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Acoustic cues for segmentation resist within speaker variation: An EEG study

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In order to recognize spoken words, listeners must map sensory information from the acoustic input onto stored lexical entries. Because the speech signal is continuous, listeners must segment the speech stream in order to recognize words. To accomplish the task of segmentation listeners use their tacit knowledge of a wide range of patterns in their native language including cues from allophonic variation, phonotactic constraints, transitional probabilities, lexical stress etc. Among those cues, there is now a growing body of evidence suggesting that fine-grained acoustic information is available for lexical access and used for segmenting the speech stream. Although it is generally agreed that acoustic cues are used on line to segment the speech signal and to bias lexical access, some important questions remained unanswered. First we ought to know whether these cues are robust enough to be used in the context of multiple productions of the same segmentation as speech is by nature variable and listeners are never exposed to invariant speech. The second important open question is that of the timing of the use of the cues.

In this study, we examined the electrophysiological correlates of the use of such segmentation cues with a modified version of the Oddball paradigm (Brunellière, Dufour, Nguyen & Frauenfelder, 2010). We used spoken utterances in French that are phonemically ambiguous (e.g., *l'amie* 'the friend' vs. *la mie* 'the crumb', both [lami]) but which show acoustic differences that are used by listeners during word segmentation (Welby, 2007; Spinelli, Welby & Shaegis, 2007; Spinelli, Grimault, Meunier & Welby, 2010). In experiment 1 (syllabic experiment), event related potentials (ERPs) were recorded while French participants were presented with four standard [la#] syllables (coming from four different productions of carrier sentences containing e.g., *la mie* [la#mi] 'the crumb'.) and a fifth deviant that could be either [la], a syllable that was excised either from another production of *la mie* [la#mi] (same segmentation condition) or [la] from *l'amie* [l#ami] ('the friend' different segmentation condition), or [li] a phonemic deviant. All stimuli were recorded by the same French native female speaker. We examined and compared the mismatch negativity (MMN) elicited for the test syllable in the different segmentation condition (for example, $[la\#]_1$, $[la\#]_2$, $[la\#]_3$, $[la\#]_4$, and test [l#a]), in the same segmentation condition (here, $[la\#]_1$, $[la\#]_2$, $[la\#]_3$, $[la\#]_4$, and test $[la\#]_5$) and in a phonemic deviant condition $[la\#]_1$, $[la\#]_2$, $[la\#]_3$, $[la\#]_4$, and test [li]). In experiment 2 (word experiment), the whole determiner-word sequences were presented (for example, $[la\#mi]_1$, $[la\#mi]_2$, $[la\#mi]_3$, $[la\#mi]_4$, and test [l#ami]).

In both experiments, results showed an increased MMN (with an onset on the beginning of stimuli) for both the phonemic deviant condition and the different segmentation condition

suggesting that even in a passive listening situation (no task), the acoustic cues that differentiate “l’a” from “la” are relevant to the recognition system (the MMN mean amplitude significantly differed from zero for all deviant types in all paradigms; $p < .001$). MMN-[la#] was significantly earlier than that observed for MMN-[l#a] (respectively +243 ms and + 289 ms, $t15=5,024$, $p < .001$).

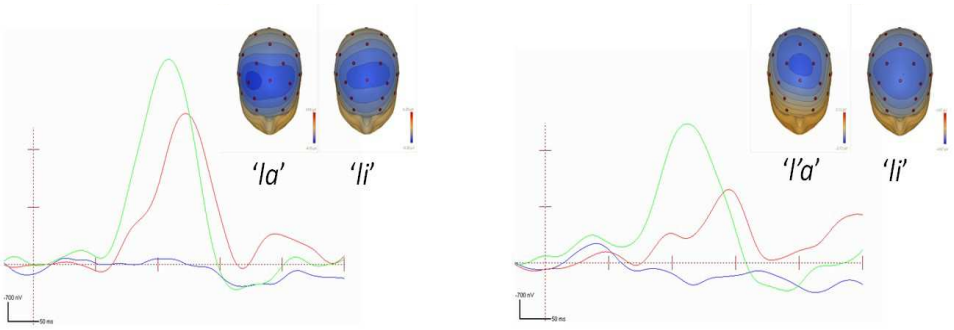


Figure. Grand average deviant – minus - standard difference signals at Fz as well as the corresponding voltage maps for deviant [la#] (left), [l#a] (right) and the control deviant [li] for the syllbic experiment. The MMNs peaked between 200 and 300 ms from deviation onset (sound onset always at 0 ms). Identity MMN (ERP for the deviant standard) is in blue, [la]-MMN in red and [li]-MMN in green. Results for the word experiment were similar.

Moreover acoustic cues are robust and remain from one production to another since listeners could discriminate between the two segmentations despite within speaker variability. Our results also complement previous behavioral findings by showing that these fine acoustic details are available as early as phonemic information.

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