Robots as Isolators or Mediators for Children with Autism? A Cautionary Tale

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Abstract

The discussion presented in this paper is part of our investigation in the Aurora project into the potential use of robots as therapeutic or educational 'toys' specifically for use by children with autism. The paper raises some cautions concerning *social isolation* and *stereotypical behaviour* frequently exhibited in children with autism. We present some examples taken from trials with the robots where the children exhibit such behaviour, and discuss possible ways of ensuring not to reinforce stereotypical behaviour and a tendency to social isolation in the children. Especially, we point out an avenue of robots becoming *social mediators* (mediating contact between children and other children or adults). The paper exemplifies interaction where social behaviour was directed at the robot which raises awareness of the goal of the research, namely to help the children to increase their social interaction skills *with other people* and not simply create relationships with a 'social' robot which would isolate the children from other humans even further.

1. Introduction

Robots and other computer-based technologies are increasingly being used in therapy and education. The discussion presented in this paper is part of our investigation in the Aurora project (AURORA, 2005) into the potential use of robots as therapeutic or educational 'toys' specifically for use by children with autism. People with autism have impaired social interaction, social communication and imagination (referred to by many authors as the triad of impairment, e.g. (Wing, 1996)). Our research focuses on ways that robotic systems can engage autistic children in simple interactive activities with the aim of encouraging basic communication and social interaction skills.

Autism is a lifelong developmental disability that affects the way a person communicates and relates to people around them. People with autism show an impairment in understanding others' intentions, feelings and mental states. They have difficulties in understanding gesture, facial expressions and metaphors and forming social relationships and relating to others in meaningful ways generally poses a big problem to them. They also have impaired imagination, i.e. the development of play and imaginative activities is limited.

Literature shows that people with autism feel comfortable in predictable environments, and enjoy interacting with computers, e.g. (Colby and Smith, 1971; Moor, 1998; Murray, 1997; Powell, 1996). Studies into the behaviour of children with autism suggest that they show a preference for interacting with objects rather than with other people. People's social behaviour can be very subtle and could seem, to those with communication problems and a deficit in mind reading skills, widely unpredictable. This can present itself as a very confusing and possibly stressful experience to children with autism, an experience that they, understandably, try to avoid. As a result, it is not just that they might demonstrate a preference for interacting with objects rather than with other people, but, as Hobson suggests, children with autism often seem to relate to a person as an object (Hobson, 2002). Different from human beings, interactions with robots can provide a simplified, safe, predictable and reliable environment where the complexity of interaction can be controlled and gradually increased.

Our previous work demonstrates that although, in experimental situations, children with autism prefer to engage with a ‘robot’ rather than a ‘human’ companion, this can be turned to their advantage (Robins, et al., 2004c; Robins, et al., 2004d). Results show that repeated exposure to a robot over a long period of time can encourage basic aspects of social interaction skills (i.e. simple imitation, turn- taking and role-switch) and can reveal communicative competence in some of the children (Robins, et al., 2004a). Imitation plays an important part in social learning both in children and adults. Nadel found significant correlations between imitation and positive social behaviour in children with autism (Nadel, et al., 1999). Her findings indicate that imitation is a good predictor of social capacities in these children, and when they are being imitated, autistic children improve their social responsiveness. Inspired by these findings, we designed our trials to progressively move from very simple exposure to the robot, to more complex opportunities for interaction, giving the children the opportunity to attempt imitation and turn-taking games with the robot. It is hoped that if a robot succeeds in engaging children with autism in a variety of interactions, including turn-taking and imitation games, then it may potentially contribute to a child’s development of interaction skills

Our previous trials also highlighted that robots (humanoid and non-humanoid) can serve as salient objects mediating joint attention between the children and other people (peers and adults) (Robins, et al., 2004b; Werry, et al., 2001). Werry *et al.* (2001) demonstrated the ability of a mobile robot to provide a focus of attention and shared attention in trials with pairs of children with autism. Here, the robot’s role as a mediator became apparent in child-teacher interactions, child-investigator interactions and child-child interactions. Furthermore, Robins et al., (2004b) showed that, in some cases, specific aspects of the robot’s behavior, such as the autonomous and predictable pattern of moving head and limbs of a humanoid robot, played a major role in eliciting skilful interaction on the part of the children with the adult present in the room at the time. The robot’s role of mediator emphasizes one of our aims, namely not to replace but to *facilitate human contact*. By being an object of shared attention, the robot may potentially become a ‘social mediator’ encouraging interaction with peers (other children with or without autism) and adults.

2. A Cautionary Tale

As described above, during all of our trials the robots were initially the main focus of the children’s attention. This was the case during the child-robot imitation and turn taking games, as well as during the trials when the robot was the object of joint attention mediating interaction between the children and other people. In this paper we focus on some cautions in this respect, which have arisen during the course of the data analysis. These cautions concern two specific but frequently related behaviours, *social isolation* and *stereotypical behaviour* which is often exhibited in children with autism.

2.1 Social Isolation

Often, children with autism are being described as socially isolated, ignoring other people near them, and often treating them as if they were objects (Hobson, 1993, 2002; Siegel, 1998; Tustin, 1990). Tustin in her review of the external descriptive diagnostic features of autism, provides a quote from Kanner that illustrates it very well: “…the people, so long as they left the child alone, figured in about the same manner as did the desk, the bookshelf, or the filing cabinet.” (Tustin, 1990). In some trials in which small groups or pairs of children with autism were exposed to the robot we have noted occasions were the children seek to have an ‘exclusive’ relationship/interaction with the robot *ignoring* their peer and the experimenter.

Examples of these behaviours from two different trials with different children can be seen below.

2.1.1 Example one

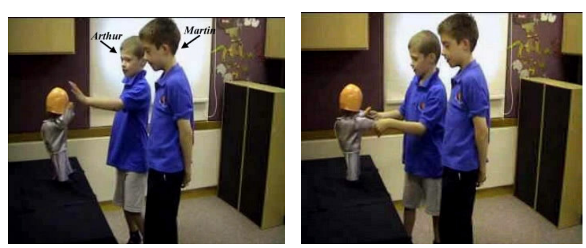

Figure 1: Arthur (left) interacting with the robot whilst Martin (right) waits for his turn.

Figure 1 above shows the beginning of the trial where Arthur (a child with autism) is interacting with the robot, in a very similar way to how he did in a previous trail (simple imitation game). Martin (a child without autism) is standing nearby awaiting his turn (all names in this paper are synomyms).

Figure 2 below shows that whilst it is Martin’s turn for interaction (the robot and the experimenter directed their attention to Martin), Arthur won't 'let go' and continued with his imitation movement, trying to get the robot's attention; and even got annoyed when this did not happen (figure 2 -right).

Figure 2: It is Martin's turn for interacting with the robot, whilst Arthur won't 'let go'.

In figure 3 below, we can see that, whilst Martin is still interacting with the robot, Arthur has stepped forward, ignoring Martin, and touches the moving hands of the robot, seeking exclusive interaction.

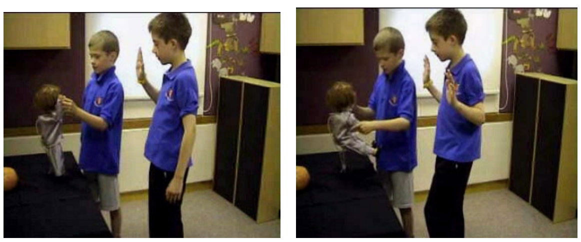

Figure 3:Arthur seeks exclusive interaction with the robot.

2.1.2 Example 2

In this example, two children with autism are playing with the robot 'together' for the first time. Each of them played with the robot individually many times in the past but here they are both exposed to the robot simultaneously.

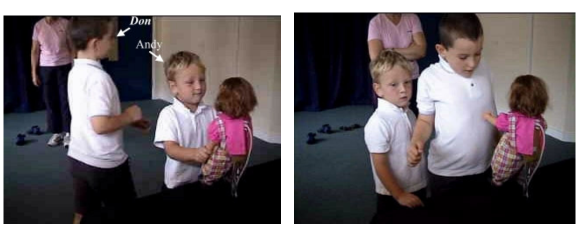

Figure 4 – Andy (left picture) and Don (right picture) Both seeking exclusive interaction with the robot.

Figure 5- Don interacting 'exclusively' with the robot, whilst Andy tries to ignore Don.

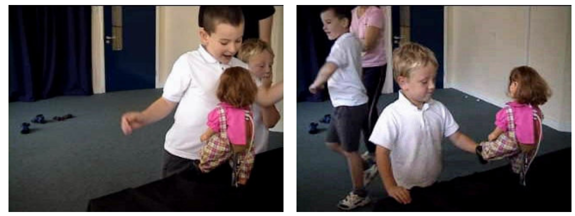

Figure 6 – Don actively seeks exclusive interaction with the robot, whilst Andy waits for exclusive opportunities to interact.

During this session, Don was asked by the teacher to show Andy how to play with the robot. Each time Don went to interact with the robot he actively ensured that he had exclusive interaction, blocking out Andy with his hands. This behaviour repeated itself on different occasions during the session, as can be seen in figures 4 (right), 5 (left), 6 (left).

Andy, on his part, was trying to ignore Don and constantly needed 'encouragement' from his teacher to look at what Don was doing (e.g. figure 5-right). He was either gazing at the robot (figure 5-left), or looking away altogether, as can be seen in figures 4 (right) and 5 (right). Andy interacted with the robot only when he had exclusive access to it, i.e. when Don had stepped away (figures 4-left, 6-right).

These situations clearly highlight that interactions in our trials need to be carefully monitored and taken into consideration when programming the robots and creating the scenarios and games to be played with the robot, to ensure that the robots encourage interaction and become *social mediators* and do not reinforce existing behaviours and become *social isolators*.

2.2 Stereotypical Behaviour

The second caution relates to the highly stereotypical behaviour also frequently noted in children with autism. These highly repetitive forms of behaviour increase social isolation and frequently become self-injurious (Van-Hasselt and Hersen, 1998; White-Kress, 2003; Hudson and Chan, 2002; Jenson, et al., 2001). Our work so far has been limited to the use of robots to develop basic interaction skills through simple imitation and turn-taking activities between the robot and child. Currently, the robots available for this kind of mediation suitable for our experiments are only capable of a relatively limited and repetitive range of movements leading to the caution that this might increase rather than decrease the incidence of these kinds of behaviours.

The following images were taken during trials where children with autism played simple turn–taking and imitation games with a small humanoid robotic doll. The Robot had a very limited range of movements, i.e. the four limbs were capable of moving up and down, and the head could move sideways. This robot's behaviour is far more stereotypical, i.e. shows little variation, as compared to a mobile robot used in other trials, as described below.

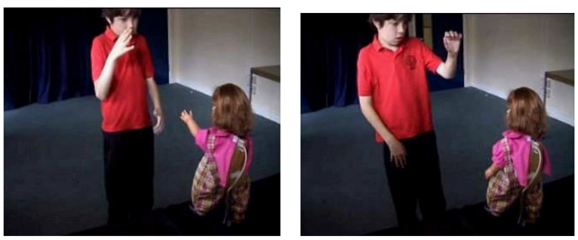

Figure 7 – Tim during a simple imitation game with the robot.

Figure 8 – Billy during a simple imitation game.

In figures 7 & 8 we can see how Tim and Billy engaged in a simple turn-taking and imitation game with the robot. The robot's movements were simple and highly repetitive, and Tim and Billy responded to them each time with almost identical movements.

In comparison, in trials with a mobile robot, where the robot was able to vary its movements during a turn-taking game, the children displayed similar, but not identical, behaviour patterns. Movements were variations of a common theme, rather than instances of a fixed behaviour repertoire. The images in figures 8 & 9 below were taken in a trial where the robot played a turn-taking game with a child. Here, the robot's behaviour varied slightly each time it approached the child or retreated from him (the angle of approach and speed differed, the robot's position relative to the child thus varied). Since the child adjusted his own movements relative to the robot's position and movements, it meant that the child repeated his response (gaze at the robot or touching the robot) each time in a slightly different manner, involving adjustments of his *whole body posture* (e.g. rolling slightly, stretching further away, using another hand etc).

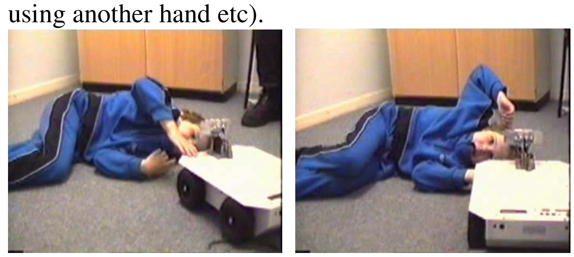

Figure 8 – The robot's varied behaviour in a simple approach/avoidance game: Two instances of approach are shown.

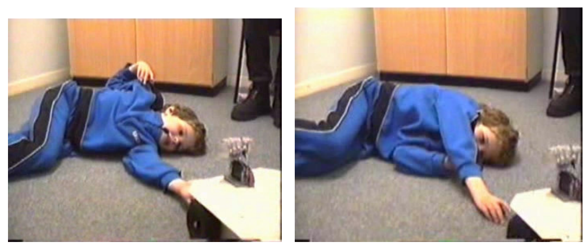

Figure 9 – The child's varied behaviour in the same game: Two instances of 'reaching out' are shown, attempts of touching the robot's front sensors which, as the child has already discovered, will make the robot approach or avoid.

In the above cases involving a mobile robot, we see two interactants that adjust their behaviour relative to, and in response to the other's behaviour, involving full-body movements and encouraging 'natural' types of movements. This situation is very different from those shown in figures 7 and 8, where the children's responses are far more stereotypical and 'mechanistic'.

Using well-defined, salient features, i.e. easy recognizable 'mechanistic' movements seems advantageous e.g. in early stages when children with autism are first being introduced to a robot. These stereotypical movements reduce the complexity of interaction (which is for the children difficult to deal with). However, in later stages, in order not to teach the children to behave like robots and to learn 'robotic movements', robots with more naturalistic, 'biological' movements would be beneficial and a suitable next step in the process of learning.

One of the advantages of using robots, as mentioned earlier, is that the complexity of interaction can be controlled. Bearing in mind the stereotypical nature of the movements of the humanoid robot which we are using, we need to ensure that, over time, we design more complex scenarios of interaction. Also, great attention needs to be paid towards the particular form and shape of movements and behaviour that we encourage in the children. After initial phases of introduction and learning, natural movements are clearly preferred over mechanistic, 'robotic' movements.

2.3 Social Behaviour: Bonding with Robots

Our approach of providing a stress free environment, with a high degree of freedom, facilitated the emergence of spontaneous, proactive, and playful interactions with the robots (Robins, et al., 2004). These interactions included, in some cases, elements of social behaviour directed at the robot.

One example of these behaviour elements occured during the last trial of a longitudinal study (Robins, et al., 2004). Here Billy ended the session running around the room and 'dancing' in front of and directed towards the robot each time he passed it (figure 10 below).

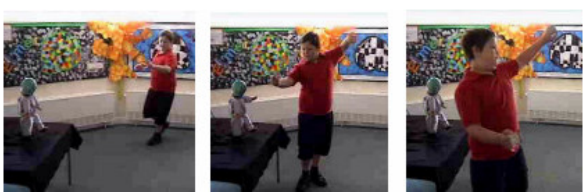

Figure 10 – Billy is 'dancing' to the robot.

Billy repeated this dance in a very similar fashion six months later during the next trial he participated in. (figure 11 below).

Figure 11 – six month later, Billy is 'dancing' again.

Another example of social behaviour displayed by Billy, is when he performed his own unique sign for *good-bye* to the robot. His teacher said at that time that it was as if he was waiting for the robot to say good-bye back to him (figure 12).

Figure 12 - Billy says 'goodbye' to the robot.

The question that must be asked throughout this research is how the children benefit from the interaction with the robots. Are they increasing their social interaction skills (*with other people*) or are we simply encouraging relationships with a 'social' robot? Billy's behaviour was clearly directed towards the robot. In non-autistic children, pretend play or play primarily targeted at other humans present in the room could serve as a possible explanation for this behaviour. However, since children with autism have impairments in these specific domains, it is unlikely that it applies to Billy. Billy very much enjoyed the interactions with the robot, he laughed and smiled during his dance. From a quality of life perspective, this enjoyment is in itself a worthwhile achievement. However, from an educational/therapeutic point of view we must ask whether this sign of 'attachment' or 'bonding' with the robot is worthwhile to pursue, reinforce, or to avoid.

For any child that is usually withdrawn and does not participate in any interaction with other people, 'bonding' with a robot could serve as leverage, and a stepping stone that could provide safety and comfort, opening the child up towards the possibilities of 'human' interactions that are far more unpredictable and complex. Thus, 'bonding with robots' could be beneficial to a child with autism, but only if it is not the ultimately goal, but an *intermediate goal* on the long path towards opening up the child towards other people[1].

3. CONCLUSION

[1] As researchers, this implies a certain responsibility and long-term commitment to this work, that is usually not supported by any existing funding initiatives.

It is not yet clear whether any of the social and communicative skills that the children exhibit during interaction with the robot would have any lasting effect and whether these skills could be generalized and applied in the children's day to day life outside the trial scenario. This aspect is part of our ongoing work. More longitudinal studies are required, together with continued monitoring of the children in their classroom and home environments. Providing experimental evidence for generalization of skills learnt in interactions with the robot is one of our current major challenges from a therapeutic/educational point of view.

From a robotics perspective the appropriate design of robots suitable in therapy and education for children with autism, including the design of suitable and naturalistic robotic movements is a major technological challenge.

References

AURORA. *URL: http://www.aurora-project.com/ last accessed 27/1/05*, 2005.

K. Colby and D. Smith. Computers in the treatment of non speaking autistic children. *Current Psychiatric Therapies* 11:1-17, 1971.

P. Hobson. Understanding persons: the role of affect. In S. Baron-Cohen, H. Tager-Flusberg, and D.J. Cohen, eds., *Understanding other minds, perspectives from autism, chap. 10*, p. 204-227. Oxford University Press, 1993.

P. Hobson. *The Cradle of Thought*. Macmillan, London, 2002.

C. Hudson and J. Chan. Individuals with Intellectual Disability and Mental llness: A Literature Review. *Australian Journal of Social Issues* 37, 2002.

Craig C. Jenson, Gene McConnachie, and Todd Pierson. Long-Term Multicomponant Intervention to Reduce Severe Problem Behaviour: A 63 Month Evaluation. *Journal of Positive Behaviour Interventions* 3, 2001.

D. Moor. Computers and people with autism. *Communication*:20-21, 1998.

D. Murray. Autism and information technology:therapy with computers. In S. Powell and R. Jordan, eds., *Autism and learning: a guide to good practice.*, 1997.

J. Nadel, C. Guerini, A. Peze, and C. Rivet. The evolving nature of imitation as a format of communication. In J. Nadel and G. Butterworth, eds., *Imitation in Infancy*, p. 209-234. Cambridge University Press, 1999.

S. Powell. The use of computers in teaching people with autism. Autism on the agenda: papers from a National Autistic Society Conference. London. In. 1996.

B. Robins, K. Dautenhahn, R. te-Boekhorst, and A. Billard. Robotic Assistants in Therapy and Education of Children with Autism: Can a Small Humanoid Robot Help Encourage Social Interaction Skills? *Universal Access in the Information Society* (in press), 2005.

B. Robins, K. Dautenhahn, R. te Boekhorst, and A. Billard. Effects of repeated exposure of a humanoid robot on children with autism. In S. Keates, J. Clarkson, P. Langdon, and P. Robinson, eds., *Designing a More Inclusive World*, p. 225-236. Springer Verlag, London, 2004a.

B. Robins, P. Dickerson, P. Stribling, and K. Dautenhahn. Robot-mediated joint attention in children with autism: A case study in a robot-human interaction. *Interaction studies: Social Behaviour and Communication in Biological and Artificial Systems* 5:2:161-198, 2004b.

B. Robins, K. Dautenhahn, and J. Dubowski. Investigating Autistic Children's Attitudes Towards Strangers with the Theatrical Robot-A New Experimental Paradigm in Human-Robot Interaction Studies? In *Proc.13th IEEE International Workshop on Robot and Human Interactive Communication - RO-MAN,Kurashiki, Japan, 20-22 September 2004.*, 2004c.

B. Robins, K. Dautenhahn, R. te Boekhorst, and A. Billard. Robots as Assistive Technology - Does Appearance Matter? In *Proc. 13th IEEE International Workshop on Robot and Human Interactive Communication - RO-MAN , Kurashiki, Japan, 20-22 September 2004.*, 2004d.

B. Siegel. *The World of the Autistic Child: Understanding and Treating Autistic Spectrum Disorders*. Oxford University Press, 1998.

F. Tustin. *The Protective Shell in Children and Adults*. Karnac, 1990.

V. B. Van-Hasselt and M. Hersen. Handbook of Psychological Treatment Protocols for Children and Adolescents. *Scandinavian Journal of Behaviour Therapy* 16:95-109, 1998.

I. Werry, K. Dautenhahn, B. Ogden, and W. Harwin. Can Social Interaction Skills Be Taught by a

Social Agent? The Role of a Robotic Mediator in Autism Therapy. In M. Beynon, C.L. Nehaniv, and K. Dautenhahn, eds., *Proc. CT2001, The Fourth International Conference on Cognitive Technology: Instruments of Mind, LNAI 2117*, p. 57-74. Springer-Verlag, Berlin Heidelberg, 2001.

Victoria E White-Kress. Self-Injurious Behaviours: Assessment and Diagnosis. *Journal of Counselling and Development* 81, 2003.

L. Wing. *The Autistic Spectrum*. Constable Press, London, 1996.