Observing the correlation between task performance and event-related desynchronization

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Introduction

The brain is one of the most complex organs in the human body. Thousands of electrical signals throughout the entire body are being sent and processed all at the same time. An electroencephalogram measures the electrical activity in the brain, usually through non-invasive means (Kaleb et al., 2013). Electrodes are placed on the scalp to measure the activity in different lobes of the brain. The electrical activity of the brain can be categorized into four different wave groups: delta (1–4 Hz), theta (4–7 Hz), alpha (7–13 Hz), and beta (13–30 Hz) (Pfurtscheller & Lopes de Silva, 1999). Of these, alpha waves were analyzed in this study. The brain waves were collected by the Emotiv EPOC+ headset. Brain waves were collected while performing a task. The task consisted of putting beads on a pole while controlling a claw via the forearm muscles. An image of the claw, the headset, and the pole can be seen in Figure 1. The Event-Related Desynchronization (ERD) was then be calculated by finding the percent change between baseline data and testing data.

The purpose of this study was to observe the change in ERD over time. This was determined by running a correlation test to see if the magnitude of the ERD and the number of beads placed on the pole when using a claw controlled by the forearm were linearly correlated. The null hypothesis was that ERD and the number of beads put on the pole were not linearly correlated.

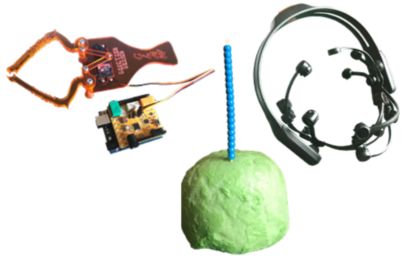


Figure 1 (left): The three main pieces of hardware used for testing. The claw is the leftmost figure, which was used to move the beads to the pole. The middle figure is the pole which the beads were placed on. The rightmost figure is the EPOC+ headset.

Materials and Methods

The researcher was the test subject for this study. Data was collected on Mondays and Wednesdays from January 18th until March 29th. Firstly, a program called Emotiv Xavier Test Bench (EXTB) was opened. This program connects to the Emotiv EPOC+ headset that the researcher utilized and displays the data from the headset on screen. The headset consisted of fourteen different electrodes that all collected data from different locations on the head. Felt electrode pads were saturated with saline solution. Then, the EPOC+ headset was placed on the head. Proper electrode connections were verified before testing began. A screenshot of the test bench is seen in Figure 2. Next, the claw was set up.

Materials and Methods (cont.)

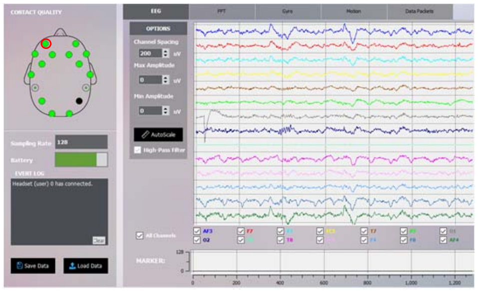


Figure 2 (left) The control panel with working electrodes and signals. The bottom right node was not soaked with enough saline solution at the time of the screenshot. The AF3 electrode is circled in red.

The task was performed using "The Claw" from the Backyards Brains website. Three electrodes were placed on the subject's left arm; two on the forearm and one on a bony landmark on the wrist. The electrodes were then connected to the provided Arduino Uno that converted the electrical signals from muscle contractions to movement in the claw. The researcher ran test trials to ensure that both programs were working properly. The Claw was set to close when the forearm was flexed.

A thin rod was placed in front of the subject along with 20 small beads. The researcher began measuring their brain waves through the EXTB program. For 60 seconds, the researcher collected data when not performing the task and remaining at rest. The reason for this was to get baseline data to use when calculating the ERD. Next, the researcher collected data when trying their best to place beads on the pole only using the claw for another 60 seconds. The number of beads on the pole at the end of the trial was recorded. This process was repeated for a total of ten trials of baseline data and ten trials of task data per collection day.

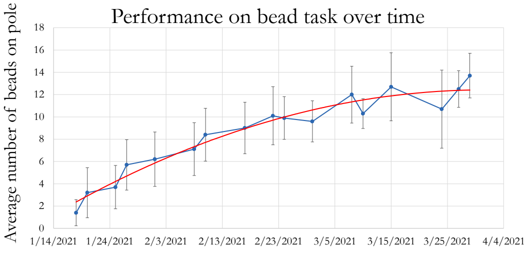
Results

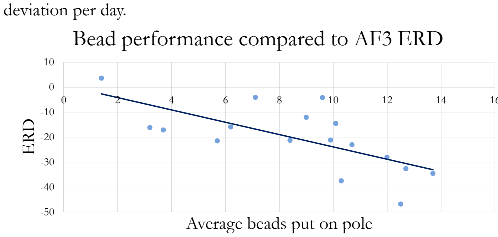
The data collected from the EXTB was saved in a .edf format. The data was then processed in EEGLab, an application that processes and derives important information from .edf files. A script was run on the data to derive the power spectra for each electrode and converted that data to an Excel spreadsheet. The power spectra is the amount of power coming from a certain frequency. The electrode looked at during this study was the AF3 electrode. Once all the files were processed, the power spectra were averaged, and graphs were made. The integral of the power spectra from 8–12 Hz was calculated for when the task was performed and when it was not. The difference of these values was calculated and then divided by that of the baseline data to find the ERD. For the beads, the sum placed on the pole each day was divided by 10 to get the average number of beads that day. A graph displaying the bead performance over time is in Graph 1.

Results (cont.)

A Pearson correlation test was run on the value for the ERD and the average number of beads placed on the pole. A graph displaying the correlation is found in Graph 2.

Graph 1 (right): The average performance per day on the bead task over time. It appears to have a strong second-degree polynomial correlation, r^2 (17) = 0.946. The bars represent the standard deviation per day.





Graph 2 (left): The correlation between ERD and task performance for the AF3 Electrode. ERD and performance on the task were strongly negatively correlated, $r(17) = -0.682$, $p = 0.003$.

Conclusions

The purpose of this study was to observe changes in ERD over time when learning a new task. The p-value of 0.003 signifies that the null hypothesis can be rejected since it is below the alpha level of 0.05. This means that ERD and skill acquisition were negatively linearly correlated. This data is important because there are few studies observing brain activity over time. This study reveals how the brain behaves and adapts over time in a long-term setting. To further research, people could run a test that isn't as physically taxing to prevent electrical noise being created from muscle movements, which interferes with data.

References

Kaleb, M., Chin-Teng, M., Kelvin, S. O., Tzyy-Ping, J., Stephen, G., Keith, W., W., Shih-Yu, L., Shao-Wei, L., & W. David, H. (2013). Real-world neuroimaging technologies. *Institution of Electrical and Electronics Engineers Access, 1*, 131–149. https://doi.org/10.1109/ACCESS.2013.2260791

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