INTRODUCTION
Spinal cord injury (SCI) is a debilitating condition that affects over 250,000 people in the United States [1]. It results in paraplegia (paralysis of the lower limbs) or in tetraplegia (paralysis of the body below the neck) depending on where along the spinal column is affected [2]. It can result from either a physical injury to the head or spine or can be caused by a degenerative disease that prevents motor signals from reaching their targets. When an individual suffers from SCI, his or her ability to complete activities of daily living is diminished [2]. The inability to do tasks like reaching for an object or going to the bathroom also affects the individual’s quality of life. A survey was conducted with those affected by SCI to understand the effects of it on daily life [2]. The participants were asked which abilities were most important to regain as well as asked what types of treatments they were willing to undergo to restore function. Many indicated willingness for a surgery after hearing about brain-machine interface (BMI) technology. The technology has been used and tested in monkeys with success [3]. Monkeys were able to incorporate the technology, often a robotic arm, into their thinking and control it to accomplish tasks. After the demonstration of safety and efficacy in monkeys, simple BMI devices were tested in humans for single tasks, but this technology had a large learning curve. The BMI technology about which the survey participants learned would restore ability in many tasks. This works because SCI does not damage the brain [2]. The neurons and connections are left intact. Prior work has been done mapping the motor cortex with electroencephalography [3]. This allows current researchers to know where to place the electrodes in the brain for the BMI to control a robotic arm.

However, the signals from the brain still need to be interpreted to be useful for controlling these neural robotics. The Michelangelo Hand is an example of brand new advancements in the precision, control, and functional abilities in these neural robotics [4]. The goal of these products is to aid those in need of a functioning hand. While basic control of these robotics can be demonstrated [3], precision is important for some activities of daily living. This research draws correlations between neural signals and the movement of a robotic arm to better understand this connection and improve the capacity of control for a robotic arm.

OBJECTIVE
The objective of this study is to develop a proper decoding model that correctly interprets signals from the brain into motor controls for a robotic arm. Success of this would mean that a user has complete control of the robotic arm, the ultimate objective. This would restore ability to individuals with SCI and improve their quality of life. One of the considerations when determining the signals and processing them into movement is the impact of distractions and their effect on the capacity of control for the arm. This study analyzes the impact of different distractions on a simple movement to determine the effect of distraction on neurological control of the robotic arm. Poor control due to distraction would lead to task impairment or imprecision with that activity.

HYPOTHESIS/SUCCESS CRITERIA
The goal of the study is to analyze the effects of distractions, so the success criteria is a trial where there is no significant (alpha level of 0.05) difference in mean trial time compared to the control trial, where there are no distractions. A distraction trial that fails to meet this success criteria would reflect a distraction that significantly impairs the individual from normal function.

METHOD
The setup for the trials involved two square targets, set up half a meter apart (the Z direction). They were placed on plane even with the robotic arm at rest (Y=0). The arm was locked from moving forward and backward (the X direction). The arm started at the right-most target. When the time began, the subject moved the robotic arm across the half meter space until the hand portion of the arm touched the other target. Then, the subject would move the arm back to the first target. This would repeat for 60 seconds. The time taken between hitting each target was recorded. This 60 second task was completed either during a distraction or no distraction (control), with the order of distractions randomized each day. Most distractions involved the subject had doing an action while moving the robotic arm to complete the task. The distractions tested were counting backwards, listening to background noise, adding or subtracting upon hearing tones, controlling the wheelchair, and answering questions. When the testing was completed, the arm motion paths were graphed in YZ space using Matlab (below).

Figure 1. This is one of the trials for the control arm motion path for the first 10 seconds of a trial. The up and down motion was unnecessary but consistent across the trials.
Also plotted was time versus Z position (side-to-side). This was used to find the exact times when the arm touched each target. This data was exported to Microsoft Excel, where the rest of the calculations were performed. Since the arm’s contact with the targets moved them slightly each time, the distance between targets was not consistent. The data was normalized so that the horizontal distance between targets for each trial was exactly the same. Then, the average mean times of each distraction trial were adjusted by the same percent change as the normalized distance to make the testing consistent. Finally, the average times of the distractions were compared to the average of the control, and significance was tested.

RESULTS

The average time taken between the targets for the control was 3.36 seconds. The average time for the counting backwards was 3.72, for background noise was 3.68, for the tones was 3.33, for the wheelchair was 3.86, and for the questions was 3.60. The average times for distractions were compared to the control with a Z-Test in Excel because the standard deviations were known. The only distraction that was significantly different from the control was the wheelchair distraction, with a p-value approximately 0.006. On average, completing one movement from target to target took .5 seconds longer for the wheelchair distraction than it normally would (as per control).

DISCUSSION

Identifying a significant distraction is important. It demonstrates where efforts need to be made to refine the neural signals so there’s no influencing from other neurons firing in response to the distractions. For this study, one act of horizontal movement over .5 meters took .5 seconds longer, on average, in the wheelchair distraction trial than the control. That’s a 15% increase in the time needed to complete the task. If it took a minute to do a task or activity, it would take 9 seconds longer while also being distracted by controlling the wheelchair. Since the study had a time limit (and didn’t go for number of times back and forth), this means that the number of times the arm completed the horizontal movements was affected. On average, three fewer movements could be completed in the one minute timeframe. This significant of a delay can relate to even further interferences with more complicated tasks. The desire of the participants of the survey was to regain the ability to do activities of daily living [2]. This difficulty shown in the wheelchair distraction inhibits an individual with SCI from completing this activity. More research and testing is needed to properly filter out extraneous neural signals and to refine the signal processing to account for distractions. Then, the users of BMI wouldn’t have reduced capabilities with distractions.

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REFERENCES


