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Use, Understanding and Learning in Virtual Environments By Adolescents With Autistic Spectrum Disorders

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Abstract: *There has been increasing interest over recent years in the application of virtual reality technology to facilitating skills and understanding for children with autistic spectrum disorders (ASDs). This paper presents a summary of a series of studies that sought to investigate three main research questions; would adolescents with ASDs be able to: (1) Use Virtual environments (VEs) appropriately? (2) Understand them as representational devices? (3) Learn new information from VEs about social skills? Overall findings suggest that some adolescents with ASDs can use, understand and learn social skills/conventions presented in VEs although some students with lower verbal IQ and weak executive skills benefited less from this kind of intervention. An important consideration for future research is the role of the facilitator in 'scaffolding' participants' use of the VEs. If the aim is to provide effective educational support, to what extent is it useful to try to separate the effect of the VE from the role of a facilitator?*

INTRODUCTION

At the time of writing, even a cursory search on the Internet for "Autism and Virtual Reality" reveals a wealth of hits reflecting the growing interest in the application of advanced technology to the educational realm of children with autistic spectrum disorders (ASDs). According to the National Autistic Society (NAS) in the UK this is part of a trend that has recognised the benefits of computers more generally for people diagnosed with the disorder, which is characterised by severe social and communicative deficits:

> "Because computers offer a context-free environment in which many people with autism feel comfortable, therapists and teachers are increasingly using virtual reality tools to teach life skills, such as crossing the road, and social skills, such as recognising emotions in other people"[15]

However, despite the burgeoning number of Internet hits, there has actually been little in the way of published, peer-reviewed, systematic research investigating the usability and potential of virtual environments (VEs) specifically for people with ASDs. There are good reasons for wanting to know more about this topic though because there are ostensible pros and cons to the approach. On the plus side, there is growing evidence that computer-based educational applications have resulted in significant improvements in the target behaviours or learning objectives for children with autism[4,10,13, 22, 2] which suggests that virtual reality could be a useful addition to any educational ICT toolkit. Doubts about the usefulness of VR for people with ASDs arise though when considering a particular aspect of the disorder: the difficulty in understanding people's behaviour and intentions in the real world, let alone within the realms of a virtual one[19]. It perhaps seems counterintuitive to facilitate social understanding or communication in the real world by immersing people in a virtual one!

However, the optimism for using VEs with people with ASDs is based on an important premise which is that interactions or experiences in a virtual world may be less threatening for people with ASDs compared to the real world because many of the inputs of real world interaction (which people with ASDs often find very confusing) can be directly controlled or manipulated. This potentially allows a forum where behaviours and responses can be practised and built-upon in a context that shares some similarities with the real world, thereby offering greater potential for generalisation. As the NAS note though, the most important feature of VR is safety: "Above all, VR offers a safe learning environment in which the individual may make

Key	
1	Choose level of difficulty within the VE by pressing corresponding number on keyboard
2	Click to hear overall task
3	Tasks and speech are heard and read simultaneously
4	Click to sit down at the table
5	Icons appear here to pay for items
6	Click to ask a question (or, when a thought bubble appears, find out what another person may be thinking)

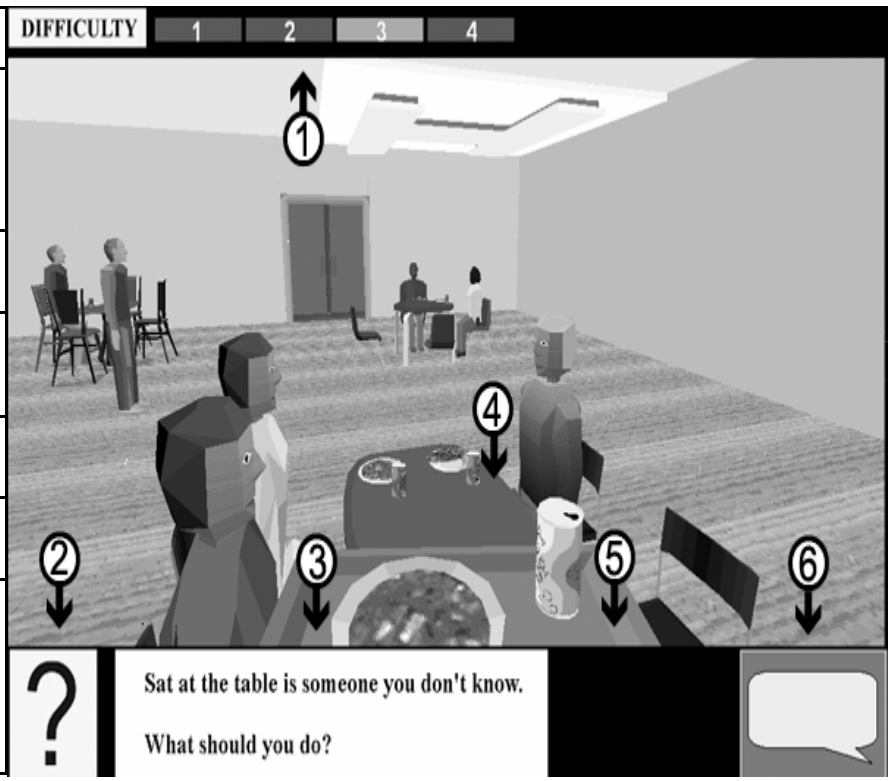


Figure 1. Screen shot of café VE illustrating the key functions of the program

mistakes which might be physically or socially hazardous in the real world" [15].

The pioneering work of Strickland[24, 23] provided an initial demonstration that young children with autism could respond appropriately to a virtual scene presented in a head-mounted display. However, the small sample size, coupled with concerns over the acceptability of the heavy headset and lack of any comparison participants meant that the results were limited. Other published articles considered the value of VEs for people with ASDs[6, 25] but (at the time) contained no practical demonstrations of their use. Consequently, there was a clear need to conduct some systematic research to consider fundamental issues about usability and interpretation; in particular, whether people with ASDs could understand a virtual environment as something that *represented* reality; that is, understand important differences between virtual and real worlds but also realise that virtual environments have enough similarities to the real world to usefully inform them about the latter.

In a three-year multidisciplinary research project based at the University of Nottingham, UK (for background information on *AS Interactive* see Beardon et al., 2001; Parsons et al., 2000) we made a start at investigating some of these issues and aimed to answer three main research questions: would adolescents with ASDs be able to (1) use the VEs appropriately? (2) understand the VEs as representational devices? (3) learn new information from VEs about social skills?

The main studies and findings are summarised below, followed by some speculation about the direction of future research in this field.

SUMMARY OF GENERAL METHODOLOGY

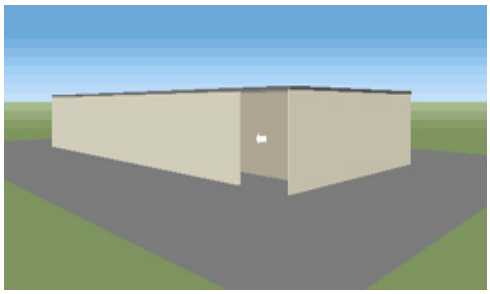
In total, there were two types of VEs – a café and a bus – both of which were presented to participants on a laptop (with a Pentium 3 650MHz Processor, 64 Mb RAM and Windows 98), but could also be used on standard desktop PCs. VEs were navigated with a USB joystick, and objects selected with a standard mouse. Not all studies used both VEs; initially the café environment was used and the bus environment added in later studies. Environ-

ments were built using Superscape Version 5.5 and run using the Superscape Visualiser. The VEs were 'single-user', meaning that only one person could navigate the scene at any one time. The content of the café and bus environments were developed from a series of design iterations[17, 7, 16], so we were confident that the scenarios were easily recognisable and usable for our target participants. Feedback and instructions for users were provided through textual and audible prompts from the programme. There were also a number of functions, represented by icons on the screen, which users could access, such as clicking on a speech-bubble icon to ask a question (see Figure 1).

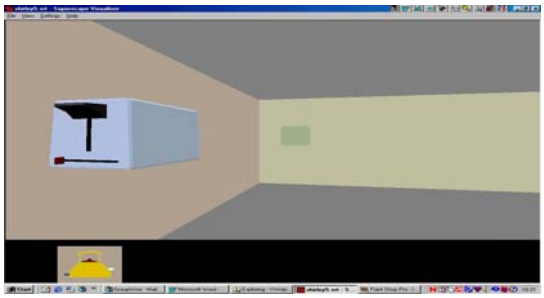
SUMMARY OF STUDIES AND MAIN FINDINGS

Study 1: The first formal study included a group of adolescents with ASDs, and two non-autistic comparison groups – one matched according to verbal IQ (mean = 69) and the other to non-verbal IQ (mean = 92). Participants were seen individually and used a training VE, which was a single-user environment navigated with a joystick and interacted with via a standard mouse. The training environment consisted of a simple building surrounded by open space (see Figure 2a). Inside the building, there were maze-like corridors (see Figure 2b). Moving around the outside and inside of the building enabled participants to practice manoeuvring in open and confined spaces, respectively. A large room was at the end of the corridor, which contained eight different objects. The objects could be seen only as a green square from a distance, but were revealed automatically as the user moved closer (Figure 2c). Clicking on an object with the mouse moved the item to the black display bar at the bottom of the screen (see Figure 2c in which the kettle has already been selected). There were five training environments in total and participants were required to find a series of four objects in a randomised order, shown on a card visible throughout the procedure (for further details see Parsons, Mitchell & Leonard, 2004).

Over four separate trials, participants with ASDs improved significantly in the time spent completing these tasks, compared to the VIQ-match group, who did not improve significantly. Crucially, by the end of the four trials, the participants with ASDs were not significantly differ-



A.



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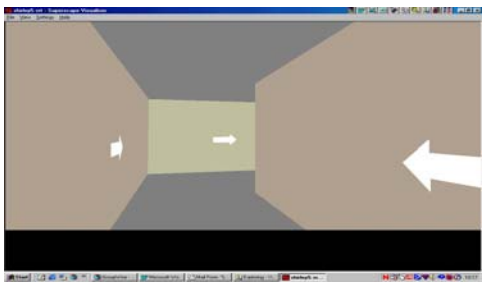
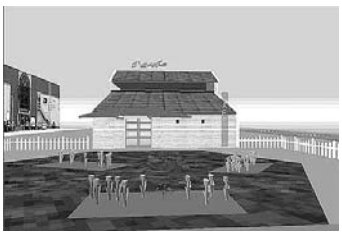


B.

D.

2 (a) Outside view of the training environment
2 (b) Corridor in the training environment
2 (c) Near and distant views of objects in the training environment
2 (d) Scene from the Virtual Café


A.

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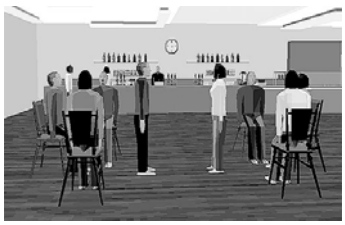
C.

Figure 3(a) starting point; 3(b) approaching the café; 3(c) approaching the counter

ent from the PIQ-match group in time taken to complete the tasks.

In addition, all participants were required to complete a number of tasks in a virtual café (an earlier version to that depicted in Figure 1 taken from Brown et al., 1999), such as find somewhere to sit, order and pay for some food, and move to the counter to order a drink. Participants were also asked to make links, as well as suggest differences, between virtual scenes encountered in the virtual cafe as well as a similar videoed scene including real people in a real bar. A video representation is different from virtual reality in the sense that it is a photo-realistic representation, which is familiar to people through the use of television and other videos. A virtual environment, by contrast, is less familiar to many people and is a more abstract form of representation. Comparing these representations enabled us to see whether participants interpreted them in similar ways. The majority of participants with ASDs understood the VE as something that represented, but was not identical to, reality. That is, they said that virtual people in the scene were talking to each other or to the barman even though they were not actually talking, but were oriented towards each other in such a way that suggested interpersonal interaction. In addition, the majority of participants with ASDs also acknowledged important differences between the VE and the video; that the people in the VE were not real but the people in the video were.

Most participants also completed the tasks in the virtual café successfully, but the groups differed significantly in one important respect. When approaching the counter to buy a drink, the participants with ASDs were judged (by naïve observers) as significantly more likely to move very close to, or walk between a virtual couple stood at the bar, compared to both the VIQ- and PIQ-matched groups. This behavior seems socially inappropriate, especially as there was a large empty space at the bar, to the right of the couple (see Figure 2d).After ruling out a number of explanations, such as weak navigational and executive skills (behaviours involved in sequencing, planning and impulse control), it seemed possible that the participants with ASDs might struggle more than others with understanding the importance of personal space in social situations (at least as depicted in a virtual environment), despite understanding the appropriate representational character of VEs.

Study 2: A second study[21] explored whether participants with ASDs adhered to social conventions generally in VEs, such as avoiding walking across a neighbour's garden and respecting the personal space of people ostensibly engaged in conversation (see Figure 3).

The majority of participants with ASDs behaved in a similar way to non-autistic comparison groups by treating the VE like a game in most situations. That is, they often walked between the two virtual people en route to a counter in a virtual cafe, however members of the ASD group were less likely to remark that this was socially unacceptable than students in the comparison groups. Students with ASDs were also more likely to walk across a neighbour's garden compared to the PIQ-match group, and a third of the ASD group (4 out of 12) showed substantial 'off-task' behaviour. This involved them walking around the café, sometimes even behind the bar, and navigating up to other people in the scene. This behaviour was shown by students with low VIQ and weak executive abilities (as assessed by the Behavioural Assessment of the Dysexecutive Syndrome; BADS[26]), and

only by a subset within the ASD group. People in this subset were also unable/unwilling to comment on the links between the VE and 'real world' behaviour, even when compared to the VIQ-match group. Thus, it is possible that a minority of students with ASDs may struggle especially with understanding how the VE can inform them about reality.

By contrast, many of the comparison participants, but none in the ASD group, reflected on the fact that they would behave differently in real life because it was not socially appropriate to walk through people's gardens, or between people having a conversation, for example:

> 'In real life, I wouldn't go though the middle, but because it's VR you treat it differently – you know it's not real. [I was] just interested in the completion of the task' – PIQ-match student.

Interestingly, although in the minority, some participants who avoided walking between the two people en route to the counter were very sensitive to the social relevance of the virtual café (including some of the ASD students), for example:

> '… if there were two people facing each other, it looked like they were having a conversation. It would not be very good to walk through. If they had their backs to each other it would not make much difference which way I was going' – ASD student.

Thus, some of the participants with ASDs showed a good understanding of particular social conventions in the VE – namely, not walking across neighbours' gardens and not walking between people having a conversation. Nevertheless, these individuals were in the minority within the group – with the remainder unwilling to respond to questions or seemingly unaware of the real world implications of their behaviour. This was in contrast to the VIQ- and PIQ-matched groups, who seemed more willing to use the path/pavement at the start of the task and more aware of how their behaviour in the VE related to real world social conventions. Taken together, the first two studies provided some in-depth information about how a group of adolescents with ASDs use and interpret VEs. In particular, there was evidence to suggest that they were on a par with typically-developing counterparts in their ability to use the VEs, and understood the scenes as appropriately representational. By contrast, the main weaknesses for participants with ASDs seemed to be in the social domain – reinforcing the view that VEs could offer some support in this area by presenting scenes and ideas that were not already well within the grasp of most students with ASDs. Thus, a remaining crucial question was whether participants with ASDs could *learn* specific social conventions using the technology.

Study 3: This was addressed in a third study[12], which included a group of six adolescents with ASDs. Participants used a new version of the virtual café with the learning objectives of finding an appropriate place to sit, and asking appropriate questions (Figure 1). Specifically, the aim was to help students understand that if there is a completely empty table available in a café then it is more appropriate to sit at it than with strangers, but if there are no completely empty tables free then it is appropriate to ask a question before sitting down (e.g.'Is it OK if I sit here?). The virtual café incorporated four different levels of difficulty as the user progressed; the café became increasingly busy and noisy, with fewer choices of appropriate seating. Participants used the VE, with the support of a facilitator (the researcher in this case) over a number of sessions. They were also asked to make judgments about where they would choose to sit, and why, in video clips of real cafes. The video clips, whilst not ideal, served as approximations to judgements about the real world. These were presented to participants for comment before and after VE use and naïve coders were asked to rate the explanations for social appropriateness.

Results showed that four of the six participants improved in their awareness of social conventions, both in terms of performance in the virtual café and in judgments and comments made in relation to the video clips. That is, a majority of participants were judged as providing more socially appropriate and insightful comments about where they would sit and why in relation to the video scenes, specifically following a session with the VE. An example of high-scoring reasoning was: "because no-one's sitting there,

I won't be in anyone's way", and of low-scoring reasoning: "so I can look at the windows".

The design of the study allowed us to pinpoint the improvement in understanding to the specific time of VE use, and not to general improvement in understanding over time. This was because whilst all participants received the same tasks, they were completed in a different order; for example, half the participants had sessions with the VE between the video measures at Time 1 and Time 2, whilst the remainder had their VE sessions between the video measures at Time 2 and Time 3. Gains in understanding should be apparent directly following VE but not necessarily during testing sessions that did not directly follow the VE. Importantly, the facilitator played a crucial role in the success of this approach, by helping the user to interpret, understand and discuss the social scenes depicted in the VE.

Study 4: Finally, after demonstrating successful outcomes in terms of use, understanding and learning in the first three studies, it was important to highlight the views of people with ASDs directly to gain a sense of how they viewed the VEs and whether they thought VEs could be useful to them in any way. Therefore, in the final study we adopted a case study approach with two adolescent males with an ASD and sought their opinions and comments over a number of sessions with the VEs, and during an informal interview[18]. Both students learned the target social conventions (these were the same as the third study) over the period of VE use, with the aid of rich discussions with the facilitator about social aspects of behaviour and what other people (in the virtual scene) could be thinking. In addition, both students commented on how the VE could be relevant to their lives, and one student excitedly remarked how he had used the information he had learned from the VE in a real life situation. He was travelling on a busy train in the summer break and there were few empty seats, so he asked a man if the seat beside him was free. The student said that he felt proud about asking the question because this was not something he would have usually done. In addition, he said how much the VE had helped him "Cause it could help me learn what polite and sensible things to do in public places" (student with ASD, aged 14).

CONCLUSIONS

Whilst anecdotal, comments like the one included above are extremely encouraging and add to our growing body of knowledge about whether, and how, people with ASDs can use, understand and learn from VEs depicting social situations. Overwhelmingly, the emerging picture from the four studies summarised here is a positive one, which can continue to be built upon in any future work. This is especially encouraging in the context of fairly limited functionality in the VE and the rather unconvincing representations of people in the scene, which were blocky and cartoon-like in appearance. Despite such limitations, many of the participants assigned representational qualities to the scene (being *like* reality in some respects but not *identical* to it) and enjoyed using the VEs. An important point to note too is that the VEs and learning objectives were designed with the input of teachers working with the participants and so were based on clearly identified needs. This was an essential part of the project and ensured that the research put the needs of participants first rather than pursuing worthy but perhaps esoteric agendas of the research team! Virtual environments and programming expertise can now accommodate far more sophisticated levels of representation as well as more finely tuned aspects of interpersonal behaviour including direction of gaze and conversation. Recent work from David Moore and his students in the UK, for example, has utilised collaborative virtual environments (CVEs) for investigating the usefulness of emotionally expressive avatars in communicative contexts for children with autism[9] as well as considering aspects of gender, personal space and anxiety, which could eventually be useful for children with autism[14]. The use of CVEs allows great potential for developing social and communicative skills in more dynamic (yet safe) environments than has hitherto been possible, thus offering greater potential for learning skills that are likely to be of use in the real world.

It is an exciting time for researchers because the potential for creating really beneficial outcomes for children with ASDs is a distinct possibility, although of course there is still a great deal to be done in research terms. There is also a need for researchers to be clear about their

aims and why participants with clinical diagnoses (including autism) are involved in studies; it could be too easy to pursue a line of investigation because it seems timely and interesting but ultimately of limited benefit to participants. There are essentially three main potential foci for 'Autism and Virtual Reality' research: what participants with autism can tell us about VR; what VR can tell us about autism and what VR can offer people with autism in terms of educational/learning needs.

In terms of what participants with autism can tell us about VR, there are substantial ethical concerns about including people with clinical disorders in research where the technology rather than the people is the primary focus. For example, the unique perspective that people with ASDs may have on the (real) world could tell us something interesting about the nature of VEs themselves, but is it ethically justifiable to pursue such a question by itself? Similarly, there is a query about what VR stands to tell us about the condition of autism *per se*? Despite substantial research on how non-autistic members of the population use, interpret and understand VEs, the links between virtual and real world behaviours are still not properly understood, including when and why people choose to apply real world conventions to virtual contexts and when they do not. Do we know enough about the use of VEs more generally to draw many conclusions about how or why participants with ASDs might respond in virtual contexts and how that links to real world understanding? Of course, answers to these questions may arise in the context of a project with a more educational focus (and this was certainly the case for the *AS Interactive* project) and would be interesting to know, but I would question using the above two foci as starting points. Instead, they could be questions that are tackled en route to a more outcome focused research approach, which provides something (however imperfect and limited) back to the relevant participant groups.

The main point is that the potential of VEs for providing powerful learning contexts for people who would really benefit from them should be the primary aim and driving force of research in this area. The question of 'what's in it for the participants?' should be at the forefront of researchers' minds as they contemplate how to take this work forward. This may mean adopting research approaches that take into account the importance of context and interaction around the computer when considering whether and how learning takes place. The challenge of this became most apparent for me in discussions about the role of a facilitator in the use of the VEs; that is, someone who sat alongside the participant and guided them verbally through the social situations depicted, perhaps asking the participant to clarify why they took that route or talking through the motive or reasoning for other people behaving in a particular way (see Parsons et al., in press and Mitchell et al., submitted).

Quite clearly, from an experimental research point of view, it becomes impossible to say what was really helping to do the job of learning; was it the 'experiential' nature of the VE and the opportunity to practice the behaviour repeatedly, or the interpretation and 'scaffolding' offered by the facilitator, or a combination of both? I would argue that, for me at least, it doesn't really matter all that much because learning coincided with use of the VE and so there was something about the context that was useful and important (Mitchell et al., submitted). Moreover, as Crook (1991) argues, the context of learning (e.g. within a classroom) should be a central consideration to the design and use of ICT resources because it is always within such a context that we would expect the real world outputs of our research to be used to (hopefully) beneficial effect:

"In order to expose where and how computers are proving potent, the design of evaluations must be sensitive to events that are taking place in the 'periphery' of the individual learner-computer interaction. In particular, evaluation should be amenable to the idea that properties of any computer application include the character of social processes that it supports during the circumstances of use" [8].

Separating out, or attempting to narrow down, the specific factors that promote learning may only be relevant if we are interested in claiming that VEs are *better than* other formats/tools/contexts for facilitating learning and I would question the usefulness of such a claim or pur-

suit of one. For if we are in the business of putting the needs of participants first and pursuing a research agenda that could be of substantial educational benefit to people with ASDs, then I think that VEs as an option amongst many for the promotion of learning is not only *good enough* but also *appropriate* and *desirable.* This will help to ensure that teachers, parents and therapists can be equipped with a toolkit of possibilities that could be used where appropriate with different children with very different needs. Ultimately, the children benefit if there are a range of stimuli and contexts in which learning takes place and that should be 'what's in it for them'!

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