Supplementary Material for:

Engaging the articulators influences perception of concordant visible speech movements

Matthew Masapollo[1] & Frank H. Guenther[1,2]

[1] Department of Speech, Language and Hearing Sciences, Boston University

[2] Department of Biomedical Engineering, Boston University

Analyses of stimulus order effects

Previous research indicates that there are robust directional asymmetries in vowel perception, such that perceivers (both adult and infant) tend to perform better at discriminating a change from a relatively less to a relatively more peripheral vowel within articulatory/acoustic vowel space (as defined by *F*1/*F*2; Masapollo, Polka, Molnar, & Ménard, 2017). These directional effects have been reported to occur in unimodal audio-only, unimodal visual-only and bimodal audio-visual vowel perception (Masapollo, Polka, Molnar, & Ménard, 2017; Masapollo, Polka & Ménard, 2017; Masapollo, Polka, Ménard, Franklin, Tiede & Morgan, 2018). In two additional analyses reported here, we examined whether there was an effect of the direction of the vowel change on subjects' mean A-prime (*A'*) scores (Grier, 1971) during discrimination of both the dynamic (Experiment 1) and static (Experiment 2) facial displays.

Dynamic speech. In the first analysis with the dynamic visual displays, we compared subjects' mean *A'* scores for each vowel contrast (English [ɛ] – English [æ] vs. English /u/ – French /u) and condition (lip tube vs. bite block vs baseline) as a function of the direction of vowel change (less to more peripheral vs. more to less peripheral). On half of the different AX trials for each contrast, subjects were presented with a less peripheral viseme (i.e., English [u] or English [ɛ]) first followed by a more peripheral viseme (i.e., French [u] or English [æ]) second, whereas the remaining half followed the reverse order. Results indicated that, regardless of vowel contrast or condition, subjects performed better at discriminating the less to more peripheral vowel changes [M = .87; SD = .07] compared to the more to less peripheral vowel changes [M = .85, SD = .07], as shown by a main effect of order of order of vowel change [$F(1, 45) = 12.969$, $p = .001$, $\eta^2 = .224$]. There were no significant two-way or three-way interactions involving the direction of vowel change (effects > .10 in all cases). Thus, engaging the articulators does not appear to disrupt this "peripherality" effect, suggesting that it is not sensorimotor in nature.

Static speech. In the second analysis with the stilled facial speech images, we examined whether there was an effect of the direction of the vowel change. Masapollo, Polka, Ménard, Franklin, Tiede and Morgan (2018) recently reported that asymmetries in unimodal visual vowel perception occur with dynamically-articulating faces, but not when those same faces are shown under static conditions. Here, we also found no significant main effect of order of vowel change

[$F(1, 44) = 2.618$, $p = .113$, $\eta^2 = .056$]. There were also no significant two-way or three-way interactions involving the direction of vowel change (effects > .10 in all cases). This finding further bolsters the claim that the processes underlying asymmetries are sensitive to speech motion (Masapollo *et al*., 2018).

Supplementary References

Masapollo, M., Polka, L., Molnar, M., & Ménard, L. (2017). Directional asymmetries reveal a universal bias in vowel perception. *Journal of the Acoustical Society of America*, 141, 2857-2869.

Masapollo, M., Polka, L., & Ménard, L. (2017). A universal bias in vowel perception – by ear or by eye. *Cognition*, 166, 358-370.

Masapollo, M., Polka, L., Ménard, L., Franklin, L., Tiede, M., & Morgan, J.L. (2018). Asymmetries in unimodal visual vowel perception: The roles of oral-facial kinematics, orientation and configuration. *Journal of Experimental Psychology: Human Perception and Performance*, 44(7), 1103-1118.

Masapollo, M., Zhao, T.C., Franklin, L., & Morgan, J.L. (2019). Asymmetric discrimination of non-speech tonal analogues of vowels. *Journal of Experimental Psychology: Human Perception and Performance*, 45(2), 285-300.