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# Neonates can extract words from continuous speech relying on distributional cues and on prosodic cues.

In order to begin to learn their language, infants must extract individual words from continuous speech. Understanding how infants manage to do this and when these skills emerge is fundamental to understanding language acquisition. Since the work of Saffran, Newport and Aslin (1996), extensive research has explored infants'abilities to use the distribution of syllables for speech segmentation, showing that infants can use variations in transitional probabilities between syllables to segment words from speech. However, further research has shown that the success on this task for both adults (Shukla et al. 2007) and infants (Jusczyk et. al 1999; Johnson & Jusczyk, 2001; Shukla et al. 2011) is affected by the presence of prosodic cues, suggesting that prosody is also a cue that guides the segmentation of continuous speech (see also Endress & Hauser, 2010). In two experiments we ask whether from birth, distributional cues alone or prosodic cues alone can cue the segmentation of words from speech.

In Experiment 1 we investigated how neonates use transitional probabilities (TPs) to extract words using functional Near Infrared Spectroscopy (fNIRS). Newborns (N=40) were familiarized to 220 seconds of continuous speech built using 4 3-syllabic words, repeated randomly (TPs of 1/3 between words and 1 within words), and afterwards they heard test blocks of words (sequences delimited by drops in the TPs) or part-words (sequences containing drops in the TPs). We predicted that if infants were able to segment the stream and extract the words, the words should be familiar, whereas the part-words should be perceived as novel. Previous fNIRS studies show an increase in HbO2 for novel stimuli and a decrease for familiar ones (Nakano et. al, 2009), therefore if infants can extract the words we should observe an increase in HbO2 for part-words compared to words. Cluster-based permutation analyses revealed two clusters with a differential activation. One cluster involved fronto-temporal channels of the right hemisphere ($p<0.01$) and the other fronto-temporal channels of the left hemisphere ($p<0.01$). This suggests that neonates are able to extract the words using TPs between syllables.

In Experiment 2 we asked if neonates could segment speech relying only on prosodic cues. To address this question we used the exact same protocol than in Experiment 1 but we modified the familiarisation phase. We generated a continuous stream by concatenating the 4 3-syllabic words in the exact same order (uniform transitional probabilities of 1). Four prosodic contours of Italian CVCVCV phrases were superimposed, preserving the duration and pitch of each phoneme, and grouping the stream in 4 3-syllabic sequences. During test blocks words (sequences marked by prosodic contours) or part-words (sequences straddling prosodic contours) were presented without prosody and separated by pauses. Removing the prosodic cues at test allowed us to examine if the infants were actually able to use the cues to extract the syllabic sequences. Cluster-based permutation analyses (N=40) revealed one clusters with differential activation on the right hemisphere ($p<0.005$), indicating that neonates can rely on prosodic cues to segment speech. Moreover, at test, the words and part-words were presented without the prosodic contours, suggesting that newborns could recognize the words across the differences in pitch and duration.

Together this experiments show that different mechanism for speech segmentation are available even from birth. The real impact for speech segmentation of each of them and their interaction remains as an open question.

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