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Perception of self- and other-referential sentences with varying emotional content: a neurolinguistic study

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Motivation and Aim: Implicit neurophysiological markers of psychological states and characteristics are widely utilized in the field of experimental psychology and psychiatry as they allow to study measurable and minimally biased reactions. In this exploratory study we aim to find new markers of language emotional processing and self-reference using spatiotemporal permutational test with clustering for electroencephalography (EEG) event-related potentials (ERP) data.

Methods and Algorithms: EEG datasets of sixty-four participants (34 females) aged between 18 and 52 ($\mu = 23.1$, SD = 7.2) were selected for this study. The datasets were acquired during a series of our previous behavioral experiments described in more detail in [1]. In short, a 128-channel EEG recording was made during which subjects were shown Russian sentences containing grammar errors and asked whether a sentence was correct or not. Unbeknownst to the participants, these sentences also described situations of anxiety or aggression and were referencing self (the reader) or other people (or were neutral/referenced an inanimate object). Two hundred sentences in total were shown, each from one of 10 categories based on emotional content, reference and grammatical correctness. EEG datasets were preprocessed automatically, using custom Python scripts and MNE, SciPy, NumPy, Pandas libraries. The pipeline for preprocessing was as follows: (1) bandpass filtering 0.1–100 Hz, notch filtering for 50 Hz; (2) detection and interpolation of noisy channels; (3) REST re-reference [2]; (4) ICA for noise reduction; (5) epoching with 0.5 s pre-stimulus and 1 s post-stimulus; (6) epoch-wise interpolation of noisy channels; (7) epoch averaging. Preprocessed data were then used to form a matrix of size $N_{subjects}*N_{channels}*N_{timepoints}$ (67*128*1500) to be used in a spatiotemporal permutation test with clustering as implemented in MNE Python [3–5]. We used the following set of parameters for the test: $N_{permutations}$=10.000; p-value for spatial cluster formation ≤ 0.001.

Results: Spatiotemporal permutation test with clustering for all conditions showed 2 significant clusters ($p_1 = 0.0015$, $p_2 = 0.0008$) of varying duration (50 ms and 100 ms) and onset (560 ms and 660 ms), but similar spatial placement (medial central electrodes) as shown in the Fig. 1 and 2. Fig. 3 and 4 show results for comparison of conditions anxiety/aggression/neutral (Fig. 3) and self/others/neutral (Fig. 4) and each have a significant cluster ($p_3 = 0.0011$, $p_4 = 0.0016$) of approximately the same duration (250 and 260 ms) and onset (550 ms), and spatial placement (medial central electrodes).

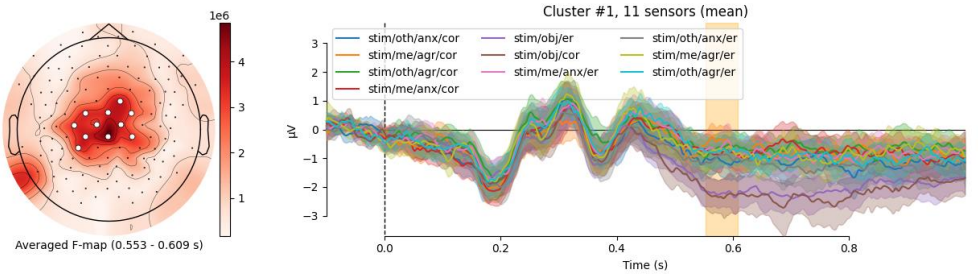

Fig. 1. Permutation test results for all conditions, cluster #1

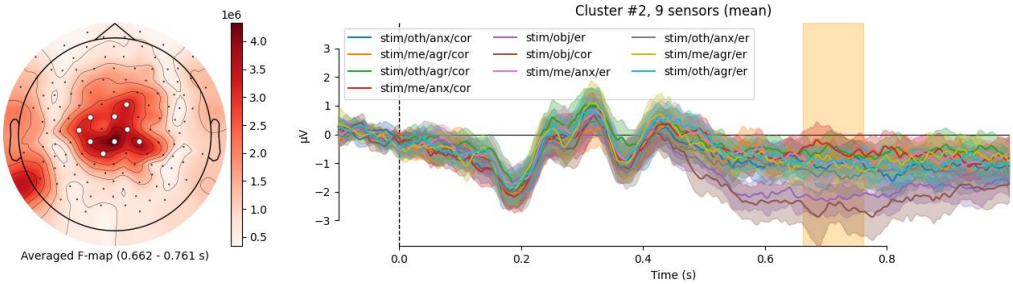

Fig. 2. Permutation test results for all conditions, cluster #2

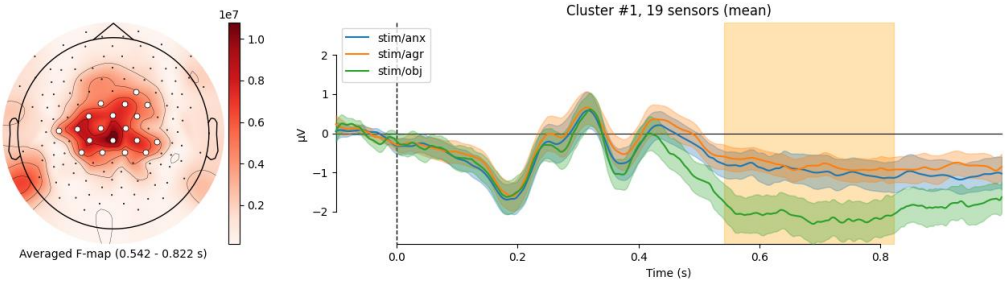

Fig. 3. Permutation test results for conditions anxiety vs. aggression vs. objective

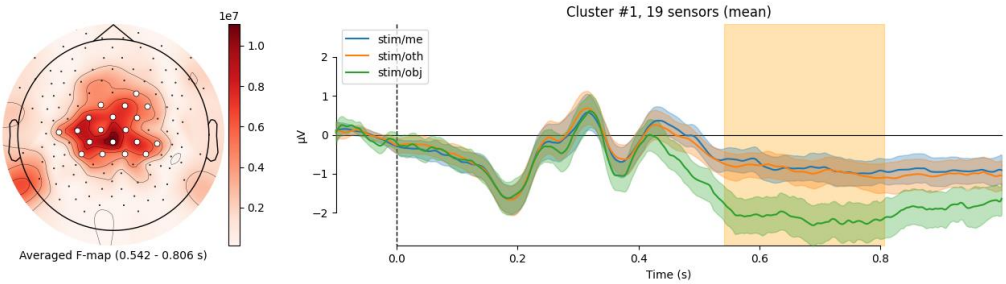

Fig. 4. Permutation test results for conditions self vs. other vs. objective

Conclusion: Our results point out that the late ERP time period (550–800 ms) may be important for linguistic emotional processing, which is also supported by the literature [6]. Neutral sentences are shown to elicit the most negative response in the later time period, which may have implications for their usage as “baseline” stimuli. Spatial characteristics of found clusters draw our attention to medial frontoparietal cortex regions.

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