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How can robots facilitate social interaction of children with autism?: Possible implications for educational environments

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Abstract

Children with autism have difficulties in social interaction with other people and much attention in recent years has been directed to robots as therapy tools. We studied the social interaction between children with autism and robots longitudinally to observe developmental changes in their performance. We observed children at a special school for six months and analyzed their performance with robots. The results showed that two children adapted to the experimental situations and developed interaction with the robots. This suggests that they changed their interaction with the robots from an object-like one into an agent-like one.

1. Introduction

Children with autism have difficulties regulating themselves in interpersonal situations and in establishing social interaction with other people. Robots are expected to be effective therapy tools for them, because they are both social agents and inanimate objects that are safe and relaxing. The robotic platform as a therapy for children with autism has been investigated in recent years, and several reports have shown that the children were able to enjoy the interaction with robots and use them as a social mediator to other persons (I.Werry, 2001)(B.Robins, 2004). However, very little information has been obtained concerning developmental changes in the relationship between children and robots. In this research, we investigated how robots facilitate and develop social interaction with autistic children longitudinally. Especially, we focused on their persistence in fixed patterns of actions that are usually restrained by teachers and parents. We think that these patterns could be used to bring out and hold the interest of autistic children in robots.

2. Methods

Trial sessions took place in a classroom at a special school, and two experimental environments with a robot (Muu) and some polystyrene blocks on a table were designed (See Figure 1). Two behavioral tasks were set up in the first session and modified in the later sessions: (i) a robot says some simple phrases, and (ii) a robot without speaking acts intentionally e.g., pushing/bringing objects and dropping them off of the table. Two male children and three female children participated in five sessions of 5-10 minutes each run monthly from October 2004 to February 2005. The robots were controlled using a wireless LAN by experimenters in the next room and a teacher remained in the experimental room to observe and help the children in trouble.

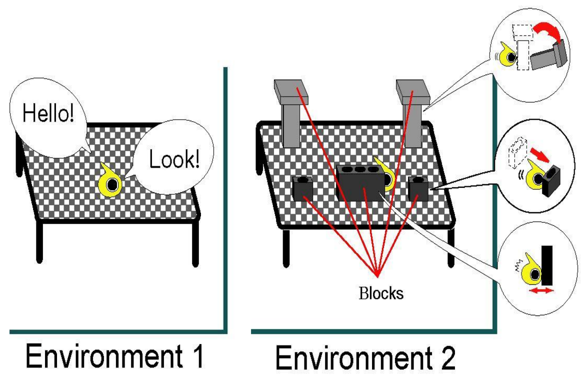

Figure 1: Two Experimental Environments.

3. Results

Among the participants, one child mostly interacted with the teacher but also with the robot, and two children did not interact with the robot. Thus, we analyzed and describe the cases of the two children who showed developmental changes in interacting with the robot.

Case1: Child A (male, 10-year-old, verbal communication)

In this case, the setup of the robot was modified monthly as follows: (session1) The robot only generated simple speech as it moved in Environment 1 → (session2) It generated speech and dropped blocks off of the table in Environment 2 → (session3) It asked the child verbally to build blocks → (session4) (session5) It asked the child verbally to build blocks and to put them into a box.

Most of his responses to the robot in each session were as follows: (1) He imitated the speech of the robot, touched and turned it. (2) Once the robot dropped a block off of the table, he assisted the robot to do it repeatedly. (3) He would try to make the robot drop a block, but it would not. His persistence in this conflicted with the situation run by the robot. After this struggle, he turned to face the robot, then listened to it, and followed it. (4) He built and put blocks in front of the robot so that it could drop them. He did not follow the instruction to put the blocks into a box. (5) He reproduced the pattern of session 4 at first. Later, he stopped cooperating with the robot and ignored its speech.

Case2: Child B (female, 10-year-old, nonverbal communication)

In this case, the setup of the robot was modified monthly as follows: (session1) The robot only pushed, brought and dropped blocks off of the table in Environment 2. → (session2)∼(session5) In addition to intentional actions, it generated some simple phrases.

Most of her responses to the robot in each session were as follows: (1) When the robot pushed a block, she rearranged it into the correct position. Her persistence in keeping the layout of blocks lasted throughout the session. Later, she intervened and touched it closely. (2) She rearranged the blocks moved by the robot repeatedly. She held the robot tightly and sometimes released it. (3) She continued to hold the robot tightly and began to say something to it. She released it just once. At the end of the session, she clearly said 'Bye-bye' to the robot with an appropriate gesture voluntarily. (4)(5) She repeatedly said 'Hello' and 'Bye-bye' to the robot voluntarily. She interacted with it verbally without holding it tightly. When the robot moved a block, she rearranged it but did not intervene in the robot 's actions.

The time series of relative distance in both cases of (session3), child A - Muu and child B - Muu, are shown in Figure 2. Figure 3 indicates each variation in the phase space of relative distance vs. change rate thereof. With respect to coordinating relative distance in interaction, these figures show that child A is more variable and dynamic than child B. It suggests that child A also organized his own spatiotemporal states more productively and showed more varied relationships with Muu.

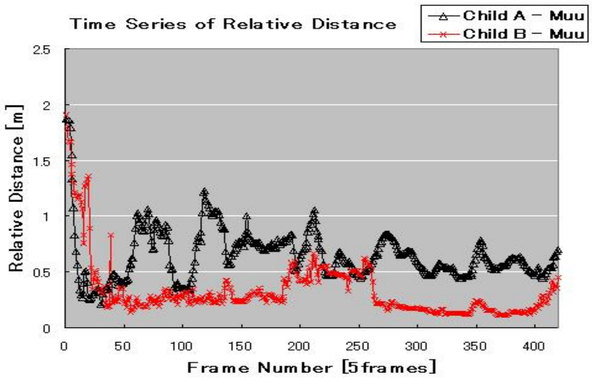

Figure 2: Time Series of Relative Distance in Interaction (in Both Cases of (session3))

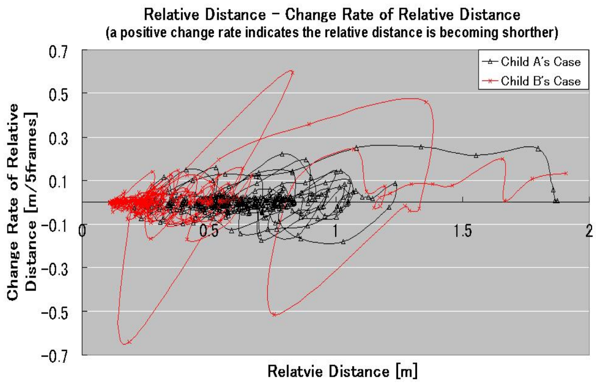

Figure 3: The Phase Space of Relative Distance and Change Rate in Interaction (in Both Cases of (session3))

4. Discussion

Both two children showed persistence in specific parts of the experimental situations. In Case1, child A continued to reproduce the action of dropping away blocks, and in Case 2, child B continued to maintain the layout of the blocks. The results indicated that they came to direct the experimental environments in a specific way and the robots destructed their patterns into more social ones. Under these constraints new actions emerged, such as building-dropping blocks in Case 1 and verbal interaction in Case 2. Further studies are required to demonstrate this speculation, but in this research we suggest that inanimate robots are able to communicate with autistic children as social agents.

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