A serious game with virtual reality for travel training with Autism Spectrum Disorder

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***Abstract*—Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impairments in social interaction and repetitive patterns of behavior. This article describes the creation of a serious game that prepares individuals with ASD to use buses as a mean of transportation. Virtual reality (VR) support was added, increasing the feeling of presence and the realism of the experience, thus increasing its potential as a learning tool. The game is currently being developed using the Unity game engine and uses the Oculus Rift as virtual reality headset. Preliminary results prove the viability of the experiment and the acceptance from individuals with ASD towards the use of the VR setup. In conclusion, the project aims to understand how games and virtual reality can be used to improve the capabilities of individuals with ASD, and help them live more independently.**

Keywords—Autism Spectrum Disorder; serious games; travel train; virtual reality; virtual reality therapy

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder responsible for impairments in social communication and interaction, and restricted repetitive patterns of behavior, interests, or activities. Currently ASD affects 1% of the population worldwide [1] and, with a cure yet to be found, individuals rely on therapies and interventions to improve and overcome its impairments. Immersive Virtual Reality (VR) technologies available nowadays are able to present users with experiences realistic enough to trick the mind and create a feeling of presence within the environment [2]. Serious games (games whose objective is learning rather than entertainment [3], regardless of the player's age) have been proven effective in ASD therapies, not only for including game design techniques to keep the players motivated, but also because individuals with ASD are often interested in computer-based activities [4]. This article describes the development and viability testing of a serious game which uses VR to rehabilitate individuals with ASD.

II. OBJECTIVES AND METHODS

The purpose of this project is to prepare individuals with ASD to use buses for transportation by placing them in a three-dimensional city and setting tasks which involve taking buses to reach specific destinations. The game developed so far provides a safe environment where players can become comfortable with the process of taking a bus. It currently facilitates independence in community travel by training activities such as planning a route and waiting for the right bus, as well as the standard bus procedures: validating the ticket, not sitting on priority seats and timely pressing the stop button. At the beginning of the game, the player can choose which task to attempt and its difficulty, allowing for progression as tasks are completed. Testing sessions were conducted to examine the following factors:

- Technology acceptance - using a Head Mounted Display (HMD) instead of a screen monitor can be overwhelming and cause motion sickness.
- Interface comprehension - interface design standards adopted for desktop applications are often inadequate for HMD as the borders of the screen are blurred and only the center is clear.
- Task performance - difference in task performance between individuals with ASD and controls (individuals without ASD).

Since different participants might need different amounts of time to get used to the game, a tutorial was created. The performance in the tutorial was used to test the interface, while the task performance was used as a first assessment of the participant's capabilities.

A. Participants

Five individuals with ASD, three males and two females, with a mean age of 32.2 years and standard deviation of 4.0, and five controls, three males and two females, with a mean age of 30.7 and standard deviation of 6.2, participated in this testing phase. This study and all the procedures were reviewed and approved by the Ethics Commission of our Faculty of Medicine from University of Coimbra and was conducted in accordance with the declaration of Helsinki. Informed consent was obtained from the parents/guardians of all participants. Participants also gave oral informed consent.

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B. Procedure

In the testing sessions the participants received the tutorial and a task. The tutorial consisted of 3 steps: going to an X marked on the floor, taking the bus number 4, and leaving in the first stop. Participants were guided step by step by the facilitators through the tutorial. The task consisted of four steps: going to the bus stop signaled in the map, taking the bus number 3, leaving in the stop closest to the police station, and going to the police station. Information about the player's performance was registered for posterior analysis.

III. Results

Throughout the testing sessions no participant with ASD reported motion sickness.

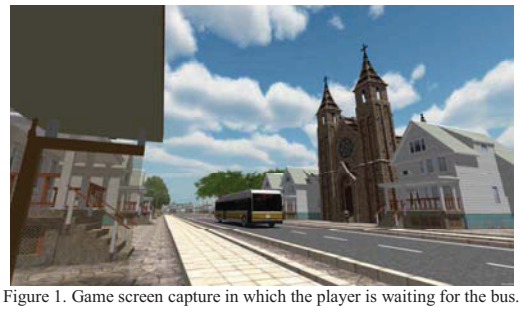

Figure 1. Game screen capture in which the player is waiting for the bus.

During the tutorial participants were asked to read the current objective out loud and identify the location of both player and objective on the map. The results are presented below in Table I and Table II for participants with ASD and controls, respectively. Table III and Table IV indicate the task duration of each participant for each task.

TABLE I. Interface test results from participants with ASD

	Participant					
Observation	**A**	**B**	**C**	**D**	**E**	**Percentage**
Can read the objective	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**80%**
Can locate the player on the map	**No**	**No**	**Yes**	**Yes**	**No**	**40%**
Can locate the objective on the map	**No**	**No**	**Yes**	**Yes**	**No**	**40%**

TABLE II. Interface test results from control participants

	Control Participant					
Observation	**F**	**G**	**H**	**I**	**J**	**Percentage**
Can read the objective	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**100%**
Can locate the player on the map	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**100%**
Can locate the objective on the map	**No**	**Yes**	**Yes**	**Yes**	**No**	**60%**

TABLE III. Task results from participants with ASD

	Task duration (minutes)	
Participant	**Tutorial**	**Task**
A	**6.58**	**4.47**
B	**4.57**	**15.95**
C	**4.44**	**3.53**
D	**9.70**	**2.42**
E	**9.20**	**17.46**
Mean	**6.90**	**8.77**
Standard deviation	**2.22**	**6.53**

TABLE IV. Task results from control participants

	Task duration (minutes)	
Control Participant	**Tutorial**	**Task**
F	**4.45**	**4.05**
G	**2.68**	**2.34**
H	**4.39**	**3.29**
I	**4.47**	**9.33**
J	**4.58**	**4.10**
Mean	**4.11**	**4.62**
Standard deviation	**0.72**	**2.44**

IV. Conclusion and Future Work

The results obtained from the interface evaluation show that some components need improvement to become more visible. Statistically comparing performance times, the mean time needed to complete the tutorial was 6.9 minutes for participants with ASD and 4.11 minutes for control participants. Further, the mean time needed to complete the task was 8.77 minutes for participants with ASD and 4.62 minutes for control participants. The difference in performance between participants with ASD and controls reveals a target for the serious game intervention. Due to the high performance dispersion, observable among the individuals with ASD, future stages will include larger study and control groups. In the next stages of development, a system to better measure the player's performance will be implemented. This system will consist of two main components: a score system which focuses on the player's actions, and a biofeedback system, based on electrodermal activity, which measures the anxiety level of the player throughout the task and adapts the environment to it. With these, it will be possible to analyze the impact of practice on both task performance and anxiety reduction. Furthermore, additional elements such as people, animals and cars will be added to increase the complexity of the tasks and travel challenges. Accordingly, results obtained in following stages will allow a more thorough analysis, and may be useful in understanding how games and virtual reality can help individuals with ASD become more independent, specifically regarding to the task of taking the bus.

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