Motivation and SMR-BCI: Fear of Failure Affects BCI Performance

S. C. Kleih[1], T. Kaufmann[1], E. Hammer[1], I. Pisotta[2], F. Pichiorri[2], A. Riccio[2], D. Mattia[2], A. Kübler[1]

[1]*University of Würzburg, Germany;* [2]*Fondazione Santa Lucia, Rome, Italy*

Correspondence: S. Kleih, University of Würzburg, Marcusstr. 9-11, Würzburg, Germany. E-mail: sonja.kleih@uni-wuerzburg.de

Abstract. Components of motivation have been shown to affect performance when using a Brain-Computer Interface (BCI) based on sensorimotor rhythms (SMR). However, usually reported results are based on relatively small sample sizes of healthy adults. Therefore, neither conclusions about motivation effects on BCI performance in larger samples nor in clinical samples can be drawn. In this study we correlated the subjective ratings of motivation of $N = 51$ healthy participants and $N = 11$ stroke patients with their SMR BCI performance and found that incompetence fear or fear of failure was significantly related to lower performance.

Keywords: Motivation, Brain-Computer Interface (BCI), SMR

1. Introduction

Psychological variables, such as motivation do have an effect on BCI performance as shown by Nijboer and colleagues (2008) who found the motivation components *incompetence fear* and *mastery confidence* to be related to BCI performance in a relatively small sample of 16 healthy participants when using an auditory SMR BCI. We were interested in (1) whether we could replicate this result in a larger sample and (2) whether it transfers to motor-impaired end-users as suggested by Nijboer and colleagues (2010). To address these questions, we quantitatively assessed components of motivation in healthy subjects and in a sample of stroke patients before BCI training.

2. Material and Methods

We included $N = 51$ healthy participants, all naïve to BCI training prior to this study. Mean age was 24.29 ($SD = 3.81$, range 18 to 36, $N = 24$ participants were female). The clinical sample consisted of N=11 stroke patients with mean age of 60.00 ($SD = 9.47$, range 41 to 75, $N = 4$ participants were female, $N = 5$ with left hemispheric and $N = 6$ with right hemispheric lesion).

For motivation measurement prior to the training sessions, the Questionnaire for Current Motivation in BCI was used, which assesses the four components *mastery confidence*, *incompetence fear*, *challenge* and *interest* [Nijboer et al, 2008]. Once before every session, we also measured motivation on a visual analogue scale (VAS) ranging from 0 to 10 (0 = 'extremely unmotivated' to 10 = 'extremely motivated'). For using the SMR BCI, healthy participants were instructed to imagine movement with either the left or the right hand. Modulation of SMR was either fed back online by means of cursor movement or knowledge of result was provided at the end of a trial. In stroke patient motor imagery was contrasted against a rest condition. While for the healthy participants our results are based on one session including 300 trials of 4 seconds duration each, stroke patients finalized between 5 and 12 sessions each including between 80 and 120 trials of 4 seconds duration.

3. Results

Overall, participants' average accuracy was 71.06% ($SD = 14.44$, range: 46.0%-95.0%) in their first session. The R^2 values were on average $M = .25$ ($SD = .21$, range: .01-.70). Spearman's rho revealed a significant positive correlation between accuracy and *interest* ($\rho = .53$, $p < .001$, see Fig. 1) and a negative correlation between accuracy and *incompetence fear* ($\rho = -.43$, $p < .01$, see Fig. 1). The QCM-BCI values were measured once prior to testing.

Overall, patients' average accuracy ranged between 77.90% ($SD = 20.32$ in $N = 11$ patients) in session 1 and 52.60% ($SD = 27.08$ in $N = 3$ patients) in session 8. Spearman's rho revealed a significant positive correlation between *mastery confidence* and performance ($\rho = .80$, $p < .05$) and between *challenge* and performance ($\rho = .83$, $p< .05$) for the whole patient sample in session 8.

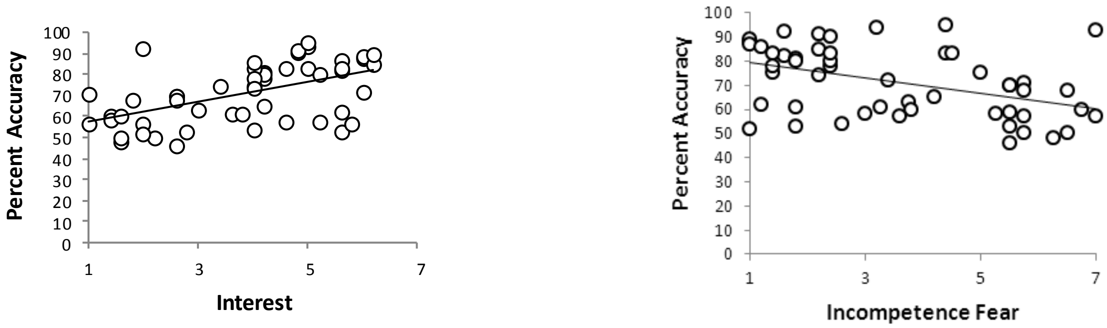

Figure 1. *The correlations between QCM-BCI scales Interest and Incompetence Fear and percent accuracy in healthy subjects.*

When investigating individual patients, we found significant correlations between motivation components and BCI performance in three patients. In patient A we found a negative correlation between *incompetence fear* and performance (ρ = -.61, $p < .05$, see Fig. 2) and in patient B a significant positive correlation between *interest* and performance (ρ = .62, $p < .05$). For patient C we found significant positive correlations between the VAS motivation values and performance (ρ = .73, $p < .01$, see Fig. 2), *mastery confidence* and performance (ρ = .70, $p < .05$) as well as a negative correlation between *incompetence fear* and performance (ρ = -.68, $p < .05$). For patient D we found a significant positive correlation between *incompetence fear* and performance (ρ = .68, $p < .05$, see Fig. 2).

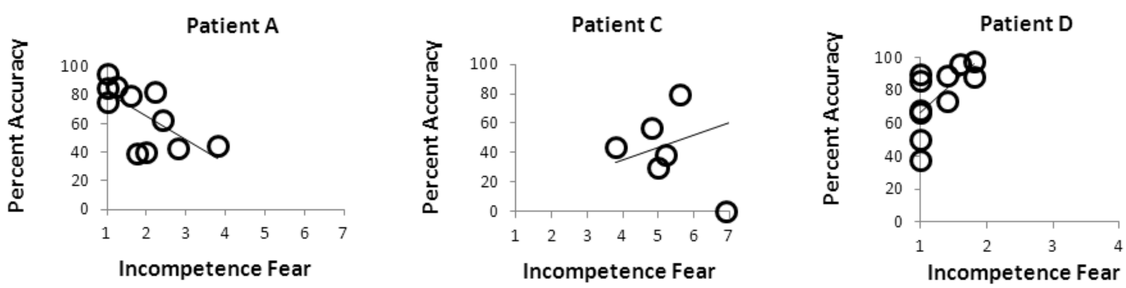

Figure 2. *The correlations between QCM-BCI motivation components and VAS motivation values with percent accuracy for three stroke patients. Every circle indicates one session's accuracy and incompetence fear value.*

4. Discussion

In a sample of healthy participants and a sample of stroke patients, we could successfully replicate the relation between motivation components and BCI performance. Several components of motivation and also the VAS motivation were related to BCI performance. The most consistent result was that *incompetence fear* affected performance in healthy participants and stroke patients alike. To estimate relevance of this effect of motivation on SMR-BCI performance, the clinical sample size will be increased. We recommend monitoring of motivation when applying BCIs in patients, because it could contribute to inter- and intra-individual fluctuations of performance.

Acknowledgements

This work is supported by the European ICT Programme Project FP7-224631. This work only reflects the authors' views and funding agencies are not liable for any use that may be made of the information contained herein.

References

Nijboer F, Birbaumer N, Kübler A. The influence of psychological state and motivation on brain-computer interface performance in patients with amyotrophic lateral sclerosis - a longitudinal study. *Front Neurosci*, 4, 2010.

Nijboer F, Furdea A, Gunst I, Mellinger J, McFarland DJ, Birbaumer N, Kübler A. An auditory brain-computer interface (BCI), *J Neurosci Meth, 167*(1):43-50, 2008.