Influence of French Cued Speech exposure on consonant production in children with cochlear implants: an ultrasound study

MACHART, L.[1,2], VILAIN, A.[2], LŒVENBRUCK, H.[1] & MENARD, L.[3]

[1]Univ.Grenoble, Alpes, CNRS, LPNC, 38000 Grenoble, France, [2]Univ. Grenoble Alpes, CNRS, Grenoble INP, GIPSA-lab, 38000 Grenoble, France,
[3]Laboratoire de Phonétique de l'UQAM, Montréal, Québec

laura.machart@univ-grenoble-alpes.fr

CONTEXT & AIMS

Cochlear implant (CI)

Access to spoken language

Improvement of speech intelligibility [1][2]

/!\ **Auditory information remains limited**[3][4]

Persistent **language disorders** [5]

Cued French (CF)

Phonetic system with a manual cue [6]

Enhancement of speech perception [7]

Reinforcement of phonological representations [8]

5 hand **positions around the face** for the **vowels**

8 **handshapes** for the **consonants**

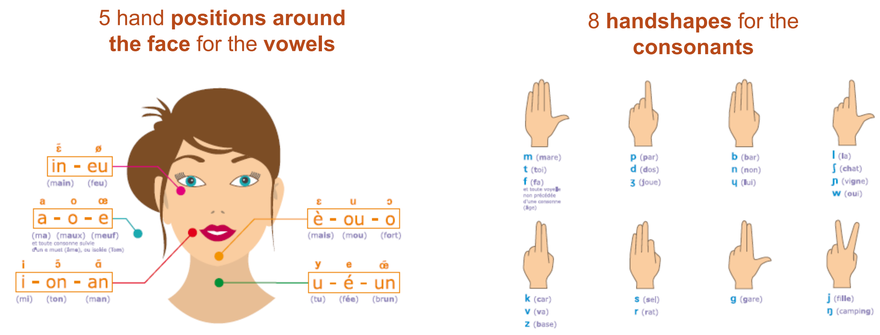

Fig. 1: Positions and hanshapes of Cued French

Source: https://alpc.asso.fr/

Research questions

(1) **Relevance of the Mean Curvature Index (MCI) measure [9] for the characterization of stop production** in children

(2) **Influence of Cued French on articulatory precision** in children with cochlear implants: do children with cochlear implants have a better representation of speech sounds when they benefit from Cued French? Are their articulatory gestures more accurate? Are their lingual configurations comparable to those of children with typical development?

(3) **Impact of simultaneous speech and Cued French production on articulatory accuracy**: does combining speech production with manual cues improve articulatory control in children with cochlear implants?

METHODS & PARTICIPANTS

Task

Picture-naming task: word-initial consonants in vowel /a/ context (stops, nasals and sibilants)
Ultrasound recording of lingual movement during production with or without simultaneous Cued French gesture production

Participants

10 children from 52 to 137 months **with typical hearing** (mean=96;sd=25.7)
4 children with cochlear implants, aged from 89 to 121 months, **exposed to Cued French** and able to use Cued French during speech production (mean=103.8;sd=11.8)

Data processing and analysis: preliminary analysis restricted to stop consonants

Tongue shapes are extracted 30ms before burst using the SLURP software [11]
Tongue curvatures are characterized with the **MCI measure** [10]

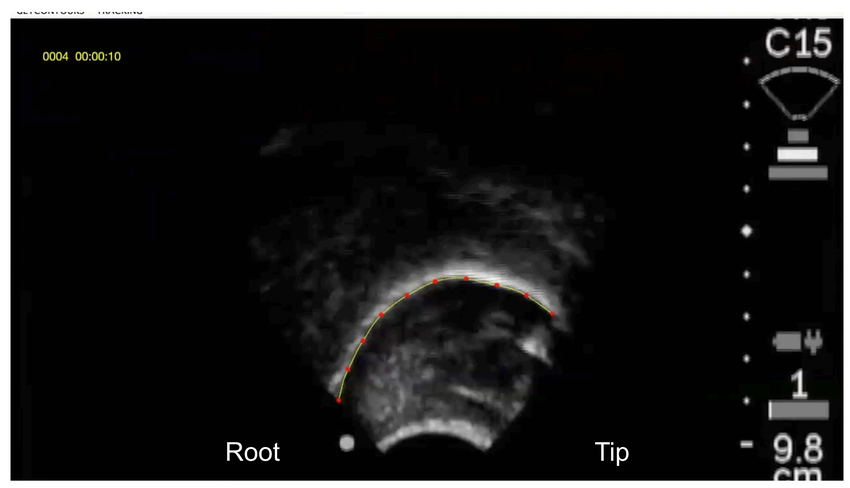

Fig. 2: SLURP software tracking tongue shapes during the production of the sentence /selekaʁɔt/ by a child with cochlear implants who is simultaneously cueing

PRELIMINARY RESULTS

Tongue curvature

Mean curvature index (MCI) seems well-adapted to the description of children stop production

- /t/ and /k/ are well distinguished in both normal hearing children and children with cochlear implants
- MCI measures are consistent with those of Dawson et al. (2015) [10]: higher curvature for dorsal /k/ than coronal /t/ stops

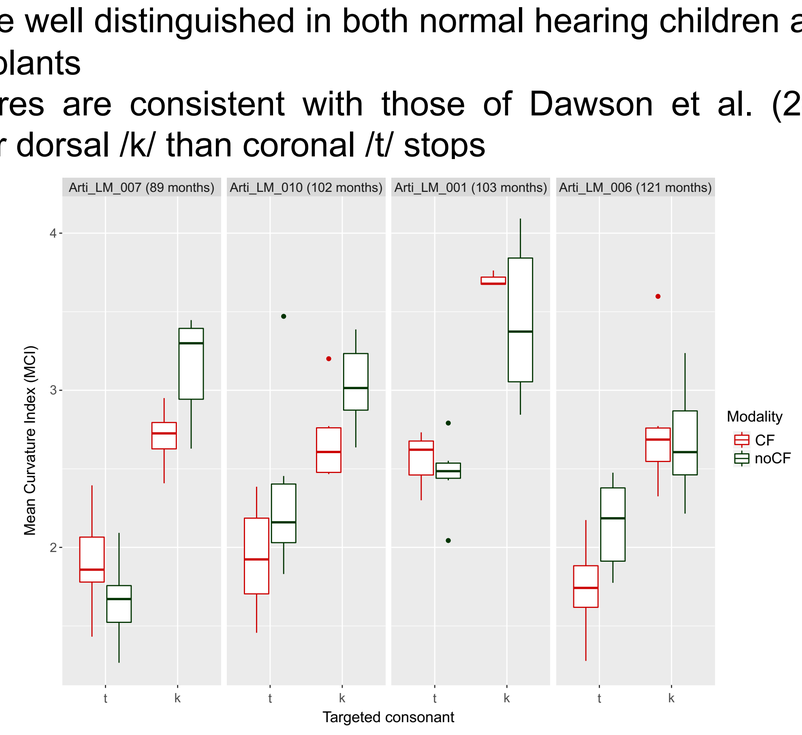

Fig. 3: Mean curvature index (MCI) for /t/ and /k/ in children with cochlear implants

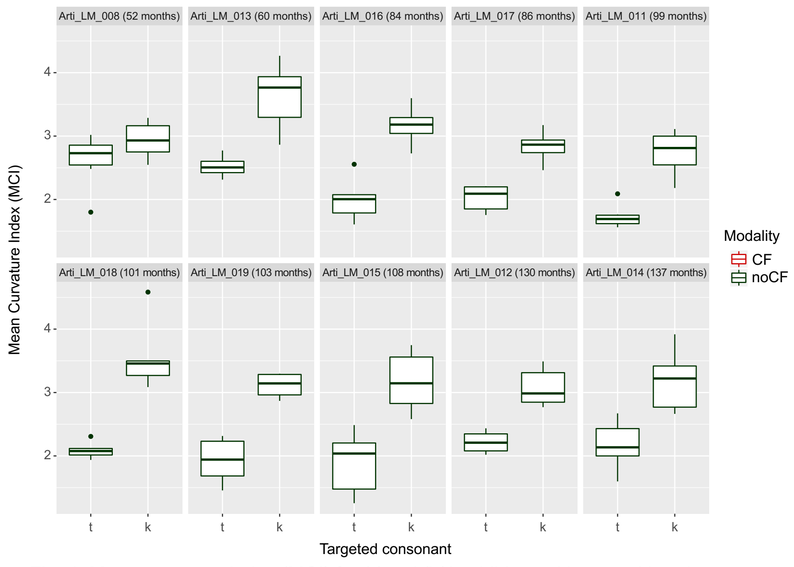

Fig. 4: Mean curvature index (MCI) for /t/ and /k/ in children with normal hearing

DISCUSSION & PERSPECTIVES

Discussion

- **MCI seems applicable** to tongue shape description during coronal and dorsal stop production in children
- Children with cochlear implants and exposed to Cued French display **similar tongue curvature patterns to their hearing peers**
- Children with cochlear implants and exposed to Cued French **produce clear articulatory distinction between dorsal and coronal stop** and the **addition of the hand does not interfere with their production**

Perspectives

- Comparison with children with cochlear implants and never exposed to Cued French
- Analysis of fricative (/ʃ/ vs /s/) and nasal (/n/ vs /ɲ/) consonants: confrontation of articulatory measures with acoustic characterization for all consonants (formant transition, spectral moments, formant values)

References

[1] Grandon, B., Martinez, M. J., Samson, A. & Vilain, A. (2020). Long-term effects of cochlear implantation on the intelligibility of speech in French-speaking children. *Journal of Child Language*.
[2] Turgeon, C., Trudeau-Fisette, P., Fitzpatrick, E., & Ménard, L. (2017). Vowel intelligibility in children with cochlear implants: An acoustic and articulatory study. *Int. Journ. Ped. Otor.*, 101, 87–96.
[3] Colin, S., Ecalle, J., Truy, E., Lina-Granade, G., & Magnan, A. (2017). Effect of age at cochlear implantation and at exposure to Cued Speech on literacy skills in deaf children. *Research in Developmental Disabilities*, 71, 61-69. http://dx.doi.org/10.1016/j.ridd.2017.09.014.
[4] Bouton, S., Serniclaes, W., Bertoncini, J., Leuwers, C., & Cole, P. (2011). Apprentissage de la lecture et développement des habiletés associées à la réussite chez les enfants munis d'un implant cochléaire : Apport de la Langue Parlée Complétée (pp. 163-188). In J. Leybaert (Ed.), *La Langue Francaise Parlée Complétée : fondements et perspectives*. Solal.
[5] Geers, A., Nicholas, J., Tobey, E., & Davidson, L. (2015). Persistent language delay versus late language emergence in children with early cochlear implantation. *Journal of Speech, Language, and Hearing Research*, Volume 59, 155-170.
[6] Hage, C. & Leybaert, J. (2006). The Effect of Cued Speech on the Development of Spoken Language, in: Spencer, P.E., Marschark, M. (Eds.), *Advances in the Spoken Language Development of Deaf and Hard-of-Hearing Children. Oxford University Press*, pp. 193–211.
[7] Leybaert, J., Colin, C., Hage, C., LaSasso, C.J. (2010). Cued Speech for Enhancing Speech Perception and First Language Development of Children With Cochlear Implants. *Trends Amplif*. 14, 96–112.
[8] Charlier, B. L., & Leybaert, J. (2000). The rhyming skills of deaf children educated with phonetically augmented speechreading. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 53(2), 349–375.
[9] Dawson, K. M., Tiede, M. K., & Whalen, D. H. (2015). Methods for quantifying tongue shape and complexity using ultrasound imaging. *Clinical linguistics & phonetics*, 30(3-5), 328-344.
[10] Laporte C, Ménard L. (2018). Multi-hypothesis tracking of the tongue surface in ultrasound video recordings of normal and impaired speech. *Medical Image Analysis*. 44: 98-114.

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