



## The Effect of Robotic Intervention on the Imitation Skills of a Child with Autism

Tracey Dryden<sup>1</sup>, Pedro Encarnação<sup>2</sup>, Joanne Volden<sup>1</sup>, Kim Adams<sup>1,3</sup>, Al Cook<sup>1</sup>

<sup>1</sup>University of Alberta, Edmonton, Alberta, Canada

<sup>2</sup>Faculty of Engineering, Catholic University of Portugal, Sintra, Portugal

<sup>3</sup>Glenrose Rehabilitation Hospital, Edmonton, Alberta, Canada

**Abstract** Children learn many skills through imitation. An important example is the development of language, where imitation of social and communicative behaviors plays a critical role. It is widely reported in the literature that children with autism have an imitation deficit. This paper presents a study on the effect of robotic versus human intervention on the imitation skills of a child with autism. Through a single-subject alternating treatment design, a first step towards answering the question whether a child with autism better imitates a human or a plain robot model is given. Results of this experiment show that the child behaves differently with the human and the robot models, being more tolerant with the latter. The results are discussed in relation to different types of imitation skills, namely mimicry, goal emulation, emulation learning, and imitation.

### Background

The relative failure to imitate others' actions is an early-appearing feature of autism [1]. It may signal the failure of fundamental mechanisms that are necessary for a range of social-communicative functions [2]. The inability to imitate influences the acquisition of other adaptive skills, which consequently must be explicitly taught [2]. Toth, Munson, Meltzoff, & Dawson [3] assessed functional and symbolic toy play skills with 60 three and four year old children with autism spectrum disorder (ASD). They found that joint attention and imitation are important “starter set” skills that set the stage for social and communicative exchanges in which language can develop. Children with autism with better toy play and imitation abilities at age 4 acquired communication skills at a faster rate than those with less developed abilities.

Robotic intervention may be beneficial for children with autism because robots are more predictable and present simpler stimuli (e.g., facial expressions) than human models [4]. Imitation in autism has been examined using robots with mixed results. In one study, children with severe autism preferred to interact with a plain, featureless robot rather than a more humanlike one [5] while in other studies, human-like robots were shown to be favored [6, 4]. Billard, Robins, Nadel & Dautenhahn [5] also report that children with autism aged 7 to 9 are able

to spontaneously imitate simple as well as complex and novel sets of coordinated robotic actions.

### **Study Objective**

The study's objective was to compare the effect of a robot model and a human model on the imitative ability of a child with autism.

### **Procedures**

A single-subject alternating treatment design was used. After approval was obtained from a health research ethics board, a 5-year-old boy diagnosed with ASD as determined by the Autism Diagnostic Observation Schedule (ADOS) was recruited. He also had severe developmental delays established by standardized measures. Using the Multidimensional Imitation Assessment (MIA) baseline imitation skills including pretend play with objects were scored 0 (no response).

A Rhino Robotics Inc XR-4(TM) robot was programmed in this study for a pick-and-place task. The participant and his mother were seated on one side of the table, facing the robot or human. Separate mats representing a forest scene were placed beside the model and the participant. The model (human or robot, depending on treatment condition) picked up an animal and moved it to their own mat. During the first baseline session, the participant was verbally instructed to help bring the animals to the forest (his mat). There were 4 sets of 5 trials with the human model in the baseline phase. The robot was randomly selected for the first set of trials in the treatment phase. There were 2-3 video taped sessions per week for 4 weeks. The participant completed 20 trials in each session (two sets of 5 trials with each of the human and robot).

### **Results**

For purposes of analysis, the task was broken into three components: (a) pick up animal; (b) move animal; (c) put animal down. Each component was scored as completed or not. The percentage of times that the participant did all three steps ("success") for each set of trials was graphed. The success rate with the human model decreased from 33.33% to 0% during the baseline sessions, and stayed at 0% during the treatment phase. Success rates with the robotic arm model varied from 0% to 60% with the majority of the errors on step three, placing the animal on the correct mat.

During session 19 the task was changed so that the robot placed the animal on the participant's mat. On all but the last trial, the participant placed the animal on his mat rather than the opposite one as the robot model did. During the subsequent human model trials in the task shift the participant correctly placed the animal on the model's mat for all trials.

The participant's mother reported that he used at least one word that he had never used prior to the study.

## Discussion

Past studies investigating social learning with children have typically not distinguished between imitation, mimicry and emulation [7].

**Mimicry** is the replication of a model's actions in the absence of any insight into why the action occurs or what goal is served [7]. There is no data in this study to support mimicry. The participant did not precisely replicate the models' actions (e.g., when the robot arm paused between picking and placing the animal). During the task shift the participant placed the animal on his mat rather than exactly copying the model and placing it on the opposite mat.

In **goal emulation**, the observer uses her own means to achieve a goal [7]. It is unclear whether goal emulation occurred in this study. When the participant tried to hand the animal to someone he may have thought the goal was to give the human an object as he does in his Picture Exchange Communication System (PECS) training and his home programming that required him to hand the interventionist the correct item. During the task shift, he initially placed the animal on his own mat, failing to achieve the same goal as the robot. In later trials, he crossed the table to place the animal, like the robot model.

In **emulation learning** observers learn about the properties and relationships of objects and often adopt their own strategies [7]. It is important to assess the child's pre-existing knowledge of the task used in the study [7]. In this study emulation learning requires understanding that the objects are animals that belong in the forest. It was assumed that the participant had no previous exposure to the animals or props used and he appeared to understand that the animals belonged in the forest. The present study used a simple meaningful action upon an object making it difficult to interpret the results since emulation learning is a potential explanation for a task involving objects [7]. Most imitation studies use only one or two demonstrations to avoid problem solving and emulation [8]. Since this study had 140 trials across seven sessions it is probable that it addressed the learning of an activity rather than imitation.

**Imitation** involves the recognition and reproduction of the goal, and the specific actions that brought it about [7]. The participant consistently picked and placed the animal on the opposite mat from that used by the model. This reversal error supports the hypothesis that the imitative deficit in ASD is a problem in self-other mapping [1]. Ohta [9] refers to this as "partial imitation," since the basic components of the imitation are correct, but the participant seems unable to alter the perspective accordingly.

The task shift in session 19 may support true imitation. When the robot first placed the animal on the participant's mat, the participant placed the animals on his own mat. This was the opposite of previous trials when he placed the animals on the model's mat. The participant performed the action at the same location as

the model supporting location enhancement [7]. On the last robot task shift trial the participant placed the animal on the robot's mat and retained this frame of reference with the human model. However, it is unclear whether the participant imitated changing the frame of reference or whether he emulated the movement and was initially confused by the change in task. Hence, there is insufficient support for the notion of self-other mapping here.

In studies of robots used with children, it is important to consider the robot's mechanical limitations (e.g., speech output). As the XR-4 robot did not speak, the present study did not provide explicit prompting from the robot.

### **Conclusions and Recommendations**

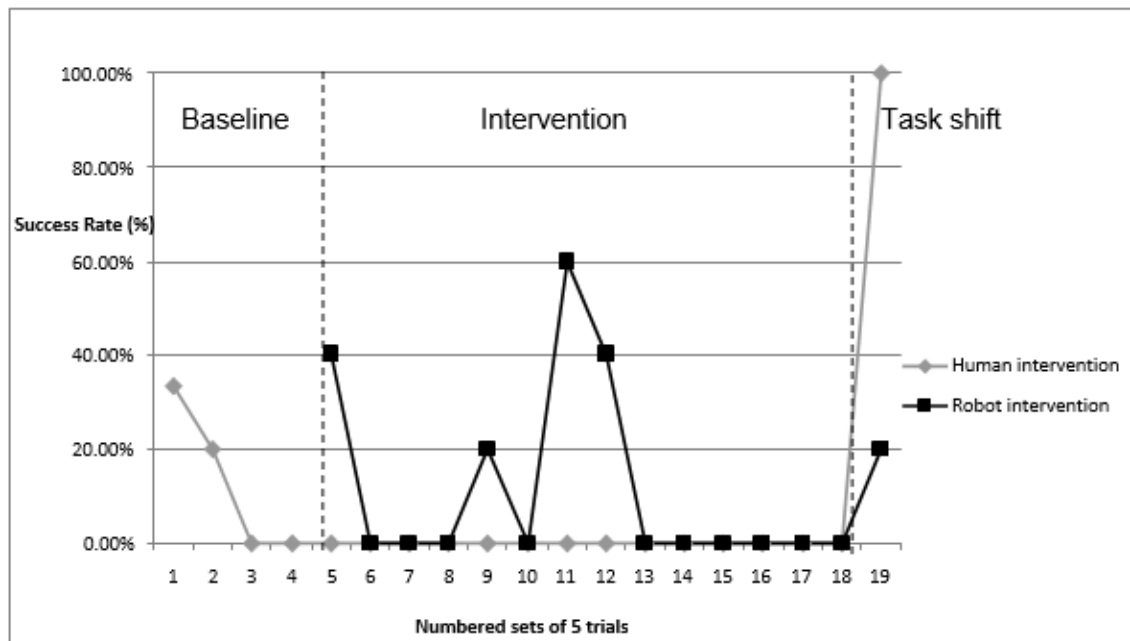
This study demonstrated the ability of robotic models to engage participants with autism. Irrelevant actions (i.e. not related to goals) are used to separate emulation and imitation where children only emulate those related to the goal [7]. Imitation of non-meaningful gestures (e.g., clapping the hands behind the head) are generally more difficult for individuals with autism compared to imitation of actions upon objects [1]. In this study, a simple goal oriented task that could be completed with little imitative ability was used, failing to distinguish between the types of learning. Based on the simplicity of the task and the limited expressive language of the participant, it is impossible to conclude with certainty whether he was emulating or imitating the human and robotic models. Future studies should employ a simple non-goal gesture task. Other interesting results from this study are that the participant's "exchange response pattern" was broken, and he used at least one word that he had never used prior to the study.

### **References**

- [1] Williams J.H.G.,Whiten, A. & Singh, T. (2004). *Journal of Autism and Developmental Disorders*, 34(3), 285-299.
- [2] Smith, I.M., & Bryson, S. (2007). *Cognitive Neuropsychology*, 24(7), 679-700.
- [3] Toth, K., Munson, J., Meltzoff, A.N., & Dawson, G. (2006). *Journal of Autism and Developmental Disorders*, 36, 993-1005.
- [4] Duquette, A., Michaud, F., & Mercier, H. (2008). *Auton Robot*, 24, 147-157.
- [5] Billard, A., Robins, B., Nadel, J. & Dautenhahn, K. (2007). *Assistive Technology*, 19, 37-49.
- [6] Massaro, D.W., & Bosseler, A. (2006). *SAGE Publications and the National Autistic Society*, 10(5), 495-510.

- [7] Want, S.C., & Harris, P.L. (2002). *Developmental Science*, 5(1), 1-13.
- [8] Smith, I.M., Lowe-Pearce, C., & Nichols, S.L. (2006). In S.J. Rogers & J.H.G. Williams (Eds.), *Imitation and the social mind: Autism and typical development* (pp. 377-398). New York: Guilford Press.
- [9] Ohta, M. (1987). In J.H.G. Williams, A. Whiten & T. Singh (2004). A systematic review of an action imitation in autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 34(3), 285-299

Rhino Robotics [http://www.rhinorobotics.com/xr4\\_flyer.html](http://www.rhinorobotics.com/xr4_flyer.html)



**Fig. 1.** Percentage of successful imitation per set of 5 discrete trials. Successful imitation is defined as complete imitation whereby the participant picked up the animal and subsequently placed it on his own mat (with the exception of task shift trials).