

LABIAL ACTIVATION IN PLOSIVES IN L2 ENGLISH BY MANDARIN SPEAKERS

Victor Wong^{*1}, Masha Chernets^{†1}, Ragul Loganathan^{‡1}, Dayeon Choi^{†1}, Amy Hong^{‡1}, Jiu Song^{†1}, Jahurul Islam^{♣1}

¹ Department of Linguistics, University of British Columbia, Vancouver, Canada

1 Introduction

An individual's acquisition of their second language (L2) is generally established to be influenced by their native language's (L1) phonological systems [1]. This concept is referred to as language transfer, or more specifically, in the case of pronunciation and sound systems, a phonological transfer. Mandarin and English have distinctly different phonological systems and constraints. Standard Mandarin features vowel (V), and more commonly, consonant-vowel (CV) syllable structures, with the default being syllable-final vowels, with the exception of three consonant codas: [n, ŋ, ɲ] [2]. Mandarin does not have oral voiced plosives, unlike English. Mandarin speakers' acquisition of codas in English syllables is affected by coda length, and possibly explained by linguistic constraints such as L1 transfer [3]. However, voiced bilabial plosives do not appear in L1 Mandarin, L2 English speakers navigate this matter by developing alternative phonological approaches in speech. These adaptations may demonstrate negative phonological transfer, where L2 learners apply familiar phonetic patterns from their native L1, leading to variations in L2 speech [4]. We hypothesize that L1 Mandarin-L2 English speakers will show greater orbicularis oris muscle activation for /p/ than for /b/ since Mandarin speakers have more training in producing /p/. We further predict that the difference of orbicularis oris activation in /p/ vs. /b/ will be larger at word-final position, where /b/ faces a dual disadvantage: challenges of coda position and the absence of /b/ in the Mandarin phonological system.

2 Method

The study analyzed 20 speakers (5 M and 15 F), consisting of 12 L1 English and 8 L1 Mandarin-L2 English speakers, who were gathered through UBC's Linguistic SONA System. All participants were undergraduate students and were aged between 18 and 23. Before participating in the study, participants were required to complete a language-based questionnaire to collect a self-report on their language background, fluency, and age of acquisition. Surface EMG measured the activation of the target orbicularis oris muscle during the production of /b/ and /p/ voiced and voiceless bilabial plosives as shown in Figure 1.

The experiment consisted of participants producing English sentence sequences that embedded the target sounds into scripted speech. Additionally, each participant was asked to

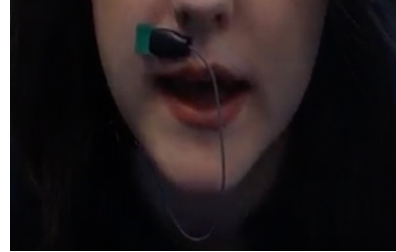


Figure 1: surface EMG attached to the orbicularis oris muscle

say nine words containing the voiceless bilabial plosive /p/ in word-initial, medial, and final positions, with each word-position group containing three words. Participants were asked to repeat the process for the voiced bilabial plosive /b/, saying nine words in word-initial, medial, and final positions, with each word-position group containing three words. To mitigate any potential order effects, participants' word trials of voiced and voiceless bilabial plosive counterparts were in randomized sequences. Additionally, R [5] was used to visualize data and run statistical analyses. The surface EMG data was then synced with the acoustic timestamps to ensure for accurate measurements. The dependent variable of this experiment was the muscle activation of the orbicularis oris muscle, whereas the independent variables for the between-subject design are the two group conditions. Group 1 consists L1 English speakers of and Group 2 containing L1 Mandarin-L2 English speakers. Further between-subject analysis investigated the effects of plosive activation and word-position for both /p/ and /b/ on the dependent variable.

3 Results

The results are shown in boxplots labelled with 3 positional conditions across word-initial (int), medial (med), and final (fin) for the bilabial plosives /b/ and /p/. Figure 2 shows muscle activation for /b/ and /p/ in all word positions split between all L1 English and L1 Mandarin-L2 English speakers.

Finally, Figure 4 shows (8) L1 Mandarin by-speaker boxplots. The boxplot showcases how word position being separated showcases different patterns of muscle activation across all L1 Mandarin speakers. Whereas shows muscle activation for all word positions for /p/ (Figure 2) and /b/ (Figure 3) compared across all L1 and L2 speakers.

A linear mixed-effects model was used to analyze the multiple independent variables and account for speaker variability and correlations within subjects. Additionally, the model analyzed the difference between the independent variables through the phones, word-position, and language groups. The L1 Mandarin- L2 English group, /p/ was significantly different ($p < .001$) from /b/, with the muscle activation increasing by 0.5663 for the voiceless bilabial plosive in this

* victorw1@student.ubc.ca

† anna.m.chernets@gmail.com

‡ ragul.loga@gmail.com

♣ dayeonchoi@gmail.com

‡ amy.hong726@gmail.com

† jessy.song.661@gmail.com

♣ jahurul.islam@ubc.ca

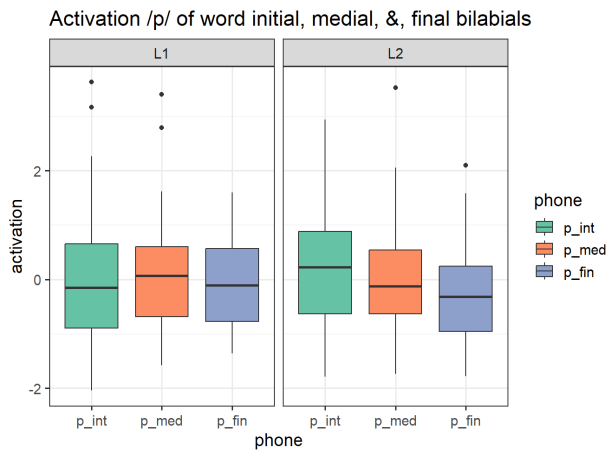


Figure 2: /p/'s muscle activation for all 20 participants

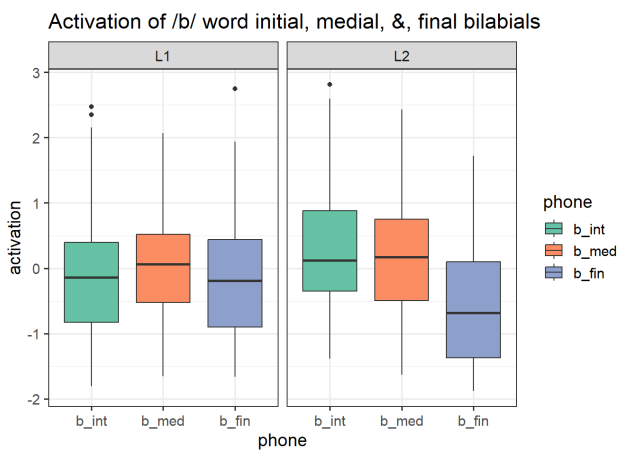


Figure 3: /b/'s muscle activation for all 20 participants.

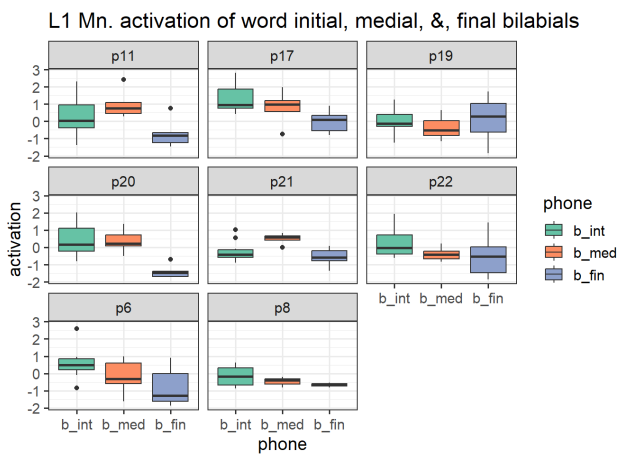


Figure 4: /b/'s muscle activation for (8) L1 Mandarin participants.

sample. The word-initial position for the voiced bilabial plosive was also found to have a statistically significant ($p < .001$) fixed effect on the orbicularis oris muscle activation, in which the /b/ phone resulted in an increase in activation of 0.7912 for this sample. The word-medial position was also found to have a significant effect on muscle activation in comparison to the word-final position. The word-final position for /b/ is thus found to cause a significant decrease in

muscle activation when compared to word-initial and word-medial positions. There was no statistically significant effect of the word position of the voiceless bilabial plosive /p/ for the orbicularis oris muscle activation. Furthermore, the L1 English speakers did not demonstrate a statistically significant difference between the voiceless /p/ and the voiced /b/ bilabial plosive. These individuals, similar to the L1 Mandarin-L2 English speakers, did not present a significant fixed effect of word position for /p/. In contrast to the L2 English speakers, the L1 English participants did not show a significant fixed effect of the word-initial position compared to the word-final position.

4 Discussion

The study examined the extent to which L1 phonological transfers from Mandarin speakers influence the muscle activation patterns in the production of English bilabial plosives /p/ and /b/, hypothesizing that L1 Mandarin-L2 English speakers would exhibit articulatory patterns suggestive of their L1 phonological restrictions. The results supported this hypothesis, showcasing significant differences in the activation of the orbicularis oris muscle between L1 English speakers and L1 Mandarin-L2 English speakers. The findings suggest that L1 Mandarin and L1 English speakers have different muscle activations of the orbicularis oris muscle. Overall, individual variations are important to highlight before concluding results because of the inter-speaker variance that cannot be seen when all speakers are combined, and the results showcase how to interpret these findings. Additionally, the results do support our hypothesis that there will be an L1 transfer of phonological rules from L1 Mandarin that would influence an L2 speaker's production of English sounds to follow L1 restrictions compared to that of an English L1 speaker. To expand upon these findings, future research could examine other muscles involved in the articulatory production of bilabial plosives, such as the depressor labii inferioris, to gain a deeper understanding of muscle activation. Overall, the study's findings regarding the word-position effect on muscle activation, and how different language backgrounds impacts English bilabial plosive production.

Acknowledgments

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