“Evaluation framework for a BCI-supported task-specific training in neurorehabilitation after stroke”

I. Pisotta1, A. Riccio1, F. Pichiorri1, G. Morone1, M. Secci1, S. Kleih2, M. Molinari1, A. Kübler2 and D. Mattia1

1IRCCS Fondazione Santa Lucia, Rome, Italy; 2University of Würzburg, Germany

Correspondence: I. Pisotta, Fondazione Santa Lucia, via Ardeatina 306, Rome Italy. E-mail: i.pisotta@hsantalucia.it

Abstract Within the evaluation framework of an innovative BCI system for post-stroke rehabilitation [Pichiorri et al., 2011], we analyzed the influence of psychological variables and the workload on patient’s performances that have been already described to have relevance in BCI training for communication purposes [Kleih et al., 2010; Nijober et al., 2010]. Mood, motivation and workload assessment was performed before, after and across training sessions on a sample of stroke patients who undertook one month Motor Imagery (MI) based BCI-training with the aim of promoting recovery of the hand function. Results showed a good level of acceptability of BCI technology for rehabilitation; motivation may contribute to variance in BCI performance and should be monitored in the settings. Workload scores were similar between intervention groups. These preliminary findings are of relevance when considering the translation of BCI technology into real clinical setting for post-stroke rehabilitation intervention.

Keywords: BCI, motivation, mood, workload, stroke.

1. Introduction

The brain-computer interface (BCI) is a promising approach to neurorehabilitation. Indeed it may be used as a device to improve motor cortical responsiveness after stroke [Pichiorri et al., 2011a]. Mood and motivation variables can play a role on motor imagery (MI)-based BCI training performance [Nijober et al., 2010]. Furthermore, estimation of workload based on a construct than summarizes many factors in addition to the objective demands of the task [NASA-Ames Research Center, 1987] should be considered when approaching the evaluation of BCI technology in real applications. In this study psychological variables such as mood and motivation and workload were assessed in stroke patients who participated to a randomized controlled trial (RCT) aiming to evaluate the efficacy of an innovative tool for BCI-supported MI practice as an adjunctive intervention for hand motor rehabilitation [Pichiorri et al., 2011]. The endpoint of this assessment was to estimate the impact of the psychological factors on the overall acceptability of BCI technology applied as a tool for motor recovery after stroke.

2. Material and Methods

Sixteen stroke patients took part in a RCT study and were randomly assigned to two intervention groups: i) a MI BCI-based training group ("BCI group") and ii) a MI training (without BCI support) control group ("CT group") [submitted abstract by G. Morone et al]. Both groups of patients undertook one-month MI practice of the grasping/extension movements of the affected hand in addition to standard care. Mood and motivation were assessed in all patients by means of a Visual Analogue Scale (VAS; from 0-not motivated to 10-very motivated) before each MI-based BCI training and MI alone session. Motivation in the BCI-group was also rated by means of the Questionnaire for Current Motivation (QCM) [Nijober et al. 2008]. Satisfaction was also estimated by means of a VAS (satisfaction: from 0-not satisfied at all to10-very satisfied) at each experimental session, in both patients’ groups. The multidimensional NASA-TLX (subscales: Time Pressure, Performance, Physical Effort, Mental Effort, Frustration, Fatigue) [Ames Research Center, 1987] was applied to evaluate the workload related to both interventions and was rated by patients after the first and the last session. Data are expressed as a mean ± SD. As for the "BCI group", BCI performances were calculated as the percentage of correct trials in a run (comprising 20 trials) and averaged to obtain one performance value for each training session (comprising 4 to 6 runs). The real-time EEG processing and feedback was performed by means of the BCI2000 software [Pichiorri et al., 2011].
3. Results

As reported by Pichiorri and colleagues (Pichiorri et al., 2011b) et al, the “BCI group” showed a significant improvement in some of the functional outcome measures with respect to the “CT group”. All patients rated their motivation (VAS mean=7.83±1.50) and their mood (VAS mean= 7.23±0.90) as high throughout the intervention sessions. In the “BCI group” the relation between BCI-performance and VAS motivation and mood scores was positive (r=0.220 p=.05). The relation between the motivational factors rated with the QCM BCI and the patient’s BCI training performances was investigated and it resulted that Incompetence-fear was negatively correlated with the performance level (r=-0.330; p=.05). A significant correlation was also present between Incompetence-fear and the Mastery confidence (r=-0.645; p=.05). Challenge was also positively correlated with Interest (r=0.561, p=.00). Finally, the results showed that the level of BCI performance was positively correlated with the level of patients’ satisfaction (VAS mean= 8.20 ±1.77; r=0.528, p=.01). The “CT group” rated their motivation (VAS mean= 7.24 ±1.95) and the satisfaction (VAS mean=7.1 ± 2.07) as high and the mood (VAS mean= 6.60 ±1.06) as medium-to-high. One-way ANOVA between the two groups was calculated with the overall workload scores as dependent variable. Two repeated measures ANOVA within the BCI group and the CT group were applied to NASA scores rated pre and post the training. The results showed no statistical differences of workload rating between groups as well as no statistical difference in the pre- and post- measure assessment within the groups. Mental Demand contributed heavily to the workload in both intervention groups and it tended to increase with training in the experimental BCI group, between the first and last training session. The opposite trend was noted in the CT group.

Discussion

The aim of this study was to analyze how psychological variables are related to the usage of BCI technology in post-stroke rehabilitation. Motivation of the patients undergoing the BCI-supported MI training was high and it did not decrease across sessions. Taken together, these findings indicate a good acceptability of BCI technology as a novel tool to support post-stroke rehabilitation. The significant positive correlation between BCI training performances and VAS motivation scores suggests that in line with previous evidence, motivation has to be monitored in this BCI application. Although with caution, we can assume that as participants became more familiar with the BCI setting and reached a higher level of performance, they experienced higher level of satisfaction using it. Similarly, a good acceptability of the BCI training may be inferred from the positive correlation between the Challenge and Interest factors of the BCI QCM; this latter finding indicates that patients were interested and involved in BCI training over time. No significant differences were found between workload overall scores obtained pre and post training between and within groups. This finding is relevant in light of the time consuming procedures associated with the BCI system usage (mounting EEG cap; washing hair, etc) that could have influenced the patient’s experience of the workload related to training.

Acknowledgements

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

References

2) NASA Human Performance Research Group 1987; Task Load Index (NASA-TLX) Ames Research Centre, NASA.