Nasal vowel production and grammatical processing in French-speaking children with cochlear implants and normal-hearing peers.

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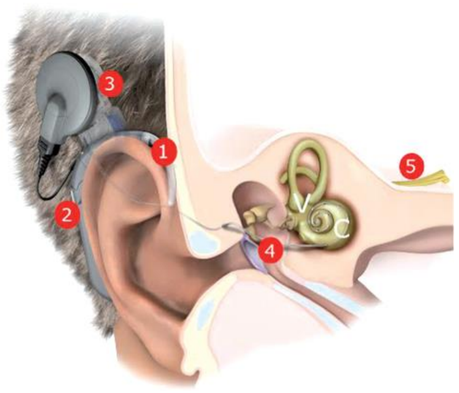
Cochlear implant



Great benefits for restoring a functional audition
- Better spoken language acquisition for children
- Favorable conditions : implantation precocity (Dettman et al.2007) and binaurality (Sarant et al.2014).

…However

- Electrodes number coding the spectral information (usually 22) <<< Sensitives cells in a healthy ear → impact on the cochlear tonotopy and the spectral resolution?

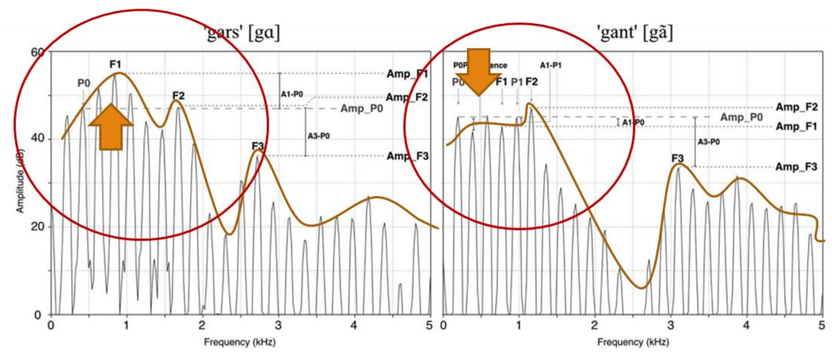
Language development and cochlear implant

➢ **Phonetic/phonology** : difficulties in perception (Bouton, 2012) of specific phonological features (nasality, place of articulation) and « visibility » effect in production (Grandon, 2016)
➢ **Morphosyntax** : often reported as deficitary in perception and production for CI children (Lenormand, 2004; Duchesnes, 2010, Bourdin, 2016)

→ CI = sufficient language input to acquire many phonological contrasts…
BUT not sufficient to process all acoustic features, especially in less salient perceptual contexts (~ processing of grammatical morpheme) ?

Vocalic nasality and cochlear implant

Nasal vowels = complex acoustic realization - distinction between oral and nasal vowels in French relies on :
- Cues related to oro-pharyngeal configuration
- Cues related to the coupling between the oro- and naso-pharyngeal areas, resulting in nasal resonance addition= fine and subtle acoustic variations → more vulnerable for cochlear implant (CI) recipients ?



➢ Bouton (2012) : oral/nasal minimal pairs less identified and discriminated by CI children
➢ Borel (2015, 2019) : nasal vowel less identified as oral vowels with close oro-pahryngeal configuration in CI adults

➔ ***Impact of these perception difficulties on the morpheme processing ?***

Method

Evaluation of grammatical/lexical morpheme processing skills and ability to phonetically mark vowel nasality + link between theses two skills

Participants

❑ *Group of typically hearing children (TH group) - N = 27 :*
Without diagnosed auditory, language, or cognitive difficulties
Grouped by age:
- 2;6 to 4;6 y.o. (N = 8)
- 4;6 to 5;6 y.o. (N = 9)
- 5;6 to 6;6 y.o. (N = 10)

❑ *Children with hearing impairment and cochlear implant(s) (CI group) :*
- N = 16
- Aged from 4 years 3 months to 7 years 6 months
- Bilateral congenital profound deafness
- Bilateral implantations (except 1 subject)
- Implantations done between 7 months and 3 years of age
- Oral communicators – sign language bilingualism for 4 subjects (CI1, CI3, CI6, and CI7)
- Use of Cued Speech (LPC) for 6 subjects.

Productive task

Picture naming task (Philippart de Foy, 2018)
➢ Target words encompassing all French phonemes in 3 positions (initial, medial, final)
➢ Various levels of Age of Acquisition (A.o.A.) and articulatory complexity.

Phonological analyses
Transcriptions of the productions and analyses using Phon (Hedlund & Rose, 2020): percentage of correct vowels (PCV) and correct consonants (PCC) + error analyses.

Acoustical analyses
➢ Characterization of oral/nasal vowels: Comparisons between nasal and oral vowels by correspondences (Borel, 2015):

- *Phonetic: /ɑ̃/-/a/ ; /ɔ̃/-/ɔ/ ; /ɛ̃/-/ɛ/*
- *Phonological: /ɑ̃/-/ɔ/ ; /ɔ̃/-/o/ ; /ɛ̃/-/a/*

➢ Acoustic cues :
- For oral configuration: Euclidean distances F1/F2
- For phonetic nasality: Delta A1P0 – amplitude ratio between the nasal pole (P0 - 1st or 2nd harmonic) and the first formant (A1).

Receptive task

- Oral word/phrase pointing task

➢ Distractors = phonological neighbor (minimal pair) or phrase containing a morphosyntactic gender or number opposition, conveyed by the addition/substitution of a phoneme
➢ Contrasts carried by oppositions between nasal/nasal vowels, oral/nasal vowels, oral/oral vowels, or phonemic addition.

Analyses

➢ Calculation of a ***d'*** score (McMillan & Creelman, 1991) for the total score and sub-scores.

Results

Comprehension task scores

Score types	TH group	CI group	Sig.
Total score	0,75 (0,11)	0,59 (0,09)	**
Number marks	0,67 (0,13)	0,55 (0,15)	*
Gender marks	0,78 (0,13)	0,61 (0,18)	*
Minimal pairs	0,86 (0,14)	0,66 (0,10)	**
Oral-nasal opposition	83,70 (13,05)	56,88 (12,50)	**
Oral-oral opposition	62,96 (21,35)	52,08 (29,74)	NS
Nasal-nasal opposition	77,78 (18,49)	68,75 (19,12)	NS

Results obtained by our two groups in the naming task, for both groups.

Significant differences between IC and NE groups observed in the majority of scores:
➢ Total score and related to number/gender marks, minimal pairs
➢ Items involving contrasts between oral/nasal vowels and with phonemic addition, but not for nasal/nasal and oral/oral contrasts
… for contrasts carried by oral/nasal oppositions

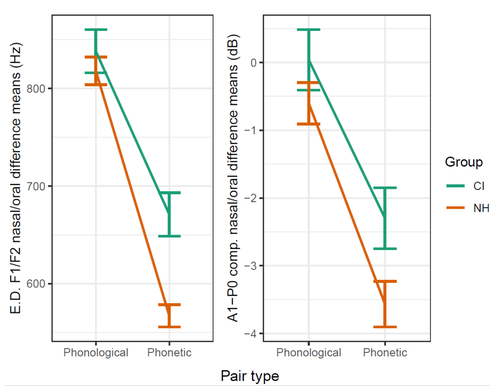
TH group : chronological age ↑ → number marks, minimal pairs and oral-nasal opposition subscore ↑
CI group : auditory age ↑ → oral-nasal opposition subscore ↑

Picture naming task

Phonological analyses

CI < TH for % of correct vowels and
➢ Error types: denasalizations of nasal consonants and nasal, nasalization of oral consonants

TH group : ↑ chronological age → ↑ % of correct vowels and consonants ; ↓ denasalization of nasal vowels
CI group : ↑ auditory age → ↑ % of correct consonants, ↓ denasalization of nasal consonants



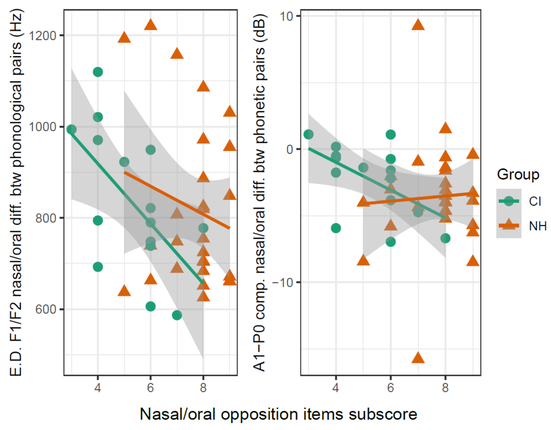
Acoustical analyses

TH : ↑ differentiation between oral vowels :
➢ for nasal resonance cue – delta A1P0
➢ for oral configuration cue – E.D. F1/F2

TH group : ↑ chronological age → ↑ higher marking using nasal resonance
CI group : ↑ auditory age → ↑ higher marking using oral configuration

Link between acoustic profile and receptive skills

Acoustic datas – comprehension task subscores



Significant correlation only in the CI group
➢ Negative correlation between E.D. F1/F2 and the oral/nasal opposition items subscore of the comprehension task
➢ Positive correlation between nasality throughout the use of VP-coupling acoustic cues (with a lowering of the A1-P0 compensated values) of the phonetic pairs and oral/nasal opposition items subscore

Discussion

Between-group differences

- lower morpheme processing skills in CI
- less nasal/oral distinctions carried by VP-coupling acoustic cues but greater nasal/oral distinctions in the formantic pattern acoustic cues → frequency informations better coded by CI + "visibility" effect ?

Link between acoustic and linguistic measures

- CI group : best performances in nasal/oral opposed items process associated with greater VP-coupling nasality marking and fewer nasality marking with the formantic pattern → importance of using fine acoustic cues in the phonological structuration and for processing grammatical and lexical morphemes carried by nasal/oral vowel distinction
- Distinct age effects: CI (auditory age) = ↑ consonant production and ↑ differences in oral configuration – TH group : better phonological structuration (consonants and vowels) and grammatical processing + ↑ oral/nasal VP-coupling marking → CI individuals possibly employ strategies more focused on perceptually salient elements (consonants, oral configurations)?

Perspectives…

- Enlarge the sample !
- Evolution of the performances ?
- Nasality acoustic cues ?

Diagnostics and interventions

- Acoustics = non-invasive measurements → considered for early diagnosis?
- Tracking progress in interventions?

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