

BOUNDARY TONE OF CHINESE INTONATION AND ITS PITCH (F_0) PATTERN

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ABSTRACT*

The results of acoustical analysis and listening test of echo question in read speech and yes-no question in spontaneous speech indicated that for intonation phrase, information about question and statement is carried by an overwhelming majority of the last one or two syllable in the final prosodic word of the prosodic phrase, but there some exception in which it is carried by its first syllable. Therefore, the tune carrying the information about question and statement is known as boundary tone. Boundary tone in Chinese is represented by the register of the starting-point of its F_0 curve and/or the slope of its F_0 curve (or the register of its starting-point and/or its ending-point). It is confirmed by synthesis that the boundary tone is indispensable to differentiate between question and statement. Identification test was adopted to verify the results above, and to find out that the slope of its F_0 curve plays a more important role than the register in differentiating between question and statement and the identification function about question and statement is not categorical, but continuous: strong question → weak question → either question or statement → non-terminal intonation → statement.

It was found that feature of boundary tone to differentiate between question and statement in Chinese is “high” and “low”. Pitch (F_0) pattern of boundary tone in Standard Chinese was given. It was single-directionally and nonlinearly that intonation acts upon on tones.

1 INTRODUCTION

“Movement of pitch in Chinese speech also expresses attitudes, moods and implication, etc., and this part corresponds in part to intonation in English.” (Zhao, 1932) Some scholars proposed that the difference between

question without “吗” (ma5 in Chinese pinyin) and statement in Chinese is related to pitch range, F_0 contour or 3 tunes of the utterance (Wu, 1980, 1990; Garding, 1985, 1987; Shen J. 1985, 1994; Shen X-N., 1989), but some scholars held there is a terminal intonation in Chinese (Chang, 1958; Hu, 1987; Jing, 1992).

As the role of boundary tone, Yuan, Shih and Kochanki (2002) had argued that “they do not need the different boundary tone to account for the difference between interrogative and declarative intonation in Chinese.

This paper was divided into 8 parts. Following part 1 “introduction”, two factors in Chinese intonation: stress and boundary tone, was proposed in part 2. In part 3, the results of acoustical analysis were introduced. In part 4, it is was confirmed by synthesis that boundary tone is indispensable to differentiate between question and statement. In part 5, identification test was adopted to verify the results of acoustical analysis and listening test, and to determine which is more important of the register or slope of the F_0 curve in boundary tone. In parts 6 and 7, it was advocated that the way that intonation acts upon tone is single-directionally and nonlinearly, and the pitch (F_0) pattern of boundary was given. Conclusion and next work were in the last part.

2 STRESS AND BOUNDARY TONE IN CHINESE INTONATION

It was advocate (Lin, 2001) that there are two variables in Chinese intonation especially in function intonation: stress and boundary tone. Boundary tone conveys the information of mood in utterance including the declarative mood, the interrogative mood, the imperative mood, or the exclamatory mood. Stress conveys the information of focus that is represented by prominence in a utterance indicating which part in linguistic content is more important than others.

2.1 Stress is hierarchical: stress in prosodic word (hereafter PW), stress in prosodic phrase (PH) and stress in utterance. PW is a F_0 variation group and one or two syllables in it are more prominent than others. The syllable

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(s) with more prominence is (are) referred to as stress in PW. Stress in PH refers to the syllable (s) that is (are) most prominence in PWs. Stress in utterance refers to the syllable (s) that is most prominence in PHs. In the stress of PW, the register and/or range of its F_0 curve is higher and/or wider than them that follow and/or precede it. When F_0 curve in some syllable of a utterance approximates more to the F_0 contour of syllable in citation form, the syllable perceives normal stress; When the register and/or the range of F_0 curve in some syllable of a utterance is higher and/or wider than the F_0 contour of syllable in citation form, the syllable perceives emphatic stress. (Lin, 2001) It was found by Xu (2001,2002) that there are three distinct focus-related pitch ranges: expanded in non-final focused words, suppressed (lowered and compressed) in post-focus words, and neutral in all other words.

2.2 As for boundary tone in Chinese, it will be studied in the following related parts using different experimental methods and different speech materials (read speech and spontaneous speech).

3 ACOUSTICAL ANALYSIS OF BOUNDARY TONE

3.1 Echo question in read speech

3.1.1 Question information and boundary tone

3.1.1.1 Speech data

Boundary tone was found by using the following dialogue which was put in a context:

A:某先生要去 XX (城市)。(Mr. X will go to XX (city).)

B:某先生要去 XX (城市)? (Will Mr. X go to XX (city)?)

A:是的, 某先生要去 XX(城市)。(Yes, Mr. X will go to XX (city).)

The question asked by B is an echo question. In this dialogue, Mr. X contained one syllable and was replaced with Mr. Jin1, Mr. Hu2, Mr. Ma3 and Mr. wei4. Each name of the 15 cities has two syllables and one of 15 bisyllabic combinations of 4 tones in Standard Chinese. It was replaced with Xi1an1, Cheng2du1, Guang3zhou1, Zhan4jiang1; Bao1tou2, He2fei2, Shen3yang2, Da4tong2; Qing1dao3, Hai3kou3, Shang4hai3; and Shen1zhen4, Chong2qing4, Wu3han4, Da4qing4. Two speakers, C and S, played one part of A and B respectively so that both of them read the echo question and its answer (statement).

3.1.1.2 Speech sample

Speech sounds of “Mr. X”, “Mr. X will go to”, and “Mr. Will go to X (the first syllable of XX)” were sliced from the original sound with echo question using Praat 3.9. The sliced sounds, together with the original sound, were used as speech sample for listening test.

3.1.1.3 Listening test and its result

The sliced sounds, together with the original echo question produced by speakers C and S were repeated 3 times randomly. The randomized speech sample was judged by force as question or statement by 5 listeners. They also participated the following tests. The result of the listening test was given in table 1.

	Subject (Mr. X)	Predicate (will go to)	Object (some city)	
			First syllable	Second syllable
Speaker-C	21%		上午我开会。	
	8 %			
	25 %			
	99%			
Speaker-S	20%			
	11%			
	30 %			
	88.5%			

Table 1 mean percentage of each component of the utterances with echo question judged as interrogative mood by 5 listeners

It was seen in Table 1 that when the sliced sounds contained only the subject in the utterances with echo question, they were judged as question by about 20%; when the sliced sounds contained the subject and predicate, they were judged as question by about 10%; when the sliced sounds contained the subject, the predicate and the first

syllable of the object, they were judged as question by about 30%; only when the sliced sounds contained not only the subject, the predicate and the first syllable of the object, but also the last syllable of the object, the percentage judged as question was very high: by 99.2% for speaker C and 88.5% for speaker S. It was concluded that for the IP

with question, the question information is carried by an overwhelming majority of the last one or two syllables in the final Prosodic word (hereafter PW) of the IP, but there is some exception in which it is carried by the first syllable. Therefore, the tune carrying the question information is known as boundary tone.

3.1.2 Different interrogative mood for echo question in out of context

In order to study whether or not there was any difference between echo question in out of context and that in context, each of 30 (15×2) echo questions produced by speakers C and S was isolated from their context. Each of echo questions in out of context was repeated 8 times and then randomized. Each of the randomized speech samples was judged by force as question or statement by 10 listeners, among whom 5 listeners had participated the preceding test. They are young females and males who speak Standard Chinese fluently, have good hearing and listen carefully. In this listening test, each of the samples was judged 80 times. Listeners themselves decided how many times each sample was listened, but at least 3 times were asked for by the investigator. The result from this listening test was shown as follows: in out of context, for

speaker C, 14 echo questions were judged as interrogative mood by 100%, 1 echo question was judged as interrogative mood by 88%, and for speaker S, 7 echo questions were judged by 100%, 4 echo questions were judged respectively by 97%, 94%, 93% and 82%, 3 echo questions were judged respectively by 70%, 68% and 65%, 1 echo question was judged as interrogative mood by 59%.

For convenience of discussion, those that the interrogative mood was judged by 85-100% was defined as strong interrogative mood; those by 60-84% was weak interrogative mood; those by 0-10% was statement; those by 11-40% was non-terminal intonation; and those by 41-59% was “either statement or question”. Figure 2 showed the percentage of echo question in out of context judged as different mood by 10 listeners. In out of context, utterances with echo question produced by speaker C all were strong interrogative mood, but those by speaker S were 67% strong interrogative mood, 27% weak interrogative mood, 6% “either question or statement”. For echo question in out of context, its interrogative information has different degrees: some strong, some weak, some “either question or statement”.

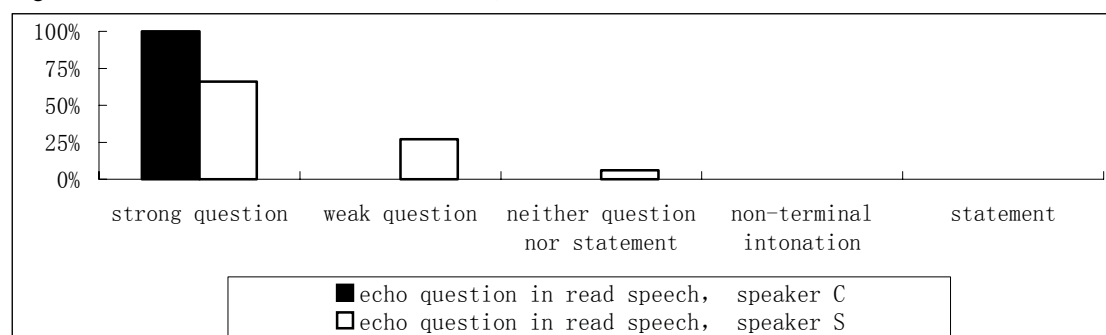


Figure 1 percentage of isolated echo question judged as different mood by 10 listeners

3.1.3. The acoustical manifestation of boundary tone in echo question

F_0 curve and the duration of “Mr. X will go to some city?” and “Mr. X will go to some city.” produced by speakers C and S were analyzed using Praat3.9. F_0 curve was checked and corrected based on narrow band spectrogram (with suitable parameters).

Two parameters, the register of the starting-point in F_0 curve and the slope of F_0 curve, were used to demonstrate the acoustical manifestation of boundary tone. The register and the slope of F_0 curve refer to those of the F_0 curve in tone-section (Lin, 1965, 1988). The distance between the register of the F_0 curve in boundary tone of IP with

question and that in the last syllable of IP with statement is presented by the difference between the values of register of them. The difference with positive number means that the register of the F_0 curve in boundary tone of IP with question is higher than that in the last syllable of IP with statement, and vice versa. More difference means more distance. The register of the starting-point in F_0 curve is expressed as semitone (music scale) calculated by logarithm of F_0 relative 64Hz with 2 as its base number. The slope of F_0 curve expresses the degree of rising or falling in F_0 curve. The register and the slope of F_0 curve in this study were only calculated on strong echo question (and yes-no question).

Table 2 showed the value of semitone about the register of the F_0 curve in boundary tone of IP with strong question is higher or lower than that of F_0 curve in the last syllable of IP with statement. It can be seen that the register

of the F_0 curve in boundary tone of IP with strong question was higher about 5.4 semitone for speakers C and 3.0 semitone for speakers S in average than that of F_0 curve in the last syllable of IP with statement.

	value of semitone about the register of the starting-point of F_0 curve in boundary tone of IP with strong echo question is higher or lower than that in the last syllable with statement (“+” high, “-” low)							
	Tone-1		Tone-2		Tone-3		tone-4	
	av.	dev.	av.	dev.	av.	dev.	av.	dev.
C	4. 6	1. 6	5. 7	1. 9	6. 8	1. 3	4. 1	0. 9
S	3. 2	0. 9	0. 8	0. 9	3. 3	1. 0	4. 6	0. 5

Table 2 value of semitone about the register of the F_0 curve in boundary tone of IP with strong question is higher or lower than that of F_0 curve in the last syllable of IP with statement

Table 3 showed the slope of the F_0 curve in boundary tone of IP with strong question and that of F_0 curve in the last syllable of IP with statement. The slope of 4 tones is calculated by tone-section. It's can be seen that the slope of tone-4 in boundary tone with strong question for speakers C and S is smaller than that in the last syllable with statement, namely, the F_0 curve of tone-4 in boundary tone with strong question is raised by a certain angle relative to that in the last syllable with statement; the slope of tone-1 and tone-2 in boundary tone with strong question for

speakers C and S is larger than that in the last syllable with statement, namely, the F_0 curve of tone-1 and tone-2 in boundary tone with strong question is raised by a certain angle relative to that in the last syllable with statement; the F_0 curve of tone-3 in boundary tone with strong question is falling-rising, but the F_0 curve of tone-3 in the last syllable with statement is only falling, namely, there appears a rising part in the F_0 curve of tone-3 in boundary tone with strong question comparing to that of tone-3 in the last syllable with statement.

the slope of the F_0 curve in boundary tone of IP with strong question and that of F_0 curve in the last syllable of IP with statement (Hz/sec.) ("+" rising, "-" falling)									
		Tone-1		Tone-2		Tone-3		Tone-4	
		av.	dev.	av.	dev.	av.	dev.	av.	dev.
C	ques.	89	126	130	135	(-399) + (+235)	(95) + (68)	-270	54
	Stat.	38	59	72	86	-263	63	-445	109
S	ques.	457	147	458	70	(-382) + (+525)	(78) + (24)	-377	364
	Stat.	-152	134	-95	256	-44	136	-477	192

Table 3 the slope of the F_0 curve in boundary tone of IP with strong question and that of F_0 curve in the last syllable of IP with statement

Because the F_0 curve of tone-1, tone-2 and tone-4 in boundary tone with strong echo question is raised by certain angle relative to that in the last syllable with statement, and there appears a rising part in the F_0 curve of tone-3 in boundary tone with strong echo question comparing to that of tone-3 in the last syllable with statement, we calculated the value of semitone of the register of the ending-point of F_0 curve in boundary tone with strong echo question relative that in the last syllable with statement. Table 4 showed the value of semitone of the register of the ending-point of F_0 curve in boundary tone

with strong echo question is higher or lower than that in the last syllable with statement. It can be seen in Table 4 that whether tone-1, tone-2, tone-3 or tone-4 for speakers C and S, values of semitone about register of the ending-point of F_0 curve in boundary tone with strong echo question are positive, which means that F_0 curve in boundary tone with strong echo question is rose relative to that in the last syllable with statement. In 4 tones, F_0 curve of tone-3 in boundary tone with strong echo question is rose with much more greater extent than that of tone-1, tone-2 and tone-4. This is because the later part in F_0 curve of tone-3 in

boundary tone with strong echo question is rising.

	value of semitone about the register of the ending-point of F_0 contour in boundary tone of IP with strong echo question is higher or lower than that in the last syllable with statement (“+” high, “-” low)							
	Tone-1		Tone-2		Tone-3		Tone-4	
	av.	dev.	av.	dev.	av.	dev.	av.	dev.
C	6.64	1.52	8.28	1.99	13.62	2.20	5.97	0.97
S	11.23	3.03	5.03	3.52	8.35	2.42	7.47	2.04

Table 4 value of semitone about the register of the ending-point of F_0 contour in boundary tone of IP with strong echo question is higher or lower than that in the last syllable with statement

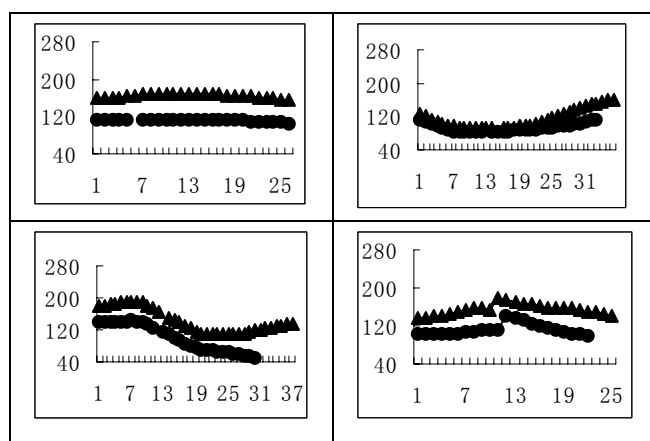


Figure 2 F_0 curves of the last two syllables “xi’1 an1”, “shen3yang2”, “qing1dao3” and “chong2 qing4” in echo question “某先生要去某城市?” and its answer “去某城市。” for speaker C

Figure 2 showed the F_0 curves of the last two syllables in echo question “某先生要去某城市?” and its answer “去某城市。” for speaker C. There were four charts in Figure 2: the upper-left was the F_0 curves of xi’1 an1; the upper-right was that of shen3yang2; the lower-left was that of qing1dao3; the lower-right was that of chong2qing4. In each chart of Figure 2, the line with solid circle indicated the statement, the line with triangle indicated the question. It can be seen in Figure 2 that the register of the starting point and ending point of the F_0 curves (or its slope) in the last syllable takes the role in differentiating between question and statement.

It was concluded from the acoustical analysis of echo question that boundary tone of echo question in Chinese is presented by the register of the starting-point and/or the slope of its F_0 curve (or its starting-point and/or its ending-point).

3.2 Yes-no question in spontaneous speech

3.2.1 Speech material and listening test

Speech material used to study yes-no question comes from a speech data bank of telephone-dialogue in which

there is more than an hour dialogue (Yuan, 1999). In the speech data bank, there are only 133 IPs with yes-no question in which the F_0 curve in each IP is correctly displayed or can be checked by following its narrow band spectrum. 133 IPs with yes-no question were sliced by Praat 39. The 133 IPs with yes-no question plus 10 IPs with statement to get a group of 144 IPs used in a listening text. Each of 144 IPs was repeated two times and randomized to get a group-1 of listening sample. Each of 144 IPs was repeated two times and randomized once again to get a group-2 of listening sample. According to the same procedure, a group-3 and group-4 of listening sample were got. The 4 groups of listening sample were stored in computer. The randomized speech sample was judged by force as question or statement by 5 listeners. They had participated the preceding tests. In this listening text, each of 144 IPs was judged 40 times. In order to avoid incorrect judgment caused by tiredness, the 4 groups of listening sample were arranged in 4 working section (2 in the morning and 2 in the afternoon). Listeners themselves decided how many times each sample were listened, but at least 3 times were asked by the investigator.

3.2.2 Different mood of yes-no question in out of context.

The result of the listening test about different mood of yes-no question in out of context was given in Figure 3. It can be seen in Figure 3 that in 133 IPs in context were judged as question, but in out of context, 39% was judged again as question (19% of strong question and weak question), 17%, 33% and 11% were judged respectively as statement, non-terminal intonation and “either question or statement”. For yes-no question in out of context, its interrogative information has different degree: strong question→weak question→“either question or statement” → non-terminal intonation → statement. This paper only used the IPs with strong question and statement to analysis

their acoustical manifestation, but didn't discuss the IPs with weak question and non-terminal intonation.

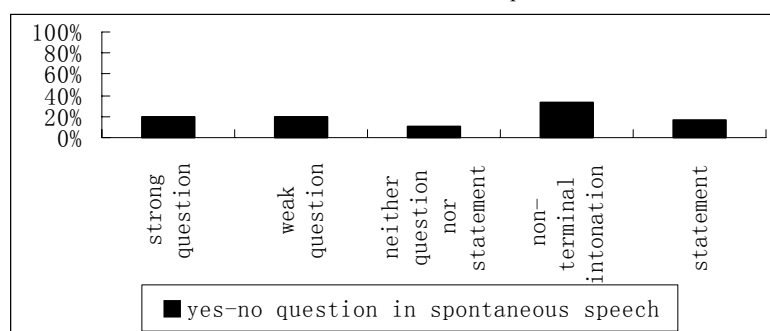


Figure 3 the percentage of 144 IPs with yes-no question in out of context judged as different mood by 10 listeners

3.2.3 Acoustical manifestation of boundary tone in yes-no question

For yes-no question, only the slope of F_0 curves was discussed. Table 4 given the slope of F_0 curves in boundary tone with strong question when they were in out context and in the last syllable of the IP with statement. It can be seen that in yes-no question of spontaneous speech as in

echo question of read speech, the F_0 curve of tone 1, tone 2 and tone 4 in boundary tone with strong question is raised by certain angle relative to that in the last syllable with statement. In yes-no question, there isn't data about tone-3 with strong question.

	the slope of F_0 curve in boundary tone with strong question when they were in out context and the last syllable of the IP with statement. (Hz/sec.) (“+” rising, “-” falling)											
	Tone-1		Tone-2		Tone-3		Tone-4		“的”		“了”	
	av.	dev.	av.	dev.	av.	dev.	av.	dev.	av.	dev.	av.	dev.
Question	93	100	490	126			-126	188	61	73		
Statement	49	158	208	133	-398	290	-536	316	-226	89	-202	67

Table 4 The slope of F_0 curves in boundary tone with strong question when they were in out context and in the last syllable of IP with statement

3.3 Acoustical manifestation of boundary tone

Acoustical manifestation of boundary tone was derived from echo question in read speech and yes-no question in spontaneous speech. In short, the boundary tone in Chinese is represented by the register of the starting-point of its F_0 curve and/or the ending-point of its F_0 curve (or the register of its starting-point and/or its slope). As for the register, F_0 register of boundary tone of IP with question is higher than that of the last syllable of IP with statement; the F_0 curve of tone 1, tone 2 and tone 4 in boundary tone with strong question is raised by certain angle relative to that in the last syllable with statement; in the F_0 curve of tone 3 in boundary tone with strong

question, there appears a rising part comparing to that of tone 3 in the last syllable with statement.

4 BOUNDARY TONE IS INDISPENSABLE TO DIFFERENTIATE BETWEEN QUESTION AND STATEMENT

The acoustic analysis, listening test and identification test above have indicated that boundary tone is indispensable to differentiate between question and statement in Chinese. This was further confirmed by synthesis. In the following, two examples was given.

Example 1:

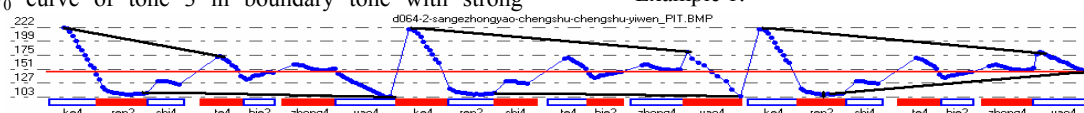


Figure 4 F_0 curve, duration and F_0 top and bottom lines of three IPs “ke4 ren2 shi4 te4 bie2 zhong4 yao4” (guest is particular important)

In Figure 4, there were three IPs: IP-1, IP-2 and IP-3. IP-1 and IP-2 were judged as statement, and IP-3 as question by all of 10 listeners. IP-1 was selected from a

database of telephone dialogue, but IP-2 and IP-3 were synthesized by using Praat 39 to change F_0 of the beginning point, F_0 of the beginning and ending points and slope of

F₀ curve in the last syllable “yao4” respectively.

Based on stress-principle (Lin, 2002), F₀ top and bottom lines of three IPs were constructed that were plotted with straight line in figure 4 and 5.

It can be seen in Figure 4 that although F₀ of the beginning point of F₀ curve of the last syllable “yao4” in IP-2 was raised comparing to that of t IP-1, “yao4” in IP-2

was only sounded with more stress than that in IP-1, and it was still judged as statement. IP-3 was judged as question, just because F₀ of the beginning and ending points of F₀ curve of the last syllable “yao4” were raised simultaneously so that the slope of its F₀ curve was decreased relative to horizontal line.

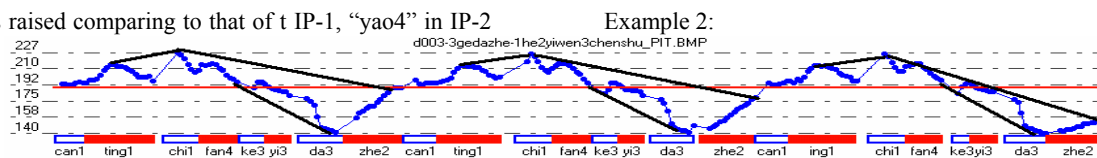


Figure 5 F₀ curve, duration and F₀ top and bottom lines of three IPs “can1 ting1 chi1 fan4 ke3 yi3 da3 zhe2”(having meal in dinning room can be discounted)

In figure 5, there were three IPs: IP-1, IP-2 and IP-3. IP-1 and IP-3 were judged with question and statement by all of 10 listeners respectively, but IP-2 was judged with question by 70% of 10 listeners. IP-1 was selected from a database of telephone dialogue, but in IP-2 and IP-3, F₀ curve of the last syllable “zhe2” was derived by changing the F₀ curve of the last syllable “zhe2” to get the different mood. In IP-2, although the starting and ending points of F₀ curve of the last syllable “zhe2” were lowered by 10Hz, its mood was still question. In IP-3, the ending point of F₀ curve of the last syllable was further lowered by 15Hz so that the slope of F₀ curve was sufficiently decreased, so its mood was judged as statement

It should be pointed that in the three IPs, F₀ top and bottom lines were the same: F₀ top lines were first rising and then falling, bottom lines were declined.

These two examples demonstrated that difference between question and statement depended not only on the F₀ register, but also on the slope of F₀ curve of boundary tone. Boundary tone is indispensable to differentiate

between question and statement in Chinese.

5 IDENTIFICATION TEST ABOUT BOUNDARY TONE

Two types of perceptual tests are required to study speech categorical perception: an identification test and a discrimination test (Strange and Jenkins, 1978). In this study, Identification test was adopted to verify the results of acoustical analysis and listening test, and to determine which is more important of the register or slope of the F₀ curve in boundary tone. The discrimination test was not done in this study because it had been found that the interrogative information of either echo question or yes-no question in out of context has different degree in acoustical study: strong question→weak question→“either question or statement”→non-terminal intonation→statement.

5.1 Identification test of boundary tone in IP “还有房间” (there still is a room)

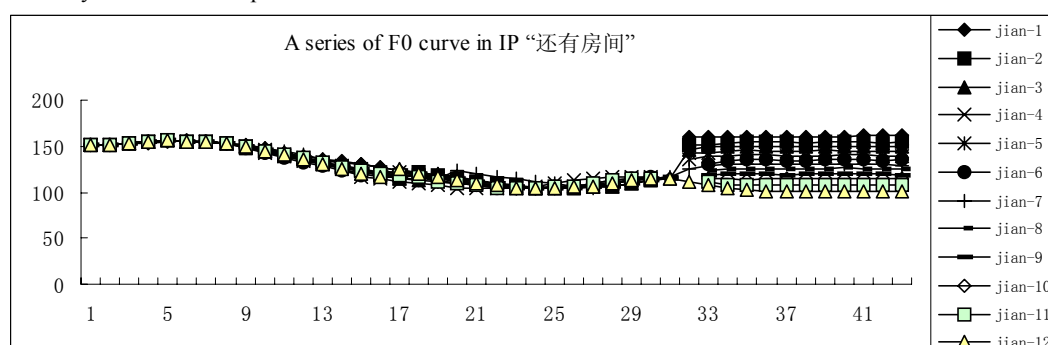


Figure 6.1 a series of F₀ curve in IP “还有房间” (there still is a room) in which only the register of F₀ curve in the last syllable “间” (bay) was changed

Figure 6.1 showed a series of F₀ curve in IP “还有房间” (there still is a room) in which only the register of F₀ curve in the last syllable “间” (bay) was changed. In the

series, there were 12 F₀ curves. The series of F₀ curve in IP “还有房间” was used to synthesis by prrat 39 to get a group of stimulus in identification test. Each of stimuli was

repeated 8 times and then randomized. The group of stimulus was stored in computer. The listeners and procedure of identification test was the same as in the listening text.

Figure 6.2 showed the identification function that the stimuli in Figure 4.1 were judged by force as question and statement by 5 listeners. It can be seen in Figure 6.2 that

different mood can be got by only changing the register of F_0 curve in the last syllable “间” (bay) of “还有房间” and the different mood is as follows: strong question→weak question→“either question or statement”→non-terminal intonation→statement. The definition about the different mood was same to that above.

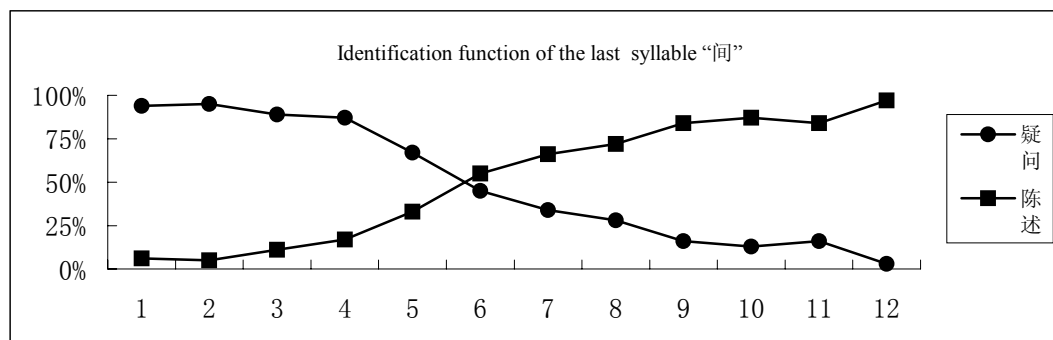


Figure 6.2 the identification function that the stimuli in Figure 4.1 were judged by force as question and statement by 5 listeners

5.2 Identification function of boundary tone in IP “特别重要”(particular important)

When boundary tone is tone-4, difference between question and statement not only relies on register of its F_0 curve, but also on slope of it. Therefore, there were two kinds of identification function of boundary tone in IP “特别重要” (“particular important”). One is that only register of its F_0 curve was changed, another is that only slope of its F_0 curve was changed.

5.2.1 Identification function of boundary tone in IP “特别重要” in which only the register of the F_0 curve in its last syllable was changed

A series of 7 F_0 curves in IP “特别重要” were got by only changing the register of the F_0 curve of its last syllable (Figure 7.1 was omitted). Figure 7.2 showed the identification function that the stimuli in Figure 5.1 were judged by force as question and statement by 5 listeners. It can be seen in Figure 5.2 that different mood can be got by only changing register of F_0 curve in the last syllable “要” (bay) of “特别重要” with the exception of strong question. Since maximum percentage of the series of the F_0 curves judged as interrogative mood was only 79% and 74%, they were weak question according to the definition in 3.1.2. If register of the F_0 curve were still raised, sound quality of the stimulus would be bad.

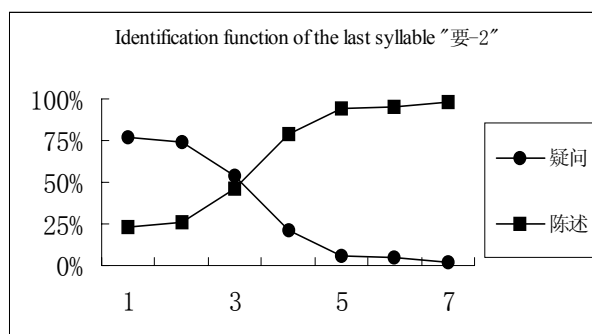


Figure 7.2 the identification function that the stimuli in Figure 5.1 were judged by force as question and statement by 5 listeners

5.2.2 Identification function of boundary tone in IP “特别重要” in which only the slope of the F_0 curve in its last syllable was changed

Figure 8.1 showed a series of 7 F_0 curves in IP “特别重要” in which only slope of the F_0 curve of its last syllable was changed. Figure 6.2 showed the identification function that the stimuli in Figure 6.1 were judged by force as question and statement by 5 listeners. It can be seen in Figure 6.2 that different mood can be got by only changing register of F_0 curve in the last syllable “要” (bay) of “特别重要” and the different mood is: strong question→weak question→“either question or statement”→non-terminal intonation→statement.

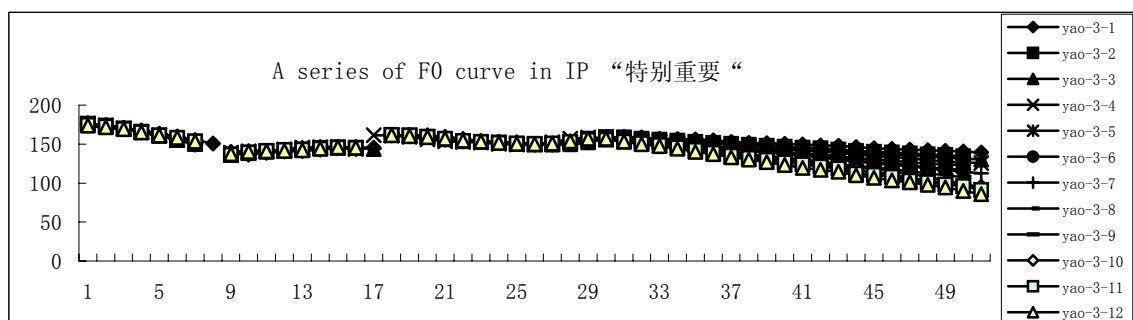


Figure 8.1 a series of 7 F_0 curves in IP “特别重要” in which only the slope of the F_0 curve of its last syllable was changed

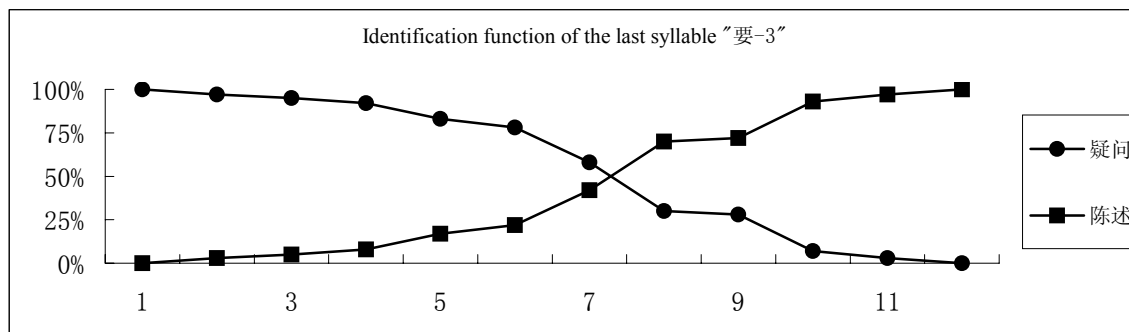


Figure 8.2 the identification function that the stimuli in Figure 6.1 were judged by force as question and statement by 5 listeners

5.3 The results in identification test

It was found in the identification function that different mood could be acquired by only changing the register or slope of the F_0 curve in boundary tone; the slope of the F_0 curve in boundary tone takes an more important than the register of its F_0 curve, this result was got by comparing the difference between figures 8.2 and 7.2. the identification function between question and statement is not categorical, but continuous: strong question → weak question → “either question or statement” → non-terminal intonation → statement.

6 THE RELATION BETWEEN TONE AND INTONATION

The relation between tone and intonation in Chinese will be expounded by boundary tone and stress. It is stress and boundary tone that lead to the different degree of F_0 curve in related syllable in an utterance.

The process from the F_0 contour in each isolated syllable to the F_0 curves in the utterance was illustrated in Figure 9. The process is as follows: F_0 contour of each syllable in citation form → tone sandhi in lexical word → prosodic structure (prosodic constituents, stress) → IP with statement → IP with question. IP stands intonation phrase.

The upper part of Figure 9 showed the F_0 contour of the isolated syllables: “酒” (wine), “厂” (factory), “买”

(buy), “酒” (wine), “可” and “以” (can), “打” and “折” (sell at a discount). These 8 syllables make 4 lexical words: “酒厂” (wine factory), “买酒” (buy wine), “可以” (can) and “打折” (sell at a discount). Because tones in “酒厂”, “买酒” and “可以” are consisted of in form “tone-3+tone-3”, the first tone-3 become like tone-2. F_0 curves in these four words were showed in the upper-middle of Figure 9. In the lower-middle of figure 9, F_0 curves in the IP with statement “酒厂买酒可以打折。” were shown. Since “以” in “可以打折” was changed also into tone-2, “可以” and “打折” were uttered tightly, these two lexical words made a prosodic word. A F_0 reset occurred between “可” in “可以打折” and its preceding syllable “酒” so that “酒场买酒” was a prosodic word too. In the prosodic word of “酒厂买酒”, “酒” in “酒厂” and “买” in “买酒” were changed into tone-2, but not like “以” in “可以打折” that was changed into tone-2, “厂” wasn’t changed into tone-2, so “酒厂” and “买酒” in “酒厂买酒” were not uttered very tightly. The prosodic word of “可以打折” was named as complex PW, but “酒厂买酒” was named as compound PW. In the compound PW of “酒厂买酒”, the register of F_0 curve in “酒” was higher than that of its following syllables “厂”, “买” and “酒”, so the first syllable “酒” was most prominent, and the first syllable “酒” was stress in the PW. In the compound PW of “可以打折”, the register of F_0 curve in “可以” was higher

than that of its following syllables “打折”, so “可以” was most prominent and was stress in the PW. In the IP with statement, the F_0 range of “可以打折” was wider than

that of “酒厂买酒”, so “可以” was most prominent and was stress in the IP with statement.

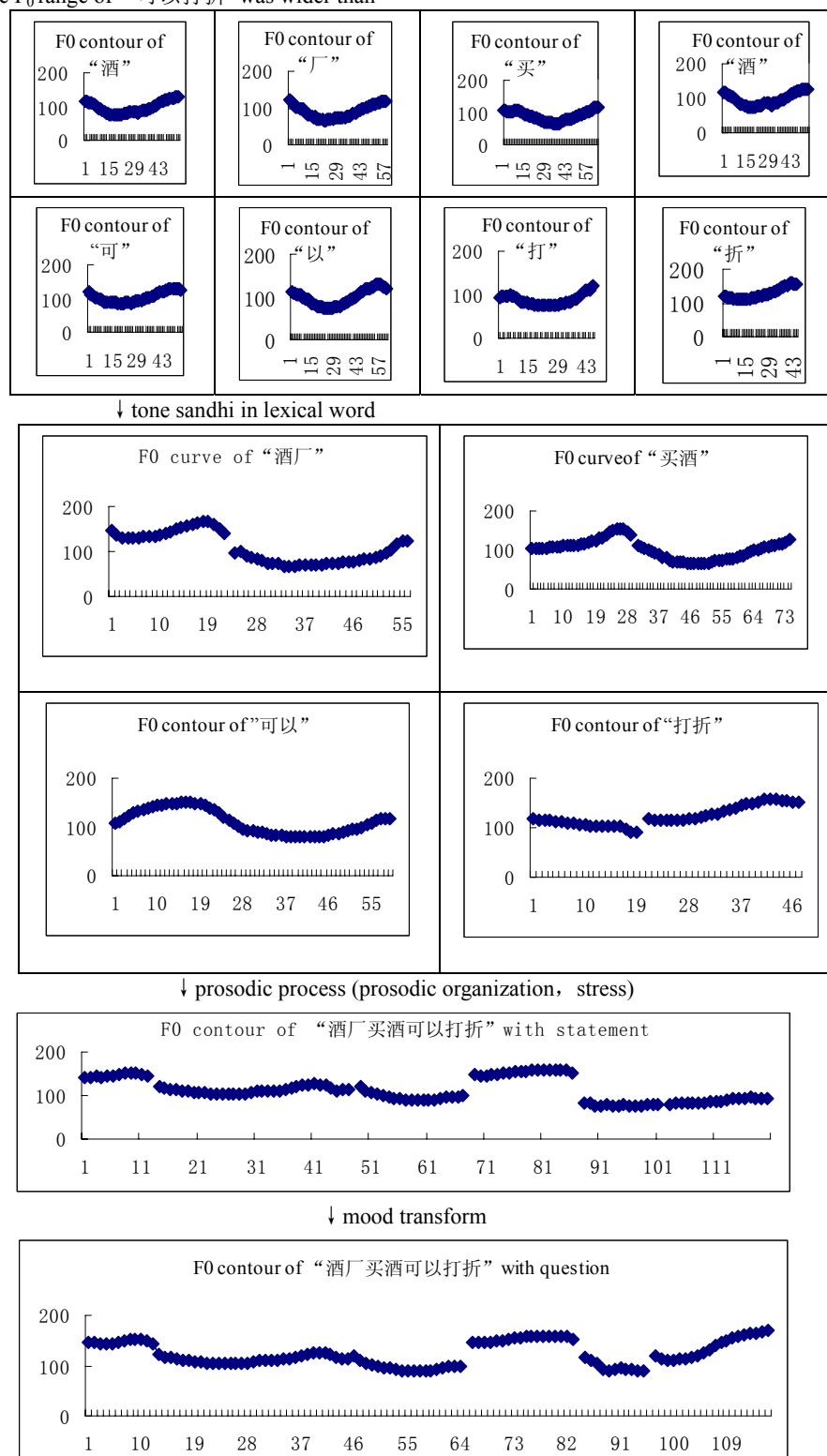


Figure 9 the process from F_0 contour in each isolated syllable to F_0 curves in the utterance

When both moving up the register of F_0 curve in the last syllable of “折” in the IP with statement “酒厂买酒可

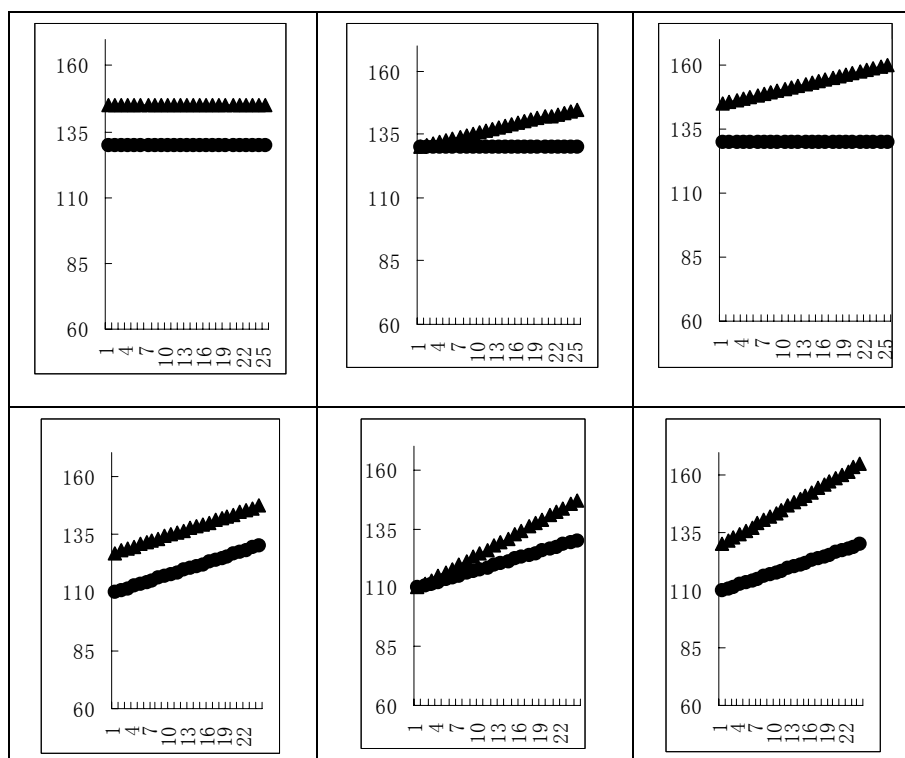
以打折” and rising up the register of the ending point in its F_0 curve, a interrogative mood could be realized. The F_0 curve of the IP with question “酒厂买酒可以打折?” was shown in the lower part of Figure 9.

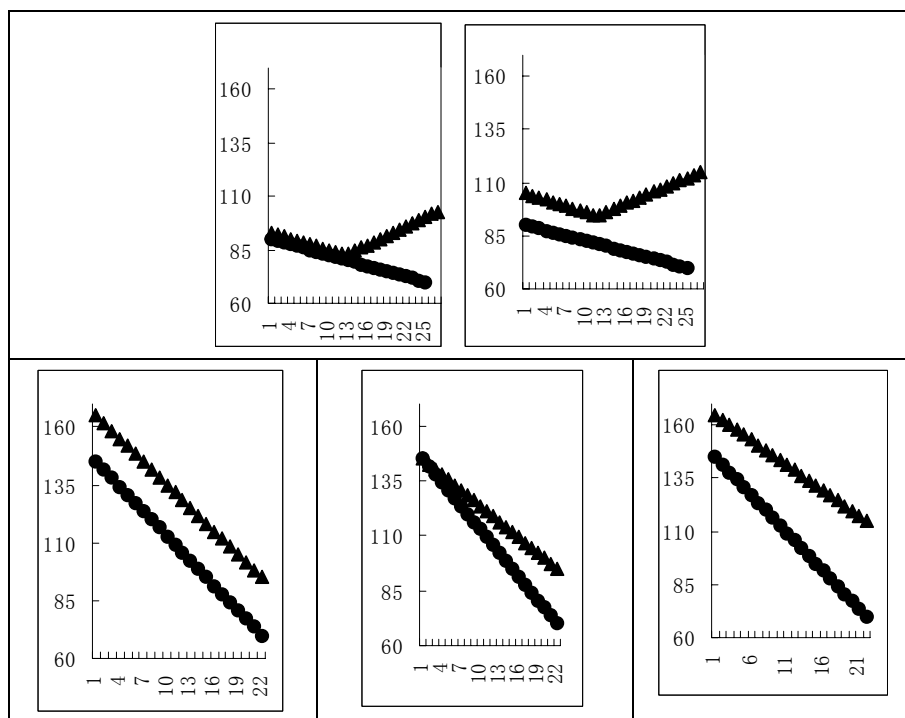
It was advocated that the F_0 curve of each syllable in an utterance is conditioned by stress and boundary tone, and that the F_0 contour in any isolated syllable couldn't resist the action of intonation. It is single-directionally and nonlinearly that intonation acts upon tones.

7 F_0 PATTERN OF BOUNDARY TONE

Figure 10 showed the F_0 pattern of boundary tone in Standard Chinese. The F_0 pattern was derived based on that boundary tone in Chinese is represented by the register of the starting- point of its F_0 curve and/or ending-point of its F_0 curve (or the register of the starting-point and/or the slope of its curve). In Figure 10, there were four rows of chart. The first row showed the F_0 pattern of boundary tone with tone-1, the second row was the F_0 pattern of boundary tone with tone-2, the third row was the F_0 pattern of boundary tone with tone-3, and the last row was the F_0 pattern of boundary tone with tone-4. In each small chart, the line with solid circle indicated the boundary tone with statement; the line with solid triangle was the boundary tone with question. When the boundary tone is with tone-1, tone-2 or tone-4, there are three ways to change statement

into question and vice versa. The first way is that F_0 curve of its boundary tone moves up or down with certain semi-tone. The second way is that the starting point of its F_0 curve keeps stable, but to rises up or down the ending point of its F_0 curve. The third way is to not only to moves up or down the starting point of its F_0 curve, but also rises up or down the ending point of its F_0 curve. When the boundary tone is with tone-3, there are only two ways to change statement into question and vice versa. F_0 curve of the boundary tone with tone-3 is always falling in the IP with statement, but it is always falling-rising in the IP with question. In the first way of realizing the boundary tone of tone-3 with question, the first falling part keeps stable and the second part of F_0 curve rises up or down. But in second way, the register of the first falling part moves up and the ending point in second rising part rises up or down. In any one of the three ways of boundary tone with tone-1, tone-2 or tone-4, the F_0 curve that moves up or rises up could give an impression with a interrogative mood, but the F_0 curve that moves down or falls down could give an impression with a declarative mood. In short, the feature of boundary tone with question is “high” relative to that with statement, but the feature boundary tone with statement is “low” relative to that with question.



Figure 10 pitch(F_0) pattern of boundary tone in Standard Chinese

8 CONCLUSION AND NEXT WORKS

8.1 Conclusion

8.1.1 The results of acoustical analysis and listening test indicated that the tune carrying the information about question and statement is known as boundary tone. Boundary tone in Chinese is represented by the register of the starting-point of its F_0 curve and/or the slope of its F_0 curve (or the register of its starting-point and/or its ending-point). 2) The identification test was adopted to verify the results of acoustical analysis and listening test, and to find out that the slope of its F_0 curve is more important than that of the register in differentiating between question and statement, and the identification function about question and statement is not categorical, but continuous: strong question $\rightarrow$ weak question $\rightarrow$ either question or statement non-terminal intonation $\rightarrow$ statement.

8.1.2 The result of this study didn't support the view that the difference between question without “吗” and statement in Chinese is related to pitch range, F_0 contour or “3 tones” of the utterance. It was proposed that the boundary tone is indispensable to differentiate between question and statement.

8.1.3 Feature of boundary tone to differentiate between question and statement in Chinese is “high” and “low”, just as the feature of that in English. In English, the

acoustic manifestation of boundary tone with question or statement is rising or falling (Ladd, 1996), but in Chinese, the acoustic manifestation of boundary tone with question or statement is high or low register of the starting point of its F_0 curve and/or ending point of its F_0 curve (or its slope). And F_0 pattern of boundary tone was given.

8.1.4 It was single-directionally and non-linearly that intonation acts upon tones.

8.2 Next works

That the identification function about question and statement is continuous will be researched further.

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