CHARACTERIZING SENSORIMOTOR PROFILES IN CHILDREN WITH RESIDUAL SPEECH ERRORS

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INTRODUCTION

- Most children with speech sound disorder recover, but ~25% show persisting errors past age 6 [1]; ~1-2% continue with residual speech errors (RSE) into adolescence and beyond [2].
- Ability to predict when errors will persist is crucial for evidence-based clinical decision-making.
- Children with reduced motor skill are considered most likely to develop persistent errors [3], but the means available for measuring motor involvement are limited.
- The objective of this study is to evaluate tongue complexity as a potential measure of motor skill while examining the relationships among sensorimotor factors in children with RSE.
  - We measured tongue complexity before & after treatment for rhotic targets; we also collected measures of somatosensory and auditory function.

OBJECTIVES

1. Quantify the relationship between tongue complexity and perceived accuracy of speech.
   - Hypothesis: higher tongue complexity associated with greater perceived accuracy

2. Determine if somatosensory acuity and tongue complexity are related (controlling for auditory acuity).
   - Hypothesis: somatosensory acuity is associated with higher tongue complexity

   Understanding the connection between motor skill (via tongue complexity) and sensory capacity may offer insight into how these skills cooperate during speech.

TONGUE COMPLEXITY

- According to current models of speech production, speech is produced by executing a stored motor plan [e.g., 4].
  - "Motor skill" can refer to the robustness of the feedforward plan.
    - Degree of differential control of anterior & posterior lingual regions connected with achievement of adult-like speech [5].
  - Degree of lingual differentiation was approximated by using ultrasound-based indices of "tongue complexity."
    - Modified curvature index (MCI) [6] is the integral of absolute curvature (reciprocal of the tangent circle) at each point.
    - For adults, higher MCI values in phonemes with multiple constrictions (i.e., l9) than single constriction (i.e., t) [6].
    - Number of NINFL points (NINFL) [7] is the number of thresholded curvature sign changes along the contour.

- For children producing /i/ & higher NINFL based on classification (TD > RSE; accuracy (correct > incorrect), and treatment (post > pre) [7].

SOMATOSENSORY ACUITY

- Somatosensory and auditory feedback modulate speech production (e.g., 4).
  - Somatosensory acuity should correlate with tongue complexity based on evidence that:
    - Tongue complexity is lower in children with RSE than TD peers [7].
    - Poorer acuity associated with more complex tongue shapes at post-treatment.
    - Somatosensory acuity is lower in adolescents with RSE than TD peers [9,10].
  - We used an oral stereognosis task in which children used their tongue tip to identify various sizes of capital letters on plastic strips [11].
    - Letters presented in an adaptive staircase fashion where size decreased after correct and increased after incorrect responses.
    - Score is average size of correct responses.
    - Stereognosic measures tactile acuity; other tasks may also tap into proprioceptive somatosensory acuity [12].

METHODS

1) Are tongue complexity and perceived accuracy related?
   - Linear mixed-effects regression predicting accuracy (cosine transformed \( \hat{\rho} \)) from tongue complexity
   - Separate models for MCI and NINFL
   - Fixed effect of pre/post; random effects (child, word)

2) Are somatosensory acuity and tongue complexity related?
   - Linear mixed-effects regression predicting tongue complexity from somatosensory acuity
   - Separate models for MCI and NINFL
   - Fixed effect of pre/post; controlling for auditory acuity; random effects (child/word)

RESULTS

CONCLUSIONS

Q1 Findings:
- Perceived accuracy was significantly higher at post-treatment than at evaluation.
- Small magnitude interaction between tongue complexity and pre/post suggests that association between tongue complexity and perceived accuracy was slightly higher at post-treatment than at pre-treatment (but limited association in either case).

Interpretation:
- Previous research has shown a positive association between tongue complexity and accuracy [7]; unclear why not significant in the present sample.

Q2 Findings:
- Poorer acuity associated with less complex tongue shapes at pre-treatment, but more complex tongue shapes at post-treatment.
- MCI: Interaction between somatosensory acuity and pre/post (small magnitude)
- NINFL: Interaction between auditory acuity and pre/post (small magnitude)
- Unclear why auditory acuity showed strong time-based relationship with NINFL.

Next steps:
- Assess proprioceptive acuity as more important than tactile acuity for /i/.
- Test whether there is an association between tongue complexity and acoustically measured accuracy (Q1); Determine whether time-based association between tongue complexity and auditory acuity is robust (Q2).

REFERENCES


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