International Journal of Bioelectromagnetism
Vol. 13, No. 2, pp. 80 - 81, 2011
www.ijbem.org

Visually Multimodal vs. Classic Unimodal Feedback Approach for SMR-BCIs: A Comparison Study

Tobias Kaufmann[a], John Williamson[b], Eva Hammer[a], Roderick Murray-Smith[b], Andrea Kübler[a]
[a]*Department of Psychology I, University of Würzburg, 97070 Würzburg, Germany*
[b]*Department of Computing Science, Glasgow University, Glasgow G12 8QQm Scotland*

Correspondence: Tobias Kaufmann, Department of Psychology I, University of Würzburg, Marcusstr. 9-11, 97070 Würzburg, Germany.
E-mail: tobias.kaufmann@uni-wuerzburg.de, phone +49 931 31 81084, fax +49 931 31 82424

Abstract. In a classic unimodal hand vs. foot sensory motor rhythm based brain computer interface (SMR-BCI) participants control the direction of a computer cursor movement by either imagining hand (upward cursor movement) or foot movement (downward). Herein we present a visually multimodal feedback approach that provides participants with additional information on their actual ability to control the cursor. Two groups of participants performed either the classic or the multimodal feedback approach. Preliminary results are promising in that the increased complexity of the display has not led to a worsening of performance due to anticipated higher attentional demands of processing of multimodal feedback information.
Keywords: Brain Computer Interface, sensory motor rhythm, visually multimodal feedback

1. Introduction

Brain Computer Interfaces (BCI) based on modulation of sensory motor rhythms (SMR) classify differences in EEG patterns during different types of movement imagery (MI) tasks such as hand or foot MI [Pfurtscheller et al., 1997; Kübler et al., 2005]. For example in a two class hand vs. foot paradigm these differences enable a BCI user to control an object in a two-dimensional movement environment, such as a cursor on a computer screen. In this case hand motor imagery moves the cursor upward; foot MI downward. Hence, controlling a cursor is often a balance of two distinguishable imaginations. To stabilize the control and make it less susceptible for short, recurring EEG changes, it is not the sign of the classifier output (actual movement imagery) but the sign of the integrated classifier output (movement imagery over time) that controls the cursor direction.

In the classic visually unimodal feedback approach, participants are presented with a cursor in the form of a ball as shown in Figure 1A. Cursor control is instantiated by observing its movement direction, which provides participants with feedback that allows for counteracting if the cursor changes to the unintended direction. This bears the problem that participants cannot interfere before the unintended direction change is visible, leading to a delayed reaction. Furthermore the classic feedback does not contain information on the quality of the control signal as it only gives feedback about which MI is classified at the observed time point. For example, the cursor could move into the correct direction although the MI is poor and could be improved, but the participant would not know.

This lack of information led to the idea of multimodal feedback providing the user with additional information about the current MI (sign of the classifier output, decoded in colour of the cursor) and the strength of the current MI (absolute value of the classifier output, decoded in intensity changes of the cursor) as shown in Figure 1B. Furthermore, the cursor was simulated as a fluid to strengthen the dynamics of the feedback. For example, the feedback will result in a burst if the MI is strong throughout the whole trial (Figure 1C3), and in a tail if weak at the beginning but then enhanced (Figure 1C2).

The herein presented work investigated if this multimodal feedback approach could be used to control an MI based BCI and compared the performance to the classic feedback approach.

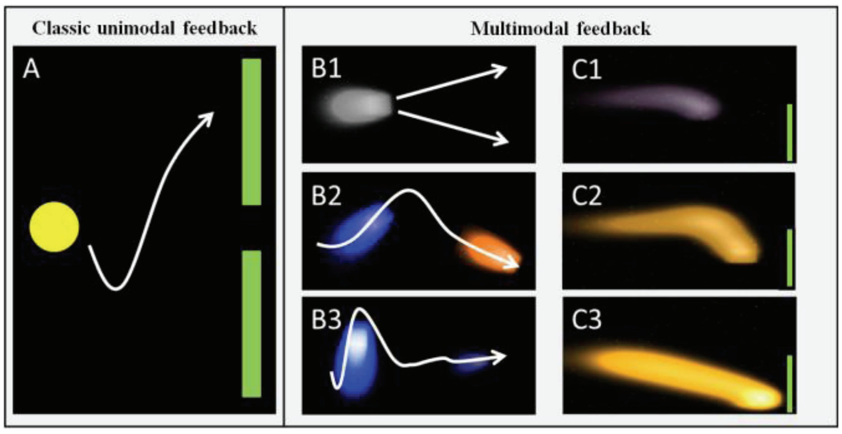

Figure 1: *(A) Classic unimodal feedback; (B) Modalities of the multimodal feedback: Feedback information is decoded in the cursor's direction (B1), colour (B2) and intensity (B3); (C) Screenshots from different multimodal feedback trials with weak (C1), medium (C2) and strong (C3) MI.*

2. Material and Methods

To date N = 16 subjects participated in the study. EEG was recorded from 16 channels (FP1, FP2, F3, Fz, F4, T7, C3, Cz, C4, T8, CP3, CP4, P3, Pz, P4, Oz) with mastoid ground and reference. Signals were amplified using a g.USBamp device and recorded with BCI2000 software [Schalk et al., 2004]. Following a between-subject design, participants were divided into two groups, one group for the unimodal, one for the multimodal feedback. Both groups performed the same screening task. Afterwards data was analyzed offline and the best features were selected for the feedback session. The classifier was not adapted any further after being set up before the feedback session. The procedure was approved by the Ethical Review Board of the Medical Faculty, University of Würzburg, and participants gave their informed consent prior to the experiment.

3. Preliminary Results

Six participants were excluded from data analysis as they did not reach a performance level above 60% during the feedback session. The remaining N=5 subjects per group achieved performance of 80.2% (unimodal group) and 82.7% (multimodal group). Preliminary results revealed no significant difference between groups (Mann-Whitney U Test; $z = -.73$; $p = .548$).

4. Discussion

Motor imagery for cursor control requires focused attention to process the feedback information and keeping in working memory the overall goal of reaching the required target. Thus, more complex feedback information might have lead to confusion and disturbance. However, the herein presented work revealed that participants were still able to control the BCI with the same accuracy as compared to unimodal feedback. This is encouraging and we will further investigate which feedback information in particular may help the user to increase BCI performance.
Due to the small sample size, final conclusions cannot be drawn and data collection will be continued with additional subjects and sessions. The contribution of each feedback parameter to cursor control will be investigated.

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. We would like to thank Andrew Ramsay[b] for his valuable contributions.

References

Kübler, A., Nijboer, F., Mellinger, J., Vaughan, T. M., Pawelzik, H., Schalk, G., McFarland, D. J., Birbaumer, N., and Wolpaw, J. R. (2005). Patients with ALS can use sensorimotor rhythms to operate a brain–computer interface. *Neurology* 64, 1775–1777.

Pfurtscheller, G., Neuper, C., Flotzinger, D., and Pregenzer, M. (1997). EEG-based discrimination between imagination of right and left hand movement. *Electroencephalogr. Clin. Neurophysiol.* 103, 642–651.

Schalk G, McFarland DJ, Hinterberger T, Birbaumer N, Wolpaw JR. (2004) BCI2000: a general-purpose brain–computer interface (BCI) system. *IEEE Trans Biomed Eng,* 51(6):1034–43.