Pre-activation negativity (PrAN): A neural index of predictive strength of phonological cues

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Occurring at rates of up to 6–7 syllables per second,[1] speech perception and understanding involve rapid identification of speech sounds and pre-activation of morphemes and words.[2] Using event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI), we have investigated the time-course and neural sources for phonological cues pre-activating word endings[3-6] and syntactic structures[7] as participants hear unfolding words. The ERP results have led us to propose a new brain potential: the 'pre-activation negativity' (PrAN) (Figure 1).[3,4] PrAN is an electrically negative deflection occurring at 136–280 ms following a number of different phonological elements (segmental phonemes,[3] morphologically conditioned word accents,[4-6] and left-edge boundary tones[7]). These phonological elements have in common the fact that they cue relatively few possible word- or sentence-level continuations. Thus, PrAN for word beginnings was found to increase gradually with a decrease in the number of possible word completions[3,4] and an increase in the lexical frequency[3] of those completions. In other words, PrAN became stronger the more certain participants could be about the continuation of a word at a certain point due to a relatively more reduced lexical cohort[8] containing relatively more frequent words. At the clause level, absence of a "left-edge boundary tone" at the beginning of an embedded clause was also shown to produce a greater PrAN as compared to the presence of a boundary tone.[7] The embedded clause context without a left-edge boundary tone led to increased certainty regarding the upcoming syntactic structure of a clause, due to it being associated with fewer syntactic possibilities than if there had been a boundary tone.

For real words, the PrAN for processing of word accents, which are important phonological cues in morphological prediction, correlated with blood-oxygen-level-dependent (BOLD) activity in the left superior temporal gyrus and pars triangularis and orbitalis of the left inferior frontal gyrus (IFG). These are areas of the ventral processing stream, relevant for whole word form access.[9-11] Forcing morphological processing by using pseudowords yielded a more left-frontally distributed PrAN,[12] possibly reflecting involvement of the part of the dorsal stream handling grammatical processing.[13] The PrAN for word beginnings with few possible completions was associated with a BOLD increase in the pars opercularis of the left IFG and angular gyrus of the left parietal lobe. The activated areas are in line with the dorsal brain stream for predictive processing, also engaged during sensorimotor and auditory-motor mapping[9] as well as lexical selection.[14] Left-edge boundary tones cueing syntactic structures activated IFG, pars opercularis, but extended more ventrally than the activation observed for word beginnings.[7]

This presentation will show the time-course and neural underpinnings of the online processing of phonological cues to lexical, morphological, and syntactic pre-activation. Thus, based on ERP-BOLD correlations, we suggest that the PrAN for phonological cues to word forms might be subdivided into an early phase (136 ms),[5,13] involving the ventral processing stream, and a later phase (200 ms), with neural sources along the part of the dorsal stream dealing with sensorimotor and auditory-motor processing.[3,5] The early activation of the ventral stream can be interpreted as representing initial lexical access.[14] The later engagement of the dorsal stream could reflect lexical selection through inhibition of competitors in the activated lexical cohort. The PrAN for phonological cues to grammatical structures seems to have sources in the part of the dorsal stream dedicated to syntactic processing.[15] Finally, PrAN could be thought to be similar to the contingent negative variation (CNV) in that it reflects expectancy for a not yet heard part of a stimulus. However, PrAN's timing is much earlier and rather overlaps the N1 and P2 components, from which PrAN differs in not responding to physical characteristics of phonological cues *per se*, but rather to their predictive potential.

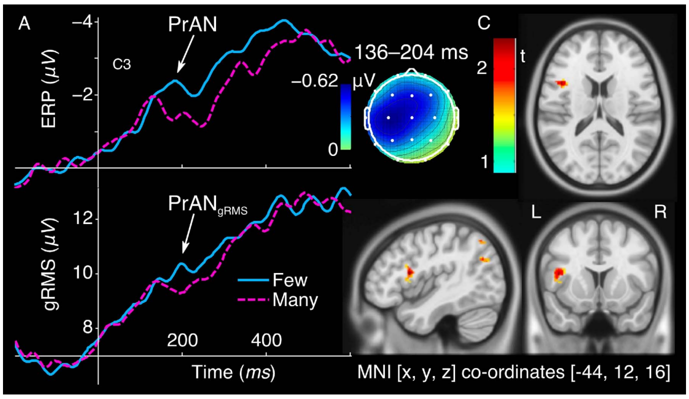

Figure 1. *Pre-activation negativity (PrAN) and possible neural sources at word beginning during online speech processing. PrAN increased with certainty about upcoming word endings, i.e. with fewer possible word completions with higher lexical frequency.*[3]

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