Prosody Transfer and Suppression: Stages of Tone Acquisition

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Abstract

This study investigates how native English speakers acquire Mandarin lexical tones, and whether they can express declarative and question intonation in a tone language. Production errors suggest three stages of tone learning. The first stage is characterized by a high error rate resulting from prosody transfer. The second stage shows moderate success in the suppression of L1 prosody especially in the utterance-initial positions. In the third stage, the error rate is low and the error patterns suggest that it is difficult to maintain tonal contrast in unstressed positions and with question intonation. Both male and female learners in general succeeded in suppressing declarative intonation but all female learners in the study failed to suppress question intonation. No learners in this study succeeded in using native-like declination for statements.

Index Terms: Tone acquisition, tone error pattern, prosody transfer, L1 prosody suppression

1. Introduction

The acquisition of lexical tone is a dynamic process where a second language (L2) learner adjusts to a situation where the fundamental frequency ($f_0$) channel is used to encode lexical information in addition to paralinguistic information. Doing so requires the enhancement of the existing language faculty in the brain and the recruitment of additional neural and cortical areas [1, 2, 3, 4], which poses an interesting challenge to L2 learners.

Transferring selective properties of the first language (L1) into L2 is a strategy commonly employed by L2 speakers [5, 6], and subtle cues of L1 prosody may persist in the speech of fluent L2 learners, contributing to the perception of foreign accent [7]. Surprisingly, [8] did not find strong evidence of prosody transfer from English speakers learning Mandarin. They hypothesized that learners had limited attention span, and the high demand of lexical tone learning trumped the paralinguistic function of intonation. [9], in contrast, did find evidence of English-to-Mandarin prosody transfer.

The current study revisits the issue of prosody transfer with attention to individual differences, investigating how native English speakers acquire Mandarin lexical tones, and whether they express declarative and question intonation while still producing correct tones.

Production errors suggest three stages of tone learning. The first stage is characterized by high error rate resulting from prosody transfer. The second stage shows moderate success in the suppression of L1 prosody especially in the utterance-initial positions. In the third stage, the error rate is low and the error patterns suggest that it is difficult to maintain tonal contrast in unstressed positions and with question intonation. Both male and female learners in general succeeded in suppressing declarative intonation but all female learners in the study failed to suppress question intonation. No learners in this study succeeded in using native-like declination for statements.

2. Experiment Design

Digits and phone numbers in Mandarin tone 1, the high level (H) tone, were chosen as the experimental materials in consideration of ease of production, the learner’s vocabulary size and their command of grammar, as well as whether the same text can be naturally expressed both in declarative and question intonation.

Among four Mandarin lexical tones, tone 1 is the easiest for L2 learners to master [10]. In terms of motor control, simulation models by [11] showed that a sequence of Mandarin tone 1 requires the least articulatory effort. Additionally, English speakers are capable of producing monotone English speech which has $f_0$ contours that are similar to that of a Mandarin tone 1 sequence. Hence, tone errors in tone 1 sequences are more likely to be cognitively, rather than articulatorily based.

Telephone numbers were chosen to test utterance-level tone production because it can be used to convey declarative and question intonation without additional lexical items in both Mandarin and English. Furthermore, a ten-digit US telephone number in the format of ddd-ddd-dddd includes three phrases with at least three digits per phrase, allowing for the comparison of utterance initial, medial and final phrases, as well as phrase initial, medial and final syllables.

2.1. Subjects

Eight subjects were recruited to participate in the study. Two were native speakers of Chinese (1 male, 1 female). They served as the control group. Six L2 learners of Mandarin (3 male, 3 female) were recruited. They all spoke English natively. Among them, two (1 male, 1 female) were bilingual and had exposure to a tone language at home. One spoke Vietnamese and the other Cantonese. At the time of the recording, four learners were taking First Year Chinese (the second semester) and two were taking Second Year Chinese (the fourth semester).

2.2. Material

The experimental stimuli includes Chinese digits 1, 3, 7, 8 read in isolation and a digit string 338-811-3783 san1 san1 ba1-bal yil yil-san1 qi1 bal san1 in the format of a telephone number. This string was randomly generated from the tone 1 dig-
Table 1: Background and tone production error rate from all learners.

<table>
<thead>
<tr>
<th>Language</th>
<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>F</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Yr of Study</td>
<td>1</td>
<td>E+V</td>
<td>2</td>
</tr>
<tr>
<td>% Error in Digit</td>
<td>56%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>% Error in Utt.</td>
<td>98%</td>
<td>45%</td>
<td>40%</td>
</tr>
<tr>
<td>Utt. Dur (seconds)</td>
<td>5.73</td>
<td>4.81</td>
<td>5.00</td>
</tr>
</tbody>
</table>

2.25 seconds and 2.62 seconds. That is about twice as fast as monolingual English students. However, their speaking rate were faster compared to monolingual speakers with comparable error rates.

A logistic regression model followed by ANOVA was conducted predicting the tone production outcome (correct/incorrect) from sentence position (1 to 10), intonation type (declarative and question), gender and year of study and the interaction of position and gender. There were significant main effects of position ($p < 0.0001$) and gender ($p < 0.00001$). The effects of intonation type and year of study were not significant. There was a significant interaction of position and gender ($p < 0.00001$).

4. Discussion

4.1. Production by native speakers

Native speaker’s production is used as the gold standard against which L2 production is evaluated. Figure 1 shows averaged $f_0$ contours from the female native speaker saying phone numbers
4.2. Production by learners

Learner’s error rate is a good predictor of error type. One possible explanation is that learners go through predictable developmental stages of prosodic learning, and each stage is associated with characteristic error types. Naturally, early learning stages imply more errors, hence the correlation between error rate and error type. Table 1 sorts learners by error rate. Using the gaps in their error rate as the cut-off points, we combined learners into three groups as shown in Table 1, and report their error rate by sentence position in Figure 2 together with representative pitch tracks from each group in Figure 3, where averaged pitch tracks of the declarative sentence are plotted in filled circles and question in open circles.

4.2.1. Stage I: Prosody Transfer

Stage I represents the initial learning stage where tone error rate is high. Error analysis shows that the errors reflect L1 prosody transfer.

An example of Stage I production is shown in the top panels of Figures 2 and 3. Figure 2 shows 100% error in most sentence positions and Figure 3 shows that the digit string production is dominated by an English-like alternating pitch pattern. The speaker consistently used a falling pitch (H+L) and a rising pitch (L+H) to convey statement and question, respectively.

This speaker was able to produce correct tones for each of the Mandarin digits in isolation, demonstrating a knowledge of both tone shape and lexical tone association, though her performance was unstable even in monosyllabic production.
4.2.2. Stage II: Suppressing L1 Prosody

In Stage II, error rate reduced considerably both in monosyllabic production and in sentence production. Learners were able to suppress L1 prosody occasionally and have better control of tone production early on in an utterance. However, they were not able to maintain consistent performance throughout the sentence even though in this experiment the target tones are all the same. The English-like alternating pitch pattern surfaced sporadically in the later part of the utterance.

The middle panel of Figures 2 combines data from three learners with sentence error rate from 20% to 45% and plot them by sentence position. The first two syllables of the digit string have the lowest error rate, while the 5th digit, being in the medial syllable of a medial phrase, has the highest error rate. Both positional dependent error patterns may be related to attention [15].

The middle panel of Figures 3 shows averaged pitch tracks from a male speaker in this group. This speaker typically had correct tone production in the beginning and the end of the utterance, though he was unable to convey the distinction between declarative and question intonation.

4.2.3. Stage III: Stress and Intonation Type

In Stage III, learners had good command of lexical tone shapes, as shown in the 0% tone production error in digits produced in isolation. Tone in sentence production was good too, with only occasional errors.

The bottom panel of Figures 2 combines data from two learners in this group. There were no errors in the first two syllables of the digit string. Error rates in other positions were low but the medial positions of phrases still posed problems, where the pitch pattern resembles English unstressed syllables. A possible explanation is that the learners were comfortable with the production of connected speech but were affected by the stressed/unstressed distinction in English, while speakers in Stages I and II were not fluent enough to express the stress/unstress contrast. Interestingly, the error rate in the utterance-final position did not show comparable improvement from Stage II. Error analysis show that most Stage III errors in this position came from female learners using the rising pitch movement (L+H) for question intonation. It appeared that female speakers pay more attention to sentence level prosody. In an attempt to convey question intonation but unable to do so with correct tones, they made mistakes by transferring question intonation from English and overwrote lexical tones. Male learners did not make tone errors in this position, but they also didn’t differentiate question and statement intonation. No errors were found in the production of statement. There was no evidence that either female or male learners transferred English statement intonation to Mandarin.

5. Conclusions

This study investigated L2 Chinese learners productions of Mandarin high level tones in monosyllables and in utterances. The results identified several stages of prosody learning with characteristic error patterns. L2 errors reveal some aspects of English prosody that play a dominant role in L1 to L2 prosody transfer, as well as the capability to suppress L1 prosody in more advanced learners. The findings have implications to the teaching and learning of a second language, as proper prosody control is essential to effective speech communication.

Brain imaging research found a left hemispheric advantage among native and bilingual Mandarin speakers processing Mandarin lexical tones, but not for nonnative speakers, though tone learning was associated with an expansion of neural process within existing language-related areas. It is possible that the three stages of prosody learning proposed here might be associated with different activations in the brain. We hypothesize that learners in different learning stages would exhibit a quantitative difference in the neural correlates and we plan to pursue this area of study in the future.

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7. References