Tracking development of somatosensory acuity: Age-based comparison of three measures

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Rationale. Many children with speech sound disorder (SSD) recover spontaneously or in treatment, but an estimated 25% of children with SSD show persisting errors past six years of age [1] and 1-2% persist with SSD in adolescence and adulthood [2]. Various sensorimotor skills are required to achieve typical speech production, but the trajectory along which individuals acquire such prerequisite skills is unknown. Knowing the developmental timeline of sensorimotor abilities will help researchers determine whether specific sensorimotor delays can predict persistent atypical speech patterns, which could in turn guide evidence-based assessment and treatment decisions for this clinical population.

Background. Speech production is guided by auditory and somatosensory targets that shape and update the motor plan through corresponding feedback channels [3]. The importance of somatosensory feedback has been documented in studies showing that somatosensory acuity influences speakers' degree of articulatory distinction between target sounds [4] and in studies where oral anesthesia or physical perturbations lead to reduced speech precision [5, 6, 7, 8]. However, minimal research to date has measured somatosensory acuity in children. In the current study, we administer three somatosensory tasks to ≈60 children (ages 9-15). We first ask whether there is relationship between age and somatosensory acuity in the child sample. We then ask whether our child participants and 20 female adults (ages 18-30) from a previous study [9] differ in somatosensory acuity.

Methods. (1) An oral stereognosis task [10] was used to measure tactile input received by the tongue. Participants used their tongue tip to identify a letter embossed on a plastic strip. The letter size increased following an incorrect and decreased following a correct response. The score is the average letter size of the correct responses, where smaller indicates higher acuity. See Figure 1 for a depiction. (2) A novel phonetic awareness task was used to measure the proprioceptive sense of articulator position. Participants were provided with a model and prompted to repeat 1-2 sounds (e.g., "Say 'ee' like in 'heat"') multiple times and answer a question about the sound/s. Questions involved classification of consonants as being produced with the front or the back of the tongue (n = 9) and identification of relative lingual position for vowel pairs (front versus back; high versus low; n = 27). Overall percentage accuracy is the outcome measure. See Figure 2 for a visual schematic of this task. (3) A bite-block task with auditory masking based on [11] was used to measure the ability to compensate for perturbation using only somatosensory

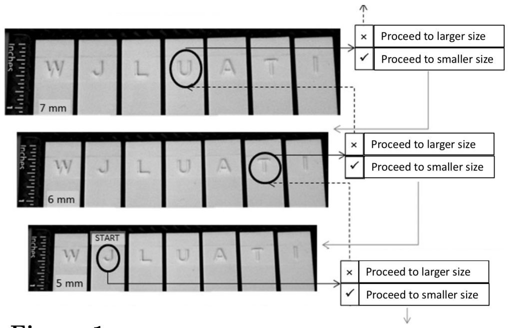

Figure 1: *Plastic letter strips in oral stereognosis task, adapted from Steele et al. [10] with permission.*

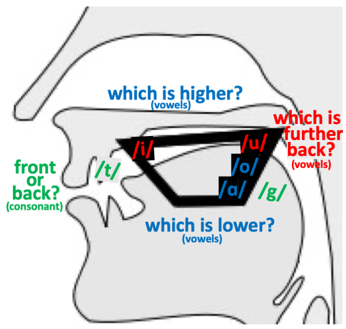

Figure 2: *Phonetic awareness task depicting prompts asking where the tongue is in oral cavity.*

feedback. Auditory masking featured a combination of babble via insert headphones and pink noise via bone conduction headphones; participants used visual feedback to maintain a low vocal volume to ensure full masking. At baseline, participants produced the vowels /i,æ,u,ɑ/ in the "hVd" context in random order. In the bite block phase, a tongue depressor was placed between the front incisors, horizontally to create a closed jaw for low vowels and vertically to create 1.75cm of jaw aperture for high vowels. The outcome measure is the difference in mean Euclidean distance in F1-F2 space between baseline and bite-block conditions for each vowel, where a smaller distance indicates greater compensation. See Figure 3 for a photo of this task.

Figure 3: *Bite-block setup with tongue depressor between front incisors with masking through air & bone conduction.*

Analysis. To determine whether there is an association between age and somatosensory acuity, we will examine linear regression models predicting each somatosensory measure from age. We will examine regression coefficients and R^2 values between models to determine the strength of each measure's relationship with age. To determine whether the child and adult groups differ in somatosensory acuity, we will run a two-sample t-test for each task, correcting for multiple comparisons. We hypothesize that somatosensory acuity will be predicted by age, and that the association will be strongest for the phonetic awareness task, where metalinguistic awareness may influence performance. We also hypothesize that adults will show greater somatosensory skill than children in all three tasks. We currently have collected measures from 19/20 adult participants and 37/60 child participants. We anticipate all data collection to be complete by April 2020.

Discussion. The current study will address an understudied research area by measuring somatosensory skill in child participants and comparing child and adult somatosensory performance. Both of these analyses have the potential to shed light on the developmental trajectory of skill in this domain. These developmental findings can inform future research in determining whether one task or a combination of the three tasks is best suited for measuring somatosensory skill in child populations. Finally, we plan to investigate the association between somatosensory skill and speech production ability in the current child sample and in an age-matched sample of children with persistent SSD in future studies. The current line of research has the potential to enable future researchers to use these measures in assessment and treatment planning for clinical populations.

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