

# Pitch Prominence and Tonal Typology for Low Register Tone in Mandarin

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## Abstract

This paper tries to explore the relationship between pitch prominence and tonal typology by examining pitch behavior of the 3<sup>rd</sup> tone, a low register tone, in different accent contexts under Mandarin Chinese. The primary results obtained so far show that, pitch level of the 3<sup>rd</sup> tone is obviously lowered in focal condition, which is mainly manifested by lowering the L-point value of its F0, rather than raising the H-point value. This peculiar prominence pattern is not only reverse to the general model well established as the H raising effect in many languages of the world, but also remarkably diverse from the case of low register tone in Cantonese, another Chinese dialect typologically different from Mandarin. Considering on this deviation and referring to similar findings reported in other languages, we propose that implementational strategy of pitch prominence in certain language may be restricted by not only phonological contrast, but also by typological distinction.

**Index Terms:** pitch prominence, 3<sup>rd</sup> tone of Mandarin, register, typology

## 1. Introduction

As one of the prosodic means for the focus expression, pitch prominence has been well established as the H raising effect in focal condition. It was reported not only in intonation languages, but also in tone languages. However, some reversed fashions have been found recently. For example, Genzel, S. and Kügler, F. [1] reported a reversed manner of pitch prominence in Hindi, where the effect for the L tones results in a pitch span change by lowering L tones, raising H tones, or both, and the tonal distinctions are made sharper. That makes Hindi an interesting case in terms of prosodic typology concerning the expression of focus. In addition, similar case was also reported for Akan [2], in which a significantly lower realization of both H and L tones under corrective focus in *ex situ* and *in situ* focus constructions was found, it is contrary to the prediction that High and Low tones are raised in *ex situ* focus constructions. These results thus contradict with the view of the effort code that predicts a positive correlation of more effort resulting in higher F0 targets.

Actually, this phenomenon was found in Mandarin Chinese some decades ago. For example, based on the clear experimental evidence for the lowering of F0 minimum in the L as well as the R tone, Xu, Y.[3] pointed out that focus expands in Mandarin rather than just raises the tonal pitch range, though the conclusion was challenged by other studies, such as Wang et al [4]. Almost at the same time, several relevant studies [5,6,7] also reported that the manner of pitch movement for the focus expansions in Mandarin is largely depends on tonal categories. Specifically, pitch prominence in focal condition is realized as an obvious lifting on pitch level and expansion on pitch range, which is mainly satisfied by raising the F0 value of its high point (hereafter H-point, i.e., the top point) in general. However, it is except in the case of the 3<sup>rd</sup> tone (hereafter T3), where the prominence is not

realized by raising of pitch level, but lowering it instead, and is mainly satisfied by lowering the F0 value of its low point (hereafter L-point, i.e., the bottom point), which is obviously deviated from that of T1, T2 or T4.

Referring to the contradictory findings above, a consideration raised here is whether the difference on implementational strategy is related to their distinction in prosodic typology, such as tone language vs. intonation language, contour tone vs. register tone, and so on.

As a preliminary study, the present paper tries to discuss this relationship based on an investigation in the T3 case in Mandarin, including a brief comparison between Mandarin and Cantonese will be referred as well.

## 2. Pitch prominence for T3 in Mandarin

Many studies have reported the peculiarity on pitch prominence of T3, but the conclusions are inconsistent up to date. The main arguments are mainly referred to: (1) whether or not the prominence of T3 can be manifested through pitch regulation in itself? (2) If yes, then how is it done, by lifting of F0 H-point, or Lowering L-point? There are at least two different viewpoints.

One of them suggests that pitch level of T3 drops, as opposed to the case of other tones, and it is mainly manifested by L-point lowering, instead of H-point raising of its F0, as mentioned above in [5, 6, 7], because T3 has a distinctive feature of low register [5, 8]. In addition, it seems to have been proved by a quantitative analysis and synthesis of focus in Mandarin [9], in which the tone commands', that referring to focus, result in a higher pitch for tones 1, 2 and 4, but causes a lower and full pitch for the case of tone 3.

Another viewpoint suggests that focus information in T3 case is implemented by adjusting F0 H-point of the neighboring tones, so as to foil the focal information of T3 [10, 11, 12]. For example, Chen [12] claimed that pitch prominence of T3 can not be implemented through pitch regulation of itself, although some cases do show a L-point depressing of the F0, it is mostly manifested through raising F0 H-point of its neighboring tones', especially through the following ones'. Consequently, the exact strategy of pitch prominence in T3 case remains unclear up to date.

According to the situation described above, there are some factors may affect the consistency of results in the previous investigations. First, only the H raising effect was employed as the scale of pitch prominence, but regardless of the role of L-point behavior. Secondly, the register feature of T3 was usually ignored, and a general distinction on F0 movement between T3 and other tones was often left out; thus, the F0 behavior observed in focal case might be a mere mixture only. In addition, as the focal accentuation in natural speech is always co-occurred with other factors such as phrasing, intonation and so forth, thus, the F0 manifestation must reflect those influences synchronically. On the other hand, the majority of experimental materials tested in previous studies were designed for the comparison between typical focus and non-focus cases, and deliberately preventing other

factors' effects. In this case, systematic differences between observed results and real situation are inevitable.

To explore the strategy on pitch prominent of T3 in real speech, the present study was conducted in two steps. At first, a preparatory test was conducted, through which all T3 distributed naturally in a set of discourse corpora were tested, involving both accented and un-accented tokens, so that to observe F0 movement behavior can be observed in general. After that, a further study was carried out, where the attention was paid to the comparison among the tokens with different focal degrees. For this purpose, the range of test materials was narrowed into two sets of clauses and sentences, but the speakers were extended from 1 male and 1 female to 2 males and 2 females, so that we may validate whether the phenomenon observed from preparatory test reflects a general rule or not.

## 2.1 Preliminary test

### 2.1.1 Test Materials

Heretofore, the speech materials used for studies on prosodic prominence were deliberately designed for the comparing between typically focused vs. non-focused instances. However, in real speech, the influences resulted from multi-factors are unavoidable, so any results obtained from designed materials should be proved by natural speech. This study tries to employ new test materials and methods to unfold as precisely as possible the real situation that occurred in natural speech.

Speech materials used for preparatory test include 1 male and 1 female speakers' utterances, which were extracted from the ASCCD discourse corpus read aloud by multi-speakers. This set of materials consist of 4 paragraphs, containing a total 290 syllables, among which 44 are with T3. In order to observe T3's F0 movement behavior in general, all the tokens, including accented and un-accented cases, were included in the test.

### 2.1.2 Observed result

From this part of observation, some preliminary results can be summarized as follows:

(1) When comparing with the unaccented case, the most peculiar point of accented T3 is the expansion of pitch range and lowering of pitch level, a tendency accordant in different speakers' speech. For instance, as shown in the upper part of Figure 1, as a function of sentence focus, the F0 curve of the accented 简/jian/ obviously stands out of the two unaccented tokens of 以/yi/: its pitch range is larger than that of the unaccented 以/yi /; the pitch level is lowered and closer to that of the 以/yi/ near the end of the utterance. Apparently, it is a resultant of a more typical manifestation on its phonological target than those of the two tokens of 以/yi/s, with its L-point sharply driven down and obviously broken through the declination trend for the whole utterance. In addition, a more typical example can be found from the bottom of Fig.1, where the 好/hao/ is located at the beginning of the sentence, but its pitch level and the L-point of F0 is lowered obviously due to its accented status in certain context.

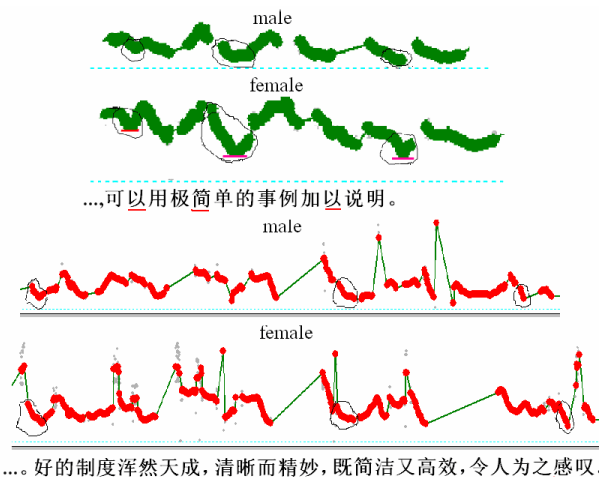


Fig.1: Examples of T3's F0 curve in Mandarin discourse

(2) At the same time, from the curves of F0 movement, like the examples shown in Fig. 1, an H-point raising does occur more or less at the onset of the T3 in most cases, no matter the token is accented or unaccented. However, it is obvious that, unlike its L-point lowering, such onset F0 raising is not an intrinsic feature in itself, but is induced from some external effect, because its onset target is underlying low (i.e., 2 of 214, according to the 5 levels of tone marker system of Chinese). In terms of Yi Xu's TA model [13], this effect is carried out from the offset F0 of its preceding tone due to co-articulation effect. In the fact, the specific height of onset F0 does depend on the offset F0 of the preceding tone. This fact indicates that, such onset F0 raising is not related to pitch prominence.

(3) When compared with its well-known variation of pitch contour (i.e., 21 or 211), a relative typical contour (i.e., 214) appears occasionally in various cases, but is not limited in the pre-pause position as suggested in some studies. Moreover, it seems irrespective of its accented status, either accented or un-accented cases are involved, though it is more abrupt in focal condition. For instance, as can be seen from the upper part of Fig. 1, the contour shape of the two unaccented 以/yi/ is similar to that of the accented 简/jian/.

## 2.2 A constrictive investigation

### 2.2.1 Test Materials

T3 examined in this section occurs in two sets of clauses as follows.

Set1: (世间的<sup>1</sup>问题, 原来极复杂的), 可以用极简单的事例加以说明。

(Originally very complicated problem in the world), can be illuminated by using quite simple instance)

Set2: 现代经济学是这样表述的: 制度至关重要, 制度是人选择的, 是交易的结果。

It is described in such a way in modern economics: institution is most crucial, institution is chosen by people, and is the result of bargaining

The material in set1 is a clause within a sentence. There are totally four T3 syllables in the clause, namely, 可/ke/, 以/yi/ (hereafter yi-a), 简/jian/ and another 以/yi/ (hereafter yi-b), since the 可/ke/ has become a 2<sup>nd</sup> tone following the tone sandhi rule, thus, only three T3s (as marked with italics) to be examined. Perceptually, /jian/ is accented whereas /yi-a/ and

/yi-b/ are unaccented in this clause. Because the word 简单的 (*simple*), where /jian/ sits on, is in a narrow focus position, which is elicited from the background of 世间的问题, 原来极复杂的 (*Originally very complicated problem in the world*) and is semantically opposite to the word 复杂的 (*complicated*).

The material in set2 is a complex sentence consisting of 4 clauses, which includes totally 4 T3 syllables, i.e., 表/biao/, 紧/jin/, 选/xuan/ and 果/guo/. They are all located at a broad focal area in each clause respectively. Relatively speaking, their accent degree should be in order of /xuan/ > /jin/ > /biao/ > /guo/ according to their grammatical position in the clause. In the fact, this cline has been proved by perceived impression.

### 2.2.2 Methods

Pitch prominence in natural speech is relatively compared to those of non-prominent parts within certain prosodic domain. However, it must be influenced by other prosodic factors at the same time, such as phrasing and underlying declination due to physiological mechanism. In order to examine pitch manifestation of T3 at any position, and to try to eliminate the influence from pitch declination, we set a reference scale to normalize the measured F0 as the equivalent of perceived pitch measurements. The scale is defined as the following equation:

$$F0r = f0h.b - (f0h.b - f0h.e) / (syll.n - 1) * (ta.n - 1)$$

Here *F0r* represents the pitch value (Hz) of the reference scale corresponding to certain position of the tone in test, *f0h.b* is the pitch height (i.e., pitch level) of the beginning syllable and *f0h.e* is that of the ending syllable of certain clause, *syll.n* is the number of total syllables in the clause and *ta.n* is the order number of the tone in test. Both the direction and magnitude of pitch deviation for each test tone can be obtained by calculating the difference between measured value and reference value. If the calculated deviation is a minus value, it means the pitch of the test tone is lower than the reference scale. On the contrary, if the result is in a positive value, then it means the pitch of the test tone is higher than the reference scale.

The pitch data were measured as the raw F0 values in Hz at first, and then transformed into a log scale in semitone (St.), so that the acoustic parameters can be made as close as possible to the pitch perception.

### 2.2.3 Test results

The data obtained from test 1 are summarized in Fig.1 and Table 1. First, from Fig.1 we can see that the deviation on H-point (shown as the red column) of the accented /jian/ is not much higher than that of the unaccented /yi-a/, and even lower than that of the unaccented /yi-b/. On the other hand, however, its L-point (shown as the blue column) is significantly lower than that of /yi-a/ or /yi-b/. And such a regular phenomenon presents identically in all of the 4 speakers' utterances.

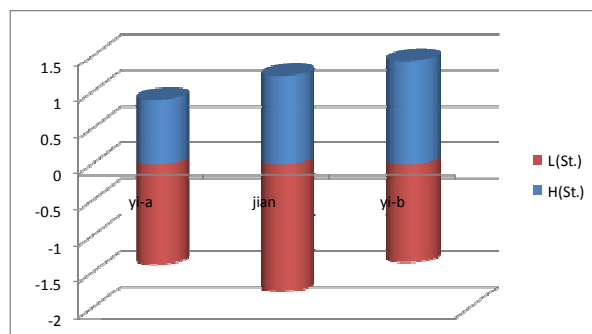


Figure 2: Illustration on the H- and L-point (St.) deviated to the reference scale in accented and unaccented T3

Secondly, according to the data listed in Table1, pitch level of T3 in the clause is driven down generally, and there exists obvious difference between the accented /jian/ and the unaccented /yi-a/ and /yi-b/, though the magnitude of deviation in the male speakers case is smaller than that of the female ones', and the data of male speakers are even higher than the reference scale in the unaccented /yi-a/ case. All these differences indicate that a sharply pitch lowering is the key point for the prominence of T3 in utterance.

Table 1: Pitch level (St.) deviated from reference scale in accented and unaccented T3

	f	m
<b>jian</b>	<b>-1.485</b>	<b>-1.148</b>
Yi-a	-1.203	1.014
Yi-b	-0.183	-0.187

The result from test 2 is summarized in Table 2, which gives an additional comparison among the T3s, with different accent degrees in the sentence. From the data listed in the table, we can see that, T3's L-point is all deviated downward from reference scale regardless of their accent degrees, but the magnitude regularly depends on their accent degrees. On the other hand, the H-point exhibits a rather irregular situation and has no clear relation to their accent degrees. It may be why some people consider T3 has no clear contribution to prosodic prominence [12, 14], since their attention were concentrated on the behavior of H-point, while ignoring that of L-point.

Table 2: H- and L-point value (st.) deviated from reference scale of T3 with different degree of accentuation

	biao	jin	xuan	guo
L-point	-1.572	-1.625	-1.807	-1.33
H-point	0.771	-1.118	0.64	-1.38

The results obtained in this section indicate that the impression gained from the preparatory test is valid.

### 2.3 Summary on pitch prominence pattern of T3

The data obtained here have confirmed our previous suggestion, that is, pitch level of T3 is drops, as opposed to the case of other tones, and it is mainly manifested by lowering the L-point of F0, rather than raising the H-point. Perhaps, it is another strategy to deliver focal information due to its low register feature.

These facts demonstrate clearly that, pitch prominence in T3 is also implemented by pitch regulation in itself, not

depending on the H-point raising of the neighboring tones, though its implementation manner is different from that of other tones.

### 3 Discussion

#### 3.1 Pitch prominence and language Typology

##### 3.1.1 Different strategy on pitch prominence

From the results obtained in this investigation, and referring to some related findings in other languages, the strategy on focus expression is not only related to the distinction between intonation language and tone language, but also related to the typological difference between tone languages, and even related to the register distinction among the tones in the same language.

In the case of the tone languages, pitch prominence is mainly implemented by raising pitch level and expanding pitch range, but reversed strategy has been found in several languages as mentioned at the beginning of this paper. It is likely determined by their typological distinction.

##### 3.1.2 Typology of tone language

Typologically, there are two basic types of tone system: contour tone and register tone (i.e., level tone, static tone, or stepping tone) [15]; however, they are not absolutely distinguished. According to Maddieson, I.[16], there is at least one level tone within the contour type system, and vice versa. Therefore, the unique ones usually become marked features if combined with phonological contrast in certain language, and the strategy difference on pitch prominence may be related to such marked features. Difference on prominence pattern of the L register tone existing between Mandarin and Cantonese can serve as the evidence.

#### 3.2 A Brief comparison between Mandarin and Cantonese

##### 3.2.1 Different manner on pitch prominence of the L tone

Mandarin and Cantonese are two well-known dialects of Chinese, both having L register tone in their tone systems. However, referring to focus expression, the behavior of F0 movement is different from each other. Apart from the sharp F0 lowering occurring in T3 of Mandarin, the L tone of Cantonese is also exhibit as F0 raising in focal condition [17]. To explore the working mechanism, a typological comparison between the two dialects was taken.

##### 3.2.2 Typological comparison between Mandarin and Cantonese

Typologically, the tone system of Mandarin belongs to the contour type, T3 is one of the level tones within the system, though it is phonologically represented as low-falling-rising (214) tone. Because T3 is phonetically realized as low-falling (21) or low-level (211 or 11) [18, 19, 20, 21], which is characterized as level tone with a distinctive feature of L register, it is obviously distinguished from the H register of T1, T2 and T4. Relatively speaking, for the tone system of Mandarin, contour distinction combined with H register is a

default feature, while level combined with L register is a marked one.

On the other hand, according to the Dictionary of Cantonese [18], among the 9 tone system of this dialect, 6 are level tones without pitch rising or falling, whereas the other 3 are just with slight pitch undulate. The 6 level tones were usually represented as 3 long tones of 55, 33, 22 and 3 short ones of 55, 33, 22 respectively. Thereby, the tone system of Cantonese seems to belong to the register type, and it is obvious that level and L register in Cantonese is a default feature, rather than a marked one as the case in Mandarin. Hence, the disaccord of prominence pattern between them is probably resulted from their typological distinction.

#### 3.3 Preliminary conclusion

##### 3.3.1 Pitch prominence and tonal typology

The primary results obtained so far show that, pitch manifestation of individual tones in real speech not only depends on their intrinsic distinction of contour feature, but is also determined by register distinction. The case of T3 in Mandarin Chinese is a good example. As the essence of underlying phonological target, the effect from its low register feature is not limited only to the manifestation of pitch range in focal condition, but also directly determines the direction and manner of pitch prominence in this case.

Accordingly, we would claim that the strategy on focus expression in a language is determined by various typological distinctions, including the types of intonation language vs. tone language, contour tone vs. register tone, as well as default feature vs. marked feature within the same language.

Moreover, from a brief comparison conducted between Mandarin and Cantonese, and referring to some related opinion claims concerning other languages, the direction and manner of pitch prominence for certain tone in natural speech are closely related to either of phonological features or typological characteristics.

##### 3.3.2 Pitch prominence and articulatory effort

Focal accentuation is often expressed by pitch prominence, which is usually regarded as a more articulatory effort and resulting in higher value of F0 manifestation. However, the data obtained so far indicate that greater effort does not necessarily result in a higher F0. Since pitch prominence is essentially a perceived impression based on a greater contrast to that of the unaccented constituents, both of F0 value raising or lowering are valid to form such a contrast. The peculiar prominent pattern of T3 in Mandarin is a good evidence, because its L register target shows a sharp contrastive F0 difference with neighboring constituents in a natural fashion, which is determined by phonological constraints of the language, no matter in accented or unaccented condition. The only difference between accented and unaccented case is that its F0 lowering, especially the L-point lowering will become much sharper, so as to make a stronger contrast in perception.

In conclusion, the specific direction (raising or lowering) of F0 movement for the focal expression in certain language is restricted by various factors, particularly by the phonological contrast and typological distinction. These confirm the view that there is no positive correlation between more effort and higher F0 manifestation [1].

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