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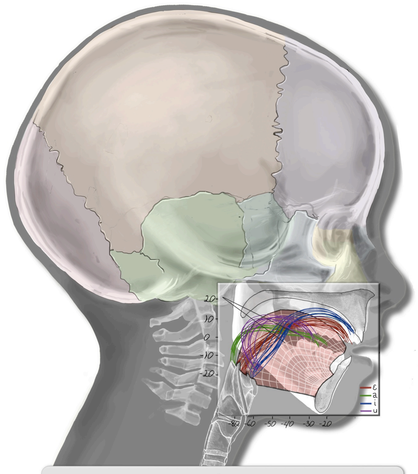

Speech motor control in 4-year-old children versus adults: anticipation as an index of speech motor control maturity

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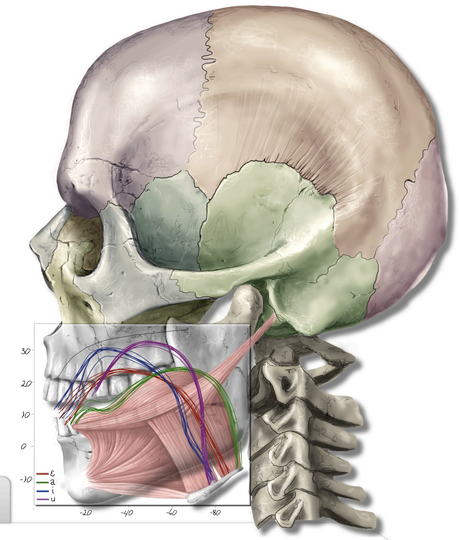
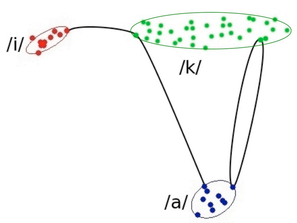


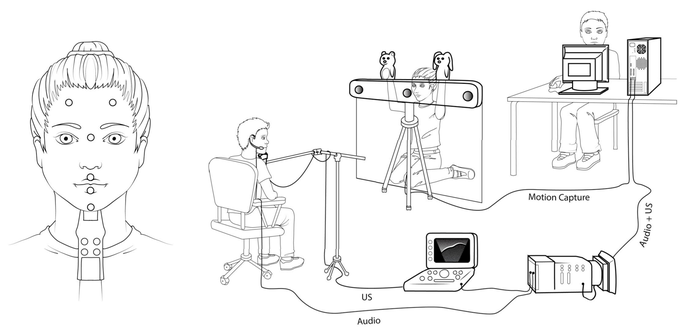
Introduction

- How do children learn to produce speech sounds and sequences of speech sounds from a motor control perspective?
- Anticipatory coarticulation is largely planned: mature speakers use motor equivalence strategies to minimize articulatory effort while keeping acoustic variability within an acceptable range.
  - Planning such contextual variability requires precise sensori-motor relationships.
  - Aim: test whether children's sensori-motor representations are mature enough to use similar strategies.



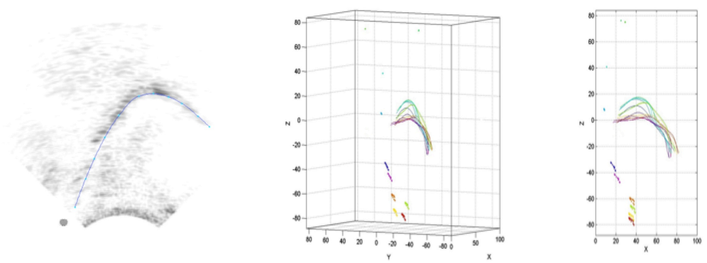
Methods (1/2)

- Twenty 4-year-old Canadian French children and ten young adults participated in the experiment.
- Corpus:
  - Isolated vowels /i e ɛ a u/
  - V_1-C-V_2 sequences with C among /b d g/, V_1 among /ɛ a/ and V_2 among /i a/
- The task was presented as a puppet game.
- Tongue movements were recorded (ultrasound tongue imaging with the HOCUS system) synchronously with the audio signal.



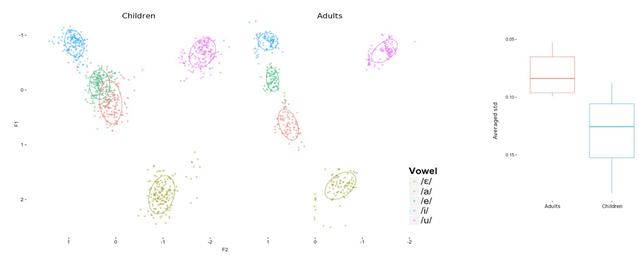
Methods (2/2)

- Two indices were measured:
  - token-to-token variability (acoustic and articulatory data)
  - anticipation of V_2 in V_1 (acoustic and articulatory data)

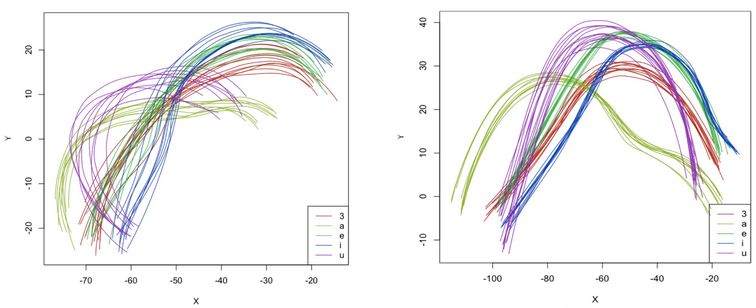


Results (1/2)

- More token-to-token variability in children.



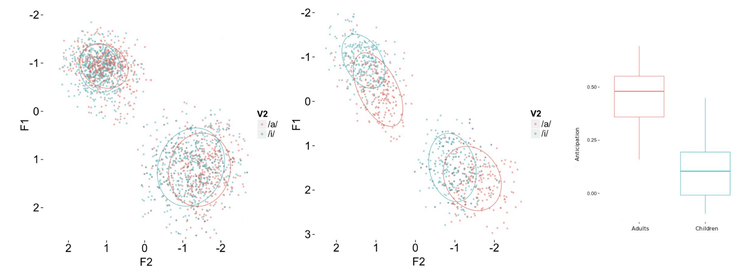
Acoustic realizations (z-scored) of isolated vowels for all children (left) and all adults (middle). Averaged std is 64% larger in children (right).



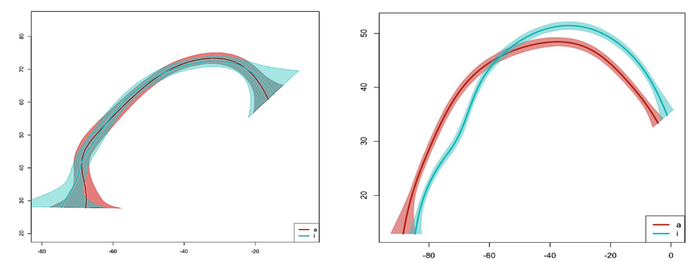
Token-to-token variability of isolated vowels for an example child speaker (left) and an example adult speaker (right), axes are in mm, tongue tip on the right.

Results (2/2)

- No (or very limited) anticipation of forthcoming gestures across syllable boundaries in children.



Acoustic realizations (z-scored) of /a/ and /ɛ/ as V_1 for all V_1-C-V_2 sequences in the contexts V_2 = /a/ (red) and V_2 = /i/ (blue), for all children (left) and all adults (middle). Anticipation is significantly more important in adults (right).



Mean tongue contours and 95% Confidence Intervals for /ɛ/ as V_1 in the contexts V_2 = /a/ (red) and V_2 = /i/ (blue) for an example child speaker (left) and an adult speaker (right) for /ɛdi/ vs. /ɛda/ sequences, axes are in mm.

Conclusion

- Speech motor control in 4-year-old children is immature as evidenced by (1) more token-to-token variability for vowel production and (2) less anticipation of forthcoming gestures across syllable boundaries.
- Our interpretation is that the neural representations of children's speech motor systems are immature, particularly in their incapacity to account for the appropriate articulatory variability compatible with correct perception of the target sound, in the context of motor equivalence strategies.