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Blink Artifact Rejection Reduces P3 Speller Accuracy but May Prevent Unintended Blink-Based Control

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Introduction: The P3Speller, first proposed by Farwell and Donchin [1], relies on the P300 brain response. The P300 is well-studied in various application domains and recording standards are available [2]. These standards are not followed by most brain-computer interface (BCI) systems, mainly for reasons of speed. One recommended technique is blink artifact rejection. Of available techniques, we focus on FORCe [3], a recent artifact rejection methods designed for BCI that works on 1 s electro-encephalogram (EEG) segments.

Material, Methods and Results: This study uses recorded data from [4], [5], where participants used a BCI on three separate days to produce three sentences per day, with one extra training file on day one. Data is from the first 33 participants to complete the protocol. There were 10 participants with amyotrophic lateral sclerosis, 9 age- and gender-matched neurotypical controls, 4 with neuromuscular dystrophy, and 7 additional controls.

We used 1 s EEG segments starting from 100 ms pre-stimulus to capture the 0-800 ms window used in our online studies. Each EEG datafile was segmented, passed through FORCe, and decimated by a factor of 13 prior to least-squares classification. The results were compared to an identical processing chain without FORCe or any other artifact rejection. Separate classifiers were trained and tested on their own processing chains.

Of the 297 sentences analyzed, using FORCe decreased BCI accuracy in 204 sentences, had no effect in 48, and increased accuracy in only 45. Assuming a binomial distribution, the 95% confidence bounds on FORCe producing strictly lower BCI accuracy are 0.63 to 0.74. However, a small subgroup of participants did not follow the overall trend, including one participant whose FORCe accuracies were all greater than or equal to those without FORCe (probability by chance estimated at 1 in 1000).

Discussion: For some participants, the grand average waveforms show no large structural changes aside from an overall decrease in amplitude (figures on poster). However, for the participant whose accuracy was most reduced by FORCe, blink artifact appears to have overlapped the P300 Event-Related Potential complex, and thus been used for online BCI operation. This participant appeared to withhold blinking until target flashes, and tended to blink after targets. In contrast, the participant who was helped most by FORCe seemed to blink immediately after all stimuli, rather than showing target/non-target differences. The overall downward trend is more difficult to interpret – not all participants showed obvious blinking trends or changes in morphology. Notably, the finding of blink rejection reducing accuracy are not in accord with [6], possibly due to differences in the methods used.

Significance: The results indicate that blinking patterns may be used unconsciously by participants to boost P3 Speller performance. In some cases this fact may be obvious under inspection, leading to an enjoinder for all BCI researchers to inspect P3 waveforms rather than rely on algorithmically-set weights. Further, BCI labs working with P3 spellers are encouraged to revisit their blink detection algorithms, or begin using them if not doing so already. While BCI accuracy may be reduced by these algorithms, failure to use blink rejection may lead to false conclusions about the performance of the BCI.

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