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An Innovative Method for Detecting P300 Signals in Patients with Disorders of Consciousness

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Introduction: Distinguishing between patients in a vegetative state (VS) and those in a minimally conscious state (MCS) is challenging due to the complexity of clinical manifestations and the limitations of current diagnostic tools. Behavioral differences between VS and MCS can be subtle and are often easily mistaken for reflexive or random activities. Passive acoustic P300 has emerged as a valuable tool for detecting cognitive functions, even in individuals unable to actively engage or respond. The primary challenge lies in reliably detecting the P300 component, as its latency, amplitude, spatial distribution, and polarity can vary significantly across patients [1].

Material, Methods and Results: A dedicated software was developed to generate a P300 sequence of acoustic stimuli, consisting of 50 target and 250 standard stimuli. Twenty-seven non-responsive subjects were tested (10-20 EEG System) before they were diagnosed, with the stimuli being the patient's name and a masked version of the same name to preserve the same envelope. The NPXLab suite was used for signal preprocessing (including ICA, filtering, etc.). A custom software implementation was used to compare responses to target and standard stimuli with the following methodology with no assumptions regarding P300 latency, amplitude, spatial distribution, and polarity:

1) For 1000 iterations, 50 standard stimuli were randomly selected to compute the standard responses for each channel before (-1750ms to -250ms) and after (250ms to 1750ms) the stimuli.
2) After each iteration, a t-test on each of the 14592 samples (768 per 19 channels), was conducted between the standard and target responses for all channels.
3) Samples with a statistical difference (t-test) less than 0.01 were counted
4) Histograms (pre, post, standard, target) were constructed from all iterations, with the number of samples identified in step 3, and compared. (Fig. 1).

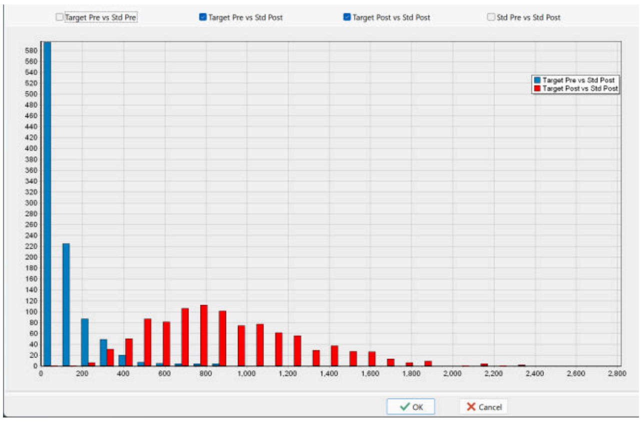

Figure 1: *Histograms relative to the number of statistically different samples computed by comparing Target Pre vs Standard Post epochs (blue) and Target Post vs Standard Post epochs (red) of one subject. It can be deduced that Standard Post activity is similar to Target Pre stimuli (values are close to the 0 bar), while Standard Post and Target Post stimuli activities belong to a different distribution (KS test p<0.001).*

All 17 subjects who exhibited a significant difference between standard and target responses (K-S test) were later diagnosed as MCS, with no false positives observed. Five false negatives were detected.

Conclusion: Accurately differentiating between VS and MCS is crucial for determining appropriate treatment, guiding rehabilitation efforts, and making end-of-life decisions. Here, a method that is shaped for each subject is shown.

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