

# FEATURES OF PROSODIC HIERARCHY BOUNDARY BETWEEN UYGUR AND MANDARIN CHINESE

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## ABSTRACT

The study explored the perception and acoustic features of prosodic hierarchy boundaries in Uygur and Mandarin Chinese. The results of the perception study showed that native speakers of Mandarin Chinese were more sensitive to prosodic hierarchy boundaries than native speakers of Uygur. The results of a detailed acoustic analysis indicated that the acoustic features of Uygur prosodic hierarchy boundaries were rather complicated than those of Mandarin Chinese. The pauses, the lengthening of pre-boundary syllable and the pitch variation were the acoustic correlates of prosodic hierarchy boundaries in Uygur. However, the pauses, the minimum pitch of pre-boundary and post-boundary syllables differed across the prosodic hierarchy boundaries in Mandarin Chinese. In addition, disyllabic words and trisyllabic words occur most frequently as prosodic words in Mandarin Chinese and Uygur respectively. The results of the present study indicated the influence of language typology on speech perception and acoustic features of prosodic hierarchy boundaries.

**Keywords:** Uygur, prosodic hierarchy boundary, Mandarin Chinese

## 1. INTRODUCTION

The acoustic properties may vary depending on prosodic hierarchy boundary in each language. A fairly “mainstream” version of the prosodic hierarchy proposed by Nespor & Vogel [4] and Selkirk [5] rank as mora, syllable, foot, prosodic word, prosodic phrase and intonation phrase. Studies like Cao [1], Wang [6] and Lin [3], suggest that the lengthening of the pre-boundary syllable in duration, pitch variation and pauses affect the prosodic hierarchy boundary markedly in Mandarin Chinese. Different from Mandarin Chinese, Uygur, as a non-tone language, belongs to Turkic branch of Altaic language family. Chao and Zhu [2] suggest that the stress of the word falls

on the last syllable and it is rich in language inflections and its syllable structure is rather complicated than Mandarin Chinese. Therefore, the effect of language typology may manifest itself along different prosodic hierarchy units and acoustic parameters in Uygur. The present study consists of two parts. The purpose of the first part was to conduct a perceptual experiment to investigate boundaries of three targeted prosodic hierarchy units (prosodic word, prosodic phrase and intonation phrase). The second part aimed to find out the influence of language typology on prosodic hierarchy perception, acoustic features and the units of prosodic words.

## 2. MATERIALS AND METHODS

### 2.1. Participants

All participants examined in this study were born in Urumqi. In the perception experiment of Uygur, participants were sixteen Uygur university students (8 males, 8 females), between the ages of 20 and 25, and two male Uygur English teachers (30/40 years old). In the perception experiment of Mandarin Chinese, sixteen Han university students (8 males, 8 females), between the ages of 18 and 20, and two male Han English teachers (30 years old) participated in it. All subjects exhibited normal hearing sensitivity.

### 2.2. Stimuli

Urumqi news on January 10, 2009 (Uygur and Mandarin Chinese versions) was selected. Both of them were produced by one male and one female broadcaster and the whole duration was 361 seconds (Uygur) and 423 seconds (Mandarin Chinese) respectively.

### 2.3. Task procedure

The experiment consisted of two passive listening tasks. The first task required a judgment of pause in the news. The second task required subjects to respond by marking 1-3, matching in prosodic

word, prosodic phrase and intonation phrase. The stimuli were presented three times through the earphone in a quiet classroom. Pauses should be signaled on a piece of paper containing the orthographic transcription of each piece of news, without any kind of punctuation marks.

## 2.4. Acoustic analysis

For each prosodic hierarchy boundary, the pauses, duration of the pre-boundary syllable, the maximum and the minimum pitch of pre- and post-boundary syllable and the fundamental frequency of pre-boundary syllable were measured from the sound waveform and spectrogram by Praat (Paul Boersma and David Weenink).

## 3. RESULTS

### 3.1. General characteristics of perceived boundaries

The total number of syllables in Uygur news is 1900 and that in Mandarin Chinese news is 1974 (excluding the syllables at the end of the news). For all the syllable boundaries, 298 (Uygur) and 546 (Mandarin Chinese) syllable-boundaries were perceived as prosodic hierarchy boundary. The ratio of prosodic hierarchy boundaries to the total number of syllables in Mandarin Chinese (28%) is more than that of Uygur (16%). The perceptual results of all the eighteen Han Chinese listeners for prosodic hierarchy boundaries in Mandarin Chinese were significantly correlated (*Pearson's r*  $\geq 0.514$ ,  $p < 0.01$ ). However, the perceptual results of only eight Uygur listeners (including two teachers) correlated significantly (*Pearson's r*  $\geq 0.374$ ,  $p < 0.01$ ).

### 3.2. Pauses

Table 1 and Table 2 both indicated that pause was the acoustic correlate of strong prosodic boundary both in Uygur (*Pearson's r* = 0.797,  $p < 0.001$ ) and Mandarin Chinese (*Pearson's r*,  $p < 0.001$ ). The further analysis was a repeated measure ANOVA across subject and prosodic hierarchy boundary.

For pauses at prosodic hierarchy boundaries in Uygur, the main effects of SUBJECT and PROSODIC HIERARCHY BOUNDARY were qualified by a significant SUBJECT  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(14,1014)=4.53$ ,  $p < 0.001$ ]. Moreover, 29% of silent pauses (more than 100ms) were discovered at the boundary of prosodic word

and 100% of the silent pauses were identified at the boundaries of prosodic and intonation phrase. The mean duration of the silent pauses at the boundary of prosodic phrase was equal to 1.7 times the mean duration of all the syllables (167ms) and that at the intonation phrase boundary was equal to 4.4 times the mean duration of all the syllables.

For pauses at prosodic hierarchy boundaries in Mandarin Chinese, the main effects of SUBJECT and PROSODIC HIERARCHY BOUNDARY were qualified by a significant SUBJECT  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(34,4865)=6.09$ ,  $p < 0.001$ ]. Moreover, 10% of the silent pauses (more than 100ms) had been discovered at the boundary of prosodic word. 62% of the silent pauses had been found at the boundary of prosodic phrase and 100% of the silent pauses had been identified at the boundary of intonation phrase perceived by subjects. The mean duration of the silent pauses at the boundaries of prosodic and intonation phrase were equal to 0.6 and 1.8 times the mean duration of all the syllables (191ms) respectively.

**Table 1:** Perceived pauses at prosodic hierarchy boundaries (ms) (Uygur).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	207	0	326	49.29	92.22
Prosodic phrase	43	134	428	279.28	57.43
Intonation phrase	48	169	2357	740.19	482.15

**Table 2:** Perceived pauses at prosodic hierarchy boundaries (ms) (Mandarin Chinese).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	315	0	114	6.52	20.52
Prosodic phrase	146	0	436	113.72	120.91
Intonation phrase	85	86	832	342.92	118.75

### 3.3. Duration of pre-boundary syllable

Table 3 and Table 5 showed the duration of pre-boundary syllables both in Uygur and Mandarin Chinese lengthened with the prosodic hierarchy boundaries. Besides, the duration of pre-boundary syllables was normalized (Table 4 and Table 6).

For the normalized duration of pre-boundary syllable in Uygur, the main effect of PROSODIC HIERARCHY BOUNDARY on the duration of the syllable was qualified [ $F(2,1015)=11.53$ ,  $p < 0.001$ ]. There was no significant main effect of BOUNDARY (prosodic word or phrase) on the duration of the syllable [ $F(1,719)=0.56$ ,  $p > 0.05$ ],

but a significant main effect of BOUNDARY (prosodic or intonation phrase) [ $F(1,730)=92.85, p < 0.001$ ]. It indicated that lengthening of the pre-boundary syllable is the acoustic feature which can distinguish prosodic phrase boundary from intonation phrase boundary.

For the normalized duration of pre-boundary syllable in Mandarin Chinese, the main effects of SUBJECT and PROSODIC HIERARCHY BOUNDARY were not qualified by an insignificant SUBJECT  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(34,4845)=0.75, p > 0.05$ ]. The lengthening of pre-boundary syllable did not differ across the prosodic hierarchy boundary.

**Table 3:** Duration of pre-boundary syllable (ms) (Uyгур).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	207	66	356	169.00	56.25
Prosodic phrase	43	62	354	183.30	59.10
Intonation phrase	48	10	405	193.44	78.99

**Table 4:** Normalized duration of pre-boundary syllable (ms) (Uyгур).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	207	0.58	1.90	1.05	0.24
Prosodic phrase	43	0.55	1.44	1.02	0.20
Intonation phrase	48	0.60	1.92	1.08	0.31

**Table 5:** Duration of pre-boundary syllable (ms) (Mandarin Chinese).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	315	67	369	197.44	53.47
Prosodic phrase	146	69	386	227.21	56.39
Intonation phrase	85	129	310	217.05	44.74

**Table 6:** Normalized duration of pre-boundary syllable (ms) (Mandarin Chinese).

	N	Minimum	Maximum	Mean	Std. Deviation
Prosodic word	315	0.50	1.64	1.02	0.20
Prosodic phrase	146	0.40	2.79	1.09	0.23
Intonation phrase	85	0.68	2.22	1.08	0.21

### 3.4. Pitch

The present study also investigated the variation of the maximum and minimum pitches of the pre-boundary and post-boundary syllables in Uyгур. The results of descriptive analysis indicated that the mean minimum and maximum pitch of pre-boundary syllable was higher than those of post-boundary syllable, which was affected by the stress

position in Uyгур. There was a significant main effect of PROSODIC HIERARCHY BOUNDARY on the minimum pitch of pre-boundary or post-boundary syllable [ $F(2,898)=14.81, p < 0.001$ ]/ [ $F(2,898)=10.09, p < 0.001$ ]. Furthermore, the main effects of SUBJECT and PROSODIC HIERARCHY BOUNDARY on the minimum pitch of pre-boundary syllable were qualified by a significant SUBJECT  $\times$  BOUNDARY (prosodic word or phrase) interaction [ $F(7,677)=3.54, p=0.001$ ]. Moreover, there was a significant main effect of PROSODIC HIERARCHY BOUNDARY on the maximum pitch of pre-boundary or post-boundary syllable [ $F(2,898)=10.51, p < 0.001$ ]/ [ $F(2,898)=14.65, p < 0.001$ ]. The main effect of BOUNDARY (prosodic word or phrase) on the maximum pitch of pre-boundary or post-boundary syllable was qualified [ $F(1,677)=7.99, p < 0.05$ ]/ [ $F(1,677)=5.80, p < 0.05$ ].

However, descriptive analysis indicated that the mean minimum and maximum pitch of pre-boundary was lower than those of post-boundary syllable in Mandarin Chinese. Further analysis was calculated across the rising tone, the falling-rising tone and the falling tone. The main effect of TONE and PROSODIC HIERARCHY BOUNDARY on the minimum pitch of pre-boundary syllable was qualified by a significant TONE  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(4,403)=4.11, p < 0.05$ ], and there was a significant main effect of HIERARCHY BOUNDARY on the minimum pitch of post-boundary syllable [ $F(2,403)=11.76, p < 0.001$ ]. In addition, the main effects of TONE and PROSODIC HIERARCHY BOUNDARY on the maximum pitch of pre-boundary or post-boundary syllable were not qualified by an insignificant TONE  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(4,403)=2.47, p=0.05$ ]/ [ $F(4,403)=0.53, p > 0.05$ ].

Furthermore, the fundamental frequency of the pre-boundary syllable was normalized as three models:

$$(1) \quad p_1 = \frac{P}{P_{PSDWord}}$$

$$(2) \quad p_2 = 12 \lg \left( \frac{P}{20} \right) / \lg(2)$$

$$(3) \quad p_3 = 12 \lg \left( \frac{P}{P_{lw}} \right) / \lg \left( \frac{P_{hw}}{P_{lw}} \right)$$

Where  $P_{PSDWord}$  is the mean pitch of all the syllables in a prosodic word;  $P_{lw}$  is the minimum pitch of a prosodic word;  $P_{hw}$  is the maximum pitch of a prosodic word.

The results indicated that there was a significant main effect of HIERARCHY BOUNDARY on  $P_2$  or  $P_3$  of pre-boundary syllable in Uygur [ $F(2, 940)=9.77, p=0.001$ ]/ [ $F(2, 940)=17.30, p<0.001$ ]. The main effect of BOUNDARY (prosodic word or phrase) on  $P_2$  was qualified [ $F(1,700)=12.96, p<0.05$ ]. In addition, there was a significant main effect of BOUNDARY (prosodic or intonation phrase) on  $P_2$  or  $P_3$  [ $F(1,658)=7.23, p<0.05$ ]/ [ $F(1,658)=29.36, p=0.001$ ]. Therefore, fundamental frequency differs across prosodic hierarchy boundaries. In Mandarin Chinese, the main effects of TONE and PROSODIC HIERARCHY BOUNDARY on  $P_1, P_2$  or  $P_3$  of pre-boundary syllable were not qualified by an insignificant TONE  $\times$  PROSODIC HIERARCHY BOUNDARY interaction [ $F(2,295)=0.96, p>0.05$ ]/ [ $F(2,295)=1.35, p=0.05$ ]/ [ $F(2,295)=0.64, p>0.05$ ]. Thus, fundamental frequency did not differ across prosodic hierarchy boundaries.

#### 4. DISCUSSION

The study investigated the perception of the prosodic hierarchy boundaries in Uygur and Mandarin Chinese. The perception study showed that native speakers of Mandarin Chinese tend to be more sensitive to the prosodic hierarchy boundary than native speakers of Uygur, since their perceived results were significantly correlated and the proportion (the number of perceived silent pauses/total number of syllables) was higher than native speakers of Uygur. Thus, the language typology would affect the perception of the prosodic hierarchy boundaries.

The acoustic analysis of Uygur and Mandarin Chinese prosodic hierarchy boundaries showed that the acoustic features of Uygur prosodic hierarchy boundaries were rather complicated. The pauses, the lengthening of pre-boundary syllable and the pitch variation (the minimum pitch, the maximum pitch and fundamental frequency) differed across the prosodic hierarchy boundaries in Uygur. The pitch variation is due to fixed stressed pattern of Uygur. However, in Mandarin Chinese, the pauses and the minimum pitch of pre- or post-boundary syllables differed across the prosodic hierarchy boundaries. Therefore, the

language typology would affect the acoustic features of prosodic hierarchy boundaries in different languages.

It is important to note that disyllabic and trisyllabic words take up the majority of Mandarin Chinese and Uygur prosodic words respectively from the present study. Besides, the present study found out that monosyllabic words like / $\emptyset$ / (home, VC syllable structure) and /koʃ/ (a pair of, CVC syllable structure) can be prosodic words in Uygur.

#### 5. ACKNOWLEDGEMENTS

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#### 6. REFERENCES

- [1] Cao, J.F. 2001. Linguistic and Phonetic cues for rhythm in Mandarin Chinese. In Cai, L.H. (eds.), *Modern Phonetics in the New Century*. Beijing: Tsinghua University Press.
- [2] Chao, X.R., Zhu, Z.N. 1985. *An Introduction to Uygur*. Beijing: Minzu Press.
- [3] Lin, M.C. 2002. Prosodic structure and intonation in Standard Chinese. *Reports of Phonetic Research 2002*. Beijing: Chinese Academy of Social Sciences.
- [4] Nespors, M., Vogel, I. 1986. *Prosodic Phonology*. Dordrecht: Foris.
- [5] Selkirk, E.O. 1986. On derived domains in sentence phonology. *Phonology* 3, 371-405.
- [6] Wang, B. 2002. *The Research on Perception of Prosody in Mandarin*. Ph.D. Thesis, Chinese Academy of Science.