*Short project report*

# Virtual reality and robots for autism: moving beyond the screen

## Introduction

The autism and technology field is growing rapidly, as evidenced by a proliferation of apps and environments designed for use by or with autistic people (Fletcher-Watson and Durkin, 2015). Many of these technologies have taken the form of targeted instruction or interventions which address the core deficits associated with autism (Odom et al., 2015; Grynszpan et al., 2014; Fletcher-Watson, 2014). Part of the desire to incorporate digital technologies into autism interventions stems from the seeming *affinity* that autistic people have with technology. Interactions with technology are typically predictable, endlessly repeatable, can be customised and tailored to individual users, and adapted to their changing needs. As such, they offer a "safe space" within which to learn and practice new skills. Technology is not without its critics, however, who cite its potentially high cost and lack of general availability as barriers to adoption, along with fears that technology use could exacerbate social isolation (S. Parsons and Mitchell, 2002).

## The 'Digital Bubbles' seminar series: The technology bubble

The 'Innovative technologies for autism: critical reflections on digital bubbles' seminar series is funded by the ESRC to explore and critically reflect on the design, development, evaluation and use of technology for, by and with autistic people. The first two seminars focused on innovative technologies for supporting social communication and engagement, respectively (S. Parsons et al., 2015; Yuill et al., 2015), while the third seminar considered the participatory design of such technologies (Brosnan et al., 2016). This paper adds a further perspective by focusing on recent innovations in the field,

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considering their relative affordances, costs and benefits, and the ways in which such technologies might mediate different types of interactions (human to human and otherwise)[1].

**Virtual Reality (VR) for assessment and intervention**

Thomas Parsons, from the University of North Texas, discussed the particular value of virtual environments (VEs) for neuropsychological assessment, as VEs can simulate real world contexts and everyday scenarios in ways that other approaches to assessment cannot. He argued that VE-based assessment can offer distinct advantages over paper-based or computer-based tests of cognitive constructs such as executive function, attention and memory. The simulation offered through VE technologies allows assessment to include multi-tasking, inhibition, and observation/enactment of real behaviours in real time, thus increasing ecological validity whilst maintaining the same levels of structure and control as laboratory-based experiments. Such simulations can also present stimuli to multiple modalities simultaneously (e.g. auditory and olfactory, in addition to visual), further increasing ecological validity. Although the high cost of VEs is a potential disadvantage, Thomas Parsons noted that mainstream consumer VR systems such as the Oculus Rift have brought the price down considerably.

Lina Gega, from Northumbria University, described technological interventions designed to be used in conjunction with Cognitive Behavioural Therapy (CBT). Gega described a unique VR environment in which individuals see life-sized projections of themselves interacting with specially scripted and edited video clips of everyday

[1]More information about this seminar, including presentation materials and video interviews of the speakers, can be found on the seminar website (www.digitalbubbles.org.uk).

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scenarios. Such a system is both cost effective and relatively easy to use whilst still providing the user with a realistic experience. In a study of anxiety and social phobias (Gega et al., 2013), positive results were obtained through the use of the VR system in conjunction with CBT, with participants noting that the anticipation of a situation was often more distressing than the actual experience. The affordance of the 'virtual' aspect of VR allowed participants to approach situations they had previously been reluctant to tackle. As it became easier for them to carry out certain behaviours in the VR system, they became more confident in trying out these behaviours in the real world. Indeed, one of the audience members, in reflecting on Gega's talk, commented that:

> *' NOT being "real" has a benefit – can enable people to challenge own thinking...'*

Overall, the discussion of these different applications of VR technology highlighted that *simulation* remains an important and beneficial line of enquiry for the field. It positions the technology as a tool through which authentic responses can be encouraged and observed, and where the line between real and virtual represents an interesting quandary. On the one hand, the more blurred the line, the greater the potential ecological validity of VR. On the other hand, a more distinct line between real and virtual can be helpful for encouraging initial exploration of anxiety-provoking situations since it is clear that the virtual scenarios are (deliberately) *not the same as* the real world. The extent to which the line is deliberately distinct or blurry, and the relative advantages of this for different objectives, are major research questions that remain to be explored. This point aligns with questions raised at the first seminar about the increasingly artificial distinction made between the digital and the real world, as

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technologies become more pervasive and embedded in everyday life (S. Parsons et al., 2015).

**Technologies for embodiment and interaction**

In contrast to the use of technology for *simulating* real world interactions, two of the speakers positioned technologies as media for *supporting* real world interactions.

Narcis Parés and his colleagues from the Universitat Pompeu Fabra in Barcelona have designed a number of large-scale technology environments for children with autism which aim to support spontaneous, unscripted interaction, and are very different from standard PC, laptop, tablet, or smartphone technologies. All of the environments have been designed to support full body interaction, allowing children to interact with the environment, and with others in the environment, through movement, gestures and touch (Mora Guiard et al., 2014).

Parés presented a series of environments based on Embodied Cognition, a theoretical perspective which highlights the importance of embodiment for social perception and social understanding (di Paolo et al., 2010). He first described a multisensory environment for children with severe autism, developed within the MEDIATE project (Parés, 2005). The environment incorporated numerous multimodal stimuli designed to encourage playful interaction and give children a sense of control over the environment and, ultimately, a sense of agency, something that is frequently absent from their daily lives. Parés also discussed incorporating elements of surprise and unexpected events as triggers for spontaneous social interaction, as well as game play situations which require collaboration or help from others in order to progress. In

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Pico's Adventures (Malinverni, 2016a), game play was physically controlled, with collaboration requiring coordinated movements and gestures with others. In Lands of Fog (Malinverni, 2016b), pairs of children explored a virtual land initially covered by fog. Interaction with the other child, although not required for play, could be unobtrusively scaffolded by surprising and exciting events that occur when children are in close proximity to each other.

Parés' work as a whole highlights the fact that communication and interaction extend beyond verbal exchanges to include such physical manifestations as interactional synchrony, collaborative behaviours, and proximity. Rather than focussing on the technology itself, Parés recommends that designers first consider the types of communication and interaction they wish to foster. Only then should they think about the properties and affordances of specific technologies (and/or configurations of technologies), and the ways in which these properties might support and motivate the desired interactions.

Similarly, Ben Robins, from the University of Hertfordshire, considered the role of robots as motivators for social interaction skills, noting that their use with autistic individuals offers a number of benefits. For a start, human social behaviour can be very subtle whilst appearing wildly unpredictable to a person with autism. Robots can provide a context which is simplified, safe, predictable and reliable. Furthermore, the complexity of interaction can be tailored and adapted to individual children as appropriate. Finally, real time interaction in playful scenarios allows for full body interaction (similar to Parés' work), providing opportunities for researchers to study the role of body movement and gaze in social interaction. Like the other speakers,

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Robins was keen to emphasise the role of robots as mediators of, rather than replacements for, human-human interaction.

Robins described work examining the influence of a robot's physical appearance on children's interactions with it (Robins et al., 2006), where researchers found that children appeared to prefer robots with very plain features, perhaps because of their simplicity. Robins then described work with KASPAR, a robot who is clearly non-human, but has some recognisable human features (Robins et al., 2009). KASPAR became, for children with autism, an "attractive object of shared attention", leading them to exhibit interaction skills that they were not previously thought to possess.

Robins concluded with a question around how best to evaluate the effectiveness of technologies for autism. The heterogeneous nature of autism makes between-group comparisons difficult. Furthermore, using a neurotypical control group to evaluate technology not originally designed for them seems inappropriate. Although randomised control trials (RCTs) are the "gold standard" of evaluation, are they necessarily the most appropriate, or would qualitative methods, such as case studies, provide a more ecologically valid account of technology use *in situ*? These important methodological questions link to those raised at the third seminar (Brosnan et al., 2016).

**Key messages**

A number of common themes emerged from the day's presentations and audience discussions.

*Technology as a tool*

All speakers agreed that technology is just one tool, amongst others, for use by practitioners, therapists, teachers and carers. Furthermore, its use should not simply

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replicate existing practice (particularly when the desired outcomes can be achieved by less costly, more accessible means). As Thomas Parsons noted, new technologies are of interest to the extent that they allow us to ask new questions. New answers to these questions might in turn inform the development of new approaches, interventions and understandings for people with autism.

*Humans in the loop*

Technology should not be a substitute for human expertise or human-human interaction. Thomas Parsons noted technology's role in providing practitioners with more fine-grained, ecologically valid information during assessment, while Gega noted its role in treatment as a space for individuals to practice skills taught in therapeutic sessions. Parés and Robins both stressed technology's ability to mediate and scaffold human-human interactions, in some cases providing people with "something worth communicating about" (Alcorn et al., 2013). In all cases, the speakers highlighted the importance of considering technology in the context of human-human interactions, where technology becomes part of a communicative loop, rather than replacing individuals within the loop.

*Avoid focusing on specific technologies*

Debates in the field often focus on a particular technology, e.g. "Are robots / virtual environments / social media helpful or harmful for autistic people?". Both Parés and Robins highlighted the need to look instead at the specific features, characteristics and affordances of a given technology, and to carefully consider how these features might support and motivate the specific behaviours and interactions we wish to encourage.

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*Context and the 'whole person'*

All of the technologies placed a high value, implicitly or explicitly, on naturalistic contexts, and on engaging with the whole person. The everyday contexts provided by VR systems allow practitioners to study realistic behaviours, which can lead to more accurate diagnoses and/or more targeted support. Similarly, both robots and full body interaction technologies allow people to interact not just verbally, but through movement and gesture. From a theoretical perspective, such technologies might provide a means for better understanding the relationship between embodiment and the development of social understanding.

*The importance of interdisciplinary teams*

The design of any new technology requires the concerted efforts of an interdisciplinary team. It should be grounded in the substantial body of theoretical and empirical knowledge emanating from fields such as psychology, education and neuroscience, and incorporate the expertise and experience of practitioners. Perhaps most importantly, the ultimate users of such technologies should play a pivotal role in their design, and have a voice in the initial decisions around what is designed for them, and how. Again, these messages resonate strongly with previous discussions (Brosnan et al., 2016) and are recurrent, and important, themes for the field.

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## References

Alcorn, A. M., Pain, H., and Good, J. (2013), "Discrepancies in a virtual learning environment: something worth communicating about for young children with ASC", In *Proceedings of the 12th International Conference on Interaction Design and Children*, ACM, pp. 56-65.

Barry, O. (2015), *A video-based virtual environment for teaching social skills to adolescents with autism: in search of generalisation* (Doctoral dissertation, Cardiff University).

Brosnan, M., Parsons, S., Good, J. and Yuill, N. (2016), "How can participatory design inform the design and development of innovative technologies for autistic communities?", *Journal of Assistive Technologies.* Vol. 10 No. 2, pp. 115–20.

Di Paolo, E.A., Rohde, M., and De Jaegher, H. (2010). "Horizons for the enactive mind: Values, social interaction, and play." *Enaction: Towards a new paradigm for cognitive science*: 33-87.

Fletcher-Watson, S. and Durkin, K. (2015), Uses of new technologies by young people with neurodevelopmental disorders: Motivations processes and cognition. In D. Riby and J. ven Herwergen (eds.) *Neurodevelopmental Disorders: Research Challenges and Solutions*, Psychology Press, Taylor and Francis Group, London UK.

Fletcher-Watson, S. (2014), "A targeted review of computer-assisted learning for people with autism spectrum disorder: Towards a consistent methodology", *Review Journal of Autism and Developmental Disorders*, Vol. 1 No. 2, pp. 87–100.

Gega, L., White, R., Clarke, T., Turner, R., and Fowler, D. (2013), "Virtual environments using video capture for social phobia with psychosis", *Cyberpsychology, Behavior, and Social Networking*, Vol. 16 No. 6, pp. 473-479.

Grynszpan, O., Weiss, P. L., Perez-Diaz, F., and Gal, E. (2014), "Innovative technology-based interventions for autism spectrum disorders: A meta-analysis", *Autism*, Vol. 18 No. 4, pp. 346–61.

Odom, S. L., Thompson, J.L., Hedges, S., Boyd, B.A., Dykstra, J.R., Duda, M.A., Szidon, K.L., Smith, L.E., and Bord, A. (2015), "Technology-aided interventions and instruction for adolescents with autism spectrum disorder", *Journal of autism and developmental disorders,* Vol. 45, no. 12, pp. 3805-3819.

Malinverni, L., Mora-Guiard, J., Padillo, V., Valero, L., Hervás, A., and Parés, N. (2016a), "An inclusive design approach for developing video games for children with Autism Spectrum Disorder", *Computers in Human Behavior*.

Malinverni, L., Mora-Guiard, J., and Parés, N. (2016b), "Towards methods for evaluating and communicating participatory design: A multimodal approach", *International Journal of Human-Computer Studies*, Vol 94, pp. 53-63.

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Mora Guiard, J., Malinverni, L., and Parés, N. (2014), "Narrative-based elicitation: orchestrating contributions from experts and children", In *Proceedings of the extended abstracts of the 32nd annual ACM conference on human factors in computing systems*, ACM, pp. 1159-1164.

Parés, N., Masri, P., van Wolferen, G., and Creed, C. (2005), "Achieving dialogue with children with severe autism in an adaptive multisensory interaction: the "MEDIATE" project", *IEEE Transactions on Visualization and Computer Graphics*, Vol. 11 No. 6, pp. 734-743.

Parsons, S., and Mitchell, P. (2002). "The potential of virtual reality in social skills training for people with autistic spectrum disorders", *Journal of Intellectual Disability Research*, Vol. 46 No. 5, pp. 430-443.

Parsons, S., Yuill, N., Brosnan, M. and Good, J. (2015), "Innovative technologies for autism: critical reflections on digital bubbles", *Journal of Assistive Technologies,* Vol. 9 No. 2, pp. 116–21.

Parsons, T.D. (2015a), "Ecological validity in virtual reality-based neuropsychological assessment", In Mehdi Khosrow-Pour (Ed.), *Information Science and Technology, Third Edition* (pp. 214- 223), Hershey: IGI Global.

Parsons, T.D. (2015b), "Virtual Reality for Enhanced Ecological Validity and Experimental Control in the Clinical, Affective and Social Neurosciences", *Frontiers in human neuroscience*, 9.

Robins, B., Dautenhahn, K., and Dickerson, P. (2009), "From isolation to communication: a case study evaluation of robot assisted play for children with autism with a minimally expressive humanoid robot", In *Second International Conferences on Advances in Computer-Human Interactions*, IEEE, pp. 205-211.

Robins, B., Dautenhahn, K., and Dubowski, J. (2006), "Does appearance matter in the interaction of children with autism with a humanoid robot?", *Interaction Studies*, Vol. 7 No. 3, pp. 509-542.

Vereenooghe, L., Gega, L., Reynolds, S., and Langdon, P.E. (2016), "Using computers to teach people with intellectual disabilities to perform some of the tasks used within cognitive behavioural therapy: a randomised experiment", *Behaviour research and therapy*, Vol. 76, pp. 13-23.

Yuill, N., Parsons, S., Good, J. and Brosnan, M. (2015), "Knowing me, knowing you: perspectives on awareness in autism", *Journal of Assistive Technologies.* Vol. 9 No. 4, pp. 233–38.

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