A Study on Prosodic Distribution of Yes/No Questions with Focus in Mandarin

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Abstract Chinese intonation is reflected by adjusting the types of pitch, duration and intensity variants of a series of syllables. The purpose of present study is to compare the difference between yes/no questions with or without particle. The method of experimental phonetics was applied to investigate the performance of pitch, duration and intensity of questions. The results showed that since the particle ("吗") played the main role in conveying the question information, it is not necessary for the particle to enhance its prosodic elements at the same time, while the question without particle had to improve its pitch, duration and intensity of the final meaningful syllable to realize the interrogative effect.

Key Words Yes/No Question, Particle, Focus, Prosodic Elements

1. Introduction

Chinese is a tonal language, and tone is closely related to intonation. The tone of Chinese is the type of pitch variation of syllables, while the intonation of Chinese is reflected by adjusting the types of pitch variants of a series of syllables. Chao Yuenren is the earliest scholar who made a systematic analysis of Chinese intonation. Chao (1932, 1933, 1956, 1968) repeatedly stated that the actual pitch in Chinese speech is the algebraic sum of tone and intonation. Chao (1933) also pointed out that the difference between Chinese tone and intonation, and vividly explained the relationship between tone and intonation by using two classical metaphors, i.e., "rubber band effect" and "wavelet plus wave", showing that Chinese intonation is reflected in the tonal changes at the intonation level.

The intonations of different types of sentences are different. The difference between question and statement intonation has attracted much attention in Chinese intonation study. Among these studies, many researchers have pointed out the characteristics of question intonation. De Francis (1963) claimed that the whole pitch level of the interrogative is higher than that of the declarative. Disagreeing with De Francis, Tsao (1967) argued that the whole pitch level has no difference between the two types of intonation and interrogative intonation in Chinese is 'a matter of stress'. Shen J. (1985, 1994) proposed that the top line and the base line of a pitch contour are independent in the prosodic system of Chinese. The top line of interrogative intonation falls gradually whereas the base line undulates slightly and ends at a much higher point (compared to declarative intonation). Shen X. (1989) pointed that compared to statements, interrogative intonation begins at a higher register, although it may end with either a high key (in unmarked questions and particle questions) or low key (in A-not-A questions, alternative questions, and wh-questions). That has also been supported by Ni and Kawai (2004), who used the same sentence materials in distinguishing interrogative intonation with assertive intonation. In Pan-Mandarin ToBI (2005), interrogative intonation is mainly associated with a high boundary tone in the intonational tone tier. Kochanski & Shih (2003) studied the difference between question and statement intonation in Chinese with Stem-ML, found that the 'diverse' difference between interrogative and declarative intonation in Mandarin Chinese can be accounted for by two consistent mechanisms: an overall higher phrase curve for the interrogative intonation, and higher strength values of sentence final tones for the interrogative intonation. And there were studies regarding to the temporal scope of the rise/fall contrast in questions versus statements. Many experimental studies have concluded that the relevant acoustic difference only occurs at the end of the sentence (Chang ,1958; Fok-Chan, 1974; Vance, 1976; Lee, 2004; Lin, 2004). Likewise, in the autosegmental and metrical phonology of intonation (AM theory) (Ladd, 1996; Pierrehumbert, 1980), the statement/question contrast is said to be linked only to boundary tones. A boundary tone, transcribed as H% or L% for a high- or low-pitched tone, is defined as a phonological tone located only at the right

edge (i.e., the end) of an intonational phrase, although it may take the entire intonational phrase as its association domain.

As observed by Cooper et al. (1985), Xu & Kim (1996) and Xu (1999), when not given any specific context or instructions, speakers in a recording session often spontaneously emphasize a particular part of a sentence in an unpredictable manner, which means that the occurrence of focus cannot be easily prevented, and thus its effect, if any, cannot be easily avoided. Hence, it is possible that at least some of the discrepancies in the reported question intonation are due to uncontrolled spontaneous focus. In Shen's (1990) study, for example, focus can be anywhere in unmarked and particle questions, but in A-not-A questions, focus is likely to occur on the positive component, in disjunctive questions, on the alternative components, and in wh-questions, on the wh-words, especially when used as nouns (Ishihara, 2002; Li & Thompson, 1979; Tsao, 1967). Consequently, the phenomena she observed are likely to be the combined effects of interrogative meaning and focus.

From above, we can see that the previous studies have basically get the characteristics of question intonation by comparing with statements, especially in the aspect of pitch. However, according to Crystal (1972), intonation is not a single pitch contour or pitch system, but a complex that closely connects the sound level with other prosodic elements, such as stress, rhythm, and speed. Shi (2017) denoted that intonation is an orderly change in the speech flow of people's speeches, which is characterized by the degree of pitch fluctuations in the domain level and range, the duration and the intensity. Shi put forward the Intonation Pattern, that is, the expression pattern of the interaction of pitch, duration and sound intensity in sentences. In terms of pitch, it is the positional relationship of the range and height of the word's domain represented by the fluctuation format of the sentence tonal curve (represented by the sentence domain map and undulating scale map). In the aspects of duration, it is the distribution pattern formed by the dynamic change of the relative length in time of each pronunciation in the sentence (shown by the diagram of pause-extension). As for the intensity, it is the distribution pattern formed by the dynamic change of the relative intensity of each word in the sentence (with the figure of intensity ratio). (Shi, 2017)

The present study was therefore designed to address three issues regarding question intonation in Mandarin. (1) What are the characteristics of the duration and intensity of the question intonation besides the pitch? (2) Since there are different types of questions, we want to get a better understanding of some certain type of interrogative sentence. And yes/no questions with or without particle "吗"（ma）will be investigated this time, aiming to explore the effect of particle "吗" (ma) on the interrogative intonation. (3) The occurrence of focus cannot be prevented, and researchers have investigated the focus in some questions. How about the focus performs in yes/no questions? It is important for us to know about that more specifically. From these aspects, an acoustic experiment was conducted to answer these questions.

2. Methods

2.1 Materials

The two groups of interrogative sentences used for the experiment were selected from Shen's (1982) study. Each group includes 4 sentences (each consists of 6 syllables, all having identical tones: high, rising, falling-rising or falling, corresponding to tone 1, 2, 3 or 4), as shown in table 1. The sentences were to be produced with focus at the initial position. The only difference between the two group of sentences is whether there is a particle "吗"(ma) at the end of sentences, that is, the yes/no questions with particle "吗" (ma) (named "QP"), and the yes/no questions without particle "吗" (ma) (named "N-QP"). The bold characters indicated the position of focus. Each sentence was to be repeated 2 times by each subject. Therefore, a total of 128 sentences (8 sentences × 2 repetitions × 8 subjects) were investigated.

Table 1. The experimental materials

Yes/no Questions with	Tone1	该**孙英**开飞机吗？ [kai55 sun55 iŋ55 kʰai55 fei55 tɕi55 mA?] (Should Sun Ying fly the plane?)
	Tone2	由**国华**来完成吗？[iou35 kuo35 huA35 lai35 uan35 tʂʰəŋ35 mA?] (Is it done by Guohua?)

particle” 吗” (QP)	Tone3	请**小宝**逮老鼠吗？[tɕʰiŋ214 ɕiau214 pao214 tai214 lau214 ʃu214 mA?] (Will Xiaobao catch the mouse?)
	Tone4	让**树庆**去种菜吗？[rɑŋ51 ʃu51 tɕʰiŋ51 qɕʰy51 tʂòŋ51 tsʰai51 mA?] (Will Shuqing go to plant vegetables?)
Yes/no Questions without particle “吗” (N-QP)	Tone1	该**孙英**开飞机？ [kai55 sun55 iŋ55 kʰai55 fei55 tɕi55 ?] (Should Sun Ying fly the plane?)
	Tone2	由**国华**来完成？[iou35 kuo35 huA35 lai35 uan35 tʂʰəŋ35 ?] (Is it done by Guohua?)
	Tone3	请**小宝**逮老鼠？[tɕʰiŋ214 ɕiau214 pao214 tai214 lau214 ʃu214 ?] (Will Xiaobao catch the mouse?)
	Tone4	让**树庆**去种菜？[rɑŋ51 ʃu51 tɕʰiŋ51 qɕʰy51 tʂòŋ51 tsʰai51 ? (Will Shuqing go to plant vegetables?)

2.2 Subjects

Eight native speakers of Mandarin, 4 males and 4 females, served as subjects. They were all born and living in Beijing where Mandarin is the vernacular. They had no self-reported speech and hearing disorders. The average age was 23 then.

2.3 Recording

Recording was done in a sound-treated laboratory at BLCU. Praat program controlled the flow of the recording. The subject was seated comfortably in front of a computer screen. The microphone was about 2 inches away from the left side of the subject’s lips. The target sentences were displayed on a computer screen, one at a time, in random order. Subjects were instructed to read each sentence fluently and naturally. The utterances were directly digitized onto a hard disk at 22.05 kHz sampling rate and 16-bit amplitude resolution.

2.4 Measurements

Using the Praat program (www.praat.org), the waveform and spectrogram of each sentence and a label window were displayed automatically on a computer monitor. Two custom-written scripts were used for the original data, one for the pitch (F0), another one for the duration (ms) and intensity (amplitude product, which is proportional to the intensity and duration of the selected segments). Then the raw data will be converted into corresponding undulating scale, pause-extension and intensity ration. The data after converted are all expressed as a percentage, representing the relative proportional relationship of pitch, duration and intensity respectively. All the calculation methods can be referred to studies of Shi et al. (2009, 2010) and Liang & Shi (2010).

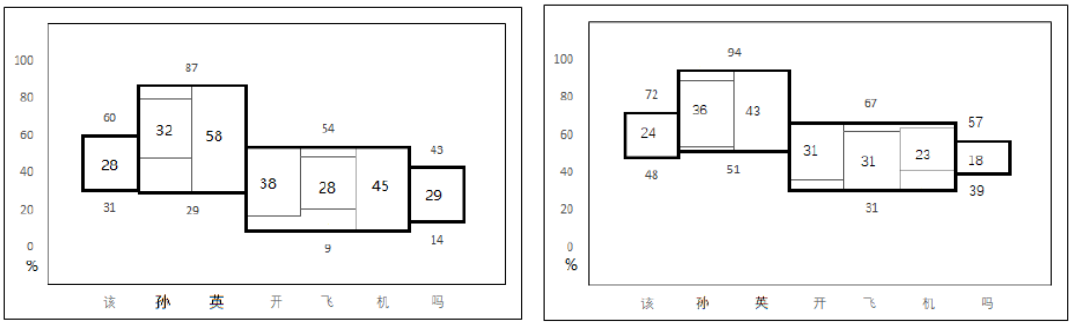
3. Results

3.1 Analyses and results of pitch pattern

The characteristics of the pitch were displayed by the undulation scale of the intonation visually. All the subjects were divided into two groups according to gender, and the semitone values were obtained, with the reference frequency at 55 Hz for the male and 64 Hz for the female. Since there were a total of six sets of sentences in Shen’s (1982) study, all the semitone values of the six groups of sentences were integrated for normalization, and then the maximum and minimum semitone values were selected as the two poles of the domain (i.e.,100% and 0%) for the male and female respectively. And then we can get the domain of the six groups of sentences and make comparative analysis through the undulating graph.

3.1.1 Pitch pattern of yes/no questions with particle (QP)

Figure 1 was based on the average percentage for the four yes/no questions with particle “吗” (ma). The figure includes 7 small frames made up of thin lines and 4 larger boxes made up of thick lines. The number in the small frame represents the range of the domain of that syllable, while the numbers above and under the larger box represent the top line and the base line of the word domain. The vertical axis represents the range of speakers’ intonation while the horizontal axis showing the syllables of the experimental sentences. 0% indicates the minimal limit of the range, with 100% indicating the maximal limit. In order to compare conveniently, we chose the sentence in Tone 1 as the representative sentence under the graph.



a 男 (gāi sūn yīng kāi fēi jī ma ? “Should Sunying fly a plane?”)

b 女 (gāi sūn yīng kāi fēi jī ma ? “Should Sunying fly a plane?”)

Figure 1. The Undulating Scale of QP in Mandarin (in Percentage)

Table2. The Bipolar Semitone Values of the Sentence Domain with particle (in Semitone)

The Bipolar Semitone Values （in Semitone）	Male	Female
The Top Limit	23.23	30
The Base Limit	9.91	16.79

As shown in Figure 1, the pitch domains of the final syllables of focus were the biggest among all the syllables, with the male 58%, female 43%. And the top lines of the focus final syllables were also the highest (male 87%, female 94%), showing an obvious trend of rising. The initial syllable of the focus did not present that obvious characteristics in terms of the range of domain and the top line. The domain of the pre-focus at the initial position of the sentence was almost minimal, while the male’s was the smallest, and the female’s was second to the smallest (only 6% difference). And the disparities were over 20% between the top lines of the pre-focus domain and the focus (male 27%, female 22%). However, the gap between the base line of the two domains was not obvious (male 2%, female 3%). With regard to the post-focus, we can see that, the three-syllable domain was compressed compared to the focus, with the top line (nearly 30%) and base line (nearly 20%) both declining significantly. Compared to the initial and final syllables in the post-focus, the range of the middle syllable domain was narrower (except the female) and the top line of that was lower, which indicated the weakness of the middle syllable. Then the final particle “吗” almost has the smallest range of domain and the lowest top line.

To investigate the Undulating Scale, we made a quantified description of the pitch difference of the top line and base line from the initial phrase to the final phrase. Specifically, we subtracted the pitch value of the top line of one phrase from that of the following phrase to obtain the difference between top lines of the two phrases, showing the pitch fluctuation of the top lines. The same is true with the base line. A positive value of the deviation indicates a drop of pitch, while a negative value indicates a rise in contrast. From Figure 1, comparing the focus and the pre-focus, the difference between the top lines of the two phrases in male sentence was -27% while that of the base line was 2%, and those in the female sentence was -22% and -3% respectively. There was a sharp rise between the pre-focus and the focus, especially at the level of top line. Then deviations of the top line and base line between the focus and post-focus in the male was 33%

and 20%, while those of the female were 27% and 20%. The huge drop was presented in both of the top line and base line, with the top line showing a more obviously falling feature. Compared with the post-focus, the final particle's top line fell by 11% and the baseline rose by -5% in the male, and 10% and -8% in female. The pitch decrease of top line and increase of base line indicated the range suppression of the final particle. Overall, there was a significant declination of pitch from the focus to the end, and the downward trend from focus to post-focus was the most remarkable.

In the terms of the sentence domain, it can be seen from Figure 1 that the top line of the focus (male 87%, female 94%) was the top limit of the sentence and the base line of the post-focus (male 9%, female 31%) was the base limit of the sentence. The range of the sentence domain was 78% for male and 63% for the female. The data illustrated that the relative position of yes/no questions with particle "吗" (ma) was extended from the bottom to the top of the male's domain, while that of the female was much higher and narrower than the male.

3.1.2 Pitch pattern of yes/no questions without particle (N-QP)

The yes/no questions without particle is actually expressed by the interrogative intonation. Similarly, when analyzing the pitch distribution pattern of the yes/no questions without particle, we also got a graph of the undulating scale (Figure 2).

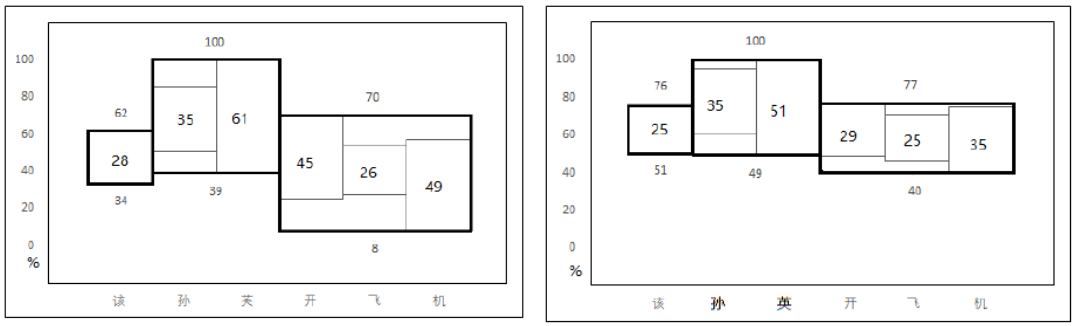


Figure 2. The Undulating Scale of N-QP in Mandarin (in Percentage)

Table 3. The Bipolar Semitone Values of the Sentence Domain without particle (in Semitone)

The Bipolar Semitone Values （in Semitone）	Male	Female
The Top Limit	25.5	31.24
The Base Limit	9.74	18.62

Same as the former type of sentence, the biggest domain range was located at the final syllable focused, with the male 61% and the female 51%. And the top lines of that in both groups reached to 100%, while the initial syllable of the focus did not show the biggest range and the highest top line yet. The range of the pre-focus domain was compressed significantly, with the top line much lower than the focus, whose difference was 38% for male and 24% for female respectively, though that of the base lines between the two domains was very slight. Then comparing the post-focus with the focus, we found that the domain of the post-focus was much lower than the focus (top line – 30% for male, 23% for female). The range of the post-focus domain in the female set was much smaller than that of the focus, which indicated its suppression of post-focus domain, while in the male group the range of post-focus was flat with that of focus. The range of the post-focus middle syllable was much smaller than the initial and final syllables in the post-focus, showing the weakening of the middle syllable in a phrase. And the final syllable of the post-focus, namely the end of the sentence, presents an expansion of its range just before the boundary of the sentence.

Based on the quantified description of the Undulating Scale, the difference between the top line and base line of the pre-focus and focus for male was -38% and -5% respectively, while that in the female group was -24% and 2%. This demonstrated that the pre-focus top line rose sharply to the focus, with the base line fluctuated slightly. Then compared

with the focus, the top line and base line of the post-focus was 30% and 31% for male, 23% and 9% for female. The great decrease from focus to post-focus indicated the emphasis effect on focus. In general, the declination of pitch from focus to the end was very significant, especially the top line.

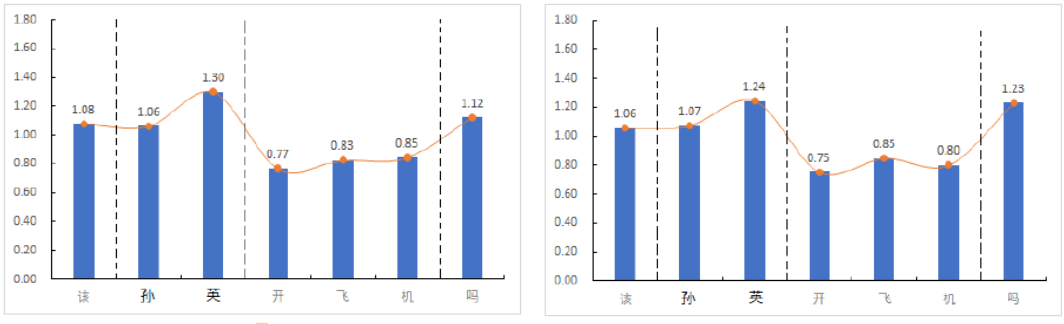
In terms of the sentence domain, it was clearly visible that the top line of the focus (100% for both groups) was the top limit of the sentence and the base limit was located at the final syllable of the post-focus, i.e., the end of the sentence, 8% for male and 40% for female. And the range of the sentence domain was 92% for male and 60% for female, the domain of the female much narrower than the male. The data of the sentence domain helped to show that the relative position of yes/no questions without particle was distributed from the lower part to the top in the speakers' total domain, with a wider distribution in male group and a much higher domain in female.

3.2 Analyses and results of duration pattern

Duration delay is the pause and extension of speech in continuous discourse. The pause on the speech graph usually corresponds to the silent segment, and the extension corresponds to the lengthening of the duration. Generally, the delay at the boundary has great change. Lehiste (1970) first noticed the extension before the boundary in continuous speech. Cao (1998) analyzed the phonetic rhythm of Mandarin, and found that the pause and extension before boundaries were two means of expressing duration. And the ways of applying rhythm boundaries at different levels were different. The boundary of the rhythm group, equivalent to the entire paragraph and sentence, was always marked by a pause, and there was generally no obvious extension of the boundary. And the boundary of the phrase segment group was always marked by an obvious pre-boundary extension and a relatively short pause. Yang (1997), Qian et al. (2001), Xiong (2003), Wang et al. (2004) investigated the acoustic characteristics of different prosodic units. The results on duration showed that there widely existed the lengthening of syllable at the end of the prosodic boundary. And the pause marked a higher level of the rhythm boundary compared to the extension. Shi et al. (2010) studied the parameters of duration with the Pause-extension. The Pause-extension reflects the characteristics of duration of intonation and can describe the speaker's acoustic performance on the intonational duration. It indicates that the segment is delayed when the value of Pause-extension is greater than 1.

3.2.1 Duration pattern of yes/no questions without particle (N-QP)

We got the average value of pause-extension in both gender groups by calculating the pause-extension value of all the subjects in yes/no questions with particle "吗" (ma) (see Figure 3).



(gāi sūn yīng kāi fēi jī ma ? "Should Sunying fly a plane?") (gāi sūn yīng kāi fēi jī ma ? "Should Sunying fly a plane?")

Figure 3. The Pause-extension of QP in Mandarin (in millisecond)

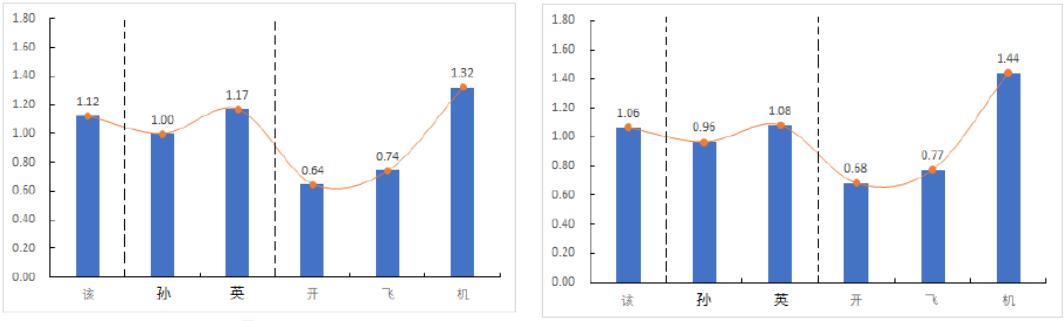
Table 4. The Average Syllable Duration of the Sentence with particle (in millisecond)

	The Average Syllable Duration (in millisecond)
Male	239.17
Female	235.17

From the above data, we got the following results. Except the post-focus phrase, the pause-extension values of other syllables were all greater than 1, showing the lengthening of their duration. The longest duration was located at the final syllable focused, and the second to that was at the end of the sentence, where was the particle "吗" (ma), with 18% difference in male and only 1% in female compared to the longest duration. Then the durations of the focus initial syllable and the pre-focus syllable were very close to each other, on the verge of 1, in the third place. As for the durations of the three syllables in the post-focus phrase, they were approximately 20% shorter than the average syllable duration. From a holistic point of view, the duration of the pre-focus and focus were extended and presented a rising trend, then the duration was shortened significantly when it comes to the post-focus, and a suddenly reversal lengthening after that at the end of the sentence.

3.2.2 Duration pattern of yes/no questions without particle (N-QP)

The pause-extension values of the questions without particle were averaged, and the average duration of the sentences for different gender was obtained, as shown in the following figure.



a 男 (gāi sūn yīng kāi fēi jī ? "Should Sunying fly a plane?")

b 女 (gāi sūn yīng kāi fēi jī ? "Should Sunying fly a plane?")

Figure 4. The Pause-extension of N-QP in Mandarin (in millisecond)

Table 5. The Average Syllable Duration of the Sentence without particle (in millisecond)

	The Average Syllable Duration (in millisecond)
Male	256.568
Female	250.865

As shown in Figure 4, except the initial and middle syllable in the post-focus phrase, other syllables' duration was much longer or close to the average duration. In this type of yes/no questions, the final syllable of the post-focus, namely the end of the sentence reached to the longest in duration, which was much longer than the final syllable of focus, with 15% difference for male and 36% for female. The duration of the final syllable in focus was close to that of the pre-focus, only 5% and 2% than the pre-focus in male and female respectively. As for the initial syllable of focus, its duration was the average syllable duration in the male group while only 4% shorter than the average duration in the female. Then in the post-focus phrase, the first two syllables, following the focus immediately, were greatly shortened. And the duration of the syllables in post-focus phrase showed a trend of gradual extending (10% for male, 9% for female) first and then lengthening to a larger extent (58% for male, 67% for female). Overall, the duration of the sentence illustrated a trend of extending slightly at first, then shortening, and finally extending significantly.

3.3 Analyses and results of intensity pattern

The intensity ratio is an important quantitative indicator of tonal analysis in terms of intensity. The speech intensity is easily affected by many factors, such as the strength of the speaker's voice, the distance from the lips to the microphone when it is pronounced, and the settings of the recording device. The measurement of the intensity ratio can eliminate such

accidental factors via the ratio between the amplitudes of syllables, making them normalization and comparable. The measurement index of the intensity ratio is obtained by calculating the amplitude product, which is the sum of the amplitudes of the sampling points on the selected segment. Its size is proportional to the amplitude and duration of the selected segment, which is equivalent to the energy used in the pronunciation. The intensity ratio can be calculated through the way that the amplitude product of one syllable is divided by the average amplitude product of all the syllables in the sentence. If the intensity ratio is greater than 1, it indicates an increase in intensity. (Tian, 2010; Liang & Shi, 2010)

3.3.1 Intensity pattern of yes/no questions with particle (QP)

Through the average calculation, the intensity ratios of both gender groups can be obtained, as shown in Figure 5.

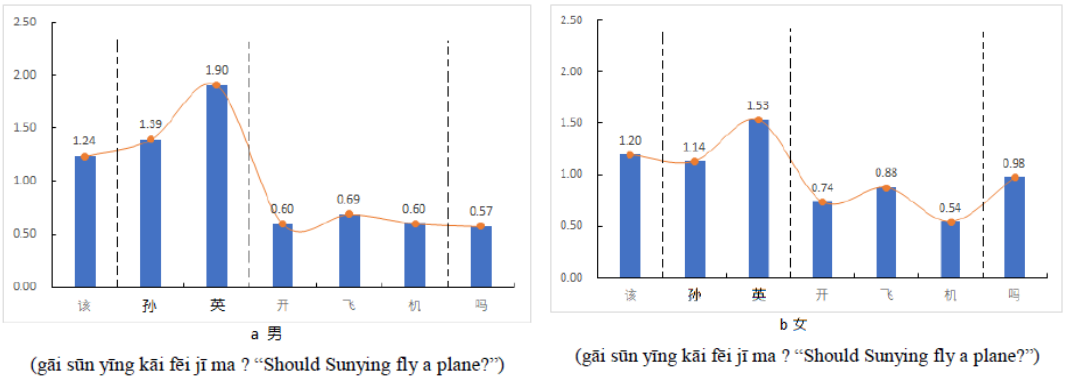


Figure 5. The Intensity Ratio of QP in Mandarin

Table 6. The Average Amplitude Product of the Sentence with particle

	The Average Amplitude Product
Male	115.628
Female	114.435

As can be seen from the figure, the boundary between the focus and the post-focus can divide the intensity ratio of the yes/no questions with particle "吗" (ma) into two parts. In other words, the intensity ratio before the focus boundary was significantly larger than 1, while that after the focus boundary less than 1, and this feature was especially prominent in the male group. Among all the syllables in the question, the final syllable of focus had the greatest intensity ratio, illustrating the maximized enhancement of its intensity. The intensity ratio showed a rising trend from the pre-focus to the focus final syllable in male group, while that decreasing slightly at first and increasing sharply then in the female group. Regarding the post-focus, the intensity ratio of the three syllables was much close to each other with the middle one a little larger in the male group, and there was small difference in that of the female group has small difference, with the intensity of post-focus final syllable reaching to the lowest in the sentence. The intensity ratio of particle "吗" (ma) in the male group was almost half of the average, close to that of the post-focus. In the female group, the intensity ratio of the particle was close to 1, going to reach to the average. As a whole, similar to the declination feature of pitch, the intensity of this sentence type also presented decreasing feature from the focus to the end.

3.3.2 Intensity pattern of yes/no questions without particle (N-QP)

Figure 6 illustrated the intensity ration of yes/no questions with particle "吗" (ma) in the male and female group.

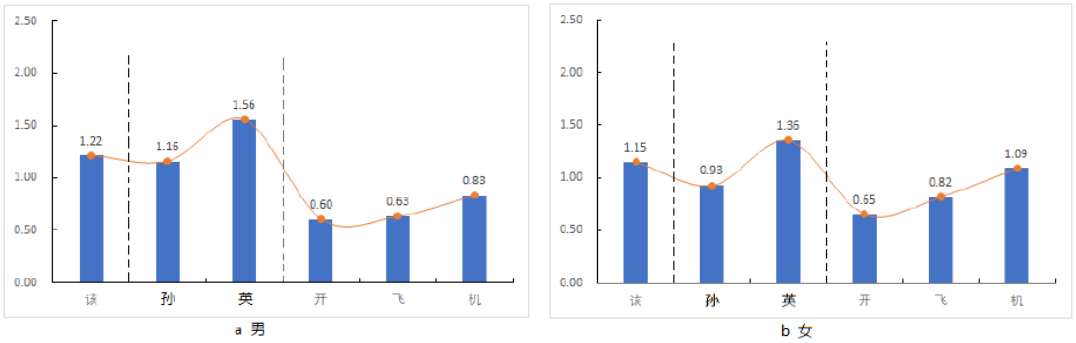


Figure 6. The Intensity Ratio of N-QP in Mandarin

Table 7. The Average Amplitude Product of the Sentence without particle

	The Average Amplitude Product
Male	119.724
Female	152.854

In the yes/no questions without particle, the intensity ratio of the focus and pre-focus was much larger than 1, except the initial syllable of the focus in female (93%, close to the average). The maximum intensity ratio was located at the position of final syllable in the focus, with 156% for the male and 136% for the female. They both showed the enhancement to the greatest extent. The pre-focus was second to that, and there was a big difference between the second one and the first one (34% in the male group, 21% in the female group). The intensity ratio of initial syllable focused was much less than the final syllable, while it was in the third place close to the pre-focus in male and even less than the final syllable of the sentence in the female. The intensity of the post-focus was weakened to some extent and the three syllables presented an increasing trend in intensity, which also showed that the rising amplitude of male was much smaller than that of female. Compare with the first syllable of the last phrase, the intensity of the final syllable in the question was enhanced to a certain extent, even greater than the average in the female set. The intensity illustrated a decreasing trend from the focus to the post-focus, meanwhile an increasing trend of intensity from the pre-focus to the focus and in the post-focus phrase can be detected.

4. Discussion and conclusions

This study investigated the two types of yes/no questions with focus through experiments on the suprasegmental features. From the experimental results, we have a general understanding of the characteristics of the two sentences. Comparing the two sentences from the perspective of pitch, we found that the top limit of the question without particle (N-QP) was much higher than that of the question with particle "吗" (QP), while the base limit of N-QP was much higher than that of QP in female and close to each other in male. The range of QP domain was wider in female, with the N-QP domain much wider in male. As for the domain of phrase, almost every phrase domain was greater in the questions without particle. And when it comes to the focus and post-focus in the two questions, the top lines of the two phrases was much higher in the question without particle, and more importantly, the difference between the focus and post-focus performed smaller in N-QP. Liu (1988) argued that the intonation pitch at the end of the yes/no questions with particle "吗" (ma) usually rises, and can also be flat or even falling, which means the question information is conveyed by the particle rather than the intonation. Meanwhile, the intonation pitch of the yes/no questions without particle must shows the previous feature, due to the question information expressed via the interrogative intonation, that is, the performance of the top lines of the focus and post-focus in questions without particle expresses the interrogative intonation.

Besides the pitch, one of our aim to observe the characteristics of duration and intensity in these questions has been

reached. In terms of the duration, the longest duration was located at the end of focus, while the particle was slightly prolonged in QP. However, similar phenomenon did not happen to the duration of the focus in N-QP, and the final meaningful syllable ("机") became the longest in order to meet the requirement of interrogative expression. The feature of intensity of the two questions' focus was consistent with that of duration, illustrating that the intensity of QP focus was enhanced much greater than the N-QP. The particle at the end of QP sentence shared its intensity with the focus, whereas the intensity of the final meaningful syllable in N-QP got much stronger.

In addition, when comparing the gender difference in each question, we found that the female had a much higher top limit and base limit no matter in percentage or absolute semitone while the male's sentence domain and phrase domain were much wider in percentage. As for the duration and intensity, the average duration and amplitude product of QP was much greater in the male group. And the N-QP sentence showed us that the pause-extension and intensity ratio of its pre-focus and focus was bigger in the male while that of the post-focus larger in the female. In general, the characteristics of each question were consistent in the gender group.

Wang & Shi (2010), Yan et al. (2015), pointed out that, compared with the statement, the pitch of the yes/no questions intonation in Mandarin is improved overall, and the domain of the end of the sentence is greatly expanded. The pitch of the end in yes/no questions expressed by interrogative intonation shows a rising trend and that in the questions with particle "吗" declines in the contrary. It is now well established that focus plays a critical role in determining the global pitch shape of a declarative sentence. In general, a single (non-final) focus is manifested as tri-zone pitch range adjustments: expanding the pitch range of the focused item, suppressing (lowering and narrowing) the pitch range of all post-focus items, and leaving the pitch range of pre-focus items the same as that in a sentence with no narrow focus (Botinis et al., 2000; Cooper et al., 1985; Selkirk and Shen, 1990; Shen, 1985; Thorsen, 1979; Xu, 1999; Xu & Xu, 2005; Liu & Xu, 2005). However, different from previous studies, the pre-focus pitch range was also compressed by focus, which has been shown in previous works on statements with focus (Huang, 2018; Qin, 2018). And this difference may be caused by the different experimental methods. Influenced by the focus in the questions, the pitch in both questions showed a declination trend. In addition, focus has also been found to be accompanied by an increase in duration of the focused words (Cooper et al., 1985; Xu, 1999). And this was verified in the present experiment. Besides the duration, the intensity of focus was realized by great enhancement to highlight its function.

In the two questions, the focus was emphasized through its domain range, the top line, as well as the pause-extension and intensity ratio, showing the synchronized performance of pitch, duration and intensity. Though the domain of pre-focus was compressed by the focus, its duration and intensity got a certain degree of extension and enhancement. The post-focus performed consistent weakening in the three prosodic elements. With regard to the final particle in QP, except its prolonged duration, the pitch and intensity has not been expanded. Meanwhile, compared to the former syllable, the final meaningful syllable in N-QP has got enhanced in the three prosodic elements to some extent, especially in duration.

In short, the three prosodic elements of each syllable are synchronized or not in the fluctuation of the intonation. In the yes/no questions with particle "吗" (ma), the particle "吗" played the main role of conveying the question information, which allowed the great declination of pitch and guaranteed to strengthen the focus. However, since no other things helping to express the question information, though also restrained by the focus, the final meaningful syllable in yes/no question without particle had to improve its top line and domain, and expand its duration and intensity to some degree in order to show the interrogative intonation. Furthermore, the difference in semantic and grammatical levels between the yes/no questions with particle "吗" (ma) and the questions expressed by interrogative intonation have corresponding quantitative expressions at the prosodic level, and that requires further research.

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