

Interactions between phonological and lexical processing in children with hearing loss

BACKGROUND: Very early on, children are able to process acoustic information to gradually access the phonological system of their native language(s) (see e.g., Werker, 2018 for a review). Doing so, they become specialized in the phonology of their L1(s), and can then rely on their phonological system to build stable lexical representations (Stoel-Gammon, 2011). Only a few studies have explored lexical access and the factors affecting processing for children with Hearing Loss (HL) (e.g., Schwartz et al., 2013; de Hoog, et al., 2015), who may have a delay or difficulties in acquiring the phonological system of their L1 (e.g., Warner-Czyz & Davis, 2008). Specifically, little is known about the specific use of the segmental information during lexical processing, in children with typical development but also in the case of a Hearing Loss: Does different access to auditory information lead to different lexical processing? For example, cochlear implants (CIs) transmit a partial version of the speech signal by means of electric impulses to the cochlea's inner cells, while external hearing aids or unaided ears provide a version of the speech signal through acoustic transmission, that is both different from transmission with Typical Hearing (TH) but also with CIs.

METHOD: We used a visual world paradigm with eye-tracking. A target-word was presented orally, along with a set of four pictures depicting the target word, its phonological competitor, and two semantic distractors to both words. Phonological neighboring word-pairs were contrasted on either the first or second segment in a word-initial CV sequence. We used five different vowel and five consonantal contrasts (see Table below), each relying on one or two phonological features (80 items in total). We recorded the participant's response, reaction time and gaze fixation. Response accuracy was analyzed with generalized mixed-effect models (GLM), log-transformed reaction time (RT) with linear mixed-effect models (LMM) and gaze fixation with generalized additive mixed-effect models (GAMM).

PARTICIPANTS: Forty-seven children participated in the study: 27 children with TH aged 6;2 to 12;11 ($M=9;0$, $SD=1;11$) and 20 children with HL aged 6;5 to 13;9 ($M=10;03$, $SD=1;11$). Six of the children with HL were using an electrically-transmitted signal (two CIs or one CI combined with either a hearing aid or FM-system), eight of the children with HL were using an only-acoustically-transmitted signal (no device at all, two HA or one HA, possibly combined with a FM-system) and one was using a bone-conducted signal (with one bone-anchored implant). For five children, we did not have any information on the devices used.

RESULTS: The children with HL had a significantly lower accuracy ($M=92.06$, $SE=6.76$) than their peers with TH ($M=97.40$, $SE=3.42$). A higher accuracy was associated with a longer hearing experience, a more advanced vocabulary development and higher age, but not with a better phonological working memory (WM). A quicker decision (i.e., lower RT) was only associated with a higher age and longer hearing experience. More distance between target and phonological competitor (i.e., more contrasting features) improved accuracy but not RT. Other segmental factors (consonant vs. vowels, types of contrast) did not affect accuracy or RT. Gaze fixation was delayed in the group of children with HL (see Figure), and facilitated with a more advanced vocabulary development for children of both groups. Processing the phonological contrasts was easier with more distance between target and competitor (see Figure) and for children with TH only, with vocalic over consonantal contrasts. We could only find a small between-group differences for place of articulation and roundedness. There was no evidence of an effect of phonological WM in either group, and of hearing age in the children with HL. Device and HL laterality could not explain variability in RT, accuracy or Gaze fixation patterns.

DISCUSSION: The ability to build stable phonological and lexical representations is apparently not prevented by HL and by the quality of input provided by devices (HAs or CIs) as indicated by similar processing of the contrasts by the two groups. Delays for children with HL might indicate a stronger effort needed to retrieve the word from their mental lexicon.

Table: contrasting features and choice of words in the study

Target segment	Number of contrasting features	Features	Example Target-Phonological Distractor <i>English translations</i>
Consonant	1	manner	Pass-Fass, /pas/-/fas/, <i>passport-barrel</i>
		place (plosive)	Brille-Grille, /bʁilə/-/gʁilə/, <i>glasses-cricket</i>
		voicing	Kabel-Gabel, /kabəl/-/gabəl/, <i>cablе-fork</i>
	2	place + manner	Tisch-Fisch, /tɪʃ/-/fɪʃ/, <i>table-fish</i>
		place + voicing (plosive)	Tuch-Buch, /tu:χ/-/bu:χ/, <i>cloth-book</i>
Vowel	1	front-back	Bad-Bett, /ba:t/-/bet/, <i>bath-bed</i>
		height	Mund-Mond, /mʊnt/-/mo:nt/, <i>mouth-moon</i>
		roundedness	Kiste-Küste, /kɪstə/-/kʏstə/, <i>box-coast</i>
	2	front-back + height	Rübe-Robbe, /rybə/-/rɔbə/, <i>beet-seal</i>
		front-back + roundedness	Koffer-Käfer, /kɔfə/-/kɛ:fə/, <i>suitcase-beetle</i>

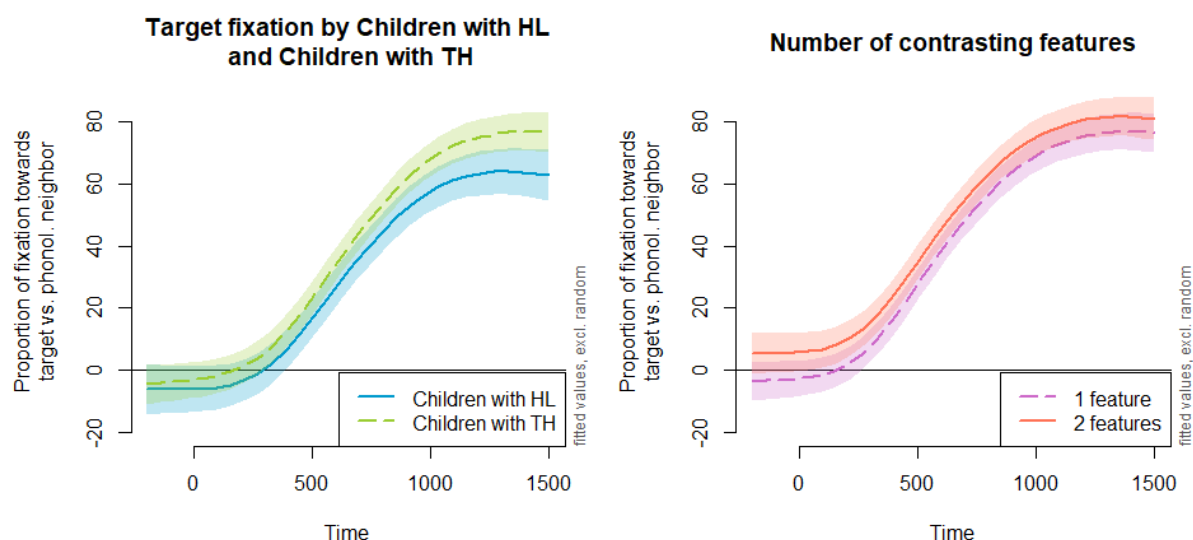


Figure: Evolution of gaze fixation – Target vs. Phonological neighbor

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