

SOCIAL ROBOTICS

Helping Children Socialize



Social robotics for Autism Therapy

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Indian Institute of
Science



Academy for Severe
Handicaps and Autism

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Abstract

While Autism Spectrum Disorder is on the rise, research on social robotics to help design interventions for ASD is low and inconsistent. Moreover, no such intervention in India is yet formalized and practiced. Our current work focuses on a small scale study to formulate an intervention to aid ASD communication and we show how the intervention helped the focused children in a short span of time.

1 Introduction

1.1 Autism Spectrum Disorder

Autism Spectrum Disorder, or ASD, is a developmental disorder that not only affects communication and interaction but also motor skills and co-ordination. Being a developmental disorder, its effects can be detected within two years of life. The disorder is called a *spectrum* because it manifests in various intensities among individuals and the severity and symptoms may vary from one individual to another.

The most common symptoms of ASD include deficits in social communication and social interaction, repetitive and restricted behaviors, functional limitations which further hinder their social assimilation [1].

1.2 Communication Challenges in ASD

Although the symptoms in ASD may vary, one common problem most individuals face is social communication and interaction. Few of the communication problems that are most commonly observed are:

- **Echolalia** : repetition of another person's spoken words. For instance, children with ASD in response to, "What is your name?" may reply by repeating the question instead of actually responding with their names [10].
- **Uneven Language Development** : Most children with ASD suffer from uneven Language Development. They either do not have language (non-verbal) but can read/write, or they may have language skills different from the normal level of ability. Some may face issues with sentence construction and others may have poor comprehension or reading skills [6].
- **Joint Attention** : Joint attention or shared attention is the shared focus of two individuals on an object. It is achieved when one individual alerts another to an object by means of eye-gazing, pointing or other verbal or

non-verbal indications. Children in ASD struggle in this area and hence find it difficult to establish social communication [5].

- **Turn Taking** : Turn-taking is a type of organization in conversation and discourse where participants speak one at a time in alternating turns. Children with ASD usually have narrowed focus and are unable to follow social cues of waiting and taking turns to speak [4].

For demonstration purpose, we recorded few communication interventions that are practiced in **ASHA** - *Academy for Severe Handicaps and Autism* in their classroom setting.

1.3 Social Robotics

The term *Social Robot* was first used by [7] to denote robots whose primary function was to perform some form of interaction with humans. The term was used to differentiate social interaction from the teleoperation function already present in human-robot interaction (HRI).

1.4 Social Robotics to aid communication in ASD

1 in 59 children in US are diagnosed with ASD according to *Centers for Disease Control and Prevention, USA*, and the numbers are rising at record rates every year. Even with such large population being affected, most of the intervention programs designed for ASD lack sufficient research to prove their efficacy [8]. One of the reasons for the above could be due to large heterogeneity in autism spectrum. To highlight this, a common adage in autism research used is:

If you have seen **one** child with autism, you have seen **one** child with autism.

One motivation for introducing technology in autism intervention programs is the affinity ASD children have towards structured and predictable environments [2, 3], and structure and consistency is intrinsic in robots. Moreover, with interventions designed with social-robots, human-intensive and repetitive therapies can be automated. This can be a boon in resource-challenged countries such as India. Studies on efficacy of use of robots as an aid in therapy to improve ASD symptoms have been both low and inconsistent [9]. In addition, there is no proper statistics available on ASD children in India.

Thus, the big question our research aims to answer is:

Can Social Robotics help in aiding social communication among ASD children?

2 Small Scale Study

2.1 Study Objectives

We conduct a small scale study with 6 children on ASD spectrum from one of the oldest special schools in Bangalore, **ASHA** - Academy for Severe Handicaps and Autism. This study had two primary objectives:

- Design interventions using a social robot that can help in ASD communication
- Identify whether the intervention bring any positive changes in the ASD children.

2.2 Interaction Modules with Social Robot

The Social Robot used in the experiment was Cozmo, a toy robot by the company Anki. The robot had its own SDK, camera and speaker which helped us to code the required modules.

4 intervention modules were finalized.

Talk to me module was designed where Cozmo asked self-introductory questions and the child was required to answer them. This helped address the social introduction problem in ASD children.

Story Time module was designed to address auditory comprehension. In this the SE read the story to the child and informed the child that Cozmo would ask questions related to the story.

Spell it out addressed auditory comprehension and recall. In this Cozmo asked the child to spell words from the story that was narrated to them above. The child could verbally answer or write the spelling on a writing pad and then pronounce.

Read with me was targeted at joint attention and turn-taking abilities. A script was given to child and Cozmo and the child read out alternate lines from the script. The child had to pay attention to what Cozmo reads out(Joint Attention), wait for their turn and read their line when Cozmo was done reading his own line.

3 Success Stories

After 7 sessions, we discussed with the teachers for any notable improvement in their children and we list them down below, as recorded from each child's special educators' notes.

3.1 Improvement in Self-Introduction

Participant 5(name withheld) was known to be verbal and had reading comprehension. But he struggled with responding in long-sentences. The **Talk to Me** session was specially beneficial to him as the teachers noted he **tried to respond to Cozmo in full sentences**. This was also noticed in quantitative evaluation, where the number of prompts reduced considerably within just 4 sessions.

3.2 Improvement in Repetition task - Spelling

Participant 1(name withheld), although verbal and capable of comprehension, struggled with repetitive tasks such as spelling. According to his teachers, it was difficult to reason with him and would avoid writing. But he responded very differently in **Spell it Out** session with Cozmo. He would **try to recall spellings**, even write them out if he failed **on receiving a negative feedback from Cozmo**. Although, making children write was not one of our experimental objectives, it was a happy by-product of the session which the teachers appreciated greatly

3.3 Improvement in Turn Taking

For Participant 4, English was not the language of choice. Still he followed through all the tasks in the session. The most remarkable improvement according to his SE was in the **Read with Me** session. He **would wait for the robot to finish his turn and then start reading his designated line**.

3.4 Improvement in English Responses

Participant 3 struggled with framing sentences in English. But he responded to robot in English despite it not being his language of choice The number of prompts from the teachers also reduced considerably over the sessions.

4 Conclusion

Although, special educators track their students progress on a regular basis based on their IEPs(Individual Education Program), the progress usually takes a long time. In this study, we were able to observe progress in **4 out of 7 children over only a period of 6 sessions**. This in itself, encourages us to believe that there is **sufficient potential in this mode of learning**.

In addition, we tried to measure very fine-grained progress in the communication challenges faced by these children, hence the experiment design was kept simple and user-friendly. We believe that if repeated over a larger set of ASD children,

we will be able to repeat our results and help majority of the children who participate in our study.

This study was focused on finding a **simple yet effective protocol to design a triadic intervention program for ASD communication**. Moving ahead, we can personalize or broaden the scope of addressable communication challenges to conduct a full-fledged research while also helping the ASD children overcome their social barriers.

5 Acknowledgments

We would like to thank ASHA for their undaunted support in helping us understand Autism, their diagnosis and intervention processes as well as conducting our experiments and lending their helping hands whenever needed.

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A Experiment Design Details

A.1 Testing the waters

Initially it was important to understand the ASD children's engagement with the robot to further execute our experiments. Towards this end, we conducted a session(with 7 children from ASHA, as selected by the special educators, to observe their reaction to the robot. The teachers introduced Cozmo the robot to the students, and 4 out of 7 children engaged with the robot in various capacities. The responsive children asked proactive questions to the robot like, "Come to my table robot!". These were the same kids who did not respond to greetings from strangers.

When Cozmo asked the students their names, the more verbal children responded without any prompts from their special educators. As the special educators narrated a story to the children, Cozmo asked a few questions based on the story and 3 out of 7 children responded to the questions.

This established two things for us. Firstly, the hypothesis that few ASD children respond to inanimate objects like robots more than they respond to strangers seemed to be true. Secondly, in a group setting, some children direct the flow of conversation and subdue others. For the latter reason, we went towards one-on-one sessions with the ASD children and their special educators.

A.2 Interaction Goals

The aim of encouraging the use of a social robot in autism therapy is to help the special educator in accelerating progress with a child with communication challenges. Using the robot as a motivator, we wanted to design interventions that establish a *triadic relationship* between the robot, the child and the special educator. The aim of the following experiment was to measure if there is any progress in identified social communication challenges of each child with the help of social robot aided interventions.

A.3 Interaction Strategies

The interventions designed with the social robot had to maintain a *triadic relationship* between the robot, the child and the special educator(henceforth referred to as SE). This relationship can be established in two forms:

- **Social robot as a co-instructor** :The SE moderates the intervention session, informing the child that the social robot will be an instructor in the lessons.

- **Social robot as a co-learner** : The SE establishes the social robot as a peer in learning.

From our conversations with the SEs in ASHA, we found that ASD children in the intervention programs respond well to encouragements or prompts navigating them through the session. Thus it was decided that the social the social robot would be providing positive and negative reinforcements (“Good Job” or “Let’s try again”) as and when the child performs said task successfully and unsuccessfully, respectively. These comments needed to be short keeping their comprehension skills in mind. Furthermore, comments needed to be varied enough so that echolalia is not encouraged. After few rounds of discussions with the SEs, speech therapists and our observations of the intervention programs in ASHA, we decide to design intervention around 4 areas:

- Greetings and Self-Introduction
- Story Comprehension and Recall
- Auditory Comprehension
- Encouraging full-sentence responses

A.4 Screening Criteria

As mentioned above, 6 children were selected for the experiment. The children were selected by the special educators and the program coordinator who is a subject matter expert in ASD intervention programs. All the children selected belonged to moderate to high functioning autism spectrum with varied level of reading and comprehension skills. All the children were verbal.

A.5 Data Collection Procedure

All the sessions conducted were observed in a fly-on-the-wall procedure, where the the observer in no way interferes with the session. The observer manually recorded the quantitative evaluation parameters for each session, such as number of prompts, etc.

For qualitative evaluation, each child’s special educator made a note of their progress on challenge areas.

A.6 Experimental Setup

The setup is shown in figure 1. The child is accompanied by his SE, and the robot, Cozmo, is in front of them. The experiment was carried out in Wizard-of-Oz style,

meaning the actions were manually controlled by the operator unbeknownst to the child.



Figure 1: Experimental Environment[Faces blurred owing to Privacy reasons]

A.7 Evaluation Criteria

We primarily wanted to understand whether there is any progress in the children's communication skills. Towards this end, few quantitative and few qualitative criteria were used to measure progress.

A.7.1 Quantitative Evaluation Criteria

- **Number of Prompts** : Prompts can be any verbal or non-verbal gesture made by the SE or the robot to illicit response from the child
- **Accuracy** : Ratio of correct responses to the total number of responses by the child
- **Reformulations** : Number of times SE modifies the original question asked by the robot to explain to the child
- **Initiations** : Number of times SE reveals part or whole of the ideal response to the child

- **Translations** : Number of times SE translates the robot’s question to the child’s language of choice.

A.7.2 Qualitative Evaluation Criteria

As previously established, each ASD child have their own unique set of challenges. This is reflected in their IEPs(Individual Educational Program). We consulted the SE of each child to identify any area where the child made progress and recorded SE’s inputs for the same.

A.8 Results

7 sessions were carried out with the 6 children with the 4 modules listed above. 1 session was carried out without the robot to check if children react differently. The results are shown in tables 2, 3, 4,5.

For the module Spell It Out, only 3 children out of the 7 participated based on their vocabulary levels. For the Read with Me module which was closer to free conversation than the rest of the modules, a remark column was added to denote individual activities which are not captured in other criteria.

Date	Student	#cozmo pro	#teacher pro	#incorrect an	#correct answers	reformulation	initiation	translation	strays from topic	#prompts	accuracy
NO COSMO		0	0	0	5	0	0	0	2	0	1
12-July		0	0	0	5	0	0	0	0	0	1
16-July		0	0	0	5	0	0	0	0	0	1
18-july		0	1	0	5	0	1	0	0	2	1
24-July		0	0	1	5	0	0	0	0	0	0.8333333333333333
NO COSMO		0	12	2	5	2	1	1	1	16	0.714285714285714
12-July		3	7	2	5	0	4	0	1	14	0.714285714285714
NO COSMO		0	8	2	5	0	0	4	0	12	0.714285714285714
12-July		3	2	2	5	0	0	5	0	10	0.714285714285714
16-July		1	0	1	5	0	1	1	0	3	0.8333333333333333
18-july		3	1	3	5	0	2	0	0	6	0.625
NO COSMO		0	9	2	5	6	0	0	0	15	0.714285714285714
16-July		1	3	1	5	0	0	1	0	5	0.8333333333333333
18-july		2	1	4	5	0	0	0	0	3	0.5555555555555556
24-July		0	1	1	5	0	0	0	0	1	0.8333333333333333
NO COSMO		0	12	2	3	0	0	1	0	13	0.6
12-July		1	1	0	1	0	0	0	0	2	1
16-July		1	3	4	4	0	0	2	0	6	0.5
18-july		3	2	3	4	0	0	0	0	5	0.571428571428571
24-July		1	1	1	5	0	0	1	0	3	0.8333333333333333
NO COSMO		0	4	0	5	1	0	1	0	6	1
16-July		1	0	0	5	0	0	0	0	1	1
18-july		0	1	1	5	0	0	0	0	1	0.8333333333333333
24-July		1	0	1	5	0	0	0	0	1	0.8333333333333333

Figure 2: Results of Talk to Me with different Children

A.9 Insights

The tables 2, 3, 4 have been color coded as follows: green if the improvement is drastic, yellow if no significant improvement and red for no effect on performance.

Date	Student	#cozmo prompts	#teacher prompts	#incorrect answers	#correct answers	reformulation	initiation	translation	strays from topic	#prompts	#correct answers	total answers
NO COSMO		0	2	0	7	1	0	0	0	3		1
12-July		0	0	0	7	0	0	0	0	0		1
16-July		0	0	0	7	0	0	0	0	0		1
18-July		0	0	0	7	1	0	0	0	1		1
24-July		0	0	0	7	0	0	0	0	0		1
NO COSMO		0	10	2	7	0	7	6	0	23	0.7777777777777778	1
12-July		1	7	0	7	0	1	0	0	9		1
NO COSMO		0	12	1	6	3	3	4	0	22	0.8571428571428571	1
12-July		2	3	3	7	0	2	4	1	11		0.7
16-July		0	4	2	7	0	0	2	0	6	0.7777777777777778	1
18-July		1	3	0	5	1	3	0	0	8		1
NO COSMO		0	5	2	5	3	1	0	0	9	0.7142857142857143	1
16-July		3	2	3	7	0	1	2	0	8		0.7
18-July		3	3	2	7	0	3	0	0	9	0.7777777777777778	1
24-July		1	1	2	7	0	0	0	0	2	0.7777777777777778	1
NO COSMO		0	12	2	6	0	0	4	0	16	0.75	1
16-July		1	3	1	7	0	1	2	0	7		0.875
18-July		1	2	1	7	0	0	3	0	6		0.875
24-July		0	3	1	7	1	0	0	0	4		0.875
NO COSMO		0	8	2	6	4	3	6	0	21	0.75	1
16-July		4	2	2	7	1	0	2	0	9	0.7777777777777778	1
18-July		2	1	1	7	0	0	0	0	3		0.875
24-July		1	2	1	7	0	0	0	0	3		0.875

Figure 3: Results of Story Time with different Children

Date	Student	#cozmo prompts	#teacher prompts	#incorrect answers	#correct answers	reformulation	initiation	translation	strays from topic	#prompts	#correct answers	total answers
12-July		3	3	1	5	0	1	0	0	7	0.8333333333333333	1
16-July		1	1	1	5	0	3	0	0	5	0.8333333333333333	1
18-July		0	4	0	5	1	6	0	0	11		1
24-July		2	1	2	4	0	0	0	2	3	0.6666666666666667	1
16-July		0	3	0	4	0	3	1	0	7		1
18-July		0	6	1	5	0	5	0	1	11	0.8333333333333333	1
24-July		0	2	0	5	0	2	0	0	4		1
16-July		0	4	1	4	0	0	0	0	4		0.8
18-July		1	1	0	5	0	0	1	0	3		1
24-July		1	2	1	4	0	0	0	0	3		0.8

Figure 4: Results of Spell it Out with different Children

As we see, Talk to Me module, record progress for 4 out of 6 children in either prompts(reduced) or accuracy(improved) or both. Story Time module indicated progress for 5 of the 6 children. Spell It Out module brings progress in 2 out 3 children. For Read with Me module, the number of prompts did not change significantly, so we used SE's qualitative evaluation to indicate progress, if any.

Date	Student	#cozmo pron	#teacher pro	initiation	translation	strays from topic	Remarks
12-July	[blurred]	0	1	0	0	0	
16-July	[blurred]	0	0	0	0	0	
18-july	[blurred]	0	0	0	0	2	
24-July	[blurred]	0	0	0	0	0	
12-July	[blurred]						entire passage was prompted
12-July	[blurred]	0	4	0	2	2	
16-July	[blurred]	0	2	0	1	0	unfinished session
18-july	[blurred]	0	7	6	0	3	
16-July	[blurred]	0	1	3	0	0	
18-july	[blurred]	0	3	1	0	0	
24-July	[blurred]	0	0	1	0	0	
12-July	[blurred]	0	4	0	1	0	
16-July	[blurred]	0	2	0	0	0	
18-july	[blurred]	0	1	0	0	0	
24-July	[blurred]	0	0	0	0	0	able to pronounce full words more
16-July	[blurred]	0	1	0	0	0	
18-july	[blurred]	0	0	0	0	0	prounounces rainbow in local language
24-July	[blurred]	0	0	0	0	0	

Figure 5: Results of Read with me with different Children