SPEAKING VERSUS SMILING: THE LABIODENTALIZATION OF BILABIALS IN KOREAN

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1 Introduction

Speech production generates many instances of conflict between synchronous movements in opposing directions. With the various processes that occur in the production of different sounds, suppression of certain movements over others is likely to occur. Previous research exploring this conflict focused on the labiodentalization of bilabial sounds (i.e., /p/ → [f]) during smiled speech in English. The conflict between the lip spreading/opening that occurs when smiling and the compression/closing of the lips required to form bilabial stop sounds (/p/, /b/, /m/) was found to result in labiodentalized variants of English bilabial stops [1].

While conflict between opposing movements occurring simultaneously has been found to occur in the production of English bilabials, it remains unclear whether this resolution is the result of a physiological or phonological (i.e., learned substitution) process, considering that the English inventory contains labiodental tokens. The present study thus undertakes an investigation of Korean, a language containing no labiodental tokens in its inventory. More specifically, the exploration of this language in particular presents an opportunity to explore whether labiodentals are naturally emergent or if they are learned over time. Moreover, whether the body resolves conflict between opposing movements through an additive mechanism (i.e., tug-of-war) or suppression of certain movements remains unclear. If labiodentalization were to occur in Korean, the ways in which speech postures interact with and conflict with speech sounds may be further explored.

2 Method

2.1 Video

Twenty-four videos of 26 native Korean speakers were selected from the video platform YouTube and examined for production of /m/, /b̥/, /pʰ/, and /p/. YouTube was chosen for its abundance of interviews and vlogs (i.e., video blogs), which provided a clear headshot of each speaker's face for natural running speech. All videos met the following criteria: only one speaker's face was shown per frame, each speakers' native language was Korean, and there were instances of both smiling and neutral faces while producing a bilabial sound. Portions of speech were manually coded as "smiled" or "neutral" based on the video.

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2.2 Analysis

Videos converted into WAV Audio files and transcripts containing bilabial phonemes were manually aligned at the sentence level using *Praat* [2]. Bilabial tokens were also manually aligned and annotated with their condition (i.e., neutral or smiled), phoneme, and token number.

The facial behavior analysis software *OpenFace 2.0* [3] detects facial action units (FAU) and calculates the degree of intensity of these FAUs. Using the timestamps extracted from *Praat* annotations, the degree of activation of the FAUs "lip corner puller" (which is activated during smiling) and "lip tightener" (which is activated during bilabial closures) were analysed using *OpenFace 2.0*. The annotated tokens were then extracted and manually coded as bilabial or labiodental.

3 Results

A total of 308 productions of labial phonemes were found from the 26 speakers, with 165 in the neutral condition and 143 in the smiled condition. Among the 143 labial phoneme productions found in the smiled condition, there were 26 cases produced as labiodental stops.

Table 1 summarizes the number of bilabial and labiodentalized realizations of each phoneme including /m/, /b̥/, /pʰ/, and /p/ produced in both neutral and smiled conditions. Figure 1 illustrates the ratio of labiodentalization of /m/, /b̥/, /pʰ/, and /p/.

Table 1: The number of each phoneme realized as a bilabial or labiodentalized closure in neutral versus smiled conditions.

Condition	Closure	/m/	/b̥/	/pʰ/	/p/
Neutral	# of Bilabials	98	51	15	1
	# of Labiodentals	0	0	0	0
Smiled	# of Bilabials	89	38	13	3
	# of Labiodentals	18	7	1	0
	Ratio of labiodentalization	0.2	0.18	0.08	0

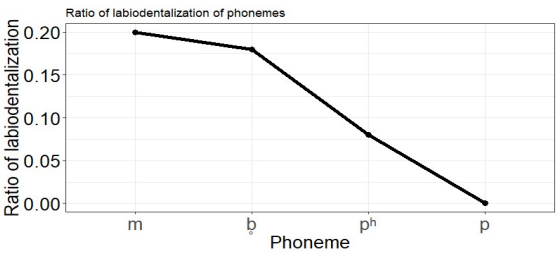

Figure 1: Ratio of labiodentalization of /m/, /b̥/, /pʰ/, and /p/.

The "lip corner puller" intensity 200 ms prior to and 130 ms following the release of labial productions, as seen in Figure 2, shows the greatest intensity when producing a labiodentalized closure in the smiled condition. Less intensity was observed when producing a bilabial closure in the smiled condition, and the lowest intensity was evident when producing a bilabial closure in the neutral condition. Additionally, Figure 3 presents the "lip tightener" intensity during the same period as shown in Figure 2. The greatest intensity was observed when a bilabial closure was achieved in the smiled condition. A lesser intensity was observed when producing a labiodentalized closure in the smiled condition and a bilabial closure in the neutral condition.

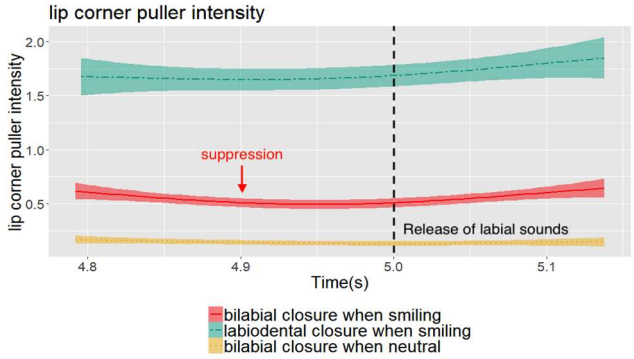

Figure 2: "Lip corner puller" intensity surrounding the release of labial closures.

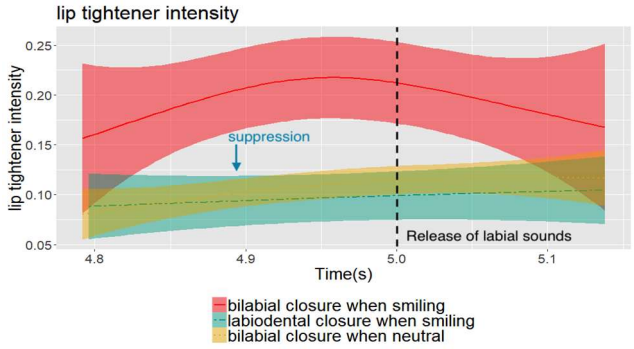

Figure 3: "Lip tightener" intensity surrounding the release of labial closures.

4 Discussion

Results shown in Table 1 reveal that labiodentalized bilabials are evident in Korean speech, which suggests that the smiling versus lip-closing conflict is resolved as a physiological process. Figure 1 further indicates that the greatest ratio of labiodentalization is observed in /m/ followed by /b̥/ and /ph/, while no labiodentalized /p/ was observed. Previous research found various intraoral pressures [4] and muscle activations [5] for /m/, /b/, and /p/ closures in an increasing order. Our results suggest that the frequency of labiodentalization decreases when stronger muscle force and intraoral pressures are required for bilabial segment production in Korean, which is consistent with the previous findings for English [6].

FAU intensity results indicate greater "lip tightener" intensity when producing bilabial closures in the smiled condition compared to the neutral condition, indicating that augmented lip closing force is required when smiling. Furthermore, greater "lip tightener" intensity is found in bilabial closures compared to labiodentalized closures produced when smiling, suggesting a suppression of lip closing force when a labiodental variant is produced while smiling. Regarding "lip corner puller" intensity, decreased intensity is observed when producing bilabial closures compared to labiodentalized closures in the smiled condition, indicating that the force of smiling gets suppressed with stronger lip closing force.

Regarding the limitations of this study, whether intensity of FAU could represent activation of certain muscles accurately remains unknown, and further studies could investigate the correlation between facial muscle activation and FAU.

5 Conclusion

Labiodentalization of bilabial stops when smiling in Korean points to a physiological rather than phonological resolution process. Our FAU results corroborate findings from the previous study in English, further suggesting that the smiling versus lip-closing conflict could be resolved via suppression of one or the other movement.

Acknowledgments

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