The Use of RoboParrot in the Therapy of Children with Autism Children: In Case of Teaching the Turn-Taking Skills

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Abstract. In recent years, robots have been used in many therapy applications for children with autism spectrum disorder. This paper presents the use of a parrot-like robot as an intervention tool for turn-taking therapy. A verbal turn-taking game, between a child with autism and a partner which can be the robot or a therapist, is designed and implemented. The intervention was conducted in a single subject study format and the effect sizes for different turn-taking variables are calculated. The effectiveness of the robot in the turn-taking therapy, from the therapist's point of view, is evaluated using a questionnaire. The results show that, the child-robot interaction had larger effect sizes than the child-trainer effect sizes in most of the turn-taking variables. Also the feedback by the therapist suggests that the robot is appealing to children. It is also suggested to add other functionalities to improve its interaction with children.

Keywords: Human-Robot Interaction; Autism spectrum disorder; Turn-taking therapy; Child-robot interaction;

1 Introduction

Nowadays, Robot-Assisted Therapy (RAT) is one of the main utilizations of social robots that is used for children with developmental disorders such as Autism Spectrum Disorder (ASD) [1, 2]. Individuals with ASD are characterized by deficits in communication and social skills to restricted or repetitive behaviors, such as language, imitation, social behaviors, and flapping respectively [3]. There are many researches demonstrated that robots are attractive to kids with autism. Thus, robots are used for therapies such as improving turn-taking, concentration skills [4, 5], imitative game playing [6], and social behavior [7]. To teach imitation skills, Zheng et al. [8] used a robotic system

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with real-time performance evaluation and feedback. Their result showed that the robotic system was more engaging than a human therapist for children with ASD and had relatively better performance. Robota [9] is a tele-operated humanoid robotic doll that is used to improve social interaction of children with autism. Also children with ASD showed less autistic behavior in presence of Nao, a humanoid robot, than in presence of their teacher in a class session [10]. Probo is a huggable robot that is used as a story teller in a few researches [11]. The results show that the social behaviors of children with autism better improved when Probo told a story compared to a human [11].

The above studies show the potential of using robots in autism therapy and that is why we have conducted this study by using a parrot-like robot (Fig. 1) for turn-taking therapy. The reasons for selecting a parrot model are parrots' appearance and their ability to speak that make them a lovely pet for people and can be useful for encouraging children with autism to speak. The reason for selecting turn-taking therapy is its importance for success in different social situations, such as in dialogue with other people. Also it is very time consuming and exhausting task for speech therapists and for children. Finally, the long lasting turn-taking therapies impose extra charges on the families of children with autism.

Fig. 1. The RoboParrot

To teach turn-taking, we designed a turn-taking game as the therapy scenario between a child and a partner (the robot or a trainer). The game contains three category of things, i.e. fruits, animals, and body parts to be named by the child or his/her partner. Two variables, i.e. turn-taking and turn-telling, were determined to be evaluated during the therapy sessions. Turn-taking is referred to the behavior in which the child acts upon his/her turn. Turn-telling is referred to the behavior in which the child determines whose turn it is, i.e. he/she answers the "whose turn is it?" question. The descriptions of sub-variables of the above two variables are:

- **Non-Directed turn-taking (ND):** The subject performed turn-taking without any help from others.
- **Directed turn-taking:** the subject performed turn-taking with help from others which can be done verbally, i.e. Verbally Directed (VD) turn-taking, or by physically pointing to the person whose turn it is, i.e. physically Directed turn-taking (PD).
- **False Answer (FA):** the subject could not correctly determine the turn, i.e. tell the turn, at a given instance.
- **Correct Answer (CA):** the subject could correctly determine, i.e. tell the turn, the person whose turn is at a given instance.
- **Correct Answer Directed (CAD):** the subject needed guidance to correctly determine, i.e. tell the turn, the turn at a given instance.

Based on these two variables, i.e. turn-taking and turn-telling, and an interview form provided for therapists, we assessed the child-robot and child-trainer sessions. The results were divided in two parts: Qualitative results which contain effect sizes' comparisons and quantitative results which contain interview forms evaluation and overall observations performed by evaluating the sessions' recorded videos.

2 Method

The robot: RoboParrot is a parrot-like robot based on a toy from Hasbro toy company[1] with newly designed and customized controller board and sensors. It has 2 motors: a motor is used for movement of eyes and beak and the other motor for moving body, head, and wings. The robot can detect when its beak is touched and shows random movement or voice in response. Also the robot has a list of recorded words and sentences for basic interactions, such as "Hello" and "How are you?", and for playing the turn-taking game, which includes the name of fruits and animals. A camera is used for recording training sessions for later evaluation. The robot is semi-autonomous such that an operator controls the robot remotely. In order to attract children, several features, such as funny laughing and a parrot coo voice, are implemented [12, 13].

Participants. The subject was selected from a pool of 28 children with ASD who were diagnosed by two experts, a psychologist and a psychiatrist, in two different temporal situation and location based on DSM-IV-TR. The selected subject was one of the 19 children, out of the 28 children, who did not show turn-taking ability in a card-based turn-taking test. The subject could interact verbally and could be placed among children with medium autism severity, based on GARS scale.

Experimental design. A single subject study using cross treatments, cross variables, and AB design was used to assess the effectiveness of the current training program. The

[1] http://www.hasbro.com

cross treatment consisted of two distinct treatments, i.e. treatment by a trainer and treatment by the robot. The cross variables included two variables, i.e. the number of successful turn-takings and the number of successful turn-telling. An AB design contains two phases, i.e. a baseline ("A" phase) with no intervention, and an intervention ("B") phase.

Procedure. In order to get better understanding of the reaction of the children to the use of robot in the turn-taking therapy, we tested it on 28 children with ASD. In the first test, the children had to name a set of cards alternatively with the robot. The cards consisted of pictures of fruits, animals, and body parts. Based on the children's competency in correctly naming the cards, they were grouped into basic, with 3 children in it from whom only one completed the therapy, and advanced groups. Then the turn-taking intervention was performed on the basic group.

Baseline (A). Before entering the intervention phase, we conducted a warm up session in which the child got familiar with the robot and could interact with it. Then, during the baseline sessions, we showed the pictorial cards to the child and asked him to name them in turn with the therapist/robot. If the child could not name the cards in turn, then the trainer verbally (VD) or physically directed (PD) the subject to his turn. In the turn-telling sessions, the same approach was used to determine the base lines.

Intervention (B). We designed intervention sessions such that each one lasted, at least, 6 minutes (3-4 min child-trainer; 3-4 min child-robot). We investigated turn-taking variables in 15 sessions and turn-telling variables in 11 sessions. The therapy was performed once or twice a week in which the order of child-robot and child-trainer was changed in each session. For example, if a session was started with child-robot training the next session was started with child-trainer training.

In the baseline sessions, the trainer explained the scenario, either the child-robot or the child-trainer approach, to the child. Then the trainer or the robot named the card and then asked the child to name it. If the child was not successful following the scenario, even with verbal direction, the therapist physically directed him using physically directed approach by pointing to him or to the robot/trainer to show him the turn.

Tools. Our instrument was an open-ended questions interview, containing 6 questions. The content of interview consisted of questions regarding the efficacy of the child-robot turn-taking therapy.

Analysis method. We chose a mixed method approach to understand the efficacy of the child-robot turn-taking therapy.

Quantitative analysis. The quantitative analysis consisted of descriptive findings and inferential results. The descriptive findings include the frequency ratios for all sessions' data and mean and standard deviation for baselines and intervention sessions, distinctly.

Qualitative analysis. These findings were extracted from the interview form and session video recordings. The video recordings were evaluated to determine the changes in the number of interactions during therapy sessions. The interview results are used to gather the trainer's feedback and evaluation on using the robot for turn-taking therapy.

3 Results

Quantitative results. The descriptive results for the two variables (turn-taking and turn-telling) are displayed in Fig. 2 and Fig. 3. All raw data were turned into frequency ratio. To start turn-taking training we had two baseline sessions followed by 15 intervention sessions. Since the subject did not have turn-telling at all, the baseline sessions started on the 5^{th} and 6^{th} sessions of the study. The Standardized Mean Difference (SMD) Effect sizes for the turn-taking and turn-telling sub-variables are presented in table 1.

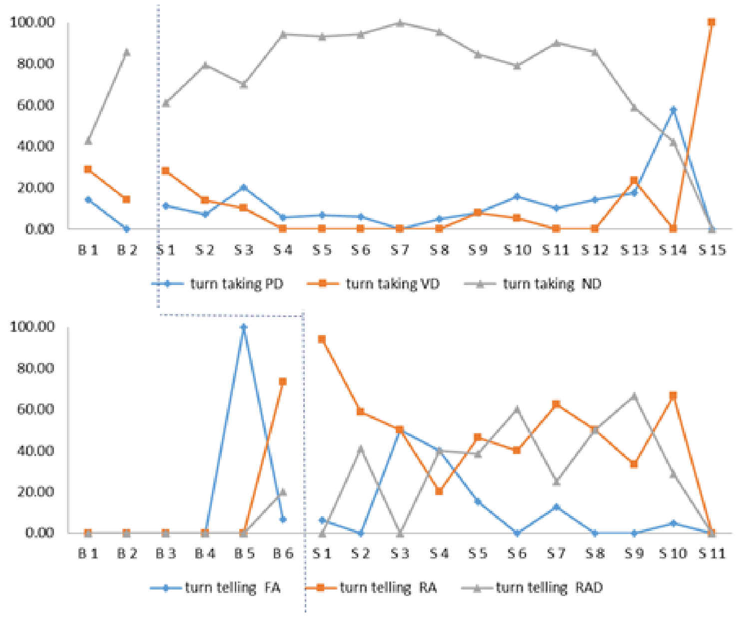

Fig. 2. The change in the turn-taking and turn-telling indices in the child-trainer sessions. The vertical axes show the percentage in each session and the horizontal axes show the session indices

In the child-robot-training sessions PD and ND sub-variables have increased while VD index has decreased. In the turn-telling category, FA has decreased while RA and RAD have increased. The effect sizes of sub-variables can be used to rank them based on their importance in the turn-taking and turn-telling interventions (Table 1).

By comparing the child-trainer-sessions to the child-robot ones, it can be realized that the child-robot intervention sessions have been more effective. In other words, a comparison between the base-line and intervention sessions shows that most of the sub-variables, in particular VD, ND, and RA, have improved. Indeed, these increases are much more in child-robot sessions compared to child-therapist sessions.

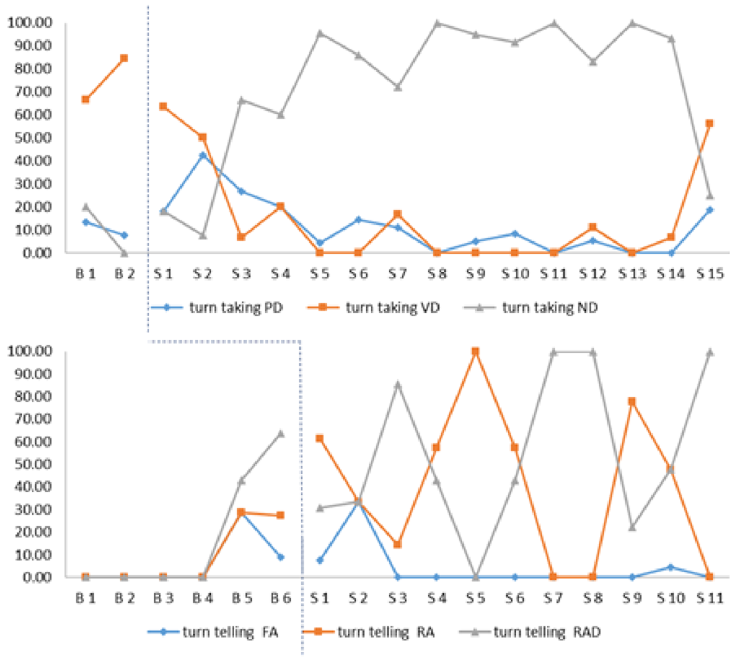

Fig. 3. The change in the turn-taking and turn-telling indices in the child-robot sessions. The vertical axes show the percentage in each session and the horizontal axes show the turn taking index.

As it can be seen from the data, visualized in Fig. 2 and Fig. 3, the child progress is not a stable one. This is due to the fact that the child was inattentive and distracted once in a while which necessitates further study on the same child or a bigger pool of subjects.

Table 1. SMD values for both of the two scenarios (Child-robot and Child-trainer)

	Child-robot sessions				Child-trainer sessions		
Turn taking	PD	VD	ND	**Turn taking**	PD	VD	ND
	0.28	4.74	4.45		0.5	0.88	0.35
Turn telling	FA	RA	RAD	**Turn telling**	FA	RA	RAD
	0.18	1.71	0.37		0.33	0.73	3.05

Effect size analyses: In the child-trainer-sessions, the biggest effect sizes are related to VD, RA, and PD respectively. That means the child-trainer sessions further influenced on reduction of verbally directed turn-taking. Furthermore, the rise in RA could be the direct result of the training. In fact, after a child-trainer session, it is expected to need less verbally directed training by the trainer since the subject should have learned turn-taking. In contrast, the increase in PD could be due to the help needed in more difficult or new situations. It could also be based on the fact that the child needs more than verbal direction when he was distracted in the given task.

In the cases of child-robot-sessions, the biggest effect sizes are related to VD, ND, RA, and DC respectively. That means the child-robot sessions further influenced on reduction of VD which matches our expectation. Furthermore, the increase in ND and RA is also expected since the training is supposed to help the child to take turn without direction, i.e. ND case, or answer the "whose turn is it?" correctly, i.e. RA case.

Qualitative results. The feedback from the therapist suggests that the robot is a good therapy support system. It may also be used at home by parents who are educated enough to use such a piece of technology. The session videos were evaluated by an expert who found that the robot is a very good motivating media. Furthermore, it was obvious that the child was more encouraged and involved in the therapy sessions when the robot in involved.

4 Conclusion and Future Work

In this paper we presented the effect of using RoboParrot in training of children with autism in order to determine the differences between training with the robot and training with a therapist. We designed a simple turn-taking game between a child and a partner to investigate how children with ASD interact with the robot. We compared the variables that can describe the quality of this turn-taking game between the child-trainer and child-robot scenarios. We used a questionnaire to evaluate the effectiveness of the robot from therapists' point of view. The results show improvement in both child-robot and child-trainer therapies but SMD effect sizes were larger in most of the sub-variables in the child-robot therapy than the child-trainer therapy. The questionnaire's results showed the advantages of using the robot.

The study showed that the child collaborated more in child-robot sessions compared to child-trainer sessions. In other words, there were times that the child was distracted and non-cooperative with the therapists. However, he was cooperative when the robot got involved in the therapy. It showed that the robot is a good encouraging media, for children with autism, in therapy sessions.

In the future, we need to further test this approach on more children since our study was limited to one child. This was because out of three originally selected children two quitted the therapy at the middle due to family relocation. Also, having more samples would help us to get better insight about using robots in therapy sessions. Furthermore, we need to check the effect of the therapy in real world situation such as answering phone calls or participating in real world conversations.

Also, we plan to add variety of games and activities in order to increase children's ability to generalize turn-taking skill. Also we are in the process of adding extra functionalities to the robot for extending the attractiveness of the robot. Finally, although we did not see habituation of the robot in the therapy sessions, however, further study is needed to evaluate the habituation effect.

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