AI for Mental Health Advancement

From Early Alerts To Continuous Support

Overview of ADHD Diagnostic Tool for Children

1. Intro:

Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental condition that affects many children, often leading to challenges in academic performance and social interactions. Early and accurate diagnosis is crucial for effective intervention. This submission presents an innovative diagnostic tool designed to assess ADHD in children through an engaging series of games.

2. Tool Description:

The proposed tool utilizes a gamified approach to gather comprehensive data on a child's behavior and attention levels. By incorporating interactive gameplay, the tool aims to create a comfortable environment for children, minimizing anxiety often associated with traditional assessment methods.

3. Key Features:

- **Game-Based Assessment**: The tool consists of a variety of games tailored to measure different aspects of attention and impulsivity. These games are designed to be enjoyable and engaging, ensuring that children are motivated to participate fully.

- **Data Collection Metrics**: Collecting data that would help diagnose the different aspects of ADHD such as impulsivity or lack of attention, which include eye-tracking data, input data etc.

- **Real-Time Feedback**: The tool provides instant feedback on performance, which can be valuable for parents and clinicians. It highlights areas of concern and offers insights into the child's attention and impulse control.

4. Benefits:

- **Engagement**: The game-based format is less intimidating than conventional tests, promoting a more accurate reflection of a child's abilities and behaviors.

- **Comprehensive Data**: The tool aggregates various behavioral metrics, allowing for a multidimensional analysis of attention-related challenges.

- **Accessibility**: By utilizing technology, the tool can be easily administered in various settings, making it accessible for a broader range of children.

5. Conclusion:

This innovative diagnostic tool represents a significant advancement in the assessment of ADHD in children. By leveraging the power of play, it provides valuable insights into attention and impulsivity while creating an enjoyable experience for young users. Early detection and intervention are vital in managing ADHD effectively, and this tool aims to enhance the diagnostic process through engaging, data-driven methods.

Objectives

Innovative Assessment: Develop a gamified diagnostic tool to assess ADHD in children through engaging gameplay.

Data Collection: Gather comprehensive behavioral data on attention, impulsivity, and engagement using metrics such as eye tracking, input jitter, and attention span.

Minimize Anxiety: Create a comfortable assessment environment to reduce the stress associated with traditional diagnostic methods.

Real-Time Feedback: Provide instant feedback to parents and clinicians to facilitate understanding of a child's attention and impulse control.

Enhance Early Diagnosis: Improve the accuracy and efficiency of ADHD diagnosis to support early intervention and management strategies.

Accessibility: Ensure the tool is easily administered in various settings, making it widely accessible for children.

Technical approch

1. Mobile Development:

We aim to deploy custom analytics through short, visually appealing minigames designed for children using the Flutter Casual Games Toolkit. These games prioritize accessibility and simplicity, while ensuring enough variety to capture a wide range of behavioral data that could be useful for evaluating ADHD-related factors, including attention, hyperactivity, and impulsivity.

2. Data collection:

Metrics would touch on multiple sides of ADHD, such as attention deficits, hyperactivity, impulsivity. Some of these metrics could be:

- **Eye/Gesture Tracking:** The tool monitors how consistently a child's eyes are focused on the player character. Some minigames might even involve the player using hand gestures to command the player, which are detected via the user's camera. Sustained attention is a critical factor in diagnosing ADHD, and this metric provides insight into visual engagement and immersivness.
- **Input Jitter:** By analyzing the consistency of player inputs (e.g., jumps, movements), the tool assesses impulsivity and motor control. High variability in inputs may indicate challenges with impulse regulation, a common symptom of ADHD.
- **Attention Span:** The duration of time a child remains engaged in the game is recorded, helping to evaluate their ability to maintain focus over extended periods.

We list more potentional metrics in the Background Research section.
Data collection will involve trial and error to determine the optimal format for our AI model—either numerical values or time-series data, allowing behavioral changes to be captured over time.
To enhance our data analysis, we will employ techniques for filtering outliers and normalizing data, using statistical methods, such as *Z-scores*.
It is worth noting the complexity of the some of the collected data. Eye/Gesture Tracking would require *Computer Vision* technology to calculate gaze estimation, locate where the user is looking, or detect hand gestures. We plan on using the GazeCapture dataset, and training a *Convolutional Neural Network* to do these tasks.
We plan on using PostgreSQL, a robust relational database which ensures data integrity, and if possibly needed employs useful extensions for time-series data such as TimescaleDB.

Protecting user privacy is paramount in our app. We will implement robust data security measures, including encryption for sensitive information and secure storage practices. User data will be anonymized to prevent identification of individuals, ensuring that personally identifiable information (PII) is not linked to our analytics. Additionally, we will comply with data protection regulations such as GDPR and HIPAA.

3. Model building:

Our *Feed-Forward Neural Network (FFNN)* model will be trained on a labeled dataset comprising data from a diverse cohort of subjects, including both neurotypical children and those diagnosed with ADHD. The dataset will be proportionally stratified to ensure a balanced representation of both groups, facilitating robust training and evaluation.

A critical aspect of our methodology involves *feature engineering,* where we will apply *Principal Component Analysis* (PCA) to reduce dimensionality and extract key features that exhibit significant variance correlating with ADHD diagnoses. This process will help identify and prioritize features that are predictive of ADHD while discarding those with minimal contribution to model performance, thus enhancing the overall model efficiency and interpretability.

Upon completion of training, the model will output a continuous score normalized between 0 and 1, reflecting the likelihood of ADHD presence for a given input. This score will be stored in a database, enabling comparative analysis with historical data. Importantly, this scoring mechanism is designed to function as a supplementary tool for healthcare professionals, rather than as a standalone diagnostic criterion.

Additionally, an optional interface for ADHD specialists will be integrated, providing deeper insights into patient profiles and facilitating more informed clinical decision-making.

Innovation

Our solution stands out for two key reasons:

1. Early ADHD Detection for Parents:

Our app provides a user-friendly way for parents to explore potential ADHD indicators in their children from an early age. Rather than diagnosing ADHD, the app offers guidance on whether to consult a healthcare professional, potentially connecting them to online resources through a dedicated parent interface. This approach is not only more affordable and convenient than an initial doctor's visit but also addresses the sensitivity many parents feel about seeking an ADHD diagnosis, especially given that over 60% of the population uses smartphones. Our innovative computer vision technology reduces costs by utilizing accessible smartphone capabilities instead of expensive specialized hardware like Tobii eye tracking.

Supporting our approach, a study demonstrates the feasibility of mobile eye tracking technology, highlighting its value in research: "Valliappan, Nachiappan, et al. 'Accelerating Eye Movement Research via Accurate and Affordable Smartphone Eye Tracking.' Nature Communications, vol. 11, no. 1, 2020, article 1836, https://doi.org/10.1038/s41467-020-18360-5."

2. Standardizing ADHD Diagnosis:

Our solution also aims to enhance the standardization of ADHD diagnosis through advanced data analytics and collaboration with mental health professionals. By leveraging data collection and analytics, we uncover insights that traditional methods might overlook, advancing our understanding of ADHD.

Feasibility

1. Technical Feasibility:

The app leverages existing smartphone technology, including camera capabilities and advanced computer vision algorithms for eye tracking and behavioral analysis. With the widespread availability of smartphones, we can reach a broad user base without requiring specialized hardware. Our development team possesses the expertise needed to create an intuitive user interface and integrate machine learning models for data analytics, ensuring the app's functionality aligns with user needs.

2. Operational Feasibility:

The app will be designed with a user-friendly interface for parents, facilitating easy access to ADHD-related resources and insights. Partnerships with mental health professionals will enhance the credibility of our recommendations and provide a pathway for users seeking further assistance.

3. Economic Feasibility:

The cost of developing the app is manageable, given the utilization of existing technologies and resources. By replacing expensive hardware with smartphone capabilities, we can minimize costs while maintaining accuracy. Our app's subscription or freemium model can generate revenue while remaining affordable for parents. Additionally, the potential for partnerships with healthcare providers could open additional funding avenues, further strengthening the app's financial viability.

Background Research

Symptoms of ADHD detectable by computer vision

We have done our research, and found some analysable types of metrics, that could help with ADHD detection.

1. Dynamic Deep Learned Facial Action Units:

Facial action units (AU) are movement of individual or group of facial muscles defined according to the Facial Action Coding System (FACS]. Anatomically based descriptors of facial expressions, they can be a good representative of the emotional and mental state of a person and can encode a large number of social signals

2. Head Pose:

One of the major challenges for people with ADHD is their inability to do tasks which requires sustained attention. The pose of the head (in 3D space) can provide valuable cues about the attention state of a person at a certain instance of time. Since the participants in our study were required to complete the task by looking the computer screen, any deviation of the head pose away from the computer screen would indicate loss of attention.

3. Response Times:

The time taken to respond to each set of questions in the study was also used as features.

4. Cumulative Distance:

Hyperactivity is another major challenge associated with ADHD, implying that individuals with ADHD tend to display much higher levels of motoric behaviour than healthy individuals. The movement can be in the form of whole body movement or smaller movements confined to head (rotation) or hands and legs (fidgeting)

Research papers:

"Recent research has suggested a causal relationship between playing action video games and improvements in a variety of visual and attentional skills (e.g., [Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. Nature, 423, 534-537]). The current research sought to replicate and extend these results by examining both expert/non-gamer differences and the effects of video game playing on tasks tapping a wider range of cognitive abilities, including attention, memory, and executive control. Non-gamers played 20+ h of an action video game, a puzzle game, or a real-time strategy game."
https://pubmed.ncbi.nlm.nih.gov/18929349/
The effects of video game playing on attention, memory, and executive control Walter R. Boot *, Arthur F. Kramer, Daniel J. Simons, Monica Fabiani, Gabriele Gratton

"Video game–based therapeutic interventions have demonstrated some effectiveness in decreasing the symptoms of attention deficit hyperactivity disorder (ADHD). Compared with more traditional strategies within the multimodal treatment of ADHD, video games have certain advantages such as being comfortable, flexible, and cost-efficient. However, establishing the most appropriate type(s) of video games that should be used for this treatment remains a matter of debate, including the commercial existing video games or serious video games that are specifically constructed to target specific disorders. This guide represents a starting point for developing serious video games aimed at treating ADHD. We summarize the key points that need to be addressed to generate an effective and motivating game-based treatment. Following recommendations from the literature to create game-based treatments, we describe the development stages of a serious video game for treating ADHD. Game design should consider the interests of future users; game mechanics should be based on cognitive exercises; and therapeutic mechanisms must include the control of difficulty, engagement, motivation, time constraints, and reinforcement. To elaborate upon this guide, we performed a narrative review focused on the use of video games for the treatment of ADHD, and were inspired by our own experience during the development of the game "The Secret Trail of Moon."
https://pmc.ncbi.nlm.nih.gov/articles/PMC9379781/
Research on the feasibility of eye tracking and its utilites
"Valliappan, Nachiappan, et al. 'Accelerating Eye Movement Research via Accurate and Affordable Smartphone Eye Tracking.' Nature Communications, vol. 11, no. 1, 2020, article 1836, https://doi.org/10.1038/s41467-020-18360-5."

The following study even provides a dataset that is very useful:
EEG data for ADHD / Control children provided on IEEEDataPort

"This study proposes a novel convolutional neural network (CNN) structure in conjunction with classical machine learning models, utilizing the raw electroencephalography (EEG) signal as the input to diagnose attention deficit hyperactivity disorder (ADHD) in children. The proposed EEG-based approach does not require transformation or artifact rejection techniques."

Behrad TaghiBeyglou, Ashkan Shahbazi, Fatemeh Bagheri, Sina Akbarian, Mehran Jahed

https://www.sciencedirect.com/science/article/pii/S2666990022000313

Projects Examples:

EndeavorRx® - ADHD Video Game Treatment for Kids | FDA-authorized

EndeavorRx is an FDA-approved digital therapeutic video game created by Akili Interactive, specifically designed to improve attention function in children with ADHD aged 8 to 12. It is the first video game authorized by the U.S. Food and Drug Administration (FDA) as a prescription treatment for ADHD, marking a significant milestone in digital health and non-pharmaceutical interventions for cognitive disorders.

EndeavorRx uses adaptive algorithms to create a personalized gameplay experience that targets attention areas in the brain. In the game, players navigate a colorful, alien-like world in a small spacecraft, dodging obstacles, collecting targets, and multitasking to complete various challenges. This gameplay structure is intended to engage brain networks associated with attention, helping improve focus, working memory, and other executive functions over time.

The game is prescribed by a healthcare provider and can be used alongside traditional ADHD treatments such as medication and therapy. Clinical trials have shown that regular use of EndeavorRx can lead to measurable improvements in attention and impulse control, making it a unique, scientifically backed tool for ADHD management.

https://www.additudemag.com/akili-interactive-funds-adhd-video-game-treatment/

PlayAttention is a neurofeedback-based cognitive training program designed to improve attention, focus, and self-regulation skills, particularly for individuals with ADHD. It uses specialized hardware, such as a wearable armband with sensors, to monitor brain activity and provide real-time feedback on the user's level of focus. This biofeedback system is combined with gamified exercises that challenge executive functions, such as attention, memory, impulse control, and organization, through interactive tasks.

The program tracks users' attention levels and adjusts the difficulty of activities based on their performance, helping them practice sustained focus. By training with PlayAttention, users can improve their cognitive skills, including impulse control, focus, and organization, which are often challenging for individuals with ADHD.

PlayAttention is widely used in homes, schools, and clinics and is often part of a comprehensive ADHD management plan. It's available for children, adolescents, and adults, making it versatile for anyone seeking non-pharmaceutical ADHD support and cognitive training.

https://www.playattention.com

"Less than six months after publishing the results of a successful study, the company behind a therapeutic video game — dubbed "digital medicine" for ADHD — has raised $55 million to bring the treatment tool to the general public. The company, Akili Interactive, announced the financing in a statement released yesterday."

Game designs and concepts :

Themes for Stop-signal or Go/No-go games can include cartoon-like characters. The Go/No-go task is designed for young people where the Go and No-go signals are cartoon graphics, where Go or No-go signal stimuli are presented momentarily in a random binary sequence and the player is asked to respond to Go and ignore No-go. The design for a newly implemented game, Awkward Owls.

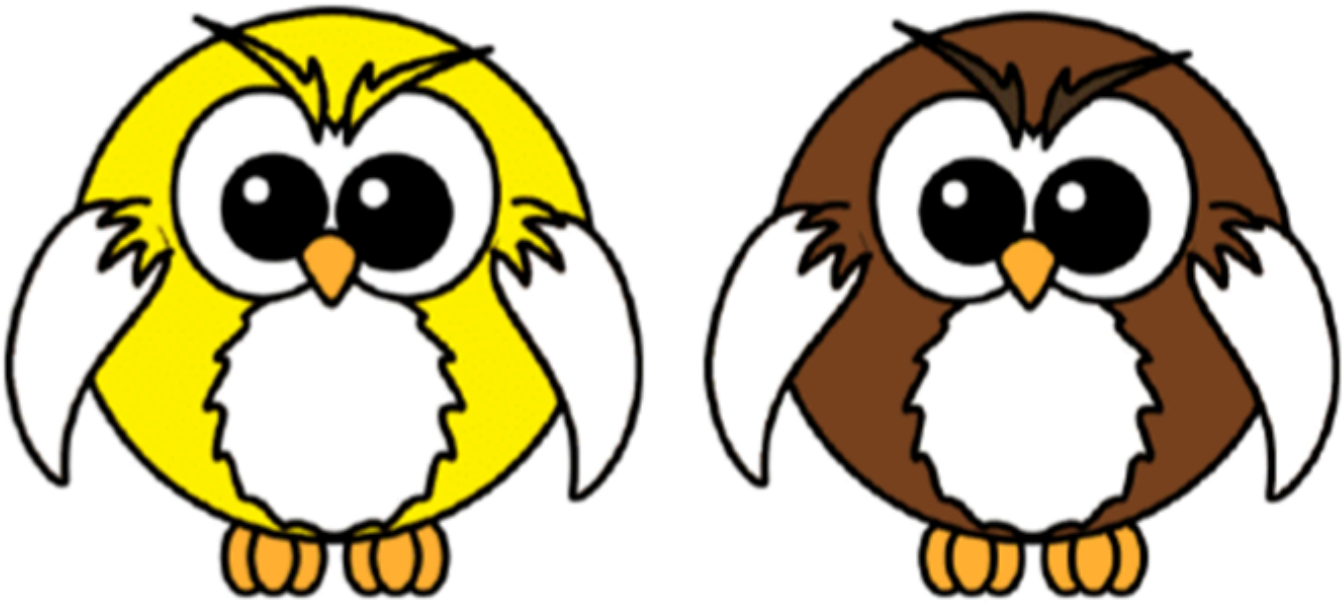


Fig. 3. Awkward Owls Go / No-go task graphics including yellow owl Go signal & brown owl No-go signal. [Graphics adapted from openclipart.com]

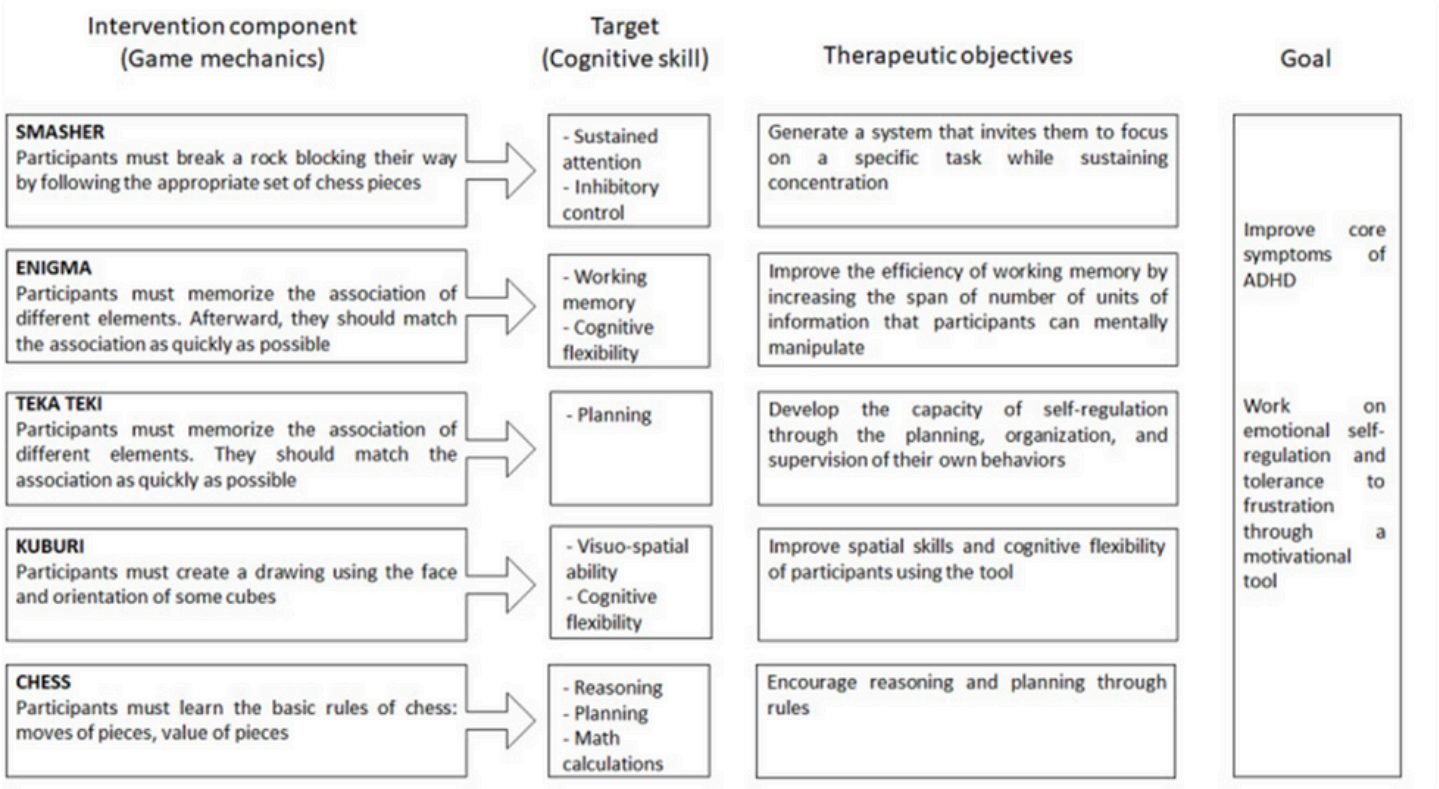
In the game, the player is presented with a narrative where they are a conservation volunteer who is asked to collect rare yellow owls for a wildlife survey. As is usual with Go/No-go tests, brief and variable inter-stimulus intervals are used to make it harder to anticipate the upcoming stimulus, and so the player's response has to be kept primed and ready throughout. Scoring is based on reaction times to the Go and No Go stimuli, together with penalties for the number of missed Go selections and any incorrect No-go selections. The Go:No-go ratio is also recorded. After each response (if any), a message is displayed, either Hoot! or Boo!!! depending on the stimulus.

EPELI :

The newly developed VR game, Executive Performance in Everyday LIving (EPELI), performed better than standard behavioral tests in distinguishing children with ADHD from those without ADHD in a small study of 76 subjects. According to the study, "EPELI showed predictive validity as the ADHD group exhibited higher percentage of irrelevant actions reflecting lower attentional-executive efficacy and more controller movements and total game actions, both indicative of hyperactivity-impulsivity."

EPELI presents 13 task scenarios to players over 25 to 35 minutes. Each scenario includes one general topic (e.g. morning routines) and 4 to 6 subtasks (e.g. wash hands). Participants engage in an instruction phase and execution phase for each scenario. The execution phase must be completed within 90 seconds.

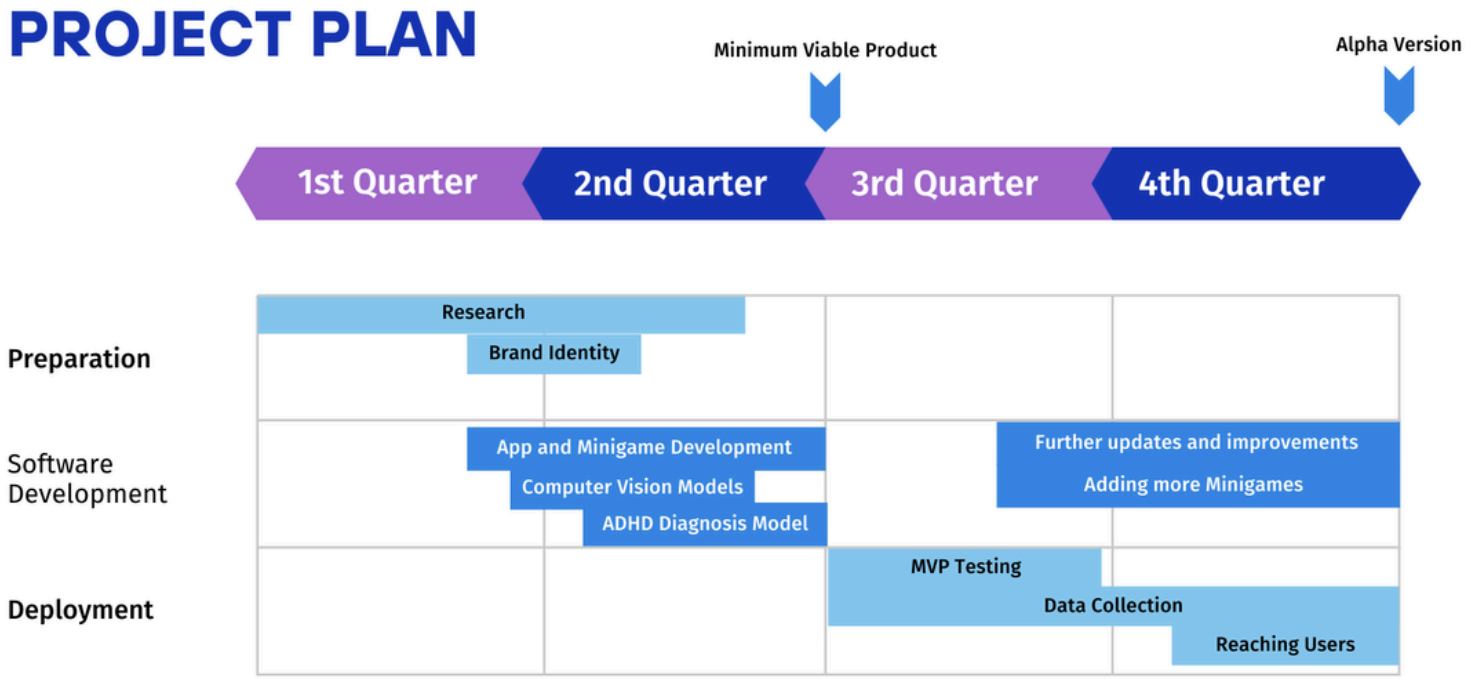
The ADHD children's gaze paused longer on different objects in the environment, and their gaze jumped faster and more often from one spot to another. This might indicate a delay in visual system development and poorer information processing than other children.



Project Plan

We aim to first deploy our **M**inimum **V**iable **P**roduct, as a prototype for our TSYP 2024 submission, as well as to perform tests to understand more about the performance of our solution. This is what we expect our project plan to be up until the Alpha Version.

Our development loop runs heavily on testing, to check the performance of our AI models, and to continuously update our solution, such that it gives better results.



Research: Searching for techniques and solutions for ADHD diagnosis, as well as possible interpretable symptoms is a long process that is required for us to start planning what our solution will do exactly.

Brand Identity: Our app should be appealing to the users, especially the youngs one. As such, much care should be put into deciding what our design identity is, as well as designing assets for our minigames

App and Minigame Development: As we discover more about what sort of data we could extract, we start implementing proposed minigames, that act as the basis of our solution, and that would start helping us collecting data.

Computer Vision Models: We need to integrate Computer Vision models into our minigames, to extract data like Eye Gaze, as mentioned previously. These models will probably use pre-existing datasets, or even models that are ready for use, they just need implementing.

ADHD Diagnosis Model: We will train our model with mock data at first, to see if it's properly distinguishing between two different types of incoming data. If so, then it should be able to properly distinguish between ADHD and non-ADHD users, given if they have different collected data.

MVP Testing: After we release our model, we should test to see if it's actually accurate. We would test the model on children of both categories, and start performing data analysis, to discover which data matters, and which data doesn't. This is an important step, and our development loop will rely heavily on testing.

Data Collection: We continue anonymously collecting data from users (with their consent, and with proper privacy measures), as it is the fuel that makes our model give better results, as well as discovering and understanding more about the symptoms and diangosis of ADHD.

Reaching users: We will start promoting our app to users, that could be either professionals that seek to help imrpove our app, or parents that want their child to use the app. This is essential, as feedback from users is what tells us what we should change about our solution.