Motivation affects Performance in a P300 Brain Computer Interface

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Abstract. In this study we investigated the effect of motivation on Brain Computer Interface (BCI) performance. We pooled N=90 participants from six different data sets for analysis. The group of the highest motivated participants (N=24) performed significantly better in their BCI task as compared to the least motivated group (N=22). Therefore, we recommend to monitor motivation in BCI settings and to increase it in a training setting.

Keywords: Brain Computer Interface (BCI), motivation, P300

1. Introduction
Brain Computer Interfaces (BCIs) allow for muscle-independent communication [Kübler and Müller, 2007]. However, performance varies between individuals. One possible explanation for interindividual performance differences is the influence of psychological variables like mood and motivation [Kleih et al., 2010]. Our goal in this study was to judge the robustness of psychological influencing variables on BCI performance by pooling a sample of participants (N=90) who underwent different BCI protocols.

2. Material and Methods
2.1. Sample
We included N=90 participants in this analysis. Within this participant group there were N=13 people diagnosed with amyotrophic lateral sclerosis (ALS), the other participants were healthy volunteers. The mean age of participants was 29.29 (range: 19-73).

2.2. Protocols and questionnaires
Six different protocols concerning the number of training sessions, the training task, the session lengths, matrix size and presentation settings (e.g. inter stimulus interval) were used to train the six subgroups (N=9, N=33, N=14, N=14, N=14, N=17) who were pooled for this study. Five groups of participants were trained with a protocol based on the classic visual P300 Speller (N=73) [Farwell and Donchin, 1988] while one participant group (N=6) was trained with an auditory P300 device [Schreuder et al., 2010]. Before each training session, motivation was assessed by a visual analogue scale (VAS) and the 18-item Questionnaire for Current Motivation in BCI (QCMBCI [Nijboer et al., 2008]) comprising the subscales interest, mastery confidence, incompetence fear and challenge. Items had to be judged on a 10 cm line for the VAS and on a 7-point Likert scale for the QCM. Performance was defined as the percentage of correct selections (accuracy). In this preliminary analysis we focused only on the first training session.

3. Results
3.1 General results
The overall average performance was M=86.03% (SD=24.81). Average values for motivation are presented in table 1.
Table 1. Average values of motivation

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>M</th>
<th>SD</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>QCMinterest</td>
<td>4.94</td>
<td>1.32</td>
<td>1.87</td>
</tr>
<tr>
<td>QCMmastery confidence</td>
<td>5.55</td>
<td>.87</td>
<td>3.257</td>
</tr>
<tr>
<td>QCMincompetence fear</td>
<td>2.04</td>
<td>.91</td>
<td>14.6</td>
</tr>
<tr>
<td>QCMchallenge</td>
<td>4.97</td>
<td>.89</td>
<td>2.56.5</td>
</tr>
<tr>
<td>VAS motivation</td>
<td>8.27</td>
<td>1.75</td>
<td>.710</td>
</tr>
</tbody>
</table>

3.2 The effect of motivation on BCI performance

We found a significant positive correlation between accuracy and the values of the VAS motivation ($r=.26, p<.05$). When comparing the least ($N=22, VAS$ values $< 5.2$) and the highest ($N=24, VAS$ values $> 9.7$) motivated participants, we could strengthen the previously reported correlation between the VAS motivation values and accuracy and found a significantly better performance in the higher motivated group ($Z=2.06, p<.05$, see figure 1). Furthermore, we found a significant positive correlation of incompetence fear and accuracy ($r=.22, p<.05$).

![Figure 1](image.png)

Figure 1. The higher motivated participants (measured by the VAS motivation) achieved higher accuracy in their P300 task compared to the least motivated participants.

4. Discussion

This preliminary analysis revealed a small, but significant influence of motivation on BCI performance, even though data from different protocols and two input modalities (visual and auditory) were pooled. Further analysis will separate healthy and patient participants to gain better insight on psychological influencing variables in BCI performance. The time course of the motivation effect for individuals who participated in multiple BCI sessions and for other BCI input signals like sensorimotor rhythms (SMR) await further investigation.

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References