The Effect of Task Based Motivation on BCI Performance: a Preliminary Outlook

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Abstract. Brain-Computer Interface is an alternative method of communication. The present BCI operates via event-related potentials (ERPs) extracted from the electroencephalograph (EEG). Items (i.e., alphanumeric characters and keyboard commands) attended to by the subject should produce a P300 ERP; unattended items should not. Participants are assigned to either a Motivation condition or a Non-motivation condition. We hypothesized that performance on a copy spelling task will be affected by an individual's motivation, or drive, to perform well. Before the BCI task is introduced to the subjects in the motivation condition, they are read a paragraph describing the importance of the task. Subjects in the non-motivation condition are introduced to the BCI task and begin the experiment. Mean accuracy in the motivation group was 93%, significantly higher than accuracy in the non-motivation group, 84% ($t < .001$). These results show that motivation can be an important factor to successful BCI use. Motivation should be considered as a factor that will influence BCI performance in disabled populations because potential BCI users who are less motivated may negate trends in the performance of motivated subjects.

Keywords: EEG, P300, Motivation, Brain-Computer Interface, Event-Related Potential

1. Introduction

A brain-computer Interface (BCI) provides a method of non-muscular communication. The BCI described here uses event-related potentials (ERPs) of the electroencephalogram (EEG) to select items from an array of alphanumeric characters. The paradigm is based on the design first described by Farwell and Donchin, 1988. Subjects observe an array of alphanumeric characters. The items in the array flash in rapid succession, while the subject attends to the specific item they wish to select. Motivation has been shown to affect BCI performance in non-disabled subjects and subjects with amyotrophic lateral sclerosis [Kleih et al., 2010]. Here we present a novel motivation manipulation to further investigate the relationship between BCI performance and level of motivation. We hypothesized that those with higher task-based motivation (i.e., willingness to participate in a task [Appel and Gilabert, 2002]), would perform better on a copy spelling task, and that they would produce higher amplitude ERPs. Given the attentional demands of the BCI, motivation to perform well can have a considerable impact on performance, especially in an ALS population because they often tire quickly and have limited time and access to BCI use.

2. Materials and Methods

Subjects (n = 14; 5 male) from the ETSU participant pool were enrolled in the study. BCI2000 was used for data collection and stimulus presentation. The study was approved by the East Tennessee State University Institutional Review Board.

EEG was recorded with a 32-channel tin electrode cap (Electro-Cap International, Inc.). All channels were referenced to the right mastoid and grounded to the left mastoid. Impedance was reduced to below 10.0 kOhm before recording. Two Guger Technologies g.USBamps were used to record EEG data, which were digitized at 256 Hz, and bandpass filtered from 0.5 to 30 Hz. Stepwise linear discriminant analysis was used to classify ERP responses. Only electrodes Fz, Cz, P3, Pz, P4, PO7, PO8, and Oz were used for online BCI operation [Krusienski et al., 2006].

Subjects were randomly placed into the motivation condition or the non-motivation condition. Subjects in the motivation condition (n = 6) were read a paragraph stating the importance of the research. For example, they were told that people with ALS and other conditions could have their ability to communicate completely abolished by disease, and because of the importance of this research for these people, they should give 100% of their attention and effort to the task so that the data would be extremely accurate. After being read the paragraph, the subjects were given the opportunity to opt out of the study without penalty if they felt unable to give their full attention to the task. Only one participant chose to leave. Subjects in the non-motivation condition (n=8) were not read the paragraph and

proceeded with the study. The Stanford Sleepiness Scale [Hoddes et al., 1973] and the On-line Motivation Questionnaire (OMQ) [Boekaerts, 2002] were administered prior to completing calibration and a copy spelling task. Calibration consisted of 18 characters; online testing consisted of 24 characters. Following the BCI task, subjects completed the post task portion of the OMQ and stated their motivating factor for anecdotal purposes.

3. Results

As shown in Table 1, mean accuracy for the motivation group was 93% and mean accuracy for the non-motivation group was 84% ($t < .001$). In addition to performance differences, the r^2 values for the main positive and negative components of the ERP are visually higher for the motivation group (Fig. 1, top left), than for the non-motivation group (Fig. 1, top right). The waveforms at Pz for the motivation group suggest higher amplitude positive peaks and an earlier negative peak than the non-motivation group (Fig. 1, bottom row). Scores on the Stanford Sleepiness Scale were similar in the two conditions. All except for one subject reported being "wide awake" or "functioning at a high level". Scores on the On-line Motivation Questionnaire range from 17–68. All subjects reported high levels of motivation and the score were statistically similar across conditions (motivation, 57.00, non-motivation 52.71; $t < 1$).

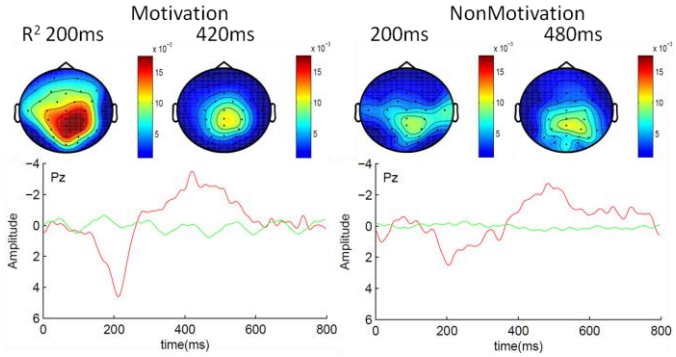

Figure 1. *R2 topographies and Pz waveforms for the motivation group (left) and non-motivation group (right).*

Table 1. *BCI accuracy by subject in the motivation and non-motivation conditions.*

Motivation			Non-Motivation		
Sub	Age	Acc	Sub	Age	Acc
004	19	1.00	002	23	1.00
005	20	0.92	003	19	0.79
009	22	0.63	006	21	0.63
012	21	1.00	008	26	0.96
013	29	1.00	011	23	0.88
015	22	1.00	014	22	1.00
			016	23	0.88
			017	24	0.54
Mean	22.17	0.93		22.63	0.84
StDev	3.54	0.15		2.07	0.17
SE	0.59	0.02		0.34	0.03

4. Discussion

This study examined the effects of a motivation induction on BCI performance. The induction consisted of a paragraph describing the importance of the research, which was read to the motivation group. All procedures were identical for the non-motivation group except they were not read the paragraph. Data show that the motivation group obtained significantly higher accuracy and had larger ERP components than the non-motivation group. Moreover, the two groups did not differ on measures of sleepiness and motivation. Thus, the data suggest that implicit motivation affects task performance. This may be especially important for disabled subjects because they stand to gain the most from BCI use.

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