Students with Attention-Deficit/Hyperactivity Disorder and Utilizing Virtual Reality to Improve Driving Skills

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ABSTRACT

Attention-deficit hyperactivity disorder (ADHD) is a developmental disability that affects both adolescents and adults in the current time. With driving being a staple part of the American lifestyle, it is clear that such disabilities can inhibit the progress for one's journey of learning to drive a motor vehicle. Relevant research and studies suggest that there is a correlation between an increased number of driving citations and people with ADHD, along with evidence of moderate driving issues within sample groups of people with ADHD. With virtual reality (VR) becoming a principal technology of the modern world, perhaps its uses can extend to benefiting those with developmental disabilities such as ADHD. Through the creation of a driving simulation, users can use VR technology to practice the necessary skills needed to drive, without the risk of physical injury to themselves or others. with the purpose to aid the learning experience of those with ADHD, the simulation can be designed with specific features present to help them maintain focus on the important details needed for practicing safe driving.

CCS CONCEPTS

• Human-centered computing → Virtual reality; **• Computing methodologies →** *Perception.*

KEYWORDS

Virtual Reality (VR), Attention-deficit hyperactivity disorder (ADHD), Driving Simulation

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1 INTRODUCTION

Attention-deficit hyperactivity disorder has an estimated prevalance of 2.5 percent in adults worldwide [3]. It is described as the most common neurobehavioral condition of childhood that negatively affects a person's attention span and impulse control. [4] It's not difficult to see that there exists a correlation between adolescents and young adults with Attention-Deficit Hyperactivity Disorder (ADHD), and unsafe driving practices such as: speeding, frequent lane departure, unstable vehicle control, etc. [1, 7, 8, 11]. Studies point out that such driving behavior is a primary consequence of inattention [1], where about 25-30 percent of 1.2 million police reported crashes annually are caused by driver inattention [10]. Research on people with ADHD finds that distractibility is a very common characteristic for them [1, 7, 11]. As motor vehicle crashes result in the leading cause of death for people of ages 4-29 years old [8], the inattention and high potential loss of focus of drivers has become a concern. A potential benefit could be the introduction of Virtual Reality (VR) for the purposes of learning to drive safely. VR provides a physically safe experience compared to real world driving, and can be tailored with specific features that can benefit the user's learning experience. With distractibility being a major cause for motor vehicle crashes, having an immersive driving simulation that helps grab the attention of the user can aid in their practice for safe driving and maintaining focus.

1.1 Research Question

Can VR be a beneficial tool to provide a safe space for students with Attention-Deficit Hyperactivity Disorder to learn driving skills? If so, what important features can be implemented to help grab the user's attention for important details needed to practice safe driving?

2 RELATED WORK

The use of Virtual Reality (VR) and the creation of driving simulators has already been introduced into the realm of learning how to drive. Daniel J. Cox and his colleagues [2] have used VR driving simulations to conduct research and evaluate the potential improvement of driving for people on the Autism Spectrum. Their test pool was split into groups where one group received routine driving testing which consisted of a DMV training manual along with a training program, while the rest tested their skills on the VR driving simulator. The simulation itself had three variations: a driving simulation that provided automated audio feedback, a standard simulation one that did not, and one that had incorporated eye-tracking. The researchers found that the VR driving simulator training led to improved scoring on general tactical driving performance (maneuvering the vehicle while negotiating different traffic situations), as the composite score calculated for the Standard (no audio feedback) and Automated (audio feedback present) VR simulated training were superior to that of the Routine Training. Seeing as how a VR driving simulation has significant potential

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to aid people on the Autism spectrum in their driving experience; there is a great potential for a similar tool to benefit those with another developmental disability like ADHD.

If a driving simulation was to be produced with the intent of benefiting the learning experience of those with ADHD, what features should be implemented or kept in mind to allow for such a simulation to become effective? Leo Gugerty [6] brings up the phenomena known as attention capture, stating that conspicuous events such as sudden movements can cause one to bring their attention to the stimulus which leads to comprehension and awareness of the event. As people with ADHD have trouble maintaining focus, being able to keep the user's focus on important details or events would be very important to one's learning process. Gretchen Geng [5] emphasizes this point by highlighting that teachers who used non verbal gestures to point out important information to students with ADHD, allowed for the student's attention to be focused, albeit for a short amount of time before the action had to be repeated. Geng also mentions how teachers would use verbal communication, voice control, and repeated short instructions in combination with the visual component to help the students maintain focus. This connects with the benefit of the Automated Virtual Reality Simulation from Cox's research [2] which used an automated voice to provide important feedback to the user. Siwei Ma and Xuedong Yan [9] further emphasized the use of improved visual cues to help bring attention and one's focus to important pieces of information such as traffic lights and lanes, which proved beneficial to people without learning disabilities.

3 METHODOLOGY

This project will be using the Unity Game Engine to create and develop the driving simulation. To maintain focus on developing the new and unique features, already existing assets for the car and environment will be taken from the Unity asset store. To allow the simulation to be compatible with the Oculus Quest VR headset and controllers, it is also necessary to install and import the necessary tools kits.

3.1 Basic Driving Simulation

With a car object imported into the scene, it will require some implementation of receiving player input to produce the visual output of the car moving around the generated environment. This requires coding C Sharp scripts that will then be added to specific game objects. The first script will deal with player input by reading an input being made; in the case of this study the Quest 2 right trigger would cause the vehicle to accelerate in the positive direction, the left trigger would cause the vehicle to accelerate in the negative direction (brake then reverse), and the right joystick would read X axis inputs for vehicle steering. The next script is to ensure that the player inputs will translate over to the car object, allowing the wheel colliders to turn, accelerate, or decelerate based on our variable values and player input.

3.2 Visual Cue Features

To keep to the theme of attention grabbing, the use of visual cues to help the user pay attention to important details can be very beneficial. The first visual cue that is implemented is a target ring over traffic lights that will appear when the car object enters a predetermined location in proximity to that specific light. The ring itself will surround the three color traffic lights, and change color depending on which color light is active at that moment. Once the car object enters the trigger box collider, the ring will appear over the traffic light to draw the user's attention to it. As the car object leaves the area, then the ring will disappear. This is to ensure that only one ring is enabled at a time as to not cause any visual over stimulation, or desensitization to the visual cue.

Figure 1: Both Implemented Visual Cue Features

The lane alert feature is similar to that of the traffic light ring feature. Each road will have skinny rectangular prism with a box trigger collider that stretches along the road's lane. This object will stay completely transparent until the car object enters the box collider's trigger. This will the cause the box to appear with a red color and 40 percent transparency, indicating to the user that their car is dangerously moving into the other lane.

3.3 Audio Cue Features

When the car object does not stay in the correct lane, and the visual alert appears, an audio cue will play on a loop to grab the attention of the driver, indicating their mistake. As Gretchen Geng mentioned in her study, using both audio and visual cues at the same time is a more effective way to garner the attention of students with ADHD. The audio cue tied with the visual cue can prove a more effective combination than just either or.

The main audio cue implemented happens when the user will not be looking at the road in front of them for two seconds. An invisible object will exist in front of the user's render view when they would be looking forward. If the player camera is not pointed at that transparent object for two seconds and therefore the object is not rendered by their view (they turn to look at the sides, up, or behind them), an audio cue will play to remind them to look forward. The audio clip will play on a loop until the user camera is pointed back at the transparent object. To ensure that the user is not desensitized to the alerting sound, it will not be one continuous note, but a pulse.

4 TESTING

A small test pool of people was recruited to test and try out the simulation for the purpose of providing feedback, along with ranking the effectiveness of the features implemented. Testing was conducted by first fitting the Quest 2 headset on and adjusting to provide the user with a comfortable experience. Then the user was given the Quest 2 controllers and were told what buttons and triggers to press for acceleration, deceleration, and the proper joystick for steering. The user then deployed the game. Upon confirming that the user had a successful deployment where they could see the steering wheel and road in front of them, they were told to begin and play for two and a half minutes. When the participants questioned on what they should aim for when playing, they were told to just drive around the created environment and aim to obey traffic laws to the best of their abilities. After the two and a half minutes had passed, the user was sent out a questionnaire to complete. The questions asked were in regard to the feel of using the Quest 2 headset and controllers, the feel for driving in the simulation, the effectiveness of the attention grabbing features, and a space for the users to provide their own feedback or go into more detail about their experience.

The Control Group consisted of 10 people of all backgrounds and with mixed experience on using VR and/or driving. Unfortunately, due to a lack of resources and inopportune timing, only one person who was diagnosed with ADHD agreed to test out the project. The person diagnosed with ADHD agreed to test out the simulation without taking their prescribed medication.

5 RESULTS AND FEEDBACK

5.1 Using the Quest 2 Headset and Controllers

From the Control Group, the general consensus of first time users for the Quest 2 headset and controllers was that it was easy to get familiar with. When given proper instruction prior to putting everything on, they felt confident within a few seconds of using the Virtual Reality technology. Those with prior experience agreed with this consensus. Some minor issues that arose were those participants who wore glasses, as they would either need to take them off or try wearing the headset with them on. This choice was ultimately left to the user. One user had trouble putting on the headset due to their voluminous hair, though this was easily fixed with the strap adjustments. As per any user discomfort found, one participant exclaimed one minute and fourty-six seconds into their test that they began to feel motion sick. They claimed to feel a sense of light-headedness and dizziness. Those who wore the headset while also wearing their glasses brought attention to the small discomfort of their glasses being pushed in, as well as the issue of fogging which hindered their sense of sight.

5.2 Feeling of Driving

Figure 2 shows the participant ranking for the feel of driving in the simulation. The X axis is the rank scale between 1-10, while the Y axis represents the number of participants who voted that specific rank. The rank of 1 on the scale indicates that the user did not enjoy the feeling of driving at all, and the rank of 10 indicates that the user did enjoy the feeling of driving. With an average of 7.667 and a median of 8, it seems there are improvements that could be made. Some participants also specified in their feedback their ideas to make driving better: Making the brake input a separate button such as the grip trigger, and having the steering input be the left joystick rather than the right. One of the users who rated lower

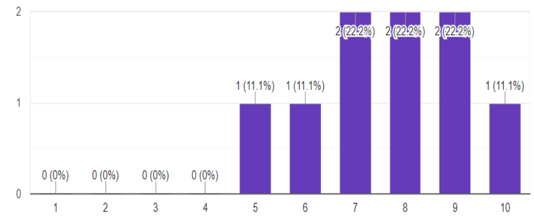

Figure 2: Feel for Driving

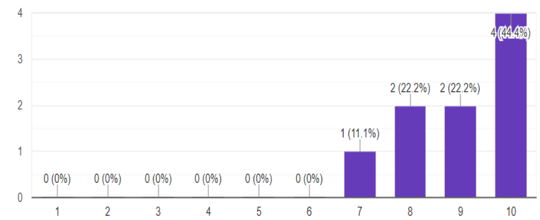

Figure 3: Effectiveness of Traffic Light Visual Cue

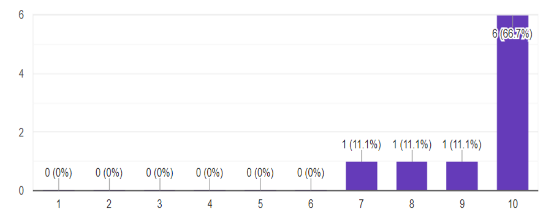

Figure 4: Effectiveness of Lane Alert Visual Cue

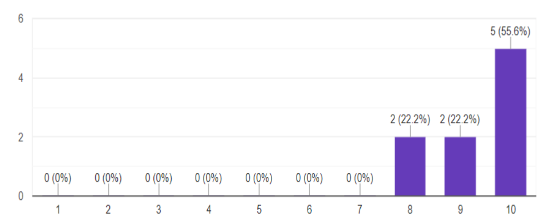

Figure 5: Effectiveness of Lane Alert Audio Cue

on the scale highlighted the difficulty of driving in the environment due to the 90 degree square turns (not including the intersections). They claimed that such sharp turns were only possible by either driving over the corner curb, or dangerously passing through the opposite lane.

5.3 Attention Grabbing Features (Visual)

Figure 3 shows that the visual cue of the rings around the traffic lights that appear when the user gets in range, was considered to be an effective attention grabbing tool. On the scale, 1 represented: Not effective at all, while 10 represented: Very much effective. The Control Group had a average of 9 and a median of 9 as well. The