Touchscreen-Mediated Child-Robot Interactions Applied to ASD Therapy*

Paul Baxter[1][‡], Silviu Matu[2], Emmanuel Senft[1], Cristina Costescu[2], James Kennedy[1],
Daniel David[2] and Tony Belpaeme[1]

Abstract— Robots are finding increasing application in the domain of ASD therapy as they provide a number of advantageous properties such as replicability and controllable expressivity. In this abstract we introduce a role for touchscreens that act as mediating devices in therapeutic robot-child interactions. Informed by extensive work with neurotypical children in educational contexts, an initial study using a touchscreen mediator in support of robot-assisted ASD therapy was conducted to examine the feasibility of this approach, in so doing demonstrating how this application provides a number of technical and potentially therapeutic advantages.

INTRODUCTION

The application of robots to aid in the therapy of children with Autistic Spectrum Disorders (ASD) has become increasingly established [1], [2], with evidence suggesting that it can provide beneficial outcomes for the children [3]. In addition to this, recent efforts have emphasised providing an increasing degree of autonomy for the robot [4].

Providing such autonomous behaviour in interaction contexts is a challenging task, with sensory and motor limitations imposing a number of constraints. In our previous work, we have developed a methodology that makes use of a touchscreen mediator between children and robots to overcome a number of these difficulties: the Sandtray [5]. In this setup, a child and a robot engage in a collaborative task that is provided on the touchscreen (e.g. sorting of images into categories). The Sandtray has been successfully applied to a range of neurotypical child-robot interaction studies in various contexts, for example behavioural alignment [6], education [7], and others. As the Sandtray was inspired by the therapeutic intervention of sandplay (with this having proposed advantages for children with ASD [8]), we now seek to apply this same methodology to robot-assisted ASD therapy.

Touchscreens (without the robot) have found previous applications to this domain [9]. For example, a touchscreen has been used to enforce collaborative activity between pairs of children with ASD, resulting in an increase in coordination and negotiation behaviours [10], a finding supported elsewhere [11]. Furthermore, there have been attempts to enable sandplay therapy-like interactions with touchscreens [12],

[1]Centre for Robotics and Neural Systems, The Cognition Institute, Plymouth University, U.K.,
[2]Department of Clinical Psychology and Psychotherapy, Babes-Bolyai University, Romania
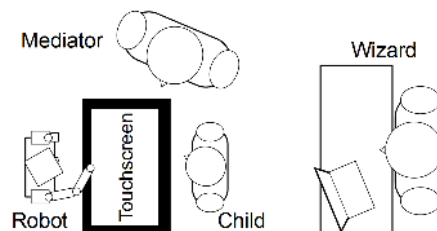[‡]paul.baxter@plymouth.ac.uk

Fig. 1. Indicative setup and use of touchscreen for child-robot therapeutic interaction - robot is controlled by a wizard, and the mediator provides input to interaction if needed (*not to scale; positions are indicative only*).

although our approach differs in both application context and involvement of the robot. These studies indicate the suitability of using touchscreens for children with ASD.

There are a number of advantages afforded by the use of such a mediating touchscreen in HRI. Firstly, it provides a shared space for collaboration that does not require complex manual dexterity for either the child or the robot; indeed it provides the same affordances for both interactants (pointing and dragging). Secondly, it reduces the sensory processing load (vision processing) on the robot since information on screen-oriented activity by the child can be obtained directly from the touchscreen. Thirdly, it provides a straightforward means of changing the task (or more broadly the interaction context) by just changing the images displayed on the screen: for instance, a sorting task can be appropriate for domains as diverse as mathematics and nutrition just by changing the pictures displayed.

The aim of this contribution is to motivate and illustrate how such touchscreen mediators can specifically serve as useful tools in the domain of robot-assisted therapy by first describing an application currently in progress, and then discussing the opportunities and challenges for the future.

APPLICATION CASE STUDY: TURN-TAKING

An initial application to ASD therapy has been implemented and evaluated. Turn-taking is an important social skill that is used as part of therapeutic interventions [13]. We have created an emotion image categorisation task (using *sad* and *happy* faces) on the Sandtray for a child and Nao robot to play, with robot verbal behaviour used to encourage turn-taking behaviours. For this study, the robot was explicitly remote controlled (*wizarded*) by a remote operator (fig. 1).

With a four year-old girl with ASD, six interaction sessions with the Robot-Sandtray turn-taking task were conducted over a period of four weeks. Other robot-based
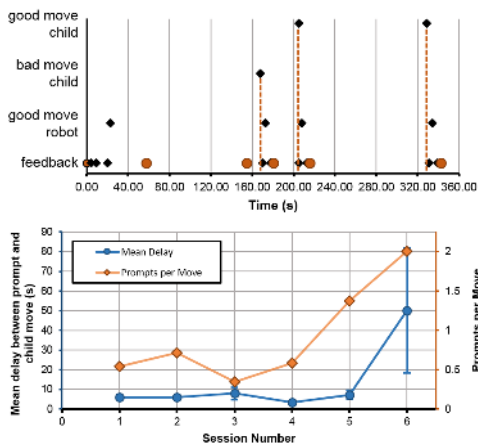
Fig. 2. (*Top*) Sample data from the sixth child-robot Sandtray turn-taking interaction session. The *feedback* was employed to encourage the child to move and to give them feedback. Orange circles indicate robot encouragements for the child to take a turn. (*Bottom*) Trends over six sessions, showing change in delay between robot prompt and the child moving, and the mean number of prompts per child move (*with 95% CI*).

therapy activities were conducted at a separate time. Each interaction had a mean length of 11:06 mins (*sd 5:03 mins*).

Since interaction data can be captured through the touchscreen, it is possible to retrospectively examine the events that occurred and their timing. Considering the relationship between robot encouragement and child moves in a single interaction (e.g. fig. 2, top), the data suggest that both the number of robot encouragement instances required before the child made a move, and the delay between suggestions and actual moves increases over time (fig. 2, bottom). A clinical explanation for this relationship is not proposed here, although the ideal behaviour in this context is a turn-taking interaction with the robot, without necessarily requiring explicit prompting. What can be noted though is that data such as these provide some insight into the interaction between the child and the robot over time.

DISCUSSION AND OPEN QUESTIONS

The examination and use of touchscreen-derived information has two benefits. Firstly, it may come to constitute an additional source of information for the therapist to aid in diagnosis or inform future therapy, with additional processing making aspects of emotion available for example [14]. The extent to which this is clinically useful is an open question that requires investigation. It should however be noted that we do not suggest that such data can replace traditional diagnosis information, rather that it can provide supplemental information. It should be further noted that the touchscreen-derived information alone is likely to be insufficient to provide a complete characterisation of the child's behaviour.

Secondly, since the information captured by the touchscreen is directly accessible to the robot system, it can be used by the robot to adapt its behaviour to the specific circumstances of an individual child in individual interactions, e.g. [6]. In the case of autonomous robot behaviour, such a

source of information that does not require the overhead of complex visual or audio processing is a significant benefit.

Extensive previous work has been conducted with this touchscreen mediated interaction between (neurotypical) children, and robots. While this has shown that the touchscreen effectively constrains the content of the interaction (thus facilitating robot autonomous behaviour) [15], it is an open question as to whether a similar effect (such as helping to maintain focus on the interaction) is observable for children with ASD, or over what time scales such an effect may be manifested.

To conclude, we have presented data from an example set of interactions between a child with ASD and a robot in the context of the Sandtray. This provides an illustration of the type of data that is readily available through the use of the touchscreen mediation technology. While further development and data collection is required (and is ongoing), we suggest that the use of touchscreens as mediators for child-robot interactions in the context of ASD therapy provides benefits in terms of behaviour characterisation and technical feasibility that should be further taken advantage of.

REFERENCES

[1] B. Robins et al, "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*, 4(2): 105–120, 2005.
[2] B. Scassellati et al, "Robots for use in autism research," *Annual review of biomedical engineering*, 14: 275–94, 2012.
[3] C. A. Costescu et al, "The Effects of Robot-Enhanced Psychotherapy: A Meta-Analysis," *Review of General Psychology*, 18(2): 127–136, 2014.
[4] S. Thill et al, "Robot-assisted therapy for autism spectrum disorders with (partially) autonomous control: Challenges and outlook," *Paladyn*, 3(4): 209–217, 2013.
[5] P. Baxter et al, "A Touchscreen-Based "Sandtray" to Facilitate, Mediate and Contextualise Human-Robot Social Interaction," in *7th HRI Conference*. Boston, MA, U.S.A.: IEEE Press, 2012, pp. 105–106.
[6] P. Baxter et al, "Cognitive architecture for human-robot interaction: Towards behavioural alignment," *Biologically Inspired Cognitive Architectures*, 6: 30–39, 2013.
[7] J. Kennedy et al, "The Robot Who Tried Too Hard: Social Behaviour of a Robot Tutor Can Negatively Affect Child Learning," in *10th HRI Conference*. Portland, Oregon, USA: ACM Press, 2015, pp. 67–74.
[8] L. Lu et al, "Stimulating creative play in children with autism through sandplay," *Arts in Psychotherapy*, 37: 56–64, 2010.
[9] W. Chen, "Multitouch Tabletop Technology for People with Autism Spectrum Disorder: A Review of the Literature," *Procedia Computer Science*, 14(1877): 198–207, 2012.
[10] A. Battocchi et al, "Collaborative puzzle game: a tabletop interface for fostering collaborative skills in children with autism spectrum disorders," *Journal of Assistive Technologies*, 4(1): 4–13, 2010.
[11] G. F. Mireya Silva et al, "Exploring collaboration patterns in a multitouch game to encourage social interaction and collaboration among users with autism spectrum disorder," *Computer Supported Cooperative Work (CSCW)*, 24(2-3): 149–175, 2015.
[12] M. Hancock et al, "Supporting sandtray therapy on an interactive tabletop," *28th CHI Conference*, pp. 21–33, 2010.
[13] C. A. Pop et al, "Enhancing play skills, engagement and social skills in a play task in ASD children by using robot-based interventions. a pilot study," *Interaction Studies*, 15(2): 292–320, 2014.
[14] Y. Gao et al, "What Does Touch Tell Us about Emotions in Touchscreen-Based Gameplay?" *ACM Transactions on Computer-Human Interaction*, 19(4): 1–30, 2012.
[15] J. Kennedy et al, "Constraining Content in Mediated Unstructured Social Interactions: Studies in the Wild," in *5th AFFINE Workshop at ACII 2013*. Geneva, Switzerland: IEEE Press, 2013, pp. 728–733.