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Consonant production in children with cochlear implants and exposed to Canadian French Cued Speech: An acoustic and articulatory study

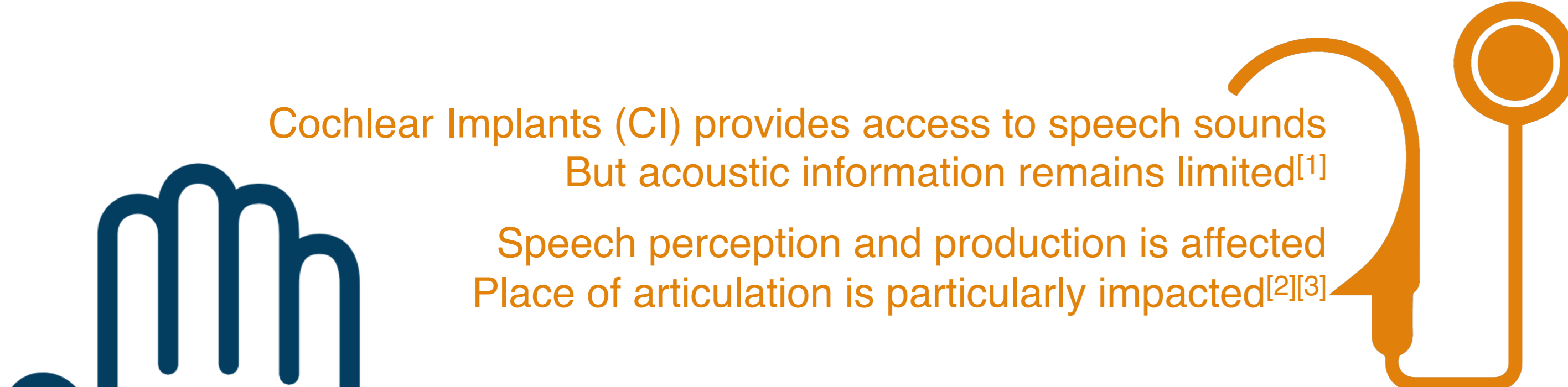
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CONTEXT & AIMS



Cochlear Implants (CI) provides access to speech sounds
But acoustic information remains limited^[1]

Speech perception and production is affected
Place of articulation is particularly impacted^{[2][3]}

Cued speech enhances speech perception^{[4][5]} and phonological development^{[1][2]}

Cued speech enhances speech production: voicing, nasality, manner and place of articulation^[6]

Cued speech use before implantation improves speech intelligibility^{[6][7]}

Research question
Canadian French Cued Speech proficiency may **improve articulatory precision** in children with CIs

- Do children with CIs have a better representation of speech sounds when they benefit from cued speech?
- Are their articulatory gestures more accurate?
- Are their lingual configurations comparable to that of children with typical hearing?

METHODS & PARTICIPANTS

Task
Picture-naming task with word-initial consonants in vowel /a/ context: “tapis” /tapi/ carpet, “carotte” /kaʁɔt/ carrot, “sapin” /sapɛ̃/ fir tree and “chapeau” /ʃapo/ hat

Simultaneous acoustic and ultrasound recordings during production

Participants

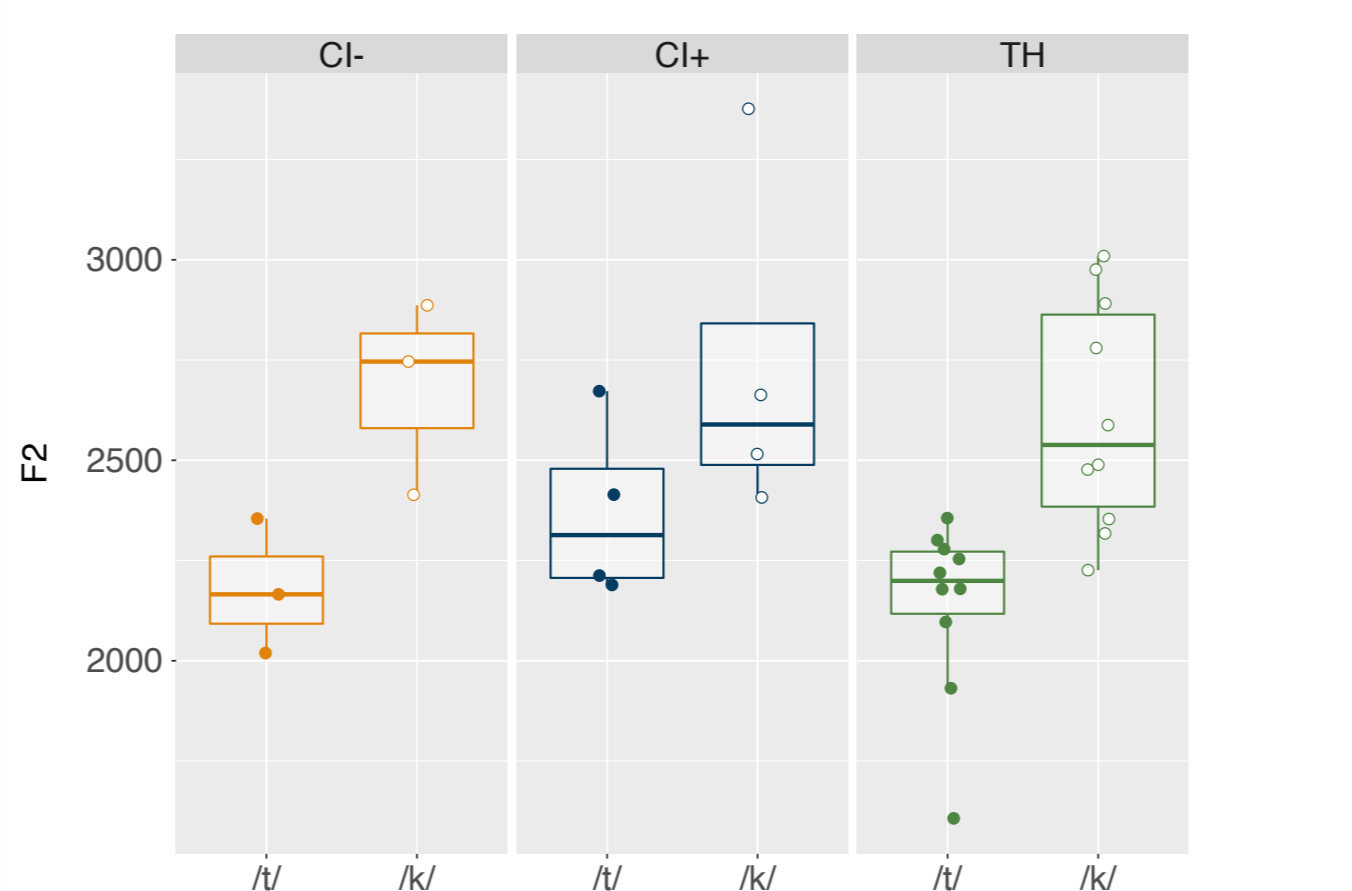
CI-	CI+	TH*
N = 3	N = 5	N = 10
From 65 to 133 months (age = 101 months, SD = 27.95)	From 89 to 121 months (age = 103.55 months, SD = 10.85)	From 52 to 137 months (age = 96.25 months, SD = 25.68)

Data processing
Formant values **F1, F2 and F3** at consonant offset and spectral **centers of gravity** at fricative mid-point were extracted using PRAAT^[9]
Tongue contours were automatically extracted at burst point using the SLURP algorithm^[10] and characterized with the front-back index^[12], the constriction place^[13] and the MCI values^[11]

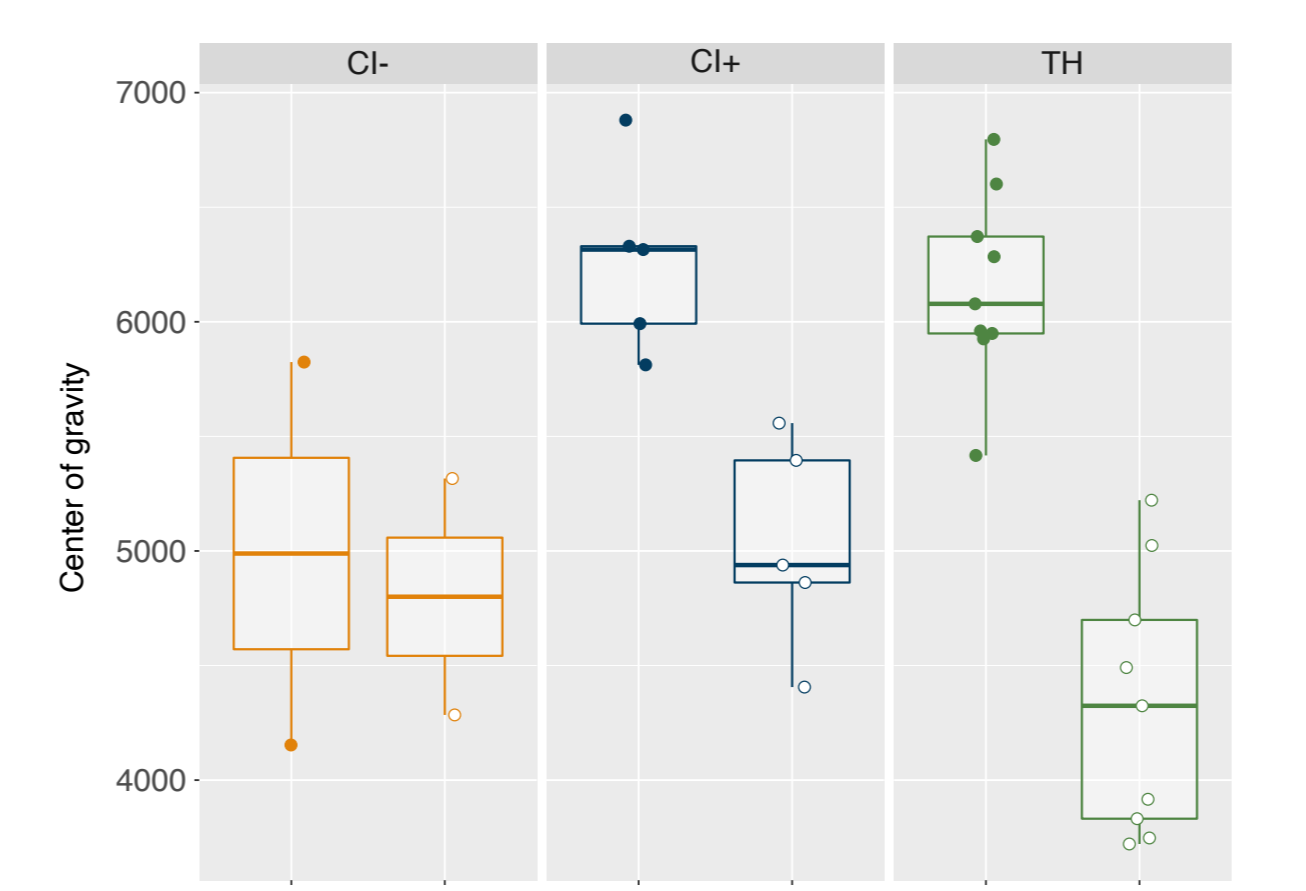
Statistical analysis
Linear mixed-effect models (*lme*) with a backward step-wise variable selection and multiple comparisons

RESULTS

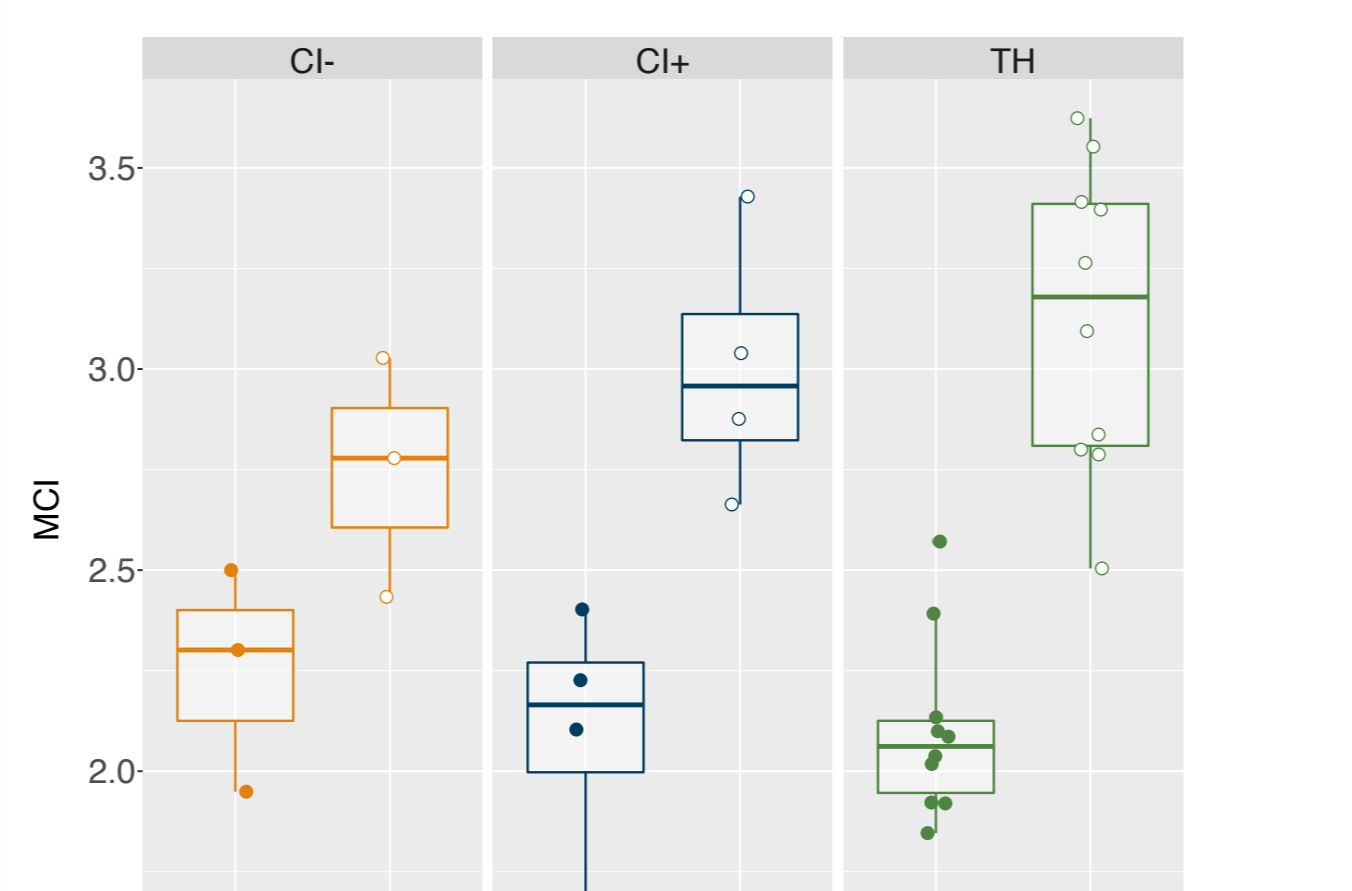
	Stops	Fricatives
F1	/t/ > /k/	CI+: /s/ > /ʃ/ ; CI- and TH: /s/ = /ʃ/
F2	/t/ < /k/	CI+ and TH: /s/ < /ʃ/ ; CI-: /s/ = /ʃ/
F3	/t/ = /k/	CI- and CI+: /s/ > /ʃ/ ; TH: /s/ = /ʃ/
Center of gravity		CI+ and TH: /s/ > /ʃ/ ; CI-: /s/ = /ʃ/ Lower contrast in CI-
Front-back	/t/ more anterior	CI+: /s/ more anterior ; CI- and TH: /s/ = /ʃ/ Higher contrast in CI+
Constriction	/t/ more anterior	/s/ more anterior
MCI	/t/ < /k/ Slightly lower contrast in CI-	/s/ < /ʃ/



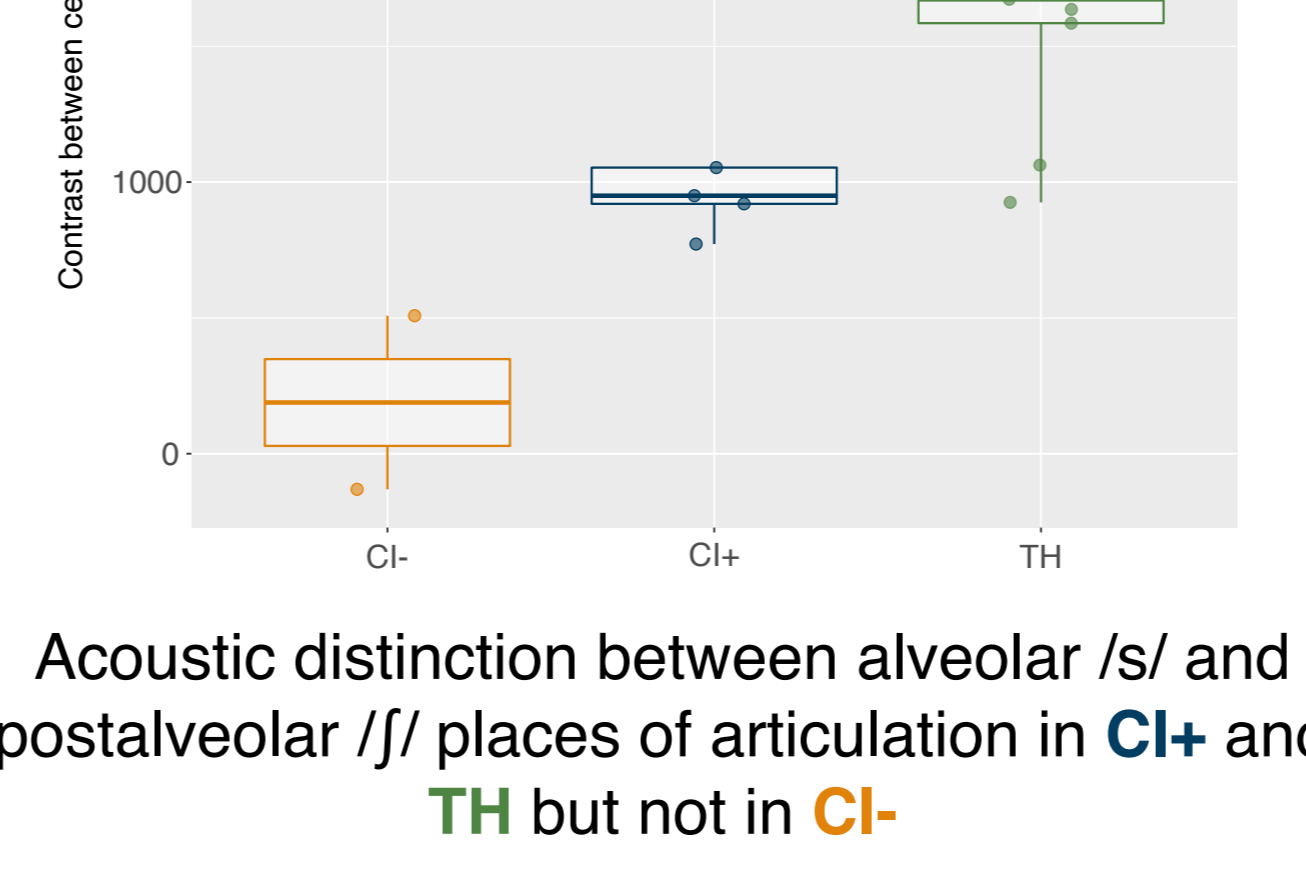
Acoustic distinction between alveolar /t/ and velar /k/ places of articulation, with no group effect



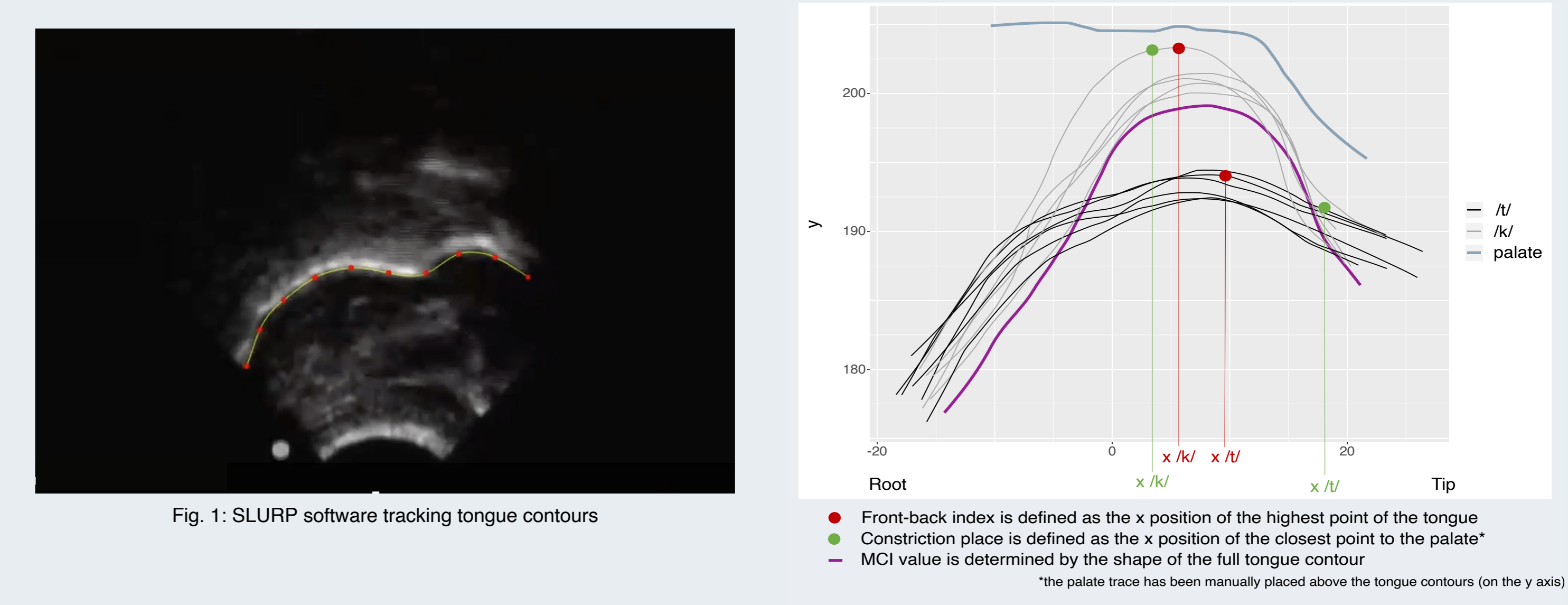
Acoustic distinction between alveolar /s/ and postalveolar /ʃ/ places of articulation in CI+ and TH but not in CI-



More precise articulatory distinction between alveolar /t/ and velar /k/ places of articulation in CI+ and TH than in CI-



More precise articulatory distinction between alveolar /s/ and postalveolar /ʃ/ places of articulation in CI+ than in TH and CI-



DISCUSSION & PERSPECTIVES

Discussion

- Quantitative measures of stop and fricative articulation in children with CIs and typical hearing
- F2 can be used as an acoustic correlate of stop and fricative place of articulation in children
- The results argue for the use of articulatory measures to further assess speech production in children
- Because different strategies are used by children to produce a similar target, a single measure is not sufficient to characterize speech production in children
- The higher the receptive cued speech proficiency, the better the differentiation of places of articulation in stop and fricative consonants

Perspectives

- Record more participants in each group
- Comparison with children with cochlear implants and who have never been exposed to cued speech
- Testing the effect of adding cued speech gestures simultaneously to speech production

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