Accelerating the Initial Learning of a Motor-Imagery Based Brain-Computer Interface Through Mind-body Awareness Training

Kaitlin Cassady, Alex Doud, Emal Alwis, Albert You, Arman Shahriar, Bin He, *Fellow, IEEE*

In recent years, increasing research efforts have been aimed at the development of noninvasive brain-computer interface (BCI) systems as potential therapeutic outlets for individuals with physical disabilities [1]. However, a substantial limitation of these systems is the lengthy training time that is required by users to achieve satisfactory performance [2,3]. Even after training, some BCI users still fail to achieve clinically useful performance [4]. Mind body awareness training (MBAT), in the forms of Yoga and meditative practices, has become prevalent due to an increase in awareness of the potential health benefits, and improvements in concentration that this training may provide to practitioners. As such, a formal investigation of MBAT practices in the context of motor-imagery (MI) based brain-computer interface training may identify a means to reduce the training obstacles to BCI competency. The aim of the present study is to discover whether experience with MBAT practices, such as yoga and/or meditation, can accelerate the initial learning of a 1D sensorimotor (SMR) based BCI.

To test this hypothesis, 12 subjects with regular exposure to yoga, meditation, or a combination of both practices, in addition to 20 healthy control subjects with little or no MBAT experience participated in three 2-hour brain-computer interface training sessions. Furthermore, 5 experimental subjects with little or no prior MBAT experience participated in a 6-week series of intensive Yoga Nidra training, which was taught by a certified Yoga Instructor; this training consisted of at least three 1-hour Yoga Nidra classes per week for 6 weeks. Upon completion of this Yoga Nidra training, these subjects also participated in three, two-hour BCI training sessions.

All subjects used motor imaginations of each hand to control the movement of a computer cursor to the left or right side of a screen, and then progressed to an up vs. down control task, which consisted of imagining both hands vs. a volitional rest state. In order to achieve 1D BCI competency, four consecutive, 3-minute trials with accuracies of $\geq 80\%$, or an average session accuracy of $\geq 80\%$ were required in each left vs. right and up vs. down task. Overall, 75% of subjects with regular MBAT experience achieved 1D BCI competency in three experimental sessions, while only 40% of healthy controls achieved the same level of BCI performance. In addition, 80% of subjects who participated in the experimental Yoga Nidra training passed the pre-defined threshold to achieve 1D BCI competency.

Subjects with regular MBAT experience identified the practices of Yoga Nidra, Vinyasa, meditation, and Reiki as the most useful in learning to control a MI-based BCI. Such practices are aimed at learning to consciously direct awareness to specific areas of the body. The results of the present study suggest that MBAT may provide an effective method to reduce the time it takes subjects to successfully control a MI-based BCI. The potential to integrate MBAT practices into BCI training holds great promise for future SMR-based BCI research that aims to further enhance BCI systems for healthy and paralyzed patient populations where lengthy training periods remains a significant problem.

REFERENCES

[1] He B, Gao S, Yuan H, Wolpaw J: "Brain-Computer Interface," In He B (Ed): Neural Engineering, Springer, pp. 87-151, 2013.

[2] T. J. Bradberry, R. J. Gentili, J. L. Contreras-Vidal, "Fast Attainment of computer cursor control with noninvasive acquired brain signals ," in *Journal of Neural Engineering*. vol. 8, 2011, 036010.

[3] J. R. Wolpaw, D. J. McFarland, "Control of a two-dimensional movement signal by a noninvasive brain-computer interface in humans," in Proceedings of the National Academy of Sciences of the United States of America, vol. 101, 2004, 17849-17854.

[4] D. Tkach, J. Reimer, N. G. Hatsopoulos, "Observation-based learning for brain-machine interfaces," in Current Opinion in Neurobiology, 2008, vol. 18, pp. 589-594.

This work was supported in part by NSF CBET-0933067, ONR N000141110690, NIH R01 EB006433-01A2.