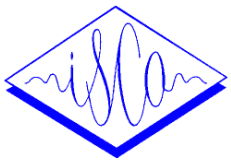

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PROSODIC FEATURES DETERMINING THE COMPREHENSION OF SYNTACTICALLY AMBIGUOUS SENTENCES IN MANDARIN CHINESE

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ABSTRACT

This paper investigates the prosodic features that can disambiguate polysemous sentences in Mandarin Chinese and confirms the results of the acoustic investigation by means of a series of perceptual experiments using synthesized speech stimuli. Judging from the results of both the acoustic and perceptual experiments, it is concluded that a pause and stretched word duration before a syntactic boundary are the two primary prosodic cues to disambiguate polysemous sentences in Mandarin Chinese.

I. INTRODUCTION

Prosodic features indicating syntactic boundaries seem to be language-specific. Certain prosodic features unique for one language used in another language display a "foreign accent" and often cause serious communicative impairment. This is especially so when two languages differ substantially in their prosodic characteristics.

The main objective of this study is to investigate the prosodic features that can disambiguate polysemous sentences in Mandarin Chinese and to confirm the results of the acoustic investigation by means of a series of perceptual experiments using synthesized speech stimuli.

II. TEST SENTENCES

The Syntactic Structures of Test Sentence (1)

A.[我 [和 [[哥哥 的] 老師] 去了.

I, and my brother's teacher (two of us) went.

B.[[[我 和 哥哥] 的] 老師] 去了.

The teacher for both me and my brother (just one teacher) went.

The Syntactic Structures of Test Sentence (2)

A.[老王 拿了 封信] [出来] [交給 我].

Wang took the letter, came out and handed it to me.

B.[老王 拿了 封信 出来] [交給 我].

Wang took the letter out and handed it to me.

＊In traditional Chinese linguistics, A in Test Sentence (2) is differentiated from B in that "出来" (verb) in A are full tones whereas "出来" (directional complement) in B are neutral tones.

III. EXPERIMENTAL PROCEDURES

The test sentences written in Chinese characters were uttered by a native female speaker of Mandarin Chinese in her thirties born and brought up in Beijing. Five tokens were selected from ten repetitions of A and B of each test sentence and analysed with Kay-Elemetrics DPS-Sona-Graph Model 5500-1 and the acoustic analysis system using NEC-PC9801RX2, developed by Prof. Miyoko Sugito of Osaka Shoin Women's College. The fundamental frequency, duration and amplitude for each word were measured and all of the acoustic measurements were put to statistical analyses.

IV. ACOUSTIC CHARACTERISTICS BASED ON THE EXPERIMENTAL RESULTS

4.1 Pause and Word Duration

Test Sentence (1)

i) A pause is always found immediately before "和" in A.

ii) The duration of "我" in A is stretched 3.9 times as much as that in B.

Test Sentence (2)

i) A pause is always found immediately before

"出来" and "交給" in A.

ii) A pause is found only immediately before "交給" in B.

iii) The duration of "信" in A is stretched 1.4 times as much as that in B.

iv) The vowel duration of "出" in A is 2.1 times longer than that in B.

4.2 Fundamental Frequency

Test Sentence (1)

i) The Fo descent of "我" in A is bigger than that in B.

ii) The Fo rising of "和" in A is higher than that in B.

Test Sentence (2)

i) When comparing Fo values between A and B, only the word "出来" turned out to be statistically significant ($p<0.01$).

ii) The Fo contour of "出" in A tends to keep itself level, the lexical Tone 1. On the other hand, the Fo contour of "出" in B behaves as a typical neutral tone, a low falling contour (Tsukuma, 1988).

4.3 Amplitude

Test Sentence (1)

i) No significant difference between A and B is observed.

Test Sentence (2)

i) When comparing amplitude values between A and B, only the word "出来" turned out to be statistically significant ($p<0.01$).

ii) "出来" in A shows a greater amplitude value than that in B. This result indicates that the full lexical tone as seen in A always has a greater amplitude value than the neutral tone as seen in B (Tsukuma, 1985).

V. AUDIO SIGNALS AND Fo CONTOURS

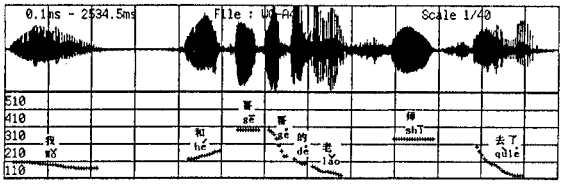

FIG. 1. Test Sentence (1)-A

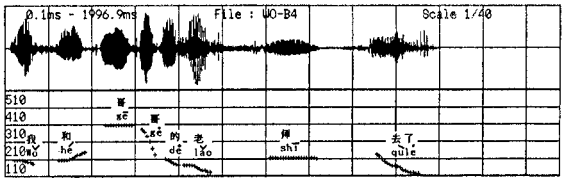

FIG. 2. Test Sentence (1)-B

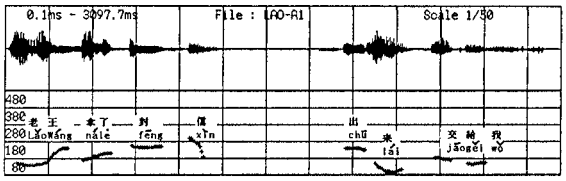

FIG. 3. Test Sentence (2)-A

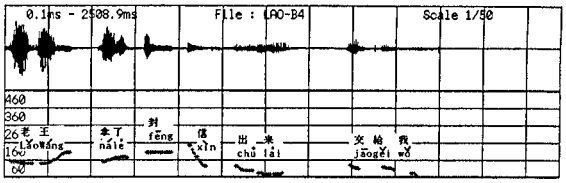

FIG. 4. Test Sentence (2)-B

VI. PERCEPTUAL EXPERIMENTS

In order to investigate to what extent the pause, stretched duration and Fo contour resetting at the syntactic boundary contribute to the correct comprehension of the ambiguous sentences, a perceptual experiment was carried out.

Using the editing function of Kay Elemetrics DSP-Sona-Graph Model 5500-1, a pause found in A was cut off step by step, and pauses of various lengths were inserted in B. Edited stimuli were randomized and given to 30 native speakers of Mandarin Chinese for the perceptual tests.

The perceptual judgements were based on five scales; (1)···confident judgement as A, (2)···less confident judgement as A, (3)···ambiguous judgement, (4)···less confident judgement as B, (5)···confident judgement as B.

The scores were pooled and averaged and then ANOVA was applied to see if there were statistically significant differences among processed stimuli.

Edited Stimuli	我	Pause	和	Judgements
1. Original stimulus WO-A.	534ms	197ms	244ms	1.23
2. Pause is cut by 197ms.	534ms	0ms	244ms	1.27
3. Stretched Vowel of "ǎ" is cut by 200ms.	334ms	0ms	244ms	2.63
4. Stretched Vowel of "ǎ" is cut by 400ms.	134ms	0ms	244ms	3.13
5. Consonant part of "ǎ" is cut by 100ms.	134ms	0ms	144ms	4.17
6. Consonant part of "ǎ" is cut by 130ms.	134ms	0ms	114ms	4.43
7. 200ms pause is inserted after "老师".	134ms	0ms	144ms	4.40

TABLE 1. Edited Pause and Duration Stimuli with Their Perceptual Judgements of Test Sentence (1)-A

Edited Stimuli	我	Pause	和	Judgements
1. Original stimulus WO-B.	122ms	0ms	225ms	4.27
2. 200ms pause is inserted before "和".	122ms	200ms	225ms	2.30
3. 400ms pause is inserted before "和".	122ms	400ms	225ms	1.93

TABLE 2. Edited Pause and Duration Stimuli with Their Perceptual Judgements of Test Sentence (1)-B

Edited Stimuli	信	Pause	出来	Judgements
1. Original stimulus LAO-A.	325ms	575ms	513ms	1.06
2. Pause is cut by 200ms.	325ms	375ms	513ms	1.56
3. Pause is cut by 400ms.	325ms	175ms	513ms	2.05
4. Pause is totally cut off, and the final "n" of "信" is cut by 25ms.	300ms	0ms	513ms	3.79
5. Pause is totally cut off, and the final "n" of "信" is cut by 50ms.	250ms	0ms	513ms	4.23

TABLE 3. Edited Pause and Duration Stimuli with Their Perceptual Judgements of Test Sentence (2)-A

Edited Stimuli	信	Pause	出来	Judgements
1. Original stimulus LAO-B.	225ms	0ms	481ms	4.88
2. 200ms pause is inserted before "出来".	225ms	200ms	481ms	3.54
3. 400ms pause is inserted before "出来".	225ms	400ms	481ms	2.38
4. 600ms pause is inserted before "出来".	225ms	600ms	481ms	1.64
5. 800ms pause is inserted before "出来".	225ms	800ms	481ms	1.67

TABLE 4. Edited Pause and Duration Stimuli with Their Perceptual Judgements of Test Sentence (2)-B

It is clear from the above tables that the listeners' judgements were gradually reversed from A to B by cutting off the pause step by step, and from B to A by inserting pauses. It should also be noticed that even if the pause is completely removed from Test Sentence (1)-A and 200ms of the pause from Test Sentence (2)-A, no significant reversal in the listeners' judgements took place. However, only 200ms of a pause inserted in B substantially reversed the trend of the listeners' judgements from B to A. It can be assumed that when there are two distinctive acoustic cues for the meaning of A, namely, a pause and stretched word duration before the syntactic boundary, the removal of just one cue or the removal of just one part of it would not change the perceptual tendency. On the other hand, when there is no distinctive acoustic cue for the meaning of A, (i.e. in the case of B), a pause inserted stands out and therefore changes the perceptual tendency. To support this assumption, it is observed that when the pause and the stretched vowel-part of the word just before the pause in A were removed to the maximum extent (but within a natural range), the perceptual judgements became reversed.

Incidentally, the pause of 200ms inserted just before "老師" did not affect the perceptual trend.

Ⅶ. CONCLUSION

In Mandarin Chinese it seems sufficient enough to signal the syntactic boundary by means of a pause and stretched word duration. This may be because Mandarin Chinese has two prosodic characteristics. First, it is a tone language. In other words, there exist fixed Fo patterns at the word and phrase levels in Mandarin, and these systematic interrelations in Fo among the neighbouring words and phrases cannot be easily broken. Because of this prosodic characteristic, it cannot bear any more extra burden on the Fo parameter for indicating the syntactic boundary. Secondly, it has stressed and unstressed syllables. However, this has a less important role than the Fo characteristic in Mandarin, which is similar to English. Thus, the duration parameter, which is the second most important next to the Fo parameter for stress, can afford to be manipulated for signalling the syntactic boundary in Mandarin Chinese.

Like Japanese, whose Fo parameter can be manipulatable for indicating a syntactic boundary (Azuma, Tsukuma, 1989), Mandarin Chinese also carries a specific lexical tone for each mono-syllabic word. Usually, four lexical tones change their Fo shapes when interacted with one another in a phrase or a sentence, but the Fo contours of words normally change smoothly from one syllable to another. When this smooth Fo transition is interrupted by the existence of a pause and stretched word duration, it may be considered that there exists a syntactic boundary.

However, it is very common that more than

two prosodic features come to the surface in a natural language. So, a prominent Fo raising after a syntactic boundary is almost always attended with a pause in Japanese, and a pause and stretched word duration before a syntactic break are always accompanied by substantial Fo discontinuity.

REFERENCES

[1] J. Azuma and Y. Tsukuma, "Contribution of Fo and Pause toward the Comprehension of a Syntactically Ambiguous Japanese Sentence: In the Case of the Kinki Dialect," *The Bulletin of the Phonetic Society of Japan, Vol. 191*, pp.1-5, 1989. (In Japanese)

[2] Y. Tsukuma, "The Interaction Between Word and Sentence Prosody: Acoustic and Perceptual Studies in Chinese, Japanese and English," Ph.D. Thesis, Essex University, pp.125-156, 1985.

[3] Y. Tsukuma, "Neutral Tones in Mandarin Chinese:An Analysis Based on Acoustic-Phonetic Data," *Beacon, No. 23*, Kenmei Women's Junior College, pp.29-54, 1988.

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