ANX Dread: A virtual reality experience to explore anxiety during task completion

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ABSTRACT

The use of virtual reality as an assistance technology is of wide interest [2, 9, 10]. In particular, recent work in the use of virtual reality to help users manage psychological challenges has been fruitful [5, 7, 11]. In this poster, we present a student capstone project, focused on studying users experience focused on anxiety driven by task completion.

This VR experience, named 'ANX Dread', immerses users into a mildly stressful environment of a malfunctioning spaceship with simple puzzle like tasks to complete. The experience, built with Unity, includes an integrated heart-rate monitor. The project was built as a part of the capstone experience for the 'Computing for the Interactive Arts' minor for the 2018-19 academic year by a team of five students from various academic backgrounds. This poster presents the system and a study reflecting the user's sense of anxiety within the experience.

CCS CONCEPTS

• **Software and its engineering → Virtual worlds software**; **Interactive games**; • **Applied computing → Computer games**;

KEYWORDS

virtual reality, anxiety, bio-feedback

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1 INTRODUCTION

The negative overwhelming feeling of anxiety is experienced by nearly 40 million people in the United States. Even more concernedly, approximately eight percent of young people, children, and teenagers experience anxiety with symptoms developing at young ages [3]. Virtual Reality has shown to be helpful as an assistance technology for users with various physical and mental conditions [2, 9, 10], and recent work in the psychological domain shows great promise [5, 7, 11].

Rooted in a growing concern for anxiety in young people, this project aims to explore the application of virtual reality in support of furthering studies regarding managing stress and anxiety. Inspired by projects such as 'Injustice' [4], this project follows a similar approach of putting the user in an immersive environment to explore their reactions to anxiety-provoking situations. Specifically, our system was designed to explore users' reactions to simple tasks in simulated stressful and fictional settings, namely a malfunctioning spaceship. Additionally, part of the study examines the user's level of anxiety and stress with respect to specific game elements.

This project was created as a part of the 'Computing for the Interactive Arts' (CIA) minor. This cross disciplinary minor focuses on creating a collaborative, cross-disciplinary environment in which Art and Design students integrate coding and algorithmic thinking in creative works and in which Computer Science students apply the principles and methodology of design thinking to visual applications. The minor culminates in a two-quarter long capstone project, in which teams of students from mixed educational backgrounds work together to make a final creative, technical project. The project presented here is a part of the 2018-19 capstone project built by five students.

2 ANX DREAD: THE EXPERIENCE

The goal of the ANX Dread virtual reality experience is to explore users' reactions to stress and anxiety associated with task completion. The project includes a virtual reality experience in which the user must escape a broken spaceship by completing simple tasks

in the digital world. To contextualize the project we describe the basic user experience here:

The user starts in a dark control room where only a large control panel appears, with a large yellow button that can be pressed. Once pressed, the control panel prompts the user to choose a character; however when one of the available characters is selected, the ship malfunctions, which is signaled by a stressful series of events: the control room lights turn on, the only exit door inside the space is broken, shown by the fact that it loudly moves up and down. A HUD appears, which displays the user's heart rate, and a clock starts counting down from five minutes. The user's heart beat can be heard throughout the entire experience. If the clock runs out of time before the user reaches the end of the experience, it begins to count in negative time.

The user's first task is to figure out how to fix the broken door. See Figure 1. To the right of the door there is a panel of broken pins with the instructions "Solder the broken pin headers" directly beneath it. A spotlight illuminates a soldering iron on the nearby shelf, to draw the user's attention to the necessary tool to solve the puzzle. The user must trace the correct path of pin headers to fix the door with pin's coloring used to help the user find the correct path.

Once the door has been fixed, the user enters a labyrinth of long, dark hallways, riddled with explosions of sparks and smoke. See Figure 2. The explosions are periodic enough to keep the user in a constant state of suspense. A gradient of the colored lights at the end of each corridor guides the user to the end of the labyrinth. Every white light leads to a dead end, while the gradient of colors, starting with blue and ending with red, leads the user to the end of the labyrinth. The user has to figure this out, as no instructions are given.

Once the user reaches the end of the maze, the outside of the ship is visible through windows and the user discovers that the space ship is floating in space. At that point, the user arrives at a fork in the path. Both the left and right option look the same, each a dark hallway leading to a possible exit door dimly lit by a flickering light. In reality, both options lead to the end of the game, but it is presented in a way to give the user the illusion one unchangeable decision holds the final outcome of the experience.

After the decision is made, the hallway is lit with spinning siren lights, and the user can see a door with a hand scanner at the end. See Figure 3. Before the user is able to reach the end, the hallway elongates to emulate the "Vertigo Effect" seen in many movies. When reached, the hand scanner fails two times before finally letting the user through the door and into the open space outside. Each failure notifies the user to "calm down" in order to be able to exit the ship.

Finally, at the end of the experience, the door opens, revealing that the user must jump out of the ship. Once the user leaps into space, a giant cake shows up, floating below the user. The cake is used to act as an award and draw the attention of the user. Once the user lands on the cake, the experience ends and credits scroll down indicating the user's success of escaping the ship.

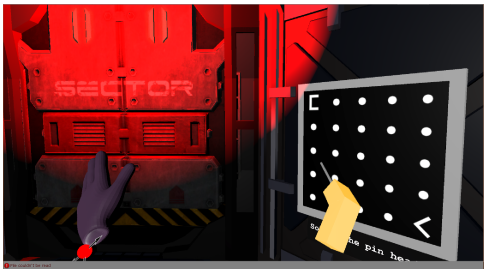

Figure 1: Soldering Puzzle: One of the tasks that the player must complete to escape the malfunctioning ship is to fix the broken door using a soldering iron by tracing a specific path.

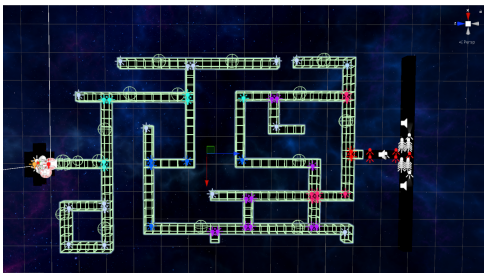

Figure 2: Maze: One of the tasks the player must navigate to escape the ship in a maze.

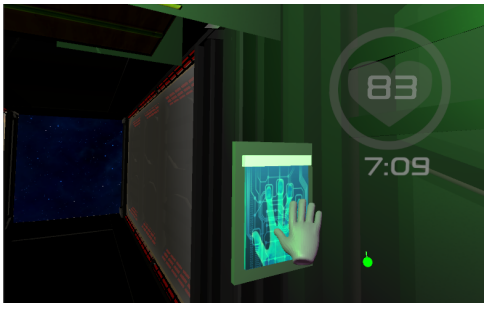

Figure 3: Heart Rate Door: Initially unable to open the door, the player is urged to calm down as the heart rate must be lowered. Here, the user finally opens the door with the hand scanner successfully.

2.1 System development

ANX Dread was developed in the Unity 3D environment using the HTC Vive VR system. Resources in making the project include free and purchased models found in the Unity store and the web and original content developed by the team. A majority of the assets in the VR environment, including the walls, floors, ceilings, lights, come from a Sci-Fi modular pack. Students self-taught themselves necessary technology to integrate into the project via tutorials and references.

At the beginning of the VR experience, the user can interact with the environment via the in game"hand", which is a 3D model that

is mapped to the Vive Controllers. See Figures 1 and 3 for example images. The hands are able to collide and grab certain objects in the environment, as the user progresses through the experience. The user navigates the VR environment by holding onto a certain button on both controllers, while simultaneously swinging their arms in a walking motion. Collision detection between game elements is used in the soldering puzzle.

2.1.1 Heart Rate Monitor. One of the primary goals of the project was to explore anxiety associated with task completion in VR, thus, a heart rate monitor was incorporated into the experience. The sensor was used to integrate biofeedback, i.e. heart rate information into the experience. The sensor was integrated into the system using an Arduino Uno, and a pulse sensor developed by Yuri Gitman [6]. The pulse sensor came with an Arduino library that could handle all of the data collected from the Arduino. One of the pre-written scripts was modified for this project to print the current beats per minute (BPM) to the serial port that the Arduino is connected to in order to send feedback into the Unity VR experience. See Figure 7 for example data. An open source library called WRMHL [1] enables the system to read any data coming in from a specified serial port, using Microsoft's .NET Framework 2.0. In order to make the library work for the existing project, any 'empty queue' conditions are filtered out from the Arduino. This is implemented via a peek at the queue to filter the incoming data to only contain valid BPMs.

One important detail for the the integration of the heart-rate monitor is that the VR experience includes a scene change midway through. To handle this, the heart rate script needs to close communication to the Arduino at the end of the first scene so that it can be re-initiated at the start of the second scene. Without this alteration, Unity would try to have two instances of communication to the Arduino, which would result in no information.

The Arduino and pulse sensor assembly is harnessed in a fanny pack, that is wrapped around the user's back during the experience. The pulse sensor comes out of the pack and clips onto the ear lobe, which goes underneath the headphones. This set-up minimizes extraneous movement that could trigger false readings for the pulse sensor. Figure **??** demonstrates the minimal impact this system has on a user's VR experience.

3 USER STUDY

We conducted a user study to explore user's stress and anxiety levels during task completion. The study measured the user's speed at completing tasks, the heart-rate and the self reported experience via a post-task survey. The main questions in the survey include:

(1) Did you experience anxiety while completing the tasks in the experience?
(2) Please rate each task/experience from most anxiety inducing (5) to least anxiety inducing (1):
  (a) Spaceship Breakdown
  (b) Puzzle
  (c) Maze
  (d) Extending Hallway
  (e) Heart Rate Door
  (f) Other
(3) Could you imagine this kind of experience helping you practice managing stress?
(4) Did you experience any physical sensations during the experience?
  (a) Heart Rate Increase
  (b) Sweating
  (c) Body Tensing
  (d) Fatigue
  (e) Other
(5) Questions regarding other smaller components within the experience. Each was ranked from the least anxiety inducing (1) to the most anxiety inducing (5)
  (a) Did the heart rate monitor and heart beat sound cause you any anxiety?
  (b) Did the countdown cause you any anxiety?
  (c) Did the sound effects throughout the experience cause you any anxiety?
  (d) Did the particle effects, the steam clouds and sparks, cause you any anxiety?

3.1 Subject Selection and Data Collection

The pool of subjects included Cal Poly undergraduate and Graduate students who were recruited via in class announcements and Facebook postings who were asked to voluntarily participate in a questionnaire/study. No incentives were offered. Thirty participants were observed by investigators. Videos of user experience were collected if participants allowed. In addition a clip on heart rate monitor was used with participants permission, and recorded heart rate information throughout the experience.

4 RESULTS

Of the thirty participants in the user study, a little more then half (56.7%) reported that they had used VR prior to the ANX Dread experience.

In terms of measuring users' anxiety responses, a majority of the users rated the following experiences as most anxiety inducing: *Maze* and *Other Experiences (including: heart rate monitor, heart beat sound, timer display, sound effects, and particle effects, such as steam cloud and sparks)*. We found the *Maze* component to be significantly more anxiety inducing than most other components. Specifically, one-way ANOVA between subjects was conducted to compare the effects of the VR experience on anxiety in participant (N = 28) self rated anxiety levels. Specifically, considering the various tasks in the experience against one another, the maze condition stands out. ($F(4) = 3.69$, $p < 0.01$) There was a significant difference in mean anxiety between the maze condition and the other conditions, specifically: 'Spaceship breakdown' ($p = 0.0184$), 'Soldering Puzzle' ($p = 0.0348$), and the final 'Heart Rate Door' ($p = 0.0184$). See Figure 4 for data.

	Spaceship Break Down	Puzzle	Maze	Extending Hallway	Heart Rate Door
Spaceship Break Down	1	0.9996	**0.0184**	0.4385	1
Puzzle	0.9996	1	**0.0348**	0.5749	0.9996
Maze	**0.0184**	**0.0348**	1	0.6436	**0.0184**
Extending Hallway	0.4385	0.5749	0.6436	1	0.4385
Heart Rate Door	1	0.9996	**0.0184**	0.4385	1

Figure 4: Results from one-way ANOVA between subjects to compare self rated anxiety levels in participants (N = 28). Chart compares each condition and listed the given p-value

In addition, post HOC comparisons indicate mean self-reported anxiety levels for the Maze condition (M = 3.79, SD = 1.07) was significantly higher than the mean level for the Spaceship Break Down condition (M = 2.75, SD = 1.32), the Puzzle condition (M = 2.82, SD = 1.28), and the Heart Rate Door (M = 2.75, SD = 1.40). See Figure 5 for complete data.

	M	SD
Spaceship Break Down	2.75	1.3229
Puzzle	2.8214	1.2781
Maze	3.7857	1.0666
Extending Hallway	3.3214	1.2188
Heart Rate Door	2.75	1.4044

Figure 5: Mean and Standard Deviation for level of anxiety felt for each condition given by self-reporting participants

The *Other Experience* components had a mean self-reported anxiety level of 3.46 out of 5. While we can not statistically say it was significantly higher than other components, we can conclude that they were the second highest mean anxiety level, right behind the *Maze* component. Standard deviation was 1.318 for this component. Among these, the timer had the most votes as anxiety inducing. However, when the timer turned negative, it served as source of relief. One user commented on their fear of everything ending when the clock expires, but instead felt relief when the clock turned negative, reminding them that "life goes on even past deadlines, no matter how the deadline turns out."

Based on results from the surveys related to physical sensations section, we found that the common side-effects from anxiety inducing components in our experience were heart rate increase, body tensing, and sweating. See Figure 6 for details.

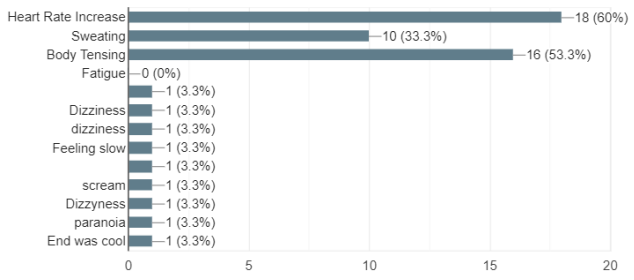

Figure 6: Physical Sensations experienced during VR experience. Users were asked to check the physical sensations they experienced as well as any additional ones.

From Figure 6, we had 60% of users report feelings of heart rate increase. Figure 7 shows one user's heart rate data, collected via Arduino and PulseSensor, displayed over time as they completed the experience. From each participant's data collected we consistently see an increase in heart rate from the user's given resting heart rate. During the initial 'crash' portion of the experience, users had an average heart rate of 96.67, during the puzzle portion users had the lowest average heart rate of 96.39, during the maze portion users had an average heart rate of 97.12, and during the hallway portion users had the highest average heart rate of 99.07.

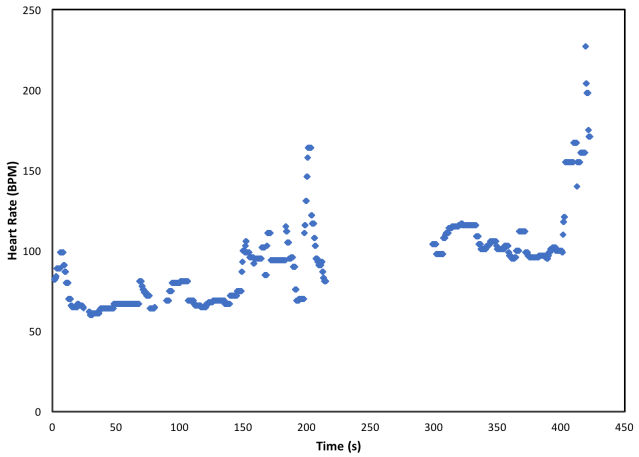

Figure 7: Heart rate feedback recorded from the PulseSensor for a single participant throughout the whole experience. The momentary break in the flow of data is due to the scene change in between the end of the maze and the start of the extending hallway.

To validate our heart rate data obtained by the Arduino and PulseSensor we also used a Fitbit Versa in initial testing. Upon comparison with the Arduino and PulseSensor data, we found the PulseSensor had some issues with sudden movements causing spikes in the data making certain portions of the data unreliable. As seen in Figure 7, the heart rate appears to be particularly high in the first thirty seconds. This correlates with common anxiety the users may initially feel from trying VR for the first time or being in a room with strangers.

Additionally, the heart rate begins to read over 200 BPM at the end of the sample. This was due to removing the PulseSensor after the credits started to roll. Although there were outlying spikes in the data, the overall trend of each participant's data seems to reflect how they actually felt while in the experience.

5 CONCLUSIONS AND FUTURE WORK

We have presented the results of the 2018-19 CIA minor capstone project focused on exploring user anxiety and stress during task completion in VR. The system specifically simulates a mildly stressful environment of a malfunctioning spaceship with the user needing to complete simple tasks to escape the ship. A user study measuring experience indicates that users experienced the most anxiety during the maze component of the experience. We conclude that when designing a future VR experience, a *Maze* component or some of the individual components included in the *Other Experience* section could potentially be used to induce anxiety in their participants.

The system included a heart rate monitor which fed data back into the VR HUD for the user. As noted, this was one of the 'Other Experiences' that contributed to user anxiety. We would like to continue to explore the use of biofeedback to better understand the role this particular component played in user experience and how it could be used to help users manage anxiety.

The premise of the project was to design a seemingly stressful environment and gain insight from our user tests on what components triggered the most anxiety and if it was relieved, then how. Knowing what causes anxiety and what brings relief is the first step to developing methods to manage stress and/or anxiety. The next step would be to directly apply our findings to develop experiences that aid in the users' stress and anxiety management skills. Additionally, future work includes developing a better understanding of the role the heart-rate monitor plays in user experiences and guided activities related to calming a users senses, taking inspiration from recent work in some games [8].

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