Vocational Training with Immersive Virtual Reality for Individuals with Autism: Towards Better Design Practices

Lal Bozgeyikli[1,*] Evren Bozgeyikli[1] Andrew Raij[2] Redwan Alqasemi[3] Srinivas Katkoori[1] Rajiv Dubey[3]

[1]Department of Computer Science and Engineering, University of South Florida

[2]Institute for Simulation and Training, University of Central Florida

[3]Department of Mechanical Engineering, University of South Florida

Abstract

In this paper, an immersive virtual reality system for vocational rehabilitation of individuals with Autism Spectrum Disorder (VR4VR) is presented. VR4VR uses immersive virtual environments to assess and train individuals with Autism Spectrum Disorder (ASD). This paper discusses lessons learned from the testing sessions with neuro typical individuals and individuals with ASD in regards to better design principles. During testing sessions, participants used VR4VR system to practice six skills identified as transferrable and useful in many common jobs. These six transferable skills were cleaning, loading the back of a truck, money management, shelving, environmental awareness and social skills. This paper presents VR4VR system, design considerations for the ASD population and lessons learned from the testing sessions with the aim of giving insight to future virtual reality systems for individuals with ASD.

Keywords: Virtual reality, vocational rehabilitation, autism spectrum disorder, design practices.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems— Artificial, augmented, and virtual realities; K.4.2 [Computer and Society]: Social Issues — Assistive technologies for persons with disabilities

1 Introduction

The US Census Bureau estimates that there are 54.4 million Americans that have some form of disability [1]. 64% of them are classified as having severe disabilities. According to the US Bureau of Labor Statistics, the employment rate of individuals with disabilities has a ratio of 3:10 as compared to the employment rate of individuals without disabilities [2]. However, more than 66% of the surveyed individuals with disabilities stated a desire to be employed [3]. Accessibility to proper, safe job training is a significant limiting factor in the employability of individuals with disabilities [4].

Virtual reality (VR) applications for training and rehabilitation have been increasing in recent years. Virtual reality offers several benefits to individuals with disabilities such as: (1) increased safety; (2) customization of training through creation of personalized scenarios and real-time individual-specific adjustments; (3) repetitive training opportunities; (4) real time smart prompts that are contextualized to the scenario at hand; (5) automated session recording, data collection, assessment and reporting; and (6) reduced transportation to training sites.

Although there are recommended design practices for virtual reality applications targeting neuro typical users, there are not well established design practices regarding individuals with ASD. Individuals with ASD may have different characteristics and needs than neuro typical users. Thus, previously studied design principles for neuro typical users may remain ineffective for this special group of individuals. This calls for research in the area of better design practices for virtual reality applications targeting individuals with ASD.

Our virtual reality system for vocational rehabilitation (VR4VR) originally aims to improve job training for three disability groups: Autism Spectrum Disorder, Traumatic Brain Injury and Severe Mobility Impairment. However, this paper focuses on the ASD audience of the system only. Previous work indicates that individuals with ASD that are trained repetitively with a customized program are more likely to attain and retain jobs that fit their unique skill sets and behaviors [5]. Our VR4VR thus aims to provide new opportunities to repetitively train and assess critical job skills in a safe, customizable environment.

Our VR4VR system is designed to offer vocational training in the form of transferrable skills that were selected based on their prevalence in the employment of the special groups of audience with disabilities. The vocational skill modules for individuals with ASD consist of cleaning, loading the back of a truck, money management, shelving, environmental awareness and social skills. An earlier version of our system can be found in [6]. While developing the system, several in-house testing and discussions with the specialized ASD job coaches were performed. After the system was iterated several times and ready for testing of the targeted audience, testing sessions with neuro typical individuals and individuals with ASD were performed. These testing sessions provided valuable insight on better design practices for training applications using virtual reality that focus on individuals with ASD.

2 Related Work

Applications utilizing virtual reality for training individuals with disabilities have been increasing considerably lately. Several studies show the effectiveness of immersive virtual reality as a training tool with successful transfer rates of skills from virtual worlds to real life [7, 8, 9].

Many studies focus on the use of virtual reality for children with ASD. Self et al. used a virtual reality environment to teach fire and tornado safety skills to children with ASD [10]. The participants were trained using either an integrated visual method or virtual reality. Josman et al. studied the effectiveness of virtual reality in teaching safe street crossing skills to children and adolescents with ASD [11]. The users controlled an avatar in a desktop virtual environment and tried to avoid cars while crossing a street. Maskey et al. focused on using virtual reality along with

*email: gamze@mail.usf.edu

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cognitive behavior therapy to reduce some phobia and fears in young people with ASD such as crowded buses and pigeons [12]. The authors developed a CAVE virtual reality environment and exposed the users to the feared stimulus gradually with an accompanying psychologist. Cheng et al. used immersive virtual environments to enhance social skills of children with ASD [13]. In the study, non-verbal communication, social initiations and social cognition aspects of social skills were explored.

There are also some studies that examined effective use of virtual reality in training adults with ASD. A study that concentrated on providing assistive prompts for individuals with disabilities related to job tasks, such as food preparation, was proposed by Chang et al. [14]. Mechling and Ortega-Hurndon used video based instructions to help individuals with disabilities in learning some job tasks [15]. Bian et al. utilized an advanced virtual reality driving environment to train individuals with ASD on driving skills [16]. The system collected real time physiological data and the difficulty level was changed on the fly accordingly. Smith et al. used an immersive virtual reality system for job interview training of individuals with ASD [17]. The system consisted of a desktop job interview simulation with virtual people.

All these previous works provided valuable insight and different perspectives on how to utilize virtual reality for training individuals with ASD. Results of these studies indicate that VR is a suitable medium for individuals with ASD to learn and train. Many studies also indicate findings on successful transfer of the learned skills afterwards. However, there are still many unclear aspects in designing effective virtual reality experiences for individuals with ASD such as: How should the tasks designed? Which virtual reality components are better to use? What are their preferences in virtual environments? How can we provide more comfortable VR environments for individuals with ASD so that they can benefit more from training? In this paper, we try to provide contribution towards better design practices for training applications for individuals with ASD that utilize virtual reality.

3 VR4VR System

Our VR4VR aims at training individuals with ASD on transferrable vocational skills in immersive virtual environments. The system was developed for adult users who are older than 18 years of age. The system is composed of the following hardware components: a Head Mounted Display (HMD); an optical motion tracking system with 12 cameras; a large 180^0 curved curtain screen; controllers; tangible objects equipped with optical markers that can be tracked real time by the system; and a tablet computer for remote control panel for the job coaches.

Our VR4VR system offers six different skill modules for vocational training of individuals with ASD: cleaning, loading the back of a truck, money management, shelving, environmental awareness and social skills. These six skills can be seen in Figure 1. Each skill module is structured to have three subtasks of increasing difficulty, each having their own three levels: (1) a tutorial level; (2) a training level without distracters; (3) a training level with distracters.

Tutorials are designed as animated virtual characters that first explain the trainee what needs to be done and then demonstrate the task. In designing the tutorials, the job coaches' advice and the previous studies stating demonstration as the best way to learn for individuals with ASD was taken into account [18, 19]. Figure 2 presents a screenshot from the tutorial level of the cleaning module. There are several virtual environments in which these skill modules take place such as warehouse, grocery store and outdoor parking lot.

Our VR4VR system utilizes various assistive prompts to help the users to remember how to perform the vocational tasks. In each level, if the user cannot perform the relevant task within a minute, a prompt is presented in the form of verbal instructions, pictographs and animations. These assistive prompts are designed to have brief verbal instructions and simple pictures, following the advice of the job coaches. In Figure 3, some assistive prompts used in our VR4VR system are presented.

Individuals with ASD may negatively respond in various ways to out of the routine common events such as chatting co-workers and some noises [20]. This may cause a shift in their attention and degrade their work performance. In the proposed VR4VR, we utilize a wide range of virtual distracters in the form of audio, visuals and animations such as chatting virtual coworkers, lightning and announcements. These distracters are both automatically applied and triggered by the job coaches in real time. This way, job coaches can assess the users' reactions to certain distracters and focus on some to practice for overcoming them or omit some if they think that the user will not be able to overcome these distracters.

Figure 1: Practicing vocational skills in immersive virtual reality. Top left: cleaning. Top right: loading the back of a truck. Middle left: money management. Middle right: shelving. Bottom left: environmental awareness. Bottom right: social skills.

To evaluate trainee performance based on the system parameters, a custom scoring algorithm was implemented. For the scoring algorithm, completion time, number of prompts given, and number of incorrect actions taken by the trainee were taken into consideration for each level. An automatically calculated score out of 100 is given for each level. The users are presented with their scores immediately after completing each level.

VR4VR provides the job coaches with a remote control interface on a tablet computer. Using this interface, they can control various parameters of the system such as: starting and stopping modules/subtasks/levels; taking notes; triggering distracters; reviewing trainee reports; keeping track of the elapsed time, remaining instances and scores.

Figure 2: A tutorial level of the cleaning module.

Figure 3: Examples of the assistive prompts used in the VR4VR system.

4 Lessons Learned

Testing sessions have been performed with 10 neuro typical individuals and 5 individuals with ASD. Neuro typical participants were aged between 20 and 49, with a mean age of 27.6 years. Participants with ASD were aged between 20 and 27, with a mean age of 23.2 years. Participants with ASD were diagnosed with Autism Spectrum Disorder. All participants with ASD were able to verbally communicate and use a joystick. All participants with ASD were classified to be on the high functioning side of the spectrum by the job coaches. Participants with ASD did not have any co-morbid disabilities.

Here, we present the lessons learned regarding the best practices in designing virtual reality training experiences for individuals with ASD. These are mainly based on the job coaches' comments and suggestions made throughout these testing sessions, suggestions of the users with ASD who tried the system, and observations of the authors made throughout the testing sessions. We have worked with six different job coaches, who are experts in vocational training of individuals with ASD, throughout the VR4VR project. These job coaches have been providing vocational rehabilitation services to individuals with ASD for many years. The job coaches have specialized knowledge in vocational training of low, medium and high functioning individuals with ASD.

- **Encouragement**

Using encouraging words such as "Good job!" and "Well done!" is very important for motivating individuals with ASD. We observed significant increase in the motivation of the participants with ASD when they heard such affirmative words both from the system and the job coaches. We did not observe such a positive effect in neuro typical participants. Although these words are very good for increasing the motivation of the users with ASD, the job coaches state that it is also very important to have a smooth transition in training applications. Since the users may not receive such positive feedback on every task they properly complete in real life, fading out the encouraging words as the training progresses is suggested to be a good practice, until a new skill is trained on.

- **Progress Tracking**

It gave the users comfort to know how many instances of the task remained. We observed that users with ASD often repeated out loud how many objectives they had. As the job coaches asked if they got bored, they answered no. The job coaches state that it is common in individuals with ASD to find comfort in routines and trackable processes. So it is suggested as a good practice to provide the users with ASD with their progress updates.

- **Orientation**

Some instructions might be confusing for individuals with ASD if they require two opposite actions. An example is if there is a table on the right side of the room and the user gets the instruction to reach the left side of the table, it may confuse individuals with ASD. We observed such confusion in participants with ASD while we did not encounter such an effect in neuro typical participants. It is a good practice to analyze all components of the system together while designing instructions, to avoid confusion caused by the environmental components.

- **Avoiding Negative Words**

Using words that might be misunderstood as being offensive turned out to be a bad practice. Our VR4VR presented the users with a visual stating "Subtask Failed" at the end of the levels that the users could not complete successfully. Users with ASD got noticeably upset when they saw this visual. The job coaches later stated that the users may have interpreted the phrase as "I am a failure" instead, and got discouraged. They advised us to use affirmative alternatives even in negative situations.

- **Using Bright Colors**

Some individuals with ASD had difficulty in distinguishing darker colors in the virtual environments. The job coaches state that it is better to use bright colors to get their attention when presenting important information. Maintaining good contrast between the background and the presented information is also a good practice based on our observations.

- **Using Human Voice Overs**

Some individuals with ASD get irritated by computer generated voices. Following the job coaches' advice, we changed all computer generated verbal instructions with human voice overs. Even if the user does not get irritated, the job coaches state that human voice overs would provide better transition to real life for individuals with ASD.

- **Gradually Increasing Difficulty**

To provide a comfortable and effective training environment for individuals with ASD, all job coaches agree on the importance of gradually increasing level of difficulty in tasks. We observed this effect on the users with ASD who tried our VR4VR's six different skills. The users more effectively trained on the skills that had more distinguishable gradual level of difficulty. On the other hand, the loading the back of a truck skill did not provide a comfortable training experience for individuals with ASD since it had a larger framework. Training the users on small aspects separately, then building on these small aspects is suggested to be a good practice for designing training experiences for individuals with ASD.

- **Brief Prompts**

When providing prompts and pictographs to individuals with ASD, being very brief is of utmost importance. Directions should be as short and precise as possible, breaking down the tasks. Otherwise, users with ASD might have difficulty in following the directions and stop following what is presented. In our VR4VR, simple pictographs that broke down the steps and gave clear directions such as “Do not throw fragile boxes from a large height” worked well while more general ones such as “Put all of the boxes inside the back of the truck” did not work well.

- **Consistency**

Individuals with ASD might give importance to certain out of context aspects, such as alignment of objects, when a task is learned. It is important to keep these aspects consistent throughout the experience. In our VR4VR’s shelving module’s second subtask, the labels were projected to the front of the boxes whereas in third subtask they were projected to the top. Many users with ASD tried to put boxes in the third subtask rotated so that their labels matched the orientation of the boxes in the second subtask. It did not make a difference in terms of task performance, but there has been confusion in the users which was not intended to be a part of the training.

- **Repetition**

The literature and the job coaches state that individuals with ASD benefit from repetition of a learned task for reinforcement. Repetitive tasks might seem boring for neuro typical individuals and designers may put effort into avoiding this. But for individuals with ASD, repetition provides valuable training; they might even feel more comfortable when presented with repetitive tasks. We observed this during the testing sessions of our VR4VR. Neuro typical individuals showed signs of boredom whereas individuals with ASD did not, when repeating the learned task several times.

- **Clarity and Literacy of the Instructions**

As we observed from the testing sessions and the feedback from the job coaches, the instructions should be as clear and literal as possible. We encountered some instances in which the users with ASD interpreted the instructions differently. This did not mean that their interpretations were wrong; they were just out of context for the designed tasks. An example was where the virtual instructor told the user to find the dry dirt piles and the user found a small dark spot on the texture on an environmental wooden prop and tried to vacuum clean it for a long time.

5 Conclusion and Future Work

This paper presents our VR4VR system, which utilizes six transferrable skill modules within immersive virtual environments for vocational training of individuals with ASD. Lessons learned from the testing sessions are shared. Individuals with ASD have different characteristics than neuro typical users. This calls for more careful design of virtual reality experiences considering their needs. Although more detailed and data based studies are needed to form a well-established literature in this area, this paper aims to contribute to the future virtual reality applications for individuals with ASD with shared lessons learned.

As future endeavors, a user study is currently being performed with individuals with ASD. After the completion of this user study, the system will be updated according to the feedback collected from the job coaches and the participants. In parallel, a user study for individuals with Traumatic Brain Injury is being performed and training modules for severe physical disabilities are being developed for VR4VR system.

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References

[1] M. Brault. Americans with disabilities: 2010. US Census Bureau, Census Brief, 2012. Internet: http://www.census.gov/prod/2012pubs/p70-131.pdf [Jan. 21, 2016].

[2] Persons with a Disability: Labor Force Characteristics. Internet: http://www.bls.gov/news.release/disabl.nr0.htm [Jan. 21, 2016].

[3] Empowerment for Americans with Disabilities: Breaking Barriers to Careers and Full Employment. Washington, DC: National Council on Disability, 2007. Internet: http://www.ncd.gov/publications/2007/Oct2007 [Jan. 21, 2016].

[4] Autism Speaks, Autism in Big Business Report. Internet: https://www.autismspeaks.org/sites/default/files/docs/qbe_large_business_report.pdf [Jan. 21, 2016].

[5] Autism Speaks, Family Services, Employment Think Tank. Internet: https://www.autismspeaks.org/sites/default/files/as_think_tank_exec_summary_web1.pdf [Jan. 21, 2016].

[6] L. Bozgeyikli, E. Bozgeyikli, M. Clevenger, S. Gong, A. Raij, R. Alqasemi, S. Sundarrao and R. Dubey. VR4VR: Towards Vocational Rehabilitation of Individuals with Disabilities in Immersive Virtual Reality Environments. In *Proceedings of Workshop on Virtual and Augmented Assistive Technologies (VAAT) at IEEE Virtual Reality*, pages 29-34, March 2014.

[7] M. J. Smith, M. F. Fleming, M. A. Wright, M. Losh, L. B. Humm, D. Olsen and M. D. Bell. Brief Report: Vocational Outcomes for Young Adults with Autism Spectrum Disorders at Six Months After Virtual Reality Job Interview Training. In *Journal of Autism and Developmental Disorders*, 45, pages 3364-3369, 2015.

[8] A. Leonard, P. Mitchell and S. Parsons. Finding a place to sit: a preliminary investigation into the effectiveness of virtual environments for social skills training for people with autistic spectrum disorders. In *Proceedings of the 4th International Conference on Disability*, pages 249-257, 2012.

[9] J. Cromby, P. Standen, J. Newman and H. Tasker. Successful transfer to the real world of skills practised in a virtual environment by students with severe learning difficulties. In *Proceedings of the 1st European Conference on Disability, Virtual Reality and Associated Technologies*, pages 93-101, 1996.

[10] T. Self, R. Scudder, G. Weheba and D. Crumrine. A Virtual Approach to Teaching Safety Skills to Children with Autism Spectrum Disorder. In *Topics in Language Disorders*, Volume 27 No. 3, pages 242-253, June 2007.

[11] N. Josman, H. Ben-Chaim, S. Friedrich and P. Weiss. Effectiveness of Virtual Reality for Teaching Street-Crossing Skills to Children and Adolescents with Autism. In *International Journal on Disability and Human Development*, 7, pages 49-56.

[12] M. Maskey, J. Lowry, J. Rodgers, H. McConachie and J. R. Parr. Reducing Specific Phobia/Fear in Young People with Autism Spectrum Disorders (ASDs) through a Virtual Reality Environment Intervention. In *PLoS ONE* 9(7), 2014.

[13] Y. Cheng, C.-L. Huang and C.-S. Yang. Using a 3D Immersive Virtual Environment System to Enhance Social Understanding and

Social Skills for Children With Autism Spectrum Disorders. In *Focus on Autism and Other Developmental Disabilities*, pages 1–15, 2015.

[14] Y. Chang, L. Chou, F. Wang and S. Chen. A kinect-based vocational task prompting system for individuals with cognitive impairments. In *Personal and Ubiquitous Computing*, 17, 2, February 2013.

[15] L. Mechling and F. Ortega-Hurndon. Computer-based video instruction to teach young adults with moderate intellectual disabilities to perform multiple step, job tasks in a generalized setting. In *Education and Training in Developmental Disabilities*, 42, pages 24–37, March 2007.

[16] D. Bian, J. Wade, L. Zhang, E. Bekele, A. Swanson, J. Crittendon, M. Sarkar, Z. Warren and N. Sarkar. A novel virtual reality driving environment for autism intervention. In *Proceedings of the 7th international conference on Universal Access in Human-Computer Interaction: user and context diversity* - Volume 2 (UAHCI'13), pages 474-483, 2013.

[17] M. Smith, M. Fleming, M. Wright, M. Losh, L. Humm, D. Olsen, and M. Bell. Brief Report: Vocational Outcomes for Young Adults with Autism Spectrum Disorders at Six Months After Virtual Reality Job Interview Training. In *Journal of Autism and Developmental Disorders*, 45(10), pages 3364-3369, 2015.

[18] D. Hagner and B. Cooney. I Do That for Everybody: Supervising Employees with Autism. In *Focus on Autism and Other Developmental Disabilities*, Volume 20-2, pages 91-97, 2005.

[19] E. Notbohm. 10 Things Your Student with Autism Wishes You Knew. In *Children's Voice* Volume 14 Issue 3 Page 34, 2005.

[20] D. Hendricks. Employment and adults with autism spectrum disorders: Challenges and strategies for success. In *Journal of Vocational Rehabilitation*, Issue 32, pp125-134, 2010.