Do Trait Anxiety Scores Reveal Information About Our Response to Anxious Situations? A Psycho-Physiological VR Study

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ABSTRACT

As the consequences of anxiety and depression have been compared to obesity and smoking as predictors of physical health, further findings, more advancements, and new technology are necessary to help those struggling with psychological disorders such as anxiety. This study investigates the potential relationships between Trait Anxiety or general anxiety scores and physiological and perceived reactions to a simulated virtual reality (VR) experience that induces mild anxiety as well as the ability to recover from the anxious event. The study additionally explores a potential relationship of a medical diagnosis on the physiological and perceived reactions to the simulated environment designed to induce mild anxiety and the potential effect on the ability to recover from such an event.

Eighteen adults participated in the IRB (Institutional Review Board) approved study by completing a consent form, followed by the Trait Anxiety Questionnaire corresponding to the State Trait Anxiety Inventory form Y-2 to assess general anxiety levels. Participants additionally recorded a self-reflected Likert-scale interpretation of their perceived anxiety on a scale of one to ten after each phase of the study (Baseline, Introduction, Virtual Reality, Recovery). The experiment was designed to elicit mild anxiety with an ambiguous introduction and a shocking VR experience.

The results showed no statistically significant difference between those with higher general anxiety with Trait Anxiety scores above 40 and those with lower Trait Anxiety in their percent increase of heart rate and increase of self-reflected anxiety score between baseline and VR phases as well as between baseline and recovery phases. Additionally, participants with medical diagnoses of anxiety showed no statistically significant difference in their percent increase of heart rate from baseline to VR phases as well as from baseline to recovery phases than their counterparts without any diagnoses of anxiety disorders. There is a potential indication, however, of a possible pattern of individuals with higher general anxiety (Trait Anxiety scores above 40) having a less-severe reaction, physiologically and perceptively, to an anxious situation than individuals with lower Trait Anxiety scores. This could indicate the possibility of desensitization to anxiety with frequent exposure. Conclusions of this study call for further investigation into this potential pattern and evaluation of future assistive technologies for individuals with anxiety.

CCS CONCEPTS

• CCS → Human-centered computing → Accessibility → Accessibility technologies

KEYWORDS

Anxiety; Psychophysiology; Generalized Anxiety Disorder; Virtual Reality; Electroencephalography; Gamma band; Psychotherapy

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1 INTRODUCTION

A recent study found that in comparing anxiety and depression to obesity and smoking as predictors of physical health, that anxiety and depression are as strongly predictive of poor future physical health as obesity and smoking, and that anxiety is independently linked to poor physical health. Participants with high levels of anxiety and depression were found to face 65 percent increased odds for a heart condition, 64

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percent for stroke, 50 percent for high blood pressure and 87 for arthritis, compared to those without anxiety and depression [6]. According to the World Health Organization (WHO), one in thirteen globally suffers from anxiety [2]. These findings are a great cause for concern. There is an apparent need to prioritize research on anxiety and the technology that helps alleviate the critical symptoms. Some research supports the idea confidently, stating that with early detection and treatment, certain health problems may be prevented, thus improving quality of life [4].

The first step in developing new, novel ways of improving quality of life for the large population of individuals suffering from anxiety disorders is to study and investigate the relationships anxiety has with physiological phenomenon such as cardiovascular function. While reliable sources like Johns Hopkins School of Medicine have stated that anxiety may have an association with tachycardia, increased blood pressure and decreased heart variability [9], the variability of physiological responses to anxiety is ambiguous. This ambiguity demands a person-centered approach in which devices designed to alleviate anxiety must recognize and adapt to the user and their personal reactions to anxiety. Additional research on anxiety has shown promise in the use of wearable technologies to track stress levels using biosignals such as ECG (electrocardiogram), GSR (Galvanic Skin Response), respiration rate, and blood pressure [4]. Similar studies emphasize the value of those metrics in an important comparison to subjective measures such as the State Trait Anxiety Inventory and Likert-scale self-reflective scoring [12]. The use virtual reality (VR) to study anxiety is newly emerging as an incredibly immersive and safe environment to analyze anxiety in many contexts of fear [7].

In this study, an immersive, commercially available VR game was used to induce anxiety in a controlled environment in order to study the physiological response in heart rate in eighteen participants. The study uniquely investigates the potential connections between trait anxiety scores, perceived self-reflected anxiety on a Likert scale, and heart-rate to answer the question: Does higher general anxiety levels affect the perception of an individual's anxiety? All participants were asked to fill out the Trait Anxiety Form (Y-2) of the State Trait Anxiety Inventory after having read and signed an IRB-approved consent form. The State Trait Anxiety Inventory is a questionnaire comprised of two forms, Y-1 and Y-2, designed to assess an individual's current anxiety state (State Anxiety) and general anxiety state (Trait Anxiety), respectively. The Y-2 form was selected in this study to subjectively and uniformly assess each participant's general anxiety levels before observing their objective sensor data. The questionnaire is composed of twenty questions that evaluates stable aspects of "anxiety proneness" and general states of calmness, confidence, and security that an individual exhibits [11]. Participants additionally filled out a Likert scale self-reflectance on their perceived anxiety, intermittently throughout the phases of the study, on a scale of one to ten. The study was split into four recording intervals or phases: baseline, introduction, virtual reality, and recovery. In the interest of designing a person-centered approach to this study, all participant data is presented only as a comparison to their personal baseline data. This experimental design takes into account that individuals have varying baseline physiological states and varying severities of reactions to anxiety while allowing all participants to be compared to each other.

2 METHODS

2.1 Aim

The aim of this study is to explore the relationship of trait anxiety to severity of physiological reaction to an anxious situation. The results and analyses presented here are an extension of our earlier work in [13].

2.2 Subjects

The participants for this study were eighteen adults comprised of nine males and nine females from ages nineteen to seventy. Of those participants, thirteen had no clinical diagnoses of anxiety disorders and five had a clinical diagnosis of an anxiety disorder. All participants were asked to complete the State Trait Anxiety Inventory (STAI) questionnaire Y-2 corresponding to Trait Anxiety to assess a standard for general levels of anxiety across participants. Each participant then began a succession of four phases of physiological recording beginning with their baseline, then after a brief introduction, after the VR simulation and lastly a recovery or rest recording.

Through recruitment efforts, eighteen participants volunteered their time to support the research on the response of the brain and body to VR simulations. These eighteen adults consisted of an even split of eight females and eight males. The information form participants filled out was designed to be inclusive of all gender identities as the participants were asked to write down their gender expressions rather than select one. Additional information that was gathered included age, anxiety diagnosis, and year of diagnosis, if applicable. The average age of the eighteen participants was 32 years old with a standard deviation of 16.7. Five of the eighteen said they had a clinical diagnosis of anxiety; of those five, two were female and three were male. Exclusion criteria for the study included individuals under the age of 18 or over the age of 60, or non-English speakers. These criteria were chosen for crucial communication and minimal risk of fall or cardiac reaction.

2.3 Apparatus and Measures

The equipment used in this study included a desktop computer running a commercially available VR simulation using an HTC Vive, a Wearable Sensing EEG system, a Muse EEG system, an Apple watch, and a Q-sensor.

2.3.1 HTC Vive

Virtual Reality equipment is an important part of this study as the game needed to feel as immersive and realistic as possible. The HTC Vive was chosen for its compatibility with the game, its ease-of-use, and its high-quality display. The HTC Vive setup includes a headset with large goggles that adjust by Velcro to fit each user, with an internal digital display. Each participant was also handed one controller with vibrotactile feedback to initiate the elevator sequence within the game once communication is established, and the participant was given instructions through a set of earbuds.

2.3.2 Apple Watch

The Apple watch was used to continuously record and store heart rate information. The method of heart rate detection used by the Apple Watch is called photoplethysmography; it incorporates the use of LED lights and photodiode sensors on the back of the watch (placed against a user's wrist). This method of heart rate detection is generally accepted to provide valuable information about the cardiovascular system [10]. This heart rate sensor was chosen for its method of recording and its ability to be used reliably during movement. The sensor supports a range of up to 30 to 210 beats per minute, and involved no active effort or use from the participant for operation of the device.

2.3.3 Affectiva Q-Sensor

The Q-sensor by Affectiva was a great initial fit for this study as it is a wearable wrist sensor designed to record skin conductance or electrodermal activity through a small sensor placed on the bottom of the participant's wrist and tightened with Velcro. Electrodermal activity (EDA) fluctuations are then recorded onto a computer at a sample rate of 8 hertz using the Q-live software. This device uses small, inconspicuous electrical signals of less than 5 microwatts of power to measure the participants' skin conductance. After each phase of the experiment, the files were saved as CSV files for later analysis. However, the information from this sensor was not used in the data analysis for this paper (discussed later).

2.3.4 EEG Systems

Two EEG headsets were used in the study to observe neuro-activity during the VR simulation. The data from these headsets were not used in the analysis for this paper (discussed later). The headsets used consisted of the Wearable Sensing DSI-7 Dry Electrode Headset and the Muse. The Wearable Sensing Headset uses seven sensors at positions F3, F4, C3, C4, Pz, P3 and P4 of the 10-20 International Standard [1]. The wireless dry-electrode system was used at a sampling frequency of 300 Hz.

The second EEG system used is a much smaller system with five sensors. The adjustable, lightweight, wireless design was easy to use and gave activity information for positions Fpz, AF7, AF8, TP9, TP10 of the 10-20 International Standard. This headset sampled at a rate of 256 Hz throughout each of the four phases of the study.

2.3.5 Anxiety Measures and Scoring

Participants were asked to complete two measures of anxiety, the one-time STAI Y-2 form, corresponding to Trait Anxiety, to establish quantifiable general anxiety levels as well as four Likert-scale self-reflected anxiety scores after each phase of the experiment. State Anxiety was chosen because it has been determined to be able to be used in clinical settings to diagnose anxiety or distinguish it from depressive symptoms [3] as opposed to state anxiety which corresponds to how an individual is currently feeling. The questionnaire is comprised of twenty items in which an individual reflects their agreement with the statements given on a scale of 1 to 4 representing 'Almost Never', 'Sometimes', 'Often', and 'Almost Always'. The score on the questionnaire is calculated by totaling the values (1 to 4) on the negative statements (ex: I feel like a failure), and reversing, then totaling the values (1 to 4) of the positive statements (ex: I feel pleasant).

These measures are incredibly important for our purposes as they may reveal information about how individuals with higher general anxiety levels perceive their anxiety as more or less severe than those with low trait anxiety scores.

2.4 Procedure

The EEG, GSR (galvanic skin response) and heart rate sensor data for this study was gathered and collected across four major intervals or phases. The participants began with a baseline recording, followed by the introduction, VR, and recovery phases. Each participant took from fifteen to thirty-five minutes to complete the study; for some, the study took longer due to sensor connectivity issues. Upon arrival, each participant read and signed an IRB-approved consent form, followed by the STAI Y-2 form, the subject information form, and then finally, the Likert-scale reflection of their baseline anxiety level on a scale of one to ten. Afterwards GSR and HR sensors were attached to the participant on either wrist along with the EEG system on his or her head.

2.4.1 Baseline

To begin the baseline phase of the experiment, the participant was asked to record their self-reflected anxiety on a Likert-scale from one to ten at what they consider their baseline anxiety level. Afterwards, the participant was assisted with wearing the two wrist sensors and the EEG headsets. A one-minute recording of EEG, skin conductance and heart rate began once the individual was seated comfortably and quiet. The baseline phase serves to be most crucial in designing a study in which the impact and uniqueness of the individual's experience does not get lost in the data. A person-centered approach is incredibly important to take into account the ambiguity of anxiety itself and the variability of the severity of reactions and progression of symptoms. At every stage after baseline, data sets were compared to baseline as either a percent increase for sensor data or a numerical increase from baseline of the self-reflected Likert-scale anxiety scoring.

2.4.2 Introduction

The introduction phase of the experiment serves an unnecessary but interesting purpose as an additional layer of true anxiety. While the line between fear and anxiety is often blurred, researchers agree that anxiety is often "objectless" [5][8]. Participants have signed and agreed to participate in a study in which we explore the brain and body's response to VR, but they don't necessarily know what they will be doing in the simulation.

This ambiguity is harnessed to create an initial bump of anxiety. The introduction phase begins with a one-minute recording of all sensor data as the research conductor reads aloud the statement "The virtual reality you are about to experience might provoke some stress of anxiety. Just to remind you, you can remove the headset if you feel uncomfortable. If you begin to feel nauseous or sick, please let one of the operators know and we will escort you to a seat and make a receptacle available." As the consent form had stated, the study has minimal potential risk including a possible heightened state of anxiety. The script serves to create an ambiguous and objectless fear in which participants don't know exactly what to expect. Once the recording has ended, participants record their post-introduction self-reflected anxiety on a Likert-scale of one to ten.

2.4.3 Virtual Reality

After successful baseline and introduction recordings, the HTC Vive headset is carefully placed over the Wearable Sensing and Muse EEG headsets. Once the Velcro straps are adjusted and the participant feels secure, the participant is instructed to reach over their shoulder to a set of earbuds and place them comfortably in each ear. Communication from this point forward is done through the microphone of an additional laptop at the researcher's desk that is connected to the desktop in which the VR will be run. Once the participant confirms they are able to hear the researcher, they are handed an HTC Vive controller to hold in their dominant hand. The desktop and the HTC Vive run a VR game called Richie's Plank Experiment, commercially available on Steam. Initially, the participant finds themselves on the ground floor of an elevator and they are instructed to select the "Plank" option on the panel to their right. Once the participant adapts to the use of the controller and successfully presses the correct button in the simulation, a 30 second recording of all sensor data begins and the participant is instructed to wait for further instruction. The elevator gradually goes up to the top floor of a skyscraper overlooking a simulated city. Once the doors of the elevator open, the participant will notice there is nothing but a plank stretching over open air in front of the elevator doors (see Fig. 1). Once the thirty seconds have elapsed about fifteen seconds after the elevator doors open, a one-minute recording begins as the participant is told "The objective is to walk to the edge of the plank and return to the elevator. You will have one minute to complete this task." It is important to note that there is a physical plank of wood in front of the participant that creates an additional layer of immersion as they feel the edges of the wood with their shoes (see Fig. 2). At this point, if the participant is unable, or expressed excessive hesitation, to leave the elevator, he or she was encouraged to do his or her best. The recording was stopped when the individual completed the task or the one minute elapsed. Afterwards, the participant is readily helped with removal of the headset and guided to a seat to reflect his or her Likert-scale anxiety score and rest before the final recording phase.

2.4.4 Rest and Recovery

The rest and recovery phase plays an important role in this experiment as the data gathered after an anxious event has ended may be indicative of a sustained heightened level of anxiety common in individuals with anxiety disorders. This one-minute recording of all sensor data is represented in further analysis as the ability to recover to baseline. After the recording, the last Likert-scale self-reflected anxiety score is completed and the study is complete.

Figure 1: Richie's Plank Experiment, a commercially available game on Steam, was used in this experiment as the method of inducing mild anxiety in voluntary participants. This screenshot from the game accurately portrays exactly what the participant sees during the virtual reality phase of the study. The participant is challenged to walk to the edge of the plank and return to the elevator in which the plank is stretching outwards from. Figure is from [13].

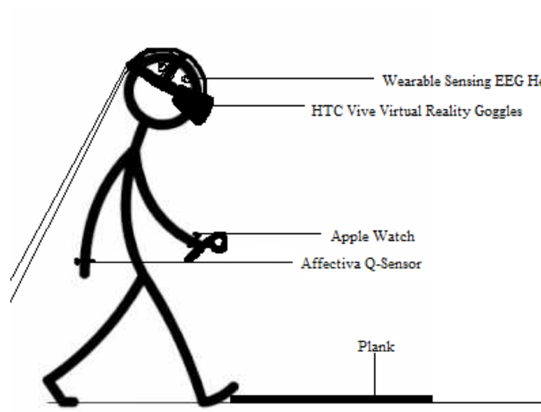

Figure 2: This image depicts the design of the experiment in placement and setup of the equipment used including the HTC Vive Virtual Reality Goggles, the Apple Watch used for heart rate capture, the Affectiva Q-Sensor, the Wearable Sensing EEG Headset and the physical plank on the ground. Figure is from [13].

4.5 RESULTS

In order to explore any relationships with perceived anxiety as a measure of increased heart rate and diagnosis or high trait anxiety scores, the data was split into two groups. Those who were calculated to have scored above 40 on their total trait anxiety form and are considered to have relatively higher than average anxiety and those who scored below 40 who are therefore considered to have average or below-average levels of general anxiety. The threshold was determined by the standard state-anxiety threshold point [11]. Coincidentally, the trait anxiety score of 42 also represented the median score of the collective eighteen participant scores. This divide in participant data was crucial to determining if higher general anxiety has any correlation with more significant percent increase of heart rate during anxious situations from baseline heart rate.

Separately, participants were split into two groups of those with an anxiety disorder diagnosis and those without. The divide was, unfortunately, skewed with only five of eighteen participants disclosing their diagnoses and thirteen who did not have any diagnosis. Nevertheless, the data was divided to observe any patterns in whether a diagnosis of anxiety impacts the self-reflected scores in comparison to those without who experienced similar percent increase in heart rate during the simulated anxious scenario.

While EEG, heart rate, and GSR data were collected, for the purposes of this analysis, only heart rate and subjective measures of anxiety (Trait anxiety and self-reflected anxiety) were used in data analysis. It is important to note that in exploring and studying a disorder as ambiguous and variable as anxiety, a person-centered approach was crucial to representing each participant's experience. For this reason, all data is presented as a comparison to baseline recordings. Heart rate is represented as a percent increase in beats per minute from the individual's average (resting) one-minute baseline recording. To best represent the severity of anxiety each participant underwent after baseline in the introduction, VR, and rest phases, the maximum heart rate values in each recording data set were used to analyze their percent increase from their baseline average. This method was invoked to observe any significant increase in sensitivity to the simulated anxious environment, physiologically. All sensor data and subjective anxiety scoring collected were carefully analyzed in Microsoft Excel or Google Sheets with anonymous numbers assigned to all eighteen participants.

The results were analyzed and organized to investigate the potential relationship between higher trait anxiety and percent increase in heart rate values from baseline to VR phase and baseline to recovery phase in comparison to increases in self-reflected Likert-scale scoring of perceived anxiety. The same relationship was analyzed between individuals with and without diagnoses of anxiety disorders as well.

4.5.1 Self-Reflected Score Differences from Baseline to Virtual Reality Phase

Average baseline to VR phase difference in self-reflected scores for individuals with Trait-anxiety scores above 40 was 2.55 with a standard deviation of 2.25; while individuals with Trait scores below 40 had an average baseline to VR phase difference of self-reflected anxiety scores of 2.86 with a standard deviation of 2.73. Due to small sample size, a two-tailed unequal variance (heteroscedastic) *t*-test was used in statistical analysis of potential significance of self-reflected score differences from baseline to VR phases between eleven participants with higher Trait-Anxiety scores above 40 and seven participants with lower scores below 40. The resulting *p*-value was 0.81, and therefore, deemed statistically insignificant.

The average baseline to VR phase difference in self-reflected anxiety scores for individuals with a diagnosis of anxiety was roughly 3.2, the highest difference among all groups, with a standard deviation of 2.39. The group of participants without any diagnosis of anxiety averaged a baseline to VR phase difference in self-reflected anxiety score of 2.46 with a standard deviation of 2.42. An additional two-tailed unequal variance *t*-test was used to evaluate a statistical difference between the self-reflected score increases from baseline to VR phases of five participants with diagnoses of anxiety disorders and thirteen participants without any diagnoses. The resulting *p*-value of 0.48 in this data set was also statistically insignificant. Fig. 3 depicts a side-by-side comparison of the differences in Likert-scale self-reflected anxiety scores from baseline to VR phases.

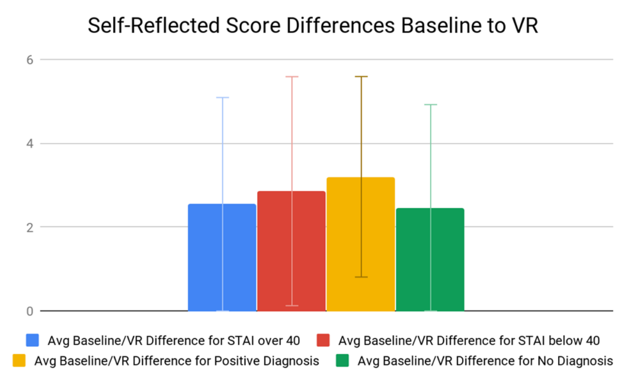

Figure 3: Comparisons of the differences in Likert-scale self-reflected anxiety scores from baseline to VR phases. The error bars represent the standard deviation among groups.

4.5.2 Percent Increases of Heart Rate from Baseline to Virtual Reality Phase

The average percent increase of heart rate from baseline to VR phase of individuals with higher Trait Anxiety scores above 40 was roughly 28.06% with a standard deviation of 0.17. While the average percent increase of heart rate from baseline to VR phase for participants with lower trait anxiety scores of below 40 showed an average increase of 37.38% with a standard deviation of 0.26. A two-tailed unequal variance *t*-test found a *p*-value of 0.42 indicating no statistical significance.

Between the five participants with diagnoses of anxiety and the thirteen without, those with a diagnosis were calculated to show an average percent increase of heart rate from baseline to

VR phase of 31.31% with a standard deviation of 0.05. The participants without a diagnosis showed a similar percent increase in heart rate between baseline and VR phase of 31.83% with a standard deviation of 0.25. A two-tailed unequal variance *t*-test resulted in a *p*-value of 0.94, indicating no statistical significance between the data of those with and without a disorder. Fig. 4 depicts a side-by-side comparison of the average percent increase of heart rate from each individual's baseline heart rate recordings.

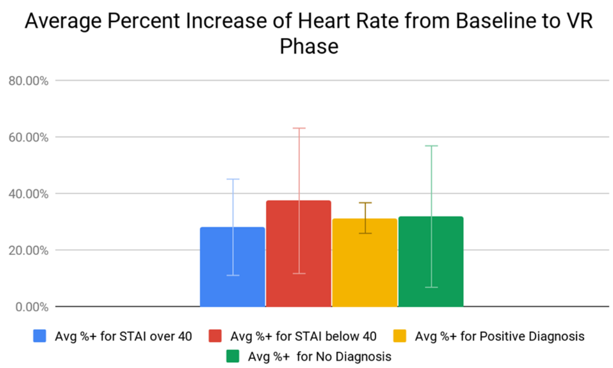

Figure 4: Comparison of the average percent increase of heart rate from each individual's baseline heart rate recordings. The error bars represent the standard deviation among groups. The notation "%+" refers to percent increase.

4.5.3 Self-Reflected Score Differences from Baseline to Recovery Phase (Ability to Recover)

The average self-reflected score differences from baseline to recovery, representing the ability to recover in participants with higher Trait-Anxiety scores of above 40 was 0.36 with a standard deviation of 1.63. Those with lower trait anxiety scores below 40, showed an average self-reflected anxiety score difference of zero, implying full recovery to baseline anxiety levels with a standard deviation of 0.58. A two-tailed unequal variance *t*-test determined a *p*-value of 0.51 which indicates no statistical significance.

Interestingly, those with an anxiety disorder diagnosis averaged a self-reflected anxiety score difference of 1.4 from baseline to recovery, with a standard deviation of 1.67, potentially indicating a more difficult process of recovery/recuperation after an anxious event. Participants without a diagnosis showed a difference of -0.23 in self-reflected anxiety scores from baseline to recovery with a standard deviation of 1.67. Using a two-tailed unequal variance *t*-test to determine statistical significance yielded a *p*-value of 0.09 and therefore resulted in no statistical significance. Fig. 5 depicts a side-by-side comparison of the differences in Likert-scale self-reflected anxiety scores from baseline to recovery phase.

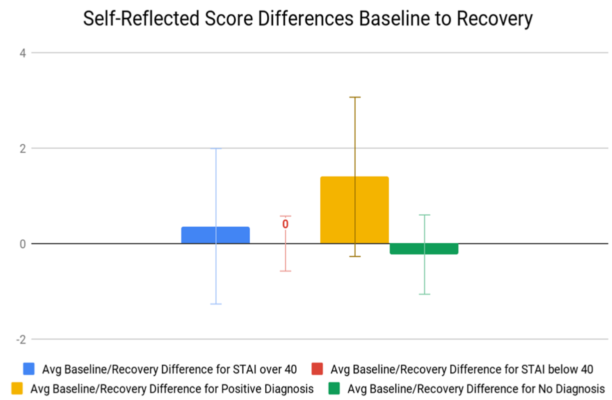

Figure 5: Comparison of the differences in Likert-scale self-reflected anxiety scores from baseline to recovery phases. This represents the participants' ability to recover from an anxious event. The error bars represent the standard deviation among groups.

4.5.4 Percent Increase of Heart Rate from Baseline to Recovery Phase (Ability to Recover)

Participants with higher Trait-Anxiety scores of above 40 showed ability for more than full-recovery of baseline heart rate with an average difference of baseline to recovery of -3.13% and a standard deviation of 0.07. Their counterparts with lower Trait-anxiety scores show a residual average of 4.99% increase in heart rate from baseline to recovery phases with a standard deviation of 0.09. The two-tailed unequal variance *t*-test resulted in a *p*-value of 0.08 between these groups concluding no statistically significant difference.

Similarly, participants with diagnoses of anxiety disorders showed a difference of -0.1% in average heart rate between baseline and recovery phase, also implying full recovery with a standard deviation of 0.06. The majority of participants who do not have a diagnosis of an anxiety disorder on average ended the study with a slightly higher heart rate increase of 0.08% with a standard deviation of 0.1. A two-tailed unequal variance *t*-test between these groups resulted in a *p*-value of 0.96 and therefore the data has no statistical significance in the difference between these groups. Fig. 6 depicts a side-by-side comparison of the average percent increase of heart rate from each individual's baseline heart rate recordings to their recovery phase.

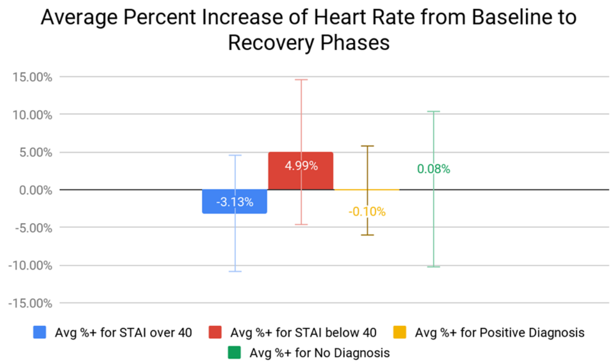

Figure 6: Comparison of the average percent increase of heart rate from each individual's baseline heart rate recordings to their recovery phases. These numbers represent their ability to recover from an anxious event. The error bars represent the standard deviation among groups. The notation "%+" refers to percent increase.

4.6 DISCUSSION

We hypothesized that individuals who have higher general anxiety levels with Trait Anxiety scores above 40, will have a more severe reaction to an anxious environment possibly as a result of sensitivity to panic; potentially meaning that frequently experiencing anxiety leads to more severe physiological and self-reflected reactions to more mild anxious situations. Additionally, we hypothesized that individuals with a diagnosis of anxiety would perceive their anxiety was more severe than their counterparts at similar heart rate increases. The reasoning is the potential of a diagnosis to create an awareness of anxiety that causes an individual to potentially overestimate their anxiety. The information to answer these hypotheses could be crucial to designing adaptable, effective treatments for anyone experiencing anxiety. Due to the ambiguous and variable nature of physiological reactions and symptoms to anxiety, the study was designed with a person-centered approach in data analysis. Each participant's heart rate data was represented as a percent increase from their baseline recording, ensuring there was no bias from the wide range of resting heart rates. The self-reflected Likert-Scale anxiety scores were analyzed as an increase from baseline scores as well. It was taken into account that there was potential for the stigma of psychological disorders, and anxiety specifically, to influence the participants reflections of anxiety throughout the study. To address this, researchers ensured complete privacy while participants recorded their self-reflected scoring on the Trait Anxiety questionnaire as well as during the Likert-Scale self-reflected anxiety scoring after each phase of the experiment. Questionnaires and forms were not reviewed until the experiment was over and the participant had left the room. Additionally, all participant data was kept anonymous during analysis.

The purpose of this study was to explore and understand what effect, if any, does having higher levels of general anxiety have on the physiological reaction to anxiety and the perception of anxiety. This information could shape future health media technology for individuals with anxiety. The results of this study presented no statistical significance among any groups of data. Individuals with higher anxiety had no statistically different reaction in heart rate or self-reflected anxiety from baseline to VR phase than those with lower general anxiety. Additionally, individuals who had diagnoses of anxiety disorders had no statistically significant difference in percent increase of heart rate or self-reflected anxiety scores from baseline to VR than those who had no diagnosis. In terms of their ability to recover to baseline values, participants with higher trait anxiety scores showed no statistical significance in percent increase of heart rate or self-reflected anxiety scores from baseline to recovery than individuals with Trait Anxiety scores below 40. Additionally, participants who had diagnoses of anxiety disorders showed no statistical significance in the percent increase of heart rate or self-reflected anxiety scoring from baseline to recovery than participants without a diagnosis of an anxiety disorder.

While the presented study has two main limitations, namely, an imbalanced sample size, and a small participant pool, some interesting potential patterns are visible. It appears from the data that while the difference is statistically insignificant, individuals with higher levels of general anxiety (Trait Anxiety scores above 40) showed to have had a less-severe reaction to the anxious situation in terms of percent heart rate increase from baseline as well as self-reflected anxiety scoring. However, while their percent increase of heart rate from baseline showed that the group was able to fully recover (and pass) baseline heart rate from the anxious event more effectively than any other group, while the difference is insignificant, their self-reflected scores perceived more anxiety than their counterparts of participants who scored below 40 on the Trait Anxiety Questionnaire. This information could potentially indicate that individuals who experience anxiety more frequently and regularly, have more effective coping mechanisms or less sensitivity to anxiety that allows them to have a more controlled experience and even fully recover most effectively, although they may not perceive it to be that way. Could frequent exposure to anxiety allow an individual to adapt to anxiety and therefore experience less severe reactions both perceptively and physiologically? Is there a way to create safe and controlled virtual environments to implement an exposure therapy technique for individuals with general anxiety disorder?

5. CONCLUSION

The results of this research study will impact the future of assistive technology health media for individuals who suffer from anxiety to any degree. The study analyzed percent increases in heart rate to explore the relationships between the impact of different levels of general anxiety on the physiological reaction of the body to an anxious situation and its impact on the ability to recover to baseline. The analysis looked into possible connections between perceived anxiety and percent increase in heart rate as well as the effect that a medical diagnosis of anxiety could have. While none of the data groups analyzed showed any statistical significance, some potential patterns are visible in the data between lower general anxiety and a less-severe reaction both physiologically and perceptively to anxiety.

To further investigate this possibility, an additional study is required in which more sensor data is used alongside a much larger sample size. It would be of great significance to the study to incorporate heart rate variance as a metric of observing anxiety as well. Such a study will be useful to serve as a control experiment to future research in the effectiveness of various assistive technologies in relieving anxiety.

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