Controlling ADHD Emotions

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1 INTRODUCTION

HCI researchers have recently explored the idea of using biofeedback games to help children with Attention Deficit Hyperactivity Disorder (ADHD) regulate their emotions. However, the realm of helping adults who have ADHD is understudied. ADHD is a condition that consists of difficulty with controlling attention, which can affect the ability to multi-task, self-regulate emotion, and control impulsivity. Because of these difficulties and the challenges of navigating a society that requires constant self-management of attention, people with ADHD report lower self-esteem and more troubled relationships than those without [9]. Biofeedback games and other mindfulness techniques have the potential to help people with ADHD train a greater awareness of their own emotional processes and ultimately more effectively self-regulate emotional responses.

We present a biofeedback game that enables participants to practice breathing exercises indirectly while playing the game. Current biofeedback games are centered around the idea that the participant wins by controlling their breathing[7, 8]. However, the challenge for people with ADHD is not that they do not know how to control their breathing, but they struggle with multitasking; which means that it can be difficult to both control breathing *and* handle a difficult situation in the moment. The purpose of our game is to have the participant fully engaged into the game while the system is monitoring their deep breathing. If the participant can keep their deep breathing consistent, the system increases the difficulty and progresses the game. If not, they will have to readjust and control their breathing or they will not be able to progress in the game.

Our biofeedback game allows participants to indirectly work on their respiration techniques and develop their ability to use those techniques while their focus is elsewhere. The user's goal is to win the game, but they cannot win unless they can control their breathing at the same time. This permits users to develop the skill of staying calm without having to think about it through multitasking their breathing and playing the game. As a user plays the game, they will develop strategies for keeping their breathing consistent, recognize and adjust to patterns of the game, and adapt to focusing on more than one thing at a time.

For this summer, we implemented a game that is similar to Tetris, and we used a computer vision library to detect movement correlated with deep breath. Our implementation of Tetris will be adapt the game's state to the participant's current breathing state's correlating action.

2 BACKGROUND

The existing work of biofeedback games to help people with ADHD is limited in the HCI community. While there has been other biofeedback games to help children with ADHD or other biofeedback ways to increase emotional regulation, ways to assist adults with ADHD has been understudied.

Children and adults with ADHD share similar symptoms, but they react very differently to the symptoms. Some applications to help children with ADHD includes tracking emotional outbursts[1] and biofeedback games[2, 7, 8]. Applications that track a child's outburst are effective to track a pattern of what could be considered a trigger to the child[1]. These applications help avoid the outbursts, but cannot know what to avoid until they see it. Biofeedback games for kids is increasing because there is some relationship between games and children to help cognitive rehabilitation[3]. In ChillFish[7], children use their inhalation and exhalation to control the vertical position of the puffer fish to collect as many stars as possible. This game is intended to help children learn relaxing breathing exercises, and to help them calm down after emotional outbursts. However, the difference in adults and children is that adults already know relaxing breathing exercises. They do not need to learn how to calm down after an emotional outburst, but rather learn to calm down while being challenged by the stresses in the moment. Our biofeedback game would be a traditional game with adaption properties so when the user provides the game with respiration input, the game will react accordingly to their respiration cycles.

In the HCI community, biofeedback games have been used for a multitude of purposes. While some biofeedback games have an objective to help mental health [6, 10], a main purpose has been to practice calming techniques to help regulate emotions [4, 5]. In Chill-out [5] , the purpose of the game is to help people learn to stay relaxed while adapting to new challenges. Players are penalized in the game by increasing difficulty when they have a higher breaths per minute rate than the reference point. This allows users to have to quickly adjust to fix their breathing to get the difficulty level to be easier. Nevermind is a biofeedback game that adapts the game to the user's physiological state [4]. This results in the game's

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horror-themed settings to become more disturbing if the player is having an increase of negative arousal. While these adaptions of biofeedback games have been effective, it can be less effective for people with ADHD because the idea of being penalized while already in a stressful mood can tend to make things worse before they get better. The fluctuations of difficulty based upon the player's mistakes can make users lack motivation to play longer because it can attack their self esteem. In our game, we allow players to learn to quickly adapt to a new scenario while still playing at their ability. It will keep their motivation without hindering on their self esteem pushing them to do worse in the game.

Our biofeedback game presents a traditional game with adaptation to the user's respiration. If the user can keep their respiration consistent and reaching the goals at intervals, they will be able to constantly progress to more difficult levels. This will motivate players to obtain the highest possible score for themselves or until they lose the game. However, if a player does not keep their deep breathing consistent, every irregular breath will cause the game to modify the current board and will stop the progression of moving on to a new level until their breathing is consistent again. This will teach users to adjust to situations quickly and efficiently to get back to progressing in the game without hindering their self esteem of their abilities. Our game allows users to progress consistently, so when they make a mistake, their progress would be stagnant rather than rising or lowering at that moment.

3 METHODOLOGY

3.1 Algorithm

In this work, we adapt the difficulty of game to correlate to a person's respiration with the expectation that the user will learn how to control their breathing while adjusting to the corresponding actions of the game. We use an algorithm where states of relaxation, which we define as those with breathing rates less than or equal to 6 breaths per minute and increasing ($BR \leq 6 \wedge \triangle BR > 0$), are rewarded with points and increases difficulty in levels, while non-relaxation penalizes players by not allowing the player to earn points or increase levels. Since our hypothesis is for games where the objective is to achieve the highest possible score and play until you lose, there is not an overall time component so the difficulty of the game is contingent upon the speed that the game is going.

We use a proportional integral controller to adapt the game:

$$\epsilon(t) = b_0 - b(t)$$

$$d(t) = K_p \int \epsilon(t)$$

where $d(t)$ is the game's difficulty level, and $\epsilon(t)$ is the error in the current breathing rate $b(t)$ relative to the desired value of $b_0 = 6$. The term K_p is a proportional value that causes the game to either increase or decrease difficulty depending of the difference between the respiratory rate and the desired value. Our implementation uses $K_p = 0.5$ as an empirical value. If $\epsilon(t) < 0$, then difficulty should decrease until the person's breathing rate is closer to the desired value. However, if $\epsilon(t) < 0$, but $\epsilon(t) > \epsilon(t-1)$ or if $\epsilon(t) = 0$, then the difficulty of the game should be stagnant. In order to increase difficulty in the game and to earn more points, the user must keep their breathing rate shorter than the desired value.

The purpose of the game is to construct a person to practice slow respiration behaviors while multitasking to become a habitual behavior. This process of habit formation is the aim of this work to help people learn to stay in a relaxed state while partaking in another activity that can result in duress. Since the goal of the game is to achieve the highest score without losing, the player should constantly aim for longer breaths, so they can receive more points in the game. The incentive to receive more points is predicted to be able to have a player repeat good behaviors that can transform into healthy habits.

3.2 System Design

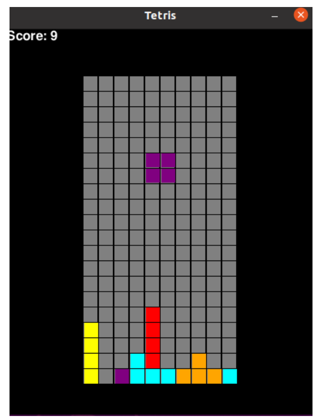

Figure 1: An image of the game in play

We created this algorithm to be implemented in a game similar to Tetris called TetriBreath. The goal of the game is to match different shaped blocks up with each other to build lines up to clear. Every line that is cleared, the user will receive a point. This is shown in Figure 1. After they reach a specific number of points, the level will increase which result in the game getting faster. Once the blocks fill the entire board to the top of the screen, the game will be over. This is shown in Figure 2. While the user is playing the game, OpenCV will capture a live video stream to see if the user is taking deep breaths or not.

TetriBreath and OpenCV will be running in parallel to each other to keep the game adapting to the user's breath. We will use face detection to see the shape of the mouth in the current frame. While users breath in through their nose, they should breath out through their mouth which should result in an 'O'-like motion that OpenCV can detect and and adapt the game's state to. OpenCV will also be calculating the meanshift to assess how much extra motion is happening in the camera. We show this in Figure 3. If there was a lot of motion outside of the mouth opening and closing, then we can expect that the player was fidgety and not in a relaxed state while playing.

3.3 Experimental Design

We will validate our approach with an experimental protocol that consists of two groups and three phrases. The first group will be the

Figure 2: An image of the game when the user has lost

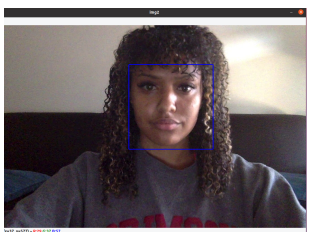

Figure 3: An image of the meanshift being collected in OpenCV

group (BFG) to play the biofeedback game where the respiratory rate must be slow and consistent to achieve progress, while the second group (RP) will just play the game regular without needing to focus on their breathing. The three phases will be comprised of a pretest, game play, and a post-test to evaluate if there was any progress. The pretest and post-test will be a self-reported questionnaire of their current emotional state and how they regulate stressful situations. This questionnaire can help address which symptoms in participants can be assessed the most through this biofeedback game. Since our approach is addressing emotional regulation and multitasking between low respiration rates and something that creates physiological arousing i.e. video games, we hope to see a decrease in stress, activity, and impulses in the BFG group during post-test.

There will be six participants in each group. Individuals will be between the ages of 18-25. We will attempt have the groups evenly split by gender since there is some discrepancy between ADHD and gender. However, whether an individual will be in the GBF group or the control group will be random. Each individual will self report their ADHD symptoms through a questionnaire given before they play the game, and then retake the questionnaire to assess if there was any progress made. While individuals play the game, participants will be recorded throughout. In both groups, before the game begins, players will need to align themselves in the camera to fit the desired starting position, then the game will start while the video and audio will capture their movements throughout the game.

After the experiment, we anticipate that there will be a difference in pretest vs. the post-test for the GBF group while the RP group should have similar results before and after. After they play, we expect to see that the BFG group is more motionless than the RP group due to the fact that the BFG group will be actively practicing deep breathing, so they should be in a more relaxed state then the RP group. We will capture the differences in motion by using OpenCV.

4 RESULTS

The results will be updated when our study takes place.

5 DISCUSSION

We have proposed a new approach to help people learn to keep their deep breathing consistent while under a form of duress. Our strategy incorporates monitoring respiration rate and movement while playing a game, practicing the act of multitasking, and adapting the game to motivate players to practice relaxing behaviors consistently. We tested the practicality of this approach by creating a game named TetriBreath, a biofeedback game that that will reward players for sustaining deep breaths and restrict their progress when not. We will be testing TetriBreath against a non-adaptive non-biofeedback version of the game to see how effective TetriBreath can be in building habit formation of deep breathing skills while in a stress-induced task.

TetriBreath trains people to think of their deep breathing while performing a task (i.e. a game) that is designed to fully engage the user. This is the biggest difference between current relaxation practices, which encourages practices that are designed to fully engage the user in their breathing but does not reflect how to sustain that breathing while doing tasks the can interrupt a person's thoughts. As an outcome, we look to see if our strategy can help people form healthy breathing habits which can then be transferred during any stressful task.

Future work will extend this game to help people with other mental health conditions that have similar emotional regulation difficulties. While this game at the moment is directed to help people with ADHD symptoms, the objective to promote self-efficacy in emotion regulation which can be helpful for anyone. Additional work will be tested to dictate if the learning effects can also follow over into subsequent days; more frequent treatment sessions should result into long-term behavior habits.

6 CONCLUSION

In this paper, we have described our first approach to help people with ADHD create habits that promote healthy emotion regulation. Our biofeedback game is an appealing game, which the user must learn to balance their skill of playing the game and their ability to sustain long breaths. We plan to recruit twelve people to partake in this study to evaluate the effectiveness of this game. However, with the unprecedented events of Covid-19, we must plan to run this study in a way that can be self-reported accurately and ran from remote places.

REFERENCES

[1] Alissa N. Antle, Elgin Skye McLaren, Holly Fielder, and Naomi Johnson. 2019. Evaluating the impact of a mobile neurofeedback app for young children at school and home. In *Conference on Human Factors in Computing Systems - Proceedings*. Association for Computing Machinery. https://doi.org/10.1145/3290605.3300266

[2] Liyan Chen, Lu Lin, Jiyi Weizhou, Shaolong Lin, and Weiqiang Lin. 2020. The Research of Cognitive Rehabilitation Training System for ADHD Children. Association for Computing Machinery (ACM), 422–425. https://doi.org/10.1145/3377571.3377617

[3] Maite Frutos-Pascual, Begoña Garcia Zapirain, and Kattalin Camara Buldian. [n.d.]. *Adaptive Cognitive Rehabilitation Interventions based on Serious Games for Children with ADHD using Biofeedback Techniques: Assessment and Evaluation*. Technical Report.

[4] Adam Lobel, Marientina Gotsis, Erin Reynolds, Michael Annetta, Rutger C.M.E. Engels, and Isabela Granic. 2016. Designing and utilizing biofeedback games for emotion regulation: The case of Nevermind. In *Conference on Human Factors in Computing Systems - Proceedings*, Vol. 07-12-May-2016. Association for Computing Machinery, 1945–1951. https://doi.org/10.1145/2851581.2892521

[5] Avinash Parnandi, Beena Ahmed, Eva Shipp, and Ricardo Gutierrez-Osuna. 2014. Chill-out: Relaxation training through respiratory biofeedback in a mobile casual game. 252–260. https://doi.org/10.1007/978-3-319-05452-0_18

[6] Ofir Sadka and Alissa Antle. 2020. Interactive Technologies for Emotion-regulation Training: Opportunities and Challenges. (2020). https://doi.org/10.1145/3334480.3382894

[7] Tobias Sonne and Mads Møller Jensen. 2016. ChillFish: A respiration game for children with ADHD. In *TEI 2016 - Proceedings of the 10th Anniversary Conference on Tangible Embedded and Embodied Interaction*. Association for Computing Machinery, Inc, 271–278. https://doi.org/10.1145/2839462.2839480

[8] Tobias Sonne and Mads Møller Jensen. 2016. Evaluating the ChillFish biofeedback game with children with ADHD. In *Proceedings of IDC 2016 - The 15th International Conference on Interaction Design and Children*. Association for Computing Machinery, Inc, 529–534. https://doi.org/10.1145/2930674.2935981

[9] Tobias Sonne, Paul Marshall, Carsten Obel, Per Hove Thomsen, and Kaj Grønbæk. 2016. An assistive technology design framework for ADHD. In *Proceedings of the 28th Australian Computer-Human Interaction Conference, OzCHI 2016*. Association for Computing Machinery, Inc, 60–71. https://doi.org/10.1145/3010915.3010925

[10] Joanneke Weerdmeester, Marieke Van Rooij, Owen Harris, Niki Smit, Rutger C.M.E. Engels, and Isabela Granic. 2017. Exploring the role of self-efficacy in biofeedback video games. In *CHI PLAY 2017 Extended Abstracts - Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play*. Association for Computing Machinery, Inc, 453–461. https://doi.org/10.1145/3130859.3131299

[7] [8] [9] [3] [1] [2] [6] [4] [10] [5]