Using real-time MRI to assess the development of jaw contribution in constriction formation synergies during early adolescence

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Articulatory synergies (Sorensen et al., 2019) in early adolescence are examined using real-time magnetic resonance imaging (MRI) in an exploratory case study of a male child speaker, and compared to those of 6 healthy adult speakers.

A real-time MRI recording of the child speaker at 12-years old and a recording of the same child speaker at 14-years old were considered, alongside recordings from 6 adult speakers, aged 18-36 years old. Data for this study were obtained according to the MRI data collection protocol of Lingala et al. (2016). Air tissue boundaries were determined using a semi-automatic procedure and articulatory models for each speaker were then developed by factor analysis of these boundaries (Toutios and Narayanan, 2015).

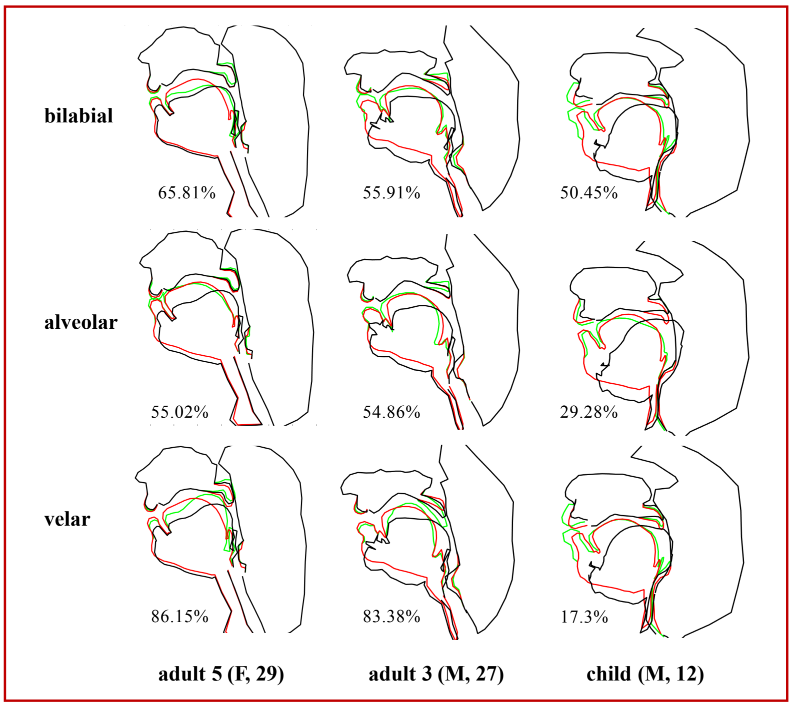

Figure 1: Example illustrations of the synergies involved in the productions of stop consonants in the sequences studied. The black line represents the vocal tract shape at the beginning of the movement (vowel); the green line represents the end of movement (consonant); the red line represents the jaw contribution to the movement. Percentages shown indicate biomarker values (smaller values correspond to greater jaw contributions).

The study analyzed two productions per speaker of the utterances /aka/ /aga/ /aba/ /apa/ /ada/ and /ata/. The procedure described in the study of Sorensen et al. (2019) was used to extract a biomarker characterizing the relative contributions of the jaw, tongue, and lips to the formation of vocal tract constrictions for the production of stop consonants.

Figure 1 shows example illustrations of synergies involved in the production of stop consonants by the speakers studied with the associated biomarker value. Figure 2 visualizes the values of the biomarkers measured. It can be observed that (a) the child speaker has greater jaw contribution during production of velar stops compared to the adult speakers, (b) the child speaker exhibits less jaw movement during alveolar and bilabial constrictions than in velar ones, and (c) the articulatory strategies for /aka/ and /aga/ become more similar with the development of the 12-year old to the 14-year old. At the moment, these observations do not correspond to specific hypotheses tested in a statistical framework but could guide future studies.

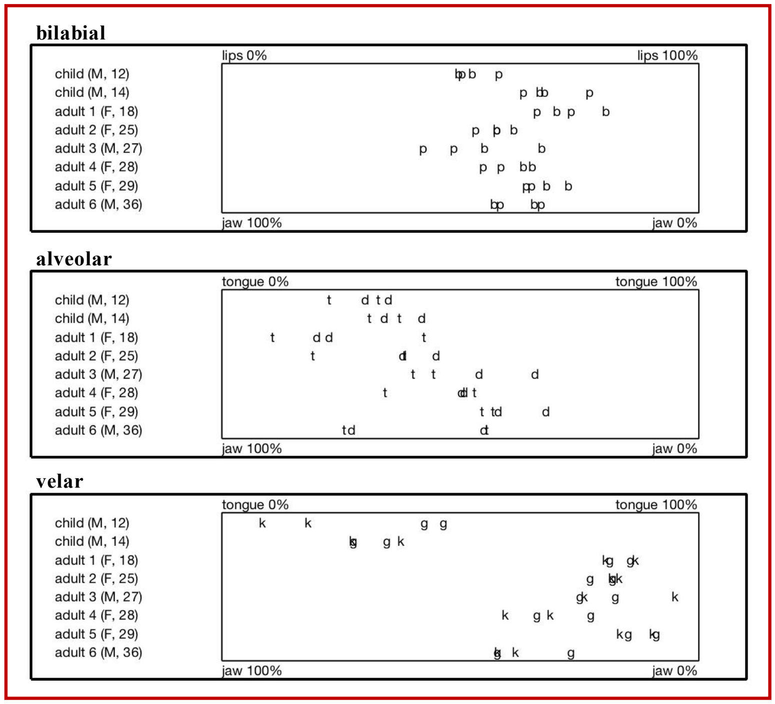

Figure 2: Biomarker values across the utterances studied.

Our findings suggest that for this child speaker there was a markedly greater contribution of jaw movement toward velar constrictions than in any of the adult speakers. However, this was not the case for bilabial and alveolar constrictions. This could be the result of different anatomical developments between the tongue dorsum, which contributes to velar constriction, and the tongue tip and lips, which contribute to alveolar and bilabial constrictions respectively. Perhaps, control of the tongue dorsum matures more slowly than the other articulators examined. Furthermore, the change towards similar articulatory strategies in /aka/ and /aga/ in the child speakers could reveal an increasing motor organization and maturation of speech motor control during early adolescence. This is consistent with previous studies that show a decreased variability in articulatory synergies through the progression towards adulthood (Walsh and Smith, 2002). Finally, the present study illustrates the potential of using real-time MRI as a non-invasive approach in examining the development of speech motor control.

References

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