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VIRTUAL REALITY SUPPLEMENT TO THE PEERS SOCIAL SKILLS INTERVENTION  
FOR ADOLESCENTS WITH ASD

by

Kevin Ambrose

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2022

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Virtual Reality Supplement to the PEERS Social Skills Intervention for Adolescents with ASD

by

Kevin Ambrose

This manuscript has been read and accepted for the Graduate Faculty in the Educational Psychology program in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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**ABSTRACT**

Virtual Reality Supplement to the PEERS Social Skills Intervention for Adolescents with ASD

by

Kevin Ambrose

Advisor: Bruce D. Homer

The purpose of this study was to replicate findings of the Program for the Education and Enrichment of Relation Skills (PEERS) parent-assisted social skills training program for a diverse group of adolescents with historical autism spectrum disorder (ASD) diagnoses in an urban locality. Additionally, this study sought to pilot a 3D multi-user virtual environment for adolescent participants and an online learning community for parent coaches; both hypothesized to reinforce the social skills curriculum. A randomized controlled trial of PEERS was completed with 12 adolescents diagnosed with ASD with some participation from their caregivers. Results show that participants who received the intervention had higher scores on social skills assessments, reduced autism spectrum symptomatology, and less problem behaviors as compared to the control group. Participants were able to navigate the online learning community and complete simple tasks in the 3D virtual environment throughout the intervention. Implications for practitioners and families were considered.

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## CHAPTER ONE

### Introduction

Students who successfully navigate their social settings are more likely to succeed academically and professionally (Hillier et al, 2007). Individuals with autism spectrum disorder (ASD) generally present with social communication and social interaction difficulties (American Psychiatric Association, 2013). For adolescents, all too often, these difficulties result in social isolation; teasing and rejection by peers; experiencing victimization; vocational failure in adolescence and adulthood; and high dependence on other adults for support (Hillier et al, 2007). Additionally, Denning (2007) reported concerns with employment, personal relationships, and independence for individuals with ASD. In a survey done by Bernard et al. (2001) in 2001 of UK parents who had adult children with ASD, 70% of a sample of 450 parents believed that their children would not be able to live independently without support and only 12% of a sample of 450 adults with a diagnosis of autism and average to above average intelligence were employed full-time. Recent studies continue to echo these results. For example, Chiang et al. (2013) described several studies reporting with low rates (<50%) of employment for adults with ASD.

Evidence supports conceptual models of autism that posit difficulties with theory of mind, the ability to infer the mental states of others, as a core cognitive difference of ASD that is partly responsible for social difficulties that individuals experience (Livingston et al. 2019). Despite these differences some individuals with ASD may develop and employ compensatory or alternative strategies that allow them to have better-than-expected social outcomes as predicted from their sociocognitive ability (Livingston et al., 2019). Executive functions, cognitive

processes involved in the control and regulation of behavior, are thought to be implicated in these compensatory processes. For example, Livingston et al. (2019) found that high compensators tended to be individuals scoring higher on executive functioning measures.

As social skills difficulties can have several negative consequences for this population, several interventions have attempted to target these skills with varying success. For example, Denning (2007) reported that Social Stories, group interventions, and peer-mediated interventions were generally effective, but drawbacks of these interventions included issues with maintenance and generalization of treatment gains. Recent reviews have highlighted additional issues that exist with current interventions including failure to assess long-term effectiveness, an absence of measures assessing intervention fidelity, neglect in collect participant data outside the experimental setting, inadequate baseline periods, no predetermination of skills needed at outset to facilitate comprehension of the intervention offered, lack of diversity in participants treated, and issues generalizing study gains to environments other than the intervention training environment (Bellini et al., 2007; Wolstencroft et al., 2018; Veytsman, 2020).

The *Program for the Education and Enrichment of Relational Skills* (PEERS) for Adolescents social skills intervention developed by Laugeson et al. (2009) has demonstrated consistent success with adolescents diagnosed with ASD. However, the PEERS intervention has primarily been studied with predominantly White participants, and with inconsistent ASD diagnostic verification. This study aimed to assess PEERS in a metropolitan setting, with a diverse population for which all individuals have had verified ASD diagnoses. Additionally, to potentially enhance the effectiveness of the PEERS intervention and attempt to address issues of generalizability, two additional components were tested in this study.

While several PEERS replications have examined the long-term effects of the intervention, and some have recently begun to use teleconferencing software to deliver the intervention, none have explored the use of virtual environments, to potentially enhance the intervention. Virtual environments allow researchers to create realistic three-dimensional representations of worlds in which there can be unlimited repetitions of a program, personalization of the content and user experience, adaptive prompting and instruction, and reduced consequences for poor task performance (Bozgeyikli et al., 2018; Parsons, 2016; Smokowski & Hartung, 2003). Virtual environments offer a distinct number of advantages that are of particular use when working with individuals with ASD. For example, individuals diagnosed with ASD may benefit from the interactive consistency of computer-based characters, the primacy of text-based communication in VR provides them with additional time to compose responses, and the inherent delays in responding may improve planning and inhibition during communicative exchanges. Several studies support the use of virtual environments and simulations with this population, and those studies have shown promising results (for a review, see Bozgeyikli et al., 2018).

Additionally, no PEERS study has explored the use of an online course in which parent coaches could share information, access intervention materials and resources, and seamlessly contact the intervention team for assistance. This was included to potentially increase parent engagement and facilitate communication with the intervention team and increase access to PEERS content (i.e., lessons, homework, call lists, etc.). This study sought to determine if these additional features would be beneficial to participant outcomes.

Broadly, this study involved recruiting adolescents with ASD as well as their caregivers, and randomly assigning them to a waitlist delayed treatment condition or an immediate treatment

condition. During the treatment condition, participants completed 16 weeks of the PEERS group social skills intervention which consisted of didactic instruction and social roleplays for adolescents and training the caregivers to troubleshoot issues with homework and serve as coaches for their child between intervention sessions. Adolescent participants were also instructed to complete quizzes and practice social roleplays in a virtual environment, while their caregivers were instructed to review the intervention content and share best practices and resources in an online course.

The primary cognitive science principle that guided this design project is the theory of situated cognition (Brown et al, 1989). Under this theory, declarative and procedural knowledge are integrated within a single framework and knowledge accrues within the activities, contexts, and culture within which it is learned. Concepts related to situated cognition that are present within this design project include means of establishing legitimate peripheral participation which involves cognitive apprenticeships, anchored instruction, developing a learning community, and assessment in situ. These concepts are further described below.

According to Driscoll (2005), legitimate peripheral participation is a concept understood as defining ways of belonging to a community of practice. Individuals using the *Virtually Augmented Social Skills Training* program were integrated into the community of the virtual environment in which the project occurs through tutorials with the software, instruction from the researchers, and shared knowledge transfer with peers. For example, individuals who partook in the study were required to take a tutorial guided by a research assistant. In the tutorial, which took place in the virtual environment, the research assistant helped participants create an avatar and perform tasks that would be part of the intervention (e.g., taking quizzes to test their

knowledge). Throughout the 16-week intervention, participants collaborated with peers to perform social roleplays while receiving direct social skills instruction as described below.

Cognitive apprenticeships also occurred with participants learning from fellow PEERS participants in the research lab and from research assistants within the virtual environment. These interactions allowed a participant to explore the resources available to them within the virtual environment and become embedded members of the community of learners involved in the study. These apprenticeships were well planned and monitored with the interactions with computer agents, peers, and researchers being scripted to the greatest extent possible. Moreover, interactions between the participant-apprentices and “masters” under this apprenticeship model were made to reflect interactions that the participant will encounter in real life situations.

Anchored instruction, which uses “anchors” (e.g., cases, stories, or situations) to facilitate instructions, occurred in each session with the participant viewing a role-play scenario and being asked to develop possible solutions for a problem presented within the scenario (Yilmaz, 2011). Moreover, the participants were invited to explain the solutions that they created for different problem situations and the consequences that they believed would occur for the solution presented.

Participants in this study were members of a learning community and had opportunities for reflection and peer review at the end of each session. For example, at the end of each session, the researchers restated the goal(s) that the participants were engaged in completing, summarized the results of the session, and asked participants to reflect on their participation. Overall, this study used a constructivist approach in which the participants worked as social actors and participated within the microworld of the virtual environment that was created for their social skills training. Participants became part of a community of learners and, even when outside of

the lab setting, they had access to learning materials. For example, participants were able to access a private island to practice role-plays, test their knowledge, or ask questions about the skills they were acquiring as they wished. Lastly, participants accessed Moodle, an open-source learning management system, through a secure website to view PEERS materials, post helpful information, and revisit any PEERS sessions they had completed.

This study employed a virtual environment to help address issues of poor generalization of social skills improvements noted in the social skills literature. The theory of situated cognition provides the basis for which this project is designed and concepts stemming from this theory are present throughout the design of this project.

The study tested the PEERS for Adolescents intervention, which is designed to promote social skills in middle and high-school students with ASD. The balance between laboratory control and naturalistic tasks for participants is a main concern for social skills researchers. VR has the potential to provide an ecological approach to the assessment of the PEERS intervention by assessing social behavior with tasks that are representative of real-world skills, and, therefore, possibly increasingly predictive of real-world performance. Additionally, virtual assessments bolster efforts to lessen reliance on self-and parent-report measures that are potentially biased as well as decrease the amount of effort to conduct assessments. Importantly, VR interventions have the potential to reach adolescents and families in areas that are without trained therapists and are generally cost-effective in regard to short-term and lifetime intervention costs. Lastly, virtual environments offer tirelessly, consistent instructors in the form of computer-based agents and scripted interactions; can offer game-like rewards for task completion; and offer controlled environments in which participants can safely practice their skills with prompt feedback (Bekele et al., 2016). A virtual environment named *OpenSimulator* was employed to test the research

question: does using a virtual environment in a social skills training study lead to improved generalizability of potential study gains relative to the results as reported in previous PEERS studies? Moreover, this study aimed to explore the use of virtual technology and its effects on the motivation and engagement of study participants from pretest to posttest. This study evaluated the ability of technology to create a community of learners and determine whether total interactions with the online learning environment (a Moodle course) was related to participant social improvements.

The study occurred in a laboratory environment for 16-weeks. Each intervention session lasted for 1.5 hours and occurred once a week. As a design research project, during and after the intervention, feedback from participants was obtained to aid in improving the design of future iterations of the *Virtually Augmented Social Skills Training* program.

To summarize, the study was designed to address the following research questions:

1. Can the significant findings of previous PEERS studies be replicated in an urban, metropolitan setting?
2. Does the use of a virtual environment lead to increased effects of the PEERS intervention relative to previous PEERS studies?
3. Does the use of a virtual environment lead to increased motivation in the PEERS intervention as compared in treatment and wait-list control groups?



## CHAPTER TWO

### Literature Review

#### Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a complex developmental disability that involves two primary diagnostic criteria. The first is persistent difficulties in social communication and social interaction across multiple contexts such as deficiencies in social-emotional reciprocity; nonverbal communication behaviors used for social interaction; developing, maintaining, and understanding relationships. The second is restricted, repetitive patterns of behavior, interests, or activities that include two of the following: stereotyped or repetitive motor movements; insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior; highly restricted, fixated interests that are abnormal in intensity or focus; or hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (American Psychiatric Association, 2013). These symptoms may be present from early childhood and limit or impair everyday functioning.

Incidence measures the number of new cases of a disorder in a specific time period, divided by the number of persons at risk for the disorder during that time period. Prevalence measures the number of diagnosed persons within a population in a specific time period, divided by the total persons in the population in that time period. The prevalence of ASD has increased dramatically in the last 20 years rising from 1 in 150 children to a current estimate of 1 in 54 children in the U.S. according to the Center for Disease Control and Prevention (Maenner et al., 2020). Studies of incidence and studies of successive birth cohorts had previously indicated that incidence rates had not changed significantly over this time frame, though new evidence suggests that the cumulative incidence rate of ASD may rise in the future (Schendel & Thorsteinsson,

2018). There are several possible explanations for the increase in prevalence. For example, Taylor (2006) reported that research has shown that, in some populations, diagnostic substitution has occurred in which diagnoses of intellectual disability have decreased in concert with an increase of ASD diagnoses. This may be due to ASD developing into a less stigmatizing and socially acceptable disorder. In addition, legislative changes partly explain increases in prevalence as they resulted in increased entitlement to services as well as changes in definitions of disorders and impairments (Taylor, 2006). Revised diagnostic criteria, better diagnostic tools, and an increased awareness of the disorder may also be partially responsible for increased prevalence (Taylor, 2006).

The etiology of Autism is presently not fully understood and presents a complex problem for researchers as a mix of environmental and genetic risk factors have been implicated (Gyawali & Patra, 2019). Large gender differences and a high male to female ratio of diagnosis has been a hallmark of ASD, with some studies reporting ratios as high as 5:1 (Ferri et al., 2018). Several theoretical explanations for these differences exist including sex hormones, differences in immune function, and underreporting and under-diagnosis of females with ASD (Ferri et al., 2018). As with etiology, interactions between sex, genes, and the environment may be responsible for the male bias seen in the ASD literature. Unlike the etiology, the symptomatology of ASD is well established. ASD is characterized by difficulties in the domains of social communication and behavior functioning.

### ***Core Deficits***

Much of the ASD literature highlights core problem areas such as impaired social interaction and communication; stereotyped repetitive behavior; limited engagement in meaningful repetition; gaze following difficulty; poor Theory of Mind (ToM) performance;

difficulty forming age-appropriate peer relationships; sensory processing difficulties; atypical sensory-motor responding; and limited understanding of social cues, reciprocal conversation, and appropriate use of humor (David et al., 2008; Hillier et al., 2007). Parents of youths with ASD report that their children exhibit emotional and behavioral difficulties such as affective, anxiety, attentional, conduct, oppositional, and somatic problems (Kanne et al., 2009).

Many of these behavioral and social competence difficulties which are the hallmark symptoms of autism are linked to issues with cognitive processes called executive functions. Executive functions (EF) are cognitive processes that are involved in the control and regulation of thought and behavior (Miyake et al., 2000). Miyake et al. (2000) performed a confirmatory factor analysis to develop a three-factor model of theorized EF—set shifting, working memory manipulation, and prepotent response inhibition. Cognitive abilities, such as interference control, inhibition, integration across space and time, set-shifting (a lower-level form of cognitive flexibility), and set maintenance, planning, and working memory as well as the initiating and monitoring of such activities are processes that involve EF (Hill, 2004).

Difficulties spanning these cognitive processes have been attributed to individuals on the autism spectrum. For example, historically, individuals with ASD were consistently found to exhibit poor self-control, impulsivity, erratic careless responses, poor initiation, and inflexibility (Monks et al., 2005). Researchers have noted that cognitive flexibility, which requires an individual to successfully switch between two tasks or sort the same stimulus by different features, is another EF subdomain where difficulties are present for individuals with ASD. For instance, studies found that those diagnosed with autism and average or above average intelligence could inhibit responses to stimuli, but were significantly impaired in their ability to

set-shift when compared to non-ASD control groups (Ozonoff et al., 1994; Ozonoff & Strayer, 1997).

However, new evidence has revealed limitations in previous studies. Demetriou et al. (2018) conducted a meta-analysis of EF studies of ASD individuals. The researchers found that while across the studies reviewed, individuals with ASD performed significantly worse on EF when compared to neurotypical (NT) controls, no specific subdomain of EF was implicated. Overall, in their research, Demetriou et al. (2018) found only a moderate effect for EF in ASD and they noted that across studies most measures of EF, except for informant-based measures, were unable to discriminate between ASD and NT populations. The researchers highlighted that multiple reasons could explain why this finding contrasted with established findings, including previously unaccounted for bias dependent on the characteristics of the informant (e.g., how well they know the individual, where they observed the individual, etc.), characteristics of the task (e.g., complexity, open-ended vs structured format), or characteristics of the individual (e.g., ASD severity or the presence of competing mental health issues such as anxiety or depression). Additionally, Gardiner and Iarocci (2017) also noted that typical EF measures are performance-based and are not always predictive of real-world abilities.

Another social competence relevant cognitive processing skill in which inconsistent performance issues are observed is in theory of mind which describes the awareness of mental states and the ability to use this awareness in interpreting, explaining, and predicting the behavior of self and others (Astington & Pelletier, 2005). To assess theory of mind, researchers have developed a number of simple and complex tasks. A simple theory of mind task involves a subject predicting where someone will look for an object a child sees moved to another location, but another person does not see moved. Another popular test is the “unexpected content” task

which involves predicting what someone will say is inside a familiar container (e.g., a candy box), when the child subject has seen that the box contains pencils, not the expected candy, but some other person has not yet seen inside the box.

Passing a theory of mind test involves cognitive skills that support the verbal processing, memory of key narrative events, and inhibition of spontaneous responses that are central to the tasks (Tager-Flusberg, 2007). It is no surprise that Harris et al., (2008) found a strong correlation between ToM and executive function after controlling for IQ, with individuals performing poorly on one trait performing poorly on the other and vice versa. Over the years, research has shown that individuals with ASDs generally perform poorly on both simple and complex ToM tasks. For example, in a study by Baron-Cohen, Leslie, and Frith (1985) 80% of a group of children with ASD failed false belief tests which asks an individual to predict another's behavior when their beliefs are different from that others'. Multiple studies have shown that individuals with ASDs perform significantly less well than typically developing controls on the Strange Stories advanced ToM task which asks for individuals to answer a physical question and a mental question about the content of a story they have read (Happe, 1994; Jolliffe & Baron-Cohen, 1999).

However, in these studies, even a small number of individuals with ASDs pass theory of mind tasks suggesting that theory of mind is not an all or nothing trait for individuals in this population, the existence of issues with how ToM is measured, or the impact of traits from co-occurring diagnoses. Recent studies have highlighted the role of attention deficit hyperactivity disorder (ADHD) in EF impairments. For example, Lukito et al. (2017) reported that there was an association between EF impairments and increased ADHD symptoms in ASD samples that may be due to the type of diagnostic measure and informant. Findings of parent informants rating

individuals with co-occurring ADHD and ASD as having higher ASD trait severity were theorized to be due to bias in parent-report assessments or lack of the rater's clinical judgment. In addition, the majority of studies in the ToM literature with this population has had small sample sizes and a small range of ToM tasks, tend to use older children as participants, fail to employ developmentally sensitive tasks, and use restrictive pass/fail scoring systems (Steele et al., 2003). In a study by Steele et al. (2003) designed to alleviate these issues, over two thirds of individuals with ASD showed significant developmental changes in ToM abilities over the course of a year with some individuals passing the most advanced ToM tasks.

Some studies suggest that patterns of poor and inconsistent theory of mind performance from individuals with ASD may stem from information processing where systematic issues for this population are observed. For example, in instances where individuals with ASDs successfully infer mental states, they are hypothesized to activate different brain regions and use neurocognitive systems different from typically developing individuals or matched peers with intellectual disabilities (Tager-Flusberg, 2007). A study by Ruffman, Garnham, and Ridout (2001), found that in contrast to well-matched children with mental retardation, children with ASD did not look at the correct location on theory-of-mind tasks, although the two groups performed at the same level when answering the verbal test questions. Thus, ASDs are hypothesized to use compensatory strategies to perform ToM tasks; though these strategies are hypothesized to beget concrete and rigid expectations of what happens in familiar events which can impact the understanding of the variable aspects of social experiences and may further explain difficulties these individuals have regarding social competence (Loth et al., 2008). Livingston et al. (2019) operationalized compensation as the discrepancy between sociocognitive ability, (e.g., performance on ToM measures) and observer-rated social behaviors (e.g., ADOS).

Compensation explains not just how some individuals with ASD successfully complete ToM tasks, but how those with ToM difficulties perform adequately socially and how those with similar ToM abilities have differing social outcomes (Livingston et al., 2019). EF has been proposed to play a role in this compensation process, though it is not yet been elucidated (Livingston et al., 2019).

Some theories of ToM competence highlight the role of development and social interaction experience in the successful completion of advanced ToM tasks. Hayward et al. (2018) sought to compare responses of adolescents to vignettes that contained novel and ambiguous stimuli and vignettes with familiar and unambiguous stimuli to assess whether different cognitive processes were involved in each condition. Moreover, in response to research evidence of response latency and errors decreasing with age, the researchers sought to explore any developmental trends that might be present from childhood to adolescence. Therefore, the authors developed the FASC (Flexibility and automaticity of social cognition) task which consisted of 8 cartoons with ambiguous and unambiguous scenarios as well as the presence or absence of language use. The FASC was constructed to diverge from common advanced ToM measures—which consist of “pass-fail” scenarios with one inherent correct solution—to an adaptive measure in which scenarios have a number of plausible solutions. This adaptive reasoning is proposed to be similar to the type of reasoning done during social interactions which may involve ambiguous information and call on a participant to successfully infer another’s mental state. Findings demonstrated that the presence or absence of ambiguity and the presence of either verbal or non-verbal content predicted the flexibility and automaticity of responses in participants. Additionally, Hayward et al. (2018) posited that, as children age through adolescence, their ability to flexibly and automatically provide reasons for social behavior

increases. This study provides support for theories that underscore the importance of social interactions in the development of social skills through an accumulation of experiences that lead adolescents to produce, conventional, inflexible, automatic, “stock” responses to familiar and unambiguous scenarios.

Hayward et al. (2018) noted that ambiguous scenarios required longer response times signaling the use of more cognitive resources to produce flexible responses. Research has indicated that cognitive flexibility is a sensitive predictor of social skills training outcome and observed cognitive flexibility issues explain difficulties in transferring therapeutic gains in social skills training to new contexts and novel situations for individuals with ASD (Berger et al., 2003). In addition, cognitive flexibility problems are evidenced in the stereotyped repetitive patterns of behaviors, issues in adaptive functioning, and perseverative responses that individuals with ASD exhibit more frequently than typically developing individuals or individuals with developmental disabilities (i.e., ADHD) in situations that call for flexibility in functioning (Geurts et al., 2004).

One last skills related to social competence is central coherence, or the tendency to integrate local information in the search for global meaning and focus on the whole rather than the part of any stimulus in order to create higher order meaning through the integration of disparate information (Frith & Happe, 1994). Thus, central coherence theories expect that individuals with ASDs will generally perform better on tasks when piecemeal or “local” processing is required than when holistic or “global” processing is required. Research partly supports this theory and indicates that individuals with ASDs exhibit a tendency to process information in parts rather than wholes. For example, individuals with ASD have performed better than peers on the Wechsler Block Design Subtest, in which individuals must construct



figures by referencing segmented and unsegmented diagrams, in relation to other subtests (Siegel et al., 1996).

Shah and Frith (1993) also note that segmenting figures did not aid individuals with ASD on a block design test in their study, which led them to believe that these individuals already perceive the designs in a fragmented way. Further, autistic individuals are faster and more accurate than controls at seeing embedded figures within a more complex whole pattern (Mottron et al. 2003; Shah & Frith 1983). Despite some evidence for theories of weak central coherence in ASD, Mottron et al. (2003) found no differences between adolescents with ASD and typically developing adolescents on global processing tasks, which contradicted notions in the literature that some findings of superior local processing in ASD warranted a global processing detriment. Thus, it is reasonable that Frith and Happe (1994) suggested that central coherence processing in individuals with ASDs should be viewed as a different cognitive style rather than an impairment. This difference in processing style may partially explain issues with social competence seen in individuals with ASD. For example, Ke and Moon (2018) posited that complicated social situations may result in cognitive, sensory, or psychomotor overload during which then leads to difficulties in the performance of higher order cognitive processes. This aligns with the theory of enhanced perceptual functioning (EPF) proposed by Mottron et al. (2006) and further described by Mukerji et al. (2013) which supposes the primacy of perceptual processes (auditory and visual) over social or higher order cognitive processes as an explanation for the distinct pattern of behavioral, cognitive, and neural performance seen in ASD.

Many explanations have been proposed as potential causes of these characteristics observed in individuals on the autism spectrum. For example, Van Hecke et al. (2015) noted that for children and adolescents with ASD there is a growing body of evidence for differences in

neural activity such as lower or hypo-functional connectivity between cortical regions, hyper-functional connectivity in some regions, and atypical functional lateralization (e.g., right hemisphere dominance during verbal and spatial activities) when compared to typically developing (TD) controls or neurotypicals. Stevens (2015) posited that these differences are the result of “impoverished social environments” which, following the theory of activity-dependent synaptic plasticity, leads to over-pruning of brain regions that are important for the development of socially appropriate behavior. Demetriou et al. (2018) even proposed aberrant interconnectivity as potentially responsible for findings of no significant differences between EF subdomains in their meta-analysis. While these findings on their own are interesting, taken together they fail to provide a consistent and substantive explanation for the characteristic differences in social functioning experienced by individuals on the spectrum.

Overall, while the literature supports the view that poor ToM development accounts for some of the social and communication difficulties that define ASDs, recent research has begun to question these assumptions. For example, ToM task related improvements do not generalize to novel situations for individuals with ASDs (Parsons & Mitchell, 2002) and a meta-analysis of research assessing ToM interventions has not demonstrated consistent success for improving social competence (Fletcher-Watson et al., 2014). These findings highlight the need to explore potential explanations for social and communication difficulties outside of neural and cognitive differences, particularly as interventions derived from these explanations have not found consistent success. For example, alternative explanations such as the social insight problem hypothesis by Gray and Garand (1993) and the paucity of social experience hypothesis of Stevens (2015) have led to the use and popularity of explicit rule-based social skills interventions.

Together, these central difficulties of ASD lead to demonstrated difficulties in social processing and, in turn, social and communication difficulties. Social skills are those specific non-verbal and verbal behaviors that result in positive social interactions and are necessary for interpersonal communication (Elliot & Gresham, 1987). For example, smiling, making eye contact, asking and responding to questions, and giving and acknowledging compliments during a social exchange are social skills (Rao et al., 2007). Individuals with ASD generally present with social skills difficulties and experience negative outcomes in many social contexts. Moreover, many of the physical behaviors exhibited by individuals with ASD, such as restrictive stereotyped movements, make it difficult for them to seamlessly integrate into some social environments.

### ***Mental health correlates of ASD***

It would be remiss not to note that the social difficulties noted above occur primarily in interactions between individuals with ASD and those who are typically developing. Bagatell (2010) explained that the difficulties that “autistics” face are in many ways socially constructed. Autistics, Bagatell (2010) stated, must deal with the intolerance of society to their differences in preferred interactions and diversity in processing information. In the past, these differences have been thought to result from a lack of social motivation or disinterest in interpersonal relationships, but research indicates that individuals with ASDs value and desire relationships similarly to their TD peers (Zinck et al., 2021).

Differences in processing social information may explain many of the social difficulties autistics have with relating to their typically developing peers. For example, Zinck et al. (2021) found that, compared to TD counterparts, during an open-ended interview regarding personal/family history and existing interpersonal relationships, individuals with ASD were less

likely to discuss mental states of self and “other”. Additionally, ASD participants were more likely to reference self-beneficial (i.e., aspects of interpersonal relationships that benefited them) rather than mutually beneficial aspects of their interpersonal relationships. These findings are similar to those in previous studies which reported that autistic adults used fewer mental state expressions than typical adults in open-ended self-descriptions; were unlikely to use self-reflections when spontaneously asked to describe their thoughts; and did not seek to determine how their thoughts compared to others as typically developing individuals did (Zinck et al., 2021).

Morrison et al. (2019) conducted research that compellingly supports the notion that social impairment is not a fixed characteristic of individuals with ASD, but a fluid attribute of the social context. Difficulties in social functioning may simply result from a lack of "fit" between the individual and the social environment as well as a mismatch between the social and communication styles of ASD and TD individuals. Morrison et al. (2019) sampled 125 (67 ASD and 58 TD) participants aged 18 to 45 years old, formed pairs (ASD-ASD, ASD-TD, and TD-TD), instructed the participants to engage in five minutes of unstructured conversation, and then used self-report ratings as well as video observation to assess the conversations. The researchers found that, while individuals with ASD were rated less favorably on interaction measures by both ASD and TD interaction partners, the ASD individuals showed a greater preference for future interactions with ASD conversational partners over TD partners, while TD partners greatly preferred future interactions with TD conversational partners. This finding, while not statistically significant, lends credibility to the theory that social difficulties observed in ASD may be based on traditional ASD-TD social contexts in which their difficulties are seen as greater and lead to negative social consequences when compared to ASD-ASD interactions.

Morrison et al. (2019) found, as in previous studies, that individuals with ASD were rated as less attractive, more awkward, and less warm by their conversation partners—both TD and fellow ASD individuals. However, in their correlational analyses, Morrison et al. (2019) found that ratings of awkwardness and warmth were less predictive of interest for future interactions for ASD raters than it was for TD raters. In addition, findings of social interest for the ASD group are contrary to theories of low social motivation for ASD individuals. Also, Morrison et al. (2019) reported that ASD individuals reported feeling closer to their conversational partners than TD individuals. This difference in closeness was theorized to result from a dearth of social interactions and social experiences which may heighten the feelings of closeness in a brief interaction. This theory may explain why individuals with ASD tend to overshare during social interactions. Lastly, Morrison et al. (2019) found that individuals with ASD had higher levels of self-disclosure with ASD partners than TD partners which they conjectured may have resulted from shared experiences, common dispositions, and shared interests. Though, it is possible that greater self-disclosure is part of the ASD social interaction style.

Additionally, difficulties in inferring mental states of "the other" goes both ways. A plethora of studies have demonstrated ASD individual's difficulties in ascertaining the thoughts and emotions of typically developing individuals, but recent studies have found that TDs have similar difficulties in understanding the mental states of ASDs (Edey et al., 2016; Milton, 2012). Together these studies highlight the role of the social context as well as the opinions, expectations, and beliefs of typically developing individuals in the social difficulties that individuals with ASD experience. Improvements in social functioning may not be made just by direct instruction in social skills and measured by counts of social interactions, but by making

social accommodations or modifications to the environment to accept the neurologically diverse ways in which individuals with ASD process information and subsequently communicate.

### **Social Skills Interventions**

Interventions for individuals with ASD that highlight the promotion of social skills and the reduction of behaviors that may interfere with the production of social skills are becoming increasingly prevalent in ASD research and there are many different intervention/treatment packages from which to choose (Wolstencroft et al., 2018). Gates et al. (2017) conducted a meta-analysis of 19 randomized controlled trials of group social skills interventions that employed a control group to evaluate effectiveness based on reporting source. This was an important question because, as Wolstencroft et al. (2018) noted, research has demonstrated that the choice of outcome measures and reporting sources can conceal or inflate treatment effects. For example, participant and parent reports may reflect expectancy bias, while teachers are rarely blind to a participant's treatment group membership and their reports may be less sensitive to changes in social competence due to limited opportunities to observe participants' social behaviors (Wolstencroft et al., 2018).

Overall, across all reporting sources, significant effects were medium ( $g=.51$ ). Significant findings indicated that in the studies self-report measures had the largest effects ( $g= .92$ ), followed by medium effects for task-based measures ( $g= .58$ ), small for parent report ( $g= .47$ ), and small for third-party report ( $g= .40$ ). There were no significant differences between the treatment and control groups according to teacher-reports ( $g= .41$ ) (Gates et al., 2017). When examining the self-report effects, Gates et al. (2017) found that most of the changes from pre-to post-intervention were largely due to increased social knowledge rather than improvements on social performance measures. While this is generally the case for meta-analyses of social skills

interventions, the reason for this disparity between social knowledge and social performance may be due to a lack of follow-up data measuring participant behaviors long-term after the intervention is complete. For example, Gates et al. (2017) noted that most studies reviewed lacked follow-up assessments, and therefore recommended that future studies use a broader set of measures including those for social performance and include follow-up assessments. These recommendations echo that of Wolstencroft et al. (2018), which recommended that self-report questionnaire data be combined with cognitive measures; repeated observations of behavior occur in multiple settings; and called for researchers to include measures that distinguish social knowledge acquisition and social task performance.

According to Wolstencroft et al. (2018), manualized group social skills interventions (GSSIs) usually consist of modeling of a specific social skill, roleplay practice of the skill, and personalized performance feedback. Generally, GSSIs use structured lessons or teach skills through play; require parent, peer, or teacher involvement; and multiple sessions distributed across several weeks (Wolstencroft et al. 2018). Wolstencroft et al. (2018) conducted a meta-analysis of GSSIs for ASD with waitlist control groups and participants ages 6-25 to examine social performance outcomes reported on the SRS (Social Responsiveness Scales) or SSRS (Social Skills Rating Scales). In addition, Wolstencroft et al. (2018) sought to evaluate in what ways GSSI outcomes were moderated by factors such as treatment duration, inclusion or exclusion of a parent group, and type of instruction (e.g., didactic or performance/play based). Eight studies, using five different interventions met the review criteria. PEERS, Children's Friendship Training, summerMax, SENSE theater, and an unnamed CBT (cognitive behavioral therapy) intervention. SENSE theater and summerMax were intensive 4-5hr/day 5 days/week interventions lasting from 2-5 weeks, while the other interventions were comprised of 60- to 90-

minute, weekly sessions over 10-16 weeks (Wolstencroft et al., 2018). Most of the reviewed studies targeted children under 12, while only the PEERS studies included adolescents and young adults. All reviewed studies used multiple informants, and all studies except the CBT intervention included direct parent involvement (Wolstencroft et al., 2018).

Standardized mean difference (SMD) was used to analyze outcomes for treatment group participants as compared to waitlist control participants across the reviewed studies. Values of .20-.50 were considered small, .50-.80 were moderate, .80-1.30 were large, and values above 1.30 were very large. Findings by Wolstencroft et al. (2018) revealed large effect sizes on the SRS Total score (-0.85), the Social Communication subscale (SMD= -0.89), and the Restricted Interests and Repetitive Behaviors subscale (SMD= -0.90). Wolstencroft et al. (2018) reported moderate effect sizes for the SSRS Social Skills subscale (SMD= 0.56), the SSRS Problem Behaviors subscale (SMD= -0.55), the SRS Social awareness subscale (SMD= -0.57), the SRS Social Cognition subscale (SMD= -0.53), and the SRS Social Motivation subscale (SMD= -0.55). These findings lend evidence for GSSIs in significantly reducing ASD symptoms and improving social skills in the areas of cooperation, empathy, assertion, self-control, and responsibility. Findings for reducing internalizing, externalizing, and hyperactive behaviors as measured by the SSRS Problem Behaviors subscale were not significant. Moderation analyses found significant effects regardless of parent group inclusion, though GSSIs that employed a parent group had large effective sizes vs the moderate effect sizes of GSSIs that did not employ parent groups (Wolstencroft et al., 2018). Finally, GSSIs that were longer in duration (>40hrs of contact time) and of higher intensity both had large effect sizes while those that were not had moderate effect sizes (Wolstencroft et al., 2018). These findings point to the positive effects associated with GSSIs for children, adolescents, and young adults with ASD. In addition,



Wolstencroft et al. (2018) highlighted the need for continued methodological rigor in GSSI randomized controlled trials (RCT), the use for common measures of social skills outcomes, and the development of sensitive measures to comprehensively capture the effects of treatment on social skills.

### ***PEERS***

As noted in Wolstencroft et al. (2018), for adolescents with ASD, the Program for the Education and Enrichment of Relational Skills (PEERS) is one of the few GSSIs that has demonstrated effectiveness in improving social skills. PEERS is a parent-assisted, group social skills training intervention developed by Elizabeth Laugeson and Fred Frankel as an extension of the Children's Friendship Training program which is geared toward children from 2nd to 7th grade who have difficulties making and maintaining friendships. PEERS focuses on reciprocity in conversations; reducing the salience of peer group rejection of the adolescent; addressing the effects of the adolescent's bad reputation in their current social settings; encouraging get-togethers with peers; and teaching adolescents how to handle teasing, bullying, and peer conflict (Laugeson et al., 2009). Psychoeducational and cognitive behavioral treatment techniques are used during structured 90-minute lessons consisting of previous week's homework review; skill introduction and modeling (teen group); parent handout review (parent group); peer role-playing with corrective feedback from facilitators (teen group only); homework assignment; and reunification with parents at which time adolescents provide summaries of the teen group lesson and (if needed) scheduling in-group phone calls.

**PEERS Evaluation by Intervention Developers.** The efficacy of PEERS as a manualized intervention to improve friendship quality and social skills was first examined by Laugeson et al. (2009) with an RCT that included 33 participants aged 13-17. In this study, PEERS was delivered in 12, 90-minute sessions over 12 weeks with adolescents and parents meeting concomitantly with PEERS facilitators in separate groups of 6-10. To be included in the study, participants were required to have: an ASD diagnosis; age between 13 and 17; social problems as reported by a parent; parent or family member fluent in English willing to participate in the study; verbal IQ of 70 or above on the Kauffman Brief Intelligence Test 2nd Edition (K-BIT-2; Kaufman & Kaufman 2005); no history of major mental illness; absence of hearing, visual, or physical impairments which precluded teen from participating in outdoor sports activities; and verbal expression of interest in participating in the intervention during eligibility appointment. In addition, families enrolled agreed to miss less than 2 of the 12 intervention sessions.

Results indicated that individuals in the treatment group experienced significant improvements in social skills knowledge as measured by self-report on the Test of Adolescent Social Skills Knowledge (TASSK; Laugeson & Frankel, 2006), hosted get-togethers as measured by the parent-report Quality of Play Questionnaire (QPQ; Frankel & Mintz, 2008), friendship quality as measured by the Friendship Quality Scale (FQS; Bukowski et al., 1994), and overall social skills as measured by the Social Skills subscale of the Social Skills Rating Scales (SSRS; Gresham & Elliot 1990). Laugeson et al. (2009) noted that, due to its large set of questions, the TASSK had moderate level of internal consistency with a coefficient alpha of 0.56 and a score range of 0 to 22. Limitations to this study included the reliance on parent self-report measures due to substantial missing data from teacher reports, lack of follow-up assessments, lack of

confirmed ASD diagnosis, and reliance on an instrument not normed on adolescents with ASD (SSRS). This study was groundbreaking at the time as it included one of the largest samples in an ASD adolescent social skills study and its findings departed from previous studies that had failed to find improvement on the SSRS social skills subscale.

To address some of the limitations in their previous study and test a revised version of the intervention, Laugeson et al. (2012) assessed the effects of a 14-week version of PEERS in a RCT with a sample of 28 adolescents aged 12-17, and their parents. This version of the PEERS intervention included additional content regarding cyberbullying, electronic communication, online safety, handling rumors and gossip, and using appropriate humor (Laugeson et al., 2012). In addition, the researchers added a 14-week post-intervention follow-up, revised the TASSK, and included the SRS as an outcome measure.

Results from this study demonstrated that parents in the treatment group reported significant improvement in overall teen social skills on the SSRS Parent form (SSRS-P) in comparison to parents in the waitlist control group, especially on the subscales of Cooperation, Assertion, and Responsibility (Laugeson et al., 2012). On the SRS, parents in the treatment group reported a significant reduction in ASD symptoms related to social responsiveness and SRS-P subscale analyses showed significant improvements in Social Awareness, Social Cognition, Social Communication, Social Motivation, and decreased Autistic Mannerisms (Laugeson et al., 2012). Those in the treatment group showed significant increases in parent reported hosted get-togethers on the QPQ-P, significant improvement in knowledge of social skills on the TASSK-R (Laugeson et al., 2012). At 14-week follow up, treatment gains were maintained for all outcome measures except the SRS-P Social Cognition subscale and additional significant improvements not found at T2 on the SRS-P in Social Awareness. These results

provided additional support for the effectiveness of PEERS with this population, provided data on the extent to which treatment gains are maintained, and evidence of additional improvements at posttest offered insights into the length of time it takes adolescents to put into practice the skills learned during the intervention. Limitations to this study included lack of corroborated ASD diagnoses, poor third-party rater response rate (teacher reports), and lack of a longer-term follow up assessment.

Laugeson et al. (2014) examined the effectiveness of a school-based version of the PEERS intervention that was teacher facilitated and delivered in daily, 30-minute sessions, five days a week for 14 weeks. Additionally, this was the first study to compare the PEERS treatment group to a group of students that received an alternative social skills intervention (Super Skills). Results indicated that individuals in the PEERS group demonstrated greater improvement on the TASSK; had significantly more self-reported hosted and invited get-togethers than the students in the active treatment control group; and PEERS treatment group teachers reported significant improvements on the social responsiveness, social awareness, social communication, social motivation, and autistic mannerisms. This study demonstrated the effectiveness of PEERS for adolescents in a naturalistic setting (school environment) and as compared to an established social skills program. The ability to deliver PEERS in school settings has great potential to reduce obstacles to enrollment for adolescents with ASD; while caregivers may be unable or unwilling to commit to 14 weekly 90 minute sessions, school is a mandated requirement where adolescents can receive PEERS instruction. Limitations to this study include a lack of random assignment, uncorroborated ASD diagnoses, lack of fidelity measures, low response rate from third-party (caregiver) assessments.

These studies reviewed have demonstrated the success of PEERS for short-term gains, though information on long-term maintenance of these gains or long-term intervention findings was sparse. To address these limitations in the PEERS literature, Mandelberg et al. (2014) assessed the effectiveness of the PEERS for Adolescents intervention in a study that conducted follow-up online and phone interviews with a sample of 53 former PEERS participants had complete PEERS one to five years prior. In addition to administering the TASSK student report form, the QPQ parent and adolescent report form, SSRS parent form, SRS parent form, and Vineland-II parent report, Mandelberg et al. (2014) also conducted semistructured interviews with the adolescent report Friendships and Interventions Interview (FII) to obtain information about current best friendships and any treatments or programs that the adolescent had participated in post-PEERS completion. Results from their analyses indicated that post-treatment gains were maintained for the SSRS, the SRS, the QPQ, and the TASSK. From the semistructured interviews, Mandelberg et al. (2014) learned that 78% of parents reported the PEERS intervention as being “very helpful” and 75% of adolescents reported having one “pretty close” friend.

**Marquette University Replication Studies.** In addition to the UCLA PEERS studies, research teams at Marquette University conducted several PEERS replications. Schohl et al. (2013) conducted the first independent replication of the PEERS intervention with 58 adolescents aged 11-16 to determine if the intervention could also decrease participant’s reported social anxiety as measured by the adolescent report Social Interaction Anxiety Scale (SIAS). Results indicated that participants not only significantly improved on the TASSK adolescent form, QSQ parent and adolescent form, SSRS Problem Behaviors parent form, and SRS autistic symptoms parent form, but also had significantly decreased social anxiety as reported on the

SIAS. While this study was the first to report on findings relating to social anxiety, there were several limitations including a lack of diverse participants which could hamper generalization of results to other ethnic or cultural groups, a large amount of missing data from teacher reports, and, while Dr. Laugeson was not an author on the paper, they were noted by the researchers as being instrumental in starting the PEERS program at their lab in Wisconsin.

Karst et al. (2015) sought to study the impact of the PEERS intervention on the family system. Specifically, they conducted an RCT with 81 participants to understand the impact of PEERS on variables such as family chaos, parenting stress, and parenting self-efficacy. Karst et al. (2015) measured these variables with the parent report Confusion, Hubbub, and Order Scale (CHAOS), the parent report Stress Index for Parents of Adolescents (SIPA), and the parent report Parenting Sense of Competence Scale (PSOC). Results post-intervention showed a significant reduction in family chaos and a significant increase in parenting self-efficacy for the treatment group. While these findings were promising, there were small effect sizes for these results, there was no control group without direct parent and family involvement, the control group was not restricted from participation in other interventions that may have affected outcomes, and the sample was predominantly White.

Van Hecke et al. (2015), Stevens (2015), and later Dolan et al. (2017) studied changes in electroencephalograph (EEG) asymmetry—defined as hyper-activity in the right hemisphere and hypo-activity in the left hemisphere as reported in several studies—in response to the PEERS intervention in two RCTs. EEG asymmetry has been demonstrated to predict task performance and ASD symptoms in adolescents; researchers hypothesized that observed asymmetry could change in response to intervention (Van Hecke et al., 2015). Comparing a group of ASD participants to typically developing controls and an ASD waitlist control group, Van Hecke et al.

(2015) found that the ASD group that completed PEERS shifted to a left-hemisphere dominant asymmetry when compared to the waitlist group. Autistic participants with improvements on the QSQ parent form, TASSK adolescent report measure, and SRS parent report also showed a greater degree of left-hemisphere dominant electroencephalograph (EEG) activity relative to their baseline, and neural changes were found on gamma band asymmetry for the treatment group in comparison to the waitlist control group.

In a follow-up study, Stevens (2015) added a social viewing condition for the EEG data collection and sought to correlate any observed neural changes in the ASD group with reported changes in behavior. Stevens (2015) found significant neural differences between the ASD and typically developing groups pre-intervention and significant neural differences between the ASD and waitlist control group post-intervention. As in Van Hecke et al (2015), the ASD group's neural asymmetry shifted to resemble that of the typically developing group. The novel social viewing condition was not found to assist in comparisons of the participant groups. Limitations to this study include the exclusion of left-handed and female participants, a lack of data outside of baseline on the typically developing group, a large variance in symptom severity in the ASD groups which may have been reflected in neural differences observed, a lack of control for medication usage, and a lack of control for co-occurring conditions in the ASD group.

Dolan (2017) explored the relationship between behavioral measures and changes in neural activity while also assessing the durability and maintenance of treatment outcomes with a 6-month follow up. Results from the correlation analyses indicated that significant improvements in caregiver reported social cognition and problem behaviors were related to decreases in gamma wave activity in the right temporal brain region. Additionally, follow-up data indicated that this decrease in right temporal lobe activity was maintained. Limitations to this study included the

lack of participant diversity in race/ethnicity and socioeconomic status, lack of assessment of the typically developing comparison group after baseline or an inclusion of an untreated ASD group, low sample size which limited the power of statistical analyses, and no control for medication usage.

Dolan et al. (2016) further explored the long-term durability of neurological changes on the behavioral outcomes after a follow-up period. The results indicated that the PEERS intervention changed neural activity for those in the treatment group, particularly in the right temporal region as witnessed in prior studies. Maintenance of these changes were related to parent-reported social cognition improvements and a decrease in problem behaviors at follow up. Limitations in this study were similar to those in the previous studies in regard to small, homogenous sample, no control for medication usage, and assessment of neurotypical individuals only at one time point which leaves uncertain whether changes were due to developmental and maturation effects. Additionally, Dolan et al. (2016) noted that they did not examine EEG coherence, or how well different brain regions communicate with one another.

Schiltz et al. (2018) sought to examine the effects of PEERS on reported depression and suicidality in 70 adolescents diagnosed with ASD due to the increased risk of depression, suicidality, and their correlates in this population. Reported links between problems socializing initiating and maintaining relationships, and depressive symptoms led Schiltz et al. to examine whether an intervention targeting social skills could decrease depressive symptoms in adolescents with ASD. Specifically, the researchers investigated whether PEERS impacted reported depression symptoms, any relationships between get-togethers and depression at posttest, and any changes in self-reported suicidal ideation. The researchers used random assignment to split 37 individuals to the intervention group and 33 individuals to the waitlist



control group. Schiltz et al. hypothesized that at post-intervention the PEERS intervention participants would report reduced depression symptoms while displaying a negative relationship between quantity of social interactions and depressive symptoms. Additionally, intervention group participants were expected to report reduced suicidal ideation following PEERS. Schiltz et al. measured depression symptoms with the Children's Depression Inventory adolescent report and tallied social interactions with the Quality of Socialization Questionnaire parent report.

Results revealed that the intervention group's scores on the CDI significantly decreased from pretest to posttest, while the waitlist control group's score changes did not reach significance. Significant decreases were found on subscales measuring negative mood, anhedonia, and negative self-esteem with reported main effects for group by time interaction. Additionally, Schiltz et al. found numerous negative correlations between the number of social interactions reported for each participant and their scores on the CDI with significant correlations found for the CDI total score and the interpersonal problems and ineffectiveness subscales. For suicidal ideation, the intervention group decreased their endorsement of the statement, "I think of killing myself, but would not do it" from 19% at pretest to 0% at posttest. In the waitlist control group, endorsement of this statement increased from pretest to posttest (18% vs 30%). These findings provide support for the notion that difficulties initiating and maintaining friends are related to reported depressive and other internalizing symptoms for individuals with ASD. Moreover, the results indicate the effectiveness of PEERS to ameliorate these externalizing problems, improving participant's overall mental functioning. One finding of interest was the lack of improvement on the interpersonal problems subscale of the CDI for intervention group participants. This may be due to the short length of the study and lack of follow-up, may be a result of additional attention to interpersonal problems and increased emphasis and experience of

social interactions leading to additional awareness of interpersonal difficulties, or due to the possible rigid nature of this domain of depression.

**Conversational Analysis and PEERS.** Like Rabin et al. (2018), Veytsman (2020) sought to use observational methods in addition to the standard self-report measures traditionally used to assess social skills changes post-PEERS intervention with special attention to conversation skills. In addition, they sought to increase representation of diverse individuals, particularly those who were Latinx, in ASD social skills intervention research. Veytsman (2020) selected a sample of 7, 11-to 18-year-old adolescents and their English or Spanish speaking caregivers from focus groups of Latinx families in a region of Southern California as well as from school districts, community organizations, and parent advocacy groups. The researchers sought to examine whether there were improvements in conversational skills pre-to-post-treatment on the Contextual Assessment of Social Skills (CASS), test the sensitivity of new CASS changes and items created specifically for the PEERS intervention, and explore the relationship between CASS scores and improvements on self-and parent-reported ratings of social skills. The unmodified CASS is composed of two conditions, one in which a confederate is interested and engaged in the conversation and one in which the confederate acts bored and uninterested. Changes to the CASS included the removal of the “bored” condition, the use of gender-matched confederates to reflect the expectation of adolescents to develop same-gender friendships with peers, and the addition of seven new items reflecting specific skills taught during the PEERS intervention in order to assess not just the frequency of question asking, but the quality and appropriateness of questions. Trained raters who were blind to treatment group status (pre, post, or follow-up) completed the scoring of the CASS after viewing a filmed, 3-minute interaction of the adolescent and an unfamiliar peer. Results found no significant

differences pre-to-post intervention on the original CASS score, but a significant difference was found on the new PEERS CASS score as well as on the SRS-2 total and composite scores, the Social Skills score on the SSIS, and the TASSK score (Veytsman, 2020). Significant correlations were found between both the SRS-2 and the new PEERS CASS score with the CASS Quality of Rapport Scores. In addition, change in the new CASS total score was significantly correlated with change on the SRS-2 total score. This study highlighted the effect of PEERS on conversational skills and promoted the use of observational assessments of behavior to assess post-treatment social skills intervention changes. Limitations to this study included the use of a convenience sample, the use of college-aged peer confederates during observed interactions, lack of follow-up data, lack of observation of other skills (e.g., conflict resolution), lack of control for potential differences in confederate behavior or observations of participants conducted only in unfamiliar settings.

**Cross-cultural Replications.** Several cross-cultural replications of PEERS have demonstrated effectiveness for a variety of cultures. Yoo et al. (2014) examined the feasibility and treatment efficacy of a Korean version of the PEERS for adolescent program. At posttest and at 3-month follow-up, their sample of 47 adolescents with ASD showed improvements from the pretest on the SRS parent-report scale, the TASSK self-report scale, and QPQ parent and adolescent forms as well as language, social communication, social interaction, and global emotional and behavioral problems.

Marchica and D'Amico (2016) adapted the PEERS intervention for their homeland of Canada by making changes to the implementation format with the program given in 7 weeks 2x a week. Similarly, they found that by follow-up, there were significant improvements in social skills, problem behaviors, and get togethers, though there were several limitations including

small sample size, no control group, no randomization, and no third-party raters. In Israel Rabin et al. (2018) and Rabin et al (2020) examined the effectiveness of an adapted and translated Hebrew version of PEERS also finding that their adapted version led to intervention related improvements in social competence for adolescents with ASD.

Shum et al. (2018) adapted PEERS for Hong Kong specifically and Chinese cultures in general and conducted an RCT of the intervention with adolescents diagnosed with ASD. At the outset, Shum et al. (2018) surveyed 209 adolescents to determine answers to culturally sensitive items (e.g., commonly used social media platforms, typical interests/hobbies, common conversational topics, and the names of peer groups/cliques found inside and outside of school). Some of the adaptations included providing handouts to teen participants with key terms and rules and providing roleplaying and behavioral rehearsal exercises for parents to practice their coaching skills. At post-intervention and follow-up, the researchers found that the adolescents in the intervention group significantly improved on measures of social competence, however, no improvements were found in frequency of get-togethers, and this was attributed to the academically rigorous culture of Asia.

Yamada et al (2020) conducted a cross-cultural validation study of PEERS in Japan with a convenience sample comparing adolescents with ASD in an intervention study. At the completion of the intervention, adolescents with ASD group showed significant improvements on the SRS-2 parent form and the VABS parent form composite, socialization, interpersonal relationships, and play and leisure subscales. Though Yamada et al (2020) demonstrated the effectiveness of PEERS for adolescents and families in Japan, their study had several limitations including no verification of ASD diagnosis, differences in proportions of adolescents with and

without severe mental conditions, small sample size, and baseline differences on the TASSK between the treatment and delayed intervention group.

**PEERS Synthesis.** Overall, these studies demonstrated the effectiveness of PEERS for improving the social competence of individuals with ASD. For PEERS participants, these improvements have been found to persist up to five years post-intervention. Research has shown that these improvements can be measured observationally, with questionnaires, or by evaluating brain activity. Several cross-cultural studies have shown that PEERS is an effective intervention across a variety of cultural contexts even when adaptations to the curriculum structure and content are made. Lastly, the PEERS intervention has also been found to improve social anxiety, reduce family chaos, and increase parenting self-efficacy.

### *Virtual Environments and Serious Games*

From the literature reviewed above, the effectiveness of PEERS as a group social skills intervention is evident, however, the potential for improvement to the intervention still exists. Bottema-Beutel, Park, and Kim (2018) criticized PEERS for its content which suggests that trading information is the primary purpose of conversation; the static, rule-based focus of social skills training programs which focus on adhering to specific norms and social rules rather than fostering bottom-up processes for dynamically negotiating and applying social norms during social interactions; and an absence of acknowledging the role of neurotypical hegemony in dictating the outcomes of social interactions. While this critique is well-founded and should guide future improvements to the PEERS program, it neglects to consider the developmental nature of the PEERS intervention which promotes flexibility of response as participants gain social skills knowledge or the role of facilitators and parents in providing focused and nuanced performance feedback on skill application.

Including the points outlined by Bottema-Beutel et al. (2018), a variety of methods exist to improve social skills training program such as PEERS. For example, researchers might seek to determine how to increase the ecological validity of the intervention to elicit greater improvements for participants. One method to accomplish this goal would be to augment or replicate PEERS tasks with a virtual environment. Virtual environments allow for the creation of realistic 3d representations of real-world environments which can be interacted with and explored in real time (Cobb et al., 2002). There are virtual environments that specialize in supporting interactions between two or more users known as collaborative virtual environments (CVE) and those specializing in supporting interactions for one individual referred to as single-user virtual environments (SVE). In addition, there are three further classifications of virtual environments: those that use head mounted displays; those that project virtual worlds onto an enclosed or semi-closed space, using cameras and other tools to track user movements (i.e., CAVE or cave automatic virtual environments); and those that are displayed only using monitors via a computer desktop (Bozgeyikli et al., 2018). Within virtual environments, human representations are employed and controlled by the user. An avatar is a human representation within the VE that represents an actual human, while an agent is a human representation within the VE that represents only a computer algorithm.

Virtual environments offer numerous potential advantages as standalone learning environments or as supplements to currently used intervention methods for individuals for ASD. Fletcher-Watson (2014) found that building regular rewards into an intervention program was one advantage of virtual environments. In addition, Fletcher-Watson (2014) found in their review of virtual environment research that other VE advantages included the ability to collect large quantities of participant data and the ability to map participant learning trajectories over time.

Smokowski and Hartung (2003) highlighted that virtual environment software packages provide for unlimited repetitions of program content and allow the instructor to personalize the content and user experience, promote internalization of knowledge and application of key skills, emphasize responsibility, and collect and record process and outcome data in real-time. In addition, virtual environments can increase focus by isolating an individual from their real-world surroundings, allow for just-in-time prompts and instruction, and can facilitate learning by decreasing experiences of consequences for poor task performance (Bozgeyikli et al., 2018). VR offers the best of “both worlds” as they provide researchers with granular experimental control while offering the ability to create ecologically valid scenes that users perceive as realistic and authentic (Parsons, 2016).

Within a virtual environment, researchers and facilitators can transform social interactions by altering self-presentation, situational context, and sensory abilities. Self-presentation involves systematically altering the appearance and/or behaviors of avatars from those of the participant being tracked. Situational context involves systematically altering the spatial or temporal aspects of a social situation. Sensory abilities involve allocating extrasensory tools to interactants/participants. For example, Cobb et al., (2002) noted that researchers can control the parameters within the environment (e.g., number of people, cues within the environment, number of solutions to a given problem, etc.). Cobb et al., (2002) remarked that this allows the researchers to control the number of options and decisions the user must make as well as produce different levels for each training scenario with difficulty increasing and scaffolding decreasing as a function of the user’s expertise.

Virtual worlds can capture the child’s perceptions and fantasies to help confront distorted thoughts as well as problematic behaviors (Smokowski & Hartung, 2003). For example, a

program to teach children how to interact with a bully would be able to make a bully appear to grow bigger if the input from the user was negative or have the bully shrink in size as the learner uses appropriate ways of communicating with the bully.

According to Davidson (2008) virtual environments enable enhanced communication for individuals with ASD as they often have difficulties participating in what Wittgenstein refers to as "language games", defined as the ability to use language in ways meaningful to others based on shared expectations and understanding. According to this theory, perceptual and 'processing' differences associated with ASD can hinder typical communication and make the "language games" of others unpredictable, indecipherable, and scary for those with ASD. Communicating in a text-based environment allows individuals with ASDs, who have difficulties understanding nonverbal communication, to communicate effectively (Davidson, 2008). Moreover, individuals with ASD who are often expressly direct and literal in their conversations may thrive in a virtual space such as the internet as such communication is highly desired and appears typical (Davidson, 2008). Additionally, Davidson (2008) reported one ASD individual stating that, due to the interactive consistency that computers provide (e.g., a computer has the same response for a given input), less decoding is necessary for ASD individuals during virtual interactions. Computers accommodate for difficulties that individuals with ASD have in interacting by allowing a delay in responding, facilitating contact and social support from others with similar backgrounds who may be geographically distant, and providing additional opportunities for individuals to practice interacting (Gillespie-Lynch et al., 2014). Given these perceived communication advantages, individuals with ASD may prefer to use virtual environments as social spaces within which to communicate with other similar individuals.



Davidson (2008) noted that groups of individuals with ASDs have used virtual spaces to share information regarding medication, diagnosis, scientific speculation, and politics regarding what some believe to be an ASD minority status and marginalization. For example, Davidson (2008) noted that two women with ASD formed “the autistic liberation front” within Second Life. Davidson (2008) stated that Virtual environments allow individuals with ASD to assert their minority cultural status and strengthen common ties with similarly different others in a virtual space.

Given these advantages, virtual environments have risen in popularity as potential training tools for individuals with ASD and a variety of intervention studies have employed virtual environments to teach skills to individuals with ASD.

**VR Studies Featuring Adolescents with ASD.** Feasibility and usability of VR as a potential training environment for individuals with ASD has been studied extensively. For example, Maskey et al. (2019) used VR in combination with cognitive behavioral therapy (CBT) in a randomized control trial to treat children ages 8-14 diagnosed with ASD and having a specific phobia. In this study, participants were randomly assigned to a control condition of four CBT therapy sessions with a trained therapist or a treatment condition of four CBT therapy sessions with a trained therapist in an immersive CAVE virtual reality environment (VRE).

The VRE consisted of scenes or imagery specific to each participant’s phobia. The therapist guided the child through gradual exposure therapy in which features of the VRE allowed for unlimited repetitions of scenes and changes in the phobia stimulus (e.g., the size of a dog might grow, barking could increase in frequency or intensity, or the dog could be on-or off-leash) as the child progressed through the four therapy sessions (Maskey et al., 2019). Participants were assessed on the Target Behavior rating measure, which evaluated changed in

the target phobia; the Spence Children's Anxiety Scale-parent version (SCAS-P) and child version (SCAS-C), which measured anxiety symptoms; the Fear Survey Schedule for Children (FSSC), which assessed common fears and phobias; and the Children's Assessment of Participation and Enjoyment (CAPE), which measured any increase in participation in community activities. Results on the Target Behavior measure indicated that one-third of treatment group members responded positively by showing improvement in their targeted phobia as compared to 0 control group members. No significant differences were found between groups on the FSSC, SCAS-P, SCAS-C, or CAPE.

Maskey et al. (2019) highlighted the advantages that VR offers as a tool to augment existing evidence-based treatments for individuals diagnosed with ASD. Individualized content was created, tailored to the needs of each child and their phobia, allowing multiple methods for clinicians to scaffold the development of coping skills to reduce problem behaviors and promote anxiety reduction for these children. Known difficulties with imagination tasks may necessitate altered forms of gradual exposure treatment developed for individuals diagnosed with ASD to improve treatment outcomes. Maskey et al. (2019) successfully demonstrated the benefits of such an alteration to an evidence-based method for treating phobias in children with ASD.

Bekele et al. (2014) tested a dynamic VR facial emotion recognition task incorporating eye tracking with teenagers diagnosed with ASD and matched controls (TD). Twenty participants aged 13-17 (10 with ASD and 10 typically developing) completed this proof-of-concept study. Avatars (four males; three females) resembling teens were animated within a Unity-based VR environment to display emotional expressions of fear, anger, joy, sadness, surprise, contempt, and disgust with four levels of emotional intensity (low, medium, high, and extreme). In addition, ambiguous statements that could be attributed to multiple emotional

expressions were included as context for each trial. For a total of 28 trials, participants listened to a lip-synced statement given by an avatar and then viewed one of a combination of 28 expressions/intensities. Then they were asked to specify the expression and their confidence in their choice on a 5-point Likert scale (i.e., 1= Extremely Confident to 5= Extremely Unconfident).

Participants were compared on accuracy, response latency, and ratings of response confidence. Both the ASD and TD groups were similarly accurate in specifying the emotion displayed by the avatar in the desktop VR environment. Significant differences in performance were found between the ASD and TD groups in performance between the intensity levels of the facial affect recognition task. Follow-up analyses indicated that the differences were most present at the lowest end of the intensity levels. Significant differences were also found in response latency between the ASD and TD groups, with the ASD group having greater response latency. Additionally, significant differences were found on the confidence measures between groups though there was no effect for intensity or a group by intensity interaction. In regard to gaze, while participants spent similar amounts of time looking at the avatars, significant differences were found between facial regions of gaze with ASD participants spending significantly more time looking at the forehead and TD participants looking significantly more at the mouth. Furthermore, the ASD group displayed a visual pattern of distributed gaze with a lack of focus on features of the avatar's faces relevant to the task. Overall, the researchers found that group differences emerged in response time, gaze patterns, and response confidence, but not in the correct identification of emotions.

Bekele et al. (2016) further explored the task-performance and gaze pattern differences in 12 adolescents, ages 13-17, using eye-tracking during a cafeteria-based, VR social interaction

task. The researchers employed a multimodal adaptive social interaction (MASI) platform in VR to collect and measure eye gaze, physiological, and emotion-recognition relevant EEG data in real-time. Bekele et al. (2016) hoped that by assessing these data that they would gain information regarding ways to facilitate facial emotion recognition for individuals with ASD during social interactions. The MASI system employed an occlusion paradigm for facial recognition in which a face would be presented that was occluded with portions of the face revealed in succession to focus the attention of the participant to features relevant in an emotional recognition task. Additional complexity was added to the emotional recognition task by adding a conversational element to provide a contextualized situation in which emotional recognition was measured. In total, subjects participated in three social interaction task sessions and two standalone facial emotion recognition sessions. Participants were divided into a gaze group (with a gaze sensitive version of the VR system) consisting of six adolescents with ASD and a control group made of six typically developing adolescents.

Bekele et al. (2016) measured gaze performance, latency, self-reported confidence, preference to one of the seven emotions displayed in the scenarios, and physiological features (e.g., heart rate, respiration rate, skin conductance, etc.). At pretest, compared to the control group, the facial emotion recognition performance and gaze patterns of the gaze group were demonstrably lower with individuals primarily staring at a speaker's nose and mouth rather than eyes. At posttest, results indicated that the performance of the participants in the gaze group was nearer to that of the control group with the gap between the groups closing by 3%. The researchers successfully tested the usability of their MASI VR system for adolescents while also demonstrating improvements in gaze and task performance in the experimental group. Moreover, using the VR system they were able to conduct assessment of physiological and conceptual

measures in real-time in situ as participants completed the study tasks. Due to the pilot nature of this study, the researchers did not elect to conduct a follow-up study which may have provided insight into the stability of the improvements seen in the gaze group. Additionally, Bekele et al. (2016) did not provide a thorough justification for the use of physiological measures and its relevance to the study population. A future study should include a follow-up assessment as well as additional rationale for the inclusion of physiological measures.

Serret et al. (2014) developed a four-week, serious game, virtual environment training called JeStiMule which was designed to explicitly teach emotion recognition to children and adolescents with heterogeneous ASD profiles. The researchers sought to capitalize on the advantages of VR for an ASD population such as preferences for electronic media; greater emotional processing of cartoon and avatar faces; reduced feelings of social anxiety and fear of failing or rejection within a simulated environment; improved integration of visual and auditory stimuli; greater flexibility of scenarios offered; and the presence of motivating elements such as the ability to explore a virtual space, immediate feedback, and the ability to customize one's avatar.

The JeStiMule environment was designed to link emotional and social elements with logical rules. Thirty-six children and adolescents were enrolled in the study with 33 children participating in the intervention which consisted of tasks to assist children in recognizing facial expressions, emotional gestures, and social situations. On either static or animated avatars, the researchers displayed nine facial expressions which included happiness, anger, fear, surprise, disgust, sadness, pain, neutral, and "funny face" (an intentional inappropriate facial expression). In addition to facial expressions, for each emotion, an emotional color-wheel was used to provide nonverbal codes for each emotional expression, a tactile pattern was made to associate with each

emotional expression, an auditory sequence was played, and both emotional words and idiomatic expressions were included as a description. No explicit rules were given to the participants. They were provided nonverbal cues and expected to use trial and error to learn the game while in the presence of a caregiver who was advised to provide assistance as necessary. Prior to the intervention and post-intervention, participants completed five emotional recognition tasks of the seven emotions that were displayed by avatars in one condition and by real-life faces the other condition. After creating and personalizing their avatars, participants were free to explore a virtual city that included a restaurant, theater, shop, garden, and a square. When their avatar was within a specified distance of a computer-based agent representing a city resident, a vignette of a social scenario was triggered (i.e., a “cut scene”) for their viewing.

Participants completed three phases of the JeStiMule: calibration where their sensitivity to aural, tactile, or visual stimuli was fine-tuned, learning where complexity increased from static faces to animated faces culminating in animated faces with gestures, and training in which participants completed three modules with 26 social scenarios and four scenarios to train formulating a request. Serret et al. (2014) assessed the usability and the effectiveness of the intervention program for participant performance on tasks with the avatars and with real faces which participants were not trained on using repeated measures analysis of variance with post-hoc Tukey HSD tests. Usability testing results indicated that participants were able to navigate the virtual environment and complete tasks within the environment within an expected time. Results of the effectiveness of JeStiMule indicated that participants’ emotion recognition of both avatar and real-life characters was improved after the training. Improvements were found across all participants regardless of functioning.

This study demonstrated the importance of design features for making VR interventions accessible for individuals with ASD across differing levels of ability. In addition, this study highlighted features of VR such as varied simulated environments, free exploration, user feedback, avatar customization, and researcher control of stimuli. Moreover, as the skills trained on for virtual avatars transferred to untrained on real-life character faces, this study highlights the ability for learning in highly ecologically valid virtual environments to generalize. As this was a usability study, there was no control group and while task complexity increased for some content, the tasks were not scaled based on user characteristics. Additionally, the researchers sought to emphasize that the JeStiMule environment was not designed with remediation of ASD symptoms as the goal, pointing to neurological differences that necessitate the development of compensatory strategies for improved functioning. Future studies should include a calibration of user ability and scale task complexity based on participant strength and weaknesses.

The studies reviewed above indicate that VR is a viable medium for conducting intervention for individuals with ASD. Additional research has shown that individuals with ASD can use head mounted displays to complete study tasks and both accept and enjoy the experience (Newbutt et al., 2016). Also, researchers using desktop and CAVE VR trainings and interventions for individuals with ASD have addressed teaching practical, daily living, and safety skills (i.e., grocery shopping, crossing the street); travel skills (i.e., air travel, train travel, bus travel); motor skills (i.e., gestures, visuospatial skills); and skills for training appropriate behavior for specific environments (i.e., restaurants, shopping malls, cafeterias) (Adjorlu et al., 2017; Herrero et al., 2018).

**VR Design Guidelines and Considerations.** Despite the many advantages and affordances virtual environments potentially offer for researchers and end users with ASD, few

evidence-based standards or guidelines exist for the design of these spaces. Bozgeyikli et al. (2018) reviewed VR ASD studies and communicated design guidelines and considerations that had been shared by three or more previous studies in the areas of task design, information presentation, and VR system. Some task design guidelines included inclusive or participatory design with children, parents, and other parties (i.e., teachers, community members); allowing for repetition in practicing of tasks; increasing difficulty gradually; and designing short training sessions (Bozgeyikli et al., 2018). Information presentation recommendations endorsed in the literature reviewed by Bozgeyikli et al. (2018) included using color, shape, or movement to attract attention; providing clear foreground-background differentiation; and using simplified interfaces and graphics. For VR systems, prescriptions included offering a variety of tasks, and using simple, intuitive controls and forms of input (Bozgeyikli et al., 2018).

Although these recommendations are relevant, Bozgeyikli et al. (2018) noted that these considerations had limited validity because, among other issues, they did not primarily result from studies specifically comparing study outcomes or user experience based on the VR design used and the guidelines were highly dependent on the specific study tasks and so may not generalize to other tasks. In their review of VR HMD ASD research, Bradley and Newbutt (2018) echoed Bozgeyikli et al. (2018)'s assessment of the state of VR ASD research stating that the current need is to determine which combinations of user characteristics and features and affordances of VR influence positive response to intervention, while supporting and motivating learners.

**VR Social Skills Training.** Recently, a growing number of studies have evaluated the use of VR interventions to teach social skills such as emotional recognition, joint attention, facial cues, non-verbal language, emotion regulation, conversation skills, and social cognition



(Bozgeyikli et al. 2018; Dechsling et al. 2021; Herrero et al. 2018). Notably, Ip et al. (2018) used a 14-week CAVE VR program to successfully teach emotion expression, emotion regulation, and social-emotional reciprocity to 94 children aged 6-12 diagnosed with ASD. Ip et al. (2018) used story-based scenarios in their program, had a waitlist control group, and assessed generalizability of outcomes to outside settings. Significant improvements were found from pre-to posttest for the treatment group on the PEP-3 Affective Expressions and Social Reciprocity assessment. Despite a lack of significant findings on other measures such as emotion recognition (e.g., the Faces test and the Eyes test) or adaptive skills (e.g., the ABAS-II), this study demonstrated the promise of virtual reality for training children with ASD.

Ke and Moon (2018) rated social interaction in 8, 10-to-14-year-old participants with ASD who participated in their 3D virtual playground designed in the open-source OpenSimulator virtual environment. The participants used their avatars in the OpenSim environment to engage in parallel play in games such as chess, soccer, motorcycle racing, mathematical puzzles, and scavenger hunts to name a few. Two trained facilitators “puppeteered” 3-5 avatars during each activity and used them to provide verbal and non-verbal prompts based on the participants’ needs. The children were rated 3-5 times during non-gaming interactions (baseline) across three locations (i.e., community setting such as their home or public library, via video conference, and during a VR orientation session) and then again via screen recording and non-site observations while gaming.

The targeted social skills were responding (e.g., turn taking and frequency of verbal and non-verbal responses); initiation (e.g., non-verbal interaction and verbalizations that were not a direct response or preceded by a question); negotiation (e.g., reciprocal exchange or verbal collaboration with others); self-identify (e.g., explaining one’s own perspective or preference),

and cognitive flexibility (e.g., switching between solutions, tasks, or perspectives). Results indicated that the participants made gains in the targeted social skills during the intervention with significant improvement in social interaction performance from baseline to intervention phase and a trend toward significance across all targeted skills. Based on their findings, Ke and Moon (2018) recommended design and implementation strategies for VR-based games for ASD and social skills training which included dynamically adjusting the level of difficulty and extraneous cognitive features based on individual learners' skills and interests; rewarding interpersonal interactions automatically as a game feature; adjusting game activities to encourage collaboration and team competition; and using participatory design practices to increase the sense of agency in the autistic learners.

Findings of improvement on trained social skills as in Ke and Moon (2018) and Ip et al (2018) are not uncommon in the VR social skills literature. Several VR studies targeting social skills have found similar success. Bozgeyikli et al. (2018) performed a comprehensive review of any study that aimed to improve skills of participants with ASD. In their review, they noted that over 46% of the studies that met their criteria concentrated on training individuals with ASD on social skills and assessed participants' abilities to problem solve in social scenarios; use appropriate manners, eye contact, and maintain conversation; and learn from social stories. Nearly 90% (8/9) of the VR social skills training studies reviewed that assessed ASD subjects' response to intervention demonstrated improvements in social skills and executive functions for participants with some even reporting evidence of transfer of these gains to environments outside of the VLE (Bozgeyikli et al., 2018). However, recently, Dechsling et al. (2021) reviewed VR/AR and computer-based studies with ASD participants and noted that the social skills studies

they reviewed lacked rigorous designs, had low participant counts, and needed replication to add support for their findings.

### Manualized trainings and Virtual Environments

While many VR ASD studies have targeted social skills, to date, only one manualized social skills intervention has been implemented within a virtual environment. Stichter, Laffey, Galyen, and Herzog (2014) sought to develop a virtual learning environment to address issues of poor access to evidence-based social competence instruction for teachers and students in rural areas. Stichter et al. (2014) posited that a 3D VLE would be ideal as a distance education offering and could benefit individuals with ASD who sought to learn social competence skills, which require both cognitive and behavioral practice. Stichter et al. (2014) elected to field test the impact of iSocial, a virtual adaption of the Social Competence Intervention (SCI-A) curriculum. The researchers aimed to examine the iSocial intervention's impact on social competence for students with autism and average to above average intelligence as measured by questionnaires completed pre-and post-intervention by teachers and parents and a test battery by project staff; the degree to which the iSocial 3D VLE had fidelity to the SCI-A curriculum; and the perceived social validity of the intervention as assessed by parents, teachers, and students.

Participants were 11, 11- to 14-year-old adolescents diagnosed with autism and average to above average intelligence. The iSocial curriculum consisted of 31, 45-minute lessons taken 3 days a week for four months. Participants who met criteria were enrolled, but there was no randomization to conditions. The lessons consisted of a previous skills review, new skill introduction/instruction, skill modeling, skill practice opportunities, and closing activity or skill review. A portion of the SCI-A tasks were recreated in iSocial and slightly modified where

possible to take advantages of the affordances, some tasks were modified with gamified elements, and some tasks could not be replicated and had to be redesigned entirely.

Parents and teachers completed the Social Responsiveness Scale (SRS) which measures social impairments associated with ASD in the domains of social awareness, social cognition, social communication, social motivation, and autistic mannerisms and the Behavior Rating Inventory of Executive Function (BRIEF) which rated the participants' executive functions in their environment on a 3-point Likert scale. The research team assessed participants on the Reading the Mind in Eyes test which assessed an adolescent's ability to use facial features to assess another person's mental state; the Faux Pas test which tested the child's ability to identify a faux pas in the 5 of 10 scenarios when one was present; the Strange Stories in which students were asked to make inferences about a character's mental or physical state for 8 stories; the Diagnostic analysis of non-verbal accuracy-2 (DANVA-2-CF) which asked the adolescents to identify facial expressions in a sample of 24 photos of children; the verbal fluency, design fluency, trail making, and color-word interference trials of the Delis-Kaplan executive functioning system (D-KEFS); and the Conners' continuous performance test-II which measured students' attention span and inhibition. Teachers, Parents, and students' perceptions of social validity of the intervention were rated with the Intervention Rating Profile (IRP-15). Lastly, graduate students observed teachers who implemented the intervention across the 3 rural school districts in which it was implemented and rated them on intervention fidelity.

Prior to the intervention Graduate students completed fidelity ratings of the online intervention manual compared it to its unmodified version. These ratings, when scored at posttest, indicated that the graduate student observers rated the fidelity of the iSocial intervention as comparable to that of the SCI-A from which it was derived. Results across the majority of EF

measures were quite variable and predominantly nonsignificant, though in all cases the SRS and BRIEF had positive outcomes. Moreover, the Parent rated SRS indicated significantly less impairment of social functioning and improved social responsiveness across most domains and the Parent rated BRIEF indicated that parents reported significant improvements in their adolescent's executive functions at home. Parents, participants, and teachers rated the intervention as acceptable with students agreeing that the intervention would help them get along with others.

Overall, the researchers noted that the students benefitted from the intervention, the intervention had high ratings of social validity and fidelity, and patterns in the data were similar to those from in-person administrations of the SCI-A from which the iSocial intervention was derived. Limitations included noted difficulty in translating SCI-A tasks to the iSocial VLE, a lack of direct observations of student, a small sample size, and lack of follow-up with participants on the outcome measures. The researchers were also unclear whether the lack of robust findings in student outcomes was indicative of deficiencies from addressing the targeted skills through VLE or mainly due to the tasks of iSocial not effectively addressing skills of emotion/ facial expression, attention, response inhibition, or perspective taking. This study provided an understanding of issues researchers face when creating virtual versions of pre-existing social skills interventions. While the outcomes reported were not significant, this pilot study provided evidence of the feasibility of their approach as well as the resources needed to create a fully online 3d VLE social skills intervention.

Kandalaft et al. (2013) explored the use of a 10-session, virtual reality social cognition training (VR-SCT) to teach social skills to young adults diagnosed with ASD. The sessions included making social initiations, handling conflicts in relationships, job interviews, and dating

interactions. Eight young adult participants completed the training and were assessed on social performance measures including tests of verbal and non-verbal emotion recognition such as the Advanced Clinical Solutions Social Perception Subtest (ACS-SP) and the Facial Expressions of Emotion Stimuli and Tests (Ekman 60); tests of theory of mind such as Reading the Mind in the Eyes (Eyes) and the Social Perception Task (Triangles); and test of conversational skills such as the Social Skills Performance Assessment (SSPA). Change scores from pre- to post-assessment were calculated to assess the efficacy of the intervention. Improvements were observed across all study measures and significant improvements were found for participants on the ACS-SP Total, ACS-SP Prosody, Ekman 60, and Triangles task. This study demonstrated the success of VR-SCT in improving social cognition for young adults across a number of domains. Kandaloft et al. (2013) called for future iterations of the VR-SCT to include a control group, behavioral observations of outcome measures, real-time assessment of facial affect, and tests of the feasibility of remote applications.

In a follow-up study, Didhehani et al. (2016) sought to deploy the VR-SCT with thirty children ages 7 to 16 with average to above-average IQ, diagnosed with ASD. Didhehani et al measured changes in affect recognition, social attribution, and executive functioning pre- and post-intervention. In addition, analyses were conducted to examine any differences in change between children diagnosed with co-occurring ASD and ADHD and children diagnosed only with ASD. Measures included the NEPSY-II AR to assess facial affect recognition; the Triangles task to measure social attribution; and the NEPSY-II Auditory Attention and the Analogical Reasoning Task served to assess attention and executive function. The VR-SCT, as in Kandaloft et al. (2013), consisted of 10 sessions, though the session content differed from those delivered in that study. Sessions consisted of scenarios designed to assist participants with initiating a

conversation, developing relationships, decision-making, emotion recognition, and collaboration. Significant pre-post improvements were found on the NEPSY-II AR, the Triangles Intentionality score, and the Analogical reasoning task. No significant differences were found between those diagnosed with ASD and ADHD combined and those only diagnosed with ASD on the measures. Results from the study supported the use of the VR-SCT with children and highlighted the need for a future randomized trial of the VR-SCT as well as tests of a remote delivery system.

**VR Synthesis.** The virtual environment literature overwhelmingly supports the notions that individuals with ASD are able to perceive virtual environments as representational of real-life situations, are motivated and engaged while actively participating in virtual environments, are able to apply knowledge learned within virtual environments to real world contexts, and navigate and perform tasks well within these virtual learning spaces. Findings from VR studies demonstrate that individuals with ASD who have participated in social skills interventions have shown small to moderate benefits as a response to intervention (Bozgeyikli et al., 2018).

While there are a few exceptional VR ASD studies such as Ke and Moon (2018), Stichter et al. 2014, and Ip et al. (2018), there are still several shortcomings in the reviewed literature that warrant further research. Limitations to the current use of VR as reported in studies to date include small sample sizes; few manualized, evidence-based social skills interventions (which reduces the likelihood of an intervention being implemented with fidelity and decreases the replicability of the intervention); lack of description of the design process or design features; low interactivity; lack of complexity and scalability in scenarios and tasks; lack of a control group; primary outcomes measures only of usability; focus on recognizing emotions and not training the production of emotions; and length of assessment too short to assess long-term efficacy (Grossard et al., 2017). In addition to addressing these limitations, Grossard et al. (2017)

recommend that future VR studies employ automatic feedback to user input, incorporate modules for sub-skills that support social skill improvement (e.g., joint attention), and develop realistic scenarios with story progressions to increase user engagement and immersion.

The current study will focus on addressing some of these limitations by employing a control group, using a manualized intervention, involving an individual with ASD in the design process, and describing the design process and design features.

### ***Rationale for Study***

Although the PEERS intervention has been shown to be successful, this has primarily been with White participants. Race, ethnicity, and socioeconomic status are factors that moderate and mediate the effects of interventions (West et al., 2016). One aim of the current study, therefore, is to determine if the success of the PEERS intervention would be replicated in an urban environment with participants diverse in socioeconomic status and racial/ethnic identity. To address issues of generalizability and explore ways to strengthen understanding of concepts and skills taught in PEERS, the second aim of this study is to pilot a virtual environment and an online course as supplements to the standardized PEERS intervention. As the literature notes that virtual environments may potentially engage participants to increase motivation to learn, a third aim of this study is to examine the relationship between participant motivation, particularly as it relates to experiences with the virtual environment component, and participant outcomes.

### ***Hypotheses***

The proposed study will test the following hypotheses:

H1: *Compared to the delayed treatment control group, the treatment group will significantly improve their knowledge of social skills as shown on the self-report measure the Test of Adolescent Social Skill Knowledge.*



H2: *Compared to the delayed treatment control group, the treatment group will have significantly better social interactions as reported on the parent report measure the Quality of Socialization Questionnaire.*

H3: *Compared to the delayed treatment control group, the treatment group will have a significantly greater reduction in ASD symptoms related to social responsiveness on the parent report measure the Social Responsiveness Scale.*

H4: *Compared to the delayed treatment control group, the treatment group will have significantly greater reduction of problem behaviors on the parent report measure the Social Skills Intervention Scale.*

H5: *Intrinsic motivation as reported on the self-report Isen and Reeve Motivation Scale (REFF) will significantly increase from pre- to posttest for the participants in the treatment group.*

## CHAPTER THREE

### Method

#### Recruitment and Eligibility

In line with the requirements of previous PEERS studies, to be eligible for inclusion criteria for the current study included: 1) being aged 12 to 17 and currently performing at or above grade level in their school; 2) having a documented ASD diagnosis as confirmed through most recent psychiatric evaluation and/or IEP; 3) a KBIT VIQ 65 or above; 4) be experiencing social skills difficulties; 5) an ability and willingness to speak, understand, and communicate in English; and 6) enthusiastic assent to participate. Additionally, participants' parents had to be English speaking and willing to attend 12 of 16 sessions. Excluded from this study were youth who: 1) had a diagnosis of a competing psychological disorder (e.g., major depression, schizophrenia); 2) had the presence or history of violent behavioral issues; 3) were below grade level; or 4) were non-speaking.

Potential participants were recruited through flyers posted on social media; in internet forums for parents of twice exceptional children (children who are gifted and also have a formal diagnosis of a learning, emotional, behavioral, or social issue). Participants were also recruited by referral from School Psychologists or social workers and by referrals from healthcare professionals working in hospitals, research centers, or clinics.

#### Participants

Participants were 12 adolescents (ten males and two females) ages 12-17 ( $M = 14.87$ ,  $SD = 1.6$ ) with ASD, and their 12 caregivers. Four of the participants were in middle school or the middle school equivalent grade in homeschool and eight were in high school or a homeschool high school equivalent. All caregivers were the biological parents of the adolescents. All parents

were English speaking. Five adolescents were White and seven were non-White representing a variety of racial and ethnic groups including Latinx, Asian, and African-American. ASD diagnoses were confirmed with psychiatric/medical reports which were also corroborated with the adolescent's individualized educational plan. All participants had a KBIT VIQ above 65, but there was a wide range of scores from 66 to 132 ( $M= 104.3$ ,  $SD= 23$ ). Five participants had a co-occurring diagnosis (i.e., anxiety, hyperactivity, inattention, or depression) and were currently taking medications.

### **Procedure**

Potential study participants were invited to complete an online screening questionnaire on Google Forms to confirm initial eligibility. In total, 64 individuals completed the online screening questionnaire. Of that 64, 35 were contacted and completed the PEERS phone screening interview using the Phone Screening Script. Those not contacted did not meet the screening criteria. During this screening interview, the PEERS intervention was explained and the interviewer communicated details of the research study. Adolescent and parent willingness to participate were assessed and any questions were answered. Responses were recorded into a Google form by the PEERS team member conducting the interview.

Those eligible after this interview ( $n= 23$ ) were then invited to come to the Lab at the university for an in-person screening and consenting intake appointment. During the appointment, ASD diagnosis, age, school history, and English language ability was confirmed; written parental consent and adult (social coach participation) consent was obtained; adolescent enthusiasm and willingness to participate in the intervention was assessed during a conversation with the PI and the adolescent; and written adolescent assent to participate in the study was

obtained. Any additional questions were answered and the interviewer scheduled an appointment to complete baseline measures.

The baseline appointment lasted on average 1.5 hours, and, during this time, the adolescents and parents completed demographic questionnaires, measures of social and adaptive behavior, a brief intelligence assessment, and screenings for depression and suicidal ideation. Two participants dropped out from the study at this time point. One potential adolescent participant declined to complete the child assent form and another potential participant's parent declined to enroll due to the uncertainty of assignment to a waitlist or immediate start condition as they wanted an immediate intervention for their adolescent.

Participants ( $N= 12$ ) were randomly assigned to a treatment (immediate start) or waitlist control (4-month delay) condition. Both groups were re-assessed on study outcome measures at the completion of the 4-month intervention and at this time-point, adolescents in the treatment group were also administered the Strange Stories and FASC tasks. Those in the waitlist control group began the intervention at this time point and then were reassessed after 4-months on the outcome measures. A long-term follow-up of the treatment group was planned, but due to covid-19, the research team was unable to obtain this data.

## **Treatment**

PEERS for Adolescents was implemented using the PEERS Treatment Manual (Laugeson & Frankel, 2010) and consisted of 16, 90-minute weekly sessions delivered over the course of 16 weeks. The 16-week format of PEERS adds two sessions from the relatively newer PEERS Curriculum for School-Based Professionals manual (Laugeson, 2014) which has a 16-session format, and it is the version currently endorsed by creator Elizabeth Laugeson (as there is no timeline to reprint the existing PEERS Treatment Manual). As recommended in the PEERS

manual, group size was limited to 6 adolescents and 6 parents for the respective adolescent and parent groups. Each in person PEERS adolescent session consisted of homework review, a didactic lesson, social roleplays, practice in dyads with corrective feedback from research assistants, review of the lesson, homework assignment, and a reunion with parents in the parent group. Each PEERS parent group consisted of homework review, a didactic lesson, homework assignment, troubleshooting potential issues with the assigned homework, and a reunion with the adolescents. Adolescent group leaders were upper-level undergraduate students and graduate students. The Parent group leaders were upper-level graduate students. The PEERS Treatment was provided free of charge and adolescent participants were given a prize equivalent to \$50 in value at the completion of the intervention.

An overview of the sessions their content appears below in Table 1

**Table 1**

*Overview of the PEERS Intervention Sessions*

Session #	Session Topic	Brief Overview
1	Conversational Skills 1: Trading Information	The primary goal of this lesson is to teach teens the importance of trading information to find common interests.
2	Conversational Skills 2; Two-way Conversations	The focus of this lesson is on the rules for having a two-way conversation.
3	Conversational Skills 3: Electronic Communication	This session provides specific rules for using electronics to converse with friends and potential friends.

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4	Choosing Appropriate Friends	This lesson highlights strategies for choosing an appropriate potential friend.
5	Appropriate Use of Humor	This week teaches the importance of paying attention to humor feedback.
6	Peer Entry 1: Entering a Conversation	This lesson teaches skills to help teens approach new potential friends.
7	Peer Entry 2: Exiting a Conversation	This session focuses on how to appropriately handle rejection during peer entry attempts.
8	Get-togethers	The focus of this session is on teaching teens how to organize and implement a get-together with potential friends
9	Good Sportsmanship	The content of this lesson is concerned with rules for a good sport.
10	Handling Teasing and Embarrassing Feedback	The major goal of this session is to give teens new and more effective strategies for handling teasing (verbal aggression from peers).
11	Changing Reputations	The content of this lesson provides teens with a jumpstart on changing a bad reputation.
12	Handling Disagreements	The purpose of this lesson is to teach some skills to help teens resolve disagreements with peers.
13	Handling Cyberbullying	This lesson focuses on effective strategies for combating cyber bullying.

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14	Handling Physical Bullying	This lesson focuses on appropriate strategies for handling physical bullying.
15	Minimizing Rumors and Gossip	The focus of the current lesson is on how to appropriately manage rumors and gossip.
16	Graduation and Termination	The major focus of this session is termination from this brief intervention.

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During each session, parents and adolescents attended separate concurrent groups. The parents in attendance served as social coaches and met with the parent group leader to learn about the current social skills for the weekly session, review assigned homework, share their coaching successes and troubleshoot challenges, and to plan for the upcoming homework assignments.

Under the direction of the PI who is a PEERS Certified Provider, a team of six behavioral coaches consisting of undergraduate and graduate students facilitated the adolescent group. In this group, adolescents reviewed assigned homework, received a didactic lesson on a specific social skill, viewed positive and negative roleplays demonstrated by the behavioral coaches, and practiced roleplays in dyads with corrective feedback from the behavioral coaches. These dyads were chosen by the behavioral coach serving as the group leader. If the pairing was deemed to be disruptive or uncooperative, the adolescents were re-assigned to a new dyad. Lastly, at the end of the lesson, the group leader summarized the content taught and discussed the homework assigned for the week.

## **OpenSimulator Virtual Environment**

A virtual island was created for the study in OpenSimulator (aka OpenSim or OS) with the assistance of an adolescent diagnosed with ASD. The adolescent was funded through a grant from a large metropolitan university's honors college and was highly interested in helping with this project. Over the course of two months, this adolescent designed the school building, coded the teleporters, and provided feedback on the virtual environment. The adolescent was provided with a tutorial on building and scripting within OS by the principal investigator (PI) and was also given resources on these topics to practice their skills. The PI created a private island in OS and instructed the adolescent to build a school, with 16 floors (one for each PEERS session), along with an outdoor theater, lunchroom, and classroom. In addition, the adolescent was instructed to build a teleporter system to allow participants to instantaneously move from one floor to another as well as from other points of interest on the island. The adolescent met weekly with the PI in-person to review their progress and would also send updates over email and through chat on Discord. Throughout the collaborative process, the adolescent suggested and implemented design and programmatic changes for the requested spaces, provided feedback on proposed navigation and instructional features, and planned additional features with the PI.

On this island, the study participants were able to perform additional social roleplays with their peers or with intervention staff, ask questions of staff, and complete quizzes assessing their learning using OpenSimulator, an open-source 3-D multi-user virtual environment like SecondLife (SL). Accounts for each adolescent were created giving them an avatar to access the virtual island. Participants were instructed to download the Singularity Viewer, a client application (built from SecondLife's viewer's source code) used to access virtual worlds, open the viewer on their computer, and enter in their assigned username and password as well as the



uniform resource identifier (URI) of the site with port number to access the location of the virtual environment on the PI's online server hosted on [asmallorange.com](http://asmallorange.com) (CentOS 6 LAMP).

Users whose computers were not able to access the virtual island due to performance issues (e.g., lack of a graphics card, low specifications, etc.) were given access to a frame account from Bright Canopy that allowed them to run a virtual Singularity client that could be launched from any web browser regardless of their computer's performance capabilities. Parents and adolescents were instructed to log on to OpenSimulator and visit the virtual island to practice roleplays with the PI, ask questions about PEERS session content, and complete quizzes that served to review and elucidate the content of the current week's lesson. Parents and adolescents were encouraged to schedule a time with the PI to concurrently access the virtual environment if any questions about lesson content, troubleshooting computer issues, or additional tutorials were desired. While each adolescent was assigned a standard default male or female avatar according to their declared sex, many chose to alter the likeness of their avatar and made modifications to their appearance as they saw fit. Upon arriving to the virtual environment individuals were instructed with corrective feedback in the completion of simple orientation tasks such as navigating their environment, walking, teleporting using the teleport pad designed for the study, texting, using voice, and completing tasks (e.g., taking quizzes and interacting with other avatars or objects).

### **Moodle Course**

An online course in the open-source Moodle learning management system was created for Parents to access handouts and other relevant session specific information from the PEERS treatment manual. In addition, parents had access to a glossary of key terms, video conferencing through the BigBlueButton plugin (if they could not attend a session in-person), a forum to

communicate with the PEERS team or other parents, forms for communicating planned absences throughout the intervention, and a phone roster to facilitate in-group phone calls for homework assignments. During conversations throughout the parent session, many helpful ideas ranging from potential ASD friendly venues and activities to insider information on how to apply for special needs services such as Medicaid Waivers or Access-A-Ride services were communicated. This information was added to the Moodle site for parents to access at their leisure.

## **Measures**

### ***Kaufman Brief Intelligence Test Second Edition***

A Verbal Intelligence Quotient (VIQ) was derived from the Kaufman Brief Intelligence Test—Second Edition (KBIT-2; Kaufman and Kaufman 2005). The KBIT-2 provides raw and standard scores with a mean of 100 and a standard deviation of 15. The VIQ is composed of three sections a test of Verbal Knowledge, Matrices, and finally Riddles. Internal consistency for ages 4 to 18 was reported as 0.90 for the Verbal, Nonverbal, and IQ Composites respectively. The KBIT-2 took approximately 30 minutes to administer.

### ***Vineland Adaptive Behavior Scales—Second Edition***

Adaptive behavior skills were obtained from the Vineland Adaptive Behavior Scales—Second Edition, Survey Form (Vineland-II; Sparrow et al. 2005). The Vineland Parent/Caregiver form was used to measure adaptive behavior skills with the communication and socialization domains as well as the main composite score reported. Parents rated their adolescent's behaviors as occurring either "Never", "Sometimes/Partially", or "Usually". The Vineland-II provides domain and composite scores as standard scores with a mean of 100 and a standard deviation of 15. Internal consistency of the domain scores across ages range from .80 to .95.

### ***Social Anxiety Scale- Adolescents***

Social Anxiety was measured with the Social Anxiety Scale- Adolescents (SAS-A; La Greca & Lopez 1998). The SAS-A was used to assess social avoidance and distress experienced by adolescents generally when in the company of peers (SAD-General), in new situations or with unfamiliar peers (SAD-New), and an adolescent's fear of negative evaluation (FNE).

Adolescents rated statements as "Not true at all", "Hardly ever true", "True sometimes", "True most of the time", "Always true". Higher scores indicate greater social anxiety, and a total score is calculated by summing the three subscales. Internal consistencies range from .76 to .91.

### ***Strange Stories***

Theory of Mind was derived from the Strange Stories (Happe, 1994). The Strange Stories tasks was used to assess the ability of each participant to reason about the mental states of characters in provided vignettes. Twelve vignettes were included which asked participants to assess the veracity of story content and then make a mental or physical justification for the behaviors of characters in the vignette. Participants are assessed on the correctness of their veracity assessment and justification. The stories had an internal consistency of 0.95. This measure was given as part of a separate study and was not analyzed for this study.

### ***Flexibility and Automaticity of Social Cognition***

An advanced Theory of Mind measure included was the Flexibility and Automaticity of Social Cognition (FASC; Hayward et al., 2016). The FASC is designed to measure both lower-level cognitive processes which are efficient, but lack precision, and higher-level cognitive processes which have increased accuracy, but higher cognitive demands. The FASC consists of eight cartoons that vary based on their ambiguity (ambiguous vs unambiguous) and use of language (present vs absent). A subject's responses to the cartoons are scored based on their

initial reaction time and total response time (automaticity) and total mental state term usage, total number of responses including unique mental states, total number of responses lacking mental-state reasoning, and how typical their response was (flexibility). Internal consistency data was not available for this measure. This measure was given as part of a separate study and was not analyzed for this study.

### ***Outcome Measures***

Social skills in the areas of communication, cooperation, empathy, self-control, and competing problem behaviors (e.g., bullying, externalizing behaviors, and ASD characteristics) were assessed with the Social Skills Improvement System Rating Scales (SSIS; Gresham & Elliot, 2008). Two scores are derived: a Social Skills score and a Problem Behaviors score with higher scores indicating more of the behavior measured. Internal consistency for the parent form was 0.96, while internal consistency for the student form was 0.94.

The severity of ASD social difficulties was derived from the Social Responsiveness Scale Second Edition (SRS-2; Constantino, 2012). The SRS-2 uses ratings from parents and is composed of 65-items and can be completed in 20 minutes. Five subscales are available which measure Social Cognition, Social Awareness, Restrictive and Repetitive Behaviors, Social Motivation, and Social Communication. The internal consistency of the SRS was in the .92 to .95 range.

The retention of social skills knowledge from the PEERS intervention was measured with the Test of Social Skills Knowledge (TASSK; Laugeson et al., 2012). A total score is derived with higher scores indicating greater social skills knowledge retained. The TASSK internal consistency was 0.56

The total occurrences of hosted and invited get-togethers in the last 30 days was obtained from the Quality of Play Questionnaire (QPQ; Frankel & Mintz, 2008). The QPQ is an assessment completed by parents who were also asked to report on the amount of conflict (e.g., “They criticized or teased each other”) that occurred during the get-together. Parents rate the veracity of items as either “Not at all”, “Just a little true”, “Pretty much true”, or “Very much true”. Internal consistency for the conflict scale was 0.87.

Motivation was assessed with the Isen and Reeve Motivation Scale (Motivation self-report; Isen & Reeve, 2005). This self-report measure was used to determine how motivated and interested adolescent participants were in completing the PEERS program and tasks in the virtual environment. Participants rated statements such as “It stimulates my curiosity” and “I would be willing to come back and participate in an experiment that used this activity” on a 7-point Likert scale from strongly disagree to strongly agree. Participants were instructed to keep the virtual environment in mind when completing the instrument, but no language in the instrumentation reflected this directive. The internal consistency of the scale was .92.

## Chapter Four

### Results

#### Analytical Approach

All statistical analyses were completed in RStudio and analyzed at  $p < .05$ . As in Laugeson et al. (2012), difference scores were used to assess differences between the treatment and waitlist group. Any missing data was imputed with predictive mean matching. Log transformations were used to address any outliers in the data. Freeman-Halton Fisher exact tests were used to assess pre-existing group differences in gender, race, parent education, school type, and medication use. T- tests were conducted for age, grade, Kauffman Brief Intelligence Test (KBIT) Verbal Intelligence Quotient (VIQ), Vineland Adaptive Behavior Scales (VABS) Composite, VABS Communication, VABS Socialization, and outcome variable baseline scores. Group by time interaction effects were assessed with repeated measures analysis of variance and next group mean differences were assessed by t-tests. Wilcoxon signed rank tests were performed to assess differences between groups on the Isen and Reeve motivation measure. A continuity correction was applied in follow-up analyses when comparing participant responses on the Isen and Reeve motivation measure. Lastly, exploratory correlation analyses were conducted with the Moodle site log-in and interaction data.

#### Preliminary Analyses

After assessing the percentage of missing data per group, there was 0% missing data for the treatment group and 4.5% missing data (missing at random) from two participants in the waitlist group who were missing scales. The missing data were imputed using predictive mean matching from the multivariate imputation by chained equations (MICE) package in R. Data

were screened for outliers. To address outliers, a log transformation was implemented for the Moodle interaction data. No outliers were found for the other variables.

Freeman-Halton-Fisher's exact tests comparing the treatment and waitlist control groups for baseline differences in variables for gender, race, parent education, school type, and medication use were not significant ( $p$ 's  $>.28$ ). T- tests for age, grade, Kauffman Brief Intelligence Test (KBIT) Verbal Intelligence Quotient (VIQ), Vineland Adaptive Behavior Scales (VABS) Composite, VABS Communication, VABS Socialization, and outcome variable baseline scores all failed to reach significance ( $p$ 's  $>.13$ ). Table 2 provides summary data for these scores.

**Table 2**

Mean demographic and baseline variables for *Treatment and Waitlist Control groups (standard deviations are in parentheses)*

Variable	Group		$p$
	Treatment (n= 6)	Waitlist control (n=6)	
Age	15.0 (1.3)	14.7 (1.9)	0.76
Grade	9.17 (1.5)	8.8 (1.9)	0.74
KBIT_VIQ	102 (23.1)	106.7 (24.8)	0.74
VABS_Composite	70.7 (2.3)	75.8 (6.8)	0.31
VABS_Communication	78.8 (8.9)	86.8 (8.5)	0.14
VABS_Socialization	67.2 (6.3)	64.2 (4.8)	0.38
TASSK_pre	14 (3.2)	13.2 (2.6)	0.64
QSQ_P_pre_Hosted	2.5 (1.6)	0.2 (0.4)	0.55
QSQ_P_pre_Invited	0.3 (0.5)	0.3 (0.5)	1.00
QSQ_P_pre_Invited_friends	0.3 (0.5)	0.3 (0.5)	1.00
QSQ_P_pre_conflict	2.7 (3.4)	0.3 (0.8)	0.14

Pre_Problem_Behaviors	116.8 (20.2)	122 (6.4)	0.56
Pre_Social.Skills	76.7 (21.8)	75.8 (13.7)	0.94
Pre_ASD	19.5 (9.0)	22 (4.7)	0.56
SRS_Pre	75.3 (9.9)	71.2 (12.1)	0.46

### Primary Analyses

In line with previous reported results in the PEERS literature (Laugeson et al., 2012) difference scores (DS) were calculated with the Post-test – Pre-test. For the SSIS positive difference scores indicated improvement except for the following subscales: ASD, Internalizing, Externalizing, Hyperactivity/Inattention, and Bullying. For these subscales, negative difference scores indicated improvement. For the SRS, negative difference scores indicated improvement, while positive differences scores indicated increased social problems. Lastly, for the QPQ-P, positive scores on the Invited, Invited Friends, and Hosted subscales indicated improvement in making and maintaining friendships, while negative scores on the Conflict scale indicated improvement. Mean differences scores for the SSIS-P and the SRS-P subscales along with their significance levels can be found in Table 5.

After conducting a repeated measures analysis of variance (ANOVA) to examine group by time interaction effects, difference scores were calculated for between group mean differences on outcome variables and t-tests were performed. Assumptions of normality and sphericity, and the presence of outliers were assessed prior to the completion of the analyses. There was a significant group by time interaction for the TASSK ( $p < .01$ ). In support of H1, students in the treatment group scored significantly higher on the test of social skills knowledge (TASSK; mean DS = 6.67) compared to students in the waitlist control group (mean DS = 0.5;  $F(1,10) = 23.36$ ,  $p < .001$ ;  $d = 2.79$ ). There was a significant group by time interaction on the QSQ-P Hosted



( $p < .01$ ). Similarly, in support of H2, parents in the treatment group reported significant increases in hosted get-togethers on the QSQ-P Hosted (mean DS = 2.17) compared to parents in the waitlist control group (mean DS = 0.00;  $F(1,10) = 9.49$ ,  $p < .01$ ;  $d = 1.78$ ). H3, was not supported with no significant differences between the Tx and WL groups on ASD symptoms ( $p = 0.46$ ). There was a significant group by time interaction for the SRS Total Scale ( $p < .01$ ). In support of H4, results indicated that parents in the treatment group reported significant reductions in problem behaviors on the SRS Total Scale (mean DS = -6.83) compared to parents in the waitlist control group (mean DS = 8.67;  $F(1,10) = 10.15$ ,  $p < .01$ ;  $d = -1.84$ ).

Analysis of subscales revealed significant improvements in the Treatment Group compared to the Waitlist Control Group on the SRS-P in the areas of Social Awareness [ $F(1,10) = 5.15$ ,  $p = <.05$ ), Social Communication [ $F(1,10) = 8.14$ ,  $p = <.05$ ), Social Cognition [ $F(1,10) = 8.81$ ,  $p = <.05$ ), Restrictive and Repetitive Behaviors [ $F(1,10) = 5.29$ ,  $p = <.05$ ), and the Social Communication Index [ $F(1,10) = 12.13$ ,  $p = <.01$ ]. Also, it should be noted that on the SSIS the Treatment Group's improvements relative to the Waitlist Control Group approached significance for the Self-Control, Assertion, and Empathy subscales with  $p$ 's  $<.06$ . Significant results are presented in Table 4.

**Table 3**

*Mean pre- and post-treatment scores for statistically significant outcome variables for the Treatment and Waitlist Control groups (\* indicates measure where lower score designated improvement)*

Variable	Group Treatment (n= 6)	Group Waitlist control (n = 6)	$p$
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	Pre	Post	Pre	Post	
Measures:					
TASSK	14 (3.2)	20.7 (4.1)	13.2 (2.9)	13.7 (2.9)	<.001
SRS-P Total*	75.3 (9.9)	68.5 (6.2)	71.2 (8.7)	79.8 (12.1)	<.01
QSQ-P Hosted	0.3 (0.5)	2.5 (1.6)	0.2 (0.4)	0.2 (0.4)	<.012

**Table 4**

Mean differences from T1 to T2 for *Treatment and Waitlist Control groups (standard deviations and confidence intervals are in parentheses)*

Variable	Group		<i>p</i>	<i>F</i>	<i>Cohen's d</i>	<i>CI</i>
	Treatment (n= 6)	Waitlist control (n=6)				
TASSK	6.67 (1.75)	0.5 (2.5)	<.001	23.36	2.79	(3.32, 9.00)
SSIS_ASD	-1.17 (6.49)	1.17 (3.66)	0.46	0.58	-0.44	(-9.11, 4.45)
SSIS_Social Skills	10.17 (8.56)	-3.67 (14.02)	0.06	4.25	1.19	(-1.11, 28.71)
SRS Total	-6.83 (2.3)	8.67 (9.79)	<.01	10.15	-1.84	(-26.34, -4.66)
SRS Problem Behaviors	2.17 (17.01)	11.33 (6.98)	0.25	1.49	-0.71	(-25.89, 7.56)
QSQ-P Hosted	2.17 (1.72)	0.00 (0.00)	<.01	9.49	1.78	(0.6, 3.73)
QSQ-P Invited	0.33(1.51)	0.00 (0.00)	0.59	0.29	0.31	(-1.04, 1.70)
QSQ-P Invited friends	0.33 (1.51)	-0.17 (0.4)	0.45	.61	0.45	(-0.92, 1.92)
QSQ-P Conflict	1.33 (5.05)	2.33 (3.67)	0.70	0.15	-0.23	(-6.68, 4.68)

**Table 5**

Mean difference scores for SSIS-P and SRS-P subscales

Measures	Treatment	Waitlist	<i>p</i>
SSIS-P Cooperation	2.00 (1.79)	1.00 (3.69)	.56
SSIS-P Assertion	2.83 (3.87)	-2.50 (5.09)	.06
SSIS-P Responsibility	0.67 (1.97)	-0.17 (1.94)	.48
SSIS-P Communication	5.50 (6.95)	1.00 (2.83)	.17
SSIS-P Empathy	2.00 (2.76)	-3.50 (5.47)	.05
SSIS-P Engagement	2.00 (2.83)	-0.67 (3.20)	.16
SSIS-P Self-Control	1.50 (2.43)	-3.17 (4.53)	.05
SSIS-P Externalizing	-0.83 (6.01)	2.5 (3.51)	.27
SSIS-P Internalizing	-0.17 (5.64)	1.83 (2.79)	.45
SSIS-P Bullying	1.67 (5.46)	1.67 (2.25)	1.0
SSIS-P Hyperactivity/Inattention	-0.67 (3.83)	0.50 (3.39)	.59
<i>SRS-P Social Awareness</i>	-6.67 (9.52)	3.33 (5.09)	<.05
<i>SRS-P Social Communication</i>	-3.17 (9.83)	8.00 (6.69)	<.05
<i>SRS-P Social Cognition</i>	-6.83 (7.08)	2.17 (2.23)	<.02
<i>SRS-P Restrictive and Repetitive Behaviors</i>	-3.17 (9.83)	8.00 (6.69)	<.05
<i>SRS-P Social Communication Index</i>	-7.33 (6.38)	4.33 (5.16)	<.01
SRS-P Social Motivation	-4.83 (10.21)	7.33 (13.66)	.11

**Table 6** Means for Treatment group outcome subscale variables

Measures	Pre-test (T1)	Post-test (T2)	<i>p</i> (Pre-test Post-test difference)
<i>SSIS-P Cooperation</i>	11.00 (3.29)	13.00 (3.58)	<.05
SSIS-P Assertion	9.67 (4.41)	12.50 (4.72)	.13
SSIS-P Responsibility	11.17 (4.71)	11.83 (3.43)	.44
SSIS-P Communication	10.83 (3.25)	16.33 (5.99)	.11
SSIS-P Empathy	8.00 (4.94)	10.00 (3.35)	.14
SSIS-P Engagement	8.50 (4.81)	10.50 (3.27)	.14
SSIS-P Self-Control	10.67 (5.57)	12.17 (4.07)	.19
SSIS-P Externalizing	9.83 (7.25)	9.00 (6.07)	.75
SSIS-P Internalizing	9.00 (5.51)	8.83 (5.85)	.94
SSIS-P Bullying	1.83 (2.86)	3.50 (4.23)	.49
SSIS-P Hyperactivity/Inattention	7.50 (3.73)	6.83 (3.19)	.68
SRS-P Social Awareness	68.50 (9.31)	61.83 (5.34)	.14
SRS-P Social Communication	77.17 (12.02)	69.00 (8.44)	.06
SRS-P Social Cognition	73.00 (8.51)	66.17 (3.97)	.06
SRS-P Restrictive and Repetitive Behaviors	69.17 (11.51)	66.00 (4.52)	.47
<i>SRS-P Social Communication Index</i>	76.00 (9.08)	68.67 (6.12)	<.04
SRS-P Social Motivation	70.00 (10.62)	65.17 (11.44)	.30

### ***Motivation Scores***

For the Motivation scale, information for the Treatment and Waitlist groups was not available for T1 (pretest) due to an error in which it did not print with the student baselines measures packet. Thus, H5 could not be properly evaluated. The Isen and Reeve motivation scale response data for the Treatment and Waitlist groups were obtained at T2 which was the posttest for the Tx group and the Pre-test for the waitlist group. Additionally, for the Waitlist group post-intervention (T3) response data were collected. For the analyses done, only the Waitlist T2 and T3 motivation data is reported. For the Waitlist group, the Wilcoxon signed rank test was performed with T2 and T3 scores as this was a repeated measures on a single sample. For both the T2 and T3 data, the null hypothesis stated that the scores indicated neutral engagement and motivation. The analysis indicated that the null hypothesis was rejected with  $p < .001$ . Overall, a majority of scores across responses trended toward agreement with the statements on the Motivation measure. For example, at T3 40% of waitlist participants agreed or strongly agreed that the program was fun, with another 40% of participants neutral, and the remaining 20% somewhat disagreeing. As a follow-up analyses, the Wilcoxon rank sum test with continuity correction was performed to compare T2 and T3 responses. No significant differences were found between responses on T2 and T3 ( $p = 0.25$ ) indicating that there was no change in motivation or engagement from pre-intervention to post-intervention.

It should be noted that during administration of this measure, students appeared to have difficulty separating their feelings for some perceived negative aspects of the PEERS program (e.g., an uncooperative social roleplay partner) from their experience with the virtual environment (which the measure hoped to assess). This was evident when the adolescents who indicated disagreement when asked whether they would come back and participate in an

experiment that used this activity all noted their negative experiences with one specific group member during their assigned roleplays as the deciding factor. See Figures 1 and 2 for a Gantt chart detailing the percentages of Agree, Disagree, and Neutral for T2 and T3 responses.

### ***Moodle***

Parents in both the treatment group and the waitlist group used the Moodle site extensively throughout the intervention. Exploratory correlational analyses were conducted with outcome variables by group and count of the total interactions (e.g., viewing lesson, viewing forum, viewing course files, etc.) each parent made on the Moodle course site while they received the intervention and afterwards. There was wide variability in the number of interactions parents had on the Moodle site. The mean number of interactions per parent was 86.25 with a range of 8 to 217 and a standard deviation of 60.42. One parent in the waitlist group was considered an outlier with 217 total interactions. A log transformation of all Moodle data was performed to reduce the effect of outliers on the correlation analyses. The following correlations were reported from the treatment group data. A negative correlation ( $r = -0.7$ ,  $p = 0.12$ ) was found for the mean difference SRS Total score denoting that parents with higher number of interactions had adolescents with greater improvements on the SRS. A lack of significance for this correlation may be due to the small participant number for the current study. A moderate correlation was found for the mean difference SSIS ASD score ( $r = -0.5$ ,  $p = 0.32$ ) suggesting that higher interactions were related to reductions in ASD symptoms. Weak correlations were found for the mean difference SRS Problem Behaviors score ( $r = -0.3$ ,  $p = 0.55$ ), the mean difference QSQ-P hosted score ( $r = 0.2$ ,  $p = 0.76$ ), the mean difference QSQ-P invited score ( $r = -0.03$ ,  $p = 0.51$ ), the mean difference QSQ-P invited friends score ( $r = -0.3$ ,  $p =$

0.51), the mean difference SSIS Social Skills Score ( $r = 0.1, p = 0.91$ ), and the mean difference TASSK score ( $r = 0.3, p = 0.50$ ).

### ***OpenSimulator***

Participants successfully navigated the virtual environment, completed quizzes, and met with the PI to ask questions or practice roleplays. There were issues with data extraction from OpenSimulator log files as the server in which the virtual environment was hosted had to be reset multiple times due to port access issues. The PI observed that participants performed well on quizzes in the virtual environment with scores typically of 80% or higher on quizzes. (See Appendix A for an example of a quiz used in the virtual environment and Appendix B for a video of the OpenSim Environment.) Many participants were initially accompanied by their parent when first accessing the virtual environment and would subsequently access the space on their own. Throughout the intervention, participants logged in weekly to complete quizzes and met virtually with the PI if there were any questions regarding skills learned during the adolescent session. Log-in data from OpenSimulator was not properly stored in the server due to multiple server resets throughout the intervention.



## CHAPTER FIVE

### Discussion

#### Overview of Findings

Those diagnosed with ASD encompass a diverse group of individuals in a variety of geographic communities. The current study investigated outcomes of the PEERS intervention in a large metropolitan city with an ethnically diverse group of adolescents and their parents. In response to a need to improve the accessibility of high-quality interventions as well as to increase the generalizability of post-intervention gains, the current study piloted a virtual environment and online course component as supplementary components of PEERS.

Participants in the treatment group and waitlist control group were compared on measures of social skills knowledge with the TASSK; quality and quantity of social interactions with the QSQ, severity of ASD social difficulties; and social skills in the areas of communication, cooperation, empathy, self-control, and problem behaviors. Hypothesis 1 indicated that, compared to the delayed treatment control group, the treatment group would significantly improve their knowledge of social skills as shown on the self-report measure the Test of Adolescent Social Skill Knowledge. In line with previously published PEERS studies, the results demonstrated that the individuals in the treatment group had significantly increased knowledge of social skills as measured by the TASSK when compared to the waitlist control group in support of H1. Thus, the augmented PEERS intervention led to observed improvements in participant social skills knowledge.

Hypothesis 2 stated that, compared to the delayed treatment control group, the treatment group will have significantly greater reduction of problem behaviors on the parent report measure the Social Skills Intervention Scale. In support of H2, the treatment group had

significant increases in social interactions as measured by the QSQ when compared to the waitlist control group. Thus, as in previous PEERS studies, those receiving the intervention increased their hosted and invited get togethers.

Hypothesis 3 stated that, compared to the delayed treatment control group, the treatment group will have a significantly greater reduction in ASD symptoms related to social responsiveness on the parent report measure the Social Responsiveness Scale. H3 was not supported as there were no significant differences in ASD symptoms between the groups. While ASD symptoms did decrease for the treatment group and increase for the waitlist control group from T1 to T2, the differences between the groups did not approach significance.

Hypothesis 4 stated that compared to the delayed treatment control group, the treatment group will have significantly greater reduction of problem behaviors on the parent report measure the Social Skills Intervention Scale. H4 was supported as there was a significantly greater reduction on the Problem Behaviors subscale for the treatment group when compared to the waitlist control group.

Hypothesis 5 stated that Motivation as reported on the self-report Isen and Reeve Motivation Scale (Motivation self-report; Isen & Reeve, 2005) will significantly increase from pre- to posttest for the participants in the treatment group. H5 was not supported and could not be directly assessed with the existing study data. Due to an error in the administration of the motivation measure, and it is unknown whether the items on the measure had the specificity to measure motivation as it related to usage of the virtual environment.

### **Summary of Findings Related to Study Hypotheses**

Most study hypotheses were supported. H1 which stated that the treatment group would significantly improve their knowledge of social skills on the TASSK when compared to the

waitlist control group was confirmed. H2 which stated that the treatment group would have significantly better social interactions than the waitlist control group as reported on the QPQ was confirmed. H3 which stated that the treatment group would have a significantly greater reduction in ASD symptoms related to social responsiveness as reported on the SRS was confirmed. H4 which stated that there would be a significantly greater reduction of problem behaviors on the SSIS for the treatment group compared to the waitlist group was not substantiated. H5 which stated that motivation would significantly increase from pre-to posttest for the treatment group was not confirmed.

Effect sizes reported for between-group mean-differences on the TASSK, QSQ-P, SSIS Social Skills, and SRS-Total were larger than those reported in the PEERS literature in a recent meta-analysis (Zheng et al., 2021). Zheng et al. (2021) reported pooled effect sizes of 2.15 (TASSK), 0.71 (SSIS), 0.72 (SRS Total), 0.55 (QSQ-P), while this study found effect sizes of 2.79 (TASSK), 1.19 (SSIS), -1.84 (SRS Total), 1.78 (QSQ-P). Several explanations are possible for this finding. The addition of the online course component may have enabled parents to have greater access to the intervention materials, leading to improved ability to facilitate the intervention components (e.g., homework compliance; facilitating, coaching, and providing feedback on get togethers; accessing information for in-group phone calls; etc.) between intervention sessions. Alternatively, the VR component may have allowed participants to review and test their knowledge of the intervention content, reinforcing their understanding of the skills learned outside of the intervention sessions. Conversely, the effect size finding may be a statistical artifact due to the participants themselves learning better for reasons not measured in this study or it may be due to variability stemming from the small sample in the study. Future

studies should seek to include a similar VR and online course component with a PEERS intervention to determine the reliability of the effect size difference found in this study.

### **Viability of the Virtual Environment**

The current study adds support to previous research (e.g., Bozgeyikli et al., 2018; Parsons, 2016; Smokowski & Hartung, 2003) on the usability of VR for individuals with ASD. The theory of situated cognition (Brown et al., 1989) guided the development of this project and support for this theory is evident in the outcomes for intervention participants who became part of a learning community while actively participating in PEERS. Additionally, this study provides further support for the inclusion of activities, such as those outlined below, within training programs that promote legitimate peripheral participation.

Students successfully accessed the virtual environment and completed tasks such as receiving and viewing note cards with instructions on how to navigate the virtual environment, communicating with research assistants using voice or typing, using teleporters to access different floors of the social skills school building, and completing quizzes that assessed their knowledge of each session's content and how to apply it. Parents of the adolescents successfully navigated the Moodle online course, accessed each session's course materials, and viewed announcements and message board content.

Future studies seeking a VR augmentation of PEERS should determine core PEERS skills or roleplays to develop into highly immersive, scalable scenarios. Several adaptations of PEERS have modified the intervention length and frequency with successful findings from 7 week, 14-week, and 16-week versions. Additionally, researchers have translated PEERS into several languages (i.e., Hebrew, Japanese, Chinese, and Korean) and reported results in line with previous studies in the standard English versions. Studies needed should determine which

components of the intervention can be modified to reduce the number of intervention staff and lead to transitioning the intervention to a fully online version. For example, the skill introduction and modeling typically done with one or more research staff members each intervention session can be converted to video format or animated gifs. Researchers can develop methods to analyze participant's peer roleplay content and provide corrective feedback with an automated computer-generated agent. Studies testing core components can use a variety of methods such as fidelity measures of each component; experimental designs testing modification or removal of components and the effect on participant outcomes; and requesting intervention creators to provide justification for program components and guidelines for program modification (Blase et al., 2013). After these core components are tested, the PEERS intervention may be modified determine if a VR-only version of the training is equivalent to the standard 16-week in-person version. The additional training components may potentially increase engagement with the training content and facilitate additional time for intervention participants to review and practice their skills. Thus, it is expected that these components when added to PEERS would make improve intervention outcomes overall. As computer-based interventions are easily scaled, a VR version of PEERS could significantly increase access to the intervention for individuals with ASD.

This study adds to the growing body of literature demonstrating that individuals diagnosed with ASD can successfully navigate and complete tasks within a virtual environment. Psychologists and educators must build upon this body of literature and develop VR social skills interventions that train individuals with ASD on core social skills such as emotion recognition, social cue recognition, and roleplaying skills (Moon & Ke, 2021). When designing VR interventions for training individuals on these skills, social scenarios should employ naturalistic

settings for individuals to practice and experience social situations. Moon and Ke (2021) recommend that researchers assessing VR social skills interventions, should measure the treatment integrity of the intervention, develop benchmarks for participant performance of social behaviors within social scenarios (e.g., define socially appropriate acts for each scenario), and employ automated means for capturing learning data from the VR environment.

In addition to the use of virtual environments, psychologists and educators seeking to implement social skills training programs, should follow recommendations such as those proposed by Bottema-Beutel et al. (2018). For example, the researchers stated that programs should seek to foster collaboration between facilitators and participants to promote skills in identifying and analyzing social interaction problems with tools such as the conversational analysis framework and video recording used to obtain pertinent observational diagnostic data of the participant in a natural setting. During this current study, when introducing and reinforcing peer roleplay skills or during breaks, participants often asked the facilitators how to use a skill in the context of a social problem they were experiencing. This collaborative problem-solving component should be an explicit component of PEERS or similar social skills interventions. While obtaining video recordings of the participant in a natural setting may be difficult, parents can be instructed to record their child during get-togethers and provide the intervention staff with the recordings for further analysis.

Additionally, Bottema-Beutel et al. (2018) recommend that social skills training programs promote skills and teach critical frameworks that enable participants to understand process-related information in social interactions to allow active and dynamic rather than static and scripted involvement during social interactions for participants. Often, during the intervention, participants would ask PEERS facilitators how to modify the phrasing of provided

PEERS scripts to make a conversation seem more natural. When participants understand the principal process, rather than merely the performance of a script, they will intuitively find ways to act and sound naturally when implementing skills learned during intervention sessions. Lastly, Bottema-Beutel et al. recommend the use of training programs for neurotypical individuals to reduce their use of negative stereotypes of individuals diagnosed with ASD. This last recommendation comes in response to the growing evidence of the double-empathy problem's role in the poor social outcomes that individuals with ASD experience. Future studies should build on the work of Gillespie-Lynch et al. (2015) and seek to develop training components delivered to neurotypical and non-ASD adolescents to promote the development and practice of skills that challenge inherent biases that may negatively influence relational outcomes in mixed ASD-non-ASD relational interactions.

For example, Bolis et al. (2021) noted that an “interpersonal mismatch”, particularly in autistic traits, is partly responsible for the lack of success seen in ASD-non-ASD dyads. One potential method to increase a factor they call “attunement” (i.e., the alignment of a social interaction dynamic) that is relevant for VR is providing real-time feedback of biological and social factors during social interactions (e.g., indicating differences in facial expressions, language use, posture, etc.). Building upon a suggestion by Bolis et al. (2021) a virtual environment developed to diminish interaction differences may be able to serve as a specially designed social space where individuals with ASD and non-ASD individuals can interact successfully.

### **Limitations**

Several limitations exist in this study. Like many PEERS studies reported in the literature, there was no formal measure of intervention fidelity. As this is a manualized

intervention, research assistants and the PI actively referred to the manual throughout the implementation of the intervention and at the completion of every session, performed a review to ensure that all required content was delivered. Notwithstanding these actions, it would be beneficial to implement a checklist with required session content to formally track fidelity throughout the intervention. This study included no observational measures of social competence, which limits the extent to which claims of improvement of social competence can be made. Assessment of social skills in the context of observed conversations or interactions with non-ASDs or other ASD adolescents would provide additional information regarding the extent to which adolescents completing the program were able to integrate the skills learned into their social interactions. This study included no third-party reports (i.e., teacher reports), largely due to potential missing data resulting from the diversity of educational settings in which the students were enrolled (e.g., homeschool, collaborative teaching classes, mainstream classes) and the timing of the intervention which began in summer as classes were ending, leading to difficulties in obtaining reports from a consistent “teacher”. This study included no post-intervention follow-up due to the extenuating circumstances created by Covid-19. While use of the online course and the virtual environment was constantly encouraged and promoted throughout the intervention, there was no explicit directive for parents to use Moodle or for students to use the VR component. This study, like many other GSSIs with ASD adolescents had a small sample size and low female representation making the results difficult to generalize to adolescent girls diagnosed with ASD. Also, as in Kandalaf et al. (2013), due to this study being a pilot, no statistical corrections for multiple comparisons were done.

Several technical challenges occurred throughout the intervention. There were several issues installing OpenSim as a package onto the server used and eventually the files had to be



compiled from source. Some OpenSim features did not properly load when the environment was run which limited the ability for students to customize their avatar (e.g., age, height). Moreover, the built-in avatar options on OpenSim are limited to two models and thus it is recommended for additional avatar models and skins to be installed. Lastly, due to issues in which the server had to be reset several times, there was no user log data for the OpenSimulator component. A subscription to a managed server was purchased and used in this study, but it is recommended that researchers instead select a self-hosted server.

### **Implications for Psychologists and Educators**

This study demonstrated that parent interactions on an online course site constructed to host intervention relevant materials such as parent handouts, intervention session guides, and intervention relevant announcements were related to improved outcomes on measures of ASD social difficulties as well as reductions in ASD symptoms. As summed up in Guldberg (2008), encouraging discussion and collaboration fosters student involvement and engagement in the learning process and leads to the development of a community of learners. The Moodle site and VR environment were crucial parts of the learning process in which participants exchanged thoughts and ideas; reviewed and reinforced their knowledge of the intervention; and communicated with the research team.

Adolescents and their families may benefit by having access to a community of learners between intervention sessions in which to review content, practice skills, check their understanding, troubleshoot issues, and share information. Educators and psychologists facilitating group interventions in general, and specifically parent-assisted interventions, should provide their students and clients with meaningful ways in which to engage with content learned and opportunities for discourse. To do this, as Guldberg (2008) notes, the participants must shift

their mindset from mastery of the content resulting primarily from direct instruction and interaction with the intervention team (a la master and apprentice), to a decentralized view in which mastery is developed by active membership in the community of practice. Thus, the organization of the community of practice and structuring of the learning resources are of highest import. The current structure of PEERS relies heavily on a master and apprentice model. This study introduced elements (e.g., online learning community and OpenSimulator virtual environment) to the standard PEERS intervention that altered the master and apprentice dynamic to establish a community of learners. These changes may provide an explanation for the observed larger effect sizes than in previous studies.

To facilitate participation and optimize communications, educators and psychologists may provide participants with a discussion rubric detailing the characteristics of appropriate and exemplary communication practices. In addition, discussion prompts and collaborative activities outside of the intervention can be provided to facilitate communication and promote the expectation for ongoing practice. While adolescents in PEERS are required to complete an in-group phone call assignment, parent coaches have no established communication touchpoint between intervention sessions. Encouraging discourse for parent coaches through an online forum may promote sharing of best practices, thoughts, and experiences which may in turn strengthen their sense of community and deepen feelings of shared practice.

As stated in the literature review, VR provides key benefits for social skills training with individuals diagnosed with ASD. For example, Parsons (2016) noted that VR allows for unlimited repetitions of a skill with timely, automated feedback and can present the user with simulated social interactions that are perceived as realistic and authentic by learners. Additionally, VR affords researchers increased experimental control of environmental

parameters (e.g., number of individuals within a room, how approachable the individuals are, number of social cues available, etc.) (Cobb, 2002). VR may also offer opportunities for ecological assessment of psychological processes such as executive functions related to self-regulation of behavior and emotion regulation (Monteiro, 2022). Individuals diagnosed with ASD may also prefer to use VR for socialization tasks as VR allows for asynchronous communication that requires less decoding and these interactions can be designed to have lower cognitive demands than in-person social interactions (Davidson, 2008).

Additionally, educators and psychologists may use well-designed VR components to facilitate learning and practice outside of their primary intervention settings while fostering a community of learners. Educators and psychologists should work to develop their knowledge of VR software, VR design considerations and best practices, and contraindications for VR use with specific populations or learner characteristics. The development of clinical guidelines, certifications, or licensing programs may facilitate wider adoption of VR augmented practice. In the interim, psychologists and educators may seek out learning opportunities, trainings, and literature advising on the use of VR in therapeutic applications, specifically for ASD.

VR social skills training interventions could potentially be scaled to support a larger user group with increased automation of intervention tasks and feedback. However, as tasks increase in complexity (e.g., recognize an emotion vs. have a conversation with a potential friend), software and hardware requirements, development costs, and data management costs will rapidly increase.

While this intervention was specifically designed for adolescents, modifications could be made to develop a version for children or young adults. A PEERS for Young Adults intervention exists and, with guidance from the VR social cognition training study done by Kandalaf et al.

(2013), a VR supplement tailored to young adults diagnosed with ASD can be developed. Additional focus would be placed on topics specific to young adults such as vocational skills and dating skills. Similarly, guidance for the development of virtual environments for younger children (i.e., ages 6 to 11) can be gathered from studies such as Ip et al. (2018) and the intervention focus would likely shift to training skills such as emotion recognition, emotion regulation, and social reciprocity. Additional tutorials and gamification of the virtual environment may be necessary for this younger learner group. Adaption of the VR supplement or the PEER for Adolescents intervention may be necessary to better meet the needs of different demographics.

For example, the needs of individuals who are ethnically, culturally, or socioeconomically diverse should be addressed with potential modifications to the PEERS intervention (see Appendix B for participant demographics). For example, in the study, it was observed that some parents had difficulty in seeing the importance of get-togethers with unknown peers and showed a preference for get-togethers with cousins or other non-immediate relatives. A modification was made to allow these families to set-up some get-togethers with their adolescent and these relatives. While the PEERS manual recommends get-togethers with non-family members, this may be a recommendation that is not as applicable to families of certain cultural backgrounds. Additionally, many of the families did not have homes large enough to host initial get-togethers. For these families, modifications were allowed in which initial get togethers could occur outside the home.

In agreement with recommendations by West et al. (2016), it would be useful to determine if response to the PEERS intervention varies based on participant socioeconomic status or demographic profiles. For example, facilitating the many required get-togethers over the

length of the intervention can be somewhat costly for parents and may result in missed get-togethers for participants. Additionally, while PEERS currently had tools for recording information on factors such as socioeconomic status, medical history, medication history, and biological and physiological factors, cultural factors are not assessed. In accordance with recommendations of West et al. (2016), future efforts with PEERS or similar caregiver-assisted social skills interventions should manualize methods for assessing cultural considerations and provide guidelines for adapting the intervention curriculum for diverse participants. Moreover, as noted in West et al. (2016), individuals from diverse cultural and ethnic backgrounds are not typically present in ASD research; efforts should be made to increase representation and report participant characteristics, while assessing cultural values and preferences that may be relevant to the improvement and adaptation of social skills interventions for these populations. Interventions should be individualized as much as possible and determining whether a program is culturally responsive and meets participant's needs while reducing any negative impacts on participant's lives is paramount (Kim et al., 2017).

## **Conclusion**

In summary, the findings of this replication study indicated that the previous findings of the PEERS intervention held in a randomized controlled trial conducted in a large, urban, metropolitan city with a participant pool that included a demographically and socioeconomically diverse group of adolescents with ASD. An online course for parent social coaches was correlated with reductions in the severity of ASD social difficulties and a virtual environment for adolescent participants was piloted successfully as a place for adolescents to check their knowledge, contact facilitators with questions, roleplay skills learned, and explore at their leisure. Larger effect sizes for the TASSK, SSIS Social Skills, SRS Total, and QSQ-P than had

been historically reported for the PEERS intervention were found when comparisons were made to pooled effect sizes reported in a PEERS for Adolescents meta-analysis (Zheng et al., 2021). The online course and/or virtual environment components may have contributed to these larger effect sizes and thus future studies should isolate these components using a control group to gain additional insight.

While the PEERS for adolescents training is successful in improving social skills, increasing the number of social interactions, and, as many studies have shown, improving difficulties including anxiety, depression, and family chaos, there are several improvements to be made and oversights to be addressed as described in this study. Future studies should focus on designing VR social competence tasks akin to the social roleplays practiced during PEERS sessions that take advantage of the affordances of virtual environments. In addition, future research should be done to increase the automated elements within virtual environments designed to facilitate social skills practice and promote social skills acquisition with the goal being to reach complete automation.

## APPENDIX A. SAMPLE LESSON 10 QUIZ

Quiz Example from Session 10 as formatted for the OpenSimulator Quiz Script

QWhy do people tease?

Q1. People who tease are trying to get a reaction out of you.

Q2. People who tease want to be your friend.

Q3. People who tease are trying to help you.

A1,0,0

QPeople tease because they are trying to get a reaction out of you.

Q1. Yes

A1

QWhen you get upset, are you doing what the teaser wants?

Q1. Yes

Q2. No

A1,0

QWhen you get upset, you are doing what the teaser wants.

Q1. Yes

A1

QWhen you get upset, are you:

Q1. Putting on a show

Q2. Making the teasing fun for the teaser

Q3. More likely to get teased next time

Q4. All of the above

A0,0,0,1

QWhen you get upset, you are putting on a show, making the teasing fun for the teaser, and are more likely to get teased next time.

Q1. Yes

A1

QMost adults tell teens to: tell an adult, walk away, or ignore the teaser. Do these strategies usually work?

Q1. Usually

Q2. Not usually

A0,1

QStrategies that most adults tell teens to do, like tell an adult, walk away, or ignore, don't usually work.

Q1. Yes

A1

QWhat is the first step in tease-the-tease?

Q1. Tell a teacher

Q2. Act like what the person said does not bother you

Q3. Walk away

A0,1,0



QThe first step in tease-the-tease is to act like what the person said does not bother you.

Q1. Yes

A1

QWhat is the second step in tease-the-tease?

Q1. Give a brief comeback

Q2. Give a long comeback

Q3. Tell a teacher

A1,0,0

QThe second step in tease-the-tease is to give a brief comeback.

Q1. Yes

A1

QWhat are some examples of tease-the-tease comebacks?

Q1. Whatever!

Q2. Anyway...

Q3. Who cares?

Q4. All of the above

A0,0,0,1

QSome examples of tease-the-tease comebacks include "Whatever!", "Anyway...", and "Who cares?"

Q1. Yes

A1

QWhat is the third step in tease-the-tease?

Q1. Show that you care

Q2. Do something that shows you do not care

Q3. Tell a teacher

A0,1,0

QThe third step in tease-the-tease is to do something that shows you do not care.

Q1. Yes

A1

QTrue or False: Rolling your eyes and walking away or shrugging your shoulders and walking away are examples of ways to show that you don't care

Q1. True

Q2. False

A1,0

QRolling your eyes and walking away or shrugging your shoulders and walking away are examples of ways to show that you don't care.

Q1. Yes

A1

QWhat is the final step of tease-the-tease?

Q1. Run away

Q2. Casually walk away

Q3. Tell a teacher

A0,1,0

QThe final step in tease-the-tease is to casually walk away.

Q1. Yes

A1

## APPENDIX B. VIDEO OF VIRTUAL ENVIRONMENT

Link to video of OpenSim virtual environment-

<https://www.dropbox.com/s/ljs9zdmonajgbwa/OpenSim1.mp4?dl=0>

Link to OpenSim quiz interaction-

<https://www.dropbox.com/s/diqxjznmazayqoy/OpenSim2.mp4?dl=0>

## APPENDIX C. PARTICIPANT DEMOGRAPHICS

Individual scores

**Table***Overview of participant demographics*

<b>Participant</b>	<b>Age</b>	<b>Grade</b>	<b>Sex</b>	<b>Ethnicity</b>	<b>Parent</b>	<b>Parent Education</b>	<b>Co- occurring Diagnosis</b>	<b>Medicine Use</b>
Subject 1	13.2	7	Female	White	Father	Graduate School	None	Never
Subject 2	15.2	9	Male	White	Mother	Graduate School	None	Never
Subject 3	15.7	10	Male	Biracial- Latinx/ White	Mother	Graduate School	None	Currently
Subject 4	17	11	Female	White	Father	Some College	ADHD/ OCD	Not at this time
Subject 5	15.5	10	Male	African- American	Mother	College Diploma	None	Not at this time
Subject 6	16.9	11	Male	White	Father	Some College	None	Currently
Subject 7	13.8	8	Male	Asian	Mother	High School Diploma	Learning Disability/ ADD	Not at this time

Subject 8	15.2	10	Male	Biracial African- American/ White	Father	College Diploma	None	Currently
Subject 9	15.8	10	Male	African- American	Mother	College Diploma	None	Never
Subject 10	12.6	7	Male	White	Mother	Graduate School	ADHD/ Anxiety	Currently
Subject 11	12.3	6	Male	White	Mother	Graduate School	Sensory Processing Disorder	Never
Subject 12	15.3	9	Male	Latinx	Mother	Graduate School	None	Currently

Table

*KBIT-2 and Vineland Adaptive Behaviors Scales (VABS) subscale scores for participants*

Participant	KBIT VIQ	VABS Composite	VABS Communication	VABS Socialization
Participant 1	129	74	93	61
Participant 2	100	77	96	64
Participant 3	95	72	87	63
Participant 4	128	64	75	65
Participant 5	66	69	85	61
Participant 6	73	70	75	71

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Participant 7	109	71	86	68
Participant 8	126	67	69	58
Participant 9	82	72	75	71
Participant 10	132	83	81	73
Participant 11	119	78	97	59
Participant 12	93	70	75	74

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