Can the MIQ-RS questionnaire be used to estimate the performance of a MI-based BCI?

Sébastien Rimbert, Nathalie Gayraud, Maureen Clerc, Stéphanie Fleck, Laurent Bougrain

Can the MIQ-RS questionnaire be used to estimate the performance of a MI-based BCI?

*S. Rimbert[*1,2], N. Gayraud[3], M. Clerc[3], S. Fleck[4], L. Bougrain[2,1]*
[1]Inria, Villers-lès-Nancy, F-54600, France;
[2]Université de Lorraine, LORIA, UMR 7503, Vandœuvre-lès-Nancy, F-54000, France.
[3]Inria Sophia Antipolis-Méditerranée and Université Côte d'Azur, France.
[4]Université de Lorraine-PErSEUs EA 7312, Île du Saulcy Metz, F-57045, France.
*E-mail: sebastien.rimbert@inria.fr

Introduction:
Predicting a subject's ability to use the interface with good accuracy is one of the major issues in the motor Brain-Computer interface (BCI) domain. A few recent studies show that subjective questionnaires could be used to predict the performance of motor imagery (MI) based BCI. Indeed, the Kinesthetic and Visual Imagery Questionnaire (KVIQ), could allow a better predictability of BCI-illiterate cases [1]. Another more recent questionnaire called the Motor Imagery Questionnaire Revised-Second Edition (MIQ-RS) is a suitable option for examining MI ability [2]. In 2016, Marchesotti et al. found that the representation of subjective behaviour, calculated using the MIQ-RS questionnaire, and the control of the BCI were intimately linked [3]. However, in these studies [1, 3], the performance of the classifier was calculated for a right-hand MI versus a left-hand MI task. In this abstract, we classify between resting state and imagined movement, which is a relevant classification task in BCI research [4]. The aim of this study is to answer the following question for a resting state versus MI classification task: can the MIQ-RS be used to estimate the performance of an MI-based BCI?

Material, Methods and Results:
36 right-handed healthy subjects (12 females; aged 31.3 years ± 14.4) were tested for their perception level of their visual and kinesthetic MI ability *via* the MIQ-RS questionnaire. EEG signals were recorded with a Biosemi Active Two 32-channel EEG system during a MI task (i.e. a single closing of the right hand) in one session of 40 trials. The EEG signal was bandpassed using a Butterworth filter between 8 and 30 Hz and segmented into 3.5 second trials. A Riemannian-based Tangent Space classification method [5] coupled with a Logistic Regression classifier was used to generate classification results in a 4-fold cross validation scheme. We computed the correlation between the classification results and both the kinesthetic (K) and the visual scores (V). The recovered Pearson correlation coefficient was equal to $\rho = 0.02$, (p-value = 0.87) in the first comparison, and $\rho = -0.12$ (p-value = 0.47) in the second. Moreover, we performed a Principal Component Analysis over the aforementioned three features (Figure 1A) whose analysis produced no indication of any correlation between them. Finally, we observed 3 different profiles according to users' MIQ-RS values (identified K+ and/or V+ if their score is over 70%, K- and/or V- otherwise). We computed the average accuracy of each class (Figure 1B) and performed Welch's t-test to verify the statistical significance of the differences between the average classification results. We obtained the following p-values: 0.118 between K+V+ and K-V+; 0.714 between K+V+ and K-V-; and 0.048 between K-V- and K-V+. Finally, we computed the Event-Related Spectral Perturbation (ERSP) between 5-30 Hz within each group using the EEGlab toolbox and we again compared the differences between groups. The obtained p-values were all superior to 0.01.

Discussion:

Our results revealed no correlation between the classification results and the MIQ-RS scores, contrary to those suggested by [1, 3]. While the classification results and ERSPs differ upon grouping the subjects according to their MIQ-RS profiles, we found no statistical significance (at p-value < 0.01).

Significance:

Our results demonstrate that the MIQ-RS questionnaire cannot be used to estimate the performance of a MI-BCI based on distinguishing between resting state and right-hand MI tasks.

References

[1] A. Vuckovic, BA. Osuagwu, "Using a motor imagery questionnaire to estimate the performance of a Brain–Computer Interface based on object oriented motor imagery", Clinical Neurophysiology, Vol 124, pp 1586-1595. 2013.

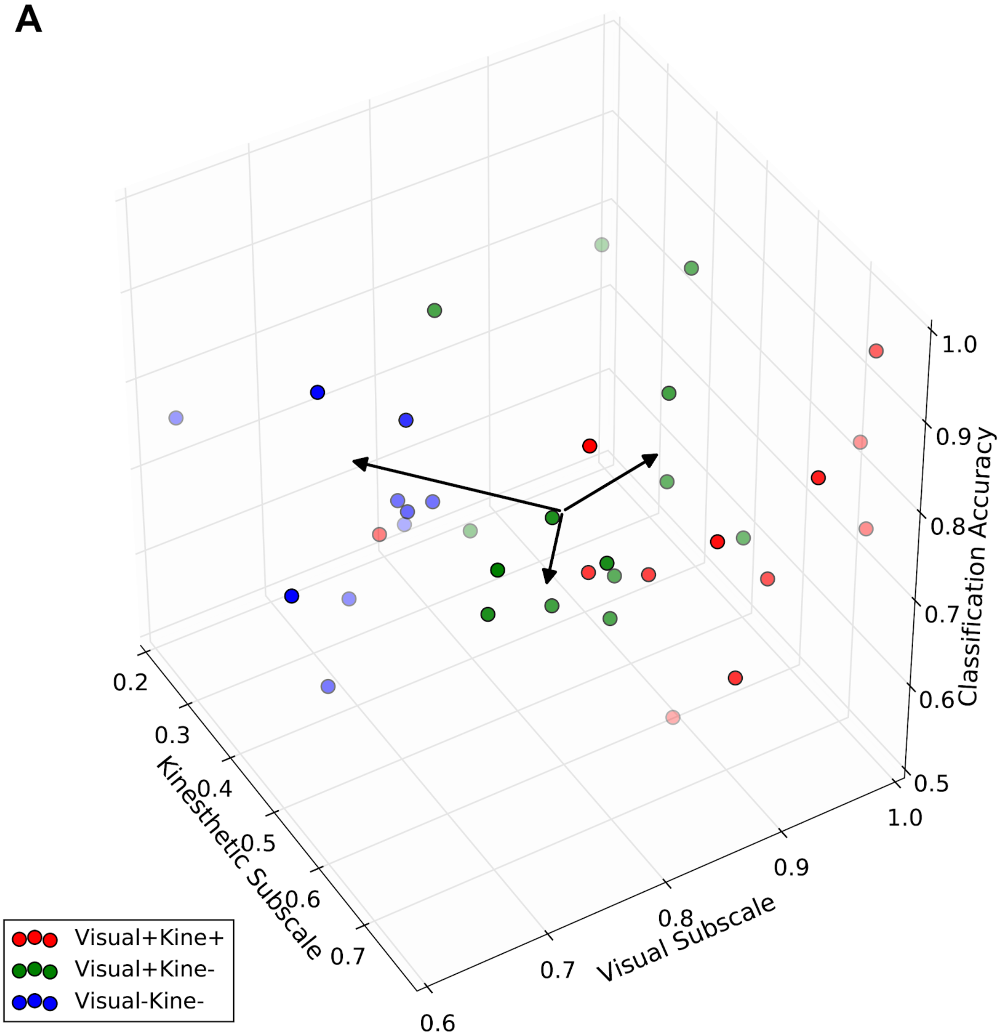
[2] A. J. Butler et al. "The Movement Imagery Questionnaire-Revised, Second Edition (MIQ-RS) Is a Reliable and Valid Tool for Evaluating Motor Imagery in Stroke Populations", eCAM. 2012

[3] S. Marchesotti et al. "Quantifying the role of motor imagery in brain-machine interfaces", Sci. Rep. 6. 2016.

[4] G. Townsend, B. Graimann, and G. Pfurtscheller, "Continuous EEG classification during motor imagery-simulation of an asynchronous BCI. IEEE Transactions on Neural Systems and Rehabilitation Engineering," 12(2), 258-265. 2004

[5] A. Barachant, S. Bonnet, M. Congedo and C. Jutten, "Riemannian geometry applied to BCI classification" in LVA ICA. Springer, Berlin, Heidelberg, pp. 629-636. 2010.

A



B

	MIQ-RS profile		
	K+V+	**K-V-**	**K-V+**
Kinesthetic scale (%)	76,69	56,93	56,26
Visual scale(%)	85,02	63,67	83,23
Accuracy (%)	83,12 ± 9,9	76,05 ± 8,8	77,05 ± 11,6
Number of subjects	12	10	14

Figure 1: (A) Principal Component Analysis performed over 36 right-handed healthy subjects for the classification accuracy, the kinesthetic subscale and the visual subscale. The explained variance ratio of each component is 41%, 34% and 25% (B) Kinesthetic scale, visual scale, accuracy and number of subjects according to MIQ-RS profile (K+V+ in red; K-V- in blue; K-V+ in green).