Proceedings of the Fifth International Brain-Computer Interface Meeting 2013 DOI:10.3217/978-3-85125-260-6-119

ERPs in the P300 BCI: Sensitivity to Matrix Size and Task

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Abstract. We investigated, using principal component analysis (PCA) on the 128 channel EEG data from six participants, the structure of the event-related potentials (ERPs) elicited by target flashes in the P300 brain-computer interface (BCI). Besides the P300, target flashes elicited an earlier, frontal positivity: the Novelty P3. The P300 was larger for the 3 participants whose task was to count the target flashes, compared to the 3 participants who merely attended to the target. The Novelty P3 tended to show the opposite pattern. Amplitudes of both components increased with matrix size (and hence with decreasing target flash frequency). These results have important implications for optimizing the performance of the BCI.

Keywords: P300, Brain-Computer Interface, Matrix Size, Task

1. Introduction

Several studies have suggested that in the P300 BCI [Farwell and Donchin, 1988], ERP components besides the P300 distinguish between target- and non-target flashes. In the present study we focus on the P300 [Sutton et al., 1965] and the Novelty P3 [Courchesne et al., 1975], which overlap in time and space (e.g., [Spencer et al., 1999], and in a previous study from our laboratory were implicated as crucial for BCI performance [Kamp et al., 2011]. An investigation of other ERP components is beyond the scope of this abstract, but will be included in future analyses. Thus, we investigated how, in the P300 BCI paradigm, P300 and Novelty P3 respond to parameters known to affect the P300 in standard oddball paradigms: the frequency of the eliciting event and the participant's task. Often, BCI researchers appear to make decisions on these parameters haphazardly; thus, our analysis could help establish better guidelines for P300 BCI use. We manipulated frequency through the size of the matrix: the larger the BCI matrix, the more rare are the target flashes. Furthermore, participants performed one of two tasks: either they counted the target flashes, or they focused on them and noted each flash to themselves.

2. Materials and Methods

Six healthy participants took part in two sessions each. In the first session they used a P300 BCI with 8 channels. The second session, from which we report results here, involved using the P300 speller with a 128 channel EGI system. Participants either focused on the target character and noted every time it flashed (attend condition; n = 3), or they counted the number of times the target flashed (count condition; n = 3). Three experimental blocks, completed in random order, included a 6 x 6 matrix including letters, 9 digits and a space bar, a 4 x 4 matrix including the letters A-P, or a 2 x 2 matrix including the letters A-D. The EEG from 128 channels was corrected for eye blinks, baseline corrected, and re-referenced to linked mastoids. The subject ERPs from target and non-target flashes were then submitted to a spatio-temporal principal component analysis (PCA; [Spencer et al., 1999]).

3. Results

As shown in Fig. 1, our PCA identified a parietal P300 and a fronto-central Novelty P3. The scalp distributions ("spatial factor loadings") closely corresponded to those obtained in prior PCA analyses of the P300 and Novelty P3 (e.g., [Spencer et al., 1999],). Both the Novelty P3 and the P300 were more positive-going for target- than non-target flashes, but the Novelty P3 peaked earlier (at about 300 ms, compared to 400 ms after the target flash for the P300). Therefore, we replicate the finding that in the P300 BCI both the P300 and the Novelty P3 distinguish between target and standard flashes and that they are distinct ERP components.

All participants who counted the target flashes showed larger P300 amplitudes than all participants in the group that merely attended to the targets. The Novelty P3 tended to show the opposite pattern. Besides this effect of task type on P300 amplitude, both Novelty P3 and P300 amplitudes were sensitive to matrix size such that larger matrices (and hence decreasing target flash frequency) were consistently associated with greater ERP amplitudes.

 DOI:10.3217/978-3-85125-260-6-119

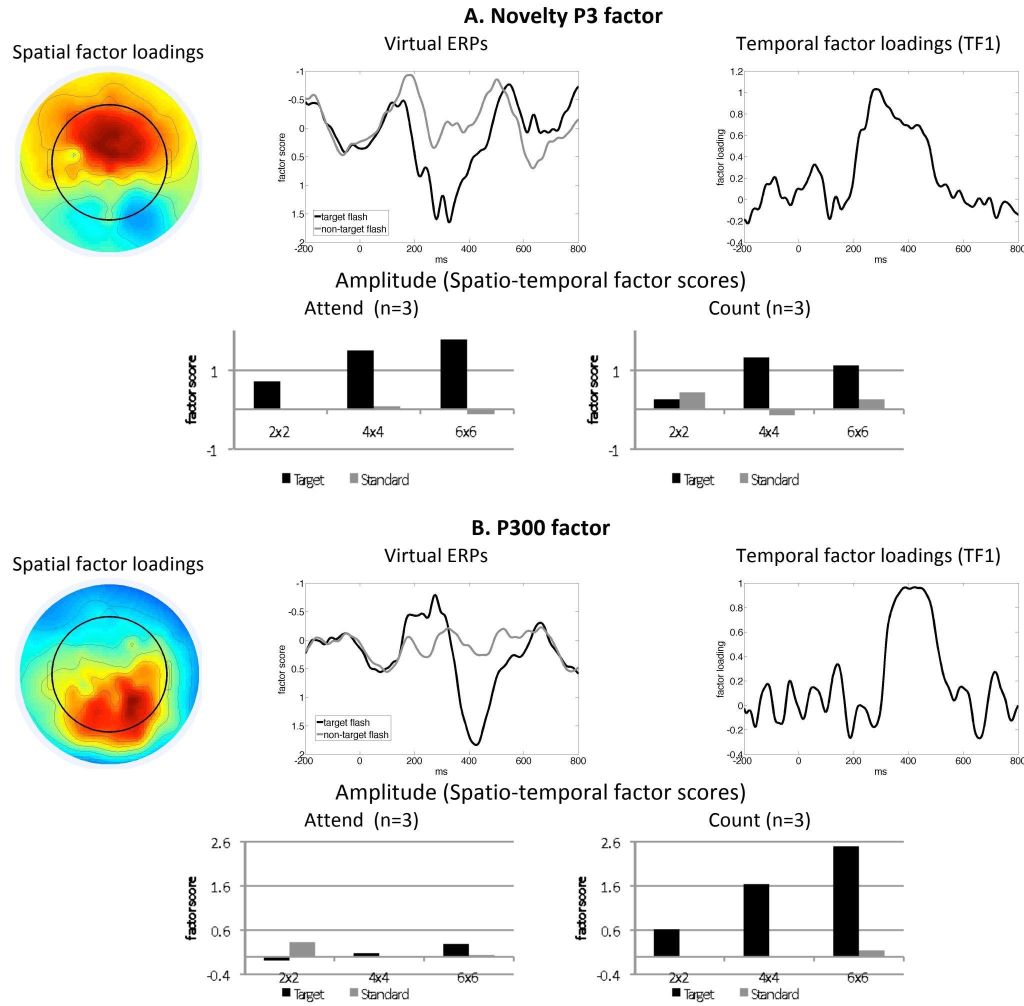

Figure 1. *Novelty P3 and P300 PCA factors. Shown are scalp distributions ("loadings"), "Virtual ERPs", the temporal factors we analyzed, and spatio-temporal factor scores as measures of ERP amplitude (cf. [Spencer et al., 1999]).*

4. Discussion

Our data show that the P300 elicited in the P300 BCI is sensitive to the participant's task, suggesting that the task that is given to an individual using the BCI should be chosen carefully in experiments and home BCI use. Both components also responded to target frequency. Future analyses will establish if the ERP patterns directly translate to differences in classification accuracy, so that the results can be used to improve performance of the P300 BCI.

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