Training Autistic Children on Joint Attention Skills with a Robot

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Abstract. Children with Autism Spectrum Disorder have issues with the development of social skills and communication. One such skills is that of joint attention (JA). JA is the sharing of attention between two people in regards to an object. There are two mechanism of JA, initiating joint attention (IJA) and responding to joint attention (RJA). This article details an experiment wherein a social robot was used to train children with ASD on their JA skills. This experiment contained a robot training group and a control group. Both groups' JA skills were tested before and after training with the robot (or a waiting period for the control group). The groups did not significantly differ on their pre-tests scores for RJA or IJA. The training group had significant improvements in both their IJA and RJA scores, while the control group did not have significant improvements. However, the groups did not significantly differ on their post-test scores for either RJA or IJA.

Keywords: Autism spectrum disorder · Social robotics · Joint attention Skills training

1 Introduction

The DSM-5 describes autism spectrum disorder (ASD) as a range of disorders characterized by social deficits and communication difficulties, stereotyped or repetitive behaviors and interests, sensory issues, and in some cases, delayed cognitive development [1]. While there is no cure for ASD, when therapy is provided early on, symptoms can greatly be reduced and abilities can be increased. Prior research has focused on therapy geared towards language, communication, and social skills [2–4]. In this article the skill of joint attention (JA) will be investigated.

Joint attention is defined as the sharing of attention between a person (child), another person, and an object or event [5, 6]. There are two mechanisms for joint attention, one

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for initiation (IJA) and one for responding (RJA). IJA is a bid to direct someone's attention toward an object, an example is a child showing a toy to a parent [7]. RJA refers to a child responding to a bid for their attention, an example is a child turning their head and looking where their parent is pointing or looking [7]. Neurotypical children develop the skill of joint attention between the ages of 6 to 12 months [5, 8].

Research has suggested that joint attention is necessary for language development [2]. It is suggested that children develop language by attending to their parent as their parent says the name of an object and point to it, this pairing of the name with an object results in language acquisition. Since children with ASD are less likely than their peers to follow the gaze or pointing of their parents, these children may not develop language skills [2]. These issues along with a propensity to make less eye contact and initiatie less showing or pointing gestures can result in a lack of both communication and social skills [2, 5, 9]. However, it has been shown that early intervention can improve non-verbal communication skills which can lead to increases in language skills and social development [2, 3, 5]. In recent years social robots have become a novel therapy for children with ASD [10–12]. It has been suggested that children with ASD respond better to robots than human therapists due to the fact that robots have stable and predictable behavior, facial expressions, and voice.

The current experiment used a robot named "CuDDler" (A*Star) to improve the joint attention skills of children with ASD, this work was an expansion of prior work [13]. The current study consisted of testing a new larger group of children, additional sessions of training, and a control group (no robot training group). The current study was a pre-post test design, wherein the children's joint attention skills were measured via the abridged Early Social Communications Scale, ESCS [14] before and after robot training (or a waiting period for the control group). Based on the prior study [13], it was hypothesized that the robot training group would show improvements in RJA skills, but not IJA skills [13]. It was also hypothesized that the robot training group would show improvements in RJA skills, but that the control group would not.

2 Materials and Methods

2.1 Participants

Participants were recruited via the early intervention center THK EIPIC Centre (Singapore). Each group (training and control) contained 10 children, for a total of 20 children (Mean age 5.3, SD = 0.7). All of the children were male, and between the ages of 4 and 6. None of the children took medication and all of them were diagnosed with ASD. Furthermore, all of them were of Singaporean descent and spoke English. The THK EIPIC Centre also provided the AEPS scores of the children. These scores were provided for fine motor, gross motor, cognitive, adaptive, social communication, and social. The researcher did not collect these scores or intend to change them, they were merely a piece of information that the Centre provided. Although the researcher did compare the training and control group on these scores to see if either of the groups had significantly different abilities. This comparison showed that the groups were not significantly different.

2.2 Stimuli and Apparatus

An embodied robot (CuDDler, A*Star) was controlled by the experimenter via a computer interface (operating system: Windows 7) which interacted with a smartphone (Google Nexus 4) inside of the robot. The control system for CuDDler was programmed using android java and C++. Stimuli were presented with two BePhones (resolution: 640×480 and screen size: 136.6×70.6 mm) using android java. The screens were placed left and right of the robot with at a distance of 40 cm (11° of visual angle of participants). The screens were tilted approximately 45° relative to the robot, making it seem as if the robot was viewing the images.

There were ten stimuli which were colorful line drawings of various objects (star, apple, ball, candle, flower, hat, heart, ice cream, plane, sweet). These stimuli were presented in four different colors (red, blue, green or yellow). Each session consisted of 20 trials with all objects in all colors appearing once. In each trial the same object (e.g., heart) was presented on both phones, but the objects were of different color (e.g., left heart blue and right heart yellow).

The stimuli were fit to the center of the phone screens (136.6×70.6 mm) and covered 2° in height and approximately 3.5° in width of visual angle of participants. On each trial the robot randomly moved its head approximately 2.3° in visual angle of participants either left or right from the midline with equal probability. The participants were seated 200 cm from the robot.

A trial ran as such, 1. the robot looked straight ahead, 2. it turned its head and said, "Look a [object type]!", this could be any of the ten object types, 3. two similar objects appeared on the phone screens (only varying by color), 4. the robot asked, "What color is this?", 5. the child named the color verbally (e.g., yellow), 6. the robot moved its arms and head around while saying "good job", and finally, 7. the robot returned to its starting position.

2.3 Procedure

There were three phases in the experiment. During Phase 1, the pre-test, the children's' joint attention skills were measured via the Object Spectacle Task (1 x), the Gaze Following Task (2 x) and the Book Presentation Task (2 x) sections of the abridged Early Social Communications Scale, ESCS [14], this test lasted about ten minutes. During Phase 2 the children either did or did not receive robot training based on the group they were in. During Phase 3, the post-test, the children were assessed with the ESCS again.

The training group, who received joint attention training via the robot, first took part in a training session where they learned the task. Then over the next four weeks they attended two training sessions per week, this resulted in a total of eight sessions (each of which were ten minutes long). The control group, who did not received training via the robot, attended the same number of sessions (all ten minutes long), however, these children played with a teddy bear or other toys and never saw the robot.

3 Analysis

Scores for IJA and RJA were analyzed based on the guidelines of the ESCS by two separate researchers [9]. One of the researchers had conducted the study and the other researcher was naive and blind to the study. No participants were excluded from data analysis. Intraclass Correlation Coefficients were used to compare the researchers' scores on the IJA and RJA measures. The results are presented in the following format: average measures intraclass correlation (lower bound, upper bound). Pre-test IJA scores: 0.884 (0.706, 0.954), pre-test RJA scores: 0.853 (0.370, 0.952), post-test IJA scores: 0.862 (0.636, 0.946), and post-test RJA scores: 0.723 (0.305, 0.890). Before being submitted to the statistical tests the scores of the two researchers were averaged.

The IJA and the RJA scales were analyzed separately. The following tests were conducted: 1. an independent samples t-test was conducted on the pre-test scores for both the IJA and RJA, to see if the two groups differed before the experiment began; 2. a paired samples t-test comparing the pre-test and post-tests scores was conducted for the robot group and for the control group; and 3. an independent samples t-test was conducted comparing the post-test scores of the robot and the control groups on both scales (IJA and RJA).

4 Results

The groups did not significantly differ on their pre-test scores for either IJA or RJA. For the IJA the training group significantly differed from pretest to post-test, $t(9) = -3.11$, $p = 0.013$, pre-test ($M = 5.75$, $SD = 3.56$) and post-test ($M = 11.15$, $SD = 4.96$), see Fig. 1. For the RJA the training group significantly differed from pretest to post-test, $t(9) = -2.75$, $p = 0.023$, pre-test ($M = 159.17$, $SD = 49.14$) and post-test ($M = 197.92$, $SD = 6.59$) see Fig. 2. While the control group did not significantly improve for either IJA or RJA from pre-test to post-test. There were no group differences on the post-tests for either the IJA or RJA.

5 Discussion

The current study used a social robot "CuDDler" (A*Star) to train children with ASD on their joint attention skills. This study was an expansion of prior work done by [13]. This expansion consisted of testing a new larger group of children, additional sessions of training, and a control group (no robot training group). Based on the prior work by [13], it was hypothesized that the training group would have improvements in their RJA (responding to joint attention) skills, however it was not expected that the training group would improve on their IJA (initiating joint attention) skills.

The two groups (training and control) did not significantly differ on their pre-tests scores for either the RJA or the IJA. However, the training group had significant improvements in both their RJA and IJA scores from pre-test to post-test. Whereas, the control group did not have significant improvements in either their RJA or their IJA scores from pre-test to post-test. However, the two groups were not significantly

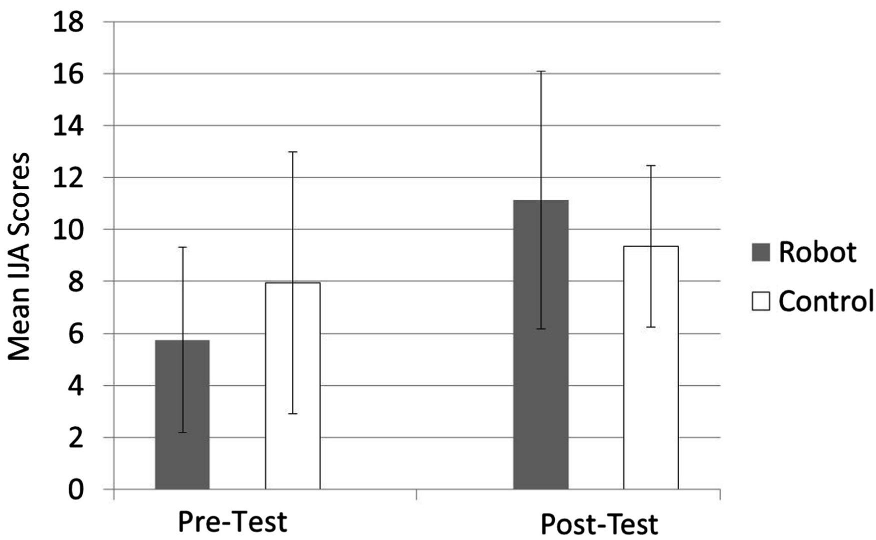

Fig. 1. Mean IJA scores with standard deviation bars for the robot training group (gray bars) and the control group (white bars). Pre-test scores on the left, post-test scores on the right.

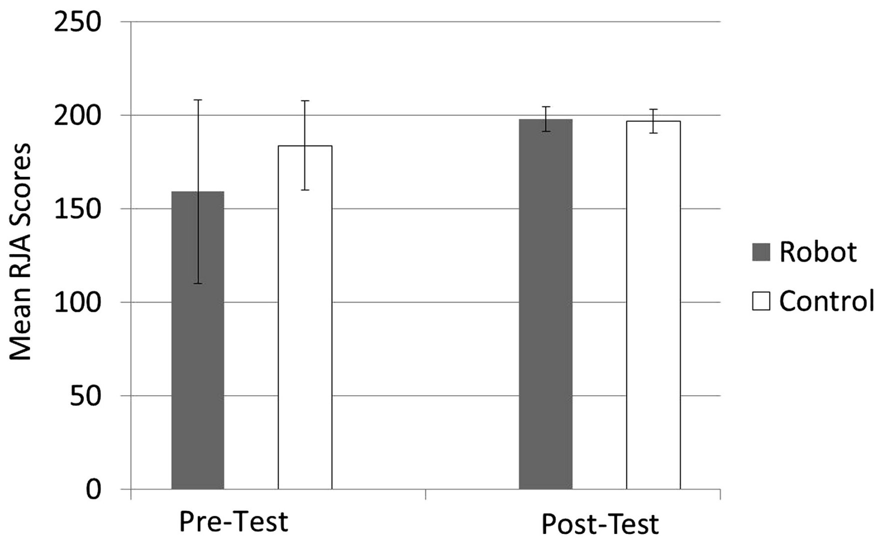

Fig. 2. Mean RJA scores with standard deviation bars for the robot training group (gray bars) and the control group (white bars). Pre-test scores on the left, post-test scores on the right.

different on the post-test scores for the RJA or the IJA. These results are contrary to [13] who only found improvements in RJA skills. However, it is suspected that the current study not only found improvements in RJA scores, but also IJA scores due to the increased sample size. Interestingly, although the groups did not have significantly different pre-test scores, and the training group showed significant improvements from pre-test to post-test on both RJA and IJA, the training and control group were not significantly different on their post-tests scores for either RJA or IJA. It is suspected that these results may be due to individual variances and the small sample size. However, it is important to note that two of the children who had great variation in their data, but showed improvement from the pre-test to the post-test had mild-to-moderate and moderate-to-severe ASD. Therefore, it may be that this type of therapy is more beneficial for those children who are in these functionality ranges.

In conclusion, while this study did show that a social robot can be used to improve the joint attention skills (both RJA and IJA) of children with ASD, the training groups scores did not surpass those of the control group. Therefore, one may wonder if this therapy is actually beneficial, however, the authors would argue that there is proof of improvement. Furthermore, it seems that this type of therapy might be the most beneficial for children with mild-to-moderate and moderate-to-severe ASD. It may be beneficial to repeat this study with only children who suffer from mild-to-moderate and moderate-to-severe ASD. Furthermore, it would be beneficial to increase the sample size of the study.

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