Does the saliency of speech sounds influence lexical access in children with or without hearing impairment? A comprehension study using eye-tracking and behavioral paradigms

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Cochlear implantation results in gains in perceiving environmental and speech sounds to its users. Yet, the signal transmitted by the cochlear implant (CI) remains partial and the perception of certain speech sounds is found to be challenging (Niparko et al., 2010), especially when the target sound shares several features with another sound of the language (e.g., Lane et al., 2007). Studies of higher levels of linguistic processing in children with CIs have mostly focused on how comprehension is influenced by their cognitive or processing abilities. For example, working-memory has been found to have an effect on receptive subject-verb agreement (Schouwenaars et al., 2017) or on understanding of questions (Schouwenaars et al., 2019) in children with CIs. Sound processing in users of CIs has been extensively studied, yet less attention has been given to how their perception of speech sounds affects how they process other higher levels of language. Very early on, children with normal hearing (NH) are able to use available acoustic information of words to build phonetico-phonological and lexical representations of words (Nazzi, 2006). In contrast, lexical access in children with CIs has been shown to be impaired or delayed (see Schwartz et al., 2013 for a review). Yet, how low- and high-level language abilities affect lexical acquisition in children with CIs has not been explored. Particularly interesting is how the segments' saliency (i.e., how individual speech sounds stand out when compared to other sounds of the language or within the speech stream) affects lexical access. In adults with NH, the saliency of consonants, based on their acoustic characteristics (Baroni, 2014) could predict how well they would be perceived.

Our study investigates segmental information in the speech stream as facilitating or hindering factor in lexical access in children with NH and children with CIs and explores factors predicting high inter-children variability in lexical access in children with CIs. It will contribute to answering the following research questions: 1) Is lexical access in perception slower in children with CI than in children with NH? How far is lexical access affected by a phonological neighbor overlapping with more or less segmental features? 2) Can the degree of saliency of the segments in words explain difficulties in lexical access? We consider saliency as the way a segment stands out 1) in comparison to the other segments in both the language inventory based on the combination of their own segmental features (intrinsic saliency) and 2) in the word structure (positional saliency). We predict that lexical access with a CI will be easier with contrasts involving more features and located in accented positions and that it will reflect difficulties in perceiving certain types of sounds with a CI, especially in high-frequency range.

To answer these questions, we built two receptive tasks. First, we use a lexical access task using picture-selection in an eye-tracking paradigm: a prerecorded word is presented orally, along with four pictures representing 1) the target word, 2) a phonological competitor and 3) & 4) semantic distractors to both words. The target word and the phonological competitor differ in 1, 2 or 3 acoustic features. Details of the task are presented in Figure 1 and Table 1 . Reaction time and accuracy of picture selection, and fixation times are measured. This setting allows us to explore the role of the segment's intrinsic saliency in lexical processing. Our second task is a web-based lexical decision task: a word or a non-word is presented orally, along with one picture, and two buttons and participants are asked to decide if the word matching the picture was correctly produced. Pairs of words and non-words were built using contrasts placed either in first or second syllables. This allows us to explore the role of positional saliency in the lexical decision process. Accuracy and reaction times are measured.

Our study will include 3 groups of 20 German-speaking participants: 1) a group of 5- to11 year old children with CIs, 2) a group of age-matched children with NH and 3) a control group of adults with NH. Reaction times and fixation times are analyzed both from the word onset and the time at divergence between word pairs.

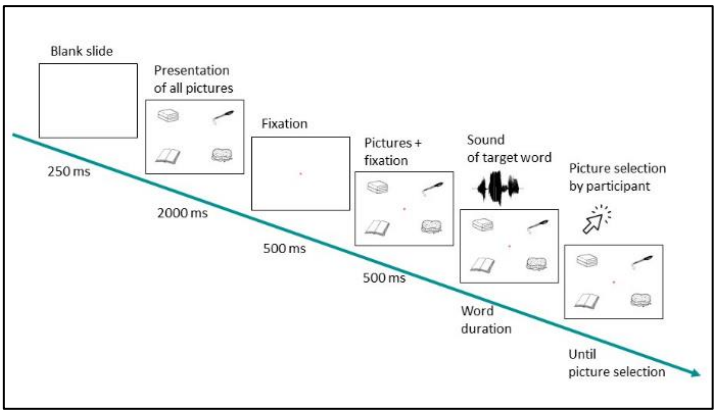

Figure 1. Eye-tracking setting in the lexical decision task (Task 1)

Segment	Number of contrasting features	Features	Nb of target words	Example
Consonant	1	manner	4	/pas/-/fas/
		place (fricatives)	4	/vant/-/zant/
		place (plosive)	4	/bʁɪlə/-/gʁɪlə/
		voicing	4	/kabəl/-/gabəl/
	2	manner + voicing	4	/bʊtɐ/-/fʊtɐ/
		place + manner	4	/tɪʃ/-/ fɪʃ/
		place + voicing (plosive)	4	/tuːχ/-/ buːχ/
	3	place + manner + voicing	4	/beːʁə/-/ʃeːʁə/
Vowel	1	front-back	4	/baːt/-/bɛt/
		height	4	/mʊnt/-/moːnt/
		roundedness	4	/kɪstə/-/kʏstə/
	2	front-back + height	4	/rybə/-/rɔbə/
		front-back + roundedness	4	/kɔfɐ/-/kɛːfɐ/

Table 1. Number and type of contrasts considered in the eye-tracking task

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