Skillia: The Ultimate Therapy Hub

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Table 1: Document version history

Version	Date	Reason for Change
1.0	28-Nov-2022	SRS First version's specifications are defined.
1.1	21-Apr-2023	SRS updated version (Dataset, MVC-laravel architecture, etc).

GitHub: https://github.com/mariam1502/ADHD-Gaming-Environment.git

Contents

Abstract

Children diagnosed with ADHD are known to lack some cognitive abilities, which causes them to face some struggles. As traditional therapy, which uses drugs for ADHD can result in serious side effects, thus, it is found that by entering the patient into a whole new gaming environment dimension of series games using Unity3d, with each game aiming to enhance a certain cognitive ability the patient lacks, these therapy sessions were proven to be a more effective than traditional therapy. Moreover, by using EEG sensors embedded inside of a headset, one aims to have the desired brain wave-length, triggering an action in Unity, then a live data-set will be sent to a machine learning model, in which the system shall adapt to each patient's state, all this by using a connection socket between python and c#. Finally, a feedback cycle will take place to assess the player's performance and the effectiveness of the games.

1 Introduction

1.1 Purpose of this document

This paper's goals are to outline the document's specifics as well as demonstrate the project's details that are to be considered in the futuristic design aspects. The documentation also shows the requirements and the list the features that are needed to complete the project. In this paper, the implementation process will also be discussed and the used methods and algorithms will be covered.

1.2 Scope of this document

The objectives and motives of the described project as well as its possible users are covered in this paper, as well as an analysis of the systems that are comparable to the project and an illustration of the overview, scope, and context of the system design. Additionally, this article provides a full explanation of the project's functional and non-functional requirements, design constraints, data design, and basic class diagram. The document also analyses potential operating scenarios and provides a timeline for the implementation of the project.

1.3 Business Context

As studies show that traditional treatment methods generally used for ADHD patients don't always achieve the best results. Not to mention, medications used alongside therapy for ADHD patients all have side effects on the patient such as depression alongside other side effects. Using an adaptive gaming environment to target and enhance the abilities that ADHD patients lack was proven to be an engaging experience for patients. In addition to that, by using a headset with EEG sensors embedded into it to constantly collect data signals from the patients before, and during the process of using the ADHD support gaming environment with a set of serious games, each targeting and working on enhancing the abilities that the patient lacks is proven to be an effective treatment method, this will ensure that the patient's status is monitored with each phase, and accordingly the gaming environment shall adapt to these changes. This method has a much higher recovery rate and has been proven to achieve better results. Thus, this project will benefit clinics that treat ADHD children by improving their treatment methods, as well as, achieving effective recovery results for the child, while ensuring that he/she doesn't undergo a stressful treatment process.

2 Similar Systems

2.1 Academic

The first study to be discussed focused on enhancing kids' motor abilities using the ATHYNOS game. Given that they are digital natives, it helps kids become more interested in physical activity and develop their body kinesthetic intelligence. They had the opportunity to develop a certain way of thinking and to be happier with their fine motor skills. The degree of difficulty in the game depends on the player's abilities and competence. When compared to the manual technique, the proposed research methodology for the times and performance provided by the ATHYNOS prototype shows statistically significant gains with 95 percent confidence. The kids made progress in their understanding of bilateral integration, sequencing, and hand-eye coordination. One of the key components of the game is its element of fun. Additionally, ATHYNOS provides feedback on the player's accomplishments and informs the users of which activities are effective. It is pertinent since it encourages kids to complete the game's objectives. [1]

Secondly, from the previously mentioned research, a continued study was made and discussed in this paper regarding how that in order to treat and prevent mental illnesses in children with ADHD, serious games are thought to be a potent mechanism. With the aim of inspiring the emotional competences of the kids who took part in this case study, the scenarios blended the integration of these games with Augmented Reality utilizing a natural user interface. The use of the ATHYNOS game prototype improved the children's ability to focus, according to the study's findings. It encourages voluntary participation and calls for a level of ongoing interest in problem-solving to support academic achievement and the learning environment. It was confirmed that the games have resulted in a sizable decrease in response time throughout the therapy sessions. Additionally, practically every child has shown a high level of motivation and curiosity, according to the therapist's observations. Furthermore, the innovative game prototype has used the developing technologies to achieve the high level of therapist satisfaction. [2]

On the other hand, in a third study, the invention of a video-game that employs a child's mental intentions as the onset signals and is detected by a low-cost brain computer interface is described in the research as a continuous attention training program for children with ADHD. The video-game is set in the cultural landscape of a coffee farmer, a prime example of a distinctive, productive, and sustainable landscape that reflects a tradition with strong symbolism not only on the national level but also in other coffee-growing and picturesque places throughout the world. Through the specific mental stages of relaxation and focus, the video-game's dynamic establishes a form of interaction. A portable BCI sensor measures a child's brain activity when they reach a certain degree of concentration and wirelessly transmits the information to the video-game to ensure that the interactions are programmed appropriately. Events like altering the speed at which the panel controls the items and enabling the player to pick objects while riding a "canopy" are just a few instances of how a real video-game was developed. This computer game is meant to help kids develop crucial skills like planning, waiting, and the ability to follow directions and complete tasks. [3]

Another study explored how background music in games affects kids with and without ADHD. They then suggested an algorithm to measure brain activity. Thus, Tetris, a well-known serious game was created. Its background music can play Beethoven, Mozart, or nothing at all. A brain computer interface device was used to record the subjects' brain activity using EEG signals. Time-domain characteristics from the Alpha and Beta bands of EEG data were used to record the impact of music, and this indicated that various musical genres have differing effects on children's attention, as, Mozart reduces Alpha-level brain activity with increasing Beta-level brain activity, while, Beethoven music increased both Alpha- and Beta level activity for ADHD children. [4]

Moreover, a fifth paper demonstrates how Neurofeedback therapy has shown encouraging outcomes as an alternative for treating ADHD problems. But, as consumers become disinterested in having long EEG feedback sessions, employing an Augmented Reality game with a MATLAB signal processing module, an AR mobile application, and an EEG Emotiv headgear has been shown to increase the effectiveness of treatment. A pilot trial, first with healthy kids, then ADHD patients, will begin with a baseline evaluation that includes assessing the threshold theta- beta ratio (TBR), Individual alpha peak frequency (IAPF), and individual alpha band width (IABW). The resting-state threshold theta- beta ratio's (TBR) large increase both before and after the intervention will confirm the effectiveness of the systems. [5]

Additionally, another study looked into and created a game based on mixed reality (MR) with customized stages, sound effects, and leaderboard based on each level, in order to be used to easily treat ADHD kids at home in an enjoyable and motivating manner, and thus, effectively treat them without the usage of medications or therapists. By using advanced test of attention (ATA), the interactive metronome (IM), and a survey, they verified the effectiveness of the treatment. A statistical analysis of the outcomes revealed a considerable improvement in impulsivity and inattention. [6]

However, in the BRAVO paper, it was discussed how an interactive virtual reality gaming environment was created with the main purpose of improving the relationship between young patients and therapies through engaging serious games to enhance cognitive of an ADHD child. During the game, the patient's behavior is monitored using on-body sensors, in order to assess the child's performance and emotional state. Consequently, the therapist can adapt the environment to the suggested suitable game and difficulty level suggested by the system. The system was evaluated by examining patients' performance; the first results already show a great potential of serious games in attracting young patients even compared to standard therapy. [7]

In the final paper, neurofeedback and Internet of Things (IoT) are used to create an adaptive attention adjustment method that connects patients and clinicians remotely, minimizing their need for face-to-face interaction, especially with COVID-19. Additionally, a Proportional Integral Derivative (PID) controller was utilized to modify the feedback task's level of difficulty in order to accommodate each person's capacity for self-regulation to offer a higher degree of regulation. According to the results obtained by comparing the original attention feedback feature theta- beta ratio during the feedback training process, the individual's feedback indicator has decreased by 77.90 percent. The individual can now adjust his attention state to the optimal baseline threshold, and the oscillation error gradually decreases to the expected threshold range. [8]

2.2 Business Applications

In this section, a couple of publicly available games that were utilized with the purpose of enhancing the attention levels, emotion recognition and management, alongside other executive abilities in children are shown.

Mightier: Firstly, a video game system is shown below that has been established to enhance children's ability to recognize and manage emotions when used in collaboration with treatment. Play is a great way for children to learn. Kids' heart rates are displayed in real-time by the gadget on the left. The games get harder as their stress levels rise. Finally, Mightier incorporates relaxation into the game.

Figure 1: heart rates

EndeavorRx: Secondly, a video game for ADHD approved by the FDA for Digital therapy called "EndeavorRx" is indicated to improve attention function as determined by computer-based testing in children aged 6 to 12 years old with ADHD. EndeavorRx concentrates on the critical brain regions involved in attention function. Each child's gaming experience is unique, and parents can monitor their progress. Patients show improvements on the Test of Variables of Attention (TOVA®), a digitally measured test of sustained and selective attention.

Figure 2: EndeavorRx

Portal: Lastly, a game titled "Portal" were a portal gun is used by players to guide a character through an abandoned research facility. It opens doorways between chambers, allowing people or things to pass through them as they would in a three-dimensional puzzle. The game is enjoyable and beneficial to the mind. Players must employ executive abilities like planning, time management, and working memory, which are areas where children with ADHD need to improve.

Figure 3: Portal 2

3 System Description

3.1 Problem Statement

In traditional practices, ADHD patients are usually treated using psychotherapy sessions combined with certain medications. Unfortunately, this method isn't 100 percent effective and can cause multiple side effects on the patient such as feeling aggressive, irritable, depressed, anxious or tense. After excessive research, we have found that a better alternative for traditional therapy and medical treatments, was creating an ADHD support through entering the patient into an adaptive gaming environment targeting the cognitive abilities lacked by an ADHD patient, tracking and assessing the performance of each patient, while adapting the gaming environment to the patient's state with each phase. This method was proven to be able to achieve much better results without the downsides found when using ADHD medications, which is why we aim to create the best gaming experience possible for children suffering with ADHD of age groups from 6 to 12 years old.

3.2 System Overview

This project suggests the usage of a gaming environment in teaching life skills that are lacking in ADHD users. The game is to be supported by various sensors such as EEG helmet to track user behavior throughout the game. Suggested games should mainly focus on enhancing:attention enhancement (self regulation), planning/organization, and social skills .Accordingly, these games should teach the following skills: Rule following, well-thought decision making, and competition of age appropriate cognitive tasks. Tracking and clustering behavioral patterns to be conducted using machine learning. Gaming components should be adaptive to tracked user behavior (increasing/ decreasing difficulty).

The Project's System overview is categorized into three main phases which are

- The Baseline as shown in fig:4.
- Skill enhancement as shown in fig:13.
- Performance Evaluation.

Firstly, the Baseline phase. The system will start by collecting EEG signals for people while playing a baseline game of a grey humanoid avatar whose responsible for collecting the largest amount of cubes in the minimal time possible. The player will play the game once using his/her brain control input and once with the keyboard input. After the game is finished his/her EEG signals will be exported as a row data set in order to be pre-processed producing a pre-processed data set for ADHD Detection as was mentioned in [**8370717**]. The pre-processing techniques used are mentioned below:

- Frequency Bands' Data Filtering.
- Data Windowing.
- Feature Extraction.

If the child was classified as an ADHD child he/she will Move on to the next phase which is the Skill Enhancement phase using a series of games. At first, the Therapist will select a skill for the ADHD patient, to enhance it, using the game system, after that, the player will start his/her serious game based on some basic therapeutic concepts used especially for ADHD patients as mentioned in [7] which are:

- Self-regulation
- Social cognitive
- Learning

To make the game more effective, we integrated two different types of games in the system:

- Cognitive Games: During the child's game play time his/her EEG signals will be recorded using the EEG headset to predict there skill level using machine learning (ML) Regressing model, based on a certain output from the ML model, an appropriate game change action will be made for example; if there skill level is in range between x% and y% the game will make action z then, a feedback loop will take place until the game is finished. This type of games is built in order to target and enhance the cognitive skills of the child.
- Behavioral Games: On the other hand, another type of serious games were built with the aim of targeting the behavioral skills of the child (i.e. enhancing the attention levels of the child through enhancing their motor skills as mentioned in [7]). During this type of game-play, the child would enter a virtual reality environment by wearing a VR headset in which the VR-behavioral games would be accessed and played by the child. There would also be feedback loop that'll until the game is finished.

Lastly, comes in the "Performance Evaluation cycle" in two forms:

- Cognitive Games Performance Evaluation Cycle: As was mentioned in [1], during the child's game play, performance matrix software will record the EEG signal in parallel in the background, after the child finishes the game , a software will generate different performance levels of different matrices such as focus, interest, stress, etc. Based on the difference between the features of the EEG data set.
- Behavioral Games Performance Evaluation Cycle: During the child's game play, his heart-rate would be extracted and monitored in order to make sure his impulsivity level is being tracked as to make sure the difficulty of the game is suitable for the child's state, and of course each game has its own score to track the child's performance.

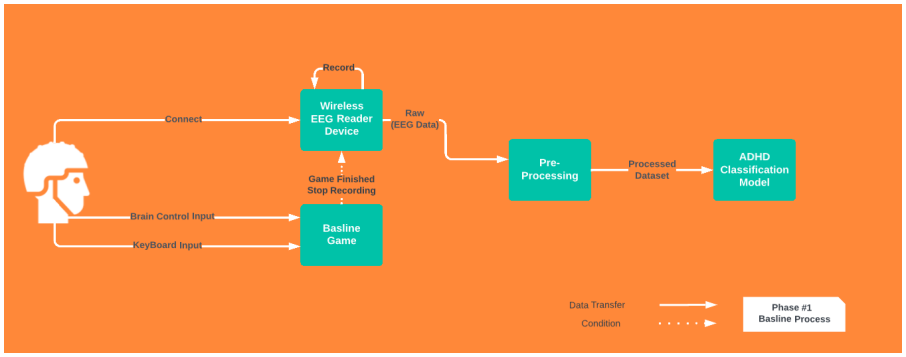


Figure 4: Phase One Overview Diagram

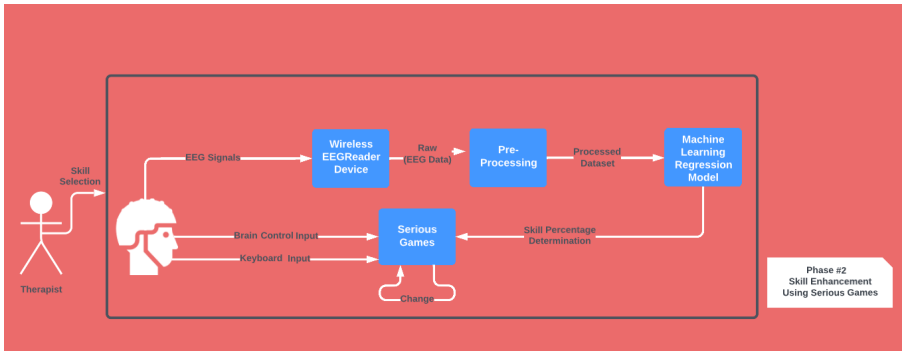


Figure 5: Phase Two: EEG Side Overview Diagram

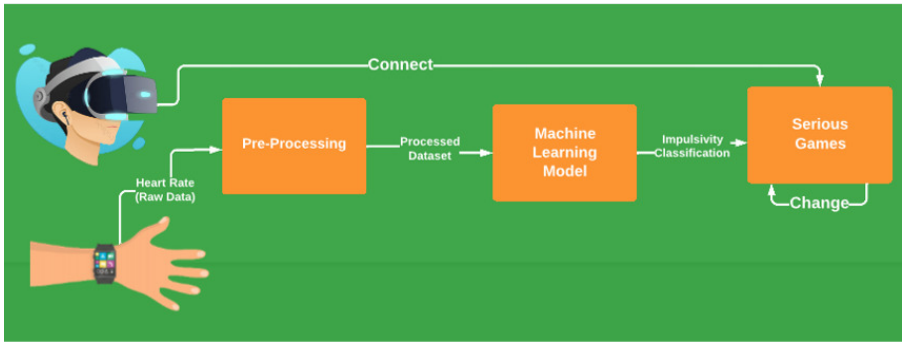


Figure 6: Phase Two: VR Side Overview Diagram

3.3 System Scope

1. Helps ADHD children to achieve a desired brain wave length throughout training sessions and extend their skill level.
2. Depending on his/her signals the therapist would pick a game that is suitable to his /her outputted brain waves.
3. The game is developed specifically for children aging between 6 to 12 years old for Targeting ADHD children to enhance some cognitive skills they lake.
4. Help therapist to keep track of children progress.
5. Provide a set of levels based on the player's brain signals

3.4 System Context

- The Therapist would be responsible for adding new patients profile to the system
- The Therapist would also have the accessibility to sign in or out to his/her personal account
- The system would retrieve all of the patients history data
- The system will identify each patient's mental health
- The system will state whether each child is an actual ADHD patient or not
- For each child they are required to play a Baseline game
- For each patient they are required to play a selection serious game
- The system will read a stream of EEG signals that are produced from the helmet

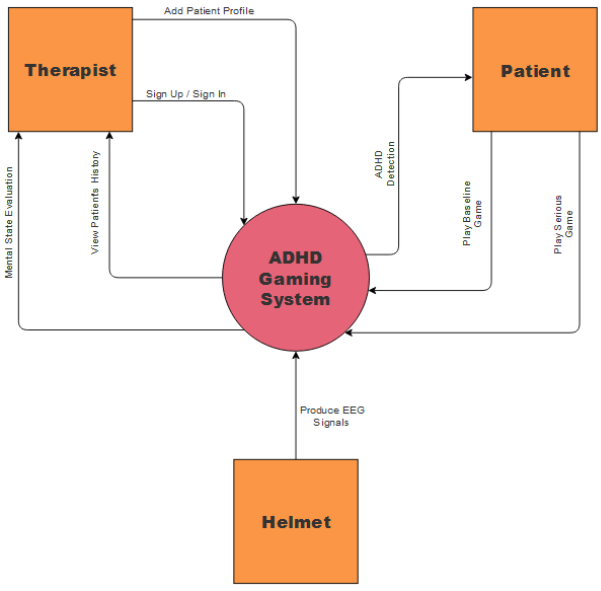


Figure 7: System Context

3.5 System Objectives

- Detecting ADHD in children from age group 6 to 12 years old using EEG signals extracted from the brain using an EEG Headset.
- Designing an adaptive gaming environment in terms of the game-play and game-components based on the cognitive and behavioral abilities of the child.
- Integrating an EEG headset to the game-play for enhancing the child's cognitive abilities.
- Integrating a VR-Headset and an apple watch for the enhancement of the child's behavioral skills.

3.6 User Characteristics

Expected users can be Therapists and ADHD children. Either for enhancing the cognitive skills of the children or for entertainment. They must have knowledge of using computers, be able to deal with user interfaces and wear EEG helmets.

4 Functional Requirements

4.1 System Functions

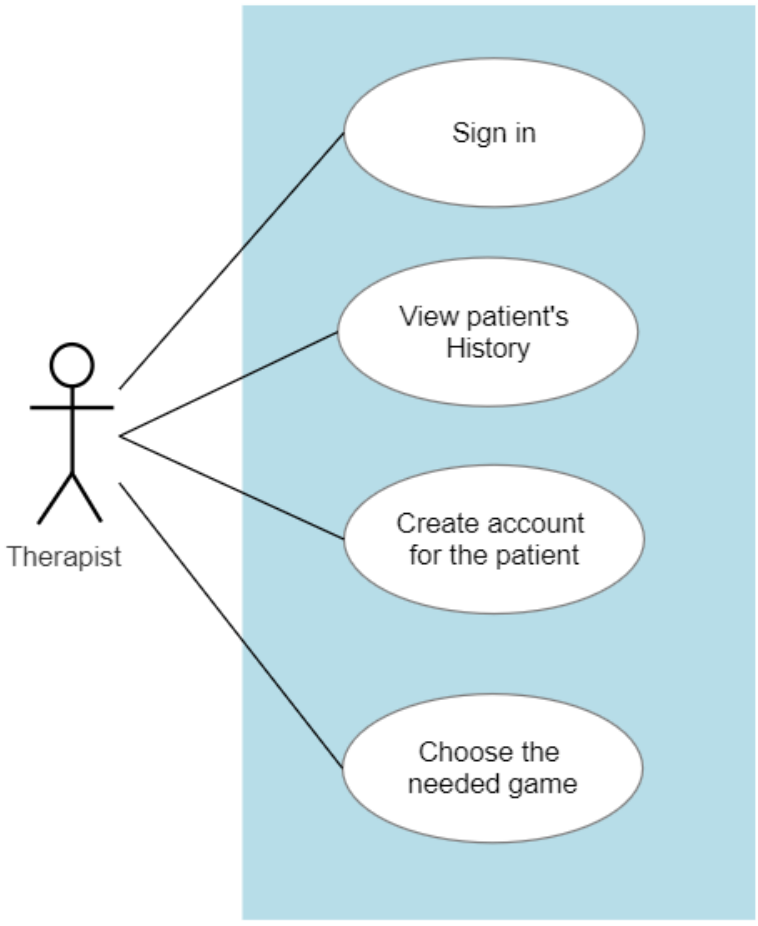


Figure 8: Therapist usecase

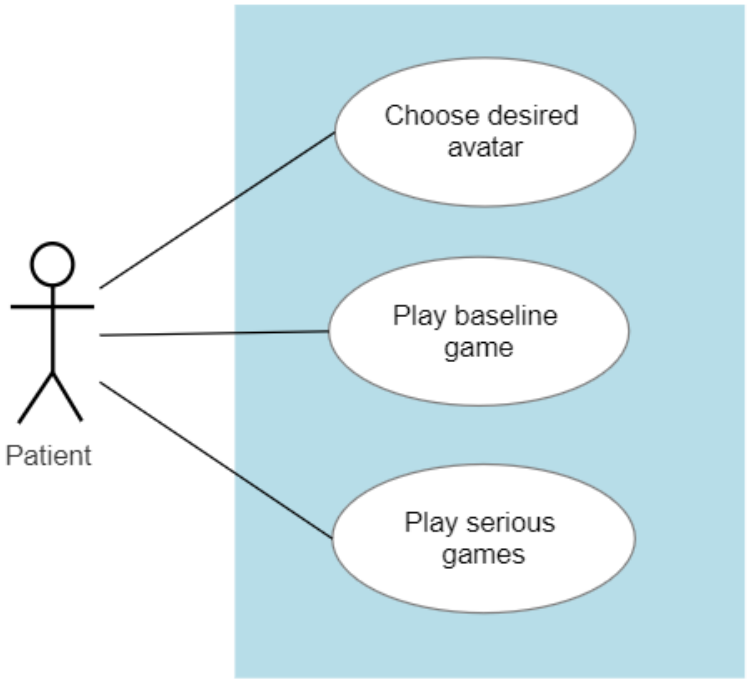


Figure 9: Patient use case

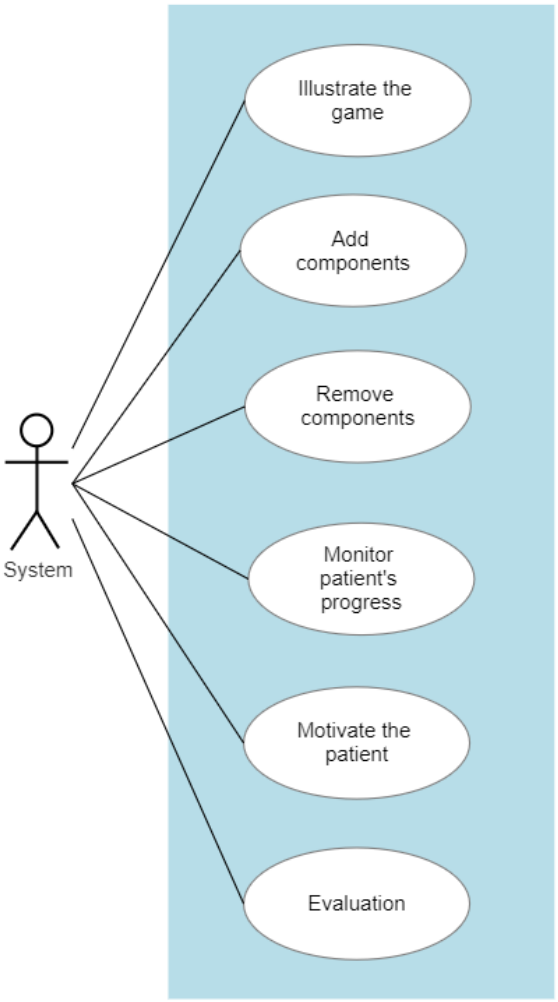


Figure 10: System use case

1. The therapist must be able to sign into the system.
2. The therapist must be able to create accounts for his patients
3. The therapist shall be able to choose the needed game for his patients
4. The therapist shall be able to view the patient's history
5. The patient shall be able to choose the desired avatar.
6. The new patient must play a baseline game.
7. The ADHD patient shall be able to play serious games.
8. The system must illustrate how to play the game through tutorial videos before the game.
9. The system shall be able to add or remove components from the game.
10. The system shall be able to monitor the patient.
11. The system shall be able to motivate the child to increase engagement
12. The system shall be able to evaluate the cognitive skills of the patient.

4.2 Detailed Functional Specification

Name	Create patient profile
Code	FR01
Priority	High
Critical	It's used by the therapist to add new patient
Description	To add new patients to the system
Input	-
Output	Patient profile will be added
Pre-Condition	Therapist must log in the first
Post-Condition	Info will be added to the patient's database
Dependency	The therapist shall log in first and then add a Client
Risk	The data is not sent to the database in the right format

Name	View patients' history
Code	FR02
Priority	Medium
Critical	It's used by the therapist to view the patient's history
Description	It'll be retrieved from the database and then shall be shown to the therapist
Input	patientID
Output	Patient's data will be displayed
Pre-Condition	Therapist must log in first, patient added
Post-Condition	Info of the patient will be retrieved from the Database
Dependency	The therapist and the patient must have an account
Risk	Can not connect with the Database, Shall not run the SQL Query

Name	Add game component
Code	FR03
Priority	Extreme
Critical	It's used by the system to add new components during the gameplay
Description	The components shall be added to the game during the gameplay
Input	gameID, mental percentage
Output	New components shall be added during the gameplay depending on the mental state percentage
Pre-Condition	The patient started playing the game, prediction of mental state
Post-Condition	Acquisition of new mental state
Dependency	The game should be developed first that has connected with a headset played by a patient
Risk	-

Name	Remove game component
Code	FR04
Priority	Extreme
Critical	It's used by the system to remove components during the gameplay
Description	The components shall be removed from the game during the gameplay
Input	gameID, mental percentage
Output	Components shall be removed during the gameplay depending on the mental state percentage
Pre-Condition	The patient started playing the game, prediction of mental state
Post-Condition	Acquisition of new mental state
Dependency	The game should be developed first that have connected with a headset played by a patient
Risk	-

Name	Game illustration
Code	FR05
Priority	Medium
Critical	For the patient to be shown a tutorial before the game
Description	A video tutorial shall be retrieved from the database and previewed before the game start
Input	gameID
Output	Preview a video tutorial for the game
Pre-Condition	Game tutorial will be previewed before the patient starts playing the game
Post-Condition	Start the game
Dependency	The game should be developed first
Risk	Problem with database connection

Name	Game motivation
Code	FR06
Priority	Medium
Critical	To make patients more excited and increase the engagement
Description	During the gameplay if the child does something right the system shall motivate the patient
Input	gameID, action
Output	Motivating the child to increase engagement
Pre-Condition	Action is made during the gameplay
Post-Condition	-
Dependency	The game should be developed first
Risk	-

5 Design Constraints

5.1 Standards Compliance

Our project's web application only runs on Windows operating systems.

5.2 Hardware Limitations

It is a must that the user has a Windows laptop with a working camera in order to assess the child's emotional state and attention levels during game-play, the EMOTIV EPOC X 14-channel wireless EEG headset

5.3 Other Constraints as appropriate

It is also crucial that the user has a stable network connection as the entire game-play process will be done on the cloud.

6 Non-functional Requirements

- **Maintainability:** In the case of system failure, the main time to restore the system mustn't exceed 3 hours.

- **Scalability:** The system must accept scalability because we aim to increase the system by adding new games that improve new cognitive skills.

- **Security:** The system must be secure for the confidentiality of the patient's data. Only the therapist (admin) on the system can view the patient's profile.

- **Performance:** The game must be highly interactive with the player. The game shall start loading in 5 seconds max, and during the game, components shall be added or removed smoothly.

- **Availability:** The system must always be available to users during working hours. In the event of an unexpected server failure, all functionalities will be available once more in 3 hours.

- **Usability:** The system shall be developed in a user-friendly, uncomplicated manner to make it easy for the children and therapists to use by using simple user interfaces and previewing game tutorials before starting the games.

7 Data Design

7.1 Database

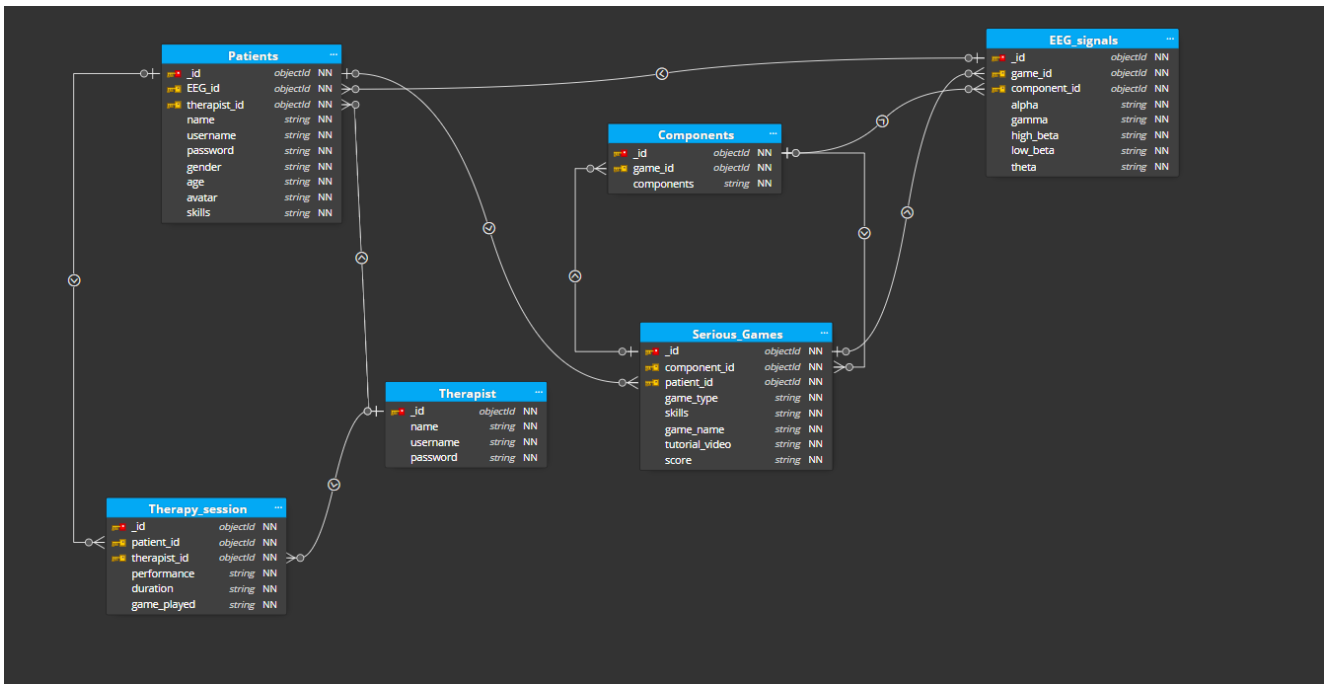


Figure 11: Database Schema Design

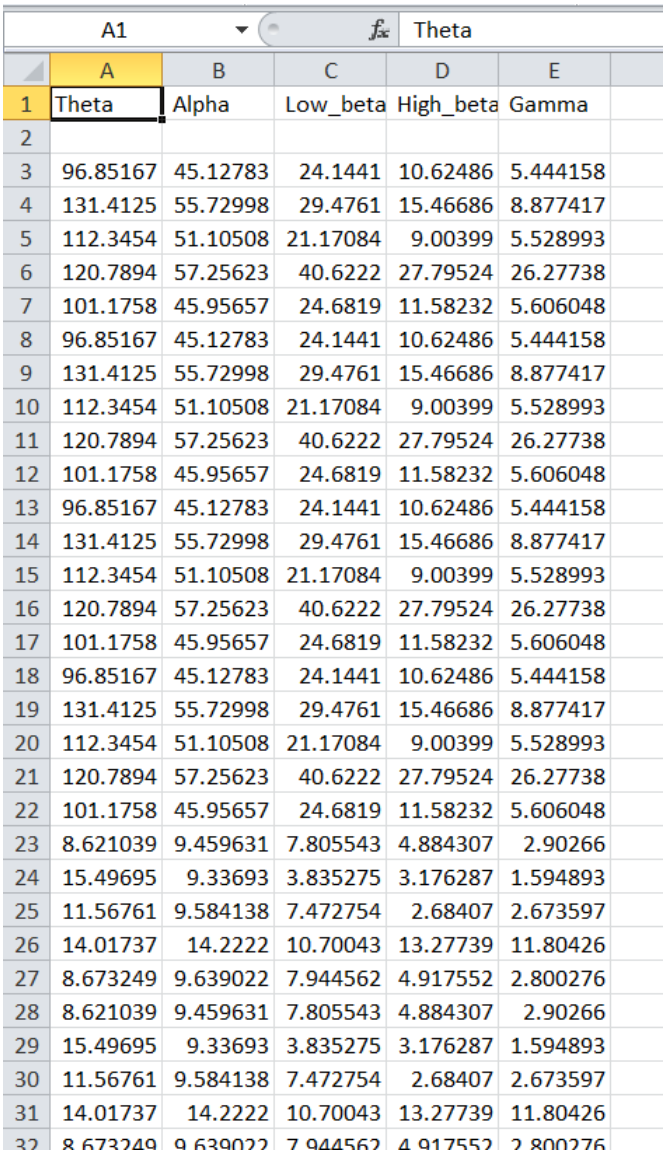
7.2 Dataset

Table 2: Emotive Dataset

Size	19.12 MB
Number of Rows	57000
Number of features	5
Link	https://ieee-dataport.org/open-access/focus-eeg-brain-recordings-adhd-and-non-adhd-individuals-during-gameplay

Table 3: NeuroSky Mindwave Dataset

Size	4.81 MB
Number of Rows	12000+
Number of features	15
Link	https://www.kaggle.com/datasets/wanghaohan/confused-eeg



	A	B	C	D	E
1	Theta	Alpha	Low_beta	High_beta	Gamma
2					
3	96.85167	45.12783	24.1441	10.62486	5.444158
4	131.4125	55.72998	29.4761	15.46686	8.877417
5	112.3454	51.10508	21.17084	9.00399	5.528993
6	120.7894	57.25623	40.6222	27.79524	26.27738
7	101.1758	45.95657	24.6819	11.58232	5.606048
8	96.85167	45.12783	24.1441	10.62486	5.444158
9	131.4125	55.72998	29.4761	15.46686	8.877417
10	112.3454	51.10508	21.17084	9.00399	5.528993
11	120.7894	57.25623	40.6222	27.79524	26.27738
12	101.1758	45.95657	24.6819	11.58232	5.606048
13	96.85167	45.12783	24.1441	10.62486	5.444158
14	131.4125	55.72998	29.4761	15.46686	8.877417
15	112.3454	51.10508	21.17084	9.00399	5.528993
16	120.7894	57.25623	40.6222	27.79524	26.27738
17	101.1758	45.95657	24.6819	11.58232	5.606048
18	96.85167	45.12783	24.1441	10.62486	5.444158
19	131.4125	55.72998	29.4761	15.46686	8.877417
20	112.3454	51.10508	21.17084	9.00399	5.528993
21	120.7894	57.25623	40.6222	27.79524	26.27738
22	101.1758	45.95657	24.6819	11.58232	5.606048
23	8.621039	9.459631	7.805543	4.884307	2.90266
24	15.49695	9.33693	3.835275	3.176287	1.594893
25	11.56761	9.584138	7.472754	2.68407	2.673597
26	14.01737	14.2222	10.70043	13.27739	11.80426
27	8.673249	9.639022	7.944562	4.917552	2.800276
28	8.621039	9.459631	7.805543	4.884307	2.90266
29	15.49695	9.33693	3.835275	3.176287	1.594893
30	11.56761	9.584138	7.472754	2.68407	2.673597
31	14.01737	14.2222	10.70043	13.27739	11.80426
32	8.673249	9.639022	7.944562	4.917552	2.800276

Figure 12: Emotive DataSet

Our Data set is divided into ADHD and non-ADHD (6 he non-ADHD, 4 ADHD). Information is collected by giving an ADHD child and a healthy child a video game to her twice. Second time playing the game using the keyboard. This data set was collected from many children. They are represented by the digits of each number. Results for each child using Emotiv and keyboard. Here is an example of her ADHD child's EEG after playing a game with the Emotiv helmet and keyboard.Emotional and a keyboard.Studies have shown that high beta is lower in her ADHD children than in healthy children. In addition, Sita is stronger with her ADHD child than others. The purpose of this data set is to determine if a child has her ADHD. Improve cognitive skills with a more precise methodology.

Theta waves: These occur when a person is in a light sleep stage or dreaming, as well as in a relaxed, meditative state of mind (commonly referred to as being on "autopilot").

Alpha waves:This wave often occurs when we are awake and resting comfortably, responding to any visual stimulation, or actively thinking about something.

Low Beta:(12–15 Hz) known as "beta one" waves and associated mostly with quiet, focused, introverted concentration. • Mid-range beta waves (15–20 Hz): known as "beta two" waves and associated with increases in energy, anxiety, and performance.

High Beta:(18–40 Hz) known as “beta three” waves and associated with significant stress, anxiety, paranoia, high energy, and high arousal.

Gamma:This is the fastest brain wave. It’s responsible for learning, memory, and processing new information.

Theta	Alpha1	Alpha2	Beta1	Beta2	Gamma1	Gamma2
9.06E+04	3.37E+04	2.40E+04	2.79E+04	4.51E+04	3.32E+04	8.29E+03
2.81E+04	1.44E+03	2.24E+03	2.75E+03	3.69E+03	5.29E+03	2.74E+03
3.84E+05	2.02E+05	6.21E+04	3.63E+04	1.31E+05	5.72E+04	2.54E+04
1.29E+05	6.12E+04	1.71E+04	1.15E+04	6.25E+04	5.00E+04	3.39E+04
3.54E+05	3.71E+04	8.89E+04	4.53E+04	9.96E+04	4.48E+04	2.97E+04
1.77E+05	5.94E+04	2.62E+04	1.51E+04	3.37E+04	3.38E+04	3.18E+04
1.22E+05	9.01E+04	6.51E+04	3.62E+04	5.30E+04	6.29E+04	5.93E+04
1.21E+04	1.96E+03	8.09E+02	1.28E+03	3.19E+03	3.27E+03	2.52E+03
1.21E+05	6.37E+04	6.82E+04	1.08E+04	8.84E+04	7.38E+04	2.27E+04
1.16E+05	4.73E+04	2.62E+04	4.16E+04	2.89E+04	3.26E+04	4.18E+04
1.86E+05	3.24E+03	3.84E+03	1.89E+04	4.30E+04	4.68E+04	1.19E+04
1.42E+05	7.51E+04	1.62E+04	4.59E+04	3.45E+04	7.49E+04	3.18E+04
4.21E+04	3.16E+03	6.26E+03	7.27E+03	1.95E+04	1.10E+04	8.15E+03
8.43E+04	2.24E+03	3.87E+04	2.17E+04	2.83E+04	8.09E+04	2.47E+04
1.80E+05	2.59E+04	2.16E+04	4.38E+04	4.44E+04	6.92E+04	2.56E+04
8.09E+04	7.99E+03	3.26E+04	1.18E+04	6.37E+04	4.10E+04	1.81E+04
1.33E+05	7.14E+03	1.43E+04	2.34E+04	6.56E+04	4.79E+04	1.65E+04
1.47E+04	1.10E+04	1.04E+04	1.43E+04	3.71E+04	6.04E+04	3.63E+04
2.68E+05	6.73E+04	3.70E+04	1.01E+04	8.08E+04	9.04E+04	2.63E+04

Figure 13: Neurosky DataSet

8 Preliminary Object-Oriented Domain Analysis

Class Diagram:

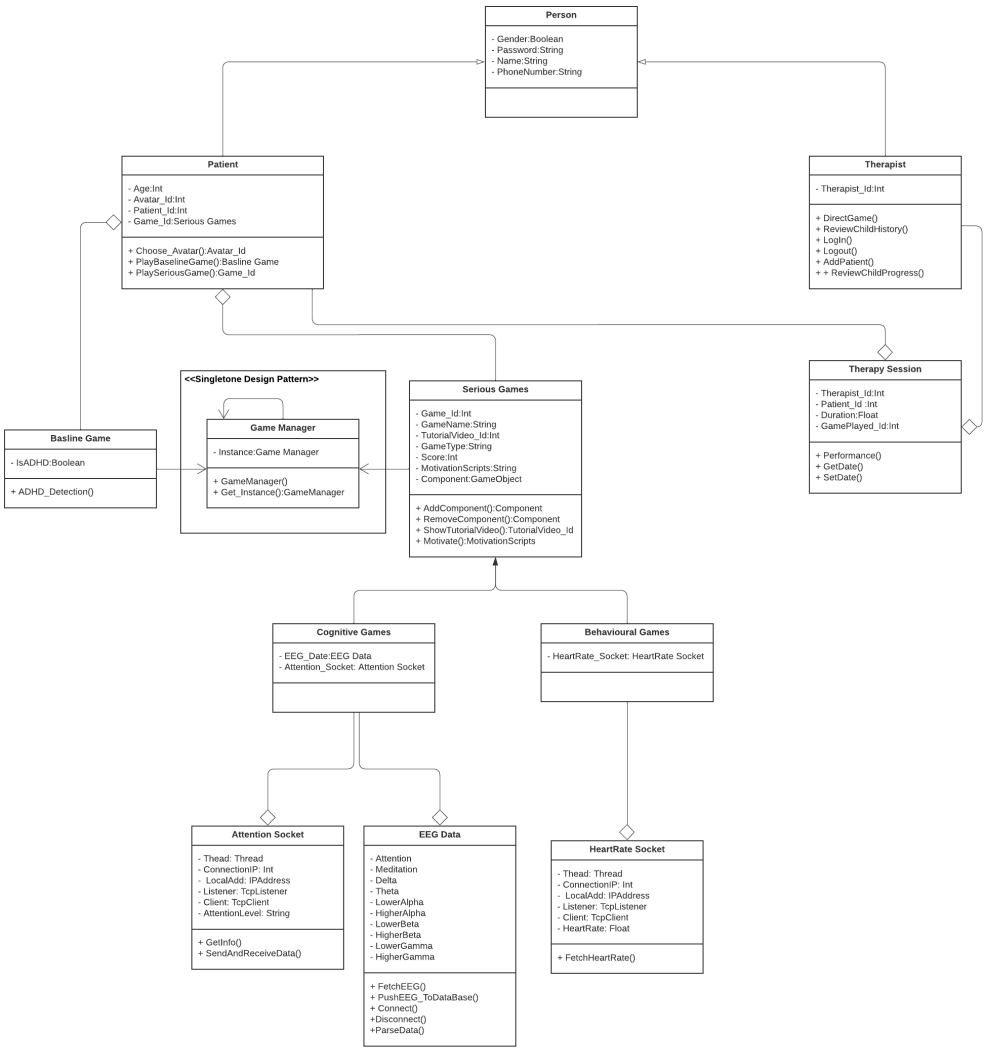


Figure 14: Class Diagram

9 Operational Scenarios

- **Therapist's Scenario**:
  Firstly, the Therapist will login to his/her account, he/she start creating his/her patient's profile to view their history for progress monitoring . After Identifying his/her patient's case,he/she will let them play the appropriate game which matches his/her patients lacked skill.

- **Child's Scenario**:
  Firstly,the child will play a baseline game to identify whether he/she a ADHD patient or not . if he/she an ADHD patient he/she will then choose his/her desired avatar to play with . after that he/she will start playing the serious game under the therapist supervision.

- **Serious Game Scenario**:
  Before each game there will a be a game tutorial for the child to illustrate how to play the game . during the game there will be a friend avatar to motivate the child to increase the game's engagement .Also based on the child's mental state the game will add/remove components making the game adaptive and responsive to his/her brain and mental state .

10 Project Plan

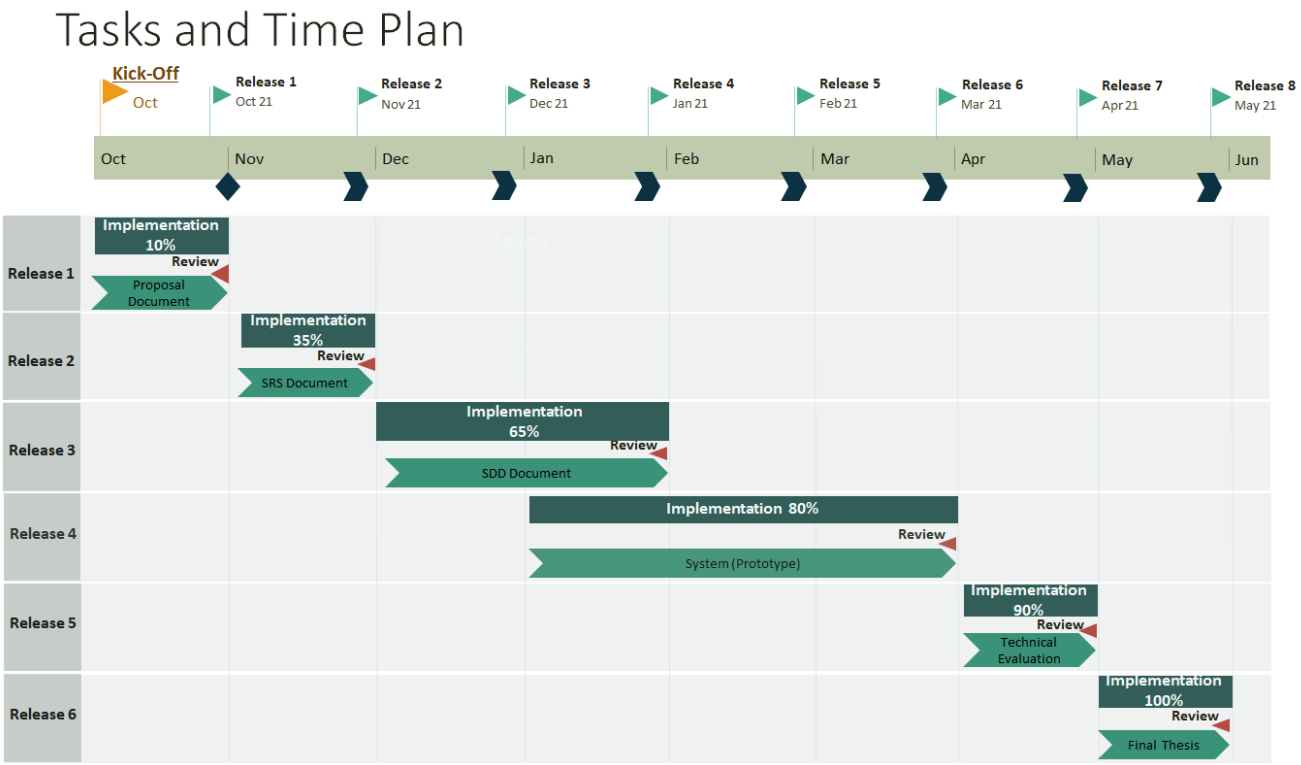


Figure 15: Tasks and Time Plan

#8			
search in game design for ADHD	Completed	Christine Ashraf Fakhry Messiha, Yola	
take an already designed game code and ed OPEN ut	Completed	mariam ismail, Youmna Youmna Ayman Abdel Rehim	
game sequence/ logic for ADHD children	Completed	Youmna Youmna Ayman Abdel Rehim Dewidar, maria	
SRS document	In Progress	Christine Ashraf Fakhry Messiha, Yola, mariam isn	High
consult a therapist about the games she uses with her k	Completed	mariam ismail, Yola	
#9			
intro / similar system / design constrains	Completed	Yola	
user characteristics / use case diagram/ non functional r	Completed	Christine Ashraf Fakhry Messiha	
data design		Youmna Youmna Ayman Abdel Rehim Dewidar	
preliminary oop		mariam ismail, Youmna Youmna Ayman Abdel Rehim	
operational scenarios	Completed	mariam ismail	
detailed functional requirments/ system context	Completed	Christine Ashraf Fakhry Messiha, mariam ismail	
heart rate detection using motion sensing	In Progress	Yola	
detect attention level using image processing	Completed	mariam ismail	
design attention indicator bar	Completed	Christine Ashraf Fakhry Messiha	
design a simple baseline game	Completed	Youmna Youmna Ayman Abdel Rehim Dewidar	
#10			
run svm model on focus dataset (ADHD/NOT ADHD)	Completed	Christine Ashraf Fakhry Messiha	

Figure 16: Tasks Distribution

#11		
finish SRS	In Progress	mariam ismail, Christine Ashraf Fakhry Messiha, Y
quantutative questionere (adhd games)		Yola
integrate codes	In Progress	mariam ismail, Christine Ashraf Fakhry Messiha, Y
VR decision	Completed	Youmna Youmna Ayman Abdel Rehim Dewidar
save train model	Completed	Christine Ashraf Fakhry Messiha
VR setup meta	In Progress	mariam ismail, Youmna Youmna Ayman Abdel Rehim
#12 OPEN		
screen recording for the demos(mariam/chris) (mariam/		mariam ismail
ppt ready		mariam ismail
make a new system overview for the VR and the apple v		
screen recording for the VR as a demo		mariam ismail, Youmna Youmna Ayman Abdel Rehim
integrate the baseline game with the attention --> to kr		mariam ismail
finish set up of VR game		mariam ismail, Youmna Youmna Ayman Abdel Rehim
need to take the approval of the Dr. the appropriate am		mariam ismail
update the SRS		
submit the Dell form DONE	Completed	mariam ismail
rehearse for the presentation		mariam ismail, Christine Ashraf Fakhry Messiha, Y
do the main latex zip file		mariam ismail, Christine Ashraf Fakhry Messiha, Y
New		

Figure 17: Tasks Distribution

11 Appendices

11.1 Definitions, Acronyms, Abbreviations

Abbreviation	Definition
ADHD	Attention Deficit Hyperactivity Disorder
APA	American Psychological Association
EEG	Electroencephalogram
BCI	Brain Computer Interface
VR	Virtual Reality
HTTPS	Hypertext Transfer Protocol Secure

11.2 Supportive Documents

In this section, a few documents and evidence that further support our project's objectives are shown.

Firstly, we were able to contact a child's therapist and she stated the following two main points:

- That the game should be designed to be ADHD friendly as it shouldn't be distracting but also soothing colours like white ,should be included as shown in Fig[18]
- According to the American university's APA (American Psychological Association), the recommended daily limit for safe technology use for children is 2 hours spread out throughout the day.as shown in fig[19]

Figure 18: The appropriate Game design for ADHD patients

Figure 19: Safe limit for technology use for children

Secondly, and of course with the patient's consent to the use of the below documents, the following are a few parts of some documents belonging to the patient's diagnosis and therapy process demonstrating her struggles starting at an early age reaching her adolescent years. Some of the figures shown are statements written by the patient's personal doctors, some are from clinics, while others are observations of her teachers in school all of whom are in London, not to mention statements made by her mother explaining the struggles of her child she observed firsthand. The mentioned statements provide further support to the aim of our project, as the documents also shows a document given by the clinic containing a list of side effects the patient might've experienced from a medication she was prescribed, and another illustrates how as the patients became older she faced some struggles when entering college as it was observed that the medication used at the time was not as effective as it was before. Consequently, our project aims to provide an alternative to the use of medication as to avoid it's drawbacks and achieve better results in ADHD support, whilst targeting the struggles mentioned below as well as enhancing the skills lacked by the patient as well.

Diagnosis:
Attention deficit disorder

Medication:
Medikinet 50mg

I reviewed Phoebe accompanied today who came to clinic on her own. I gather that Phoebe has increased her medication to 50mg and reported that this is effective. Phoebe continues to request referral to CAMHS. I did refer to Dr Newman, Consultant Child Psychiatrist, in November but Phoebe has not received an appointment and continues to raise concerns regarding anxiety and labile moods. Phoebe has rejected seeing a councillor at college due to her poor experience of using a councillor when she was at school. She informed me that shed felt art therapy in the past was very helpful, but she was not clear where this referral came from.

She described herself as either feeling very depressed or very happy and talkative and friends have commented on her extremes of behaviour. Phoebe was understandably anxious today and I needed to take her blood pressure twice, on the second reading her blood pressure was 126/87 and her weight was 60kg and her height remained at 163cm.

Figure 20: Clinic's Letter to her Doctor

Diagnosis:

Attention deficit disorder

Medication:

Medikinet 40 mg - requesting increase up to 60 mg if tolerated, **(increasing by 5 mg per week)**

I reviewed Phoebe in clinic today. Phoebe has remained on the dose of 40 mg and both Phoebe and her mother appeared unaware of the recommendation to increase the dose incrementally to 60 mg. Phoebe has now transferred to college and feels that the medication is not as effective as it could be. She can be quite hyperactive and distracted within college. She is struggling with the pace of work. Phoebe's mother also feels that she has begun to take a lot of sugary, fizzy drinks at school which also when thirsty affects her behaviour.

I gather that Phoebe mostly got grade Cs at GCSE in the summer and was slightly disappointed by her performance. I gather that she had to re-take her English. Phoebe has informed me that she has begun to self-harm and is struggling with the stress and pressures of college. Phoebe's mother has tried to support Phoebe but Phoebe has been rather resistant to her mother's help. Phoebe asked for a re-referral to CAMHS, which I am happy to make. In the interim I have suggested that Phoebe contacts the counsellor attached to the college for support.

I checked Phoebe's height, weight and blood pressure today Phoebe's blood pressure was 130/83. Her weight is 50 kg which is a slight drop from April and her height is 163 cm on the 50th centile.

Figure 21: Clinic's Letter to her Doctor

Phoebe was referred by her school nurse, Teresa Timbs, who has concerns regarding her communication skills and developmental progress. I saw her with her Mother for a neurodevelopmental assessment at Richmond Royal a few weeks ago. I am sorry for the delay in writing this report as I was recently on annual leave. Phoebe's mother reported that Phoebe has a short concentration span, throws tantrums and seems angry and frustrated when she cannot express herself to others. In class Phoebe leaves her seat and goes to the back of the class on her own and she was described by her class teacher as being very easily distracted. She fails to complete her homework and is inattentive. Phoebe goes to Stanley Junior School and has been known to the SENCO since reception year. She has extra lessons, daily in literacy.

Figure 22: Patient's Mother Statements

Date: 10th September 2010,

Dear Sir/Madam,

I am writing regarding my daughter Phoebe Brown, DOB: 30/08/1998, Phoebe had had trouble at school since she went to nursery, but her father and I were blaming it on the early year age and that she will grow out of it, up to when Phoebe was 8 years old, I knew that she wasn't just a difficult or badly behaved child, I realized that Phoebe has no control on how she behaves, so I asked for help then, by asking the school (Stanley Junior School) and then we saw a specialist after getting referred to by our GP.

Phoebe has always found it very difficult to communicate with us (her family), she always want to play alone, has never had a friend till present.

She is a middle child and her sister gets frustrated trying to get her involve in a game, conversation or any activity.

Phoebe doesn't make since, she can't hold a conversation, and doesn't know right from wrong, or how to react to situations, always over acting or no reaction at all.

She needs a lot of attention and patient with everything she does.

Phoebe doesn't know her own strength, she is very clumsy, and can never finish a task weather it is school or home by herself.

She is very sweet and loving but hard for anyone other than the family to understand that, so she always got misunderstood and bullied at school.

Up to now at 12 years old she still has tantrums if she doesn't get what she wants, and she is almost impossible to discipline as no strategy would work.

Phoebe doesn't understand what she does wrong at any level of wrong doing, she can't express herself in any situation and gets blamed for many things she didn't do.

Figure 23: Patient's Mother Statements

What sort of side-effects might I get if I am taking quetiapine?

Side effect	What happens	What to do about it
VERY COMMON *(more than about 1 in 10 people might get these)*		
Sleepiness	Feeling sleepy or sluggish. This can last for a few hours or longer after taking your dose.	Don't drive or use machinery. Ask your doctor if you can take quetiapine at a different time of day. Your doctor may be able to consider changing your dose. It should wear off after a while.
Dizziness	Feeling light-headed and faint.	Don't stand up too quickly. Try and lie or sit down if you feel it coming on. Don't drive.
Dry mouth	Not much saliva or spit.	Suck sugar-free gum or boiled sweets. If it is bad, your doctor may be able to give you a mouth spray.
Weight gain	Eating more and putting on weight, especially just after you start quetiapine.	This is less common with quetiapine than similar drugs. A diet full of vegetables, cereal and fibre may help prevent weight gain.
Postural hypotension	A low blood pressure - this can make you feel dizzy, especially when you stand up.	Try not to stand up too quickly. If you feel dizzy, sit or lie down. Don't drive. This dizziness usually wears off in a few days.
COMMON *(fewer than about 1 in 10 people might get these)*		
Headache	When your head is painful and pounding.	Ask your pharmacist if it is safe to take paracetamol with any other medicines you may be taking.
Akathisia	Feeling restless, agitated or on edge.	Try and relax by taking deep breaths. Contact your doctor if it worries you.
Anticholinergic side effects	Dry mouth, blurred vision, constipation	These are usually mild and should wear off after a few weeks. If not, contact your doctor or pharmacist.
Stomach upset	This includes feeling and being sick and getting diarrhoea.	If it's mild, see your pharmacist. If it lasts for more than a day, see your doctor

Do not be worried by this list of side effects. Some people get no side effects at all and others may get some effects that are not listed in this table. If you think you might have a side effect to your medicine, you should ask your doctor, nurse or pharmacist. If you want to know more, go to our website for links to other websites with more information.

Figure 24: Medication Side Effects

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