HHS Public Access

Author manuscript

J Autism Dev Disord. Author manuscript; available in PMC 2017 October 09.

Published in final edited form as:

J Autism Dev Disord. 2016 February ; 46(2): 658–672. doi:10.1007/s10803-015-2600-9.

Improvement in social competence using a randomized trial of a theatre intervention for children with autism spectrum disorder

Blythe A. Corbett[1,2,3], **Alexandra P. Key**[2,4], **Lydia Qualls**[1], **Stephanie Fecteau**[1], **Cassandra Newsom**[1,2,5], **Catherine Coke**[6], and **Paul Yoder**[2,7]

[1]Vanderbilt University, Department of Psychiatry

[2]Vanderbilt Kennedy Center for Research on Human Development

[3]Department of Psychology

[4]Department of Hearing and Speech Sciences

[5]Department of Pediatrics

[6]University School of Nashville

[7]Vanderbilt Department of Special Education

Abstract

The efficacy of a peer-mediated, theatre-based intervention on social competence in participants with autism spectrum disorder (ASD) was tested. Thirty 8-to-14 year-olds with ASD were randomly assigned to the treatment (n = 17) or a wait-list control (n = 13) group. Immediately after treatment, group effects were seen on social ability (d = .77), communication symptoms (d = −.86), group play with toys in the company of peers (d = .77), immediate memory for faces as measured by neuropsychological (d = .75) and ERP methods (d = .93), delayed memory for faces (d = .98), and theory of mind (d = .99). At the 2-month follow-up period, group effects were detected on communication symptoms (d = .82). The results of this pilot clinical trial provide initial support for the efficacy of the theatre-based intervention.

Autism spectrum disorder (ASD) is characterized by primary impairment in social competence (APA 2013), which impacts cognitive, behavioral, and daily adaptive functioning. In a recent review Kennedy and Adolphs (2012) provide a convincing framework for understanding social dysfunction, in which the social brain, social cognition, and social behavior are interconnected. Specifically, the social *brain* facilitates social *cognition* that consequently produces social *behavior*, which when integrated over time and context, establishes social *functioning*. This conceptualization could inform our

Corresponding Author: Blythe Corbett, Phone: 615-936-0280, Fax: 615-322-8236, blythe.corbett@vanderbilt.edu.

Conflict of Interest: Blythe Corbett is the founder of SENSE Theatre 501©(3) but does not receive any financial compensation from the organization. The other authors declare no conflicts of interest.

Compliance with Ethical Standards: Blythe Corbett is the founder of SENSE Theatre 501(c)(3) but does not receive any financial compensation from the organization. The other authors declare no conflicts of interest. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

understanding and treatment of disorders such as autism. Since ASD is characterized by measurable deficits in everyday functioning (Constantino and Gruber 2005), social interaction (Corbett et al. 2010), social cognition (e.g., Baron-Cohen 1995), and dysfunction in social brain networks (e.g., Bookheimer et al. 2008; Corbett et al. 2009; Hadjikhani et al. 2004), treatments aimed at the core deficits in social competence (APA 2013) warrant examination across these interdependent levels of analysis.

Social Competence Framework

Social functioning

In this context, social functioning refers to the integration of feelings, social interaction, and social cognition, and is considered to reflect the broad day-to-day ways in which an individual negotiates with the social world. Measures of social functioning involve multiple aspects of social competence. The most reliable measures use parent or other informant reports to sample adaptive skills in the child's daily environment, which draw upon memory of different experiences across multiple contexts (Constantino and Gruber 2005; Harrison and Oakland 2000). It is well established that individuals with ASD have impairment in social competency across many domains of functioning including a primary difficulty in communication with others (APA 2013) and notable challenges making and maintaining age-appropriate relationships (APA 2013; Bauminger and Shulman 2003).

Social interaction

Social interaction is a subset of the social functioning construct. It is emphasized because of the important role it plays in measuring and tying together the different levels of social competence. It is usually measured through direct observation between an individual and those around them within a particular context (Kennedy and Adolphs 2012). Given the observable nature of social interaction, detailed evaluation of social behavior in ASD is one of the most ecologically valid methods to measure social skills (Elliot and Gresham 1987; McMahon et al. 2013). In ASD, social interaction differs from that of typically developing individuals in the diminished quantity and quality (Lord and MaGill-Evans 1995). Specifically, children with ASD struggle with verbal and nonverbal reciprocal social communication (Beisler and Tsai 1983; Kanner 1943). One important aspect of social interaction in children with ASD is familiarity (Corbett et al. 2014c) as interacting with a familiar peer may be less stressful than interacting with an unfamiliar peer (Lopata et al. 2008).

Social cognition

Social cognition has been defined as the "processing that is elicited by, about, and directed towards other people" (Kennedy and Adolphs 2012, p. 559). It has long been speculated that individuals with ASD show impairment in social cognitive processes (Baron-Cohen 1995). One of the important milestones in adaptive perception of relevant social stimuli is developing expertise in the ability to recognize faces of conspecifics (Adolphs 1999) and social perspective taking (Gzesh and Surber 1985; Happe and Frith 1995). Many children with ASD show significant impairment in the identification and memory for facial

information (e.g., Jemel et al. 2006; Webb et al. 2010). However, not all aspects of face processing are qualitatively or quantitatively impaired (Weigelt et al. 2012).

Converging evidence over the years has shown atypical face perception processes in infants, children, and adolescents with autism (e.g., Hauck 1998; Hirstein et al. 2001; Key and Stone 2012; Klin et al. 1999; Langdell 1978; Osterling et al. 2002; Webb et al. 2010). Results from a comprehensive review of face perception and memory reported that some individuals with ASD have difficulty identifying faces using face-specific perceptual mechanisms. Additionally, most individuals with ASD show significant difficulty in remembering facial information, especially following a delay (Weigelt et al. 2012). Better face memory has been associated with more reciprocal social play in children (Corbett et al. 2014a) and fewer characteristics of autism in adolescents with ASD (Arkush et al. 2013; Eussen et al. 2015). Thus, remembering facial information is an important marker of social skills and a target for treatment.

Another important aspect of social cognition is social perspective taking (sometimes defined as theory of mind [TOM]), which is the ability to understand what others are thinking and to use this knowledge to predict how others may act (Baron-Cohen 1995). It can be measured by asking children to guess the behavior of an agent in a story or picture based on what they understand of this agent's knowledge of the situation. Typically developing children have a rudimentary understanding of another person's state of mind at 18 months, which matures into an adult-like TOM at around 6 years of age (Frith and Frith 2003). While this skill has been shown to be lacking in many children with autism (Baron-Cohen et al. 1985; Frith and Frith 2003), it may be a treatable deficit. Improvement is possible either with direct training (Fisher and Happe 2005) or following social skills treatment (Corbett et al. 2011; Corbett et al. 2014b). It is important to note that success in training TOM does not necessarily result in observable differences in social interaction and communication skills (Hadwin, Baron-Cohen, Howlin, & Hill, 1997; Ozonoff & Miller, 1995). Conversely, training in social and communication skills may not have a concomitant impact on TOM skills (e.g. Chin & Bernard-Opitz, 2000). Collectively, these studies suggest that TOM tests and programs explicitly designed to teach persons with ASD on how to process and pass TOM tests may not capture the complexity and flexibility of perspective taking in real world social contexts.

Social brain

The social brain facilitates social cognition and underlies many aspects of social competence. The use of event-related potentials (ERP) permits the measurement of brain activity associated with the processing of relevant information without the requirement of overt behavioral, cognitive, or motivational involvement. Previous ERP studies in infants, children, and adults with ASD focused mainly on the perceptual processes involved in face detection and discrimination from other stimuli and noted delays in occipito-temporal N170 brain responses to face stimuli (Elsabbagh et al. 2009; McPartland et al. 2004; O'Connor et al. 2007; Hileman et al. 2011), thought to indicate altered attention to faces. We are aware of only one study that used the parietal "old/new" ERP response to examine memory for novel faces in ASD; it reported a reduced ability to recognize repeatedly presented faces in older

children (8 to 14 years) with ASD compared to typically developing peers (Key and Corbett 2014).

Potentially Important Characteristics of Effective Social Interventions

Peer-mediation

Peers can have a profound impact on the psychological, social, and physiological functioning of other children, including children with ASD (Corbett et al. 2010; Corbett et al. 2014c; Lopata et al. 2008; Schupp et al. 2013). A primary objective of social interventions is to help children learn to interact more competently with peers in natural settings (DiSalvo and Oswald 2002); thus, the inclusion of trained peers in treatment is logical, beneficial, and economical (Barry et al. 2003; Egel et al. 1981; Lang et al. 2011; Odom and Strain 1984). Peer-mediation enhances generalization of newly learned skills (Kamps et al. 1992) and increases peer acceptance (Kasari et al. 2012). Peers can be trained to not simply be a social partner but also an intentional model of (Prendeville et al. 2006) and reinforcement for appropriate social behavior (McConnell 2002; Banda et al. 2010). Thus, peers may serve as the optimal agent of change because they are not only the interventionists, they are the intended recipients of improved social competence. Peers can demonstrate social proficiency live and in videos.

Video modeling

Video modeling has consistently gained empirical support for improving various aspects of social functioning and teaching adaptive behaviors in children with autism (Charlop and Milstein 1989; Charlop-Christy et al. 2000; Corbett 2003; LeBlanc et al. 2003; Haring et al. 1987; MacDonald et al. 2009; Maione and Mirenda 2006; Nikopoulos and Keenan 2007; Odluyurt 2013). The use of video can facilitate observational learning and generalization of behavior (Corbett 2003; Corbett and Abdullah 2005; Corbett et al. 2011; Jones et al. 2014). Another example of using peers to intervene socially is the use of scripted interactions and other program-specific methods (Banda et al., 2010; McConnell 2002). Scripted interactions are a common element of acting in a theatrical play.

Acting and Theatre – a novel context for change

Acting is an inherently interactive process that involves many aspects of socializing: observing, perceiving, interpreting and expressing thoughts, feelings and ideas. Therefore, the training in and practice of acting techniques has the potential to target core deficits in ASD such as reciprocal social communication, flexible and imaginative thinking, and theory of mind. The practice of theatrical techniques such as role-playing, improvisation, and play performance may lead to improved social competence via enhanced awareness of self and others, gains in reciprocal responding, and potential alternations in underlying neural mechanisms that support social functioning. There is a recent and growing interest in the use of theatrical approaches to facilitate social functioning in individuals with typical development and ASD (Corbett et al. 2011; Corbett et al. 2014b; Goldstein and Cisar 1992; Goldstein 2011; Lerner et al. 2011; Webb et al. 2004; Williams 1989). For example, SENSE Theatre is a theatre-based program that uses theatre games, role-play exercises, improvisation, and character development while putting on a play, to explore and practice

social interaction skills (Corbett et al., 2011; Corbett et al., 2014b). Moreover, this intervention is peer-mediated and thereby incorporates trained typically developing youth actors that serve as expert models of reciprocal social communication in a safe and supportive context (Corbett et al., 2011). Children that experience SENSE Theatre showed improvements in social abilities including social awareness, face memory, TOM, and reduced social stress (Corbett et al., 2011; Corbett et al., 2014b). While promising, the preliminary studies employed a basic pretest-posttest design without randomization or a comparison group. Therefore, non-treatment explanations for change in social abilities in participants experiencing SENSE Theatre could not be ruled out. A randomized experiment is needed to do so.

Purpose

The purpose of the study was to evaluate and extend the impact of a peer-mediated, theatre-based intervention on children with ASD utilizing a randomized experimental design measuring social ability before and after treatment across multiple levels of analysis, including neural, cognitive, and behavioral, as well as across multiple aspects of the social competence framework, including social cognition, social interaction, and social functioning. Moreover, social functioning was measured at a two-month follow-up assessment period to ascertain maintenance of treatment effects. Based on the aforementioned findings, it was hypothesized that children with ASD in an experimental group would show greater improvement in social ability across all aspects of the framework for social competence when compared to a wait-list control group.

Methods

Participants

Initial enrollment included 36 children with ASD who were recruited via fliers and notifications at area clinics and autism support organizations. Thirty-three eligible children (3 did not meet criteria) were allocated to groups based on simple randomization administered by a staff member in the Department of Biostatistics not involved in other aspects of the research. See Figure 1 for description of the participant flow information (i.e., CONSORT-required information). Seventeen children were randomized into the Experimental treatment group (EXP) and 16 were randomized to the Wait-list control group (WLC). Three participants in the WLC failed to return for post-testing due to moving, no longer available, and unknown reason. Thus, the final sample included 30 children with high-functioning ASD between 8-to-14 years. All enrolled participants were provided with a research letter containing the results from the standardized measures. The treatment was provided to eligible participants free of cost.

ASD diagnosis was based on the Diagnostic and Statistical Manual-5 (APA 2013) and established by: (1) a previous diagnosis by a psychologist, psychiatrist, or behavioral pediatrician with autism expertise; (2) current clinical judgment (BAC or CRN); and (3) corroborated by the Autism Diagnostic Observation Schedule (ADOS) (Lord et al. 2000), administered by research-reliable personnel. The selection criteria also required participants to have an intelligence quotient ≥ 70 as measured by the Wechsler Abbreviated Scale of

Intelligence (WASI) (Wechsler 1999). The demographic information is presented in Table 1[see below]. The mean age for the EXP group was 11.27 (2.51) and WLC was 10.74 (1.89). Out of 30 participants enrolled in the trial, 24 (80%) were male (13 EXP and 11 WLC), which is comparable between the groups. There were 21 total Caucasian (12 EXP, 9 WLC), 1 African-American (1 EXP), 2 Asian (1 EXP, 1 WLC), 4 Latino/Hispanic (1 EXP, 3 WLC), and 2 Multiracial (2 EXP) participants. Nineteen (63%) participants were on psychotropic medication (10 EXP, 9 WLC). Seven were on two or more medications (4 EXP, 3 WLC).

The Vanderbilt Institutional Review Board approved the study. Informed written consent was obtained from parents and child participants prior to inclusion in the study. Participation in the study required four assessment visits to the University. During visit 1 the diagnostic (ADOS (Lord et al. 2000), WASI (Wechsler 1999) and neuropsychological (Developmental NEuroPSYchological Assessment (NEPSY)) measures were administered at the Village at Vanderbilt clinic, and the ERP was conducted at the Vanderbilt Psychophysiology Lab. During visit 2 the Peer Interaction Paradigm was conducted at the Susan Gray playground in the afternoon between 2:00 – 5:00 pm. These visits were repeated post-treatment, and parent survey measures were collected at two-month follow-up. Public performances of a play were conducted following treatment for the EXP (March) and WLC (June) groups (see Table 1[below] for descriptive information).

Intervention

The experimental group received the treatment first. The intervention was delivered over 10 four-hour sessions. After the follow-up assessment sessions had been completed, the WLC group received the SENSE Theatre intervention as a 10-session summer camp model (Corbett et al., 2014b). At the end of the intervention, two public performances were held at a local university's theatre. The WLC was not assessed after receiving SENSE Theatre treatment and thus their treatment data do not appear in this article.

Three components of the treatment included training typically developing peer actors, SENSE Theatre sessions, and homework of watching and practicing with video models. Video practice was monitored by checking log-in timestamps (although the precise amount of watching time could not be confirmed). For an expanded explanation of the treatment see previous study descriptions investigating this treatment package (Corbett et al., 2011; Corbett et al., 2014b).

Peer training—The manualized program incorporates typically developing trained peer actors that are paired with a child or adolescent with ASD. Training for peers and staff was conducted at Vanderbilt Kennedy Center and included a comprehensive two-day seminar. The first day consisted of PowerPoint presentations, videos, and guest lectures on autism spectrum disorder (e.g., diagnostic criteria and symptom profiles), behavioral strategies (e.g., positive reinforcement, shaping, redirection), and modeling techniques (live and video modeling). The second day of training reviewed the 10 core SENSE Theatre principles [Provide social support; Create a fun, enjoyable and playful environment; Model warm, appropriate social interaction; Encourage and motivate interaction using behavioral techniques; Engage in directed communication; Use gestures and nonverbal communication

in directed ways; Engage in imaginative play; Empathic responding; Learning as an active process; Advance learning], ethics training (e.g., confidentiality, protection of minors), and practice of the theatrical games, improvisation, and play that would be taught to the participants. Twelve trained peers (mean age of 15.33 (1.12) years) were paired with participants with ASD. When possible, participants were paired with same-gender, same-age peers.

SENSE Theatre—Each session was held on Saturday afternoons between 1:00 – 5:00 pm at University School of Nashville. A schedule of each day was provided in advance to the parents and prominently displayed in the room on a white board. Early sessions comprised of theatrical games, role-playing and exercises. In the third session, the participants were introduced to the 45-minute play, which incorporated all the different exercises, role-plays and improvisational activities. For the remaining seven sessions, participants worked on their roles with their peers (e.g., learning their lines, songs and choreography), which included the development of their character in the play (e.g., costume, voice). Role assignments were based on a variety of factors (e.g., age, verbal ability, participant interests, and special talents) and determined by the program and theatre directors.

Video modeling—Twenty videos of target behaviors, role-plays, and songs acted out by the current typical peers, were placed on a password protected website, and participants were instructed to practice with them for approximately 15 minutes per day.

Fidelity—A comprehensive model of fidelity was followed (Ory et al. 2002). To measure change in the peers' basic knowledge of autism and behavioral methods based on learning theory, an exam containing 20 questions was administered at the beginning of the first day of training and again at the end of the last day of training. The results showed a mean pretest score of 66% (SD = 12%) and a post-training score of 84% (SD = 8%). The mean change score was 17% (SD = 12%). The delivery of the behavioral techniques (e.g., positive reinforcement, shaping, extinction) and core principles (e.g., encourage interaction, provide social support, use direct communication) was monitored by observing peer implementation using a behaviorally anchored five-point Likert scale reported as percentages. If fidelity dropped below 80%, then a "booster" session with the peer was implemented. Five research-reliable counselors behaviorally coded the peers at three time points (first, third, and fifth session) during semi-structured activities. For Day 1, Day 3, and Day 5, the mean ratings for the quality of peer tutors' implementation of behavioral techniques were 4.12 (.39), 4.56 (.40), and 4.42 (.26), respectively. The mean scores for the quality of peer tutors' implementation according to the 10 core principles for Day 1, Day 3, and Day 5 were 4.46 (.40), 4.66 (.15), and 4.61 (.25), respectively.

Dependent Measures—The descriptions of the constructs, procedures, and variables are presented in Table 2 [see below].

Social Functioning—The following measures reflect the broad day-to-day ways in which an individual negotiates with the social world and therefore were selected to assess social functioning. The *Social Responsiveness Scale* (SRS) (Constantino and Gruber 2005) is a parent-report measure covering several areas of behavior characteristics of autism with good

temporal stability (males r=.85, females r=.77) and internal consistency (Cronbach's α>.90). The communication subscale was measured at pre-test, post-test, and at a two-month follow-up.

The *Adaptive Behavior Assessment System* (ABAS) (Harrison and Oakland 2000) assesses 10 areas of adaptive functioning with good test-retest reliability (in the .90s for the measure overall and .80s to .90s for the skill subdivisions) and internal consistency (reliability estimates are .95–.98 for composite scores and .86–.93 for skill subdivisions). The social and communication scaled scores were measured at pre-test, post-test, and at a two-month follow-up.

Social Interaction—Social interaction is generally measured through direct observation between an individual and others within a particular context; thus, a natural play paradigm was selected. The *Peer Interaction Paradigm (PIP)* consisted of a 20-min semi-structured playground interaction in which the participant with ASD engaged in play with two trained, gender- and age-matched confederate peers (Corbett, Schupp, Simon, Ryan, & Mendoza, 2010). Confederate 1 elicited play as directed by periodic ear-bud-received prompts from a research personnel who was out of sight. Confederate 1 served as a novel peer during the pre-test and returned at post-test to serve as a familiar peer (these confederate peers did not participate in the intervention). Confederate 2 was a different novel peer during each playground visit. Interactions were video recorded using four professional 70 Sony PTZ remotely operated cameras housed in glass cases and affixed to the four corners of the external fence of the 130 ft. × 120 ft. playground. Audio communication was obtained by Sennheiser body pack and Audio-Technica transmitters and receivers, which functioned as battery-operated microphones that were clipped to the shirt of each child. The Observer XT was used for the collection, analysis, and presentation of observational data (Noldus 2008). Continuous timed-event coding of two primary behaviors (Group Play and Equipment Play) was conducted from the four video recordings. *Group play* is defined as the duration of activity when the participant is engaging with the group together in an activity by using the same types of equipment or toys as other members of the group. *Equipment Play* is defined as the duration of activity when the child is using equipment or toys on his/her own and not as part of a group. The Inter-rater reliability was conducted on a random sample of 20% of all coded videos. The primary coder was blind as to which videos would be checked for reliability and the time period (pre/post). Group play (k=.85), and Equipment Play (k=.82) reliability were comparable to previous studies using this protocol (Corbett et al., 2010; Corbett, Swain, Newsom, Wang, Song, & Edgerton, 2014c).

Social Cognition—NEPSY subtests (Korkman et al. 2007) of Memory for Faces (Immediate and Delayed) and Theory of Mind (TOM) were administered to assess changes in social perception using scaled scores derived from the published manual. Memory for Faces Delayed (MFD) was the primary outcome variable. The MFD requires the child to again choose the previously viewed faces after a 30-minute delay. Memory for Faces Immediate is a face recognition task that requires the child to select previously seen children's faces among three choices following a brief 5-second initial exposure. The TOM task presents a variety of social perspective taking tasks. The contextual portion requires the

child to identify a picture that most represents the feelings of a character depicted in different scenarios.

Social Brain (ERP)—While some individuals with ASD show atypical brain responses in face perception tasks, difficulties remembering faces, especially following a delay, are more common in ASD (Weigelt et al. 2012). Therefore, we chose to use the *Incidental face memory* task to examine treatment-related changes in social brain functioning. Briefly, participants viewed color photographs of 51 unfamiliar young adult faces (Radboud Faces Database; (Langner et al. 2010)) and 51 unfamiliar houses presented on a computer monitor. One image in each category was randomly selected and repeated 50 times throughout the experiment, yielding a unique set of repeated stimuli for each participant. The remaining photographs were presented once. All stimuli were presented by E-prime (v.2.0, PST, Inc., Pittsburgh, PA) in random order for 1500 ms with a varied inter-stimulus interval of 1300–1600 ms. Participants were not instructed to memorize the images or to detect repetitions. To encourage looking at the stimuli, participants were asked to press a response button when they saw the yellow smiley face (10 trials presented randomly throughout the test session). The entire task included 210 trials and lasted approximately 12 minutes. From the viewing distance of 90 cm, the stimuli subtended visual angles of 19° (h) × 16° (w) (9.21° for the attention probe).

EEG was acquired using a 128-channel Geodesic Sensor Net (EGI, Inc., Eugene, OR) with a vertex reference. Data were sampled at 250Hz with the filters set to .1–100 Hz. Electrode impedances were kept at or below 40 kOhm. Data were re-referenced offline to an average reference (Picton et al. 2000). A researcher was present in the room to monitor participants' behavior. If participants became restless, stimulus presentation was suspended until the participant was ready to continue with the task. For the test of treatment efficacy, the ERP data were quantified as the mean amplitude difference score at the parietal electrodes between 300–500 ms contrasting repeated and single stimulus conditions. For the test of differences between conditions, the ERP variable was the mean within-condition amplitude at the parietal electrodes.

Statistical Analysis

A series of Analysis of Covariance (ANCOVA) models were used to test the between-group differences on each dependent variable at the immediate post-test and at the follow-up periods using the dependent variable's pretest as a covariate. Independent sample t-tests were used to identify statistically significant differences on all pretest dependent variables. For dependent variables with a significant between-group difference at pretest (i.e., MFD and TOM), Pearson product correlations were conducted between these variables and posttest scores on all dependent variables.

ERP Data—Collected EEGs were filtered using a 30Hz low-pass filter. Individual ERPs were derived by segmenting the ongoing EEG on stimulus onset to include a 100-ms prestimulus baseline and a 900 ms post-stimulus interval. All trials contaminated by ocular and movement artifacts were excluded from further analysis using an automated screening algorithm in NetStation followed by a manual review. Data for electrodes with poor signal

quality within a trial were reconstructed using spherical spline interpolation procedures. If more than 20% of the electrodes within a trial were deemed bad, the entire trial was discarded. The mean retention rates per condition were comparable across groups and test sessions (EXP: T1=19.60, SD = 5.78; T2=22.74, SD 8.10; WLC: T1=21.83, SD = 7.24; T2 =19.94, SD = 6.99; all p values >.05), exceeded the minimum number of trials considered acceptable in prior studies of memory (e.g., (Curran and Cleary 2003), and were comparable to those reported in (Key and Corbett 2014).

Following artifact screening, individual ERPs were averaged, re-referenced to an average reference, and baseline-corrected. The specific scalp locations and time intervals were selected a priori based on results in Key & Corbett (2014) and in previously published ERP studies of recognition and recall in visual paradigms (e.g., Curran and Hancock 2007).

Results

Preliminary—Initial pretest difference between groups on diagnostic and dependent variables were tested using independent sample t-tests and are reported in Table 1 [below]. Demographic results are presented in Table 1 showing no significant between-group differences based on age, ADOS, or IQ. There were no differences on any pretest variable except MFD and TOM. However, these were nonsignificantly correlated with all post-test and follow-up dependent variables, with one exception. The pretest and post-test for the MFD were correlated ($r = .55$, $p = .002$). Fortunately, using the MFD pretest as a covariate when testing between group differences on the post-test MFD eliminates pre-treatment between-group differences on the MFD as an alternative explanation for the treatment effect on MFD.

ANCOVA assumes homogeneity of slopes meaning that the slopes of the regression lines are parallel for the association between pre- and post-test variables. This assumption was tested by examining the statistical interaction between each pretest by group interaction for the corresponding posttest. The homogeneity of slopes assumption was violated only for Equipment Play, $F(1,29) = 4.83$, $p = 0.04$; therefore, ANCOVA was not used for this variable. Instead, a mixed level ANOVA with Time as a within-subject factor was employed to test the research question regarding Equipment Play.

Primary—Table 3 [below] indicates the significant pretest-adjusted between-group differences at the posttest period. Importantly, there were treatment effects on the primary variable, MFD (Figure 2 illustrates the effect). There was also a treatment effect on the ERP measure of incidental memory for faces (see Figure 3). Additionally, there were treatment effects on the following post-test variables: ABAS Social subscale, SRS Communication subscale, PIP Group Play, MFI, and TOM (see Table 3). Between-group differences were also observed at follow-up for SRS Communication, $F(2,27) = 5.28$, $p = 0.03$. $d = -.82$. However, treatment effects on the ABAS did not maintain, $F(1,24) = 2.43$, $p = 0.13$, $d = .52$.

Secondary—The Time effect was tested within each group. However, it should be noted that such change does not indicate a treatment effect. Instead, the findings in the Primary results section reflect the treatment effects. Regardless, using paired sample t-tests, there

were Time effects in the experimental group on the following variables: ABAS Social $t(16) = -2.97$, $p = 0.009$, MFI $t(16) = -3.27$, $p = 0.005$, MFD $t(16) = -2.74$, $p = 0.015$, and ERP index of incidental memory for faces, $t(16) = 2.58$, $p = 0.02$. Time effect was also examined in the wait-list control group, and there were no significant Time effects. The results suggest that there were limited changes in skill development in the WLC group over this period of time.

As controls, we examined post-test between-group differences on Play with Equipment and the ERP index of memory for nonsocial stimuli (i.e., difference in mean amplitude between repeated and single-occurrence houses). There were no between-group differences for Equipment Play at the post-treatment period, $F(1,27) = 3.26$, $p = 0.08$, or ERP differences for the nonsocial stimuli, $F(1,26) = 1.22$, $p = 0.28$.

Discussion

Social competence is comprised of interconnected processes and skills suggesting that improvement at one level should have concomitant and measurable gains on other levels (Kennedy and Adolphs 2012). This assumes that the effect generalizes to measurement procedures that differ from the treatment context on multiple dimensions simultaneously (e.g., setting, activity, materials, persons, and interaction style). In the current study, children with ASD randomized to an EXP group that received a 10-session theatre-based intervention were compared to a WLC group on 8 pretreatment variables. The results of this pilot clinical trial provide initial support for the efficacy of the theatre-based intervention, which are outlined below for the primary (social cognition, brain, interaction and functioning) and secondary analyses (time effects and control conditions).

Primary—There were significant between-group differences on the primary dependent variable, Memory for Faces Delayed, indicating that participation in the theatre intervention resulted in improvement in social cognition for the EXP group. These findings extend two preliminary reports showing significant improvement in memory for faces in a group of participants with ASD experiencing this treatment (Corbett et al., 2011; Corbett et al., 2014b). Memory for faces is critical for establishing and maintaining social bonds; and despite the notable deficits frequently observed in persons with ASD (Weigelt et al. 2012), current findings indicate that this fundamental skill is amenable to treatment. Not only is face memory responsive to treatment but may also be associated with concomitant changes in social competence. For example, other studies have demonstrated that better face memory has been associated with more reciprocal social play (Corbett et al. 2014a) and fewer ASD symptoms (Arkush et al. 2013).

The current investigation included an ERP component to determine if neuropsychological differences would be corroborated by changes in neural response for repeated faces compared to single face presentation following exposure to the treatment. Previously, using the same ERP procedure as the current protocol, Key and Corbett (2014) showed a reduced ability in children with ASD to detect repeated faces when compared to typically developing peers, and the group differences remained 3 weeks later. The current paper improved the evidence that the treatment affected facial memory as measured by ERPs and indicates that

this measure of facial memory is modifiable. The lack of treatment effects on the ERP measure of memory for houses provides additional evidence that the observed effects were specific to memory for a social stimulus. Improved neuropsychological performance on the MFD and face-specific changes in ERPs during a passive viewing task with no instruction to attend to and remember social information suggests SENSE Theatre caused improvements in memory for faces. This could occur because the salience of faces increased as a function of elements of the SENSE Theatre experience. For example, children were engaged in many reciprocal activities with peers to include active role-playing, mirror exercises, theatre games, and performing their part in the play. This mutual visual, physical, and social engagement may have contributed to the enhanced awareness of and interest in social stimuli; namely faces. Moreover, the ongoing encouragement and support provided by the peers may further reinforce the participant's attention and memory for social information.

There was a significant between-group difference in perspective taking as shown by improvement in theory of mind skills for children who received the treatment. In a preliminary report, improvement in theory of mind skills was also shown in participants exposed to the treatment (Corbett et al., 2011). It is postulated that engagement in the theatre exercises, which include role-playing activities and improvisational games, has the ability to increase awareness of relevant social cues and perspective taking, which in turn may contribute to changes in the child's social cognitive processes and subsequent behavior. Specifically, the acting exercises with peers create the opportunity for the child with ASD to take on the perspective of another through action thereby setting the stage for different and shared points of view. Even though previous studies suggest that persons with ASD have difficulty using body language to communicate or interpret mental states (Attwood, Frith, & Hermelin, 1988; Reed et al., 2007) acting involves the whole body as well as verbal and nonverbal communication. Therefore, it is plausible that it may also contribute to increased awareness of nonverbal cues through enhanced awareness of body language.

In regards to social functioning, there were significant between-group differences in social communication based on two reliable parent report measures inferring that the treatment affected social communication gains in home and community environments. Furthermore, the treatment effect on reciprocal communication, as measured on the SRS, was maintained two months after the intervention. The results on these parent reports were consistent with direct observation of social interaction during play, which showed that the children in the EXP group engaged in more group play than the WLC group at the post-test.

Secondary analyses, which measured time effects revealed changes in the EXP group on social cognition (MFI, MFD), brain-amplitude differences (ERP incidental memory) and social functioning (ABAS). However, these time effects were not observed in the WLC group suggesting that there were more modest changes in skill development outside of the treatment context over this period of time. Moreover, control tasks revealed that the treatment had specific effect on social competence as cognition for nonsocial stimuli (houses) was unchanged as was behavior reflected in no changes in the amount of equipment play (alone, without the group).

In the SENSE Theatre, peers are the primary agents of change thus serving as teachers and recipients of the reciprocal social exchange (Corbett et al., 2014b). The supportive learning context using live and video modeling facilitates improvement in social competence. Furthermore, acting by definition is active and dynamic thereby creating opportunities for the child with ASD to practice reciprocal social communication skills in an engaging, semi-structured, and supportive context. The theatrical exercises, games, and music potentially enhance motivation to participate in the group activities thereby increasing the opportunity to learn from social experiences. The inclusion of these planned reciprocal social play activities in the theatre context may also help set the stage for interactions with peers in other social settings (Weisberg et al. 2014). Moreover, the ability of the participants with ASD to work directly, frequently, and supportively with social partners undoubtedly leads to the gains within the treatment context, and also contributes to the generalized skills observed in the playground, home, and community environments. The utilization of a peer-mediated approach with expert models underscores the importance of incorporating peers in the treatment of autism. Even though the research in peer-mediation has been overwhelmingly positive (Barry et al. 2003; Egel et al. 1981; Kamps et al. 1992; Kasari et al. 2012; Lang et al. 2011; Odom and Strain 1984), relatively few studies include trained typically developing peers in interventions for children and youth with ASD. In the current and previous studies, peers have demonstrated efficient and consistent mastery of behavioral strategies and an eagerness to participate. The supervised trained peers delivered the intervention protocol with a high degree of reliability and competence evidenced by the training and delivery fidelity ratings.

Strengths

The current study employed a WLC group, random assignment to groups, demonstrated pretreatment between-group equivalence on pretests, used established protocols to measure dependent variables, and measured social competence at multiple levels using multiple measurement approaches. There are no known harms as a result of the intervention. Finally, effect sizes were moderate to large, suggesting they are likely to be clinically important (Cohen 1992).

Limitations

Nevertheless, there are limitations to acknowledge. The parent reports and group play in the PIP produced data that could overestimate the true score systematically in favor of the experimental group. Due to low resources, the reliable personnel that engaged in the extensive coding were aware of group assignment. Even so, the coded behaviors were based on well-defined and objective criteria (e.g., duration of play behavior), and reliability of coding was high; thereby reducing concerns regarding possible bias. Parents, of course, will always be aware of the treatment group to which their children have been assigned. Greater expectancy of adaptive change in children in the experimental group can inflate scores systematically to favor the experimental group. The study would have benefited from external informants, such as teachers, to measure the maintenance and generalization of social skills in other settings. While the results show that the program is feasible to employ, the transportability of the program to other clinical, educational or community settings was not directly evaluated. Coordinating schedules of participants, peers, and counselors present

logistical considerations that may limit portability. Additionally, due to time factors and limited resources, we were not able to do follow-up testing neither on all the dependent variables nor beyond 2 months. However, follow-up testing on additional dependent variables and at greater time intervals are planned for future studies. Efforts are underway to incorporate strategies to address these limitations in subsequent studies.

Future Directions

The aforementioned findings contribute to a small but growing body of work exploring the promise of using theatrical approaches to improve functioning in persons with ASD (Corbett et al. 2011; Corbett et al. 2014b; Goldstein and Cisar 1992; Goldstein 2011; Lerner et al. 2011; Webb et al. 2004; Williams 1989). The current study was designed to measure the impact of the treatment on high-functioning children with ASD. At this time the extent to which the approach is beneficial for lower-functioning children is unclear. While gains in social functioning were observed and maintained in the home environment, efforts are underway to enlist teachers who are blind to treatment group and can provide observations as to whether changes in social communication skills generalize to the school environment. While the current study employed an individually randomized control trial, there is significant heterogeneity in ASD resulting in notable variability across individuals. Thus, a cluster randomized control trial, in which groups of participants rather than individuals are randomized (Bland 2004), may provide additional insights into the efficacy of the treatment.

Conclusions

The study extends previous findings showing that the theatre-based intervention leads to improvement in core areas of social competence for children with ASD based on behavioral and neural measures. In particular, SENSE Theatre facilitated gains in memory for faces and social communication skills. Future work will test whether this occurred because of a strong link between social cognition and interaction. It appears likely that improvement in one level of processing can result in gains in another as implied in the integration model (Kennedy and Adolphs 2012). The current investigation supports the use of the social integration model as a multilevel way to acknowledge, conceptualize, treat, and measure the complexity of social competence in autism spectrum disorder. The findings suggest that the intervention results in increased salience for social information even in the absence of explicit instruction. The results highlight important treatment components, such as peer-mediation, active practice of social functioning, and the promise of theatre-based approaches for advancing, maintaining and generalizing social competence in children with ASD.

Acknowledgments

This work was supported in part by National Institute of Mental Health R34 MH097793 awarded to Blythe Corbett. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIMH or the National Institute of Mental Health. We appreciate the peers, participants, and their families who continue to support our research.

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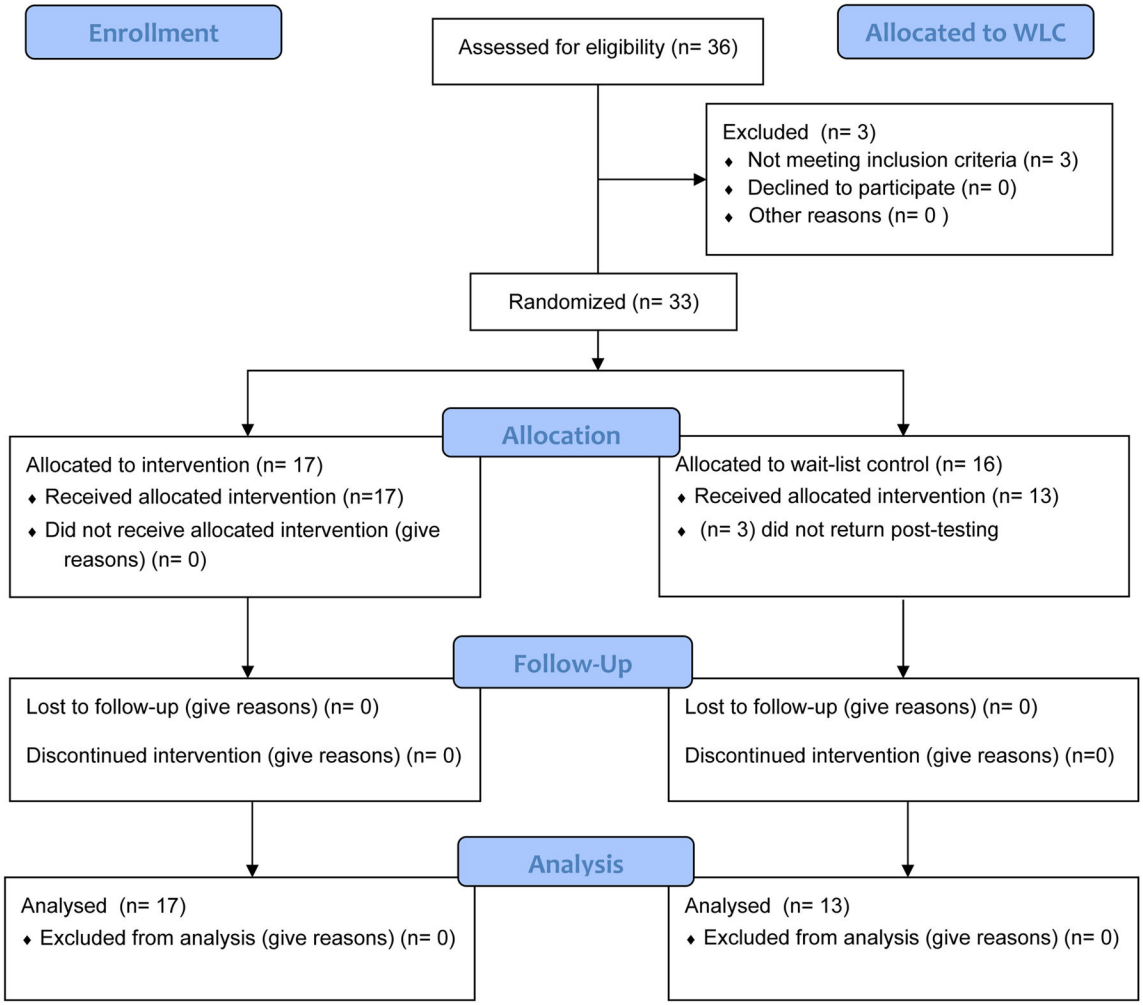

Figure 1.
CONSORT Flow Diagram

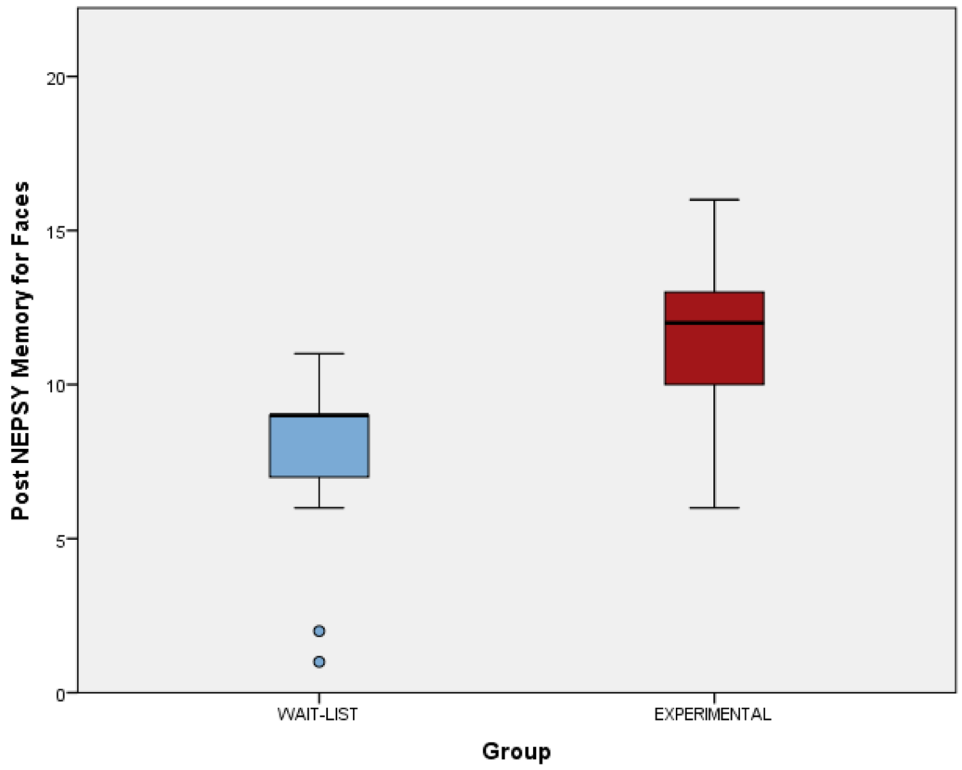

Figure 2.

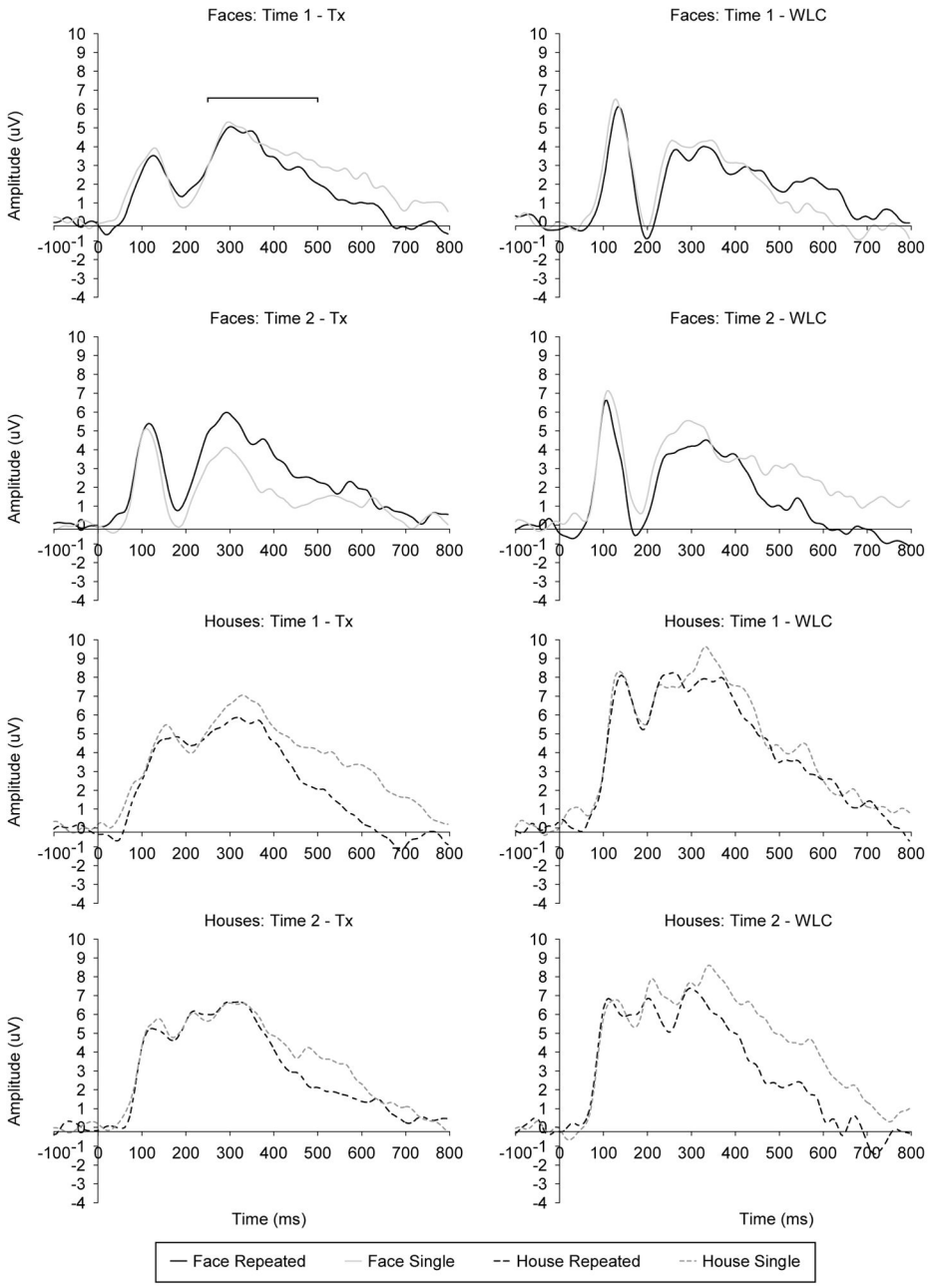

Figure 3.

Table 1

Demographic, diagnostic and pre-treatment Means, SD and Cohen's d by group

Variable	EXP M (SD)	WLC M (SD)	df	t	p
Age	11.27 (2.51)	10.74 (1.89)	1,28	−0.63	0.53
ADOS	12.47 (3.96)	14.42 (5.19)	1, 27	1.11	0.28
WASI IQ	106.06 (16.83)	95.85 (21.19)	1, 28	−1.47	0.15
ABAS Social	2.82 (1.91)	2.92 (3.17)	1, 27	0.11	0.92
SRS Communication *	76.06 (8.83)	78.08 (11.29)	1, 27	0.55	0.59
Group Play	61.9 (28.44)	60.8 (38.42)	1, 27	−.09	0.93
Equipment Play	23.72 (28.9)	28.21 (38.11)	1,27	0.37	0.72
Memory for Faces Immediate	8.59 (3.02)	6.62 (3.66)	1, 27	−1.62	0.12
Memory for Faces Delayed	9.29 (2.95)	6.69 (2.17)	1, 27	−2.67	0.01
Theory of Mind Contextual	5.18 (0.18)	4.42 (0.22)	1, 27	−2.88	0.008
ERP Faces repeated-single: mean amplitude (parietal), μV	−.386 (3.07)	.217 (2.99)	1, 29	.290	0.594

Note: EXP = Experimental Group, WLC = Waitlist Control Group, ADOS = Autism Diagnostic Observation Schedule, WASI = Wechsler Abbreviated Scale of Intelligence, ABAS = Adaptive Behavior Scales, SRS = Social Responsiveness Scale, ERP = Event related potential,

* = lower scores depict less impairment.

Table 2

Constructs, procedures, variables, and analyzed variable

Construct	Procedures/periods	Variables
Daily social functioning	ABAS Social @ all periods	Social subscale score
Daily communication functioning	SRS communication @ all periods	Communication subscale score
Social interaction with children	Group Play @ Pre-test, Post-test	Duration of group play with peers in seconds
Independent play on equipment	Equipment Play @ Pre-test, Post-test	duration of play in seconds
Immediate memory of faces	Memory for Faces Immediate (MFI) @ Pre-test, Post-test	NEPSY MFI scaled score
Social cognition delayed memory of faces after 30 min	Memory for Faces Delayed (MFD) @ Pre-test, Post-test	NEPSY MFD scaled score
Perspective taking	Theory of Mind (TOM) Contextual @ Pre-test, Post-test	NEPSY TOM scaled subscale
Social cognition incidental memory	ERP Faces	Repeated-single: mean amplitude @ parietal

Note: ABAS = Adaptive Behavior Assessment System, SRS = Social Responsiveness Scale.

Table 3

Pre-test adjusted Post Mean Differences

Measure	EXP Estimated Marginal Mean (SD)	WLC Estimated Marginal Mean (SD)	df	F	p	d
ABAS Social	4.61 (2.22)	2.88 (2.27)	1, 27	4.37	0.04	.77
SRS Communication *	73.53 (7.83)	80.23 (7.81)	1, 27	5.37	0.03	−.86
Group Play	62.75 (30.03)	39.64 (30.02)	1, 27	4.35	0.04	.77
Equipment Play	26.15 (29.83)	46.05 (29.84)	1, 27	3.26	0.08	−.67
Memory for Faces Immediate	10.63 (2.64)	8.64 (2.63)	1, 27	4.02	0.05	.75
Memory for Faces Delayed	11.03 (2.87)	8.2 (2.92)	1, 27	6.28	0.02	.98
Theory of Mind Contextual	5.18 (.74)	4.42 (.79)	1, 27	6.01	0.02	.99
ERP Faces repeated-single: mean amplitude (parietal), μV	1.84 (2.64)	−.62 (.2.63)	1, 26	6.68	0.016	.93

Note: EXP = Experimental Group, WLC = Waitlist Control Group, ABAS = Adaptive Behavior Assessment System, SRS = Social Responsiveness Scale, ERP = Event related potential,

* = lower scores depict less impairment.