Using Biofeedback Training to Focus The ADHD Mind

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Submitted for publication: 26 May 2020

Abstract

ADHD has struck the academic careers of millions of young teens as those with the disorder present lower grades and more behavioral misconduct. This paper will review existing technology assist devices for ADHD diagnosed students and develop an alternative device to work in this space. The device is a biofeedback training system that encourages fidgeting as a means to enhance academic focus. Initial subject testing was completed and the results are presented. The device is shown to be an effective tool to induce fidgeting, but connections between fidgeting and academic performance are not established.

1.0 Introduction

Attention Deficit/Hyperactivity Disorder, popularly known as ADHD, has become a prominent issue in many schools. It was found that 6.4 million kids, ages from 4-17, are affected by ADHD (Kimberly Holland and Elsbeth Riley | Illustrations by Tony Bueno, 2018). Mayo Clinic lists out several symptoms of ADHD and includes, excessive activity or restlessness, problems focusing on a task, and problems following through and completing a task ("Adult attention-deficit/hyperactivity disorder", 2019). These symptoms become problems for students in the classroom and therefore lead to poor academic performance. The abundance of literature shows that ADHD in children has resulted in lower grade averages, more suspensions, and lower standardized test scores (Daley, D., & Birchwood, J., 2010).

There are two different parts to the project: measuring the distractedness and creating a solution for the lack of focus in the classroom. It is very possible to train the mind to increase attention. One of the training devices is Myndlift. Myndlift, an app in which “users learn to regulate their brain activity”, takes neurofeedback from the patient and creates a personalized process to train them. “Neurofeedback is a form of biofeedback which uses EEG technology to read the patient's brain waves in real time and show visual or auditory feedback based on protocols determined by the neurofeedback provider,” (“Targeted Neurofeedback Protocols”, 2019). This app provides data to the therapist who can see what is happening in the brain when the patient is falling in and out of focus during his/her activities. The user completes tasks such as watching videos and playing games by focusing themselves. In one of the game activities, the character can only run if the user is focused. When watching videos, the screen dims and the volume lowers if the user is not focused. The positive and negative feedback is key in training and motivating the patient to prolong his/her attention span.

It is a common misconception that physical movement has a negative connotation: distractedness. However, research suggests that physical movement can assist the student in focusing in class (Cloud). Myndlift takes neurofeedback and tries to decrease certain brainwaves and increase others. This project will be using biofeedback to encourage fidgeting, such as leg bouncing or ankle movement, with the intent of increasing student focus on an academic task.

2.0 Methods

2.1 Motion Detection and Feedback Device

An Arduino based device was created utilizing an accelerometer, vibration motor and SD Data storage. The accelerometer is an ADXL345 digital accelerometer and is used to detect changing motion along one axis. The vibration motor will vibrate when given a signal from the Arduino. Finally, the SD card allows for the device to be portable since data can be recorded and retrieved at the end of a user's session. The device is designed to be worn on the lower leg and for the purposes of this prototype, stretchy athletic tape is used to attach the device to the leg. Since the accelerometer detects changing motion along one axis, it is important that the device is attached to the leg with the detection axis aligned with the leg.

2.2 Software

Since the device is designed to detect relative motion, a calibration is necessary in order to define the zero acceleration (stillness) range. On initiation of the program, the user remained still for 10 seconds. The first 10 values that the accelerometer picked up are averaged, then have 5 units added and subtracted to define a range of stillness.

During operation, the accelerometer reads acceleration along one dimension. Alongside this, there was a timer that kept track of the overall time elapsed as well as another timer that detected thirty seconds. The thirty second timer would reset every time the user moved out of the stillness range. If still and the timer reaches thirty seconds, the vibration motor is activated to vibrate and alert the user. This second timer would still continue counting despite having reached thirty seconds. The SD card saves data from the time when the vibration motor was buzzing and therefore only records biofeedback eventdata. A flow diagram of this algorithm is shown in Figure 1. The recorded data consists of the total time elapsed, the acceleration value, and the time on the thirty second timer for every event.

The filename used for the SD data file was static in the software which required modifying the code every use to prevent overwriting the data files from previous trials. This was to prevent any confusion when reading the data and being able to save every class separately.

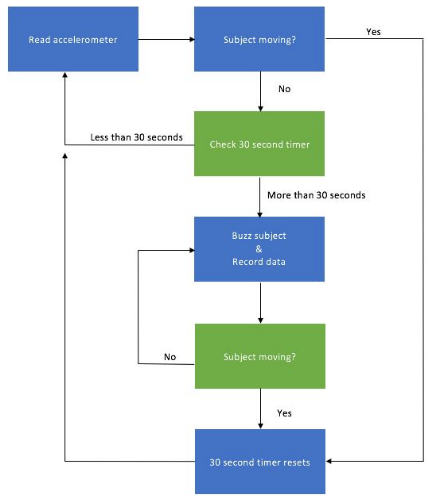

Figure 1- Software Flow Diagram

2.3 Validation

For testing the system and process, a student with diagnosed ADHD was not available. All testing was done by simulating an ADHD fidget and response by a non-ADHD person. The device was worn over the course of two and half weeks for 20-minutes each weekday, during academic classes conducted through distance learning. The data presented shows data from the first 8 sessions. Data was collected and analyzed after every class. All the data from each class was placed into a line graph to show data trends. There are three graphs which are labeled, “Average Buzzes Per Alert”, “Average Time Between Alerts”, and “# of Alerts”.

3.0 Results

Data from eight, 20-minute test sessions is shown below.

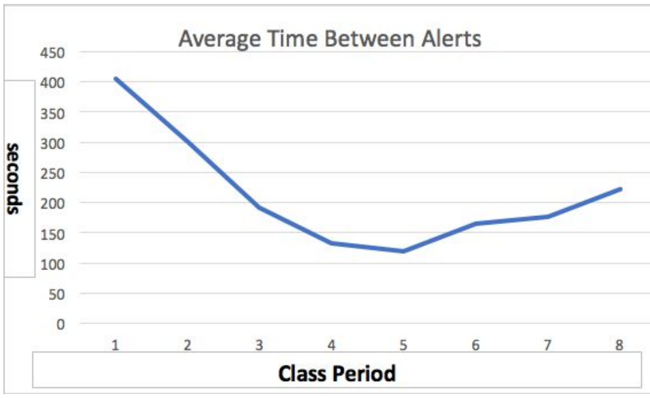

Figure 2.0

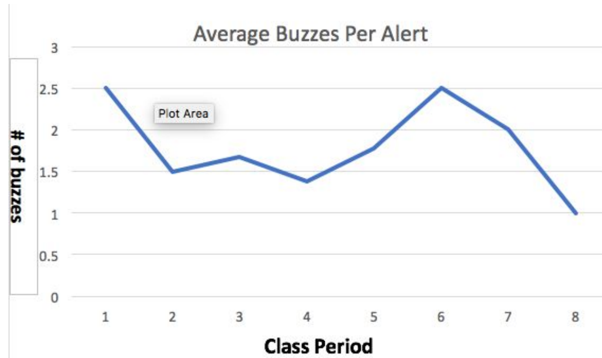

Figure 2.1

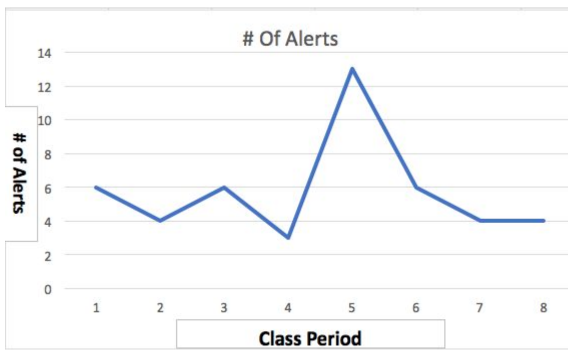

Figure 2.2

In Figure 2.1, after day 6, the graph begins to experience a downward trend. This suggests that the student was requiring fewer buzzes to start her fidget once again. In figure 2.0, presented in seconds, started to present an upward trend on day 5 which shows that the student experienced longer periods without needing an alert. Figure 2.2 shows a decline in alerts after day 5. This translates to the student needing fewer alerts per class as time went by.

The data presented does not showcase results from day 9 - 13. Testing for days 9 - 13 were conducted after a two week spring break and resulted in zero biofeedback events.

4.0 Discussion

Within graph 2.0, it is ideal to see an upward trend to prove that the device is being effective when it comes to alerting me that I'm out of focus, and therefore helping me to regain focus. In looking at Figure 2.0, there is a shallow incline after day 5. This graph shows that after some training with the device, the student was going much longer periods without needing an alert. This translates to the idea that the student was starting a trend of being focused for longer periods of time.

For graph 2.1, it is ideal to see a downward trend. The trend would relay the understanding that the student was growing more responsive to the vibration. The graph had presented the ideal data. After day 6, there was a relatively steady decline showing that it had become easier to get the student's fidget back, therefore showing that it was easier to get the student's attention back.

For figure 2.2, a downward trend is ideal. This works side by side with the second graph as it shows that fewer alerts were needed to regain attention. Figure 2.2 suggests that it was becoming easier to regain my attention and that I was requiring fewer alerts in the classroom. The data provided shows that the biofeedback training system is impactful in training a subject to prolong their fidget. With this data, also after day 5, the student was requiring fewer alerts per class.

The data and analysis above suggests that biofeedback is an effective way of training the body to maintain a fidget. Additional work on this project could be arranged into two categories: Basic Validation and Enhancements.

4.1 Basic Validation

The data sets acquired in the development of the prototype are too small to provide definitive conclusions about biofeedback training. In addition, there is no data connecting fidgeting with increased focus or academic performance. The following steps could help demonstrate a stronger connection between biofeedback training and increased attention span.

Choosing a student who has ADHD and also identifies their fidget to be beneficial to their attention span is a priority aspect of future work. Alongside this, running longer trials will allow for a greater data set. This would include full class recordings for 30 days. In addition to these aspects, designing and implementing an in-class observation protocol will be beneficial. This will provide for more accurate results as there is now observational input, to connect student attention span with the numerical data of biofeedback events. Eventually this experiment should expand to more students with similar characteristics as the primary student. This would ensure more accurate results due to larger sample size, observational input, as well as more data.

4.2 Enhancements

There are occasional problems with the SD card in which the newly named file does not appear when trying to access and import the data from a specific session. Alongside this technical error, an additional calibration of the accelerometer in the beginning of the code would also ensure accurate results. However, these are the only technical adjustments. Mounting the device onto the user must be more stable and adjustable. Some users may feel discomfort and therefore will need to personalize the placement without jeopardizing the effectiveness of the device. This also includes how the vibration motor is placed on the user. As of now, the vibration motor is taped on a few centimeters away from the entire device, while still connected. Minimizing the amount of space the device takes up while still allowing it to function as is, would cater to the user's comfort and allow for them to not be distracted by such a large device on their body.

5.0 Conclusion

The attention of students with ADHD sees benefits from their own fidget. However, students with ADHD perform poorer in their academics than those without ADHD. To assist with this, a device was created to utilize biofeedback training in order to prolong their fidget in hopes that this would positively correlate to their academic performance. This included measuring movement with an accelerometer, using a vibration motor to alert the user when inattention was suspected, and analyzing the resulted data from all testing sessions. The project only went as far as to suggest that biofeedback training is efficient in prolonging a fidget. The aspect of academics was not touched upon and would require further and more detailed testing to prove a correlation.

6.0 References

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7.0 Appendices

Device/Software User Manual
Code
Folder with all pictures can be found in Final Documentation folder
Project Journal
Proposal