Fear Elicitation In Virtual Reality

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1. PROJECT DESCRIPTION

The project focuses on creating a virtual environment that will elicit fear in participants without any phobias. The level of fear induced by the virtual environment will be adjustable during runtime. The project is being done in collaboration with the psychology department. The department will provide equipment to measure emotional responses in participants and guide our experimental design. A data analysis and visualization tool for the physiological data gathered from participants will be built for the department. This tool will be a desktop application and will assist psychology researchers by speeding up their data analysis workflow.

A study to evaluate the effectiveness of the virtual environment will be conducted. During the study, participants will have their physiological measures taken as they proceed through the virtual environment. The physiological data along with subjective questionnaires that participants will be asked to fill out will give an indication of whether the environment has generated a significant fear response. The results from other studies involving fear elicitation in virtual reality (Felnhofer, 2015; Riva, 2007) will be used as a baseline for comparison. The comparison is important because if our environment elicits a stronger fear response, it will mean that the techniques used are superior to those in the literature (and vice versa if the fear response is weaker i.e. the techniques are inferior). This will aid fear elicitation research which will have an impact on treatments of anxiety disorders such as Post-Traumatic Stress Disorder and also have an impact on entertainment like virtual reality horror games.

2. PROBLEM STATEMENT

The project has a software development component as well as a research component. The software development consists of a virtual reality environment that elicits fear and a data analysis and visualization tool. The client for both these software artifacts is the psychology department. The department has provided the main requirements for both of these systems. The research component is a study that will be conducted to evaluate the effectiveness of the virtual environment. The psychology department will assist with securing participants for the study, providing measuring instruments and guiding the design of the study.

2.1 Aims of Work

The virtual environment will be used by Siphumelele Sigwebela (a psychology masters student) in a study she is conducting. She is investigating the viability of Virtual Reality as a Mood Induction Protocol (MIPS) and comparing it to conventional MIPS such as films and pictures. She will be examining two emotions during her study, fear and sadness. She will use the virtual environment for the fear component of her study. The evaluation study associated with this project will be run in conjunction with Siphumelele's study, as both studies will take the same physiological and subjective measures. Our study will evaluate the virtual environment and compare it to other fear-inducing environments from the literature, in order to make conclusions about which techniques are more effective for generating a stronger fear response.

The virtual environment will used for psychology research however the psychology department sees fit once Siphumelele's study is completed. The data analysis and visualization tool will assist psychology researchers when they analyse physiological data measured by their equipment. The tool will enable them to perform transformations on the data, highlight specific focus areas within the data and also generate graph. This will speed up their workflow as the researchers normally have to do all this manually.

2.2 Research Question

The research question is "Can a virtual environment induce fear that is not phobia-related in participants?". The hypothesis is that the environment will generate a generic fear-response that is at least on par with other virtual environments that have been created to induce fear (Felnhofer, 2015; Riva, 2007). Physiological and subjective measures will be used to compare the levels of fear induced by the environment with those from the literature.

2.3 Important Requirements

The clients for the virtual environment and analysis tool are Siphumelele Sigwebela (masters student), Gina Gilpin (assistant) and Prof. Gosia Lipinska (supervisor) from the psychology department. The users of the virtual environment will be the subjects who agree to participate in the study. The users for the analysis tool will be researchers from the psychology department.

The virtual environment will be developed according to a script which has been provided by the Department, see appendix A. The level of fear induced by the virtual environment will be configurable at runtime. The duration of the experience will be four to five minutes. Each participant will have the exact same experience with the environment in terms of duration experience, ambience of environment and storyline of events. The only factors allowed to vary between participants is where they place their gaze, but this will not vary by much since they will be in a confined space with limited lighting. Participants will be seated throughout the duration of the experience.

The analysis tool will be a desktop application for Windows and MacOS. It will read in data physiological data measured by the Biopac hardware and AcqKnowledge software. Users will use the tool to perform transformations on the data. Transformations are manipulations of the data, specified by some formula e.g. calculating heart-rate variability from heart-rate data. The tool will also be able to visualize the data in the form of graphs, and users will be able to export these graphs.

3. PROCEDURES AND METHODS

Virtual Environment

The virtual environment is being developed using the Unity VR engine and Oculus Headset. Unity is a good choice for the development environment because the team is familiar with the platform and it has many useful features and offers a lot of support. The psychology department has provided a script for the virtual environment, see appendix A. This script will form the

base for the design going forward. The environment will be a dark and foggy underground tunnel. The participant will be on a boat as they proceed through the environment. A water monster will stalk them until the participant reaches a closed gate. Thereafter the monster will attack them and the experience will end.

The level of fear in the virtual environment will be configurable during runtime. There will be three levels of fear (ranging from scary to extremely scary). In order to vary the levels of fear, a modular implementation is being followed. The script will divided into "events". An event refers to an occurrence that grabs the participants attention, for example when the monster jumps out in front of the participant. Each level of fear will have specific events that are associated with it, see Appendix B for the full list of events. The fear level will be cumulative, meaning that when the fear is set to level two, events from both level one and level two will occur. If the fear level is set to level three, then events from all the three levels will occur. Having the fear level accumulate in this way causes the events to seem scarier because they occur with more frequency.

Level one will follow the script that was provided by the psychology department. Each level has a creature associated with it. For level one, a water monster attacks the participant. For level two, a scary clown terrorises the participant. For level three, a ghost appears. See appendix C for a diagram outlining the initial design for the virtual environment and the interplay between the different events. Assets for the environment will be purchased from Unity assets store. Funds for these assets will be provided by the either the computer science department or psychology department. See appendix D for the list of required assets.

The design of the virtual environment is being guided by the literature on fear from the field of psychology. Principles such as inducing a fear of the unknown and having a predatory threat, have been incorporated into the design (Bennet, 2017; Javanbakht & Saab, 2017; Öhman, 1986).

User Centred Design (UCD) will be used to develop the virtual environment. UCD is an iterative design process where users are central to the development of the product (Baek,2008). At every iterative step in UCD, a prototype that meets the latest user requirements is produced. The prototype is then tested by users and the feedback informs the design for the next iteration of the prototype. UCD is flexible and can handle changing requirements. This important because some assets might not be available on the asset store, and this may change the design of the virtual environment.

Evaluation study

A study will be conducted to evaluate the effectiveness of the virtual environment. During the study, the virtual environment will be set to fear level one so that the conditions are the same for all participants. The psychology department will assist with acquiring participants for the study. The aim is to get 25 participants. Physiological and subjective measures will be taken in order to determine the level of fear induced in participants, these measures will be compared with those from other virtual environments from the fear literature (Felnhofer, 2015; Riva, 2007).

The physiological measurements to be taken during the study will give an indication of the sympathetic activation of the Autonomic Nervous System (ANS).The ANS is responsible for involuntary body functions such as heartbeat, blood-flow and digestion. The ANS contains a sympathetic branch, linked to emotional responses (Mauss,2009). During the study, the physiological measures that will be taken are heart rate (HR), skin conductance level (SCL) and respiratory sinus arrhythmia (RSA). These will be measured using the BIOPAC system provided by the psychology department. The BIOPAC uses a software called Acqknowledge to store the measurements onto a computer. The data analysis and visualization tool will interface with this software.

The subjective measures to be taken are the Self Assessment Manikin (SAM), Visual Analogue Scale (VAS) and Differential Emotions Scale (DES). SAM is a non-verbal pictorial assessment technique that allows a participant to rate the arousal and pleasure felt from a stimulus (Bradley & Lang, 1994). VAS questions participants on the emotion they are feeling at a given moment. DES allows participants select the emotion they are currently feeling from a list (joy, fear, anger, disgust, surprise, sadness, guilt, contempt and shame).

Certain participants will be screened out of the study. Participants who have phobias will be screened out using the Marks and Matthews Fear Questionnaire (MMFQ) because the study is focusing on generic fear that is not phobia related. Participants with depression, post-traumatic stress disorder and alcohol misuse disorder will also be screened out because they are at risk of an extreme fear-response that could pose a risk to their health. The respective questionnaires for these are The Patient Health Questionnaire for Depression-9 (PHQ-9), The 4-item Primary Care Post-Traumatic Stress Disorder Screen (PC-PTSD) and The Alcohol Use Disorders Identification Test Consumption (AUDIT-C).

Analysis and Visualisation Tool

The analysis tool will be developed with the Python PyQT framework. The tool will be a desktop application and will run on Windows and MacOS. The framework is cross-platform, meaning that only one code-base will have to be developed in order to release on both platforms. Another advantage of using PyQT is that it will allow access to the plethora of libraries that python offers, and this will speed up development.

The tool will have to perform four functions: reading in physiological data, performing transformations on the data, displaying the data, and exporting the data out of the application. The functions have been turned into four separate modules, see appendix E for the related diagram. The GUI of the application will be a simple design consisting of two panels. One panel will be for loading files that contain physiological data and the other will be for visualizing the data and performing transformations. See appendix F for the initial GUI design. The tool will load CSV files. Visualizations will be in the form of graphs and tables. Transformations will be mathematical formulas that the user can type in to manipulate the data. An example of a transformation would be using heart-rate to calculate heart-rate-variability. More requirements need to be gathered from the psychology department concerning the types of transformations expected. The tool will also be able to export graphs and tables (created as a result of transformations) as PNG files.

Similar to the virtual environment, User Centred Design will be used to develop the analysis tool. At least two prototypes will be produced before the final product. The psychology department will provide requirements and evaluate the prototype after each iteration. A major evaluation measure is that doing data analysis using the desktop application must be faster than doing the data analysis manually. Ease of use is also another important measure that will determine whether the tool will satisfy the clients.

4. ETHICAL, PROFESSIONAL AND LEGAL ISSUES

Our research project requires ethical clearance because it may cause unwarranted harm to participants. So we will apply to the Faculty of Science Research Ethics Committee for ethical clearance. Participants will sign a consent form and will be able to withdraw from the study at any time without penalty, see appendix J for this. The experimenters will be trained in first aid, this will be important in case participants experience any discomfort or threat to their health. The psychology department will help with experiment design, and offer guidance on ethical considerations. The products created as a result of this research will belong to the University of Cape Town.

5. RELATED WORK

Most of the literature explores eliciting fear that is phobia-related. Few studies have been conducted to investigate whether it is possible to induce a generic fear-response in a virtual reality environment (Felnhofer, 2015; Riva, 2007).

A trend we noticed in the literature is that most mood induction studies use parks for their virtual environment (Felnhofer, 2015; Banos, 2004, 2008, 2012; Riva, 2007). These parks tend to be static environments that utilize simple mechanics (lighting and sound effects) to induce the desired emotion. We have decided to develop a dynamic environment that will offer rich perceptual cues for fear by using elements of story, predatory signalling and isolation. These cues have been developed in correlation with what the psychological literature on fear says is the most effective method to scare people. With this in mind we hope to produce an environment that performs as well or better than virtual parks we have been discussed in the literature, if not better.

6. ANTICIPATED OUTCOMES

The outcomes for this project will be a virtual environment that induces generic fear in participants, and a desktop application for physiological data analysis and visualisation. The level of fear induced by the environment will be configurable at runtime. The virtual environment will induce levels of fear that are on par with other virtual environments from the fear literature. The desktop application will speed up the workflow of researchers in the psychology department. Our clients will be satisfied with both these software systems and their requirements will be met.

7. PROJECT PLAN

7.1 Risks and Risk Management Strategies

See appendix G for risk matrix.

7.2 Timeline

Important Dates

See appendix H for list of important dates.

Gantt Chart

See appendix I for gantt chart.

7.3 Required Resources

Equipment and software

Access to an Oculus Rift VR Headset and a high-end desktop PC to develop the virtual reality environment is required. Psychophysiological measurement equipment in order to measure the emotional arousal of participants during the study is also necessary. Access to the AcqKnowledge software which outputs the physiological data is needed to develop the analysis tool.

People

The clients are representatives from the psychology department. They will provide the requirements for the virtual environment and analysis tool. They will also offer guidance on how to design the evaluation study and oversee the development of the two software artefacts.

7.4 Deliverables

The major deliverables for the project are the virtual environment and the analysis tool. Since the level of fear induced by the environment must be configurable at runtime, virtual environment will be developed in three iterations. Each iteration represents a fear level from level 1 (lowest fear setting) to level 3 (highest fear setting).

The analysis tool with have four modules: a data-input module for reading in data from files, an operations module for performing manipulations on the data (applying mathematical formulas), a display module for visualizing the data in the form of graphs and tables, and a data-output module for exporting the graphs.

7.5 Milestones

The deliverables due on important dates will be our milestones, see appendix H.

7.6 Work Allocation

Work will be evenly split between Hamandishe Mathivha and Thethela Faltein. Hamandishe will work on the implementation of the virtual environment. Thethela will work on the implementation of the analysis tool. Although their development work will be done separately, they will co-design the virtual environment and analysis tool and have a role in important decisions for both deliverables (e.g. choosing assets from the Unity store and selecting functionality to add to the analysis tool).

Both Hamandishe and Thethela will conduct the evaluation study for the virtual environment and the final project paper will be a product of both their efforts. The pair will also evenly divide the work required for the project poster and project website.

8. APPENDIX

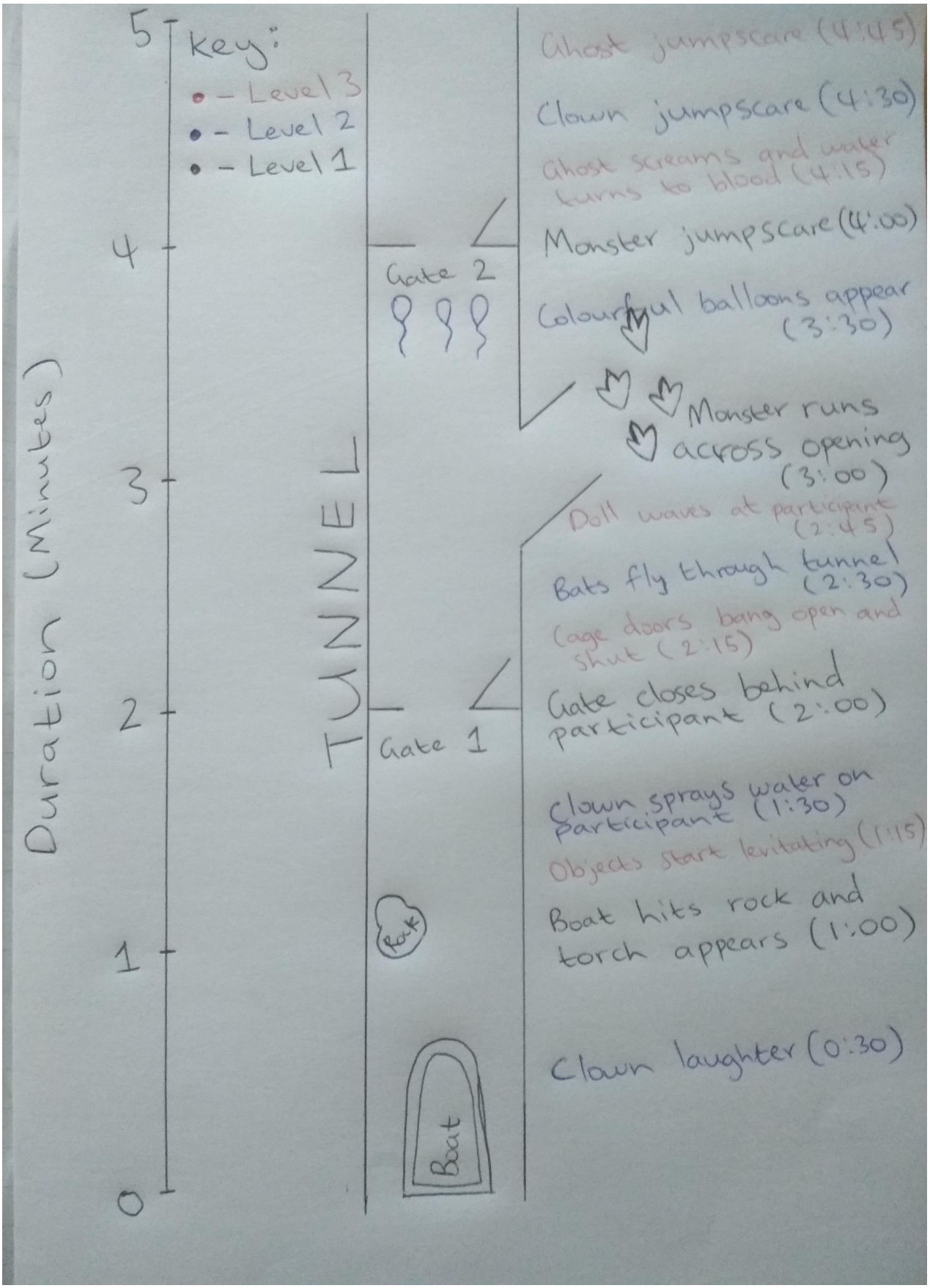
A. Virtual environment script from psychology department

The condition will immerse participants in a dark, damp underground canal. The participant will be sitting in a boat/gondola that is being controlled by an unseen operator. In the foggy darkness of the canal the participant will hear the sounds of water lapping and splashing, the hollow echoes of the tunnel, the sound of sinister breathing and dripping, which will suggest that they are not alone. After 30 seconds of acclimatising to the dim environment the participant will be informed about their only tool, a torch. Using the torch the participant will be able to explore the environment; catching glimpses of the messages written in graffiti on the walls, a closed gate behind them, indistinguishable stains on the boat, murky waters and shadow like glimpses of creatures in the tunnel. They will then hear a more distinct animal-like sound and see the abnormal shape and skin of the creatures arm. Feeling the presence of the creature draw near, the participant will look to escape only to find that through the fog there is another rusted gate before them. The creatures' presence will then escalate and the creature will attack the participant. The participant is then exposed to the creature, an amphibian humanoid with hollowed eyes, no mouth, slimy translucent skin, long arms and frog-like legs

B. Events for each level of fear

Level 1 (Water monster scare)	Level 2 (Clown scare)	Level 3 (Ghost scare)
Gate closes behind participant	Clown laughter	Objects in tunnel start levitating
Boat hits rock in water	Clown sprays water on participant	Cage doors bang open and shut
Torch appears on boat	Bats fly through tunnel	A doll that was come to life waves at participant
Water monster runs across opening in tunne	Colorful balloons appear, blood comes out when they explode	Ghost screams and water turns to blood
Water monster jumpscare	Clown jumpscare	Ghost jumpscare

C. Initial design for virtual environment



D. List of virtual environment assets

Main assets

- Water monster
- Scary Clown
- Ghost
- Scary Doll
- Boat
- Torch
- Flying bats
- Balloons
- Liquid blood
- Tunnel components (walls, gates, cages, water, fog)

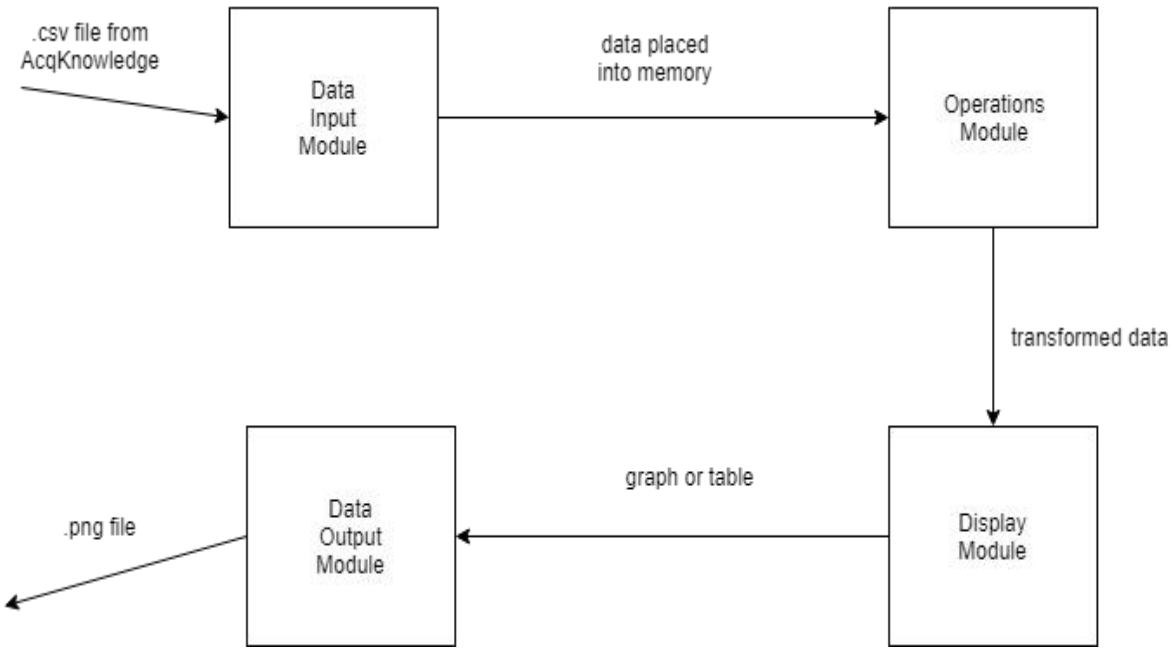
Auxiliary assets (mainly for details and aesthetic)

- Blood stains
- Dead animals
- Graffiti and wall writing
- Rocks
- Hanging rope
- Moss
- Rusted pipes

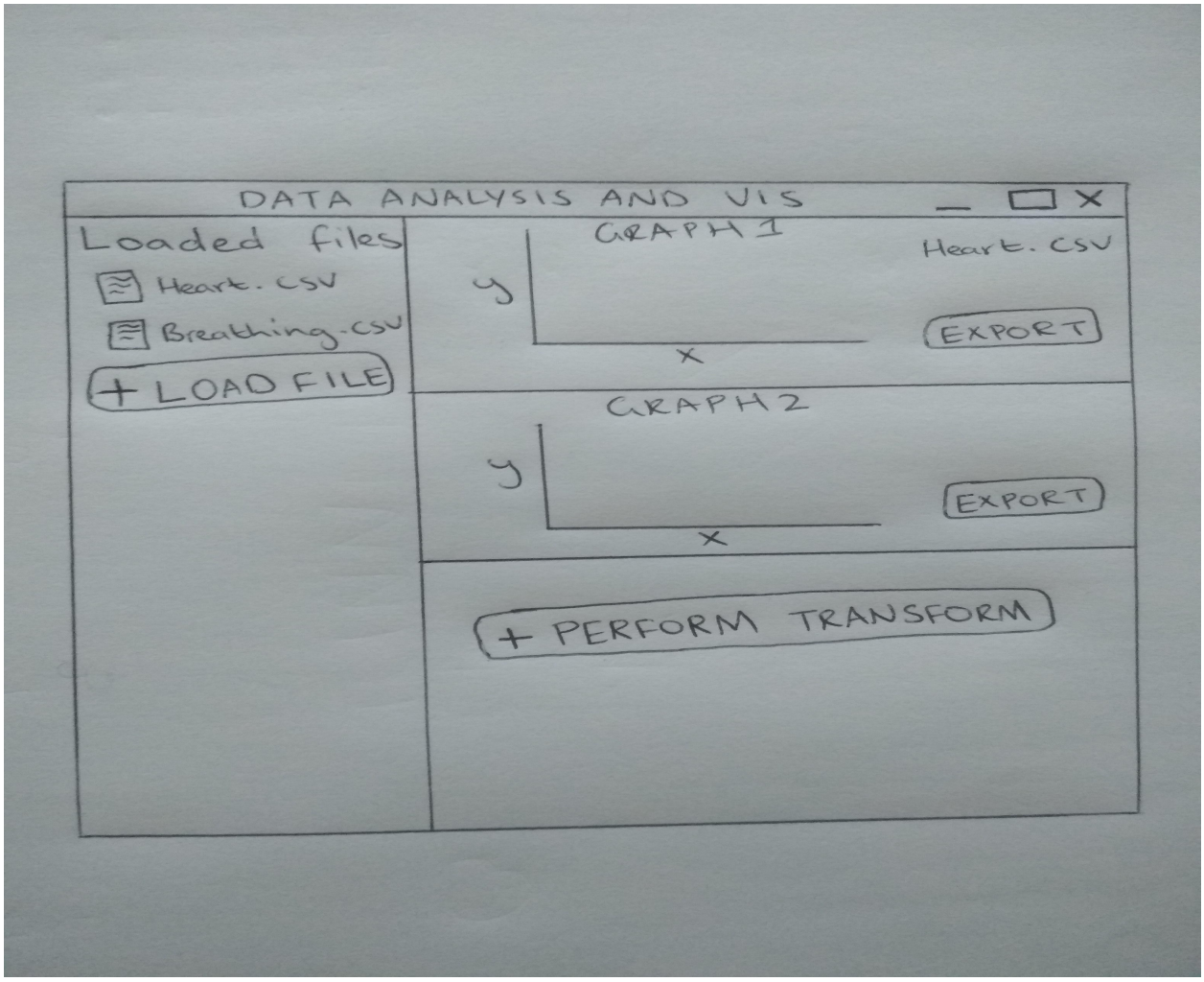
Sound effects

- Monster hissing and breathing
- Clown laughter
- Ghost scream
- Doll’s voice
- Water sounds (drips and splashing)
- Wind in tunnel
- Banging gates
- Popping balloons
- Creak of boat
- Bat sounds
- Ambient noises in tunne

E. High-level design of analysis tool



F. Initial GUI design for analysis tool



G. Risk Matrix

Risk Condition	Probability	Severity	Consequence	Mitigation	Monitoring	Management
1. Not getting enough participants for our study.	5	6	Not having enough data to make any valid conclusions. Unable to write a good project paper.	Get participants via the Psychology Department, rather than try to get them on our own. The Psychology Department requires that first year students participate in psychology research in order to get DP, this way we have a reliable pool of participants to pick from.	When people sign up to participate in our study we will ask for their contact details so that we can follow up on them a day or two before they come in for the experiment to see if they will show up.	If worst comes to worst and we still do not have enough participants, we will ask friends and Computer Science classmates to be participants.
2. Scope creep	3	8	Unfinished product by the end of the development cycle. Unable to conduct our study.	Gather clear requirements, identify core functionality and cut out any additional functionality that is not absolutely necessary. Only work on the additional functionality once the core is done.	Compare our current progress with our projected timeline.	If we start slipping behind slipping behind schedule, reduce project scope
3. Running out of development time	6	8	Unfinished product by the end of the development cycle. Unable to conduct our study.	Set up a timeline of what components need to be completed by when and deadlines for important milestones.	Compare our current progress with our projected timeline.	If we start slipping behind schedule, reduce project scope
4. Not doing thorough testing	10	4	Bugs and errors showing up during user experiments, prolonging the duration of our study and also leading to some participants dropping out.	Block of a chunk of time from the project schedule that will be dedicated to testing.	Keeping track of how many of our methods have unit tests, what systems have integration tests and the number of end-to-end tests	If we run out of time to do all these tests, then we will just do play-testing only
5. Not defining project requirements clearly	8	8	Finished product does not meet client requirements. Study does not answer the right research question.	Sit down with stakeholder early and draw up the requirements	Continuously get feedback from stakeholder throughout development	Build core functionality and leave out auxiliary feature

H. Important Dates

June
10 - Implementation phase begins (virtual environment and analysis tool)

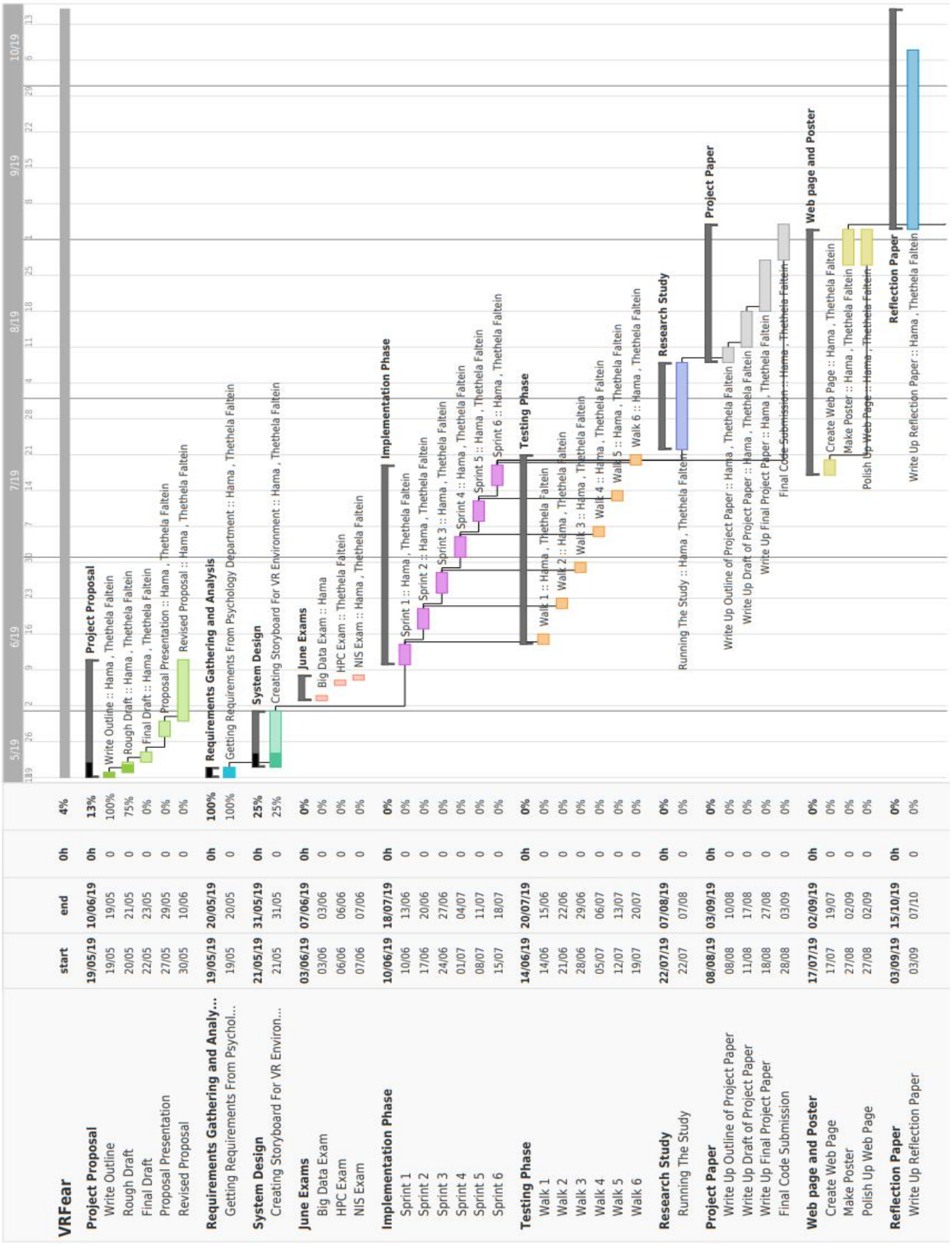
July
15 - Initial feasibility of software demo
22 - User study begins (virtual environment must be completed by this date)

August
9 - Outline of final paper due (User study and analysis tool must be completed by this date)
16 - Project paper draft due
26 - Final Project paper submission

September
2 - Final Project Code submission
23 - Poster Due
30 - Web Page due

October
7 - Reflection Paper due
15 - Open Afternoon/ Evening

I. Gantt chart



J. Consent form

Human Informed Consent Form

Instructions to the Student Researcher(s): An informed consent/assent/permission form should be developed in consultation with the Adult Sponsor, Designated Supervisor or Qualified Scientist.
This form is used to provide information to the research participant (or parent/guardian) and to document written informed consent, minor assent, and/or parental permission.

- When written documentation is required, the researcher keeps the original, signed form.
- Students may use this sample form or may copy ALL elements of it into a new document.

If the form is serving to document parental permission, a copy of any survey or questionnaire must be attached.

Student Researcher(s): _____

Title of Project: _____

I am asking for your voluntary participation in my science fair project. Please read the following information about the project. If you would like to participate, please sign in the appropriate box below.

Purpose of the project:

If you participate, you will be asked to:

Time required for participation:

Potential Risks of Study:

Benefits:

How confidentiality will be maintained:

If you have any questions about this study, feel free to contact:

Adult Sponsor: _____ Phone/email: _____

Voluntary Participation:
Participation in this study is completely voluntary. If you decide not to participate there will not be any negative consequences. Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific question.

By signing this form I am attesting that I have read and understand the information above and I freely give my consent/assent to participate or permission for my child to participate.

Adult Informed Consent or Minor Assent Date Reviewed & Signed: _____
Printed Name of Research Participant: Signature:
_____

Parental/Guardian Permission (if applicable) Date Reviewed & Signed: _____
_____
_____

Parent/Guardian Printed Name: Signature:
_____ _____

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