Chapter 1

MOBILE ROBOTIC TOYS AND AUTISM

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Abstract To help children with autism develop social skills, we are investigating the use of mobile robotic toys that can move autonomously in the environment and interact in various manners (vocal messages, music, visual cues, movement, etc.), in a more predictable and less intimidating way. These interactions are designed to build up their self-esteem by reinforcing what they do well. We report tests done with autistic children using different robots, each robot having particular characteristics that allow to create interesting interactions with each child.

1. Introduction

Autism is characterized by abnormalities in the development of social relationships and communication skills, as well as the presence of marked obsessive and repetitive behavior. Despite several decades of research, relatively little is understood about the causes of autism and there is currently no cure for the condition. However education, care and therapeutic approaches can help people with autism maximize their potential, even though impairments in social and communication skills may persist throughout life.

As engineers, we got interested in the idea of designing mobile robotic toys to help children with autism learn to develop appropriate social skills. For an autistic child, a robot may be less intimidating and more predictable than a human. A robot can follow a deterministic play routine and also adapt over time and change the ways it responds to the world, generating more sophisticated interactions and unpredictable situations that can help capture and retain the child's interest. Robotic toys also have the advantage that they can be programmed to respond differently to situations and events over time. This flexibility allows robotic toys to evolve from simple machines to systems that demonstrate more complex behavior patterns.

The general goal is to create learning situations that stimulate children, get them to socialize and integrate them in a group. People with autism are aware that they have difficulties making sense of the outside world. To help them move from predictable, solitary and repetitive situations where they feel safe to socially interact with the world, the first objective of our robotic toys is to build up their self-esteem by reinforcing what they do good. The idea is to ask the child to do something, and to reward the child if the request is successfully satisfied. To make this work, the activities and the rewards must be something that interest the child, and one of the challenges is to get the attention of the child and get them interested in interacting. Another advantage about robotic toys is that they can have special devices that are particular interesting to these children, trying to find incentives to make them open up to their surroundings. Since each child is a distinct individual with preferences and capabilities, we are not seeking to design one complete robotic toy that would work with all autistic children. We want to observe the possible factors that might influence the child's interests in interacting with a robotic toy, like shape, colors, sounds, music, voice, movements, dancing, trajectory, special devices, etc. To do so, different mobile robots have been used in tests ranging from single sessions of a couple of minutes to consecutive use over a five week period, with autistic children or young adults of 7 to 20 years old. This way, our long term goal is to design robotic toys that can take into account the interests, strengths and weaknesses of each child, generate various levels of predictability, and create a more tailored approach for personalized treatment.

2. Mobile Robotic Toys with Autistic Children

Two types of tests have been conducted with autistic children: short sessions at the Ecole du Touret, and using one robot over a five week period with groups of children and young adults at the S.P.E.C. Tintamarre Summer camp.

2.1 Short Sessions

These sessions were held in two rooms: one regular classroom and a 20'x20' room without tables and chairs. Children were allowed to interact freely with the robots. At all time at least one educator was there to introduce the robot to children, or to intervene in case of trouble. Even though these children were not capable of fluent speech, some were able to understand the short messages generated by the robots. Each session lasted around one hour and a half, allowing eight to ten children to play with the robots. No special attention was put on trial length for each child, since our goal was to let all the children of the class play with the robots in the allocated time slot.

As expected, each child had his or her own ways of interacting with the robots. Some remained seated on the floor, looking at the robot and touching it when it came close to them (if the robot moved to a certain distance, some children just stopped looking at the robot). Others moved around, approaching and touching the robots and sometimes showing signs of excitation. It is very hard to generalize the results of these tests since each child is so different. In addition, the mood of some of the children that participated to all of these sessions was not always the same. But one thing that we can say is that the robots surely caught the attention of the children, making them smile, laugh or react vocally. In general, we did not observe particular attention to the front of the robots (e.g., trying to make eye contact), mostly because most of them have devices all around them. To give a more precise evaluation of our tests, we present observations made with some of the robots used in these trials:

Jumbo. This elephant has a moving head and trunk, one pyroelectric sensor and an infrared range sensor. Jumbo is programmed to move toward the child and to stop at a distance of 20 cm. Once close to the child, Jumbo asks the child to touch one of the three buttons associated with pictograms located on its back. LEDs are used at first to help the child locate the right pictogram, but eventually the LEDs are not used. If the child is successful, Jumbo raises its trunk and plays some music (Baby's Elephant Walk or Asterix the Gaulish). If the child is not responding, the robot asks to play and can try to reposition itself in front of the child. Pictograms on the robot can be easily replaced. This robot revealed to be very robust, even though its pyroelectric lenses got damaged too. One child liked to push the robot around when it was not moving, as shown in Figure 1.1, or to make the robot stay close to her if it was moving away. The pictogram game was also very nice, but children were pressing on the pictograms instead of on the buttons. The music played and movements of the trunk were also very appreciated by the children.

Roball. Roball [3] is a spherical robot capable of navigating in all kind of environments without getting stuck somewhere or falling on the side. Interactions can be done using vocal messages and movement patterns like spinning, shaking or pushing. The majority of children were trying to catch Roball, to grab it or to touch the robot. Some even made it spin (but not always when requested by Roball though). One boy, who did not interact much with almost all of the other robots presented, went by himself in order to play with Roball. One of the games he played was to make the robot roll on the floor between his arms, as shown in Figure 1.2, and eventually let it go forward by itself.

C-Pac. C-Pac is a very robust robot that has removable arms and tail. These removable parts use connectors that have different geometrical shape (star, triangle, hexagon). When successfully assembled, the robot thanks the child and rotates on itself. The robot also asks the child to make it dance by pressing its head. The head then becomes illuminated, and music (La Bamba) is played as the robot dances, and this was very much appreciated by children. C-Pac also has a moving mouth, eyes made of LEDs, an infrared range sensor and pyroelectric sensors to stay close to the child. Children learned rapidly how to play with this robot, even understanding by themselves how to assemble the robot, as shown in Figure 1.3. The removable parts became toys on their own. Children were also surprised when they grabbed the robot by its arms or tail, expecting to grab the robot but instead removing the part from the robot. Note however that the pyroelectric lenses got damaged by the children, and one even took off the plastic cup covering one eye of the robot and tried to ate it.

Bobus. Extremely robust, this robot can detect the presence of a child using pyroelectric sensors. It then slowly moves closer to the child, and when close enough it does simple movements and plays music. Simple requests (like touching) are made to the child and if the child responds at the appropriate time, light effects are generated using the LEDs all around the 'neck' of the robot, and the small ventilator on its head is activated. Very robust, this robot is the only one with pyroelectric senses that did not got damaged. Two little girls really liked the robot, enjoying the light effects, the moving head with the ventilator, and the different textures. Figure 1.4 illustrates one of these girls showing signs of excitation when playing with Bobus. At one point, one girl lifted the robot and was making it roll on its side on top of her legs. She then put the robot on the floor and was making it roll on its side using her legs again, but by lying on top of the robot.

Figure 1.1. Pushing Jumbo around the play area.

Figure 1.2. Rolling game with Roball.

One very interesting observation was made with a 10 years old girl. When she enters the recreation room, she starts right away to follow the walls, and she can do this over and over again, continuously. At first, a robot was placed near a wall, not moving. The little girl started to follow the walls of the room, and interacted with the robot for short amount of times, at the request of the educator as she went by the robot. Eventually, the robot moved away from the walls and she slowly started to stop, first at one particular corner of the room, and then at a second place, to look at the robot moving around. At one point when the robot got to a corner of the room, she changed path and went out of her way to take the robot by its tail and to drag it back to the center of the room

Figure 1.3. Assembling the arms and tail of C-Pac.

Figure 1.4. Girl showing signs of interest toward Bobus.

where she believed the robot should be. She even smiled and made eye contact with some of us, something that she did not do with strangers. This showed clear indications that having the robot moved in the environment helped her gradually open up to her surroundings.

2.2 Trials at S.P.E.C. Tintamarre Summer Camp

In these trials, Jumbo was used one day a week over a period of five weeks, for 30 to 40 minutes in four different groups. Children and young adults were grouped according to the severity of their conditions, their autonomy and their age. Four to ten people were present in each group, along with two or three educators, and each group had its own room. Children were placed in a circle, sitting down on the floor or on small cubes depending on their physical capabilities. The robot always remained on the floor, and each child played in turns with the pictograms. Once a turn was completed, a new set of pictograms were used.

With the groups that did not have physical disabilities, children manifested their interests as soon as Jumbo entered the room, either by looking at the robot or by going to touch it, to push it, to grab the trunk or by pressing on the pictograms. The music and the dance were very much appreciated by the children. The amount of interactions varied greatly from one child to another. Some remained seated on the floor and played when the robot was close to them. Others either cleared the way in front of the robot, or moved away from its path when it was coming in their direction. The amount of time they remained concentrated on the robot was longer than for the other activities they did as a group. One little girl who did not like animals, had no trouble petting Jumbo. She was also playing in place of others when they took too much time responding to a request or did mistakes. One boy did the same thing (even by going through the circle), and he was very expressive (by lifting his arms in the air) when he succeeded with the pictograms.

To the group of teenagers, Jumbo is real. They talked to the robot, reacted when it was not behaving correctly or when it was not moving toward them. Some educators were also playing along because they were talking to Jumbo as if it was a real animal, by calling its name, asking it to come closer. When Jumbo did not respond correctly and was moving away, educators would say something like “Jumbo! You should clean your ears!” or “Jumbo has big ears but cannot hear a thing!”. One boy showed real progress in his participation, his motivation and his interactions because of the robot. His first reaction was to observe the robot from a distance, but he rapidly started to participate. His interest toward the robot was greater than the other kids. He remembered the pictograms and the interactions they had with the robot from one week to another. He also understood how to change the pictograms and asked frequently the educators to let him do it. Another boy also liked to take Jumbo in his arms, like an animal. He showed improvements in shape and color recognition.

3. Discussion

Our tests revealed that autistic children are interested by the movements made by the robots, and enjoy interacting with these devices. Note that it should never be expected that a child will play as intended with the robot. This is part of the game and must be taken into consideration during the design stage of these robots. In that regard, robustness of the robots is surely of great importance, as some of the more fragile designs got damaged, but mostly by the same child. Having removable parts is good as long as they are big enough: all small components or material that can be easily removed should be avoided. Having the robots behave in particular ways (like dancing, playing music, etc.) when the child responds correctly to requests made by the robot becomes a powerful incentive for the child to continue playing with the robots. The idea is to create rewarding games that can be easily understood (because of its simplicity or because it exploit skills developed in other activities like the use of pictograms or geometrical shapes) by the child.

In future tests and with the help of educators, we want to establish a more detailed evaluation process in order to assess the impact of the mobile robotic toys on the development of the child. We also want to improve the robot designs and to have more robots that can be lent to schools over longer periods of time. The robots should integrate different levels of interaction with the child, starting with very simple behaviors to more sophisticated interplay situations. Catching and keeping their attention are important if we want the children to learn, and the observations made with the robots described in the previous section can be beneficial. The idea is not as much as using the robot to make children learn to recognize for instance pictograms (they learn to do this in other activities), but to make them develop social skills like concentration, sharing, turn passing, adaptation to changes, etc. Finding the appropriate reward that would make the child want to respond to the robot's request is very important. Predictability in the robot's behavior is beneficial to help them understand what is going on and how to receive rewards. Also, since the robot is a device that is programmed, the robot's behavior can evolve over time, changing the reinforcing loop over time, to make them learn to deal with more sensory inputs and unpredictability. Finally, to adapt mobile robot toys to each child, reconfigurable robots, using different hardware and software components, might be one solution to explore.

Using interactive robotic toys is surely an interesting idea that has the potential of providing an additional intervention method to the rehabilitation process of autistic children. We are not alone working on this aspect. The AURORA project (AUtonomous RObotic platform as a Remedial tool for children with Autism) [2, 1, 5] is one of such initiatives addressed in the following chapter.

We are very much encouraged by the observations made, and we will continue to design new mobile robots [4] and to do tests with autistic children. The basic challenge is to design a robot that can catch their attention and help them develop their social skills by building up their self-esteem. At this point, we still need to work on simple ways of interacting with the child, to help them understand how the robot works and exploit the knowledge and skills they acquire in other pedagogical activities. Our hope is that mobile robotic toys can become efficient therapeutic tools that will help children with autism develop early on the necessary social skills they need to compensate for and cope with their disability.

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