Social Skill Focuses of Virtual Reality Systems for Individuals Diagnosed with Autism Spectrum Disorder; A Systematic Review

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A systematic review of virtual reality (VR) systems for individuals diagnosed with autism spectrum disorder (ASD) is detailed. The aim of this proceeding is to determine which social skills focuses are most important and how their potential improvements should be measured. Following the PRISMA guidelines, 48 articles were identified, and a total of 12 articles that met the a priori criteria were given full review. All 12 studies aimed to train some social skill, but there was no agreement among which single theme was most essential. The ones that received the most attention were facial expression and emotion recognition, appropriate behaviors and responses, and initiating social interactions. Only 9 studies used direct measures to assess changes made as a result of the VR systems. The ones most commonly used were subjective measures and participants' body movements and gestures. The collective impacts and limitations of the studies are presented, as well as implications for future work.

INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disability that can negatively impact a person's everyday interactions, being something as simple as difficulty in maintaining eye contact to the inability to feel empathy for another individual. As the name implies, there is a large range over which diagnosed individuals can be categorized; however, common themes across the entire spectrum are evident. The single most noticeable impairment in those diagnosed with ASD lies in their social interaction skills. Social interaction is imperative for navigating through the world professionally and socially. Not only does social interaction have the benefit of enabling the acquisition of a larger network of familiar people; it also allows humans to act appropriately among different social situations, which then allows them to feel more secure and accepted by those in their environments (Vera, Herrera, & Fernandez, 2017). Unfortunately, people with ASD show a consistent pattern of misinterpreting or ignoring otherwise important social cues. These social cues involve difficulty in maintaining eye contact (Didehbani, Allen, Kandalaft, & Chapman, 2016), irregular eye-gaze and fixation patterns (B & Lahiri, 2016), extreme hesitation in introducing oneself to a peer (Ambrose, 2015), and problems in recognizing another person's affective state (Bekele, Zheng, Swanson, Davidson, Warren, & Sarkar, 2013).

In-person psychotherapy, such as cognitive behavior therapy (CBT), has been a large proponent in treating individuals with ASD by teaching and practicing social skills in safe environments with a trusted psychologist. These one-on-one sessions have been effective in showcasing improvements in various social skills in those with ASD. Nonetheless, as with the nature of human curiosity, the topic of more-effective and faster therapies has been an area of discussion. The current trend for more-immersive and -interactive therapies has pointed towards virtual reality (VR).

With the rise of technology usage and a push for more realistic training systems, VR has gained a great deal of attention. VR involves the use of realistic computer-generated animations and a deeper level of immersion. VR has become very popular because of its potential to facilitate learning beyond the physical dimensions to which humans are confined (Halabi et al., 2017). Many industries have begun to incorporate VR into their training programs, particularly in aviation and other military domains. VR has even infiltrated the commercial market, with viewing devices now being a more-accessible add-on device to mobile phones and video game systems.

Important to this work is the fact that VR has been studied in training social skills for individuals diagnosed with ASD. With the flexibility and projected effectiveness that VR advertises, it is expected to be able to replace, or at least aid, one-on-one CBT lead by a psychologist (Milne, Luerssen, Lewis, Leibbrandt, & Powers, 2010). VR is eagerly proposed as a viable training method for individuals diagnosed with ASD because of the population's affinity towards visual imagery and sounds (Bozgeyikli, Raij, Katokoori, & Alqasemi, 2017). Because people with ASD have difficulty maintaining eye contact with others, VR systems can simulate faces and tune their realism to better cater to the visual imagery that people with ASD prefer and respond best to. This offers the advantage of having a personalized VR experience, which may help catalyze the application of social skills training to real-world applications. As with the motivation to speak to psychologists who practice CBT, VR training designers are enthusiastic to seek feedback from teachers of individuals with ASD and other learning disorders to determine the usability and potential acceptance of these systems (Nussli & Oh, 2016). Their feedback has reinforced positive attitudes towards VR as a mechanism for therapy. Another advantage of VR training is that it offers a safe and supportive environment to learn and practice social skills. This is important for people with ASD because they tend to engage in repetitive behaviors, which would be difficult to practice in the real world; any increased anxiety from such social pressure could drastically impede their abilities to learn and perform well (Didehbani et al., 2016).

Bozgeyikli et al. (2017) performed two systematic reviews concerning (1) the design guidelines for VR systems for individuals diagnosed with ASD and (2) the common characteristics of these VR systems. These guidelines included information on topics directly pertinent to the display and

design of the VR systems, such as whether or not bright colors should be used, to which three-dimensional animations those with ASD respond best, and if sounds should be loud and salient or soft and quiet. The common characteristics found in present VR systems for people with ASD included social-skills and life-skills training. While the current data collected on guidelines of how to structure a VR system are helpful, a review of *what* should be included in these VR systems and *how* improvements should be assessed is lacking.

There has been obvious and welcomed enthusiasm in the movement towards utilizing VR to train social skills in individuals with ASD, but the rush to create these VR systems may have undermined their usefulness. The specific social skills themes that these VR training systems should focus on has been overlooked; and as an unfortunate consequence, measures for potential improvements in those diagnosed with ASD via these VR systems has been largely neglected. Without a consensus on what social skills to train and how to measure the changes made by the VR systems, there is little need for these training programs. The value of these VR systems is in showing improvements in the social skills of those diagnosed with ASD, to the extent to which they can offer a replacement to or be a supportive tool in traditional CBT. Without directing the efforts of the design of these VR systems towards people with ASD, we cannot confidently say that these training systems are any better than traditional one-on-one CBT facilitated by a live psychologist.

Goals

As a result, the goals of this systematic review are to determine (1) the most important social skills that VR systems should aim to train in order to maximize the potential improvements in individuals diagnosed with ASD, and (2) the most helpful measures that would best assess the changes made by these VR training systems.

METHOD

The method for acquiring journal articles followed the PRISMA format (Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G., 2009). Journal articles were found through searches in the following databases: Engineering Village, ScienceDirect, IEEE Xplore, and Google Scholar. The keywords used to filter the results were *autism*, *virtual reality training*, and *social skills*. A systematic collection and review of the articles was completed in October 2017. After a preliminary search, the titles and abstracts of each article were filtered through precise inclusion and exclusion criteria. Only the articles that fulfilled these criteria were fully evaluated.

Inclusion criteria. Articles were included in the systematic review if they (1) discussed virtual reality systems; (2) targeted the ASD population; (3) focused on social skills training; and (4) involved some type of pilot, usability, or comparative study.

Exclusion criteria. Articles were excluded if they (1) only involved augmented reality systems, (2) were duplicates, and (3) were not in the English language.

RESULTS

Following a preliminary search that resulted in a total of 48 articles, a search that removed duplicates and only included articles in the English language retrieved 25 articles. Out of these 25 articles, only 12 were given an in-depth full-text review and are included in this systematic review.

Exclusion data. Of the 25 articles that were given title and abstract reviews, 13 were excluded for a variety of reasons, such that they did not target the ASD population, only involved augmented reality (AR) systems, tested something other than social skills (i.e., driving skills via driving simulator training), or were duplicates of previously included or excluded articles.

Inclusion data. The 12 articles that were fully reviewed were divided into two inclusive groups, meaning that they could be a member of one or both groups. The first group consisted of all 12 articles, which discussed the specific social skills that the VR systems measured. The second group consisted of 9 of the 12 articles, which described what methods were used to measure participants in evaluating their social skills (Table 1).

Table 1. Presence of Social Skills and Participant Measures

Measures	no. of studies
VR training system measures	**12**
facial expression/emotion recognition	5
appropriate behaviors/responses	5
initiating social interaction	4
dealing with a bully	3
task completion	3
introducing self	2
lowering anxiety	2
joint attention	1
Imagination	1
Participant measures	**9**
subjective measures	5
body movement and gestures	4
eye gaze	3
facial expression	3
physiological responses	1

VR social skills focuses. All 12 articles discussed some aspect of a social skill that their VR system aimed to measure and improve in those diagnosed with ASD. A total of five of the studies focused on facial expression or emotion recognition, emphasizing the importance of being able to judge another person's affective state. These studies used computer-generated faces that expressed neutral and expressive faces, and participants would have to determine which emotions the characters were feeling (Figure 1). A total of five of the studies highlighted appropriate behaviors and responses to social situations, primarily as a function of the emotions of others that were perceived in the social scenarios. Four studies aimed their efforts towards having ASD participants initiate social interactions, such as learning how to start a conversation with a peer. Three studies involved tasks in which participants had to deal with a bully, whether it was directly or in consoling a peer who had been bullied. Three studies measured task completion

in terms of the correct and incorrect number of actions, number of times a participant needed external help from a hint cue or the experimenter, and task completion time. A pair of studies focused on having participants introduce themselves to others in either a group setting with peers and a teacher or other facilitator or a single other age-appropriate individual. Another pair of studies emphasized the need to lower the anxiety that many individuals with ASD experience when put into social situations, as it is not conducive to their learning. Joint attention and the use of imagination in ASD participants were each studied in one article.

Participant measures. Only 9 of the 12 studies operationalized their indication of social skills improvement from a VR system through a participant measure. A total of five studies utilized subjective measures in which participants responded to questionnaires or interviews about their own performance, enjoyment, and perceived competence while interacting with the VR systems. A total of four studies looked at the body movements and gestures that ASD participants exhibited in response to different parts of each task, determining whether they had appropriate responses and if they were engaged with the particular VR system. Three studies directly measured eye-gaze to locate where ASD participants were focusing their attention. These eye-gaze measures included 2D coordinate fixations, fixation duration, pupil diameter, and average blink rate (Figure 2). A total of three studies analyzed the facial expressions of ASD participants while they were interacting with the VR systems to evaluate their levels of interest and enjoyment of the tasks. A single study directly measured physiological responses from ASD participants, such as their electrocardiogram results, skin temperatures, and respiration rates and patterns.

Figure 1. Realistic faces to test participants' emotion recognition (adapted from Milne et al., 2010).

DISCUSSION

Based on the current research in VR systems that train social skills for individuals diagnosed with ASD, there is large variation in which specific social skills should be targeted and how they should be measured. All 12 articles presented at least one particular social skill that they focused on teaching and practicing with people with ASD. However, no single common social skill theme received attention from all 12 studies. Furthermore, of the 12 articles, only 9 used some direct measure to assess whether the VR training caused any improvements in the social skills of ASD participants. A single participant measure was utilized by a majority of the 9 studies, but again, no single common participant measure was found in all 9.

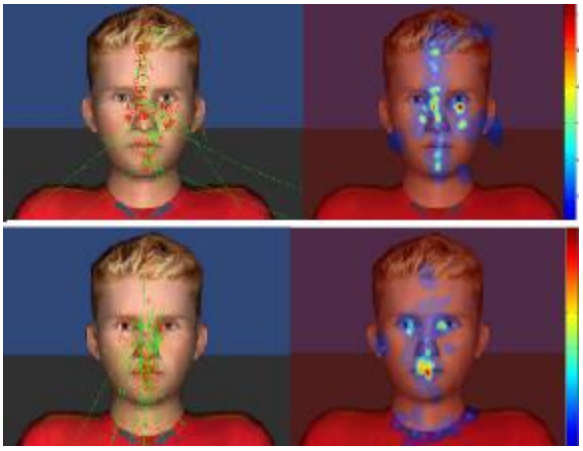

Figure 2. Eye-gaze heat map of an ASD participant (above) and a typically developing participant (below) (adapted from Bekele et al., 2013).

VR social skills focuses. Five of the studies emphasized the importance of facial expression and emotion recognition and of appropriate behaviors and responses in social situations. These data are very important because they reinforce the need for the ability to assess social situations and in knowing how to properly react to them; this is of great concern for individuals with ASD because they often have trouble doing either. Initiating social interactions, dealing with a bully, and introducing oneself to a peer received moderate attention and were the three main interactive tasks involved in any of the VR systems. Unexpectedly, dealing with a bully was a social-skills focus present in more studies than introducing oneself to a peer. In understanding the capabilities of a person with ASD, the majority of effort should be spent on improving the most basic social skills; therefore, it seems that introducing oneself to another person is more quintessential to an ASD individual's social skills set than dealing with a bully, which is much farther in the range of necessary social skills – even typically developing children have difficulty dealing with a bully. This stronger focus on dealing with a bully is inconsistent with the fundamental social skills that people with ASD often seek to acquire and should have received less attention, especially in comparison to more-imperative skills, such as introducing oneself to a peer. A pair of studies emphasized the importance of reducing the amount of anxiety that individuals with ASD feel when they are put into social situations. Minimizing anxiety allows those with ASD to shift their attention to learning rather than feeling uncomfortable and distracted. This shift increases their understanding of what they are being taught and leads to a greater likelihood of transferring information practiced in the VR systems to real-world social scenarios. For this reason, it is perplexing that anxiety reduction was not a more-common theme among the reviewed studies. Interestingly, only one study explicitly noted the significance of joint attention. Joint attention is an important indicator that a person understands the social situation and can direct his or her attention toward what someone else is referring to. This is an

essential social skill that many individuals with ASD seek to practice and have, and it should have been included in more studies and VR systems. Another study looked at the use of imagination in ASD participants. Discovering this social skill concentration in one of the studies was quite surprising because, as mentioned before, the expected social skills focuses should be those that are most fundamental, and imagination is not one of those fundamental social skills. While it is a step towards more-advanced and more-flexible social skills, it is not one of the absolutely necessary ones that people with ASD often seek to practice above all others. In that respect, it makes sense that imagination was only found in one study, but its relevance and prevalence in a VR system as part of the skillset for those with ASD is questionable.

The lack of consensus among the social skills themes in the 12 studies shows that the current VR systems that have been designed to improve the social skills of individuals with ASD are still in their early stages. Being a relatively newer technology, especially in the attempts to replace or minimize one-on-one CBT, the present VR systems have pushed their efforts towards usability rather than testing their effectiveness. There is a lot of room for growth and improvement, and hopefully, the future advancements of these VR systems will shift their attention towards what their VR systems are offering in terms of treating rather than simply using.

Participant measures. Many (five) of the studies involved subjective participant measures, such as questionnaires and short interviews. Although subjective measures can provide a wealth of knowledge of the participants' points of view of their performance and overall enjoyment of VR systems, they suffer in that they do not directly measure operationalized items. Similarly, three other studies looked at participants' facial expressions in response to different parts of the VR tasks in order to assess their satisfaction and engagement with the system. A reason for the present popularity of these subjective measures and interest ratings is likely a reflection of the current trend, which is a focus on enjoyment. If the goal of a VR training system is to evaluate whether or not it will interest participants, then subjective measures become very valuable. However, more-objective measures should have been collected simultaneously with the subjective measures in the studies to offer more than just an indication of enjoyment. Fortunately, a few studies (four) utilized objective measures, such as participants' body movements and gestures, eye-gaze patterns, and facial expressions in understanding performance rather than satisfaction. One other study directly measured participants' physiological responses during VR tasks. These direct measures included diagnostics such as heart rate, pulse, skin temperature, and respiration (Bekele et al., 2013). Direct objective measures offer more information in determining how participants are reacting to the social scenarios in the VR systems, widening the possibility for manipulating the effects of the VR training. This information can be beneficial for two reasons: (1) it allows experimenters to collaboratively agree on which social skills need the most attention, and (2) because they are objective measures, experimenters can manipulate the VR systems to produce operationalized improvements in social skills. Without the ability to measure the potential improvements a VR system has on the social skills of individuals with ASD, the VR system becomes useless; having the same value as a high-visual-load display that neglects the opportunity to challenge and educate the user. For these reasons, objective measures should have been a more-common finding among the studies reviewed. Because there is currently little research using these direct measures, their order of importance is difficult to rank. With future work, the most-indicative measurements of changes in social skills by way of VR training should be identified.

There is a clear lack of consensus among participant measures themes, and the most common ones herein have been directed towards user enjoyment rather than the actual aim of these VR systems, which is to improve the social skills of those with ASD. The reason for this finding is the same as the one for the large variability in social skills focuses. The current trend of VR in practicing social skills with individuals with ASD is still in its first stages. The present goal of these VR systems is simply to produce enjoyable and interactive scenarios. This goal is even reflected in the number of comparative studies that have been performed measuring the actual effects of these VR systems on ASD participants' social skills. Only two studies were comparative in nature, examining the differences between performance on variations of VR training systems (e.g., VR on a desktop with a screen and mouse against immersive VR with a head-mounted display). Nevertheless, given the few studies that have employed objective measures, a shift toward examining how to assess improvements as a result of VR training is expected as more VR systems are created and tested. Further work in this field should collect data from both subjective and objective measures to represent a more complete picture of what these VR systems are truly doing.

CONCLUSION

This systematic review condensed the current research on VR training systems for social skills in the ASD population, highlighting the themes of social skills focuses and participant measures. There has been a positive push towards utilizing VR as a means of learning for individuals diagnosed with ASD, and studies have shown promise in their applications. However, it is apparent that there is no consensus concerning which social skills and participant measures are the most important and should receive the most attention in implementation into a VR training system for people with ASD. At this time, there are a myriad number of these systems, but they each target a variety of different social skills. This variation may be an opportunity to train many different social skills, but it implies that we currently lack a single complete design that truly targets all of the most necessary social skills to teach individuals with ASD. With this finding, we cannot confidently say that VR training can replace or greatly aid traditional face-to-face CBT with a live on-site psychologist.

Limitations

Although there has been great enthusiasm in creating VR training systems for the ASD population, there are several

limitations to the present studies. It seems that the current trend is mainly focused on *developing* VR training systems. Many studies have reported their findings on what creates a good VR training system without providing support from a comparative experiment to see exactly how effective they are. Without testing the effectiveness of such VR training systems with the ASD population, there is little evidence in the need for their existence. The few studies that did implement comparative experiments provided richer knowledge in the feasibility of VR training systems for the ASD population; however, they themselves had limitations as well. The comparative experiments utilized rather small sample sizes, typically consisting of 4 to 10 ASD participants in the age range of 9 to 15 years old. Of all participants across the studies, all but one were categorized as high-functioning on the ASD scale. Such a small and limited representation of the ASD population makes it difficult to generalize the findings to real-world applications.

Future Work

It is worth noting the rising interest in Augmented Reality (AR). AR is behind VR in terms of technology, but it also offers great promises in this area and should be studied further.

In reviewing the present studies and their results and limitations, it is evident that there is a large opportunity for growth in the field. Implications for future studies include more comparative experiments that show the capability for improving socials skills in those diagnosed with ASD. Larger sample sizes, a more-diverse age range, and accounting for the entire spectrum, rather than only for those categorized as high functioning, are also greatly encouraged. Overall, a distinct shift in focus to identifying the particular social skills and participant measures that are most necessary for improving social skills in individuals with ASD must be accomplished. This will guide the design of these VR systems to developing social skills training that is more effective than, or at least a supportive mechanism to, traditional CBT.

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