Prosodic Encoding of Mandarin Chinese Intonation by Uygur Speakers in Declarative and Interrogative Sentences

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Abstract

As a major cause of non-native accent for L2 learners, L2 intonation plays an important role in the acquisition of L2 suprasegment. Few studies have been on the prosodic encoding of Chinese intonation by Uygur learners with Mandarin Chinese as a second language (CSL). With L2 Intonation Learning theory (LILt) as the theoretical framework, this study investigates the prosodic encoding of Mandarin intonation by Uygur CSL learners and compares with Beijing Mandarin speakers. Twelve speakers were invited to produce six pairs of Mandarin declarative and interrogative intonations in different tone sequences. It is found that for Uygur CSL learners, the pitch is falling in Mandarin declarative intonation and rising in interrogative intonation, which is similar to Mandarin speakers. However, the bottom lines in two intonations both drop slower. The interactions of L1 and L2 result in the narrowing trend of tonal pitch ranges (TPRs) in declarative intonation assimilated to L1 and the expanding trend in interrogative intonation assimilated to L2.

Index Terms: Mandarin Chinese, declarative intonation, interrogative intonation, Uygur CSL learners, prosodic encoding

1. Introduction

L2 speech production poses significant challenges for second language learners. For L2 learners with Mandarin Chinese as a second language (CSL learners), both segmental and suprasegmental errors in L2 production can result in the perception of non-native speech, especially in the case of intonation [1]. As an aspect of language prosody, intonation plays a major role in conveying communicative meanings like declaration and interrogation and expressing speaker's attitude [2, 3]. Therefore, the acquisition of L2 intonation is significant for CSL learners in the improvement of both communication fluency and speech intelligibility [4].

In tone languages such as Chinese, pitch is used both at the word level to differentiate between lexical tones and at the sentence level to signal differences in sentence types. Much attention has been paid to how pitch variation is used to simultaneously realize Chinese tone and intonation. Chao [5-7] described Chinese tone and intonation as small ripples on larger waves and proposed that intonation can expand or compress the pitch range of tone like an "elastic band", which lays the foundation for the following studies on the prosodic encoding of Chinese intonation. Generally, Chinese yes-or-no question adopts salient terminal rising intonation and the pitch curve is higher than declarative intonation, especially for the sentence-final syllable [8-10]. Within autosegmental-metrical (AM) framework, declarative and interrogative intonations can be distinguished by lowering or raising the pitch register of boundary tone [13-16]. For pitch range, Shen [17] noted that Chinese intonation is a series of tonal pitch ranges (TPRs) and provided profiles of Chinese declarative and interrogative intonations with top line and bottom line as separate variables [18-19]. Both pitch register and pitch range of local tone may change owing to global intonation, however, its basic tone shape, i.e., tonal target, is still preserved [11, 12].

For Mandarin Chinese learning as a second language, the majority of L2 suprasegmental studies target difficulties in the acquisition of lexical tones and phonetic encoding of focus resulting from tone and intonation interaction [21-26]. Studies on intonation, though relatively inadequate, also report errors in Mandarin declarative and interrogative intonations by CSL learners whose native language is non-tonal [27, 28, 29]. Based on the comparative observation of pitch contours, it is found that American learners of Mandarin involve infrequent tonal target undershoot in Mandarin intonation [28]. However, as to Uygur CSL learners, only several studies are related to perception and indicate that Uygurs are highly sensitive to the final rise of Mandarin interrogative intonation [30, 31]. The prosodic encoding of Mandarin declarative and interrogative intonations by Uygur learners is rarely discussed and what difficulties they have requires further examination.

To account for the difficulties in producing L2 intonation, L2 Intonation Learning theory (LILt) recognizes systemic, realizational, semantic and frequency dimensions adapted from [32] to characterize the similarities and differences between L1 and L2 intonations and identify where and how L2 intonation deviates from L1 intonation [33]. In the realizational dimension, both Chinese and Uygur intonations use pitch as phonetic cue for prosodic encoding but differ in the implementation [34]. For example, the intonation of Uygur yes-no question is featured by the rising pitch of sentence final syllable, instead of the raised pitch register as in Chinese [14, 35]. Therefore, this study focuses on the prosodic encoding of Mandarin intonation by Uygur speakers and compares with Beijing Mandarin speakers, thus predicts difficulties they may encounter. LILt also states that there exist interactions between L1 and L2 intonations, which leads to assimilation or polarization in L2 production [33]. Thus, considering L1 influence, this study serves to answer the following questions:

Q1: How does the prosodic encoding of Mandarin declarative and interrogative intonations by Uygur CSL learners deviate from Beijing Mandarin speakers in terms of pitch contours and TPRs?

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Q2: How do the interactions of L1 and L2 intonations for Uygur CSL learners contribute to their differences in the prosodic encoding of Mandarin declarative and interrogative intonations from Beijing Mandarin speakers?

2. Method

2.1. Participants

Twelve participants from Tianjin University including six Uygur CSL learners and six Beijing Mandarin speakers were invited for the production experiment. Both groups of participants are gender-balanced and aged from 22 to 23. Uygur CSL learners all speaking Central dialect of Uygur were born in Urumqi and passed Band 4 of HSK (Hanyu Shuiping Kaoshi, 'Chinese proficiency test'). They are able to use Chinese for daily communication but with self-reported perceivable accent. Chinese participants were born and raised up in Beijing and speak Mandarin in daily life.

2.2. Materials

Reading texts of Mandarin Chinese were six pairs of sentences with the same prosodic structure but different tone sequences (all T1, all T2, all T3, all T4, and another two sequences to eliminate the effects of tone sandhi) [17, 37]. S1 (SN refer to the N^{th} syllable from the left in sentence) to S3, S4 to S6, and S8 to S10 form prosodic word respectively. Each pair consists of one statement and one yes-no question without particle. One example of statement with all T1 are given in (a):

(a) zhang1zhong1bin1 xing1qi1tian1 xiu1 shou1yin1ji1
Zhang Zhongbin Sunday fix radio
'Zhang Zhongbin fixes the radio on Sunday.'

One pair of four-word Uygur sentences are used to elicit Uygur declarative and interrogative intonations and the declarative sentence is shown in (b). Except for the initial two-syllable word, other words all have three syllables [35].

(b) Nadäm Aygulgä xanzuqä ügätti
Nadam Ayguli-DAT Chinese teach-3PST
'Adam taught Ayguli Chinese.'

2.3. Data collection and processing

Both Chinese and Uygur participants were asked to read each Chinese declarative and interrogative sentence three times respectively in natural style without informational focus. Uygur participants additionally read Uygur sentences. Speech was recorded in a quiet room at 44.1 kHz with 16-bit resolution and saved as .wav files. Altogether 216 tokens from Beijing Mandarin speakers (6 participants × 12 stimuli × 3 repetitions) and 252 tokens from Uygur CSL learners (6 participants × 14 stimuli × 3 repetitions) were collected.

The second repetitions of the stimuli were selected. The f0 values in Hertz (Hz) of voiced part in each syllable were extracted at ten points in equal intervals to normalize in duration by the Praat script ProsodyPro [38]. To reduce individual differences, f0 values were converted to semitone (st) by:

$$\mathrm{st} = 12\log_2\frac{f_o}{f_{ref}} \quad (1)$$

where f_{ref} refers to the reference frequency and is set as 55 Hz and 64 Hz for male and female speakers respectively.

Based on the mean and normalized pitch contours of Uygur and Chinese intonations, basic pitch patterns can be observed and compared. T tests are conducted to identify the existence of significant difference in pitch contours of Chinese intonation between groups. For the measurement of pitch range, the top point values (T) and bottom point values (B) of pitch within syllable are extracted. By connecting the high points and low points, the top lines and bottom lines for intonations by two groups are drawn to compare the change patterns of pitch range. The differences in TPR between Uygur CSL learners and Mandarin speakers are measured by differences in the top point values (ΔT), bottom point values (ΔB) and widths of range (ΔR). It is visual presentation and measurements of pitch curves and TPRs that permit cross-linguistic comparison between L1 and L2 intonations in the realizational dimension. Interactions between L1 and L2 intonations on L2 production are examined by comparing Uygur learners' L2 intonation with L1 intonations by Uygur learners and Mandarin speakers.

3. Prosodic encoding of Uygur intonation

This section analyzes the basic features of L1 intonation by Uygur CSL learners. Pitch contours of Uygur declarative and interrogative intonations are shown in Figure 1, and Figure 2 illustrates the pitch ranges of syllables and their trend.

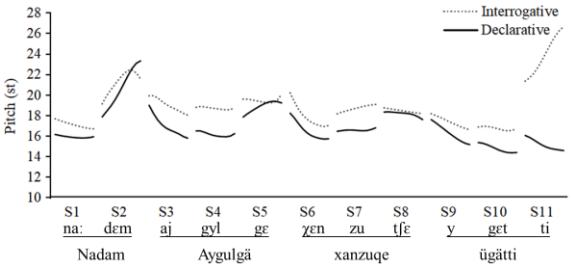

Figure 1: *Mean and normalized pitch contours of Uygur declarative and interrogative intonations.*

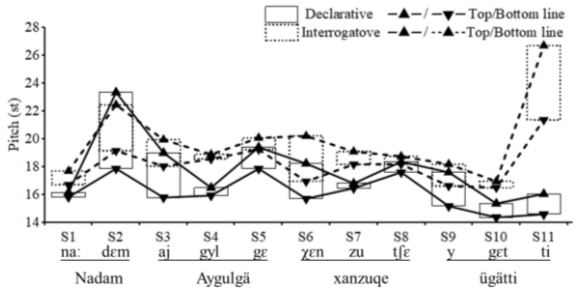

Figure 2: *Pitch ranges of syllables in Uygur declarative and interrogative intonations.*

For declarative intonation, the pitch curve displayed in Figure 1 fluctuates and begins falling from S8 to the final L tone. In the end of first three words, i.e., S2, S5, S8, the pitches rise from L tonal targets to H tonal targets and their pitch registers are raised, which marks the boundary of prosodic phrase [34]. The top and bottom lines in Figure 2 move nearly in the same pattern. Though the part of both lines in first three words runs in a zig-zag way, two lines go down in the last word. However, from S2 to S11, declination of the top line is greater than bottom line, which contributes to the overall narrowing trend of pitch range.

For interrogative intonation, Figure 1 shows that H tones are also reached in S2, S5 and S8 as in declarative intonation.

The most distinctive pitch change lies in the sentence-final syllable where the pitch register increases dramatically and the pitch rises greatly to H tone instead of L tone as in statement, which is consistent with the findings of previous studies [39, 40]. The top and bottom lines at S2, S5, and S11 climb up to high points and the pitch range of S11 is expanded markedly, but no apparent tendency of enlarging or declining can be observed for pitch range across the intonation.

Therefore, in general, pitch increases greatly in the final syllable of Uygur interrogation but declines gradually in statement and the pitch movements are generally featured by the prosodic constituents. The top line and bottom line of the pitch range develop in similar trend, indicating the correlation and synchronization of the two lines.

4. Prosodic encoding of Mandarin intonation by Uygur CSL learners

The pitch movements and changes of TPRs between Uygur CSL learners and Beijing Mandarin speakers are compared in Figure 3 and Figure 4. Table 1 shows detailed ΔT, ΔB and ΔR of each Chinese syllable. Such pitch-related differences help reveal difficulties that Uygur CSL learners may have in producing L2 declarative and interrogative intonations.

4.1. Prosodic encoding of Mandarin declarative intonation

4.1.1. Pitch contours

In Figure 3 (a), the pitch contours of Mandarin declarative intonation by Uygur CSL learners deviate from Beijing Mandarin speakers variously with different tone sequences. The pitches of T1 sequences in two groups move in the same falling pattern without significant difference ($P>0.5$), while in other tone sequences, the change patterns of pitch contours differ significantly ($P<0.01$). In T2 and T4 sequences, though pitches of two speaker groups decrease from the beginning part of intonation and reach the L tonal target eventually, the rising tone T2 and falling tone T4 in the end of first two prosodic words, i.e., S3 and S6, change in smaller scales. The whole T3 sequence demonstrates no overall falling trend like Mandarin speakers. In the T3 sequence, the turning points in the word-final syllables are higher and the dipping tone in S3 is realized as falling tone like T2.

4.1.2. Tonal pitch ranges

In Figure 3 (b), top lines and bottom lines of TPRs in two groups all demonstrate falling trends across the intonation but differ in degrees. The top line of Uygur learners falls on a larger scale but it converges to the latter in the final prosodic word. As shown in Table 1, ΔT decreases from +3.12 st in S2 to -0.04 st in S9. Therefore, the TPRs in overall declarative intonation by Uygur learners tend to narrow. For Mandarin speakers, it is the bottom line that falls in wider vertical range instead, thus their TPRs show overall tendency of expanding.

The different decline trends of bottom lines between two groups also result in the increase of differences. In word-final syllables, S3, S6 and S10, the TPRs of Mandarin speakers are expanded compared to the preceding syllables. However, for Uygur learners, ΔB of S3 (1.75 st), S6 (2.73 st) and S10 (3.15 st) are relatively larger than neighboring syllables and their ΔR are all negative (-1.02 st, -2.21 st and -3.4 st), which indicates that the pitch ranges of prosodic word-final syllables by Uygur learners are not expanded as Mandarin speakers.

4.2. Prosodic encoding Mandarin interrogative intonation

4.2.1. Pitch contours

In interrogative intonation shown in Figure 4 (a), there is no pitch contour of Uygur CSL learners that overlaps with Beijing Mandarin speakers and t tests also identify their significant differences in pitch contours for all tone sequences ($P<0.01$). In T1, T2, and T4 sequences, slight tendencies of rising beginning from S1 are observed for both groups, while the pitch registers in the speech of Uygur learners are higher. In the T3 sequence by Uygur learners, the turning points in the last words climb up,

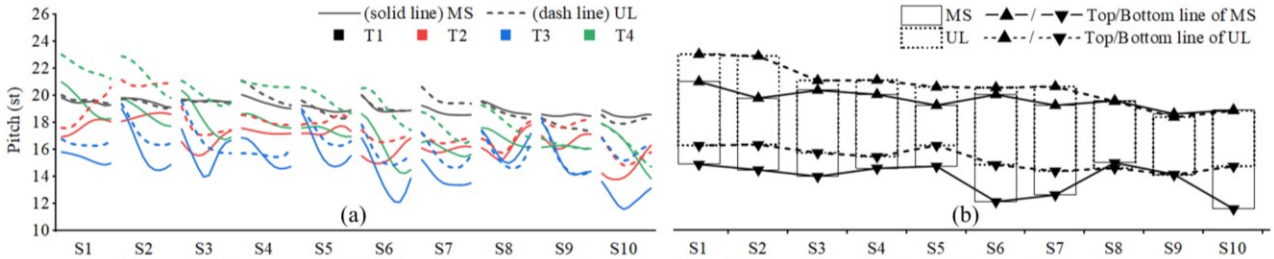

Figure 3: *Comparison of declarative intonations by Beijing Mandarin speakers(MS) and Uygur CSL learners (UL) in (a) pitch contours and (b) TPRs.*

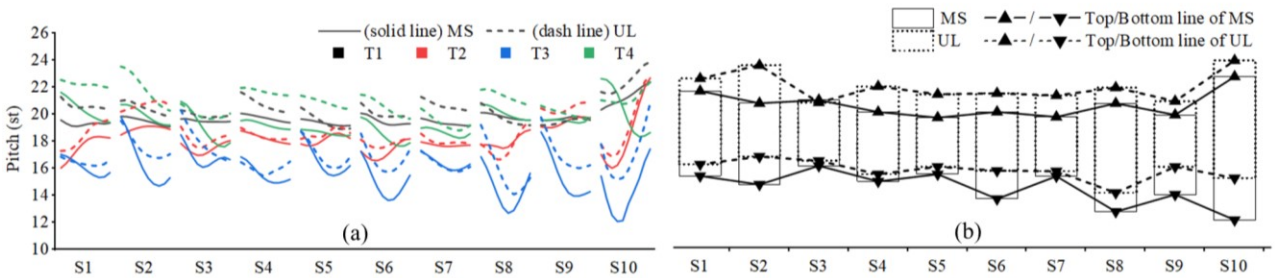

Figure 4: *Comparison of interrogative intonations by Beijing Mandarin speakers(MS) and Uygur CSL learners (UL) in (a) pitch contours and (b) TPRs.*

Table 1: *Differences in TPRs of Mandarin intonation between Uygur CSL learners and Beijing Mandarin Speakers.*

Differences in TPR (st)		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Declarative intonation	**ΔT**	+2.03	+3.12	+0.73	+1.06	+1.36	+0.52	+1.38	-0.06	-0.04	-0.25
	ΔB	+1.41	+1.87	+1.75	+0.87	+1.54	+2.73	+1.75	-0.40	-0.03	3.15
	ΔR	+0.62	+1.25	-1.02	+0.19	-0.18	-2.21	-0.37	0.34	-0.01	-3.4
Interrogative intonation	**ΔT**	+0.93	+2.82	-0.18	+1.90	+1.73	+1.38	+1.59	+1.17	+1.20	+1.02
	ΔB	+0.86	+2.07	+0.37	+0.53	+0.55	+2.09	+0.37	+1.40	+2.07	+3.10
	ΔR	+0.07	+0.75	-0.55	+1.37	+1.18	-0.71	+1.22	-0.23	-0.87	-2.08

instead of lowing as Mandarin speakers. What is interesting in T4 sequence is the different patterns of pitch movement in the final syllable. For Beijing Mandarin speakers, the original HL tone is largely preserved and the little rising tail in the end may contribute to the perceivable question mood [41]. However, in Uygur learner's speech, the L tonal target is not fully realized in the final syllable and the pitch rises to a higher point, which differs from the distinctive tonal feature of T4.

4.2.2. Tonal pitch ranges

From Figure 4 (b), top line and bottom line develop in opposite directions. Top lines of TPRs for both groups change with the rising tendency after S3 and there are dramatically increases in the last syllable S10. For the bottom line of Uygur learners, the general trend is falling gradually and the line is raised in the last prosodic word. The bottom line of Mandarin speakers, however, falls in a zig-zag way and reaches the lowest point in the end of intonation. Therefore, the TPRs in Mandarin interrogative intonation by Uygur learners tend to expand like Mandarin speakers but such tendency is less distinctive since their rising top line and falling bottom line both change in smaller degrees.

Table 1 shows that in interrogative intonation, the difference between two top lines tends to decrease but is not eliminated along with utterance since ΔT after S3 declines but is always above 1.00 st. ΔB are enlarged especially in the second half of intonation, for example, S6 (2.09 st), S9 (2.07 st) and S10 (3.10 st). The scales of TPR in S6 and S10 are also smaller than Mandarin speakers with ΔR at -0.55 st and -2.08 st respectively, which implies that the TPRs at the end of last two words are not fully expanded by Uygur learners.

5. Discussion

In the realizational dimension of intonation, differences in the prosodic encoding of Mandarin intonation between Uygur CSL learners and Beijing Mandarin speakers are found in general patterns of pitch movements and pitch range. In Mandarin declarative intonation by Uygur learners, tonal targets of word-final syllables are not fully realized in T2, T3 and T4 sequences with smaller changes between high and low points. The TPRs are narrowed gradually similar to Uygur declarative intonation. In Mandarin interrogative intonation, the original falling shape of T4 of sentence-final syllable is not preserved, while TPRs are expanded across intonation assimilated to Beijing Mandarin speakers. There are increasing deviations in bottom line of both Mandarin declarative and interrogative intonations. In addition, there are deviations at prosodic word-final position. The TPRs of last syllable in prosodic words from Uygur CSL learners are expanded similarly to Mandarin speakers in two types of intonations but the degree is smaller.

Based on the observations of L1 intonation by Uygur CSL learners and the differences in Mandarin intonation between two groups, evidence for the interactions of L1 and L2 intonations assumed in LILt is found. The interactions derive from differences between two intonations in using pitch for prosodic encoding and affect the production of L2 intonation accordingly in both declarative and interrogative intonations. In the non-tone language Uygur, the rises and falls of pitch are related to the raising and lowering of pitch register and H or L targets correspond to pitch accents and boundary tones. Therefore, Uygur CSL learners tend to deviate from Chinese speakers in T2, T3 and T4. As to the differences in pitch range, top and bottom lines in Uygur intonation tend to change in the same trends, while in Mandarin intonations the two lines tend to develop separately as stated in [14]. Thus, the trends of two lines by Uygur learners both deviate from Mandarin speakers. Moreover, their TPRs in Chinese intonation expanded on a smaller scale may stem from the pattern of prosodic boundary marking in L1 intonation that the raising pitch register is preferred instead of expanding pitch range.

6. Conclusions

Based on the framework proposed in LILt to compare L1 and L2 intonations and predict production difficulties, this study investigates the prosodic encoding of L1 intonation by Uygur CSL learners and Mandarin intonation by Uygur learners and Beijing Mandarin speakers. It is found that, for Uygur CSL learners, pitch movements are employed better in the prosodic encoding of Mandarin intonation, while the change patterns of top and bottom lines of TPRs are unstable. For example, TPRs in declarative intonation tend to narrow down, which is assimilated to L1 intonation. Different from L1, TPRs across Mandarin interrogative intonation have an increasing tendency as Mandarin speakers but is less in degree, which indicates the mutual effects of both L1 and L2 intonations.

Therefore, in addition to realization of lexical tonal targets such as T4 in the final syllable of interrogative sentence, Uygur CSL learners may have difficulties in the manipulation of TPRs. The TPRs of syllables in the end of prosodic words that are not fully expanded and the overall higher level of bottom line also give rise to their perceivable non-native accent in Mandarin intonation. In further study, prosodic structure will be considered to compare L1 and L2 intonations in other dimensions in LILt. More Uygur CSL learners with different Chinese proficiency will also be involved to investigate the effects of L2 proficiency.

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