Computer-Assisted Face Processing Instruction Improves Emotion Recognition, Mentalizing, and Social Skills in Students with ASD

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Abstract

This study examined the extent to which a computer based social skills intervention called *FaceSay®* could increase the affect recognition, mentalizing, and social skills of school aged children with Autism Spectrum Disorder (ASD). *FaceSay®* offers students simulated practice with eye gaze, joint attention, and facial recognition skills. This randomized control trial included school-aged children meeting the educational criteria for autism (*N* = 31). Results demonstrated that participants who received the intervention were able to significantly increase their affect recognition and mentalizing skills, and these improvements were also reflected in certain generalized social-skills abilities. These findings suggest by targeting face processing skills, computer-based interventions can efficiently produce changes in broader cognitive and social-skills domains.

Introduction

Difficulties with social interaction are a hallmark characteristic of autistic spectrum disorder (ASD); these include challenges with social-emotional reciprocity and impairments in emotion recognition and expression (American Psychiatric Association, 2014; Baron-Cohen, 1995). Frequently, children with ASD exhibit delays and deviations in the ability to recognize emotions in themselves and others (Harms, Martin, & Wallace, 2010). Even as adults, many individuals with ASD struggle to recognize complex emotions, have trouble expressing and regulating their own emotions, and show evidence of eye contact and facial processing difficulties (APA, 2013; Baron-Cohen, 1995, 2003; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; McPartland, Webb, Keehn, & Dawson, 2011; Pelphrey et al., 2002; Samson, Huber, & Gross, 2012).

In addition to emotion processing deficits, children and adults with ASD struggle with mentalizing, or the ability to attribute mental states such as beliefs, thoughts, feelings, plans, and intentions, to themselves and others (Baron-Cohen, 2009). Studies have demonstrated that emotion recognition and mentalizing are related in children with and without autism (Buitelaar et al., 1999; Muris et al.,1999). Additionally, neuroanatomical observations have also shown that the areas of the brain that are critical for engaging in social cognition (i.e., thinking about others' thoughts, feelings, and intentions) are also implicated in perceiving and interpreting nonverbal social signals such as facial expressions, social gestures, and eye gaze (Hadjikhani, Joseph, Snyder, & Tager-Flusberg, 2006; Schultz et al., 2003; Zilbovicus et al., 2013)., Abnormalities in these brain regions are thought to related to many of the behavioral symptoms observed in ASD (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012).).

The failure of those with ASD to accurately interpret the social dynamics of interactions reflects reduced predisposition for seeking out emotional information from another's face, otherwise known as social referencing (Moore & Corkum, 1994). These deficits, in turn, may be linked to atypical face processing, a trait also considered by some to be fundamental characteristic of individuals with autism (Rutishauser et al., 2013). Indeed, children with autism have difficulty "reading" facial expressions, matching facial expressions with verbal messages, and comprehending emotion-laden words (Hobson, 1993). Furthermore, studies utilizing multiple paradigms in addition to faces, including voice intonation and pitch, pictures of eyes, social scenes, and animated objects, indicate that individuals with ASD are weaker at interpreting more complex emotions and mental states than their typically developing peers (Amenta, Ferrari, & Balconi, 2014; Daou, Vener, & Poulson, 2014; Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011; Xu & Tanaka, 2014). It is possible that many of the broader social impairments observed in individuals with ASD may be derived from these localized face-processing difficulties.

Social cognitive theories propose that core emotion and social processing deficits observed in individuals with ASD, including difficulties with face processing, result in subsequent behavioral symptomatology (Rogers & DiLalla, 1990). For example, problems recognizing, labeling and understanding the emotional and mental states of others, coupled with an inability to discern the appropriate empathetic and congruent response, can obstruct communication and precipitate social misunderstandings. By offering interventions that provide children with the face processing skills requisite for mentalizing and emotion recognition, we can remedy a potential causal factor of many of the pervasive social skills deficits exhibited by children on the autism spectrum.

Computer Assisted Instruction in ASD

For those with ASD, computers and computer-assisted instruction (CAI) provide a method for receiving instruction and/or interaction that has a number of positive and supportive features (Golan, LaCava, & Baron-Cohen, 2007; Moore, McGrath, & Thorpe 2000; Smith & Sung, 2014). Computers are a multimodal, repetitive, predictable, and consistent system; require fewer social demands; can be used at one's own pace and difficulty level (Golan et al., 2007). CAI provides multisensory interactions, controlled and structured environments, multilevel interactive functions, and the ability to individualize instruction, all of which have been found to be successful in interventions for children with ASD (Bernard-Opitz, 1989; Chen & Bernard-Opitz, 1993; Panyan, 1984; Yamamoto & Mira, 1999). In addition, CAI are often purposefully designed to create an intrinsically motivating environment, a feature that may especially appeal to children with ASD (Chen and Bernard-Opitz, 1993; Heiman, Nelson, Tjus, and Gillberg; 1995; Moore & Calvert, 2000). Creating interesting learning environments involves the use of perceptually salient production features, such as sound effects and action, which are likely to elicit children's attention to information, and their subsequent processing of that information (Calvert, 1999). For example, CAI featuring actions or animations increases poor readers' memory of nouns by providing a visual, iconic mode that children can use to represent content (Calvert, Watson, Brinkley, & Penny, 1989).

Although CAI has been shown to be a relevant method to train and develop vocabulary knowledge and language learning for individuals with ASD (Bosseler & Massaro, 2003; Yamamoto & Mira, 1999; Whalen et al. 2006; Whalen et al. 2010), research on the use of CAI to teach complex social skills such as emotion recognition (ER) or affect recognition to individuals with disabilities is still emerging. Generally, studies have shown that a time-limited use of computer interventions with individuals with various disabilities was sufficient to teach basic ER of emotions such as happiness, sadness, anger and fear. (Blocher & Picard, 2002; Bolte, Hubl, Feineis-Matthews, Prvulovic, Dierks & Poustka, 2006; Moore, Cheng, McGrath, & Powell, 2005; Silver & Oakes, 2001). More recently, results of several studies have suggested that basic and complex ER can improve with computer intervention (Golan & Baron-Cohen, 2006a, 2006b; Golan et al., 2010; LaCava, Golan, Baron-Cohen, & Myles, 2007; Young & Posselt, 2012). Notably, a randomized clinical trial found that 20 hours of training with program called *Let's Face It!* led to improvements in facial recognition and processing skills in children with ASD (Wolf et al., 2008; Tanaka et al. 2010). Another randomized control trial using an alternate computerized intervention to improve emotion understanding in children with ASD found improvements in mental state identification, suggesting that it is indeed feasible to target mentalizing skills through CAI (Silver & Oaks, 2001). Although CAI has been instrumental in teaching specific emotion recognition and processing skills to children with ASD, most existing programs demonstrate limited generalizability of acquired skills to social behaviors and environments (Golan et al., 2010; Smith & Sung, 2014; Young & Posselt, 2012).

However, a particular CAI program *FaceSay*, has had some success teaching generalizable social skills to children with ASD in a generalizable fashion. Hopkins et al. (2011) showed in an earlier randomized-control trial that children with low-functioning autism (LFA) who received a 6-week period of intervention with *FaceSay* showed improvements in emotion recognition and social interactions. This same study showed that children with high-functioning autism (HFA) who received the *FaceSay* intervention demonstrated improvement in facial recognition, emotion recognition and social interactions compared to the control group. In blinded observations of peer interactions on the playground, children with HFA and low-functioning autism (LFA) who received the *FaceSay* intervention initiated more social interactions with their peers, made more eye contact, and exhibited fewer negative behaviors than their peers in a control group. Nevertheless, further work must be done to both evaluate the utility of the *FaceSay* software as a therapeutic tool for children with ASD and to understand the mechanisms by which *FaceSay* training impacts social information processing more broadly.

Aims and Predictions

The present study aims to expand upon initial results concerning the efficacy of *FaceSay* as an intervention tool (Hopkins et al., 2011). It has already been demonstrated that *FaceSay* training improves facial recognition in children with autism. We aim to replicate and improve upon these findings by examining what additional skills and behaviors may be impacted by this intervention.

To this end, we evaluated five different hypotheses in a group of children receiving the *FaceSay* intervention (experimental group) and a control group that was administered a CAI intervention focused on more standard educational constructs such as mathematics and reading:

Hypothesis 1. Participants in the experimental group will have a significantly higher mean pre-to post-intervention score on affect recognition as compared to participants in the control condition.

Hypothesis 2. Participants in the experimental group will have a significantly higher mean pre-to post-intervention score on mentalizing assessments as compared to participants in the control condition.

Hypothesis 3. Participants in the experimental group will have significantly lower post-intervention scores on teacher report measures assessing the participant’s social impairment as compared to participants in the control condition.

Hypothesis 4. Participants in the experimental group will have increased positive interactions with peers’ post-intervention based upon social skills observation ratings as compared to participants in the control condition.

Hypothesis 5. Participants in the experimental group will have decreased negative interactions with peers' post-intervention based upon social skills observation ratings as compared to participants in the control condition.

Methods

Participants

This study was contacted with Institutional Review Board approval from the California Graduate Institute of the Chicago School of Professional Psychology. The administration of the participating school district has provided written consent to conduct the research/collect data at their facility. Parents of qualifying students were contacted by mail with a description of the study, parental consent, and child assent forms for the students, along with stamped, self-addressed return envelopes and contact information in the event they had questions about the study or required further information. After all participants had been recruited, they were randomly assigned to a study group.

Participants included 31 elementary school students in Ventura County, California, ranging in age from 5 years to 11 years (M=7.77), who were eligible for special education services under the educationally based handicapping condition of autism in California. Of these students, 28 were male. Demographics: Caucasian: 71.9%, African America: 9.4%, Hispanic: 9.4%, Asian: 6.3%. 15 control, 16 experimental. Subjects received either the WISC-III or WISC-IV as a measure of cognitive functioning. All participants were considered high functioning, with FSIQ > 70 (M = 101, SD = 14.45). For additional information regarding participants, see Table 1.

Design and Instruments

We designed a randomized, controlled experiment to determine the effects of the *FaceSay* computer program on the ability of children with an ASD to recognize emotions, understand another's perspective, and improve their social skills in comparison to other ASD children not receiving the intervention. This study thus involved a 2 (Training) x 2 (Time) mixed factorial design. The within factor, time, had two levels, pre- and post-intervention. The between factor, training, also included two levels, experimental (*FaceSay* program) and control (*SuccessMaker®* program, see Procedures).

Materials/Dependent Variables

There were five dependent variables for this study: (1) affect recognition performance, (2) mentalizing ability, (3) social skills as assessed via teacher questionnaire, and (4) positive and (5) negative social behavior as assessed by direct observation.

Emotion/affect recognition (AR).

Affect recognition was assessed using standard scores on the NEPSY-II Affect Recognition subtest (Korkman, Kemp, and Kirk, 2007). This subtest is designed to assess the ability to identify affect from photographs of children's faces. The tasks progress from affect identification to recognition and memory for affect. Low scores in this task suggest difficulties with recognition and discrimination of facial affect. Participants were given a raw score equivalent to the number of correct responses on the subtest. The raw score was then converted to a scaled score based on age norms, and this was defined as the participant's score.

Mentalizing/theory of mind (ToM)

Raw score on the NEPSY-II Theory of Mind subtest was used to measure each participant's mentalizing skills, which includes the ability to understand mental functions such as belief, intention, deception, emotion, imagination, and pretending and to understand that others have their own thoughts, ideas, and feelings that may be different from one's own (Korkman, Kemp, and Kirk, 2007). The subtest is comprised of two tasks designed to assess the ability to understand mental functions and another's point of view. Participants' scores were defined as a raw score equivalent to the number of correct responses on the subtest.

Social skills ratings

We utilized the Social Responsiveness Scale, Second edition (SRS-2; Constantino & Gruber, 2002). The SRS-2 is a parent/teacher questionnaire consisting of 65 items that measures the type and severity of ASD-specific social deficits in children and adolescents, such that high scores indicate greater impairment. It yields a total raw score based upon teachers' numerical ratings regarding statements about each participant, which was converted to a standard score based upon age and gender norms. Participants received a total score and scores for each of five subcales: Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests and Repetitive Behaviors.

Positive interactions

Positive interactions were rated by counting the total number of times a participant spontaneously initiated and engaged in positive interactions with a peer. These positive interactions included when the participant exhibited verbal and nonverbal social behaviors that lead to effective social processes with peers and could serve to start or maintain social interactions. Specifically, these interactions were defined as direct eye contact, direct eye contact combined with a smile; a smile with no eye contact, an expression of affection delivered verbally or non-verbally, the sharing of an object or objects, the spontaneous verbal sharing of experiences or request for such, physical approach with social communication and intention, a greeting such as “hello” or another appropriate response to a greeting, or the giving of help.

Negative interactions

Negative interactions were rated by counting the total number of times instances the participant engaged in negative interactions with a peer. These interactions included instances where the participant exhibited unpleasant social behaviors that function to stop or decrease the likelihood of the development of an adequate social interaction. Specifically, these interactions were defined as physical or verbal aggressiveness, controlling behaviors in which the participant dominates peers without respecting their needs, physical but non-violent actions such as stealing another child’s toy, teasing/taunting initiated by the participant intended to invoke a negative reaction, or avoidance where the participant moves three feet or more away from another.

Procedures

To measure participant’s emotion recognition and mentalizing skills, pre- and post-test measures were administered in the school psychologist’s office at each school site by research staff. The participant was assessed in a one-on-one format for approximately 20 minutes.

Social skills information was collected from the teachers with the SRS-2. The forms were given to the teachers directly by the examiner and provided along with a return envelope to ensure confidentiality and research staff contact information in the event that they required additional instruction or support in completing the scale. Teachers were blinded to the training group membership (*FaceSay* treatment or control) of the participants.

Social skills observations were also conducted at baseline and post-intervention by two observers on the playground during recess. These observers were also blinded to training group membership. Both observers were employed by the school district, held master's degrees in mental health and/or education, and had experience and training in gathering observational data. The observations took place for approximately 10 minutes during regularly scheduled recess and lunch times. The participants were observed independently by each rater at separate time points, for a total of 20 minutes.. Inter-rater reliability for the social skills observations was determined adequate once 90% agreement was reached consistently for the coding of data during training sessions between the two observers and the primary investigator. For each 10-minute session, the observer recorded the behaviors of a single participant. The observers maintained fairly close proximity to the participants; however, they did not interact with the participants and politely declined any overtures made towards them. The participants were informed that the observer was simply interested in watching them play if the participants questioned the observer or other adult.

Intervention Procedures (FaceSay)

Once all of the pre-intervention measures were completed and just prior to beginning the computer sessions, the participants accessed the *FaceSay* program and underwent a brief training session with this examiner and the paraeducator or specialty teacher to ensure their ability to access the program and navigate through the games.

In *FaceSay*, various games are designed to teach specific social skills. The “Amazing Gazing” game was designed to teach children to attend to eye gaze and respond to joint attention, given that children with ASD have shown deficits in these areas, and these skills can be taught through interventions (Mundy, Gwaltney, & Henderson, 2010; Leekman, Lopez, & Moore, 2000). Because research studies have indicated orienting difficulties to both social and nonsocial stimuli, with even greater problems in response to social stimuli (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998), “Amazing Gazing” includes both social and nonsocial stimuli. In the game, an avatar is surrounded by an array of objects, numbers, or faces (see Fig. 1a). The participant is asked to look at the avatar’s eyes and indicate which object, number, or face the avatar is attending to. If the participant is correct, the item will light up and a verbal reinforcement will be given (e.g., “Good job, Johnny!”); if the participant is incorrect, a verbal and/or visual prompt is given to indicate the correct answer.

Joseph & Tanaka (2003) demonstrated that children with ASD do not adapt a configural strategy when recognizing faces, but rely on a more object-based featural approach. Another game, “Band Aid Clinic,” was thus developed to teach facial recognition by building on the local processing cognitive operations that children with ASD use when viewing faces. In the “Band Aid Clinic,” the participants were asked to select the appropriate face “band aid” that would fit over the avatar’s face (see Fig. 1b). The possible matches increase in number and similarity as the game progresses. The face is reconstructed by identifying the correct band aid. The goal of the “Band Aid Clinic” is to encourage processing of facial expressions in terms of their features and configuration.

Third, given that children with ASD have difficulty recognizing and identifying facial expressions from pictures of people’s eyes (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001), and given emotional expression difficulties observed in ASD (Hobson, 1986), the "Follow the Leader" game in *FaceSay* was designed to improve the ability of its users to distinguish and create facial expressions of emotions in avatars. This game component specifically emphasizes how subtle changes in eye information can alter the perception of facial expression and is designed to teach participants to look to the eyes for information and to improve their ability to read facial expression based on the eyes. The ultimate goal of "Follow the Leader" game is to teach aspects of emotional cognition and facial recognition.

In the first level of "Follow the Leader", the participant is asked to identify identical facial expressions and emotions by selecting "Yes" for same and "No" for different expressions (see Fig. 1c). The similarity of the two faces increases as the game progresses. As the game advances in levels, the participant is asked to make the avatar's twin match the avatar's expression by selecting appropriate eyes from a selection of eyes. Similarly, as the game continues, the facial expressions change and become increasingly subtle. The game thus provides practice both in more passive comparisons between facial expressions as well as more active online adjustment of an avatar's facial expressions.

Control Procedures (SuccessMaker®)

The participants underwent training sessions with specialty teachers prior to the current study. The control group participants received *SuccessMaker®* a set of computer-based courses used to supplement regular classroom reading instruction in grades K-8. Using adaptive lessons tailored to the participant's reading level, *SuccessMaker®* aims to improve understanding in areas such as phonological awareness, phonics, fluency, vocabulary, comprehension, and concepts of print. The courses aim to help the participants develop and maintain reading skills as well as provide opportunities for exploration, open-ended instruction and development of analytical skills. As the student interacted with the program the computer analyzed the participant's skill development and assigned specific segments of the program, introducing new skills as they became appropriate. Individualization allowed the participant to progress on his/her own schedule (What Works Clearinghouse, 2009). The control participants utilized *SuccessMaker®* for the same time and duration as the intervention group utilized *FaceSay*.

Results

Primary outcome variables for analyses were pre-post difference scores in dependent variables as described previously. Correlations between these difference scores are presented in Table 2. Affect Recognition and Theory of Mind scores were positively correlated with each other and negatively correlated with SRS-2 scores. No other correlations were found to be significant. Means and standard deviations of pre- and post- measures of all dependent variables are presented in Table 3.

Hypothesis 1

We hypothesized that the children who received the *FaceSay* intervention would demonstrate improved affect recognition, measured by their responses on the NEPSY Affect Recognition subtest. To assess this, we used an analysis-of-covariance (ANCOVA) approach in which the independent variable was Group (intervention or control), and the dependent variable was post-test score on the NEPSY Affect Recognition subtest. Pre-test NEPSY scores were entered as covariates in order to allow for individual differences prior to the intervention. No other covariates were entered.

There was a significant difference in post-test affect recognition score between the experimental and control groups after controlling for pre-test score, $F(1,28) = 20.45$, $p < .001$, partial $\eta^2 = .42$. The adjusted *M*s for the experimental and control groups were 12.59 and 8.50, respectively).

Hypothesis 2

We also hypothesized that participants in the experimental group would have a significantly greater improvement in their mentalizing scores than participants in the control condition, as measured by the NEPSY Theory of Mind subtest. As with Hypothesis 1, we used an ANCOVA approach with post-test NEPSY Theory of Mind score as a dependent variable, Group as an independent variable, and pre-test NEPSY Theory of Mind score as a covariate.

There was a significant difference in post-test Theory of Mind score between the experimental and control groups after controlling for pre-test score, $F(1,28) = 37.35$, $p < .001$, partial $\eta^2 = .57$ (adjusted *M*s: 12.39 and 16.85, respectively).

Hypothesis 3

Our third hypothesis was that participants in the experimental group would have significantly lower post-intervention scores on teacher report measures assessing the participant’s social skills as compared to participants in the control condition (i.e. exhibit fewer social difficulties). We conducted another ANCOVA with post-intervention SRS-2 score as the dependent measure, Group (intervention or control) as the independent measure, and the pre-test SRS-2 scores as a covariate.

There was a significant difference in post-test SRS-2 score between the experimental and control groups after controlling for pre-test score, $F(1,28) = 4.523$, $p < .05$, partial $\eta^2 = .14$ (adjusted *M*s: 67.7 and 62.3, respectively).

Hypothesis 4

It was hypothesized that participants in the experimental group would show increased positive interactions with peers' post-intervention as compared to participants in the control condition based upon social skills observation ratings. An ANCOVA approach analogous to previous analyses showed no significant differences in the number of positive social skills observations between the experimental and control groups following the intervention after controlling for pre-test numbers, $F(1,28) = 0.61$, $p > .05$ (adjusted *M*s: 6.71 and 7.61, respectively). The covariate, pre-test score was the only significant predictor of post-test positive observations, $F(1,28) = 17.24$, $p < .01$.

Hypothesis 5

Finally, we hypothesized that participants in the experimental group would show decreased negative interactions with their peers' post-intervention as compared to participants in the control condition based upon social skills observation ratings. An ANCOVA approach like those listed above found no significant difference in the number of post-test negative social skills observations between the experimental and control groups following the intervention, after controlling for pre-test numbers, $F(1,28) = 0.61$, $p > .05$ (adjusted *M*s: 0.18 and 0.55, respectively). The covariate, pre-test score, did not significantly predict post-test negative observations either, $F(1,28) = 0.627$, $p > .05$. Results of this and the preceding analyses are shown in Fig. 2)

Discussion

The purpose of this study was to investigate the extent to which *FaceSay* improves affect recognition, mentalizing, and social skills in school-aged children with ASD. The results of the present study suggest that by practicing simulated activities addressing eye gaze, joint attention, emotional cognition, and facial recognition skills on a computer, participants were able to improve their ability to recognize basic emotions such as happiness, sadness, neutrality, anger, disgust and fear. Furthermore, participants increased in their comprehension of beliefs, intentions, deception, emotion, imagination, and pretending, and improved their understanding that others have thoughts, ideas and feelings that may be different from their own. Finally, this study showed suggests that training through this software program is related to a pattern of fewer autism symptoms as assessed via teacher ratings. Thus, the results of the present study both support previous work that has demonstrated that this software improves teacher-observed social function and emotion-processing skills (Hopkins et al., 2011), as well as present new evidence that additional domains such as mentalization capability and theory of mind skills may similarly benefit.

Changes in theory of mind scores were strongly correlated with changes in affect recognition in the current study, suggesting that *FaceSay* targets these two skills in similar ways. Furthermore, changes in both of these domains were negatively correlated with changes in SRS score; that is, greater improvements in each of these domains were associated with decreased symptoms of autism as measured by the SRS-2. These results are consistent with between group findings suggesting that FaceSay is associated with improvements in examined outcome variables, and strengthen our understanding of FaceSay treatment effects at an individual level.

These results were particularly encouraging, because they demonstrate the ways that *FaceSay* can improve general elements of social functioning over and above those directly targeted by the intervention. *FaceSay* does not directly teach mentalizing, nor does it explicitly label any emotions. Rather, all of the constituent games address attention to eye gaze, joint attention bids, facial recognition, and the ability to distinguish and create emotional facial expressions in avatars. Nevertheless, the program does address mentalizing in very subtle ways. For example, joint attention bids are accompanied with questions like, “What does Rebecca want next?” that imply that others’ mental states can be deduced through an understanding of facial expressions and eye gaze. The results of the current study suggest that we can simultaneously improve emotion recognition, mentalizing skills and autism symptomatology through an intervention that primarily addresses facial processing. Future work should attempt to disentangle this relationship, using more advanced statistical models to explore possible causal relationships and underlying neural mechanisms.

Despite these encouraging results, this study found no improvements in observed positive and negative interactions on the playground. Although the *FaceSay* intervention did produce observable change in social skills, as evidence by improvements in SRS-2 scores, these changes did not translate into changes in broader prosocial and antisocial behaviors in this setting. It is possible that the observations made here were simply not an effective measure of generalizability for this intervention. Prosocial behavior requires an array of complex social and communicative skills that go beyond face processing, emotion recognition, or mentalizing. Furthermore, the number of negative observations in both groups was initially quite low, especially in the context of the high variability of those outcome measures. Perhaps a more telling post-intervention measure would be to observe children's ability to understand and respond to another person's perspective in real-life situations.

Nevertheless, the current findings suggest that the *FaceSay* program is a highly promising, efficient, and cost effective strategy for teaching affect recognition and mentalizing constructs to high functioning elementary school-aged children with ASD. It further suggests that by addressing these particular skills, we can effect real change in other behaviors outside the scope of this intervention.

Limitations and Future Directions

There are a few noteworthy limitations to the present study. Although the NEPSY is a standardized and relatively sophisticated measure of affect recognition, this study specifically assessed the recognition of six basic emotions from static two-dimensional representations of children's faces. In some cases, high functioning individuals with ASD can recognize basic emotions relatively well; however, their emotion deficits becomes apparent when the recognition of more complex emotions and mental states is required (Adolphs et al., 2001). Generally, complex emotions involve attributing a cognitive state as well as an emotion, and are more situationally dependent. Barriers to social referencing can impede the interpretation of social dynamics; thus, further work should address the effectiveness of *FaceSay* on the ability to recognize and identify more complex emotions and mental states from static as well as dynamic (e.g., video) facial expressions.

Although the study involved a number of social skills assessments, only the teacher-report measure suggested some generalizability of social skills. The intervention was implemented in the computer lab rather than the classroom setting; introducing an element to improve the generalization effects, such as having an instructional assistant review what the child learned or provide self-monitoring techniques, or instruction in a more natural setting could augment the social skills benefits observed here. Additionally, the use of a self-report measure may be useful in determining outcome efficacy; possibilities include assessments that tap into reduction of anxiety relative to social situations or changes in peer networks (Locke, Kasari, Rotheram-Fuller, & Jacobs, 2013).

Finally, expanding the number of participants in general, and including preschool, secondary school, and specialized educational settings would greatly enhance the generalizability of results to the broader ASD population.

The results of this study can be useful for parents, psychologists, educators, and specialists who live and work with children on the autism spectrum. As the prevalence of ASD increases, the identification of more evidence-based and cost effective methods to augment the education of children with ASD is warranted. This study demonstrates that CAI is a highly effective vehicle for helping children with ASD understand the social world.

Conclusions

Our results indicate that by practicing simulated activities addressing eye gaze, joint attention skills, emotional cognition, and facial recognition skills on the computer, students were able to significantly increase their affect recognition capabilities and mentalizing skills, and reduce their teacher-observed social impairment. Although these improvements were based on standardized assessments of emotion recognition and social cognition skill, the hypotheses that social interactions in the school environment would also improve were not fully supported.

This study demonstrates that the use of computer technology in helping ASD children understand the mental states of others is highly effective. The computer software program *FaceSay* improves the ability of children with ASD to recognize emotions and understand another's perspective, and shows great promise in enhancing these skills in the more general school environment. We hope these results can be useful for parents, psychologists, educators, and specialists who live and work with children with ASD.

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Figure Captions

Figure 1. Screenshots from three games within *FaceSay*. a) “Amazing Gazing,” b) “Band Aid Clinic,” c) “Follow the Leader.”

Figure 2. Post-intervention means for control and experimental groups.

Figures

Figure 1a top

Figure 1b top

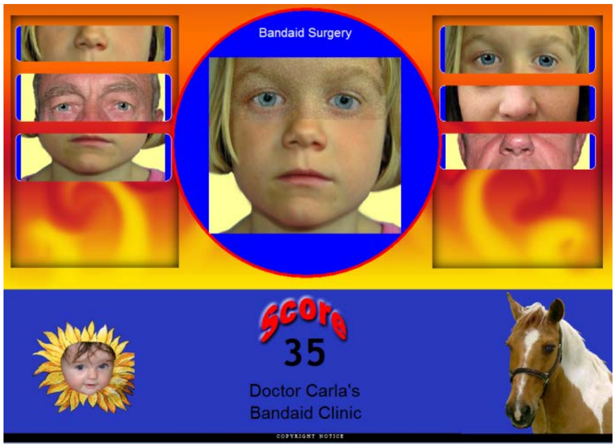
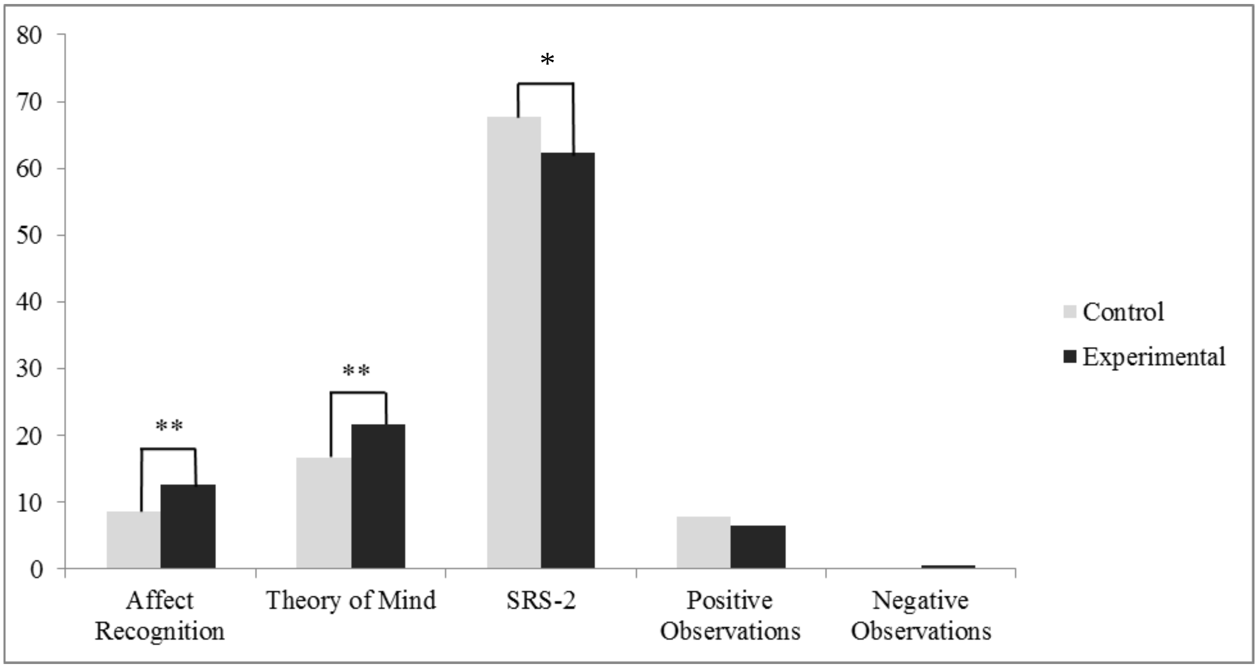


Figure 1c top

Figure 2 top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Control
Experimental
Affect Recognition
Theory of Mind
SRS-2
Positive Observations
Negative Observations

Tables

Table 1

Sample characterization means (standard deviations)

Measure	FaceSay	Control
N	16	15
Chronological age	7.68 (1.45)	7.87 (1.60)
Male:Female	16:0	12:3
IQ	104.8 (15.92)	98.53 (12.43)
SRS-2	65.18 (7.66)	65.40 (9.91)

Table 2

Correlations between difference scores for dependent variables for all groups

	1.	2.	3.	4.
1. ΔAffect Recognition				
2. ΔTheory of Mind	0.52**			
3. ΔSRS-2	-0.53**	-0.42*		
4. ΔPositive Observations	0.21	0.01	-0.27	
5. ΔNegative Observations	-0.001	0.21	-0.29	-0.13

Note. *p<.05, ** p<.01.

Table 3

Means (standard deviations) of dependent variables pre- and post-intervention for all groups

Measure	FaceSay		Control	
	Pre	Post	Pre	Post
Affect Recognition	8.63 (3.36)	12.56 (2.71)	8.73 (2.55)	8.53 (3.18)
Theory of Mind	15.38 (5.83)	21.63 (4.83)	14.80 (7.35)	16.60 (6.90)
SRS-2	65.19 (7.66)	62.25 (9.34)	65.40 (9.91)	67.80 (10.05)
Positive Observations	6.47 (3.73)	6.47 (4.37)	7.20 (3.45)	7.87 (3.53)
Negative Observations	1.00 (.93)	.56 (.95)	.80 (1.00)	.17 (.36)

The author has requested enhancement of the downloaded file. All in-text references underlined in blue are linked to publications on ResearchGate.