Can the N2pc ERP component track visual attention?

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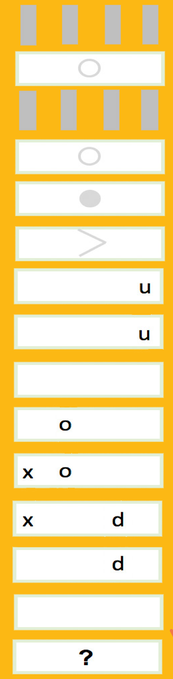
Introduction

The N2pc component is a lateralized ERP waveform that arises during visual attention deployment at posterior electrodes. The SPCN is another lateralized ERP component that reflects the maintenance of information in visual working memory. Using a modified Posner cueing task and a Dendrogram Support Vector Machine classification method, we ask whether these components can track the deployment of spatial attention while participants perform a visual task.

Method

An endogenous spatial cue was presented at the center of the screen to indicate one of four possible letter locations within a horizontal alignment. A simple arrow indicated locations closer to the center of the screen (2 & 3) whereas a double arrow indicated locations farther from the center of the screen (1 & 4). The center-to-center distance between consecutive letters was 1.5° of visual angle.
The cue duration was 250ms. After a 450ms blank pause, 4 letters appeared for 33 ms at random onset times within a 150 ms stimulus presentation window. After a 2 second pause, participants were instructed to enter the letter that had appeared at the cued position using the computer keyboard. 50% of the 1200 trials contained no letter (blank trials).



Time Course

Men = 2 Women = 12

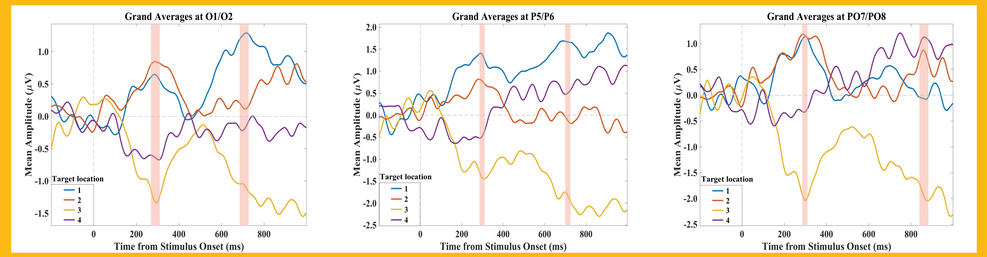
Mean age = 21

Neuropsychological/vision troubles = 0

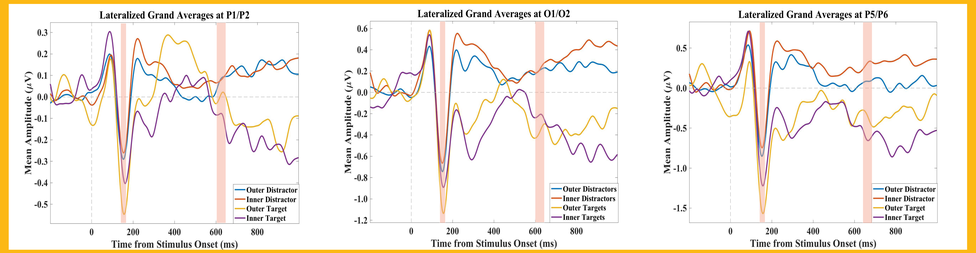
n = 14

ERP Analysis

The lateralized averages were computed from the averaged EEG signal of each trial for each participant and by subtracting the signal of the right electrode from that of its left couterpart at 3 posterior electrode pairs (O1,/O2, P5/P6, and PO7/PO8). Blank trials were matched for cued position and subtracted from trials that contained stimuli. The signal associated to distractors was also susbtracted from the signal of the targets matching their position. Time windows were selected from data observation
(O1/O2: 250-300 ms & 675-725ms; P5/P6: 275-300 ms & 700-725 ms; PO7/PO8: 275-300 ms & 825-875 ms)



The N2pc and SPCN were computed from the averaged EEG signal of each trial for each participant by subtracting the signal ipsilateral to the target from the signal contralateral to the target for 3 electrode pairs (P1/P2, O1/O2, P5/P6). Blank trials were matched for cued position and substracted from trials that contained stimuli. Signal from positions 1 and 4 were averaged together and signal from positions 2 and 3 were averaged together for targets and for distractors. Time windows corresponding to the time frame of the N2pc and SPCN components were selected (150-175ms and 600-650ms for O1/O2 & P5/P6; 150-175 ms & 650-700 ms for P1/P2).

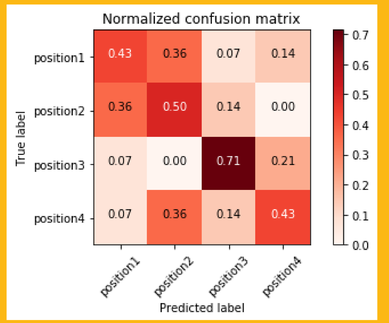


Machine Learning

A Dendrogram Support Vector Machine (DSVM) was used to classify the ERP data into 4 classes corresponding to the 4 possible target locations. This method has proven to be highly efficient with small sample sizes such as this one. The structure of the dendrogram was determined by hierarchical clustering. A leave one out cross valiation method was used to test the model. In this cases, the level of chance was of 25%.

A 51,78% ($p < 0,01$) decoding accuracy was obtained from a pooling of the total signal. Interestingly, when data from the time windows pertaining to both the early and late ERP components were used separately for classification, the late one led to a higher decoding accuracy than the early component (41,07% vs 35,7%).

A simple binary SVM was used to classify the presence vs absence of attention at a precise location, using the identity of the stimulus (targets or distractors) as indicators of attention at each position. The 4 positions on their own did not permit a classification of the presence or absence of attention. However, by combining the peripheric stimuli together and the central ones together, it was possible to obtain a decoding accuracy of 73,21% ($p < 0,001$), with a chance level of 50%. Taken alone, the first time window gave a decoding accuracy of 66,07% ($p = 0,007$), whereas the second time window gave a decoding accuracy of 76,78% ($p < 0,001$).



Discussion

The present results partially replicate those of Thiery et al. (2016), who obtained a 57% decoding accuracy for the binary target vs distractor classification and a 79% decoding accuracy for the 4 positions classification, using a similar method but with the exogenous cueing of attention instead of endogenous cueing.
Positions 1 & 2 were very rarely classified as positions 3 or 4, and vice versa. However, as per the confusion matrix, positions 1 & 2 were more likely to be wrongly classified as the other.
Interestingly, the SPCN time window permitted a better classification than the N2pc in both cases. The SPCN is an ERP component that relies on spatial components and is represented retinotopicaly. It remains to be determined what properties of the SPCN make it a somewhat better predictor of the spatial locus of attention than the N2pc.

References

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