changed to intense muscles or vice versa. That is why Mandarin students will never have a problem when they pronounce 很 hěn in 很贵 hěn guì 'very expensive.' 很 in 很贵 hěn guì can be correctly pronounced all because 贵 gu is a fourth tone with intense muscles which will avoid 很 hěn to get intense with muscle. The solution to this problem is to pronounce 很 hěn in a pseudo third tone in 很忙 hěn máng with the number of 512 or 523 in a third tone sandhi process.

No one fixed number is designated for third tone sandhi in this Seven-Level Tonal Diagram to demonstrate the dynamic behaviours of a sandhi process. However, the threshold or extremity of its dynamic behaviours can be determined. Going beyond these extremities will lead to making a mistake in pronouncing a sandhi third tone.

B. Application of Vowels (and consonants) as a Variable to Third Tone Sandhi Process

The vowels in "ji", "qi", "xi" and "yu" usually take the highest position inside the cavity of the mouth with a relatively shortened duration in Pinyin, and the highest position with the shortened duration of these sounds will usually increase the tensity of the muscles of the mouth. The relatively shortened duration and intensified muscle will not lead to a deep fall or a deep fall with a high rise. Some of diphthongs which have a relatively extended duration with relative relaxation of muscles are pronounced with a widely open mouth such as "ao", "iao" and "uo" which will be capable of a deep fall. However, "a" is the only vowel in Pinyin which is pronounced with a widely open mouth and a relatively extended duration and can still obtain its fairly high sound position with fairly intensified muscles.

C. Speech Tempos and Syntactic Structures as Variables

The syntactic structure as a variable can be found in many previous phonological studies. Taking 我也很好 Wǒ yě hěn hǎo (I am also very good) for example, there are four third tone Chinese characters (syllables) in a row. There are two different ways to pronounce this line due to various speech tempos. In a slow or regular utterance, 我 Wǒ is in a pseudo third tone marked by the jaw/chin contour of a low falling and a small rise with the number 412 or 423. In a fast speech rate, 我 Wǒ is in a pseudo second tone (to be more accurate, an incompletely neutralized pseudo second tone) marked by the jaw/chin contour of a small falling and a high rise with the number 436; 也很 yě hěn are in pseudo second tones marked by the jaw/chin contour of a small falling and a high rise with the number 436 whether in a slow or fast speech rate due to their positions of being non-initial/non-final syllables. 好 hǎo is in a pseudo third tone marked by the jaw/chin contour of a low falling and a small rise with the number of 312 different from the number of 412 for 我 Wǒ when 我 Wǒ is in a slow speech rate. It is clearly perceivable that the duration of the jaw/chin movement for 我 Wǒ is longer than that for 好 hǎo in a slow or regular speech tempo, and the starting sound position for 好 hǎo is lower than 我 Wǒ. 我 Wǒ is capable of both pseudo third tone and pseudo second tone due to its initial position in a row. The utterance of a sentence can be compared to the movement of a car which moves slowly from its static position and speed up quickly, and finally come to a stop. The jaw/chin movement for 好 hǎo cannot maintain its duration of being a full third tone due to its interaction with the short duration and fast tempo of the jaw/chin movement for the preceding syllables 也很 yě hěn. The syntactic structure as a variable can be found in another example. 老 Lǎo in 老师 Lǎoshī 'teacher' can be pronounced in a pseudo third tone with its number 412 in a slow/regular speech tempo or in a pseudo second tone with its number 435 in a fast speech tempo. However, 老 Lǎo in 李老师 Lǐ lǎoshī (a trisyllabic domain/phrase) can only be pronounced in a pseudo second tone with its number 435 due to its middle position in a trisyllabic domain in this case.

VIII. CONCLUSION

The well-known five-level tonal diagram is replaced by a dynamic seven-level tonal diagram for numerous variables with an application of only **two** ways of pronouncing a third tone --- **pseudo third tone** and **pseudo second tone**. A classroom-centered study of third tone sandhi is easier for teachers and learners to comprehend and to apply to their teaching and learning experience.

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