ASSETS 2004 Doctoral Consortium

Investigating the Mutual Effects of Physical Training and Mu-Based Brain-Computer Interface Systems

Adriane B. Davis

Department of Computer Information Systems, Georgia State University

E-mail: adavis@cis.gsu.edu

Abstract

This research seeks to investigate the possible interactions between physical training and mu-based control of brain-computer interface systems. The results of this work will provide new avenues for physical therapy and rehabilitation and spotlight the benefits of neural control of computers for both disabled and able-bodied people.

Introduction and problem description

Brain-computer interfaces (BCIs) provide an alternative means for controlling computers using neural input. Instead of using traditional mouse and keyboard devices that require physical input, users can employ their brain signals to accomplish a range of tasks such as environmental control and communication [3]. Various types of brain signals serve as the input to BCI systems. One such brain signal, the mu rhythm, is based on real and imagined movement. BCIs can take advantage of the difference in signal properties between idle and active imagery within the motor cortex to produce a control signal [3].

BCIs offer users with severe motor disabilities a nonmuscular channel for communication and control. However, the optimal brain signal for BCI control may differ between able-bodied users and physically impaired users. Recent studies have found that the mu rhythm weakens as physical ability declines [2]. Given the apparent ties of mu to physical ability, it may be possible to improve mu-based BCI control with increased physical activity.

Furthermore, an opposite correlation may be found where physical ability increases with training on mu-based BCIs, opening possibilities for therapy and rehabilitation. These critical research questions remain unanswered. Therefore, my dissertation work seeks to investigate the possible interactions between physical activity and mu-based BCI control.

Background

The relatively new field of brain-computer interfaces spans many disciplines including computer science, neuroscience, and electrical engineering. Most applications target disabled users who are cognitively intact but have such severely limited mobility that system input through physical movement is infeasible. Applications traditionally provide feedback to users through auditory and visual cues but some testing methods allow for tactile feedback [1]. Some teams have embraced the need for usability testing to determine what forms of feedback are most effective [3].

Furthermore, humans range in their physical abilities amongst disabled and able-bodied individuals; there are people who are completely locked into their bodies and those who excel at physical feats. No correlation has yet been made as to whether increased physical activity (for able-bodied users) or simply increased movement (for rehabilitative users) has an effect on the ability to control one's brain signals and certainly not vise versa.

Research questions

My research seeks to resolve the overall question of how mu-control and physical ability, or athleticism, relate. The primary questions are:

- Q1: What is the correlation of intrinsic ability for mu-control to athletic ability in humans?
- Q2: Can athletic training affect mu-control?
- Q3: Can training with mu-based BCIs affect athletic ability?

Research approach

To answer these questions, I must determine how the athletic ability of untrained users of BCIs relates to mu-based control, test the effects of physical training on mu-control, and test the effects of training with mu-based BCIs on athletic ability. First, before making any claims about users' ability for mu-based BCI control, we devised a set of objective measures to make cross-comparisons between users. The result was the BioGauge Study at the GSU BrainLab conducted in partnership with the Neil Squire Foundation in Vancouver, Canada which sought to establish a series of gauges which could be used for characterizing the technical capabilities of BCI systems.

These gauges alongside related experimental protocols formed a baseline for comparing human control of BCI systems. Each gauge was designed to characterize the controllability of a BCI system. Figure 1 illustrates the system setup for one particular gauge where the user tries to obtain a target by manipulating their mu-based brain signal to control the cursor's movement. The BioGauges Study focused on "capability" not "application." As a result, I have a set of tools to use for making comparisons of human ability to control their mu-based brain signals.

Next, I will conduct a mixed methods study (qualitative and quantitative approach) to determine the correlation between athletic ability and ability to control a mu-based BCI. I will survey participants to determine their regular engagement in various levels of fine and gross physical activity and then test their inherent, untrained control of a mu-based BCI. Then, I will conduct a study to determine if increasing physical activity in one area (e.g., adding more hours of tennis practice) has the desired effect of increasing mu-based BCI control as measured by the tools from the BioGauges Study. Finally, I will see if the opposite may be true by increasing the amount of training on mu-based BCI systems and testing for a possible increase in athletic ability (e.g., the user returned more backhand shots).

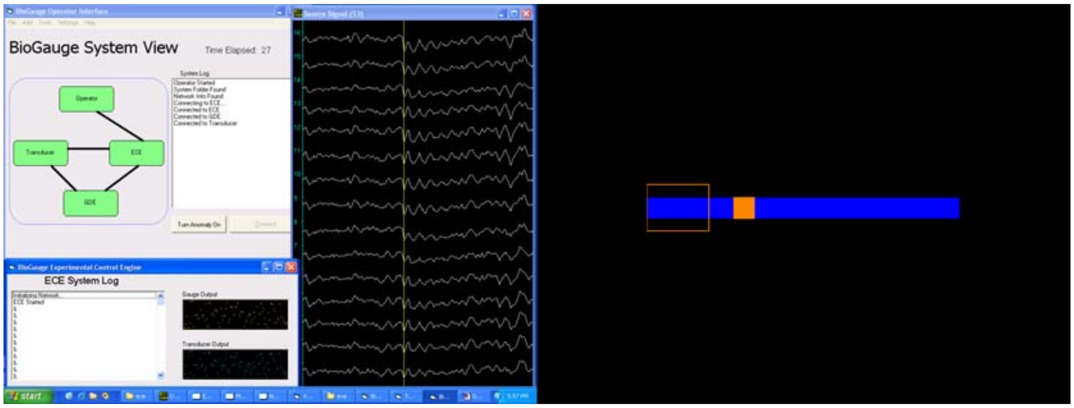

Figure 1. Illustration of system setup for the Attain Target Gauge

Current stage in program of study

In Spring 2004, I will complete my second year of studies in the doctoral program at Georgia State University in their Department of Computer Information Systems. I will have the opportunity to officially defend my dissertation proposal in Fall 2004 upon successful completion of my preliminary exams.

Acknowledgments

I would like to thank my advisor, Dr. Melody M. Moore, for her unwavering support and encouragement.

References

1. Birbaumer, N., Kübler, A., Ghanayim, N., Hinterberger, T., Perelmouter, J., Kaiser, J., Iversen, I., Kotchoubey, B., Neumann, N. and Flor, H. The thought translation device (TTD) for completely paralyzed patients. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 8 (2). 190-193.

2. Tran, Y., Boord, P., Middleton, J. and Craig, A. Levels of brain wave activity (8-13 Hz) in persons with spinal cord injury. Spinal Cord, 42 (2). 73-79.

3. Wolpaw, J.R., Birbaumer, N., McFarland, D.J., Pfurtscheller, G. and Vaughan, T.M. Brain-computer interfaces for communication and control. Clinical Neurophysiology, 113 (6). 767-791.