

A Comparison of Interactive and Robotic Systems in Therapy and Education for Children with Autism

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Abstract. In this paper we discuss the use of interactive environments in autism therapy. In particular we review the Aurora project and summarise the results of three studies within Aurora project, one using a non-humanoid mobile robot, one using a small humanoid doll robot, and the last using a touch sensitive screen. All three studies seek, in different ways, to promote social skills and an enhanced sense of self and other. We draw some comparisons between the technologies.

Keywords. Autonomous robots, interactive systems, autism therapy, narrative.

Introduction

In this paper we discuss investigations into the use of robotic and other interactive systems to promote social interaction skills in children with autism. In particular we report on the Aurora project, and experiences using non-humanoid mobile robots, a small humanoid doll robot, and a touch sensitive screen.

1. Autism

The Characteristics of Autism: Autism is a lifelong pervasive developmental disorder affecting social ability [1]. People with autism form a very diverse group, but they all exhibit impaired social interaction and communication, and have a limited range of imaginative activities. Additionally it is common to find repetitive behaviour patterns and resistance to change in routine [2].

People with autism have great difficulty making sense of the world, in particular the social world. Autobiographical accounts such as Grandin [3] show that people with autism who do live successfully in the, to them bizarre, world of so-called normal people do so at least in part by learning explicit rules: for example, remember to look interested when someone is talking to you; or, if someone smiles at you, you should smile back (note that even this apparently simple rule does not always apply).

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Autism and Narrative: Grandin comments on difficulties she has understanding narrative [4]. Children with autism have some specific difficulties with narrative; they are less likely to take account of their audience; and references to causality and affect may be missing or inappropriate [5, 6]. Abell *et al* showed, using animated triangles, that children with autism were more likely to attribute inappropriate mental states than typically developing children or those with general intellectual impairment [7]. This impairment in mentalising is often attributed to a deficit in a theory of mind. Alternatively, we may view narrative ability as causal rather than symptomatic, viewing narrative structure itself as fundamental to the perception, creation and communication of meaning in social interaction [8, 9]. It is postulated that by fitting events into a narrative pattern we construct and inhabit a meaningful and consistent world [10-14]. We are able to understand the behaviours of others (people or other agents which we imbue with intent), and we are able to respond in ways seen as meaningful and consistent. Thus we may view difficulties with narrative as underlying the social and temporal difficulties we see in autism.

2. The Aurora Project

The Aurora project is an ongoing long-term project which seeks to help children who find it difficult to interact with humans, in particular by considering the use and design of robotic and interactive computer systems[15]. Human social behaviour is complex, varied and unpredictable; robots and computers have simpler behaviours, which may be highly but not wholly predictable, and which can be gradually extended or varied. An aim of the project is to explore whether such systems can be used to elicit social behaviour in children with autism, and explore the eventual possibility of scaffolding understanding of social issues. It is central to the Aurora approach that the interactions are playful. We should stress that are not seeking, in any way, to replace the human touch of carers or practitioners. An extended discussion on the background, motivation and challenges of the Aurora project can be found in [16]. In this paper we present studies which use three different types of interactive system, carried out under the Aurora project, specifically non-humanoid mobile robots, humanoid stationary robots and an interactive system using a touch sensitive screen, see Figure 1.

Studies using an autonomous non-humanoid robot: In this series of studies the children were given the opportunity to interact with a non-humanoid autonomous mobile robot. The robot was able to move about on the floor, and the children free to react as they chose; thus a child could approach, avoid, pick up, or indeed ignore the robot, and walk, lie on the floor, crawl etc. Most of the children responded very well and took great interest to the robot [16]. In analysing the interactions particular attention was paid to



Figure 1. Some robotic and interactive systems used in the Aurora project.

issues such as joint attention, imitation, eye gaze, approach, avoidance, etc., as these are important aspects of social interaction. In one study interaction with the robot was compared with interaction with a toy of similar appearance. It was found that children with autism paid more attention to, and directed more eye gaze at, the mobile robot than the toy [17].

Studies using a small stationary humanoid robot: This study incorporates ideas from movement and dance therapy used a small humanoid doll robot, named Robota. Robota can move its arms, legs, and head, but cannot move from place to place and cannot readily be picked up. Thus, while the children are free to move, dance, sit, etc. they must be in front of or to the side of the robot to interact with it. The robot was used in two modes; display, where it dances to music in a pre-programmed way, and puppeteered, where the experimenter indirectly manipulates the robot in response to the behaviours of the child. In analysing the interactions particular attention was paid to issues such as imitation, eye gaze, approach, avoidance, and turn taking especially in the form of naturally occurring changes of lead during imitation. A longitudinal approach was adopted to allow behaviour to be elicited gradually, to allow the child to view the study as part of, rather than in conflict with, their routine, and to allow for occasional “off-days”. Reports on these studies can be found in [18, 19]. Current work with Robota is concerned with interactions involving pairs of children in order to investigate the potential of the robot as a mediator among children.

Studies Using a Touch Sensitive Screen: This study uses a touch sensitive screen to explore ideas of narrative comprehension and expression in ways which are not necessarily verbal or textual. The study compared two versions of a simple sequence and picture story completion game, one version uses laminated picture cards, the other uses draggable pictures on a touch sensitive screen [20]. The touch screen was chosen because, while many children with autism take naturally to using computers, for others using a mouse here, to cause an effect there, is an abstraction which can take a long time to master. The study differs from the ones mentioned above in that, while the child is free to stand or sit, he or she must be able to touch the screen, or physical game, to interact with it. It also differs in that it is task-based, i.e. the children are invited to play the game.

Frequently used methods of requirements elicitation and design for example, focus groups, collaborative design, questionnaires etc. were not possible with these children, nor were usual evaluation techniques. Therefore, after prior observation of the children and discussion with their teachers and therapists, a simple prototype was written and tried with 18 children. Unlike software for typically developing children, trying to keep attention and design out boredom is not an aim. It is important that the rewards reinforce the task, and the temptation to include extraneous noises, animations etc. resisted. The system, while in some sense capitalizing on the desire for repetition, should be designed to avoid meaningless repetition. The first trials with TouchStory were in part to assess the level of the narrative task, and to assess whether the use of a touch screen was feasible. The children all engaged with the narrative task, and the children were at least as engaged and successful with the touch screen version as with the physical version of the game. Most of the children understood the basics of the game, and most were able to drag without difficulty. Current work with TouchStory is a longitudinal study, on the one hand improving draggability for those children who find it difficult, and on the other hand, by use of proto-narratives identifying those aspects of narrative which *individual* children find difficult.

3. A Comparison of the Studies

A comparison of the three studies showing the differences in focus, interaction styles, types of child autonomy and control, and the elicited behaviours is presented in Table 1.

Table 1: a summary of experiences using a mobile autonomous robot, a small stationary humanoid robot and an interactive touch screen for focused study of the design of interactive systems for children with autism.

	A mobile autonomous robot	Robota (a small humanoid robot)	TouchStory (interactive touchscreen game)
Focus	Playful social interaction.	Playful lead and imitation of movement and gesture.	Understanding of narrative.
Nature of interaction	Free, playful, unstructured.	Free and guided attention e.g. 'look at this' while indicating Robota.	Task based e.g. 'would you like play my computer game'.
The mobility of the system.	The robot is mobile, and can move in 2-D space on the floor.	The robot is fixed in place but can move arms, legs and head.	The screen is fixed in place, but the pictures are draggable on the screen.
The spatial dimensions of interaction	3-D, the child can approach the robot from any direction.	3-D, but the child must be to the front or side of the robot to interact with it.	The child must be in front of the screen to use it, pictures drag in 2-D.
The stance and movement of the child during interaction.	The child is free to run around, sit on the floor, approach, avoid, and possibly pick up the robot.	The child is free to sit, stand, or move towards or away from Robota, and to touch Robota.	The child may sit or stand but must be able to touch the screen to use it.
The way in which the child controls the interaction.	Control is <i>oblique</i> , during successful interaction the child and robot are active participants in the interaction. The child can influence what game is played.	Control is <i>oblique</i> , having imitated the robot, a child might try to get the robot to imitate him. The child can influence what game is played.	Control is direct, the child directly manipulates pictures on the screen by touching and moving them. The game to be played is predetermined.
System behaviours used.	i) pre-determined ii) adaptive in the sense of taking the robot's history into account.	i) pre-determined ii) puppeteered i.e. controlled during the interaction.	i) pre-determined ii) tailored i.e. adapting to each child between interactive sessions.
Tailoring to the needs of the <i>individual</i> child	No individual adaptation was used.	Mainly by puppeteering. Changes such as hair cut or clothing cannot be, or were not, varied for each child.	The choice of stories can be individualized <i>a priori</i> (or adaptively as a session progresses, but this is future work)
Effects of adaptation/puppeteering/tailoring.	Robot seeks interaction with the child.	Real time movement of Robota's limbs and head in response to the child's reaction.	Choice of number and type of stories presented. Improved draggability of pictures.
Illustrative behaviours and emotions elicited.	i) enjoyment ii) turn-taking iii) play behaviour	i) enjoyment ii) imitation iii) joint attention	i) enjoyment ii) co-operation and shared experience iii) problem solving iv) story completion

4. Conclusions

In the Aurora project we are not seeking to promote one type of interactive system. Rather we explore the design space of interactive systems in the context of focussed studies. We thus use a variety of approaches tailored to the research topic itself (using, for example, different types of system to explore imitation and narrative); the needs of specific groups of children given the heterogeneity of the group as a whole; and the needs of specific individual children. Significantly for assistive technologists, it is common for people with autism to have difficulty generalizing, in particular in applying what is learnt in one context to another context. Future work must address this issue.

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