Motor Learning with EEG Controlled Virtual Muscle

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This research addresses whether fast skill motor learning, a subset of motor skill learning that acts to rapidly decrease response time as an activity is repeated, occurs when using an electroencephalogram (EEG) virtual muscle control system. Indirectly, this addresses the question of the motor homunculus' role in motor learning. Previous studies on the topic of motor learning implicate the motor homunculus as playing a necessary role, since its activation is seen in fast skill motor learning tasks. However, it has been unclear whether the motor homunculus activated because the use of muscles was necessary in the task or because the area is needed for motor learning. This study seeks to clarify the reason for activation of the motor homunculus and does so by using a virtual muscle, not the motor homunculus,to participate in a fast skill motor learning task. This issue is important because some brain-computer Interface-controlled prosthetics use EEG as a control system and may be unable to properly utilize motor leaning if it requires the muscle being used to be a part of the motor homunculus.

To investigate this topic, I constructed a custom EEG virtual muscle by using the Fast Fourier Transform to find the power in the 7-14 Hz range and using it to control a program I wrote which simulates a single player game of pong. Using alpha wave power to control the height of a paddle on one side of the screen, the participant attempts to reflect the ball back towards the other side of the screen. As participants played, their response time to each new ball was recorded (See Figure 1). The participant's response times indicated no negative trend that would signify the presence of motor learning. Motor learning would be signified by a decrease in response time as the participants played the game longer; however, the average response times remained constant throughout the time spent playing.

The lack of motor learning while using a virtual muscle system means that those using prosthetic limbs may not be able to form muscle memory for some tasks; however, the motor homunculus is adaptive and can adjust to the loss of a limb. Given this area's tendency to adapt, it may be able to adjust to adding new areas as well. A further study using functional magnetic resonance imaging (fMRI) could test whether the motor homunculus is being used during the fast skill motor learning pong task, and whether the motor homunculusis necessary to the development of muscle memory. The findings of this study indicate that it may take significantly longer than usual to develop muscle memory when using an EEG-controlled prosthetic, since the motor homunculus may need time to adapt to the prosthetic.

Statement of Research Advisor

Duncan's research explored whether motor skills could be learned through a virtual process which is significant to people who have lost limbs and use prosthetics. He successfully implemented an EEG-based virtual muscle control system to monitor the development of motor skills through mental repetition. Although the data collected indicated that actual movement may be necessary to develop motor skills, the research opened the door for additional studies to determine whether the motor homunculus is being used during the fast skill motor learning pong task, and whether the motor homunculus is necessary to the development of muscle memory.

-Mark Adams, Electrical Engineering

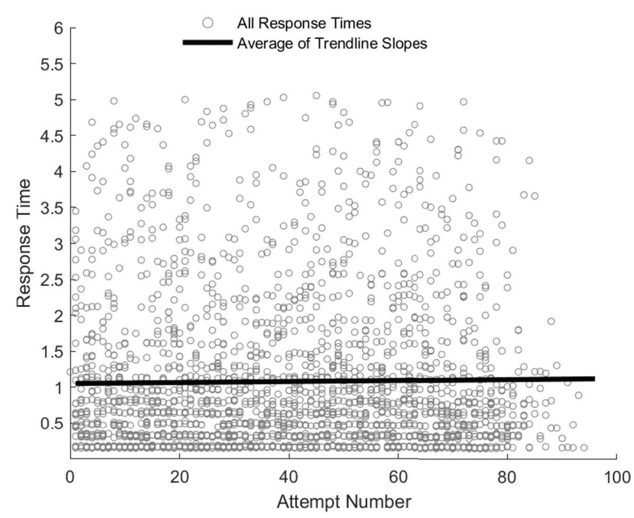

Figure 1. Response Times Relative to Pong Attempt Number Scatterplot with Trendline.