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The Effects of Motivation on Task Performance Using a Brain-Computer Interface

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Abstract. A brain-computer interface (BCI) is a method of communication that utilizes the scalp recorded electroencephalogram (EEG). A BCI requires no movement, making it a viable communication option for people who are severely disabled. Most BCI research has focused on improving BCI technology through advances in signal processing and paradigmatic manipulations. Research has recently begun to examine the influence of psychosocial factors on BCI performance. Examining psychosocial factors may be particularly important for disabled people who have several co-morbidities. The purpose of the current study is to examine the hypothesis that participants will be more motivated in a free spelling paradigm than in a copy spelling paradigm. Participants completed copy- and free-spelling tasks, order was counterbalanced. Motivation was measured after each task. Preliminary data suggests an increase in motivation after the second task regardless of which task was performed second. No differences were observed in performance accuracy between the two tasks.

Keywords: Brain-Computer Interface, Motivation, ALS, P300, EEG

1. Introduction

Noninvasive brain-computer interface (BCI) uses electroencephalogram (EEG) to provide non-muscular communication. Most BCI research has not considered how psychosocial factors affect task performance and typically considers the participant as a passive observer during BCI use. Recent research has suggested a need for studies that focus on specific qualities of BCI users, such as their levels of motivation and depression [Kleih et al., 2010; Nijboer et al., 2010]. Examination of these factors may increase BCI performance by learning more about individual users, treating them as active participants, and addressing their specific needs. The current study examined the factor of motivation. Participants completed two tasks: copy- and free-spelling. After each task their motivation to perform the task was assessed [Boekaerts, 2002]. It was hypothesized that free spelling would lead to higher motivation ratings and higher accuracy. Learning about how and why a particular person may be motivated or unmotivated can help determine what tasks may lead to higher BCI performance by fully engaging participants in the task.

2. Material and Methods

Participants (n = 16) were recruited from the East Tennessee State University (ETSU) subject pool. All participants provided informed consent and the study was approved by the ETSU Institutional Review Board.

An Electro-Cap International, Inc. cap was used to record the EEG. Stimulus presentation, EEG data collection, and online processing were all controlled using the BCI2000 software [Schalk et al., 2004]. The current study used a stepwise-linear discriminant analysis method (SWLDA) to obtain classification coefficients for each participant.

Participants were fitted with a 32-channel electrode EEG cap and instructed to attend to the screen where an 8 x 9 (72 item) matrix was presented. Participants were then instructed to attend to the target character (the character the participant is currently trying to select) by mentally saying or counting the character when it flashed. Participants were also instructed not to attempt to correct mistakes and continue with the next character if the BCI provided incorrect feedback. Two sets of calibration data for the SWLDA were collected, one for copy spelling and one for free spelling. For each participant, the words used for calibration and copy spelling were randomly selected from a database of 6,000 words. Each word consisted of six characters. Copy- and free-spelling conditions were counterbalanced. Calibration data sets consisted of three words (a total of 18 character selections). The resulting classifiers were used in the copy- and free-spelling conditions.

In the copy-spelling task, three six-letter words in one string with a space in between each word were presented. In the free spelling task, participants constructed a sentence, ranging from 20-24 characters, to spell using the BCI. Before the free spelling task each participant wrote the sentence on a sheet of paper in order to calculate accuracy. They were also instructed to correct BCI mistakes using the BACKSPACE character (denoted "Bs"). If the participant had not completed the sentence before the limit of 24 character selections the task was terminated.

Two surveys were utilized in this study: the Stanford Sleepiness Scale (SSS) was used to measure fatigue [Hoddes et al., 1973]; the On-Line Motivation Questionnaire (OLMQ) was used to measure motivation [Boekaerts, 2002]. Both instruments are self-report measures and were given three times throughout the session. The OLMQ consists of pre- and post- task components. The pre-task OLMQ and the SSS were completed immediately after the first calibration sequence. The post-task OLMQ and SSS were both given after each of the two tasks were completed. At the conclusion of the session, participants were asked a qualitative question describing their motivation for participating in the study. This served as additional data to confirm participants' responses to the surveys.

3. Results

Performance accuracy for the copy-spelling condition was calculated by dividing the number of correct selections by the number of total selections. Performance accuracy for the free-spelling condition was calculated by comparing the actual message to the intended message. Mean accuracy in the copy- and free-spelling conditions did not show a significant difference (89.69% and 86.74%, respectively ($t < 1$)). Motivation after Post test 2 (62.18) was significantly higher than motivation after Post test 1 (56.69; $p < .02$). Fig. 1 shows the relationship between motivation and accuracy for Post Test 1 (the first condition) and Post Test 2 (the second condition).

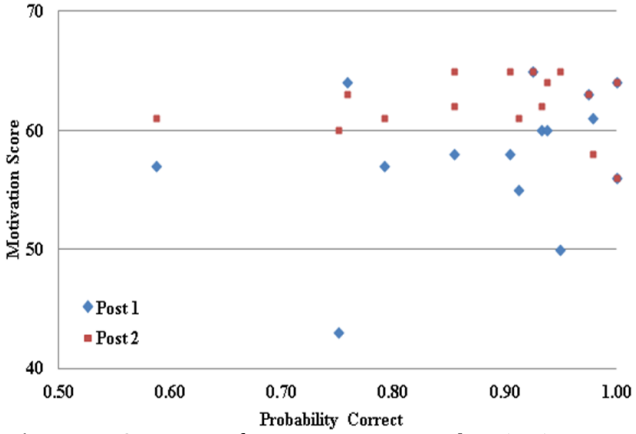

Figure 1. *Average performance accuracy and motivation scores of non-disabled participants for the first (Post 1) and second (Post 2) conditions.*

4. Discussion

This study examined the hypothesis that participants will be more motivated in a free spelling paradigm than in a copy spelling paradigm, and that their accuracy would be higher for free spelling. The current results show that motivation increased after the second task regardless of whether it was copy- or free-spelling. Furthermore, no difference was observed in accuracy between the two tasks. One possible explanation for these findings is that motivation was unaffected because accuracy was similar in both conditions. Another possible explanation is that the personal relevance of BCI use was low for these participants. Nonetheless, factors such as motivation may influence the BCI performance of disabled people. Presumably they have a higher personal investment in the technology.

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