Talking while smiling: Suppression in an embodied model of coarticulation

Yadong Liu[1], Terrina Chan[1], Gracellia Purnomo[1], Bryan Gick[1,2]
[1] Department of Linguistics, University of British Columbia, Vancouver, Canada
[2] Haskins Laboratories, New Haven, Connecticut, USA

Abstract. Previous research suggest speech coarticulation can be understood by superposition. However, whether suppression/augmentation of muscles is involved in simultaneous antagonistic movements remains unclear. This work examines activities of orbicularis oris and zygomaticus major while participants producing bilabial consonants under different facial expressions using electromyography. Results support superposition mechanism and show both suppression and augmentation of muscle when producing simultaneous antagonistic movements.

Introduction. Temporal overlap in movement control may be resolved by summing muscle activations, or "superposition" (e.g., Bizzi 1991). This has been suggested to be a valuable mechanism for understanding speech coarticulation (e.g., Joos 1948, Gick et al. 2013). Superposition can also involve commands to deactivate, known as inhibition or suppression (we follow the tradition in the speech literature of using the term "inhibition" to refer to a central neural inhibitory mechanism, and "suppression" to refer to the kinematic or muscle-level effects that may result from a neural inhibitory mechanism).

Suppression has long (if not widely) been discussed in the speech production literature, and may be essential to understanding how speech movements overlap in time. In discussions of velopharyngeal port (VPP) control, for example, Bell-Berti (1973) use electromyography (EMG) to investigate muscle activations in oral-nasal articulation, and found suppression of levator palatini (LP) at oral-nasal transitions and steep increase of LP activation at nasal-oral transitions. Benguerel (1977) observed LP suppression during nasal production in a VnV sequence. These studies suggest that, at least in part, nasalization involves not the activation of muscles, but rather an interruption of an ongoing set of activations. Tilsen (2019) incorporates neural inhibition as part of a model extending this to cases of phonological harmony.

The present study looks at another type of posture that interacts with speech movements: facial expression of emotion. Bilabial closure movements for /b, p, m/ are antagonistic with lip spreading/opening movements associated with smiling and laughing. A superposition model predicts that the outcome of such conflicts is determined by summing opposing forces (Gick et al., 2013). However, it is unclear whether the opposing activations in this case are simply additive or whether they show evidence of suppression/augmentation. Based on the previous VPP studies, we predict that there will be suppression of either opposing activation.

Methods. Fifteen undergraduate students from the University of British Columbia were recruited to participate in this experiment. Participants were video recorded and tasked to read aloud 31 different sentences, each containing one bilabial consonant (/b, p, m/), under three facial conditions (neutral, smiling, and laughing). Participants had EMG electrodes attached to their upper lip and cheek near the zygomaticus major (ZM) muscle to measure muscle activation for smiling, and near orbicularis oris (OO) to measure muscle activation for consonant production. Video data were analyzed for lip kinematics, and EMG data were analyzed for average muscle activation around lip closure across different tokens.

Results. Lip closure results indicate that labiodental stop variants occur more frequently for lower-force stops, such as /m/, under higher-force smile conditions, as in cases where the participant is laughing, as predicted. Preliminary EMG results from one speaker (Figure 1) show both augmentation and suppression of OO. When bilabial closure is achieved, increased OO activation is observed in laughing and smiling conditions, together with the increase of ZM activation. Also, OO activation drops when bilabial closure fails and labiodental closure is achieved, indicating OO suppression. These results suggest that both augmentation and suppression of OO is observed when summing opposing forces in such smile-lip closing conflict.

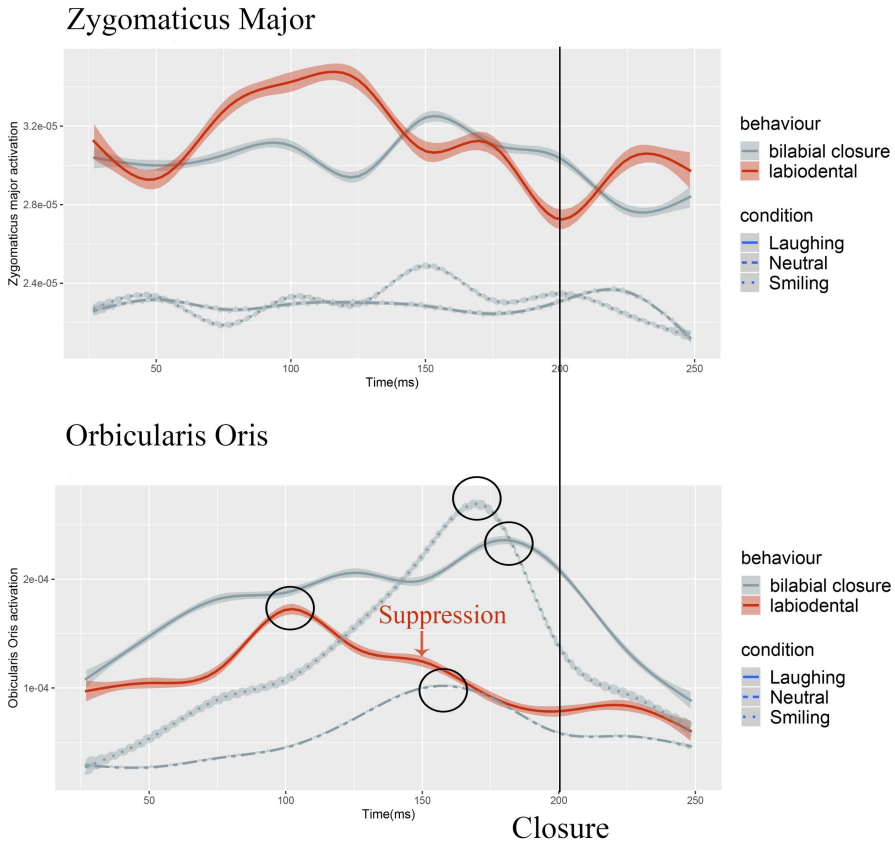

Figure 1. ZM and OO activation at bilabial phoneme production. Peaks of OO activation are circled.

References

Bell-Berti, F. (1973). The velopharyngeal mechanism: An electromyographic study.

Benguerel, A. P., Hirose, H., Sawashima, M., & Ushijima, T. (1977). Velar coarticulation in French: an electromyographic study. *Journal of Phonetics*, *5*(2), 159-167.

Bizzi, E., Mussa-Ivaldi, F. A., & Giszter, S. (1991). Computations underlying the execution of movement: a biological perspective. *Science*, *253*(5017), 287-291.

Gick, B., Allen, B., Stavness, I., & Wilson, I. (2013). Speaking tongues are always braced. *Journal of the Acoustical Society of America*, *134*(5), 4204.

Joos, M. (1948). Acoustic phonetics. *Language*, *24*(2), 5-136.

Tilsen, S. (2019). Motoric Mechanisms for the Emergence of Non-local Phonological Patterns. *Frontiers in Psychology* 10: 2143. DOI=10.3389/fpsyg.2019.02143