TIMING OF PERIORAL MUSCLE SUPPRESSION IN SMILED SPEECH

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1 Introduction

During speech production, temporally overlapping speech and non-speech movements can come into conflict [1]. How such conflicts are resolved remains poorly understood. For instance, during smiled speech, the simultaneous activation of facial-expression and speech-related lip movements can generate oppositions between Zygomaticus Major (ZM) and Orbicularis Oris (OO) muscles; ZM activation pulls the lips apart for the smile, while OO activation pulls the lips together for lip closure and rounding movements [1]. Previous research suggests that this conflict is resolved by suppression of either the smile or the lip closure movement [2]. However, the mechanism by which one or the other movement is selected for suppression, or by which this suppression takes place, remains unknown.

The present study aims to characterize the timing of the interaction that leads to this suppression, as well as the onset and length of suppression of smile when bilabial tokens are produced. Electromyography (EMG) sensors were used to measure ZM and OO activation during speech produced with neutral, smiling and laughing facial postures. Video recordings were processed using a facial tracking tool to corroborate EMG measurements and movement-based Facial Action Units (FAUs). This study seeks to analyze EMG and FAU signals to determine if they exhibit similar trends in muscle activity of the smile and lip closure, with earlier onset of changes observed in EMG signals.

2 Methods

2.1 Participants

Two female undergraduate students between the ages of 21 and 27 (M=24) from the University of British Columbia took part in the study. Both participants were native English speakers of North American English (NAE) as noted in a language background questionnaire

2.2 Experiment

This study's experimental design methodology was similar to Liu et al. [2] Two participants underwent a procedure in which EMG sensors were placed over their OO and ZM nerves.

Following the sensor placement, the participants were provided instructions to read a range of sentences incorporating the intended stimuli under three distinct facial conditions: neutral, smiling, and laughing. Concurrently, video recording was conducted to capture the participants' facial expressions, complementing the EMG recording. To synchronize the two recordings, the EMG recording commenced prior to the video recording, and in order to establish alignment, the sensors were lightly tapped three times in quick succession. This deliberate tapping induced a discernible impulse in the EMG recording, which could be correspondingly correlated with the tapping of the sensor visually captured in the video.

Figure 1: Emg sensor placement on the participant

The stimuli and sentences employed in this study were the same as those used in the study conducted by Liu et al. [2]. Participants were tasked with reading a total of 15 sentences, under three distinct facial conditions: neutral, smiling, and laughing. Each sentence featured a designated target word (see Table 1 in Liu et al. [2]) and was accompanied by an emoji, as illustrated in Figure 2. The sentences were presented to the participants in a random sequence, and they were explicitly instructed to assume the facial expression corresponding to the designated emoji before vocalizing the sentence. This procedure was repeated twice for each participant. Target sounds were annotated and EMG signal and video clip around the target sounds were extracted. Further, video clips were analyzed for facial action unit (FAU) activity using OpenFace 2.0 [3].

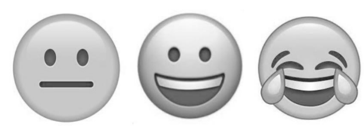

Figure 2. Emojis of neutral, smiling, and laughing

2.3 Results

OO activation and lip tightener intensity was measured by taking the normalized mean of all target tokens made by participants. The onset of bilabial closures are indicated by a dotted line in each figure. Sentences, indicated by a dashed line, began approximately seconds prior to bilabial closures in figures. Both neutral and smiling conditions produced OO activation captured by the EMG and FAUs intensity signals. The timing of the activation of the OO was however different among the two conditions being 133ms prior to the closure in the neutral condition and 156ms prior to the closure in the smiled condition. The OO reached a peak of activation at 128ms in the neutral condition and at the smiled condition. Prior to the bilabial closure the lip tightener rose 100ms in the neutral condition and 67 in the smiled condition. The OO peaks for neutral and smiling conditions are observed at 0 se

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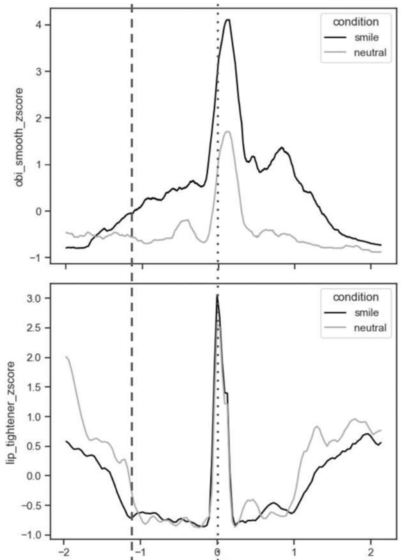

Figure 3: Mean normalized activation of the OO muscle (top) and intensity of the lip tightener FAU (bottom)

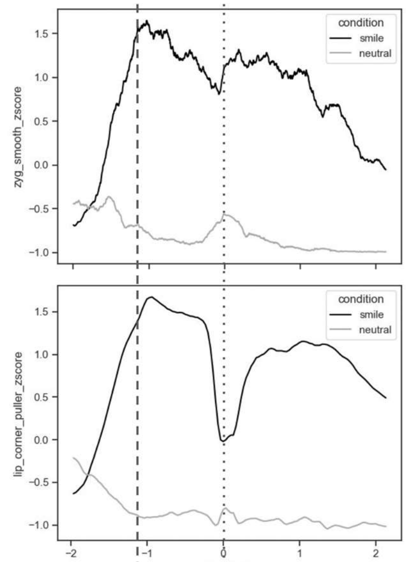

Figure 4: Mean normalized activation of the ZM (top) muscle and the intensity of the lip corner pull FAU (bottom)

In the neutral condition the intensity level reached 2.57 and in the smiled it reached 3.06. ZM activation and lip corner puller intensity was measured by taking the normalized mean of all target tokens made by participants. This is shown in Figure 4. Between the two conditions, neutral and smiled, greater intensity of both the ZM and the lip corner puller FAU intensity is shown in the smiling condition opposed to the neutral. The onset of ZM suppression 452 ms prior to the bilabial closure has an activation level of 1.28. Smiling suppression onset is demonstrated by the lip corner puller at 267ms prior to the closure with an intensity level of 1.4. Peak suppression is seen by the FAU at zero seconds with an intensity level of -0.02.

3 Discussion

Our results show the EMG signals and FAU signals exhibit similar trends in muscle activity of the smile and lip closure, with earlier onset of changes observed in EMG signals as expected. Both the OO activity and the lip tightener. FAU intensity illustrates a rise in lip activity prior to the lip closure in neutral and smile conditions, and an early rising onset is observed in the OO muscle activation. The ZM muscle activation and the lip corner puller FAU intensity present greater smile activity in the smiling condition, and show a suppression of smile occurring prior to the lip closure, with an earlier suppression observed in the ZM muscle activation. Moreover, the onset of such suppression occurs earlier than the onset of lip closure activity, illustrated as 294 ms in the muscle activation and 200 ms in the FAUs intensity, suggesting early planning in suppressing the smile. This finding is consistent with the observation in Liu et al. [2]. The onset of suppression illustrated by the lip corner pull FAU signal is comparable between findings of this study and Hung et al. [4].

The OO activity rises early and to a higher extent when producing bilabials in the smiling condition than the neutral condition, which agrees with findings observed in Sussman and Westbury [5] that earlier and greater activation for /u/ following /i/ than /ɑ/. However, the lip tightener FAU signal only exhibits higher intensity in smiling condition than the neutral, not an earlier rising onset associated with the smile.

Two key limitations were present for this study. First, a small sample size of two speakers were analyzed due to time constraints. Second, our video recording was set at a lower video quality of 30 frames per second (fps). Future research should involve a larger sample size with both male and female demographics and a wider age range when replicating this study. Recordings should also be processed at 60 fps or higher to obtain more accurate timing.

Acknowledgments

This project was funded by an NSERC Discovery grant.

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