Tongue Shape Complexity in Children with Speech Sound Disorders

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Background

• An ‘undifferentiated lingual gesture’ is a simple tongue shape with fewer inflections than needed. [1]
• Young children and children with Speech Sound Disorder (SSD) have been shown to have more ‘undifferentiated lingual gestures’. [1, 2]
• ‘Undifferentiated lingual gestures’ were first described using electrotalatography (EPG). [1]

• A new metric for measuring lingual complexity using UTI is the NINFL measure (Number of INFlections). [3]
• This study compares the lingual complexity of children with typical development (TD) and SSD across ages and consonants.
• We hypothesised that lingual motor skill maturity (higher age) and low SSD severity or TD (% Tokens Correct per consonant or PTC) are linked with more complex tongue shapes (high NINFL).

KEY FINDINGS

As age and percentage tokens correct (PTC) increase in SSD, tongue shape complexity of /l/, /r/, /t/ also increases. But there is also evidence of negative relationship between complexity and age/PTC for some consonants.

Data and Methods

• SSD: 10 tokens of /p, t, k, s, l, w, s, θ, j/ in an /CaCa/ environment, PTC rated in [6]
• TD: 1 token of /p, t, k, s, l, w, s, θ, j/ in an /CaCa/ environment, 100% correct
• Synchronised audio and ultrasound data at 100 frames per second.
• A fan-shaped grid (origin at probe centre) giving 42 radial sectors
• Annotations at the point of maximal lingual gesture
• Export of NINFL (values between 1 and 5)

Example of TD production of /l/ with NINFL = 5. NINFL captures the number of concave to convex inflections in the tongue curve in midsagittal view. [3]'s procedure for calculating NINFL trims reflex shapes and very small inflections.

Results

• Ordinal mixed models for analysing outcome variable NINFL.
• Model1: TD vs SSD
  • No systematic difference between SSD and TD in NINFL (accounting for age and consonant).
  • Higher age in TD to lower NINFL for /l/ vs. /p/.
• Model2: Effect of Percent Tokens Correct (PTC) in SSD
  • Significant effects of +Age, -PTC, and Consonant (for /l/ and /t/ compared to /p/).
  • Significant double interactions between Age and PTC (+/p/ and PTC and Consonants (+/l/, +/t/, +/l/ vs. /p/).
  • Age and Consonant (-/w/ vs. /p/).
  • Significant positive triple interaction between Age, Consonant and Percent Tokens Correct of /l/, /l/ and /t/ compared to /p/.
• The higher the Age and PTC, the higher the NINFL of /l/, /l/, /t/ compared to /p/.
• Some evidence of a negative relationship between Age and NINFL (/w/ vs. /p/ in SSD and /l/ vs. /p/ in TD), and Age and TD (l/p).

Acknowledgements

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References
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- This study compares the lingual complexity of children with typical development (TD) and SSD across ages and consonants.
- We hypothesise that lingual motor skill maturity (higher age) and low SSD severity or TD (% Tokens Correct per consonant or PTC) are linked with more complex tongue shapes (high NINFL).

KEY FINDINGS

As age and percentage tokens correct (PTC) increase in SSD, tongue shape complexity of /ʃ/, /ɹ/, /t/ also increases. But there is also evidence of negative relationship between complexity and age/PTC for some consonants.

Data and Methods

- SSD: 10 tokens of /p, t, k, s, l, w, s, θ, f, j/ in an /aCa/ environment, PTC rated in [6]
- TD: 1 token of /p, t, k, s, l, w, s, θ, f, j/ in an /aCa/ environment, 100% correct
- Synchronised audio and ultrasound data at 100 frames per second.
- A fan-shaped grid (origin at probe centre) giving 42 radial sectors
- Annotations at the point of maximal lingual gesture
- Export of NINFL (values between 1 and 5)

Results

- Orbital mixed models for analysing outcome variable NINFL.
  - Model1: TD vs SSD
    - No systematic difference between SSD and TD in NINFL (accounting for age and consonant).
    - Higher age in TD to lower NINFL for /ʃ/ vs. /p/.
  - Model2: Effect of Percent Tokens Correct (PTC) in SSD
    - Significant effects of +Age, -PTC, and Consonant (+/ʃ/ and /-l/ compared to /p/).
    - Significant double interactions between Age and PTC (-/p/). PTC and Consonants (+/ʃ/, +/ʃ/, +/l/ vs. /p/), Age and Consonant (/-w/ vs. /p/).
    - Significant positive triple interaction between Age, Consonant and Percent Tokens Correct of /ʃ/, /l/, /t/ compared to /p/.

- The higher the Age and PTC, the higher the NINFL of /ʃ/, /l/, /t/ compared to /p/.
- Some evidence of a negative relationship between Age and NINFL (/ʃ/ vs. /p/ in SSD and /l/ vs. /p/ in TD), and Age and PTC (/p/)

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References

4. Cleland, L. (2016). tonguetip to the right

Participants

- Children with Speech Sound Disorders
  - 29
  - Age: 5.0 to 12.11

- Typically developing children
  - 28
  - Age: 5.8 to 12.10

Image 1

Example EPG frame of an undifferentiated gesture produced during production of /l/ Tongue palate contact covers most of the palate from the alveolar ridge (top) to the velar region (bottom).

Image 2

Example of TD production of /ʃ/ with NINFL = 5. NINFL captures the number of concave to convex inflections in the tongue curve in mid sagittal view. [3]’s procedure for calculating NINFL trims retroflex shapes and very small inflections.

Image 3

NINFL for children with SSD or TD across consonants

Image 4

Modelled mean NINFL per age in SSD or TD

Image 5

Example TCS/PTC tongue shape in red

Image 6

Modelled mean NINFL per age in SSD or TD