Virtual Reality Cognitive Training Program

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Abstract - *The increasingly digitized world of today poses ever-growing stresses, distractions, and pressures that are seemingly insurmountable. Antithetically, the goal of this study is to use those same causal digital tools to address or even reverse some of these effects. Immersing the user into a virtual reality (VR) world and adopting ideas from BCIs (Brain Computer Interfaces), an electroencephalogram (EEG) headset, Emotiv Insight, is used to measure brain activations. The EEG data is processed and categorized into various cognitive and emotional metrics such as engagement, relaxation, focus, stress, etc. A neurofeedback algorithm will allow the dynamic change of the VR world around the user to help promote positive change in the monitored brain metrics, specifically, focus.*

Keywords: Virtual-Reality (VR), Electroencephalography (EEG), Focus, Neurofeedback, Cognitive Training

1 Introduction

The average attention span for a human today is about eight seconds; dropping due to digital connectedness and distractions from 12 seconds in the early 2000s [1]. Being distracted in the modern world is at the edge of your fingertips. By just reaching out for your smartphone, you can stare at it from minutes all the way to whole hours of immersion. With a society whose technology is advancing as fast as it possibly can, new technology is becoming more complicated and will require more focus and attention to learn and further understand them. Especially for new engineers entering the field, there is an increasing difficulty of learning. Students will require longer attention spans, better focus, and separation from daily distractions; which will be targeted and trained using this program.

Elie Venezky, author of Hack Your Brain, said, “Focus is a muscle, and you can build it” [1]. Building focus using an interactive Virtual-Reality world is the main purpose of this program. Since 72% of the general population and 97% of the teenagers (between ages of 12 and 17) are reported to regularly play video games [2], this program will be easier to learn and adapt. With Virtual-Reality, the user will experience full immersion in the training program which enables a greater improvement in the user’s focus and attention using this realism factor. However, instead of using a traditional controller or touchscreen, the user will only be using their thoughts. This furthers this idea of realism and immersion, since controllers give the mind a sense of a fictitious environment that is separate of the real world. The program integrates two distinct technologies together. The first, naturally, is virtual-reality, and the second involves electroencephalography (EEG).

2 VIRTUAL-REALITY

Virtual-Reality is used to fully immerse the user into dynamic worlds by wearing a virtual-reality headset such as the HTC Vive [3-6]. The Vive was used because it is one of the most advanced virtual-reality headsets available today. It has Unity3D support which integrates it very smoothly [7]. This assisted in designing the virtual environments a great deal. The HTC Vive was one of the few options that could be worn simultaneously with the EEG headset we used. Further on this in the next section. Eyesight adjustment is another pro the Vive has; this makes the vision more tunable to each user, thus giving a more comfortable and pleasurable experience. Removing all barriers or nuisances is key for this project to work.

This program utilizes virtual-reality since it has been proven to be effective in medical applications. For example, therapies exist that rely on mental imagery for patients who can face their phobias in controllable virtual worlds [8]. These patients were able to overcome their fears by facing them in a safe environment. This simulates what is called In-Vivo exposure therapy. The traditional treatment for phobias consisted of being exposed to the fear in real life. This often involved traveling outside the therapist’s office to a special location such as an airport for those afraid of flying, or a zoo for those afraid of animals. It also required the patient to interact directly with what they are afraid of, albeit in a small dose. With virtual-reality, there is no need to go anywhere or make special arrangements. Because the patient is relatively immersed and shown their fear, the negative thoughts are still present and can be identified. Once identified, they can be replaced with more positive thoughts. This methodology is similar to In-Vivo exposure therapy [9].

This program allows users to recreate thoughts they experience in certain environments. For example, the classroom environment, which is shown in Fig. 1, will allow the user’s mind to believe they are sitting through a boring lecture. The natural thoughts that arise related to being in a classroom are recreated. Allow for those thoughts to be recognized and measured. The next step will be to gradually replace negative thoughts and inattention with an enhanced aptitude to focus and a better attitude toward classrooms.

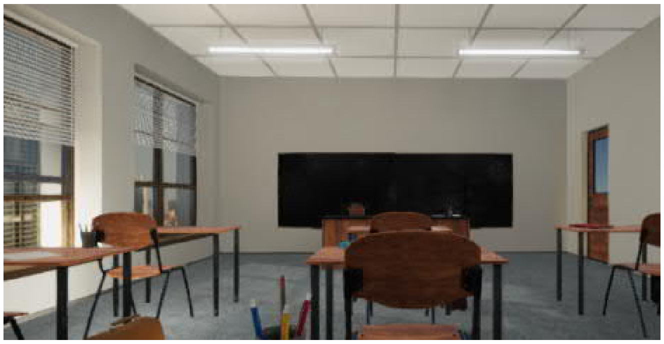

Fig. 1. Classroom environment

Another environment in the program, shown in Fig. 2, is the forest environment. It consists of a grove of trees and tall grass surrounding a campfire. Seated on a bench near the fire, the user will be asked to focus on the fire and only the fire. The level of focus will decide the color of the fire. The more focused the user, the redder the fire will get. The fire will start yellow as a baseline focus level. This environment will act similarly to the candle activity in the program. Only the candle can be seen in a dark background. The activity uses the user's level of focus to determine whether the candle stays lit or goes out, with varying middle ranges. The idea is to help visualize the user's state of mind by using neurofeedback. Hence, the environment mimics and showcases current state of mind. This allows the user to see the results of their thought patterns instantly in front of them. Enabling them to suppress negative thought that obviously kills the candle light. On the other hand, the forest environment, with its familiar surroundings of a campsite, will act to create familiar positive thoughts. These thoughts can affect attention levels.

Fig. 2. Forest environment showcasing the dynamic fire.

The last environment of the program, shown in Fig. 3, is the beach environment. This consists of a long shoreline with crashing waves on the sand. There are seagulls overhead and all the background ambience expected of a beach. This environment elicits feelings of tranquility and exclusively positive thoughts. The variance in this environment uses the climate. When the user's attention is low, the beach will be calm, sunny, gentle waves can be seen and heard in addition to the sounds of the trees rustling and birds chirping in the background. Motivating and facilitating a positive mind state. However, when the user's attention increases, dynamically and relatively, the beach will smoothly transition to a more vigorous crashing wave. A storm can be seen approaching fast and the user starts experiencing rain. The calm ambience of the beach and birds can no longer be heard. The user will be challenged with all these factors and more to maintain the higher levels of attention. In this sense, we are training the user to preserve higher levels of attention regardless of these distractions. This imitates daily life; where people are put through trouble and some inhospitable situations.

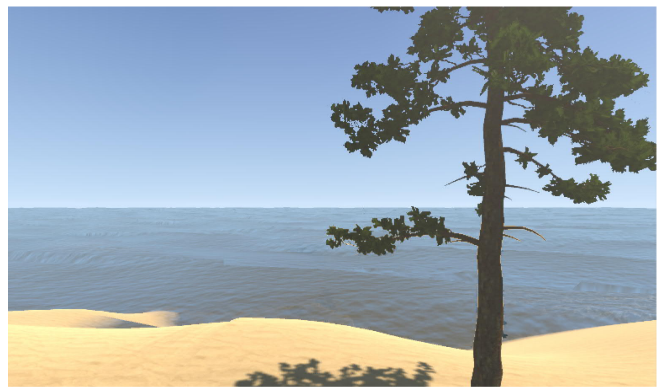

Fig. 3. Beach environment

3 ELECTROENCEPHALOGRAPHY

The crux of the program, electroencephalography, is how the brain activity is measured. The Emotiv Insight headset enables a mobile real-time solution to measure the user's cognitive state. Not needing a wired connection to the computer, facilitates the entanglement of the user. Which puts them in a more natural, unadulterated, setting. It was also chosen for the ease of use simultaneously with the HTC Vive headset. Since both headsets need to be worn together, the placement of each headset on the user's head is critical. The 5-channel Emotiv Insight gives liberty in headspace. The headset also post-processes six so called "performance metrics" from the user's brain which includes focus, stress, excitement, relaxation, interest and engagement. Neurofeedback has been proven effective in curing mental disorders such as ADHD, epilepsy, learning disabilities and many more [3]. This program's target is to implement neurofeedback and permits the dynamic change of the virtual environments to train the user's focus and attention to higher levels for longer durations of time.

4 COMBINING VIRTUAL-REALITY AND ELECTROENCEPHALOGRAPHY

Combining Virtual-Reality and Electroencephalography grants the freedom to visualize the user’s mind or brain activity in a very realistic setting. In this program, the user trains his/her focus with several Virtual-Reality worlds implementing neurofeedback. The user wears an HTC Vive Virtual-Reality headset to view the world and an Emotiv Insight EEG headset to measure and record the user’s brain activity. With neurofeedback, the raw EEG data is taken in as an input; the Virtual-Reality environment reflects the output and changes dynamically depending on the input. With this effect in the program, the user will be fully-immersed in the program which will increase its efficacy when it comes to training focus and attention. With a great portion of the population playing video games, this program should be easy to adapt into and easier to learn

5 RESULTS AND CONCLUSIONS

Virtual Reality Cognitive Training Program has enabled the brain to train as if it was a muscle. To preface the preliminary results found, consistent long-term training is needed for such a program to work. Multiple sessions throughout the week are required to start altering the way a person usually reacts to situations that negatively induce their mental states in their daily lives. Upon a few trials, it was realized that the participants received smaller raw stress scores and higher engagement, relaxation, interest and focus scores.

If used for an extended period, this program can be a powerful tool–essential in today’s world–to train the user's focus and attention. Through exposure in realistic virtual worlds, the user's mind is being trained in the most efficient way. Now with a more collaborative approach, two users can now use the program. Both users can view a three-dimensional graph of their focus state to give them an idea of their focus state. After the program has been used, the users can view their performance metric log for further analysis and see what they can improve on.

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