Optimized Reading for ADHD and Dyslexia Users In VR

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Abstract— **To combat the rising population of ADHD and dyslexic patients, current advancements in Unity and Oculus Integration are investigated and employed to design a user-friendly reading experience. Unlike physical novels that lack visual aid, our prototype ensures a distraction-free and minimalistic VR environment. It utilizes Wit.ai speech recognition to aid ADHD and dyslexic patients in mechanical and comprehensive reading. Users can also change the background color and music to enhance their facilitated experience. This approach allows the user to constantly focus on the text without averting their gaze. We believe that further development of this prototype can create a powerful tool that redefines reading E-books.**

Keywords— ***ADHD, Dyslexia, Virtual Reality***

I. Introduction

Dyslexia is a neurological disorder that disrupts reading skills and affects roughly 43.5 million U.S. citizens [1]. Patients of the most common type, *phonological dyslexia*, show extreme reading difficulties due to phonological impairment, or the inability to form cohesion within the basic sounds of a language. According to the British Dyslexia Association (BDA) [2], dyslexic individuals also struggle with verbal memory and processing speed, as well as visual cues required for technical and comprehensive reading. These individuals, however, "[excel] in other areas, such as design, problem solving, creative skills, interactive skills and oral skills [2]". Because of this, present-day health experts and engineers continue to undergo significant research and develop methodologies that aid the growing dyslexic population by recognizing and stimulating the strengths outside their mental disorders. Another mental instability that affects reading comes from ADHD or *attention deficit hyperactivity disorder*. Roughly 11.6 million U.S. citizens who suffer from this mental disorder show extreme difficulties in attention span, as well as behaving hyperactively and impulsively. These symptoms cause the inability to focus on tedious or time-consuming tasks. In a 2017 medical study, "ADHD often persists into adulthood and is a risk factor for other mental health disorders and negative outcomes including educational under-achievement, difficulties with employment and relations, and criminality [3]." Therefore, it is important to employ potential treatments/helping aids for these individuals soon after diagnosis to prolong their well-being in the long term.

We developed a Unity VR environment that helps facilitate reading as much as possible [4]. The program settles the user in a distraction-free area and utilizes Wit.ai (an open-source "speech-recognition" interface) to aid in reading large bodies of text sentence-by-sentence [5]. VR users can also optimize the experience by changing the background color/exposure (which is limited to warm colors such as peach, orange, and yellow) and the background music using voice commands [6]. With further augmentation, this software holds the potential to enhance reading focus and store a database of E-books.

II. Related Works

Many attempts to solve the issue of dyslexia through current technological advancements were proposed and accessed over the years. According to a study in November 2017, the effects of changing the background colors to optimize reading on a screen for both dyslexic and non-dyslexic users were examined. During the research, experts found that "Warm background colors, *Peach*, *Orange* and *Yellow*, significantly improved reading performance over cool background colors, *Blue, Grey* and *Green*. [6]." As such, the main project utilizes this methodology to fully optimize the focus of the user to read over long sessions without causing eye strain and/or motion sickness; and as a byproduct worsening the symptoms of ADHD and dyslexia. In 2021, a group of Arabian experts developed a VR methodology that combines entertainment with reading targeted toward general and dyslexic Arabian students. This approach places the user in a fun environment and utilizes an "Avatar" feature that guides the user on how to interact with the program. Within the program, users can specify which Arabic letters they want to learn and are prompted to trace these letters on hollow outlines. Additional tools aid the user in the program, including the Sound button (to hear letter pronunciation), the Trash button (to remove incorrect traces), and the Camera button (to take a screenshot of their work). Through a learners' satisfaction questionnaire, 80% of the students preferred the VR experience over traditional lessons, with 90% enjoying the experience overall [7]. Also, within a Mobile and Simulation-based study in 2022, a developed application called *Helply* and the NAO robot (a humanoid robot designed to detect emotional recognition) are utilized to help children overcome various types of dyslexia such as dysgraphia (difficulties in writing), and dyscalculia (difficulties in understanding numbers and math). For dyslexia reading disorders, the NAO robot records the

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pronunciations of words from the child. The NAO robot, then, checks whether the response matches the words or not. If the response is correct, then the robot will respond with positive feedback. If not, the robot will pronounce the word properly. Further research shows that the experimentation resulted in a 94% training accuracy on all the subjects [8].

Similar technological advancements were proposed and accessed by ADHD patients. In January 2023, a virtual seminar room was utilized to train gaze-based attention spans in adults suffering from ADHD. In this Unity VR simulation, the user is sat at a desk with a keyboard within a classroom full of "animated study-mates." The main objective is to focus on the canvas at the front wall and type the letters that appear as fast as possible. During the experiment, a sequence of "distractor events" will occur (such as a study mate standing up and walking to a cabinet). If the user averts their gaze from the canvas for 2 seconds or looks at the distractor for at least 0.5 seconds, a sound effect would trigger, and their field of view would fade to black. Although this seems like a powerful tool on paper, studies have concluded that patients with ADHD, "made more omission errors and showed higher CPT (or continuous performance task) reaction times, [9]". It is later hypothesized that the malfunction of the gaze-based feedback system may have caused additional distractions and stimulated more ADHD symptoms. For determining whether a patient requires ADHD treatment, another study in 2013 covers a mobile "screening tool" application that was developed to automate the diagnosis process. The experiment was split into individual mobile activities that measured attention span, organizational skills and memory impairment, impulsivity, and hyperactivity. After these tasks were conducted, medical profiles were constructed for each subject that doctors/medical experts can access and decide treatments on [10]. Finally, in August 2022, an Android "proof-of-concept" application called *Flourish* was developed in Saudi Arabia and aimed to help individuals with ADHD "better manage their symptoms and understand how they behave, [11]". To do so, the application allows the user to organize their chores based on deadline and difficulty. The individual, then, is given a schedule with their prioritized tasks and rewarded once each activity is completed. *Flourish* also comes with additional features such as chat interactions via text/voice recordings, diagrams that track behavioral patterns, and an interface that breaks down each task into steps.

III. WIT.AI

Wit.ai is a free-to-use language interface (powered by Meta) that allows the user to implement voice commands into Unity VR through speech recognition. The AI takes in sentences (either through written or verbal communication) and converts them into structured data that is utilized for actions desired by the user. Specifically, in VR, this is often useful for implementing commands that do not require graphical user interfaces or any physical interactions.

There are three components to creating a Wit.ai voice command. First, the user must create the *utterance*, or the sentence they want to say to operate a desired action. Next, the user must link the utterance with an *intent*, or the action committed when the user states their sentence. Finally, within the utterance, certain words need highlighting to create *entities*, or the variables needed for the AI to comprehend the intent desired from the user. Entities are also useful for tracking synonyms that the user states in place of the words within the utterance. With these components combined, the voice command is trained and validated by the AI and outputs a confidence level. This measures how well Wit.ai can understand the voice command when utilized within the Unity program.

To further illustrate the structure of a voice command, a sample Wit.ai command is shown in Figure 1. Here, a new utterance is named "Make background yellow", which is linked with the intent to change the background color of the VR environment. Within the utterance, the phrases Make and yellow are highlighted as entities to track the *Background Status* (or what the user wants to do with the background) and the *Background Color*. After training and validation, Wit.ai returns with 100% confidence level for both entities, showing that the AI can comprehend this specific utterance with the highest accuracy. All utterances have varying confidence levels depending on their sentence structure and length. Voice commands can drastically change how the user interacts within a VR environment. For our prototype the user can train and utilize voice commands to optimize their reading experience to their liking. Furthermore, Wit.ai allows the user to keep track of reading passages by greying out the sentences when the user reads them correctly.

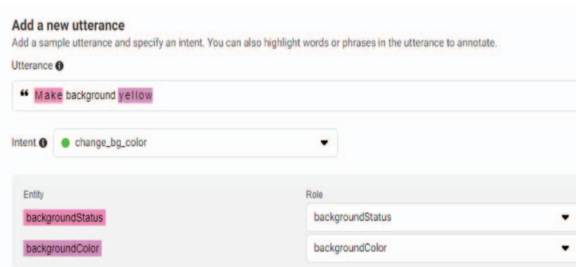

Fig. 1: Breakdown of sample voice command constructed in Wit.ai.

IV. PROOF OF CONCEPT

As stated before, our prototype is built from scratch using the Unity Engine and Oculus Quest 2. The advantage of utilizing a VR headset compared to a desktop monitor is to minimize distractions affecting users with ADHD while reading a passage of text. As shown in Figure 2, the body of text (stored in a UI) will always face the user no matter what the position/orientation of their head. Within the software, the user can hold the Primary button on either controller (X on the left, A on the right) and read each sentence out loud. Once this is done, the utterance produced by the user is sent to the Wit.ai *App Voice Experience.* This contains the Response Handler, which stores the utterance and contains a C# script that compares its data to a default string array called values[0]. Values[0] contain all of the target sentences that are found within a given passage. From here, it is decided whether or not the utterance produced by the user matches a specific sentence in the program. If the answer is "yes," then a separate C# script found within a separate Text Handler is triggered to gray-out the sentence and triggers a sound to confirm that the sentence was read correctly. If the answer is "no," then a different sound will trigger to confirm that the sentence was read incorrectly. This sentence-by-sentence format offers a helping aid to users who struggle with dyslexia and are often overwhelmed by large bodies of text.

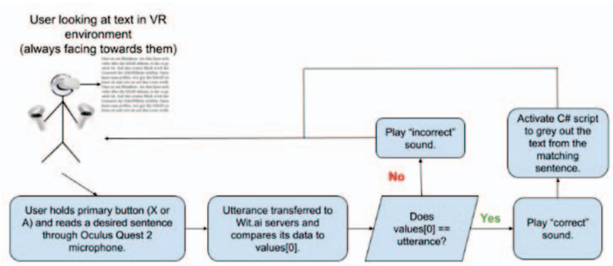

Fig. 2: Diagram outlining the procedure of the VR prototype.

V. Application Overview

The software itself provides a simplistic, minimalistic reading simulation. When entering the project in Unity VR (as shown in Figure 3), they are greeted with a single-colored environment with a Reading UI that contains text from *The Maze Runner* by James Dashner (specifically Chapter 16) [12]. Although this text cannot be changed, there are plans to further develop the software for users to download and switch between E-books. The user also cannot move in this environment; however, they can turn their heads to reposition the Reading UI. This UI faces the user no matter the orientation and its viewing distance can be increased/decreased using the left Trigger/Grip button.

Fig. 3: Prototype interface (background orange by default).

To read the text, the user holds the Primary button (either A or X) to enter "Recording Mode." During this stage, the user can read a sentence out loud. As shown in Figures 4 and 5, the text within the passage turns grey whenever the user says the first sentence correctly. If the Wit.ai servers detect that the sentence was read incorrectly, the program will make a sound indicating so. From here, the user can continue until all the sentences are greyed out on the page. When the user wants to turn the page, a conveniently placed Hand UI on the left controller (with XR Poke Interaction) contains buttons that allow the user to turn to the previous/next page. The Hand UI also includes buttons that display basic instructions (as shown in Figure 6) to utilize the program and additional voice commands to optimize their experience. These commands include changing the background color/exposure and music. The background music [13] is split into 8 tracks that the user can choose from.

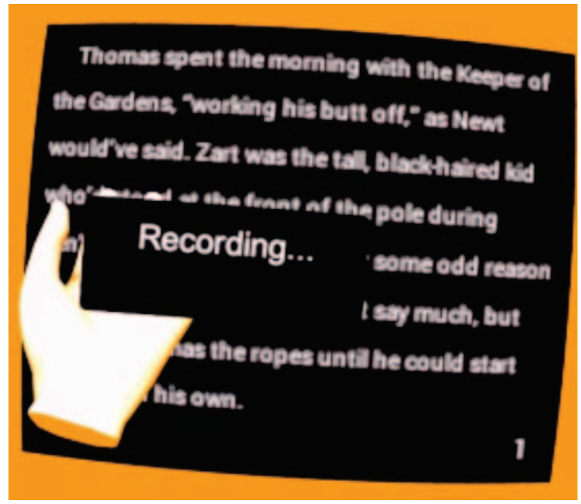

Fig. 4: When user holds Primary Button, Hand UI changes for Recording Mode.

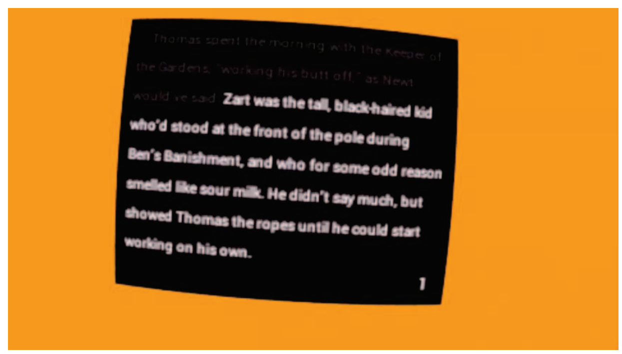

Fig. 5: Text for 1st sentence greyed out on Reading UI when read successfully.

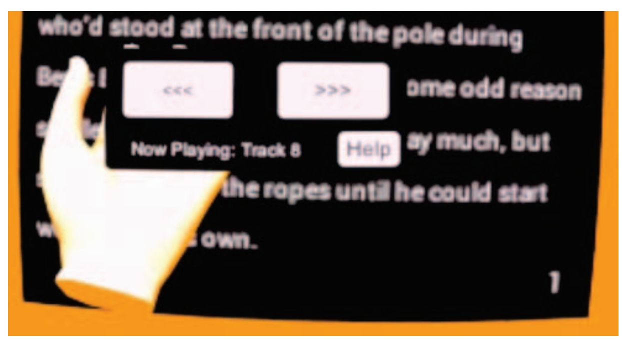

Fig. 6: Hand "Turn Page" UI showing "Track 8" playing in the background.

VI. Discussion & Limitations

While the prototype offers a simplistic, minimalistic experience that can track the progress from reading a passage, some limitations prevent the software from reaching its full potential. The first issue involves the speech recognition component, which requires uninterrupted and consistent feedback. Due to this, the user must read each sentence without taking breaks/pauses (especially on long utterances with commas, semicolons, etc.). Otherwise, the voice recorder will stop tracking while the user reads a sentence. Users may also need to repeat a sentence repeatedly due to mispronouncing a word or two. The problem can also persist due to the speech recognition mishearing a word despite the user saying the phrase correctly. Another issue with the software is that there exists a delay between when the user reads the sentence and when the C# grey-out script activates. The delay occurs when the recorded sound files are sent to the Wit.ai servers and are converted to structured data (in the form of strings). This data, then, is compared to the utterances trained and validated by the AI to confirm if the user read the sentence correctly. These time intervals between reading and processing utterances cannot be tweaked since different sound files are recorded and processed each time the user speaks into the microphone. Delays in between sentences, however, can benefit patients with ADHD and dyslexia since they may take their time reading through the passage.

With further development, additional components can increase the effectiveness of the prototype. One of these components is a voice synthesizer that tells the user how to pronounce words/sentences in a passage. Not only would this counteract the issue of mispronouncing the sentences repeatedly, but also bring audible feedback on whether the sentences are pronounced correctly. Another feature that would make the prototype more effective is a script that highlights the sentences that the user needs to read. Since quotation marks and other forms of punctuation exist in writing, patients with ADHD and/or dyslexia might have a hard time figuring out where a sentence begins and ends. Therefore, highlighting each sentence would bring visual feedback to the user prior to reading. Finally, a C# script that fades the field of view to black whenever the user does not read for a certain amount of time would enhance the impact of ADHD treatment within the software. Like the 2023 Gaze-based attention training study [9] mentioned prior, a successful methodology would force the VR user to read the passage with a further minimalization of distractions.

VII. Conclusion

Since VR is becoming more accessible to the public through increased demand and reduced prices, developers have explored the endless possibilities of this technology to aid in the entertainment and educational fields. The goal of this prototype is no different, as it aims to help patients with ADHD and dyslexia overcome their symptoms through distraction-free reading. All possible distractions were minimized as much as possible through the single-colored [6] VR environment and with the Reading UI facing the user no matter their head orientation. Various E-books already exist, and with the future expansion of the software, we plan to encapsulate and support a universal library of these forms of literature. Furthermore, research on Wit.ai will also be conducted to improve the accuracy of speech recognition and make the task of reading the sentences less of a hassle. With these objectives in mind, a final product is in the works to reintroduce reading for ADHD and dyslexic users.

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