TRACKING DEVELOPMENT OF SOMATOSENSORY ACUITY: AGE-BASED COMPARISON OF THREE MEASURES

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INTRODUCTION

- Many children with speech sound disorder (SSD) recover, but ≈25% of children with SSD show persisting errors past age 6 [1] and 1-2% persist into adulthood [2].
- Speech production is guided by auditory and somatosensory targets that shape and update the motor plan through corresponding feedback channels [3,4].
- The developmental timeline for refinement of sensory targets is not well-established, particularly for the somatosensory domain.
  - Knowing the timeline of sensory development will help determine whether specific sensory delays can predict persistent atypical speech patterns, which could in turn guide evidence-based assessment and treatment decisions.
- Importance of somatosensory feedback:
  - Somatosensory acuity influences speakers' degree of distinction between targets in production [5].
  - Oral anesthesia or physical perturbations lead to reduced speech precision [6,7,8,9].
- Somatosensory acuity can be measured in various ways [5;10-14]:
  - Majority of research has considered *tactile* aspects; also need to study *proprioceptive* aspects.
  - No standard approach. Particularly limited research with child speakers.
- **This study seeks to measure developmental changes in somatosensory acuity using three child-friendly tasks designed to tap proprioceptive as well as tactile function.**

METHODS

- **Participants:**
  - 20 female adults (ages 18-21, mean 19.4, sd = 0.9) seen at NYU as part of a previous study [15].
  - 50 typically developing children (ages 9-15, mean 13.0, sd = 1.8 yr) at NYU/Syracuse/Montclair.
- **Somatosensory acuity:**
  - *Stereognosis:* Measures somatosensation based on ability to identify shapes using the tongue tip
  - *Phonetic Awareness Task:* Measures somatosensation via explicit reflection on articulator position
  - *Bite-block:* Measures ability to compensate for perturbation using only somatosensory feedback

QUESTIONS

1. Do children and adults differ in somatosensory acuity?
2. Is there a relationship between age and somatosensory acuity?

Hypotheses:
- Adults will have greater degree of somatosensory acuity than children in all three tasks.
- Increased age will be associated with increased somatosensory acuity.

Rationale: There is a protracted trajectory of refinement of auditory acuity [16], so somatosensory acuity may also show developmental increases.

SOMATOSENSORY SKILL

1) Oral stereognosis task [17]:

- Measures tactile acuity (*Recruits spatial awareness)*
- Participants used their tongue tip to identify a raised letter embossed on a plastic strip.
- Letter size increased following an incorrect and decreased following a correct response (2.5-8.0 mm).
- **Outcome measure:** Average letter size in mm across correct responses (lower MLS = higher tactile acuity).

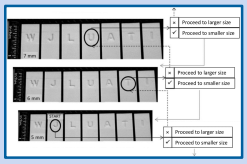


Figure (upper right): Plastic letter strips from oral stereognosis task; adapted from [17] with permission.

2) Novel phonetic awareness task (PAT):

- Measures proprioceptive and tactile awareness (*Recruits metalinguistic skill)*
- 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).
- **Outcome measure:** overall percentage accuracy

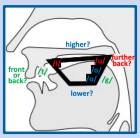


Figure (lower left): Depiction of questions asked about tongue placement in the oral cavity during phonetic awareness task.

3) Bite-block with auditory masking [18]:

- Measures proprioceptive awareness
- 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.
- **Baseline**: production of high vowels /i,u/ in "hVd" context in random order.
- **Bite-block phase**: tongue depressor placed between front incisors vertically to create 1.75cm of jaw aperture.
- **Outcome measure:** difference in mean Euclidean distance in F1-F2 space (Bark) between baseline and bite-block conditions for each vowel (smaller mean ED = greater compensation).

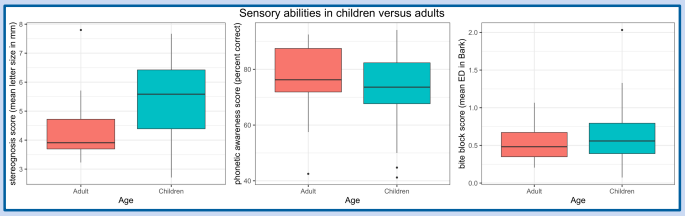
Figure (upper right): Bite block setup with tongue depressor between front incisors in vertical orientation and auditory masking through air and bone conduction.

ANALYSES AND RESULTS

1) Do child and adult participants differ in somatosensory acuity?

- Two-sample t-test for each task (correcting for multiple comparisons with Holm's correction)

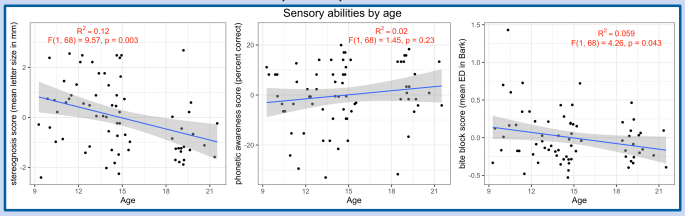
- **Stereognosis**: *significant difference* — t(44.59) = 3.62, **p = 0.0023**
- **PAT**: *no difference* — t(35.63) = -1.10, p = 0.28
- **Bite block**: *no difference* — t(55.29) = 1.54, p = 0.26



2) Is there a relationship between age and somatosensory acuity?

- Linear regression (with Holm's correction) predicting each somatosensory measure from age.
- Examined R^2 to determine strength of each measure's relationship with age.

- **Stereognosis**: *significant relationship* — β = -0.147, *SE* = 0.047, **p = 0.0086** *strongest R^2*
- **PAT**: *no relationship* — β = 0.54, *SE* = 0.45, *p* = 0.23
- **Bite block**: *possible relationship; p-value significant before correction for multiple comparisons* — β = -0.025, *SE* = 0.012, *p* = 0.086



CONCLUSIONS

- **Stereognosis was the only task that significantly differed between child and adult groups (Q1) and showed a significant association with age after correction for multiple comparisons (Q2).**
  - Suggestive of an increase in tactile acuity with increasing age.
  - However, stereognosis task requires mental rotation of letters, which may contribute to association with age.
- **Bite-block task may also show significant relationship with age.**
  - Need more data to determine whether trend is robust.
  - Bite-block task assesses proprioceptive awareness with minimal recruitment of other skills (unlike phonetic awareness and stereognosis tasks).
- **Limitations:**
  - None of these measures can be considered a pure test of somatosensory perception.
  - Auditory masking may not have been complete in bite block adaptation task.
- **Future research:**
  - Administer these tasks to a matched group of individuals with speech sound disorder.
- **Clinical impact:**
  - Well-normed somatosensory measures could inform diagnosis/prognosis and treatment planning (e.g., allocation of children with somatosensory deficits to treatment that helps compensate for this skill).

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