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ORIGINAL PAPER

Avatar Assistant: Improving Social Skills in Students with an ASD Through a Computer-Based Intervention

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Abstract This study assessed the efficacy of *FaceSay*, a computer-based social skills training program for children with Autism Spectrum Disorders (ASD). This randomized controlled study ($N = 49$) indicates that providing children with low-functioning autism (LFA) and high functioning autism (HFA) opportunities to practice attending to eye gaze, discriminating facial expressions and recognizing faces and emotions in FaceSay's structured environment with interactive, realistic avatar assistants improved their social skills abilities. The children with LFA demonstrated improvements in two areas of the intervention: emotion recognition and social interactions. The children with HFA demonstrated improvements in all three areas: facial recognition, emotion recognition, and social interactions. These findings, particularly the measured improvements to social interactions in a natural environment, are encouraging.

Keywords Autism · Intervention · Emotion recognition · Facial recognition · Social interactions · Generalization

Introduction

The development of social competence is an important goal for all children. However, some children are at risk for challenges in social competence due to deficits in social skills (Gresham 1981). Children with Autism Spectrum Disorders (ASD) are particularly affected by this impairment as evidenced by their difficulties in reciprocal social interaction skills (American Psychiatric Association 1994). Individuals with ASD display marked impairments in the use and interpretation of nonverbal behaviors, such as eye-to-eye gaze, facial expressions, body posture, and gestures to regulate social interaction (Hobson 1986). In addition, individuals with ASD often fail to monitor the effect of their conversations or behaviors on other people. For example, they frequently monopolize conversations or walk away while others are trying to interact with them (Bailey 2001). This may be the result of an inability to interpret nonverbal communications provided in facial expressions and body posture.

The ability to recognize emotions in others is a crucial component of social development (Hobson 1986). Impairment in this skill severely reduces one's ability to participate in or interpret social interactions. In order to establish the extent to which emotion recognition skills develop in children with developmental disabilities, previous research has tended to focus on children with ASD for whom impaired social development is seen as a key feature. Differences have been found between children with ASD and typically developing children. For example, Baron-Cohen et al. (1997) developed a theory of mind task where the participants looked at photos of either an entire face or just a region around the eyes to determine emotions. The researchers found that individuals with autism performed significantly worse on the task than age and IQ matched participants without autism. In addition, individuals with autism had marked deficits in their performance in the eyes-only condition. These results support the idea that emotion recognition deficits are key characteristics in understanding the social deficits of individuals with ASD.

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Emotion processing deficits may not be specific to emotions, but may reflect more general information processing deficits. For example, difficulties in processing emotional expressions in ASD may stem from more general difficulties in processing faces (Boucher and Lewis 1991) or still more general perceptual difficulties related to the processing of relational information (Shah and Frith 1993). Davies et al. (1994) performed two experiments designed to tease apart these various possibilities. Their results support the conclusion that emotion processing and face processing deficits in ASD can be attributed to more general impairment in processing of relational information. Participants in their study showed similar deficits in processing emotional, facial, and nonfacial stimuli.

Face Processing

Faces are remarkably homogenous as a class of visual stimuli in that they share a highly similar structure, always consisting of the same set of parts (e.g. eyes, nose, and mouth) in the same basic configuration (e.g. nose centered below the eyes and above the mouth). Yet, despite this basic similarity, most people can easily recognize and discriminate among hundreds of faces. This ease with which humans are able to distinguish between faces has been contributed to a holistic perceptual and encoding process (Bartlett and Searcy 1993; Mundy 2003; Rhodes 1988).

Individuals with ASD, however, appear to process faces by relying more on local facial features than on holistic facial configuration (i.e. the relationship between the different parts). For example, persons with autism show much less of an inversion effect (i.e. their performance was not impaired for recognition of upside down faces versus upright faces) compared to controls when presented with inverted faces (Langdell 1978). The lack of inversion effect is taken as a sign of a local rather than a configural or global processing of faces, since local information is most relevant in identifying inverted faces.

People with ASD can discriminate between faces (Ozonoff et al. 1990). However, as the demands are increased, or elements of emotion are included, performance is impaired for individuals with ASD (Davies et al. 1994). Joseph and Tanaka (2003) found evidence of holistic strategy use by children with autism, but, unexpectedly, only when face recognition depended on the mouth. Marked deficiencies in recognition occur when identification is dependent on the eyes. Hopkins and Biasini (2005) also found that children with autism recognized schematic face stimuli by relying on lower facial features only. The same conclusion was drawn when using photographs of faces. The Joseph and Tanaka (2003) finding is consistent with Hopkins and Biasini (2005) study: children with autism focus on the mouth when attending to faces and are poor at recognition involving eyes.

The Current Study

Recent population statistics suggest that autism is the fastest growing developmental disability in the United States, with an estimated annual cost for diagnosis, and treatment of $90 billion (Autism Society of America 2003). This growth, combined with the likely long-term implications, necessitates an immediate effort to improve social skills among children with ASD. Any technology that could teach individuals with ASD necessary social skills would not only be invaluable for the individuals affected, but would also result in financial savings. Such a technology appears to exist in the rudimentary form as avatars, computer embodied virtual people that have a knowledge base and the ability to converse with humans in natural language.

Computers are promising teaching instruments for children with ASD (e.g. Chen and Bernard-Opitz 1993; Colby 1973; Faja et al. 2008; Panyan 1984). Multisensory interactions, controlled and structured environments, use of multilevel interactive functions, and the ability to individualize instruction are some of the features that can assist children with ASD when working with computers. Those functions have been found to be successful for various computer-based interventions (e.g. Bernard-Opitz 1989; Panyan 1984; Yamamoto and Miya 1999). For instance, Chen and Bernard-Opitz (1993) found that 3 of 4 students with autism exhibited higher motivation to learn and fewer disruptive behaviors using computer-based instruction compared to more traditional personal instruction. Heiman et al. (1995) found that an interactive environment provided by a computer enhanced the reading and writing skills of children with ASD. "Baldi" was developed as a three-dimensional computer-animated talking head (avatar). It provides realistic visible speech that is almost as accurate as a natural speaker. Computer-based training programs using Baldi to carry out language tutoring for children have been found to facilitate language learning in children with ASD (Bosseler and Massaro 2003). Finally, Faja et al. (2008) found that computer-based face training can affect processing of faces. Faja and colleagues found that 8 h of computerized face training resulted in sensitivity to holistic processing. However, no difference was found in face recognition, possibly because the face training was two-dimensional.

Several published studies have evaluated the efficacy of computer or DVD video based interventions to enhance the social skills abilities of children with ASD (Bernard-Opitz et al. 2001; Silver and Oakes 2001; Bölte et al. 2002; Golan and Baron-Cohen 2006; LaCava et al. 2007; Golan et al.

2010; Tanaka et al. 2010; Whalen et al. 2010; Lacava et al. 2010). These technology-based social skills interventions all leverage the affinity of students with an ASD for the predictable and animated environment of a computer game or video (Goldsmith and LeBlanc 2004). These interventions typically do not offer the individual an opportunity for more real life like interactions. Unlike these interventions, FaceSay uses interactive, realistic avatar assistants.

Generalization, the ability to transfer a learned behavior acquired during a training activity to another similar or related activity or situation, is considered a difficult task for children with an ASD (Koegel et al. 2001). Some of the studies with children with an ASD found no generalization across tasks (Bölte et al. 2002; Silver and Oakes 2001) or only near generalization (Golan and Baron-Cohen 2006). Other studies have measured distant generalization from one setting to the next (Bernard-Opitz et al. 2001; Golan et al. 2010). While other studies mention anecdotal reports of generalization to real settings (Golan and Baron-Cohen 2006; LaCava, et al. 2007; Golan et al. 2010; Whalen et al. 2010; Lacava et al. 2010) or limited generalization to real settings in unpublished laboratory findings (Bernard-Opitz et al. 2001). None of these studies have shown social skills generalization to a real setting and several call for further research to investigate it (Golan and Baron-Cohen 2006; LaCava et al. 2007; Golan et al. 2010; Tanaka et al. 2010; Whalen et al. 2010).

The challenge of generalization to real settings has also been reported for non-computer based social skills interventions. A review of studies of social skills group interventions, for example, concludes, “there is evidence that skills may be displayed in laboratory/clinic settings, but not necessarily applied in the child’s daily life at school or home. Generalization and flexible skill use in natural environments continues to be a challenge.” (Williams White et al. 2007).

The overall purpose of the current study was to evaluate FaceSay, a new computer based social skills intervention designed and created especially for this study by Symbionica, LLC, and its use of interactive, realistic avatar assistants for social skills learning in children with ASD, including FaceSays’s potential for improving the children’s social interactions in natural environments. Previous computer based approaches to teaching face and emotion recognition skills to persons with an ASD were mostly static response based software (e.g., Tanaka et al. 2003). FaceSay, however, uses an interactive approach with computer animated avatars, both humans and animals, to create a more life-like software program to teach face and emotion recognition skills. FaceSay also includes an appealing predictability (Goldsmith and LeBlanc 2004) and restricted field of focus (Corbett and Abdullah 2005) made possible through computer technology using interactive video-realistic avatars.

FaceSay tries to incorporate activities to address known challenges for persons with an ASD. For example, in the first of the three games the goal was to improve joint attention skills by creating an interactive problem solving task focusing on tracking the eyes of the avatar to respond to the avatar’s request. The other two games are based, in part, on the idea that persons with an ASD have weak central coherence (Frith 1989). One of the goals was to increase their abililty to be more global lookers when interpreting expressions of emotions and discriminating faces. These games are described in more detail in the Procedures section of this paper.

Aims and Predictions

Aim 1 The primary aim of this study was to examine the effect of FaceSay on children’s emotion and facial recognition skill development. It was predicted that all children who participated in the training program would attain improved emotion recognition skills following the intervention (Hypothesis 1). Also, given the encouraging results of a computer-based social skills training (e.g. Bernard-Opitz et al. 2001), it was predicted that children with ASD who participated in the training would have improved facial recognition skills following the training program (Hypothesis 2).

Aim 2 The study also investigated the impact of the intervention on social behaviors in the natural environment. It was predicted that children with ASD who received the intervention would demonstrate improvements in observed and reported social skills following the intervention (Hypothesis 3). This prediction was based on the premise that the avatar based games in FaceSay would improve the face and emotion recognition skills of the participants leading to more appropriate and less dysfunctional social interactions related to improvements in the recognition of nonverbal facial communication. The improved face and emotion recognition skills should create a greater awareness of the social value of facial features, particularly the eyes, thereby increasing interest in and decreasing social confusion in real world social interactions.

Methods

Participants

The protocol for the current study was approved by the institutional review board of the University of Alabama at

Birmingham. Participants were recruited from several sources in central Alabama. All parents gave written informed consent after study procedures were fully explained. Formal child assent was obtained from children whose mental age was above seven years. Before the study began, a meeting with each parent and child was held to give an overview of the study's procedures, explain the importance of regular attendance, and to answer any questions the parent or child had.

Fifty-one children were initially enrolled in the study. However, two children were excluded from the study due to low attendance rates (one student moved and one student was hospitalized for an extended period). Forty-nine children with LFA or HFA completed the project. All the children had previously received a diagnosis of an ASD according to the criteria specified by the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association 1994) by a licensed community professional. To insure that all the participants met this criteria the investigators confirmed the ASD diagnosis with an administration of the CARS ($M = 37.14$). Due to the variability in the children's functioning, they were grouped into High Functioning Autism (HFA; KBIT greater than 70; $n = 24$) and Low Functioning Autism (LFA; KBIT less than 70; $n = 25$). Children who attended greater than 83% of the sessions were included in the analyses.

Children with a mental age between 6 and 10 years were recruited from several sources located in a large geographic area in a southeastern state in the USA. Among the children in the sample, 5 were girls and 44 were boys, ranging in age from 6 years, 3 month to 15 years, 1 month ($M = 10.17$). Possible demographic differences between the intervention and control groups of children with LFA and HFA were tested using ANOVA or Chi square. No significant differences were found between the groups. Tables 1 and 2 provide a listing of the demographic characteristics for all of the children.

Design and Instruments

The current study involved a 2 (Training) × 2 (Group) × 2 (Time) mixed factorial design. The within factor was Time, which had two levels (baseline and post-intervention). The between factors were Group, and it had two levels (LFA and HFA) and Training, and it had two levels (Avatar Training and Control).

Materials

Kaufman Brief Intelligence Test

Cognitive functioning for all groups was obtained using the Kaufman Brief Intelligence Test, Second Edition (KBIT, II) (Kaufman and Kaufman 1990). The KBIT, II assesses general cognitive abilities and generates verbal, non-verbal, and composite domain scores. The KBIT, II correlates highly with the Wechsler Scales intelligence tests ($r = 0.84$). The KBIT, II has demonstrated an internal consistency coefficient of 0.92 and test–retest reliability coefficients of 0.90. (Kaufman and Kaufman 1990).

Childhood Autism Rating Scale

The Childhood Autism Rating Scale (CARS) was used to reconfirm the previous diagnosis of ASD. The CARS is a widely used instrument developed to distinguish children with autism from those with other developmental disabilities or normal functioning (Schopler et al. 1988). The CARS has been shown to have high reliability (0.81) and internal consistency (0.94) (Perry et al. 2005). Criterion-related validity has been determined by correlating CARS diagnoses to diagnoses made independently by child psychologists and psychiatrists ($r = 0.80$). The CARS has also been shown to have 100% predictive accuracy when distinguishing between groups of children with autism and children with mental retardation (Teal and Wiebe 1986).

Emotion Recognition

Both photographs and schematic drawings were used to measure children's ability to recognize emotional expressions before and after the training. The photographs consisted of six black and white pictures that illustrate a woman with six different emotional expressions (anger, disgust, fear, happiness, sadness, and surprise). They were selected from Ekman and Friesen's (1975) photos of faces of emotional expressions. The photographs are contained in *Unmasking the Face* (Ekman and Friesen 1975) and have been used in previous studies (e.g. Hopkins and Biasini 2005; Sullivan 1996). The schematic drawings were essentially versions of a happy or smiley face that were designed to depict the six emotions and were validated by groups of undergraduate students. The drawing had to be correctly identified by at least 95% of the undergraduate students to be included in the array. The photo measure has been found to have strong reliability (0.89–0.91) and validity (0.71–0.86; Ekman and Friesen 1975).

The children in the current study were presented with the arrays of photographs and schematic drawings of emotions. Each array consisted of six faces. As they were presented the children heard a label (angry, disgusted, scared, happy, sad, or surprised) and were asked to match the emotion label by touching the appropriate photo or drawing. Presentation of the photo or schematic drawing sets was counterbalanced. The order of the six photographs and drawings within the arrays were also

Table 1 Frequency (percentage) for particpants' demographic charactersitics

Variable	LFA training ($N = 11$)	LFA control ($N = 14$)	HFA training ($N = 13$)	HFA control ($N = 11$)	Total ($N = 49$)
Gender					
Male	10 (90.9)	13 (92.9)	12 (92.3)	9 (81.8)	44 (89.8)
Female	1 (9.1)	1 (7.1)	1 (7.7)	2 (18.2)	5 (10.2)
Ethnicity					
African American	3 (27.3)	4 (28.6)	3 (23.1)	3 (27.3)	13 (26.5)
Caucasian	8 (72.7)	10 (71.4)	10 (76.9)	7 (63.3)	35 (71.4)
Other	0 (0)	0 (0)	0 (0)	1 (9.1)	1 (2.0)

Table 2 Means (standard deviations) of age, CARS, and IQ scores for all groups

Variable	LFA training ($N = 11$)	LFA control ($N = 14$)	HFA training ($N = 13$)	HFA control ($N = 11$)	Total ($N = 49$)
Age	10.31 (3.31)	10.57 (3.2)	10.05 (2.30)	9.85 (2.87)	10.17 (3.02)
CARS	38.64 (3.93)	38.92 (5.79)	36.00 (5.26)	35.00 (5.22)	37.14 (5.24)
IQ					
Verbal	52.09 (16.68)	50.00 (15.46)	92. 05 (18.63)	93.09 (21.91)	74.51 (25.59)
Nonverbal	59.00 (23.54)	58.38 (19.03)	91.76 (20.98)	93.81 (26.05)	78.86 (28.94)
Composite	55.09 (20.91)	54.79 (16.41)	91.88 (19.54)	93.00 (25.47)	75.71 (27.34)

counterbalanced. The child's emotion recognition score was the total correct responses across the 12 trials of photos and drawings.

Facial Recognition

To measure the children's facial recognition skills, the Benton Facial Recognition Test (Short Form) was administrated (Benton 1980). The Benton test is a standardized 27-item task for assessing the ability to identify and discriminate photographs of unfamiliar human faces. The test has been normed for children and adults. The internal-consistency reliability has been found to be 0.71, with a test–retest reliability of 0.66. Male and female faces are used, and the faces are closely cropped so that no clothing and little hair are visible.

The children completed the Benton test before and after the training. The faces are centered within a black background, and the entire image is 6.5 cm by 6.5 cm. For the first six items, only one of the six test faces displays the target individual, and the target image and the test image are identical. In the next seven items, three of the test faces match the target face, and the poses for the test images are different from the target image. No time limits are placed on individual items or the test as a whole. On each item, the children were presented with a target face above six test faces, and they were asked to indicate which of the six images matched the target face. For the purpose of this study, the task was slightly modified in that the target face was presented as a card instead of as a photograph in the stimulus booklet. The children were asked to match the card with the correct test image in the booklet.

Social Skills Rating System

The Social Skills Rating System (SSRS) (Gresham and Elliott 1990) was administered as both a pre- and posttest measure. It is a standardized, norm-referenced 38-item parent-report questionnaire that measures a wide range of social skills, including the broad domains of cooperation, assertion, responsibility, and self-control. The SSRS has been found to have an internal-consistency of 0.87-0.90 and test re-test reliability of 0.87 (Gresham and Elliott 1990). Children with ASD have been shown to have impairments on the SSRS when compared to the normative sample (Gresham, 1981). The total score on the 38-items yields a Social Skills standard score, which has demonstrated a test–retest reliability coefficient of 0.87 (Gresham and Elliott 1990). The parents were blind to their child's group assignment (i.e. training or control).

Social Skills Observation

To measure children's social skills, an observation of each child was conducted during recess or free time. At baseline, and following the intervention, each child was observed for two 5-min assessment periods at a random time during their school recess by two research assistants. The child was observed interacting with peers on two separate days. The two research assistants were blind to the group status of the participants in the study. Prior to collecting data, the two research assistants spent a 2 hour practice session scoring children's social interactions until 90 percent agreement had been reached consistently between the assistants and the investigator. Inter-rater reliability was established for 100% of the coding data. They then observed the social interactions and coded the interactions on a rating system that has been developed and used in previous studies (Hauck et al. 1995). The items on the rating scale assess specific social skills and produce scores for three social skills factors: positive social interaction, low-level social interaction, and negative social interaction. Positive social interactions include activities that exhibit verbal and nonverbal social behaviors that lead to an effective social process with peers. These behaviors serve to start or maintain social interactions. Low-level interactions include behaviors that indicate social intention but with minimal social enactment such as close proximity to other children without initiating a positive social interaction. Negative social interactions include unpleasant social behaviors that operate to stop or decrease the likelihood of an adequate social interaction. Each of the behaviors was coded as present, not present, or not applicable to the situation.

The observers maintained close proximity to the children during recess, whether in the gymnasium or outdoors; however, they did not interact with the children and politely rejected any overtures made towards them. Children were told by their teachers that that the observers were interested in learning about their play habits. Reliability for the two observers across the 2 social skills factors was established using Cohen's kappa (Cohen 1960). Cohen's kappas for the two raters were 0.95 for positive social interaction, 0.74 for low-level social interaction, and 0.86 for negative social interaction. According to Fleiss (1981), kappa levels of 0.40– 0.60 are fair, 0.60–0.75 are good, and 0.75 and above are excellent. Thus, these kappa levels are considered good to excellent.

Procedures

All procedures occurred at the child's school or after-school facility. At the baseline assessment session, parents of the children completed a demographic information form and the Social Skills Rating System. The children completed the Emotion Recognition test, the Benton Facial Recognition test, and the Kaufman Brief Intelligence Scale. The participants were then observed interacting with other children during recess. The research assistants completed the CARS and the Social Skills Observation. The children were randomly assigned to the training group or the control group. All post-test measures were completed within 2 weeks after the final intervention session.

Control Group

Fourteen participants with LFA and 11 children with HFA were asked to use Tux Paint, open source drawing software for children (www.tuxpaint.org), at the school with the assistance of one or two investigator(s), twice a week for approximately 10–25 min per session over a period of 6 weeks, a total of 12 sessions. The curriculum of the art software (i.e. teaching painting, drawing, and coloring) was not associated with the aims of the intervention software (i.e. joint attention, face processing, and eye gaze). This activity was selected to control for the amount of time spent playing on the computer during the study as well as social interactions with the experimenters.

Training Group

Eleven participants with LFA and 13 participants with HFA were asked to use the FaceSay software (Symbionica, LLC, San Jose, CA) at the school with the assistance of one or two investigators, twice a week for approximately 10–25 min per session over a period of 6 weeks, a total of 12 sessions. The decision to limit the intervention to 12 sessions was determined based on the limited time in the school setting that was available during one semester. In order to complete baseline measures, the intervention, and post-intervention measures, 12 intervention sessions was the maximum number that would allow for the completion of the study during one school term thus minimizing attrition and lapses in study protocol.

Before beginning the computer sessions, training sessions were conducted to introduce the children to the computer. The students learned to sit at the computer, to listen and respond to the software, and use the mouse or to touch the screen. Each student had the option to respond with either an external mouse (Logitech, M-CAA42, Fremont, CA) or a touch screen (KEYTEC Magic Touch, Richardson, TX). If the students stayed in their seat and appropriately used the mouse or touch screen their behavior was reinforced with praise or snack foods depending on the type of reinforcer that was recommended by their teacher. The computer-based intervention and control sessions began following the two training sessions and continued for six weeks.

Intervention Procedures

FaceSay is a colorful program that contains three different games with realistic avatars designed to teach children specific social skills. The avatars were animated photos of real persons that could interact with the children by drawing on a pre-programmed knowledge base. The overall goal of the games is to promote awareness of the movements and features of the face, particularly the area around the eyes. Interactive features of the software provide opportunities for children to respond to social situations. Targeted social skills included teaching specific social skills for responding to joint attention, particularly eye gaze, recognizing facial expressions and recognizing faces. The children were asked to attend to and interact with a computer animated avatar that initiated an interaction with the child and asked them to complete certain activities that involved following an eye gaze, completing a face puzzle, and matching and manipulating facial expressions. For example joint attention was taught by instructing the children to follow the avatar's eyes to determine what face or object the avatar was attending to. The tasks increased in difficulty to assure that participants of various levels could be successful as well as challenged by the tasks. For example in the joint attention task there are initially 4 response choices and as the children are successful the response choices increase to 12. In the face puzzle the children initially have 3 options to complete the face and the number of choices is increased to 6 as they progress through the game.

For the purpose of the current study, three games from FaceSay were used to teach specific social skills. The "Amazing Gazing" game is designed to teach children to attend to eye gaze, respond to joint attention and to understand that eye gaze can convey intent (see Fig. 1). In the game, the avatar is surrounded by an array of objects, numbers, or faces. The child is asked to touch the object, number, or face at which the avatar is gazing. If the child is correct, the animal "coach" avatar at the bottom right of the screen praises the child using the child's name (e.g. "Good job, Johnny!").

A second game, "Band Aid Clinic," is designed to teach holistic facial processing and face recognition. The child is asked to select the appropriate face "band aid" that would fit over the distorted portion of the avatar's face. The possible matches increase in number and similarity as the games progresses. Once reconstructed, the face "comes alive" and expresses gratitude for fixing the face. (see Fig. 2).

The third game, "Follow the Leader", is designed to teach children to attend to movements in the area around the eyes to improve their ability to discriminate facial expressions. The game specifically emphasizes how subtle changes in eye information, often ignored by children with ASD, can alter the perception of the facial expression.

In the first level, the child is asked to identify identical facial expressions of emotions by selecting "Yes" for same and "No" for different expressions. In an advanced level, the child is asked to change the expression of the avatar's twin to match the avatar's expression moving the eyes up or down. This was accomplished with the touch screen or mouse by touching or clicking a button to expand or contract the eyes (see Fig. 3).

Fig. 1 Screenshots from the "Amazing Gazing" game

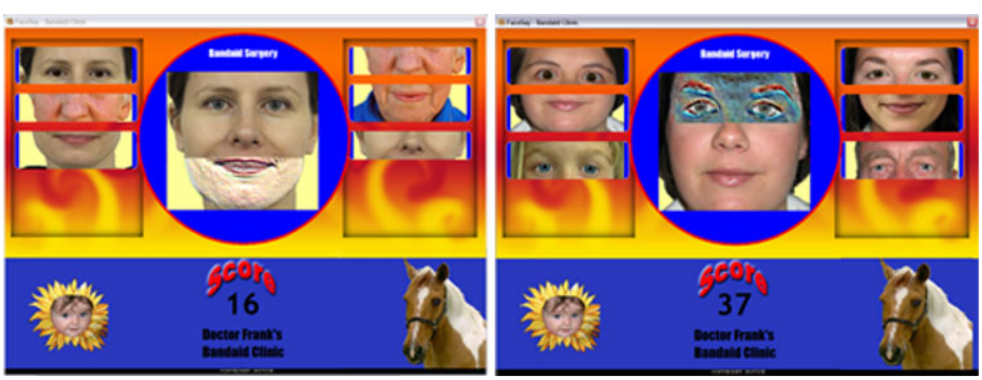

Fig. 2 Screenshots from the "Band Aid Clinic" game

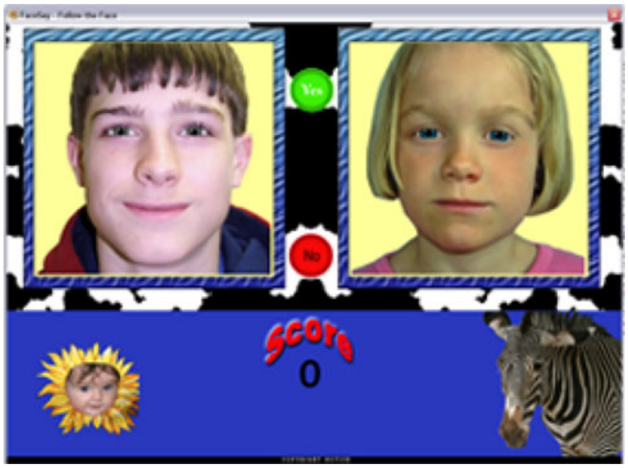

Fig. 3 Screenshot from the "Follow the Leader" game

Results

Hypothesis 1 It was hypothesized that children with LFA or HFA who received the FaceSay intervention would demonstrate increased emotion recognition skills following the intervention as measured by their responses to the six Ekman & Friesen photographs and the six drawings of facial expressions. To analyze the impact FaceSay had on emotion recognition skills, separate ANCOVAs were run for the LFA group and the HFA group. For these analyses the independent variable was the group (training or control). The dependent variable was the emotion recognition post-test score, and the covariates were the emotion pre-test score and KBIT score. Using the pre-test score and IQ score as covariates allowed an adjustment for a difference between the groups prior to treatment. In addition, the resulting analysis was capable of reflecting a change in emotion recognition skills that takes into account the cognitive functioning of each group prior to treatment.

The first analysis compared the change in emotion recognition skills for the children with LFA who received training with that of the children with LFA who did not receive the training. There was a significant difference in total emotion recognition skills (photos and drawings), $F(1, 21) = 4.52$, $p < 0.05$ (adjusted *M*s 6.53 and 5.23, respectively). Also, there was a significant difference in emotion recognition skills using only photographs as stimuli, $F(1, 21) = 4.56$, $p < 0.05$ (adjusted *M*s: 3.59 and 2.79, respectively). However, there was no significant difference in emotion recognition skills using only drawings as stimuli, $F(1, 21) = 1.64$, $p > 0.05$; (adjusted *M*s: 2.95, and 2.42, respectively).

The second analysis compared the children with HFA who received training with that of the children with HFA who did not receive the training. There was a significant difference in total emotion recognition skills (photos and drawings), $F(1, 20) = 29.31$, $p < 0.001$ (adjusted *M*s 8.70 and 6.79, respectively). Also, there were significant differences in emotion recognition skills using only photographs as stimuli, $F(1, 20) = 24.52$, $p < 0.001$ (adjusted *M*s 4.58 and 3.66, respectively), and in emotion recognition skills using only drawings as stimuli, $F(1, 20) = 15.48$, $p < 0.01$; (adjusted *M*s: 4.11, and 3.14, respectively). The results of these two analyses indicate that there was an overall change in emotion recognition skills using photographs as stimuli after training for the children who received the intervention. However, only the children with HFA who received the training improved in their ability to interpret drawings of emotions following the intervention.

Hypothesis 2 The second hypothesis was that children with LFA or HFA who participated in the FaceSay intervention would demonstrate improved facial recognition skills after the intervention. This was measured using the Benton Facial Recognition Test. To analyze the impact FaceSay had on facial recognition skills, separate ANCOVAs were run for the LFA group and the HFA group. The Benton pre-test scores and the KBIT score were used as the covariates and the Benton post-test scores as the dependent variable. The independent variable was the group (training or control). The results for children with LFA indicated that there was no significant difference in their performance on the Benton-Short Form $F(1, 21) = 0.67$, $p > 0.05$ (adjusted *M*s: 14.48 and 12.84, respectively). For children with HFA, ANCOVA results showed that the training group and the control group differed significantly on the Benton-Short Form $F(1, 20) = 10.86$, $p < 0.01$ (adjusted *M*s: 18.41 and 15.42, respectively), with the training group having significantly higher post-test scores. The results of these two analyses indicate that there was an overall change in facial recognition skills for the children with HFA who received the intervention. The analyses for Hypotheses 1 and 2 are summarized in Table 3.

Hypothesis 3 It was hypothesized that children with LFA or HFA who participated in the FaceSay intervention would demonstrate improved social interaction skills in a natural environment after the training program. To analyze the impact FaceSay had on social interaction skills, separate ANCOVAs were run for the LFA group and the HFA group for their scores on the SSRS and the Social Skills Observation. The SSRS or the Social Skills Observation pre-test scores and the KBIT score were used as the covariates and the SSRS or the Social Skills Observation post-test scores as the dependent variable. The independent variable was the group (training or control).

The first analyses compared the children who received training with that of the children who did not receive the

Table 3 Means (standard deviations) of measures of emotional and facial recognition pre and post intervention for all groups

Measure	LFA control (N = 1 4)		LFA training (N = 11)		HFA control (N = 11)		HFA training (N = 13)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Emotion test								
Pictures	2.91 (1.38)	2.91 (1.51)	2.71 (1.49)	3.50 (1.22)	3.61 (1.19)	3.31 (1.18)	4.54 (1.63)	5.00 (1.00)
Drawings	2.36 (0.67)	2.27 (1.10)	2.71 (1.38)	3.07 (1.21)	2.69 (0.95)	2.77 (1.24)	3.64 (1.91)	4.54 (1.37)
Total	5.27 (1.95)	5.18 (2.44)	5.43 (2.59)	6.57 (2.28)	6.31 (1.97)	6.08 (2.33)	8.00 (3.13)	9.54 (2.34)
Benton								
Short form	11.18 (4.87)	12.64 (4.20)	12.79 (4.19)	14.64 (4.96)	13.23 (3.37)	14.54 (3.26)	16.27 (5.91)	19.45 (4.27)
Long form	28.18 (4.21)	29.36 (4.24)	29.86 (4.72)	32.64 (6.81)	29.31 (5.59)	31.23 (5.79)	36.00 (7.03)	40.64 (6.67)

training on their parents' reported social skills on the SSRS. For children with LFA, there was a significant difference in their scores on the SSRS, $F(1, 21) = 14.42$, $p < 0.01$ (adjusted *M*s 64.99 and 58.51, respectively). Also, there were significant differences in Assertion, $F(1, 21) = 5.89$ $p < 0.05$ (adjusted *M*s 8.06 and 5.92, respectively) and Self-control, $F(1, 21) = 6.00$ $p < 0.05$ (adjusted *M*s 7.57 and 4.91, respectively). However, there was no significant difference in Cooperation, $F(1, 21) = 2.74$, $p > 0.05$ or in Responsibility, $F(1, 21) = 2.22$ $p < 0.05$ (adjusted *M*s 5.36 and 4.09, respectively).

For children with HFA who received training compared with that of the children with HFA who did not receive the training, a trend emerged in their parents' reported social skills on the SSRS, $F(1, 20) = 4.36$, $p = 0.05$ (adjusted *M*s 67.77 and 62.27, respectively). However, there were no significant differences in Cooperation, $F(1, 20) = 4.04$, $p > 0.05$, Assertion, $F(1, 20) = 0.26$ $p > 0.05$ Responsibility, $F(1, 20) = 0.31$ $p > 0.05$, or Self-control, $F(1, 20) = 0.84$ $p > 0.05$.

The second set of analyses compared the children who received the training to that of the controls on their observed social interactions. For children with LFA, there was a significant difference in their total scores on the Social Skills Observation, $F(1, 21) = 5.05$, $p < 0.05$ (adjusted *M*s 9.60 and 11.05, respectively), with the training group having significantly lower post-test scores (i.e. less inappropriate social interactions). Also, there was significant difference in their Negative Interactions, $F(1, 21) = 5.52$ $p < 0.05$ (adjusted *M*s 0.67 and 1.69, respectively), with the training group having significantly lower post-test scores (i.e. less negative interactions). However, there were no significant differences in their Positive Interactions, $F(1, 21) = 0.76$, $p > 0.05$ or in their Low-level interactions, $F(1, 21) = 0.13$, $p > 0.05$.

For children with HFA who received training compared with that of the children with HFA who did not receive the training, there was a significant difference in their total scores on the Social Skills Observation, $F(1, 20) = 13.61$, $p < 0.001$ (adjusted *M*s 7.54 and 10.46, respectively), with the training group having significantly lower post-test scores (i.e. less inappropriate social interactions). Also, there were significant a difference in their Positive Interactions, $F(1, 20) = 11.49$, $p < 0.01$ (adjusted *M*s 5.93 and 7.75, respectively), with the training group having significantly lower post-test scores (i.e. more positive interactions). However, there were no significant differences in their Negative Interactions, $F(1, 20) = 2.72$, $p > 0.05$ or in their Low-level interactions, $F(1, 20) = 0.42$, $p > 0.05$.

The analyses for Hypothesis 3 are summarized in Table 4. The Cohen's d effect size (comparing control to training post measures, post-hoc) for the SSRS Composite are 1.01 (LFA) and 0.29 (HFA) and for the SSO Total 0.81 (LFA) and 1.34 (HFA).

Discussion

The purpose of this study was to examine the effects of a new interactive software intervention for social skills for children with an ASD, including in natural environments. The results of this study provide general support for the promise of using computer-based interactive games for enhancing specific social skills. In particular, this study suggests that providing children with ASD opportunities to practice eye gaze, expression matching and face recognition in FaceSay's controlled, structured, and interactive environment with realistic avatar assistants improved their social skill. The children with LFA demonstrated improvement in two areas of the intervention: emotion recognition and social interactions. The children with HFA demonstrated improvements in all three areas of the intervention: facial recognition, emotion recognition, and social interaction in natural environments.

First, the ability to recognize unfamiliar faces improved for children with HFA following the intervention, but not for children with LFA. This difference could be an indication of individual differences such as intellectual functions. The children with LFA had significantly lower cognitive functioning than the sample of children with

Table 4 Means (standard deviations) of measures of social skills pre and post intervention for all groups

Measure	LFA control (*N* = 11)		LFA training (*N* = 14)		HFA control (*N* = 13)		HFA training (*N* = 11)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
SSRS								
Cooperation	6.09 (2.91)	6.00 (3.41)	6.43 (2.24)	8.14 (2.07)	8.38 (1.75)	7.08 (2.87)	6.36 (3.07)	6.73 (2.24)
Assertion	7.27 (2.33)	6.09 (1.97)	6.93 (2.97)	7.93 (2.62)	8.85 (1.86)	7.77 (2.68)	7.00 (2.45)	7.82 (2.63)
Responsibility	4.09 (3.01)	4.09 (2.84)	4.07 (3.19)	5.36 (2.76)	6.69 (2.75)	6.15 (3.05)	4.82 (3.49)	4.82 (3.37)
Self-Control	5.91 (2.51)	4.09 (2.34)	5.71 (2.73)	7.57 (2.56)	7.00 (1.96)	6.31 (3.17)	4.64 (2.29)	6.54 (1.50)
Composite	60.91 (8.39)	59.45 (9.49)	61.71 (8.62)	68.64 (9.93)	68.38 (7.13)	66.78 (10.68)	61.55 (9.43)	63.90 (8.84)
SSO								
Positive	7.36 (1.63)	7.82 (1.25)	7.71 (1.58)	7.46 (1.31)	6.81 (2.17)	7.54 (1.19)	6.86 (1.80)	6.18 (2.12)
Negative	0.95 (0.91)	1.68 (1.23)	0.89 (1.21)	0.68 (0.79)	0.69 (0.72)	1.35 (0.99)	0.45 (0.65)	0.59 (0.92)
Low-Level	1.82 (1.08)	1.45 (0.93)	1.39 (0.92)	1.68 (0.75)	1.35 (0.80)	1.42 (0.81)	1.36 (0.84)	1.05 (0.82)
Total	10.14 (2.17)	10.95 (1.42)	9.86 (2.48)	9.68 (1.71)	8.85 (2.58)	10.31 (0.97)	8.68 (2.11)	7.72 (2.56)

HFA. Thus, it is possible that the children with LFA did not completely understand the concepts or directions in the games, and therefore, did not fully benefit from the intervention.

Second, after the intervention, the children with LFA and HFA demonstrated improvement in their ability to recognize emotions. More specifically, children with LFA improved in their ability to recognize emotions when provided with photographs, whereas children with HFA improved in emotion recognition when provided with photographs or drawings. As the computer games only included photographs of adults and children, it is interesting to note that children with HFA generalized their improved emotion recognition skills to schematics of faces. It is also interesting to note that both groups improved their skills to label the emotions even though the computer games never mention emotion labels.

These results support the findings from other studies that emotion recognition and facial recognition abilities can be improved in laboratory settings using computer based training (Goldsmith and LeBlanc 2004). However, a major question raised by the current study, in line with the main difficulty encountered in other intervention programs for this population, is whether children's improvements were transferred into the child's more global social competence with peers and family in real settings. Results of this study demonstrate that when students with LFA and HFA were provided with an opportunity to learn and practice specific social skills in FaceSay's controlled environment that simulated a natural setting, their social interactions improved in natural environments.

Children showed improvements in their social interactions with peers and family members. More specifically, the children with HFA demonstrated growth in their positive social interaction behaviors (e.g. more likely to share experiences or an object with a peer). For children with LFA, significant decreases in their negative behaviors were demonstrated following the intervention (e.g. the children were less likely to avoid social overtures made towards them by a peer). Their parents also reported an improvement in their ability to be more assertive (e.g. initiates more social activities with peers), to be more responsible (e.g. acknowledges compliments), and to have more self-control (e.g. cooperates with family members without being told to do so).

Previous research has highlighted the role of exposure to faces in the development of face processing and its underlying mechanisms (Gauthier et al. 2000). It is possible that children with ASD avoid looking at faces during a period through which typically developing children acquire face processing skills, thus, they do not acquire such skills at a typically developing pace. The lower levels of exposure to faces that children with ASD experience relative to other children may inhibit the acquisition and development of basic face processing mechanisms. The current study indicates that with increased exposure to faces and practice recognizing key features of faces, it is possible to enhance children with HFA's face processing skills.

Implications

The purpose of the current study was to examine the effects of a computer interactive intervention program on specific social skills of children who have ASD. This study indicates that practicing simulated activities on the computer enhances facial and emotion recognition abilities. The results provide support for the effectiveness of using a computer-based interactive simulation program as a vehicle for enhancing observed and reported social skills. These results are consistent with previous results on the effectiveness of computer-based interventions for children with ASD (e.g. Bernard-Optiz et al. 2001; Chen and Bernard-Optiz 1993; Panyan 1984; Yamamoto and Miya 1999).

One of the most important factors in the success of this study was that all participants who received the intervention easily adapted to the computer interactive program. They always wanted to go to work on the computer (although a few wanted to finish an activity first), and they typically participated in the games until the activities were terminated. Although not measured, anecdotal observations of the children who received the intervention indicated that the children with ASD enjoyed the programs. They frequently asked to play the games, and became upset if there was an interruption of the sessions due to field trips or holidays. The students also provided themselves with verbal praise such as "Good job" or prompted the experimenter to say "Good job." Also, observations of the participants indicate that some of the students increased their computer skills following the study. For example, one participant who previously had no experience with computers learned to navigate a mouse, turn the program on and off, and log off the computer. An objective measure of treatment acceptability for the computer based activity and a valid computer-skills measure would serve as useful collateral data in future studies.

FaceSay, a computer program with realistic avatar assistants, appears to be a promising strategy for teaching specific social skills for children with ASD. Multidisciplinary approaches, involving educational specialists, psychologists, software designers, as well as parents and their child with ASD, could be useful. Although real-life practice remains the most important part of social skills training, computer-based simulations might be a non-threatening starting point for individuals with ASD, contributing to the facilitation of better social and communicative competence.

Limitations

A few limitations to this study design are important to note. It is not clear how length of treatment is related to the effectiveness of FaceSay. While the present study implemented training for 6 weeks, fewer sessions may have been just as beneficial. Conversely, longer term treatment might impart more improvement than found in this investigation. This issue is important to clarify when resources are limited. Another question unaddressed by the present study is the duration of improvement. This study focused on short-term follow-up. It is not yet known whether these improvements continue as children mature. Are there continued gains 6 months and a year after cessation of the training program? Although the intention of this training model is to provide children with lifelong tools to assist the child, is this goal successfully attained? Do children continue to make gains after formal involvement ends?

In addition, this study did not attempt to directly compare the computer-based program with other treatment models. What is needed in future studies are head-to-head comparisons of different programs for treating ASD, in which variables such as number of hours of intervention and parent involvement are tightly controlled, while teaching models are varied (e.g. interactive computer-based teaching vs. two-dimensional computer-based training).

The measure of social skills interactions is also subject to a few methodological limitations. First, although the current study involved a social interaction observation to evaluate if the emotion and face recognition skills taught during the intervention resulted in improved social interactions with others, the children were evaluated during recess at school with familiar peers. Thus, it is difficult to say whether the social skills learned in the intervention generalize across other real settings and to unfamiliar age peers. Second, the items on the social skills observation rating scale did not address the frequency or duration of the social skills, but rather focused on the presence or absence of each skill during the 5-min period.

Finally, the groups of children with LFA and HFA were from a sample of children with developmental disabilities coming to a specialized school or after-school center, often because parents wanted the children to receive therapy, or because their problems were particularly challenging. In this sense, it seems likely that the sample may have included children who are more severely impaired than the general population of children with ASD. The outcomes of this study might therefore be limited in terms of generalizability to the population of individuals with ASD as a whole. Thus, there is a need to replicate the findings from this study with a different sample, and ideally, from a population-based sample, where more heterogeneity is likely to be found.

Future Research

The neurobiological basis for face processing difficulties in ASD has become a topic of recent interest (Sasson 2006). It remains unclear to what extent the abnormal processing of social and emotional information in individuals with ASD could be due to a dysfunction in the amygdala, the fusiform gyrus, a lack of developmentally appropriate experience with human faces, or a combination of these factors (Sasson 2006). The theory that amygdala pathology could contribute to some of the neuropsychological impairments in social and emotional processing seen in ASD (Baron-Cohen et al. 2002) is supported by the finding that individuals with damage to the amygdala also show abnormal emotional and social processing. In particular, several studies have found that the amygdala is important for recognition of certain emotions and that it is important for making complex social judgments from faces (Adolph et al. 1994). In addition, persons with an ASD have been found to have less activation of the fusiform gyrus, a face processing area of the cortex, when viewing novel faces (Schultz et al. 2000).

The results of the current study call for neuroimaging studies to examine possible changes in the functioning of brain areas (e.g. in the amygdala, fusiform gyrus, or pre-frontal cortex), and gaze tracking studies to objectively measure attention to the area around the eyes following the use of FaceSay. Such studies would throw light on whether the observed facial processing changes reported here are arising from changes in those neural regions that are typically recruited by the brain in typically developing individuals, or if they are due to compensatory strategies by other neural regions.

This investigation focused on facial and emotion recognition skills, as well as social interaction improvements in children using FaceSay. A number of additional outcome variables could be explored in future studies, including objective measures of eye gaze and child satisfaction to the games. Also, future research should clarify which variables predict most successful utilization of FaceSay. The current study found that children with LFA or HFA who had higher initial IQ and lower autism symptomology benefited most from the intervention. The effects of other child variables, such as visual spatial ability, and behavior problems, should also be explored. In addition, parent and family variables, such as stress and depression levels, and socio-economic status may predict treatment outcomes. Since services are, at least in most areas of the country, a limited resource available to only a subset of children, determination of who benefit most from the training model is critical. Future research should also investigate the generalization from computer-based programs that explore situations in the classroom, at home, and in the community. The use of such programs and the development of additional strategies could enhance our knowledge of instructional strategies for enhancing the social skills of children with ASD. Additional computer-based programs that enhance the social skills of children who have other developmental disabilities, such as Attention-Deficit/Hyperactivity Disorder, could also further our understanding and could provide additional opportunities to expand on understanding of theory of mind and impairments in social skills.

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