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Title: Evaluating the Effects of Perceptual Training on the Application of the Mandarin Tone Sandhi Rules by English Speakers

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Biodata

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Abstract

Application of the tone sandhi rules is a widely studied topic in speech production, but the production data have rarely been perceptually evaluated. Meanwhile, whether perceptual training improves speech production at the suprasegmental level remains a question. Adopting the approach of perceptual evaluation, this study examines the effects of perceptual training on the Mandarin tone sandhi rule application by ten American English speakers. All the participants attended a pre-training recording session, a short-term laboratory training session, and a post-training recording session. Ten native speakers of Beijing Mandarin also participated in the recording as a control group. There were 192 target stimuli, with both real and wug words in each recording session. In the training session, the participants were presented with auditory and visual inputs of Mandarin tone sandhi rules, which were followed by an identification test to evaluate the training. Two trained Mandarin-speaking linguists first manually segmented the target syllables, normalized the intensity at 55 dB, anonymized the participants, and then performed the perceptual evaluation of each target syllable on a 101-point scale. A significant effect of perceptual training was found on the half-third sandhi rule, but not on the third tone sandhi. The roles of familiarity (trained versus untrained words) and context (real versus wug words) on the training effect were also investigated.

Keywords:

tone sandhi, perception and production, perception training, perceptual evaluation

Highlights

- Tone sandhi rule application was perceptually evaluated.
- The half-third sandhi rule improved after training.
- The third tone sandhi rule showed no improvement after training.

Introduction

As a tonal language, Mandarin discriminates lexical meanings by tones (Chao, 1948):

Tone1 (T1) high-level (55) “ma” (mother)
Tone2 (T2) high-rising (35) “ma” (hemp)
Tone3 (T3) low-dipping (213) “ma” (horse)
Tone4 (T4) high-falling (51) “ma” (to scold).

There are two rules of tone sandhi in Mandarin (Zhang & Lai, 2010):

- ***Third tone sandhi rule***:
  T3 (213) →T2 (35)/ T3 (213)
  lau 213 - pan 213 →lau 35 - pan 213 “boss”
- ***Half-third sandhi rule***:
  T3 (213) →21/ {T1(55), T2(35), T4(51)}
  lau 213 - ʂi55 →lau 21 - ʂi55 “teacher”
  lau 213 - liəŋ 35→lau 21 - liəŋ 35 “old age”
  lau 213 - xua 51→lau 21 - xua 51 “old say-ing”

Application of tone sandhi rules is a widely studied topic in speech production, and it has been suggested that adults can acquire non-native tonal contrasts through perceptual training (Wayland & Li, 2008; Cooper & Wang, 2013; Antoniou & Chin, 2018). However, the production data have rarely been perceptually evaluated, or have only been evaluated in isolation (Wayland, 1997). Adopting the approach of perceptual evaluation, this study is a pioneering attempt to examine the effects of perceptual training on Mandarin tone sandhi rule application by ten American English speakers.

This research addresses the following research questions:

(1) Does perceptual training improve tone sandhi rule application by English speakers?

(2) Do perceptual training effects work equally on the two sandhi rules?

(3) What are the roles of familiarity (trained versus untrained words) and context (real versus wug words) on the training effect?

Methodology

Participants

Ten native American English (AE) speakers (seven females; mean age ± SD: 21.9±1.85) participated in the study. They started their formal Mandarin learning at an average age of 17.8 (±2.25), and the average length of learning was 3.6 years (±1.37). Ten native speakers of Beijing Mandarin (six females; age: 26.7±5) were recruited as the control group, who had lived in Beijing for most of their lives (23.1±3.54 years). No hearing or speech problem was reported.

Stimuli

For the recording, we designed both real and wug disyllabic words, following the conventions in Zhang and Lai (2010). There were different types of wug words, but in our analysis reported here, we merged them into the wug word group. In total, there were 192 target stimuli with all possible tonal combinations and another 192 filler words to disguise the purpose of the experiment. All monosyllabic stimuli used to elicit speech production were read

by a female native Mandarin speaker born in Beijing, and T3 was pronounced as a full tone with a falling-rising f0 contour. The same sets of stimuli were used in pre- and post-training recording sessions. In total, there were 5,760 target syllables (192 syllables *10 subjects * 2 times + 192 syllables *10 subjects).

Also, six real words were used in the perception training and the follow-up identification test after the training. Three of them applied the third tone sandhi rule (T3+T3: e.g., /məi/ /xau/ '美好'), and the other three applied the half-third sandhi rule (T3+T1: e.g., /ʂʷəi/ /tɕəŋ/ '水晶'). A total of 72 tokens of the six words produced by five native Mandarin female speakers was adopted in the training session. Meanwhile, there were also 72 synthesized tokens without tone sandhi as the f0 contours of the sandhi syllables were replaced by the speakers' own T3 production in isolation.

Procedures

Recording

Before the recording, there was a practice session, in which the participants were asked to familiarize themselves with the materials and were then tested by dictation to ensure their basic knowledge of Mandarin disyllabic pronunciation and phonetic symbols (*Pinyin*). During the recording, the participants heard two monosyllables together with their characters (if available) and phonetic symbols presented on the screen in E-prime (Schneider, Eschman, & Zuccolotto, 2002), and were instructed to produce them as one disyllabic word. At the same time, they were recorded in Praat (Boersma, 2002) on another PC and were allowed to correct themselves. There were 24 blocks, the order of which was counterbalanced across participants. The procedures were the same for pre- and post- recordings.

Perceptual training

The AE participants attended the short-term laboratory training on Mandarin tone sandhi rules between the pre- and post- recording sessions. During the training, there were auditory and visual explanations of tone sandhi rules, as well as an auditory-only practice. The training was accompanied by visual f0 contours as in Figure 1 (without tone sandhi) and Figure 2 (with tone sandhi) (Chen, He, Yuen, Li & Yang, 2017) displayed in the explanation part. There was an identification test after the training. Trainees were asked to identify trials they heard and press "A" and "L" for correct and incorrect respectively. Feedback with accuracy and reaction time was immediately presented after each press. The ten trainees in the current study obtained an accuracy of 60% or above in the test.

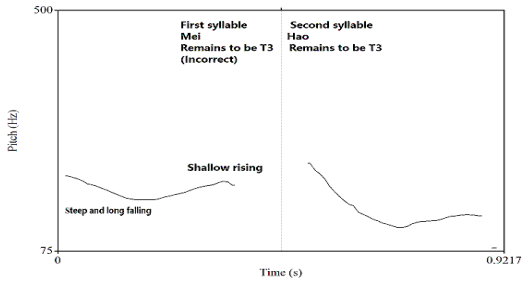

Figure 1. F0 contour of "/məi3/ /xau3/" without tone sandhi

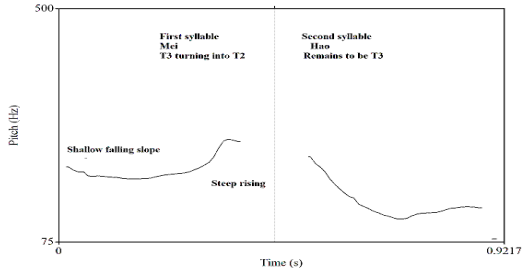

Figure 2. F0 contour of "/məi3/ /xau3/" with tone sandhi

Perceptual rating

All speech samples were first manually segmented, normalized to 55 dB and anonymized. Two trained Mandarin-speaking linguists then performed the perceptual evaluation of each target syllable on a 101-point scale. The raters were instructed to evaluate the realization of tones and avoid the effects of consonants and vowels.

Data analysis

In total, there were 11,520 rated samples (5,760 monosyllabic syllables * two raters) which included 2,880 samples applying the third tone sandhi rule and 8,640 samples applying the half-third sandhi rule. The Pearson correlation coefficient ($r=0.686$, $p<0.001$) suggests that the ratings by the two raters were highly correlated and were thus consistent. A paired samples *t*-test was adopted to examine the differences between the pre- and post-tests. The following section presents the results based on the three factors we investigated: two tone sandhi rules (half-third sandhi rule vs. third tone sandhi rule), familiarity of the words (trained words vs. new words) and lexical meaning (real words vs. wug words).

Results

The Mandarin half-third Sandhi rule

For the half-third sandhi rule, there was significant improvement ($p<0.001$) of the AE from the pre-test ($M=64.028$) to the post-test ($M=70.790$) as shown in Figure 3. There was no significant difference in the trained and new words in both the pre-test ($p=0.929$) and the post-test ($p=0.124$), but a significant improvement was found for trained words ($p=0.013$) and new words ($p<0.001$) after the perceptual training. Also, no significant difference was found in the real and wug words in both tests ($p=0.873$ for the pre-test; $p=0.171$ for the post-test). However, the training effects were significant for both real words and wug words ($p<0.001$ for both conditions).

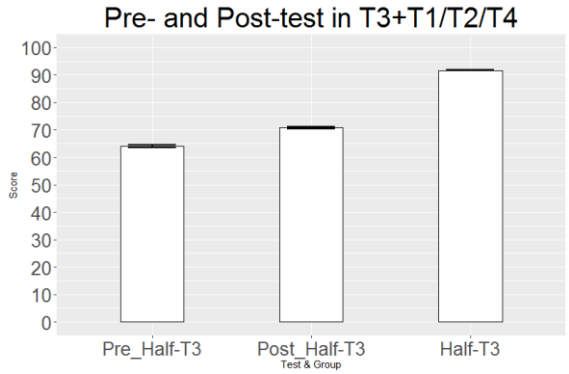

Figure 3. The overall scores for the half-third sandhi rule

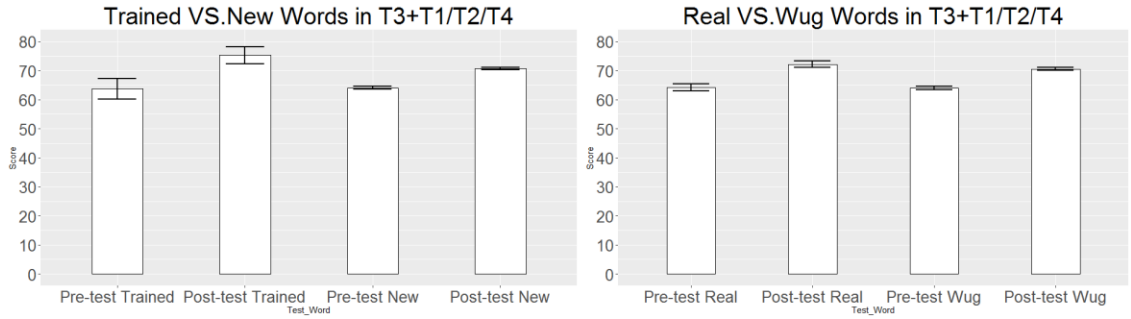

Figure 4. Mean scores of trained vs. new words and real vs. wug words

The Mandarin third tone sandhi rule

For the third tone sandhi rule T3+T3, the mean scores of AE decreased slightly from 72.51 in the pre-test to 70.53 in the post-test (p=0.070) as suggested in Figure 5. The performance of AE was considerably inferior to native Mandarin speakers (M=90.35, p < .001). The difference between the trained and new words was insignificant in the pre-test (p=0.727) but was significant in the post-test (p=0.020). In terms of trained words, the AE group did not show any significant difference in the pre-test (M=73.42) and in the post-test (M=76.47, p=0.409). For new words, the scores were lower in the post-test (M=70.13) than in the pre-test (M=72.45, p=0.420) in the AE group as shown in Figure 6 (left). There was no difference between the real and wug words in both the pre-test (p=0.074) and the post-test (p=0.605). As presented in Figure 6 (right), the scores of both real vs. wug words decreased from the pre-test to the post test, but the differences did not reach significance (p=0.142 for the real words and p=0.176 for the wug words).

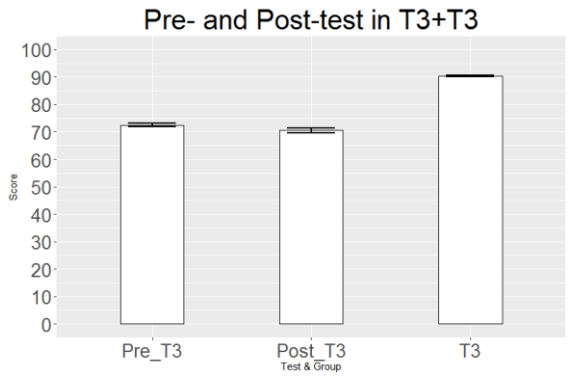

Figure 5. The overall scores for the third tone sandhi rule

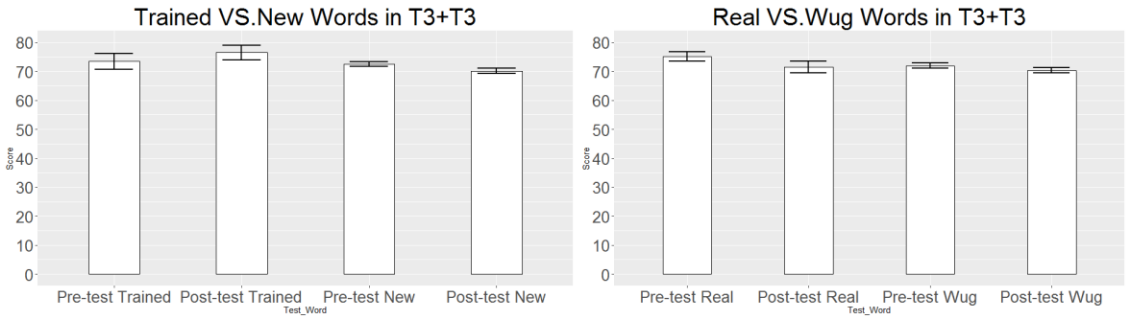

Figure 6. Mean scores of trained vs. new words and real vs. wug words

Discussion and Conclusion

For non-tonal English speakers, perceptual training may facilitate the transfer to speech production with half-third tone sandhi (T3+T1/T2/T4). This result is consistent with the evaluation of tonal Cantonese-speaking learners of Mandarin (Li, Yang, & Chen, 2018). However, the familiarity with words and lexical meaning of stimuli have little effect on the application of half-third tone sandhi rule for native English-speaking leaners of Mandarin. Unlike Cantonese trainees, who prefer to adopt the half-third sandhi rule with a lexical mechanism (Li, et al., 2018), English speakers tend to apply this rule with a computational mechanism.

On the other hand, the tone production in T3+T3 may not be improved by short-term perceptual training for English speakers in the current study. The evaluation of trained words, however, is significantly superior to that of the new words in the post-test. This preference indicates that perceptual training can play a role in applying the third tone sandhi rule in the circumstance of more exposure to the words for non-tonal speakers. Therefore, the current study shows that native English-speaking Mandarin leaners, without tonal experience in their first language, can improve their tone sandhi production, especially for the more phonetically motivated half-third tone sandhi rule.

Acknowledgements

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References

Antoniou, M., & Chin, J. L. (2018). What can lexical tone training studies in adults tell us about tone processing in children?. *Frontiers in Psychology*, *9*, 1.

Boersma, P. (2002). Praat, a system for doing phonetics by computer. *Glot International*, *5*.

Chao, Y. R. (1948). *Mandarin primer: An intensive course in spoken Chinese*. Harvard University Press.

Chen, S., He, Y., Yuen, C. W., Li, B., & Yang, Y. (2017). Mechanisms of tone Sandhi rule application by non-native speakers. *Proc. Interspeech 2017*, 1760-1764.

Cooper, A., & Wang, Y. (2013). Effects of tone training on Cantonese tone-word learning. *The Journal of the Acoustical Society of America, 134*(2), EL133-EL139.

Li, B., Yang Y., & Chen S. (2018). Perceptual evaluation of Mandarin tone Sandhi production by Cantonese speakers before and after perceptual training. In *Proceedings of the 32nd Pacific Asia Conference on Language, Information and Computation*. Hong Kong, China.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime: User's guide*. Psychology

Software Incorporated.
Wayland, R. (1997). Non-native production of Thai: Acoustic measurements and accentedness ratings. *Applied Linguistics*, *18*(3), 345-373.
Wayland, R. P., & Li, B. (2008). Effects of two training procedures in cross-language perception of tones. *Journal of Phonetics*, *36*(2), 250-267.
Zhang, J., & Lai, Y. (2010). Testing the role of phonetic knowledge in Mandarin tone sandhi. *Phonology*, *27*(1), 153-201.