The potential of virtual reality technologies to support people with an autism condition: A case study of acceptance, presence and negative effects

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Abstract. There has been much potential and discussion about the application of virtual reality technologies (VRTs) using head-mounted displays (HMDs) for users with autism However, very few, if any studies, have yet to explore and investigate the acceptance, presence and ecological validity of these platforms. On the other hand, literature is well developed in areas such as virtual environments [18], virtual worlds [9], [19] and virtual reality [20], but few have considered the resurgence in head-mounted displays for autistic users. Many of the affordances associated with VEs and VWs may be applied HMDs and VRTs and so are also seen a potential opportunity for people with autism to tackle challenges faced on a daily basis. We present findings from a study conducted in the United States that worked with a HMD (Oculus Rift) and 29 participants with an autism condition. We ran the experiment in two phases. Phase I considered acceptance of this wearable technology; looking at issues of sensitivity. Phase II consider sense of presence, immersion, ecological validity and negative effects [16]. Concluding with pre- and post- anxiety measurements [17]. The paper will discuss the quantitative findings of the study.

Keywords. Virtual reality technology, autism, head-mounted display

1.**Introduction**

Achieving independence and gainful employment can be especially challenging for the 40% of individuals with an autism spectrum disorder (ASD) who have a co-occurring intellectual disability (IQ<70) [1], [2], [3]. The nature of these co-occurring disabilities requires very explicit and carefully sequenced skills training in order for them to be successful in the future. To date, however, there is a paucity of independent living and vocational skill interventions described in the research literature for individuals with severe ASD or ASD/ID. The skills deficits, along with the lack of empirically derived interventions, create a critical gap as independent living and vocational skills are closely tied to quality of life for individuals with ASD/ID [4], [5], [6], [7]. Therefore, it is crucial to develop innovative strategies to address related training needs and provide evidence-based interventions to individuals with ASD/ID. One such innovation is the

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use of virtual reality technology (VRT) to help develop personal, social, functional, and pre-vocational/vocational skills. Standen and Brown [8], for example, have discussed the role of vocational training (among other uses of VRT for people with IDs) and

noted that: 'only one study so far has investigated the contribution that virtual environments might make to increase the employment opportunities for people with intellectual disabilities' (p. 275). Since then, a number of studies have examined the role VR can play in developing vocational skills [9], [10], [11], [12] and have each reported positive findings in the feasibility and efficacy of VR used by populations with ASD to aid job-interviewing skills.

2. Virtual Reality Technologies for people with autism

Virtual Reality (VR) provides opportunities to practice dynamic and real-life social interactions, which has been used previously and shown to be an effective intervention tool for people with autism. Its utility is likely due to several unique characteristics

Virtual Reality also represents real-life experiences in a safe, controllable manner that allow for repeated practice and exposure. It is a unique setting where individuals can explore and act without feeling threatened or frightened of real-world consequences, or they can make mistakes without fear of dangerous, real, or humiliating consequences. This is particularly important for an autism population in learning tasks and can also provide naturalistic environments with unlimited social scenarios and has been shown to replicate social conditions effectively [13].

The computer-mediated role-play might present a vital opportunity for individuals to experience different perspectives, which, in turn, might nurture more general skills in mental simulation. Responses to different scenarios can be practiced before, during or after being taught. Tasks can also be repeatedly presented and practiced in a consistent way without the fatigue; an issue sometimes associated with task repetition by human instructors [14]. The ease of repetition of the task could facilitate rote learning of social rules in a specific context before moving on to allow practice of the skill in a different context. VR also offers immediate, real-time feedback about performance and can be tailored to each individual and monitored to test his or her ability to perform certain tasks over time based on progress [15].

3. Current Study design and procedure

The current study involved using a head-mounted display (Oculus Rift ™), headphones and an input device (game-pad). As Figure 1 highlights, the study involved a portable device (PC Laptop) with the previously mentioned equipment.

The population of the study included individuals with ASD who were interested in securing an employment opportunity. It is important to emphasize their desire for receiving an employment opportunity since the intention of the study was to explore the suitability of using the VR technology as an intervention for vocational rehabilitation. A total of 29 participants with ASD were recruited from a private non-profit community rehabilitation organization (CRO) in a Midwestern state in the United State of America. Ethical considerations of the study were paramount; especially due to the preliminary nature of the study. Ethical processes of the University were followed and approval granted for the researchers to conduct the study.

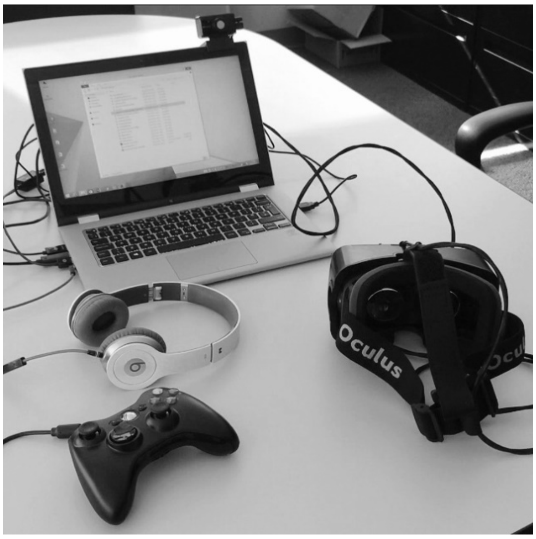

Figure 1. Equipment used in the current study

The study involved two phases. Phase 1, during which the 29 participants viewed three virtual environments wearing the HMD and headphones. The first was a virtual cinema, the second a virtual café and the third a tour of an Africa Savannah (driving a Jeep). After the participants completed the first phase of the study, they were invited to participate in phase 2 of the study, which took place few days after phase 1. Eleven participants were selected for phase two. During this phase, two longer and more intense VR scenarios were presented to the participants who wore the same set of VR equipment, and this time the session lasted for approximately 25 minutes. Specifically, these two scenes included: (1) an Apollo 11 mission in a space rocket and (2) a Tuscan Village/house tour (walking and interacting with objects). Table 1 provides an overview of the participants involved.

Table 1. Demographic characteristic of the participants who took part in Phase I and II of the study

	ASD group in Phase I (N=29)	ASD group in Phase II (N=11)
Demographics		
Mean age (SD)	32.02 (9.88)	29.77 (8.66)
Gender (%male)	76% (n=22)	91% (n=10)
Vocational History		
Full-time employed	34% (n=10)	27% (n=3)
Part-time employed	66% (n=19)	73% (n=8)
Formal ASD diagnosis		
Autistic Disorder (%yes)	55% (n=16)	64% (n=7)
Asperger's (% yes)	34% (n=10)	18% (n=2)
PDD-NOS (% yes)	10% (n=3)	18% (n=2)
Intellectual Ability		
IQ score mean (SD)	83.58 (23.69)	86.63 (30.70)

A selection of assessment instruments was used to help better understand the participants' overall enjoyment and psychological status from the use of the head-mounted display. Specific instruments included: (a) demographic questionnaire, (b) the Independent Television Commission-Sense of Presence Inventory (ITC-SoPI; [16]), and (c) the State-Trait Anxiety Inventory (STAI; [17]). ITC-SoPI was used to measure the subjective effects experienced by an individual within the virtual environment (i.e., presence of 'felt'), and STAI was used to assess participants' level of "state anxiety" (i.e., anxiety about an event; in this case the HMD VR environment) and "trait anxiety" (i.e., anxiety as a personal characteristic in general). In terms of the ITC-SoPI, a score of 1 indicated low immersion, presence and ecological validity with a score of 5 indicating a higher sense of presence. A score of 1 for negative effects indicated a report of low negativity.

4. Results

Twenty-nine participants all agreed to wear the VR head-mounted display during phase one (100%). Specifically, 86% (n=25) of the participants completed all three different virtual scenarios. Four participants requested to discontinue the experience after the virtual café scenario. Upon the completion of phase one, participants were asked to return for the phase two. Among 29 participants, 23 (79%) agreed to come back for the phase two. All Eleven participants who were selected for the phase two agreed to participate in the study (100%), and all of them completed two scenarios from the phase two. In relation to overall acceptance and enjoyment of the VR HMD, all participants reported a score of 3.0 or above (1 = not enjoy at all to 5 = enjoy the most), with a mean score of 4.32 (SD=0.69). As for the likelihood of using VR-HMD again, the majority of the participants (with the exception of two participants) reported a score of 3.0 or above (1 = not likely to 5 = most likely), with a mean score of 3.92 (SD=1.98).

In relation to immersive experience, the participants reported that the spatial presence was above average (M=3.8; SD=0.62) with both engagement and ecological validity reporting high scores (M=4.1; SD= 0.57 and M=4.0; SD=0.33, respectively). In addition, participants reported low negative effects from the use of VR HMD (M=2.0; SD=0.34). Specific to psychological influence from the use of the VR HMD, we did not find any anxiety-provoking situation from the use of the VR HMD.

5. Discussion and implication

This study provided several important insights to the two questions that we sought to address: a) is it safe for the individuals with ASD to use HMD VR interfaces (wearable-technology), and b) would individuals with ASD accept and enjoy the experience in the virtual environment? Answering the first question, the participants of the given study expressed a general acceptance of wearing VR HMD during the experiment. In addition, most of them stated that they would be interested in trying more in the future. However, although the majority of the participants gave positive feedback during and after the VR experience, there were still some negative comments.

These comments mainly focused on the visual effect of the VR experience, in which some stated that the visual effect can make people dizzy at time, and others claimed that the graphic was not smooth enough. There were still others commenting on the VR HMD which should be made to fit better and more comfortable. While these concerns were important to hear, these issues can be resolved with the advancement and adjustment of the equipment. For instance, users can feel dizzy when using a HMD due to its low or fluctuating frame-per-second rate. However, using a more sophisticated graphic card with a highly specified computer can often solve this problem. In addition, Oculus Rift, which was used in the study, was still in the beta phase (SDK 2) and so was not fully tested and commercially available. Feedback like this can be useful for the modification of HMD VR experiences to help design experiences to better suit users' comfort levels.

In addition, we did not find a significant change in anxiety level among the participants pre and post the use of the HMD. This is encouraging when considering individuals with ASD tend to resist new experiences. For most of the participants in the study, this was their first time wearing a VR HMD. While they did not necessarily feel comfortable wearing a VR HMD, they did not feel it intimidating either. As a conclusion, ASD users appeared to not experience sensory issues from the use of VR HMD [20].

Lastly, participants reported high spatial presence, engagement and ecological validity within the VR environment. In other words, the experiences viewed through the HMD were seen as 'real' and could happen in real life. This is an important indicator if we are to continue investigating the use of VRTs for populations with ASD. After all, generalization of learning and integration into real life is the ultimate purpose for the intervention.

6. Summary

While on the one hand the results tend to reveal that HMDs and VRT might be a good fit for users with an ASD, on the other hand they should be interpreted with some caution. Here we refer to the small sample included in our study, the subjective and exploratory nature of our work, dosage (or exposure) to the VRTs, and the selection criteria for Phase II of the study. We would also suggest future work match/compare results with typically developing users to help to better contextualize findings.

Notwithstanding the limitations of this work (not aligned to typically-developing users, some possible selection bias, non-targeted interventions), the findings provide some insights to the manner in which people with autism experience HMD VRTs. As such, and due to the possible wide-spread uptake of these evolving technologies, we suggest HMD VRTs could stand to have a large and meaningful impact on how people with an ASD learn and test various skills in situ settings and could be developed as a way to overcome some challenges faced by these populations.

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