Six-month-old infants' abilities to represent regularities in speech

Irene de la Cruz-Pavía (University of the Basque Country, Basque Foundation for Science Ikerbasque) and Judit Gervain (University of Padova, CNRS-Université de Paris)

Introduction. In order to acquire grammar, infants need to extract regularities from the linguistic input. From birth, infants can detect certain regularities from speech, notably repetitions. Thus, newborns show strong neural activation (as compared with a silent baseline) for syllable sequences that contain adjacent repetitions (ABB: *mubaba*). Meanwhile, their activation in response to random syllable sequences (e.g. ABC: *mubage*) is very weak (Gervain et al. 2008, *PNAS*), and does not differ from their response to the silent baseline. Here, we seek to uncover when in development infants begin to also represent sequences containing a diversity-based rule — such as the random sequences — as strongly as sequences containing a repetition-based rule. We examine thus 6-month-old-infants' abilities to represent the two types of structures. As infants begin to learn their first word forms at this age, we hypothesize that the ability to represent sequences of different syllables might become important for them.

Methods. We used NIRS to examine whether 6-month-old French learning infants' (n = 24) representation of repeated and random sequences in speech. We presented infants with Gervain and colleague's (2008) original materials (ABB vs. ABC: *mubaba* vs. *mubage*), and measured, using a NIRx NIRScout system, infants' brain responses in the bilateral temporal, parietal and frontal areas, that is, in the brain network known to be involved in language processing in adults and infants (10 channels/hemisphere). Procedure consisted of an alternating/non-alternating design (see Figure), a paradigm used extensively in developmental NIRS to test discrimination. In this design, infants listen to two types of blocks. Alternating blocks contained tokens of the two types of structures presented in strict alternation (6 blocks: half ABB-ABC, e.g. ABB-ABC: *talulu*$_{ABB1}$ *zimuta*$_{ABC1}$ *tofifi*$_{ABB2}$ *dufeto*$_{ABC2}$*…,* the remaining half ABC-ABB). In turn, non-alternating blocks contained tokens of a single structure (6 blocks: half only ABB, e.g. ABB: *dufefe*$_{ABB1}$*, fibaba*$_{ABB2}$*, zepipi*$_{ABB3}$*, lokuki*$_{ABB4}$…, the remaining half ABC). If infants discriminate both types of structures, they are expected to exhibit different neural activation in response to the alternating and non-alternating blocks. Blocks with artifacts in the signal were discarded, and we averaged responses across the remaining blocks of each condition.

Results & discussion. Using cluster-based permutation tests we examined infants' brain activation in response to the alternating and non-alternating blocks, and found an advantage for non-alternating blocks in right frontal regions. This result shows that the 6-month-old infants discriminated the two sequence types. Crucially, analysis of only non-alternating blocks revealed equally strong neural activation to the blocks containing only ABB or only ABC tokens, higher than during the silent baseline. That is, while newborns show high activation only in response to repetition-based structures (i.e. ABB), 6-month-old infants show high activation in response to repetition- and diversity-based structures (i.e. ABC).

This finding contrasts with infants' failure to detect diversity-based rules even at 12 months of age in behavioral studies (Kovács, 2014). Our results provide thus the earliest evidence that young infants encode diversity-based patterns, i.e. represent difference, in speech. This research has important implications for language development, furthering our knowledge of infants' processing of rules in linguistic stimuli.

Gervain, J., Macagno, F., Cogoi, S., Peña, M., & Mehler, J. (2008). The neonate brain detects speech structure. *PNAS, 105*(37), 14222-14227.

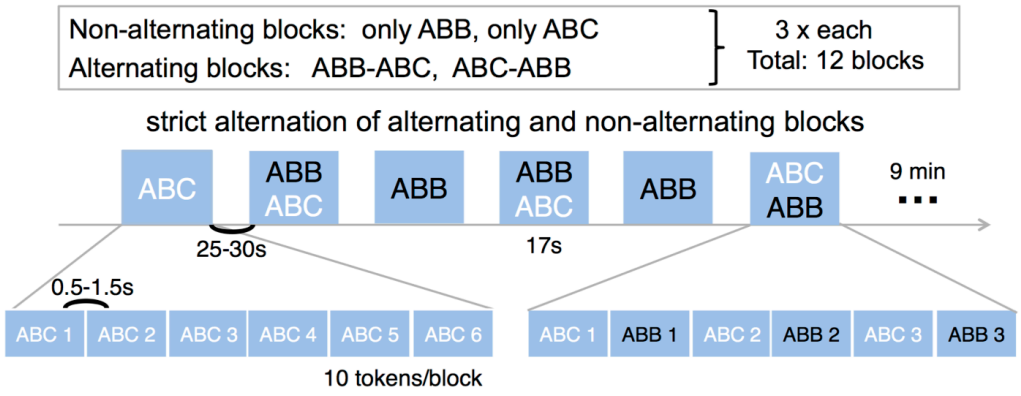
Kovács, Á. M. (2014). Extracting Regularities From Noise: Do Infants Encode Patterns Based on Same and Different Relations? *Language Learning, 64*, 65–85.

Figure. Stimuli (A), procedure (B), and layout of the regions measured and channels showing significant differences between alternating and non-alternating blocks (C)

A. Stimuli

ABB	ABC
tobibi	tobisha
lukoko	lukobi
bazeze	bazeko
kushasha	kushape
fetata	fetamu
… (x60)	…(x60)

B. Alternating/non-alternating design



C. Layout of the regions measured and results