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Virtual environments for social skills training: comments from two adolescents with autistic spectrum disorder

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Abstract

Previous research has shown that computer-based tasks can motivate people with autism and encourage learning. As a computer-based medium, Virtual Environments (VEs) offer a potentially useful tool for social skills training for people with autistic spectrum disorders (ASDs). However, there are some concerns over whether people with ASDs can understand, use and interpret the technology appropriately. This paper adopts a qualitative case-study approach to report observations of, and comments from, two adolescent boys with ASDs, gathered during a series of sessions using a virtual café and bus environment. Although there were signs of repetitive behaviours, literal interpretation of the scenes, and that the VEs were treated as not having real-world relevance, these were not the dominant modes of responding. Instead, participants seemed to interpret the scenes meaningfully and appreciated the opportunities to discuss appropriate social responses with a facilitator sitting alongside. They enjoyed using the VEs and provided specific examples of how the VEs had helped, or could help, them in the real world. This gives encouraging support for the idea that VEs can be used and interpreted meaningfully by at least some students with ASDs. The paper concludes with some considerations for the future development of VEs for members of this population.
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1. Introduction

Recent articles have demonstrated the ability of participants with autistic spectrum disorders (ASDs) to use and interpret Virtual Environments (VEs) successfully (Parsons, Mitchell, & Leonard, 2004), and learn simple social skills using the technology (Mitchell, Parsons, & Leonard, submitted). This builds on the early potential of VEs for members of the autistic population demonstrated by Strickland (1996) (see Strickland, Marcus, Mesibov, & Hogan, 1996), and suggested by others (e.g. Clancy, 1996; Trepagnier, 1999). People with ASDs can experience severe difficulties with, and anxiety about, social interactions including problems initiating and sustaining conversations, and understanding the implicit social rules that govern everyday behaviour (e.g. standing too close to others, pushing into a bus queue). This can lead to feelings of social isolation and extreme anxiousness, which can be especially pronounced for people at the 'higher-functioning' end of the spectrum with relatively normal verbal abilities because they are more likely to have an insight into their own disorder and feelings of difference from others (Ghaziuddin, Ghaziuddin, & Greden, 2002; Howlin, 1998).

VEs offer safe, realistic-looking 3-D scenarios that can be built to depict everyday social scenarios. The possibility of exploring these scenarios in real time makes them an extremely appealing tool for teaching social skills to people with ASDs (Parsons & Mitchell, 2002). Moreover, earlier research involving participants with ASDs using different computer-based packages has demonstrated the value of presenting tasks on a computer in order to enhance learning (e.g. Heimann, Nelson, Tjus, & Gilberg, 1995) and motivation (Moore & Calvert, 2000; also Chen & Bernard-Opitz, 1993). Research on the use of virtual environments by people with ASDs is still in its infancy so there is scant information about the sustainability or generalisability of outcomes. Nevertheless, studies involving other participants such as children with physical disabilities (Stanton, Wilson, Foreman, & Duffy, 2000) and adults with executive dysfunction (McGeorge et al., 2001) suggest comparability between performance in real and virtual contexts. Extending similar investigations to include participants with ASDs would provide important confirmation of whether transfer of understanding between contexts, and the sustainability of effects over time, is possible.

The present study represents a step towards this objective by utilising a qualitative, case study approach to investigate what adolescents with ASDs think about VEs and whether they think VEs could be useful to them. [1] A study on the generalisability of understanding would have questionable merit if the VEs made little sense to participants and were not considered relevant to experiences in their real life.

Comments from users and teachers suggest there is much to be gained from using the technology, not least because participants have been highly motivated by the VEs and teachers have been able to use them as prompts in small-group social skills teaching sessions (Neale, Leonard, & Kerr, 2002). For example, a female with an ASD, aged 15, said how much she liked the VEs and why they were useful for her:

[1] The study is part of a body of work carried out at the University of Nottingham, UK for the *AS Interactive* project, which has explored the potential of using desktop VEs for facilitating social skills for people with ASDs. Desktop VEs are those presented on a standard PC or laptop rather than using specialised 'immersive' equipment such as helmets or gloves. The project adopted a user-centred methodology that included direct consultation with people with ASDs and their teachers to determine specific learning needs and develop the VE programmes accordingly.

> 'I think it's brilliant. I really enjoy doing it and it may help me in the future because sometimes I have done the wrong thing' (Nottingham Evening Post, February 19th, 2002, p. 17).

In line with this person-centred approach, the purpose of this paper is to highlight some of the views of the VEs from two participants with ASDs with IQs in the 'normal' range (according to the Diagnostic and statistical manual of mental disorders – fourth edition (DSM-IV) published by the American Psychological Association, 1994, this is a full-scale IQ of 70 or above). Often, the voice of participants (especially those with special needs; Department of Health, 2001) remains unheard in many studies – perhaps necessarily so in order to focus on important and useful group differences. However, comments from the users potentially provide a rich source of information. Focusing on two participants allows us to track individual progress over a number of sessions, and allows an in-depth look at their comments. This adds an additional perspective to the work already completed, which has included larger samples of students with ASDs (Mitchell et al., submitted), as well as non-autistic comparison groups (Parsons et al., 2004; Parsons, Mitchell, & Leonard, 2005).

The importance of this combination of approaches in educational technology research is highlighted by Selwyn (2000) who suggests "...the addition of a qualitative dimension to education computing research allows a focus on what *does* happen (as opposed to what has apparently happened or what *could* happen)" (p. 95; emphasis in original). Thus, the following comments from users with ASDs are intended to provide a picture of the nature of exchanges taking place during computer-based sessions. The aim is to investigate whether there is any merit in some of the concerns raised about the use of VEs by people with ASDs. Although there are limitations to the study in terms of the small number of participants, this case study approach provides an opportunity to consider these issues in detail with the two participants.

In terms of the challenges faced by people with ASDs when using virtual technology, there has been concern about whether computer-based tasks, including VEs, are appropriate for promoting learning generally. For example, Howlin (1998) suggests that people with ASDs may find the 'non-social' nature of computer-based tasks so appealing that they become overly reliant on the technology at the expense of real world interaction. Latash (1998) makes a similar point regarding the use of Virtual Reality (VR) in rehabilitation settings: '...VR may become too safe and too attractive so that the patient can become a computer addict and reluctant to re-enter the real world' (p. 105). Thus, it seems more appropriate for social skills to be practised in supportive settings, alongside a facilitator, rather than in a context which replaces real world interaction altogether; a facilitator can play an essential role in shaping and scaffolding the learning experience for the user (Crook, 1991). In this way, the VE programs can be incorporated into classroom activity, avoiding criticisms of computers being used for meaningless stand-alone activity that may not promote desired learning (Crook, 1991; Nicol & Anderson, 2000). The overarching aim of this paper is to provide some examples of dialogue between the user and facilitator to illustrate the strength of this approach. In short, we hope to show that students are not simply placed in front of the computer in order to learn how to click the right buttons but are, instead, guided through some 'tricky' social situations with the help of the facilitator.

Aside from this more general aim, there are a number of specific considerations we hope to address. Firstly, perhaps people with ASDs could simply learn how the program should be used, rather than relate what they see to the real world. The tendency for people with ASDs to adhere to routines and rigid ways of responding (e.g. Frith, 1989), and also to interpret situations and

language in a literal, concrete way (e.g. Mitchell, Saltmarsh, & Russell, 1997), makes this a possibility. Responses from some (but not all) participants in previous studies suggest there was a tendency to tackle tasks in a repetitive way without considering the wider, social context (Parsons et al., 2005). Perhaps an indication of a failure to take on board the representational nature of the VEs used in the present study is a tendency to treat them like a game, rather than as something that has relevance to the real world. For example, some participants navigated through a neighbour's garden in the VE despite acknowledging that this would be an inappropriate thing to do in real life. Their justifications for this were along the lines of 'it's just a VE so it doesn't really matter'. This way of thinking could reduce the educational value of VEs; thus, users' comments and interactions in the VEs will be examined for evidence of rigid/repetitive, overly literal, or 'game like' (non-representational) responses, and what effect this seemed to have on their use and interpretation of the VEs. However, one explanation for why participants treated the VE like a game in Parsons et al. (2005) was that the repetitive nature of the task in the context of an experimental research paradigm may have encouraged this interpretation. The use of the VE in the present study is much less repetitive and more focused on learning which may increase the likelihood that behaviour in the VE may be linked to understanding of the real world.

An additional consideration for how users interpret the VEs is the tendency (for some participants) to 'test out' the options and possibilities offered by the program. This could be seen as a further indication that users consider the VE as a program to be played, rather than as a platform that offers a window on the social world. Mitchell et al. (submitted) showed that some participants demonstrated this tendency, for example, walking up to strangers in the virtual café to see what kind of response was made. This was seen as a positive aspect of VE use because it allowed exploration of concepts and interpretation and discussion of the social scene with the facilitator. On the other hand, the tendency to explore the VE was linked to weak executive and verbal abilities in Parsons et al. (2005), and such 'off-task' behaviour was not especially helpful to completing the required tasks. The issue of exploring the possibilities in the VEs will be considered below to see whether this helped, or hindered, participants' progress through the levels of the program.

Finally, one of the most important aspects of VE use by participants with ASDs, in educational settings, is their level of enjoyment. After all, years could be spent developing the perfect VE for social skills training, but if the user is bored by it, they will be extremely unlikely to use and learn from the program. Therefore, we wanted to form a sense of the degree of enjoyment from participants by considering their eagerness and readiness to complete the sessions, as well as any explicit acknowledgement that they were enjoying the experience.

To summarise, the main objectives of this study were to utilise the strengths of a detailed case study approach with two participants to:

(1) Investigate whether there are reasonable grounds for some of the above concerns around the use of VEs with people with ASDs in an educational context; specifically, whether participants relate their use of the VE to experiences in the real world and whether they enjoy using the VE.
(2) Provide examples of the exchanges taking place between the participant and the facilitator during use of the VE to illustrate the importance of the facilitator as well as the responses of the participant.

2. Method

2.1. Participants

John and Mike [2] are both males and were selected by their teachers for participation due to their relatively good verbal abilities. Both students were assessed for verbal IQ (VIQ), performance IQ (PIQ) and full-scale IQ (FSIQ) using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Their age and IQ scores are shown in Table 1. According to their Statements of Special Educational Needs, both boys were described as demonstrating behaviours associated, or consistent with, autism, including difficulties with social understanding. Parental permission for inclusion was obtained before the study commenced. Parents and teachers were also encouraged to talk to their children about the study before providing consent. In addition, the researchers met with the participants prior to the study to inform them about the project and answer any questions. At all times, participants were informed beforehand of when sessions were going to take place and were always given the opportunity to withdraw if desired. On all occasions, participants agreed to take part and did not withdraw at any stage. The VEs were not presented to the participants as specifically for people with ASDs, but as opportunities to consider social situations that some people may experience difficulty with.

2.2. Equipment

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. Environments 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 (Cobb et al., 2002; Kerr, 2002; Neale, Cobb, & Wilson, 2002a; Parsons et al., 2000), 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 Fig. 1).

2.3. The Virtual environments

The comments from users were gathered during a series of sessions using VEs of a café and a bus. The café VE has been used in previous studies with different participants (e.g. Mitchell et al., submitted), but the bus VE has not been tested before. Both VEs were developed after a number of consultations with autism professionals and people with ASDs, who advised on the relative importance of particular social scenarios and the frequency with which difficulties are typically

[2] Pseudonyms are used to protect the identity of participants.

Table 1
Background characteristics of participants

	Chronological age (years:months)	Verbal IQ	Performance IQ	Full-scale IQ
John	14:0	70	83	73
Mike	17:7	91	107	100

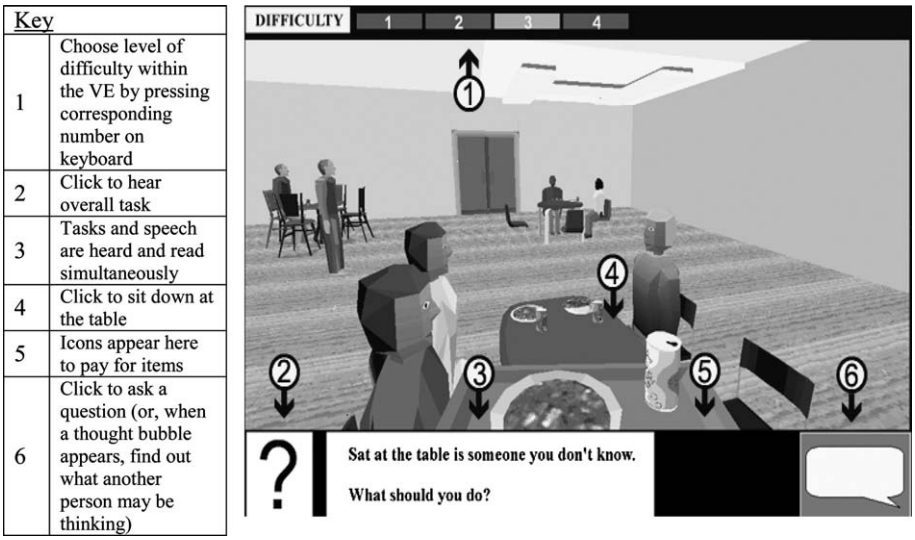

Fig. 1. Screen shot of café VE illustrating the key functions of the program.

encountered in those contexts. In both VE scenarios, the user's main aim is to find an appropriate place to sit, for example, sitting by oneself in an empty café, and with strangers (after asking an appropriate question) in a very busy café. On the bus, the user also has to find a place to sit, and scenarios include asking someone to move their bags so that they can sit down, and standing when there are no seats available. In both scenarios, users are required to queue appropriately and are provided with feedback from other customers if they push into the queue ('Excuse me, I was here first. You need to go to the end of the queue'). Verbal responses, providing both positive and negative feedback about the user's behaviour, are pre-programmed into the environments and activated by the user making a particular response.

2.4. Procedure

Both participants used the café and bus VEs over a number of sessions, in a structured format (see below). Video clips of real buses and cafes were also viewed by participants to ascertain whether any of the knowledge gained during use of the VEs would transfer to discussions of where to sit in a real café/bus. Additionally, there was a follow-up session after 3 months, to check whether any learning or understanding gained from the VE had maintained over the summer school break. A summary of general performance across these sessions is provided below, in addition to comments from, and observations of, the participants.

Structure and content of the sessions. Prior to the start of the study, the researchers joined in class activities on a number of occasions to familiarise themselves with the participants and the school. John and Mike were then seen individually (and always with a member of staff) on a number of occasions over a 3-month period for IQ assessments, video clip sessions and VE use. Sessions involving the VEs and video clips were videotaped for later analysis and were completed in the following order (each number represents a separate session with the participants, each session spaced by approximately a week except for a 3-week break between sessions 1 and 2):

1. *Wechsler Abbreviated Scale of Intelligence (WASI)*: Four separate standardised tasks designed to assess verbal and non-verbal intelligence. VIQ is assessed with the Vocabulary and Similarities sub-tests and PIQ with Block Design and Matrix Reasoning. This session lasted approximately 30–45 min.
2. *VE familiarisation*: Navigation with a joystick through 'training' VEs showing open and confined space (outside and inside a virtual building, respectively), and interaction with objects using the mouse. This session ensured users were familiar with the use of the joystick and the mouse for navigation and interaction with objects/text boxes on the screen and lasted approximately 20–30 min.
3. *Video clips*: Users viewed clips of real cafes and buses, some quite empty and others nearly full, and were asked to say where they would choose to sit and why. This session took approximately 10 min.
4. *Café VE*: With four levels of difficulty, from a scene with no queue in a quiet cafe with lots of empty tables, to a scene showing a long queue in a noisy café where users needed to 'ask' if they could sit with someone (by clicking on the speech bubble icon on the screen). The VE program and the researcher provided feedback about appropriateness of responses. The learning objectives were to queue appropriately, find a place to sit and ask an appropriate question where necessary (e.g. Is it OK if I sit here?) to a virtual person [3] in the scene. For both the café and bus VEs, participants began with the easiest level, containing the most prompts and easier social decisions, and progressed through to the hardest levels. They were encouraged to repeat a level if the learning objectives were not met, for example, if they did not join the queue in the appropriate place. This would not have been forced; if participants did not want to repeat the level at that time, they could have progressed to the next level, but on all occasions they were keen to repeat the level in order to obtain the pre-programmed positive feedback at the end: 'Well done. You have completed your task'. This session lasted 30–45 min.
5. *Bus VE*: With five levels of difficulty, from a scene with no queue for a quiet bus, to one with a long queue on a busy, noisy bus with no available seats. Users could also 'ask' a virtual person to move their bags from a seat if this was the only seat available, or stand in the aisle if there were no seats free. The learning objectives were the same as for the café VE with the addition of asking someone to move their bags from the seat. This session lasted approximately 30 min.

[3] This term will be used throughout the paper to refer to the virtual representations of people in the VEs. These are representations that are pre-programmed by the computer and not under the control of another user.

6. Café and bus VE: Both VEs, across all levels of difficulty, used in the same way as sessions 4 and 5, lasting approximately 40–50 min (there was less discussion during this session compared to the first time through).

7. Video clips: Same as session 3, using different clips. This session checked whether responses had changed during the period of VE use and lasted approximately 10 min.

8. VE follow-up and informal interview: This took place approximately 3 months after session 7, and was identical in procedure to session 6. Following their use of the VEs, users were asked some informal questions about the VEs and whether using them had made any difference to the way they approached situations in real life; this session lasted about 50–60 min.

3. Results and discussion

3.1. Summary of performance in bus and café VEs and video clips

As a descriptive, qualitative study with two participants and observational data it is not appropriate to use statistical analyses. Instead, what follows is a summary of how well participants tackled the demands of the VE programmes, how they responded to the video clips of cafés and buses, and whether their responses changed over time.

3.1.1. John

(a) VE sessions: During first use of the VEs (café followed by bus), John seemed to have a good awareness of the underlying social reasons for behaviour, for example, understanding that it was polite to queue appropriately. However, John did not seem aware of the convention of asking a stranger whether he could join them at their table in a busy café. The first time he experienced this situation in the VE he sat down without asking, at which point the virtual person sitting at the table said (according to a pre-programmed response) 'Excuse me someone is sitting there'. After a discussion about why the stranger may have said that, John repeated this error when he tried to sit at another table. In subsequent sessions, John did not make the error again and gave good reasons for needing to ask a question before sitting down: 'more appropriate!'. He also explicitly incorporated this knowledge into the next (busier) level of the café, without being prompted: 'I'll have to ask this man'. This suggests that John had learned about asking an appropriate question before sitting at a table with a stranger, and understood why this was necessary.

John extended this understanding to the bus VE and asked a virtual person whether he could sit next to them when there were no completely empty seats available. However, when the bus became busier and the only seat available was one which someone had put their bags on, John indicated that he would stand up at first, and only seemed to consider asking a question after he had been prompted by the researcher (who appears as 'F', for facilitator, in all dialogue excerpts):

F: It's a busy bus isn't it?

John: Oh there's nowhere to sit down. Only these seats. There's shopping bags on the seats. It's a bit tricky.

F: What do you think is tricky about it?

John: It's really packed

F: It is packed isn't it?

John: I'll just stand up

F: You could stand up 'cause it's busy. What else could you do if that person has a bag on their seat?

John: Ask them if they can put it on the floor

In other words, despite learning in the café VE that it is appropriate to ask people questions when you need to sit down, and applying this to the earlier levels of the bus, John did not spontaneously apply the same knowledge to a slightly different situation. Of course, John may have preferred to stand on the busy bus rather than ask someone to move their bags – the VE certainly allows this as a way of completing the task. The aim of the facilitator in the above excerpt was to make John aware of the alternatives in this situation and remind him that he had already seen another way in which he could proceed. This emphasises the benefit of using a VE – John tried out both responses and knew that he had a choice. On the second and third (follow-up) sessions with the bus VE, John spontaneously asked a question and required no further prompts from the researcher. Overall, although John required an initial prompt to remind him that he could ask someone a question, he very quickly learned that this was possible and responded in this way on later sessions.

(b) Video clips: One possible interpretation of John not making any errors in the VEs during his second and third sessions was that he could have rote-learned how to make the correct responses. However, his answers to questions about the video clips suggested that he had not simply learned which buttons to click, but had learned the underlying social concepts and used them appropriately. When shown a clip of a very busy café with no completely empty tables in his first video session (before his first VE session), the dialogue between researcher and participant went as follows:

John: It's a bit tricky...

F: Why?

John: There's lots of people sitting at most of them.

F: What could you do?

John: Wait for a table.

F: You wouldn't want to sit down next to someone you didn't know?

John: No.

F: What if they didn't move for a while and you were really hungry?

John: I'd be cross [corrects himself] – I'd cope really well.

F: Would you just sit down next to somebody?

John: Yes I would.

F: Just sit down?

John: Yes I would.

There was no suggestion from John of any awareness that it can be acceptable to sit with someone you do not know, after first asking them a question to see if a seat is available. This compared with his responses in the video clip session completed after his first VE session in which John immediately responded that he would ask someone whether he could sit with them, if the café was very busy:

John: It's a bit tricky.

F: Why is it tricky?

John: Coz there's a lot of people sitting...

F: What would you do if you were in that café?

John: Look for somewhere to sit and ask the person if I could sit with them.
F: Who would you go up to? Can you see the empty seat?
John: I could go and ask them if I could sit with them.
F: So, you could say...?
John: Is it OK if I sit here?

It appears that John did not know the social convention we were trying to teach before his use of the VEs, and this was evident both in his behaviour in the VE and his responses to the video clips. By contrast, after using the VE for the first time he learned the appropriate responses and transferred this knowledge to a discussion of what he would do in a real café, based on the scenes depicted in the video clips. This was also true for the bus VE, although it is not strictly necessary to ask someone on a bus if it is OK to sit next to him or her (based on our experience of social etiquette within a Western culture). Nevertheless, John applied his knowledge gained in the café VE to the bus VE and also the bus video clips, suggesting he was able to transfer his knowledge between VE contexts (bus to café) and between media (VE to video).

(c) Follow-up interview: This was completed 3 months after John had last used the VEs with the main aim of establishing whether John had remembered what he had learned and whether he had used this knowledge in real life settings. John explicitly recognised and spontaneously volunteered information about how he had used his knowledge gained from the VEs during the summer break:

F: In the summer holiday, did you go into a café or on a bus?
John: Not very much, but I've used public transport quite a bit – mainly went on the train to places like Manchester.
F: OK – and was there anything that you'd seen in the VE that you thought about on the train?
John: One time when I was on the way back from Nottingham the train was busy and there was hardly anywhere to sit, and I felt like sitting down so I said 'excuse me sir – is it OK if I sit here with you'.
F: And what did the man say?
John: That's OK.
F: And was that something that you remembered from using the VE?
John: Yes.
F: That's great. So you remembered that from the VE...and how did you feel when you were asking the man that question?
John: Quite proud.
F: Great, so do you think using the VE was useful to you?
John: Yes it was.
F: Can you just say in what ways you think it was useful for you?
John: 'Cause it could help me learn what polite and sensible things to do in public places.

John appeared to recognise the value of the VEs for himself and was pleased that he had been able to put what he had learned into practice. In addition, on a further visit to the school John approached the researchers and volunteered more information about a trip he had on the London Underground during the mid-term break. Again he asked someone if the seat was available and was excited that he had been able to do this. Whilst overall this suggests that John was able to learn new social knowledge from his experience with the VEs and use it in real life situations, the application of this knowledge to the Underground raises concern about inappropriate gener-

alization of social skills given that most people do not normally ask if a vacant seat is free in this context; rather they just sit down on presuming that it is free.

This observation is surprising given the rarity of generalization of newly acquired knowledge or skills in autism research (e.g. Howlin, 1998; Swettenham, 1996), although recent research has suggested some generalization of learning in some contexts (e.g. Bosseler & Massaro, 2003). Koegel, Koegel, and McNerney (2001) suggest that generalization of learning is linked to motivation and it could be that John was highly motivated by this particular task. This remains speculative and requires replication, extension and exploration in future research. A key point is that future VE development needs to carefully consider the specific contexts portrayed and the extent to which it may or may not be appropriate to generalize understanding from them.

A different interpretation for John telling us this information could be that he was eager to tell us what he thought we wanted to hear, rather than report what had happened. However, it seems implausible that John would have said any of these things simply to please us. Often, people with an ASD diagnosis find it difficult to consider the mental states and emotions of others and, as a corollary, are often very honest in their responses (sometimes to the extent of being thought rude). Thus, it does not seem very likely that John said these things simply to please us – it was more likely that he was being honest about his experiences and what he thought of them.

3.1.2. Mike

(a) VE sessions: On his first session in the café VE, Mike sat at a table with strangers without asking if a seat was available, prompting the programmed response from the stranger 'Excuse me, someone is sitting there'. After a lengthy discussion and much prompting from the researcher, Mike asked an appropriate question and was able to sit at the table, resulting in a response of 'Wow!' from Mike. On the next level, Mike spontaneously asked an appropriate question to a stranger sitting at a table, although did not seem to understand why this was necessary: 'Let's try the same trick again with these'. On his second session in the café VE, Mike again asked appropriate questions without prompting, although gave no verbal indication that he was aware of the reasoning behind this. It was not until Mike's final (follow-up) session with the café VE that he explicitly acknowledged why asking a question to a stranger in this situation was a good thing:

F: Do you remember what the best thing to do is?

Mike: Well, there's no other free tables…ask the person!

F: Why do you think it was a good idea to ask the person before you sat down?

Mike: Well, there's no actual law saying I can't sit there, but it's courtesy.

In the bus VE, Mike experienced fewer problems and always sat in a completely empty seat if there was one available. Therefore, he did not ask anyone on the bus whether he could sit down (although this is an optional question in the bus setting anyway). When Mike experienced level 4 on the bus VE – which required him to ask someone to move their bags from the seat so that he could sit down – he was noticeably flustered:

[Mike gets on the bus and collects his ticket]

Mike: Oh my God!

F: Is that what you think Mike, when you go on the bus? It's even busier.

Mike: It's not this nice Ooh shopping [points to bags on the only available seats]. Now they shouldn't really, now I don't think they're meant to do that and I would see that as rude actually.

F: I think some people do do that. It's a bit rude. The thing is, when they first got on the bus...

Mike: I would maybe do that, but if I saw somebody standing up, maybe, I would take the bags off.

After this, Mike thought he would stand up but, after some prompting, asked the person whether he could sit on the seat. The bags were moved and Mike sat down. On the following two occasions Mike used the bus VE, he was less flustered by the situation, yet still required some prompting to click on the speech bubble to ask the person a question. Generally, Mike soon became accustomed to the requirements of the VE programmes but seemed to struggle with some of the underlying social concepts at this time (see Section 3.2.2 for further details on this point).

(b) Video clips: During the video clip sessions, the difficulty Mike had in fully understanding the reason for asking a stranger whether he could sit at their table was confirmed. Even after using the café VE, and asking an appropriate question when there were no empty tables available, Mike did not utilise this knowledge when talking about where he would choose to sit in a real café. An excerpt from the video clip session, after using the VE, illustrates this point – Mike had just noticed a table with only one person and had decided he would sit there:

F: You'd just go and sit next to her would you?

Mike: Yes

F: Which seat would you sit on?

Mike: Maybe that one there [point to one nearest the camera]

F: And you'd just go up and sit down?

Mike: Yes

F: OK and why would you sit next to her rather than anybody else?

Mike: She's the closest one on the video. Doesn't always have to be a reason. You just focus on one chair and you go to it.

This final comment is insightful since it suggests that Mike was not considering the social aspects of where to sit in a café, and what others already seated in the café might think about his choice. Instead, Mike focused on the physical aspects of the environment (the chairs) and not on what he had learned during the VE sessions. As mentioned, however, Mike finally did give a social explanation for his seating choice in the follow-up session: 'it's courtesy', 3 months after his last use of the café VE. It may be that Mike needed more time to incorporate understanding of the rule into his usual way of thinking about things, which would have been missed if we had not conducted a follow-up session.

(c) Follow-up interview: Although Mike indicated he had not thought about the VE sessions during visits to cafés, or trips on buses during the summer break he nevertheless acknowledged that the VEs had been useful:

F: In terms of the café and bus [VEs], have you seen anything that could be quite useful?

Mike: Is there anything I saw and thought 'that's good'?

F: Yes

Mike: Learning me maybe how to ask people, maybe. I would be speechless if I had to come...I would just sit down!

F: So do you think that's something that might have changed after using the VEs?

Mike: Yes. I'm still very timid when I'm coming to ask people 'can I sit there please?' It's something that's difficult for me.

Although Mike seemed to struggle more than John with accepting and remembering the social responses that had been taught during the VE sessions, he mentioned the specific aspect with which he had previously encountered difficulties as the one factor that had been useful to him (asking a stranger a question). Perhaps, not surprisingly, the responses of these two adolescents with ASDs suggest that individuals will learn at different rates, and in contrasting ways. John was certainly more successful than Mike at understanding the underlying principles of the social skills and incorporating them into his real life (according to his self-report). Nevertheless, the fact that both participants did learn specific skills, and were able to say how the VE sessions had been of use to them, provides encouragement for the use of VEs in learning contexts in the future, and supports earlier work demonstrating the ability of participants with ASDs to learn effectively using this technology (Mitchell et al., submitted).

3.2. Challenges and strengths of this approach for people with ASDs

3.2.1. Repetition of responses

There was some evidence of repetitive patterns of use in our two users. For example, John and Mike navigated through the café environment in exactly the same way each time – although each chose different routes to get to the food counter. Mike seemed especially rigid, maintaining his path despite frequent encounters with chairs/tables along the way. That is, even with feedback about the environment from the visual scene (it was not possible to move forward any further whilst positioned very near to a chair), Mike failed to change his navigational route through the café. There was also some evidence of repetitive statements/verbal responses – especially from John.

However, other responses in the VEs were not rigid. John and Mike both changed their choice of food and question (Is it OK if I sit here? Is this seat available? Can I sit down?), and also sat in different places in the café and bus VEs. This suggests that they were not simply remembering and copying earlier, successful responses, but were responding differently to the changing demands of the VEs. In addition, when it was suggested to Mike that he could try taking a different route through the café to avoid bumping into chairs and tables, he did so without resistance. In line with empirical evidence (e.g. Krantz & McClannahan, 1993; Manjiviona & Prior, 1999), it seems that participants may struggle with *initiating* (some) types of responses, but not with *executing* the response once prompted.

3.2.2. Physical and literal interpretations

There was a great deal of evidence, especially from Mike, that he focused on literal interpretations of the scene. For example, he found it very difficult to understand why he could not sit in an empty chair when the person at the table said 'excuse me, that seat is taken':

Mike: Now they can actually – now is this true – can I ask if this is true? They can't actually stop you from taking a seat can they?

F: No, but if you were sitting...

Mike: It's not actually a law is it?

Mike found it difficult to understand the idea that someone can occupy social, rather than physical, space. There are many occasions on which a chair may be empty in a bar, restaurant or train, but we are told that someone is sitting there. Although a person is not physically occupying the seat at that moment, they can still stake a (social/psychological) claim to it if they intend to return. Mike struggled to accept that the seat could 'belong' to someone in that way, instead favouring a physical, literal reading of the situation. He appealed to 'laws' rather than psychological states to make sense of the situation and resolved this confusion by focusing on the need for people to leave physical markers to indicate where they were sitting:

Mike: If there was a tray there or something, then I wouldn't...That's how I would make sure people would know that I was sitting there – I would leave a tray...I'd leave something to tell people I was sitting there.

F: But if their friend had gone...to the toilet and was just about to come back

Mike: But the way I look at it is that it doesn't belong to them, it belongs to everyone. So I have the right to take it.

Mike returned to this subject many times throughout his use of the VEs and tried to understand why it is important to ask whether a seat is free. Eventually, he seemed to resolve this issue and recognised this was a courteous thing to do (see above), but it took a few months and a great deal of discussion to get to this point. Of course, it is possible that Mike could have gained this understanding in another way during the months between visits. At present it is not possible to attribute this change to his use of the VE and this is an objective that could be tackled in future research.

This tendency for literal interpretation represents a challenge for the use of VEs for people with ASDs because it highlights a particular cognitive weakness, that is, a difficulty adopting the perspectives of others and thinking about psychological states. However, the series of rich discussions around this topic, coupled with the fact that Mike returned to the topic many times to try to understand it, highlights the need for this kind of platform and suggests that we have developed it at the right level to potentially enable learning of new skills or concepts.

3.2.3. Treating the VE like a game

Mike made frequent references to the fact that he was interpreting the VE as a game 'I just use it as a game...a bit like my games at home'.

'I wouldn't do that really...but it's a game. If you're testing me, I'll go back again and do it the proper way'.

Nevertheless, despite stating this explicitly, there were a number of occasions when Mike seemed to interpret and respond to the VE as having real world relevance. For example, when choosing a seat on the bus Mike looked for one with sufficient legroom:

Mike: Now is there a front seat with legroom, or anything like that?

F: Is that why you like going at the front, because of the legroom?

Mike: Yes...No they're taken. I don't like side seats or backward seats, like that – faced backwards.

This excerpt suggests that Mike was thinking about how he would feel on a real bus and which aspects of the environment were important to him (having enough room, facing the right way). Arguably, if Mike had been thinking about the VE as a game throughout his sessions, these factors would not have been important in his choice of seating. Generally, although there may be intermittent tendencies for participants to treat the VE like a game, this did not occur in all situations. Moreover, the opportunity for promoting a 'real world' interpretation of the VEs, through discussion with the facilitator, suggests that even if users do not spontaneously apply this viewpoint, it can be encouraged during use.

3.2.4. Putting learning into practice

Some of the strengths of using VEs to teach social skills understanding to people with ASDs have already been touched upon in this article. In particular, whilst the two participants appeared not to learn initially from mistakes made early on in their VE sessions (e.g. sitting down without asking), the absence of further errors in later sessions of VE use show that the learning afforded by making the mistakes was soon incorporated into VE practice. It may be that participants with lower IQ profiles would take longer to learn the target social rules and take longer to put these into practice. Thus, it is possible that an approach involving limited verbal input would be preferable for participants with weaker verbal abilities.

3.2.5. Recognising changes and usefulness

Although conclusions from this study are limited due to the small number of participants, both our adolescent users commented on how the VEs had helped them and why they were useful. There have been statements of the value of VEs for people with ASDs (e.g. Clancy, 1996; Parsons & Mitchell, 2002; Trepagnier, 1999) as well as practical demonstrations of their use in these contexts (e.g. Parsons et al., 2004; Strickland, 1996). The addition of participants' explicit acknowledgement of the usefulness of the VEs to this growing body of evidence is encouraging, but would need to be investigated and replicated in a larger, more structured, evaluation study. Nevertheless, comments from Mike suggested he had some ideas about what VEs he would like to see developed in the future:

> 'I know what would be useful for me. 'Cause I'm wanting to learn how to walk safe from...my house to my Grandma's house...It's something that's a starter really. From A to B without any aid, that's my aim in life. So if I had a virtual route like that where you go through a city, or go down a road, and meet people...maybe people that you might not trust very much...and you're thinking 'what do I do?'...And it would help me to know if I come up against [it].'

A related point is that participants also recognised the increasing difficulty of the levels in both the café and bus VEs. For example, the excerpt included in Section 3.1.1(a), shows that John thought the fourth level of the bus VE was difficult because it was getting busier, and he repeated these comments about the higher levels of the café. Mike also noticed the changes and commented that the task had become harder as a result. This suggests that there was awareness from both

participants of the implications of the changes on subsequent social decisions in the VEs. Arguably, a lack of awareness of how the levels altered in difficulty may have indicated that participants were simply learning to click the right buttons in the right places, rather than considering a socially appropriate response.

3.2.6. Testing out' responses

Participants sometimes responded in a way that suggested they were testing the boundaries/responses of the VE, rather than behaving as they would in real life. Mike's comments included in Section 3.2.3, suggest this, as well as other statements made during the sessions, for example:

> 'Well, what happens to this? I'm just curious about this...I wonder if it will let me...'
> 'I wouldn't do it in reality, I'm just having a try – just to see what would happen'.

John also adopted this approach, although less often than Mike. For example, in the bus VE on level 4 where the user needs to ask someone to move their bags so that he can sit down, John clicked on the question choice 'Move your bags!', which prompted the rather grumpy pre-programmed response from the person 'You could say please!' John laughed and the facilitator said:

F: So why was he saying that to you?
John: 'Cause it wasn't polite to say it
F: So what could you have said that would have been better, do you think?
John: Please can you move your bags?

John knew that his first response was impolite but said it anyway, perhaps because he realised there were no real world consequences and he wanted to see what would happen. It appears that this is an important aspect of VE use because 'testing out' the possibilities affords crucial learning opportunities that may be missed if the participant learns only to click all the correct buttons. For example, saying the wrong or impolite thing in these circumstances leads to a verbal response from the programme suggesting the person is unhappy with the behaviour of the user. The user and facilitator can then discuss why that response was inappropriate, how the recipient would feel and what the user might consider doing next time to make their response socially appropriate. The VE can then be restarted so that the user can repeat the level until an acceptable response is made. In this way, the VE provides unique opportunities to learn from mistakes and practise the correct response until it is fully understood by the user. Crucially, these opportunities for learning and practise would not be available with in situ social skills training in a real café or bus, making this a key strength, and advantage, of VEs over real world training.

3.2.7. Enjoying the VE sessions

Both users seemed to be very motivated by the VEs, even after a number of (very similar) sessions, and both stated that they enjoyed the sessions. For example, John was motivated by making the 'correct' responses in the VEs:

F: Well done! That was excellent work.
John: I was really good at it!
F: Did you enjoy it?
John: Yes I did.

There were frequent laughter and jokes from the participants during the sessions, especially if they were 'trying out' responses, or if something unexpected happened. This suggests that their social faux pas were not as serious or anxiety-ridden for the users as perhaps they would be in real life. The VE allows a useful separation of the situation from reality so that users can learn about social 'errors' in a safe and (sometimes) light-hearted way. The users were also very enthusiastic about the sessions generally and were keen to know when we would be visiting next. Although 'level of enjoyment' is a difficult concept to convey in a limited space and without quantitative questionnaire responses, the fact that both participants stated explicitly that they liked using the programs is encouraging.

4. Future development of VEs for users with ASDs

The previous sections have described the usefulness, challenges and strengths of single-user VEs for teaching social skills to people with ASDs. In the following section, we briefly present some recommendations for the future development of VEs for high-functioning users with ASDs based on these observations.

4.1. The importance of the facilitator

Learning social skills is a complex process requiring (ideally) the coordination of responses with an understanding of underlying concepts. Whilst people with ASDs can learn responses and rules effectively, their grasp of the reasoning behind appropriate social behaviours may be impaired (e.g. Hadwin, Baron-Cohen, Howlin, & Hill, 1996), thereby reducing the usefulness and generalisability of learned responses. Consequently, the role of the facilitator in helping people with ASDs to learn about social skills using VEs, should not be underestimated. They are an essential part of the learning process, helping the user interpret what is happening in the scene and make appropriate responses accordingly (see also Crook, 1991; Mitchell et al., submitted). Thus, the role of the facilitator should always be adequately planned and provided for as an integral design feature of VEs for teaching social skills. This requirement does not represent a weakness in the functionality of VEs. On the contrary, the contingent interpretation and 'scaffolding' of a user's behaviour during their encounters with 'tricky' situations, built to mimic those encountered in real life, is a valuable process offered through the use of VEs. Of course, VEs are not designed to replace real world training, but are a valuable addition – offering the space and time to explore response options safely and talk through reasons and interpretations in a quiet and controlled learning environment.

4.2. Perspective taking

A particular difficulty encountered by many people with ASDs is considering what another person might think, know or feel about a particular situation (e.g. Baron-Cohen, Leslie, & Frith, 1985), which could result in seemingly (though not intentional) selfish or rude behaviour. Examples of talking through unexpected or confusing aspects of a social situation have been included above and suggest that this could help users to consider a situation from another point of view.

However, an ideal extension to this type of discussion would be if the user could actually change their perspective to that of the stranger in the same VE, so that they could immediately consider the same situation from a different point of view. This possibility could be achieved through the use of Collaborative VEs (CVEs), which allow multiple users to occupy different avatars within the same virtual space.

An initial investigation (Rutten et al., 2003) of feasibility and usability studies on using CVEs in this kind of context has used Massive 3 technology (Purbrick & Greenhalgh, 2000). One of the features of this system is that the whole virtual experience may be recorded and then replayed from any angle (Greenhalgh, Flintham, Purbrick, & Benford, 2002) and paused, slowed down or re-wound. In practice, the usability of the current technology meant that it was difficult for teachers to control the replay facility and the level of reflection on the replayed behaviours was minimal. It was also unclear whether the students understood that they were watching a replay of the scene in which they had previously been in control of one of the characters, a fundamental requirement if this use of technology is to be successful. It should be emphasised that these observations were based on an initial one-off trial and not an in-depth study, which would be required to gain a better idea of how the 'record and replay' function might work. Thus, whilst current technology may not yet be sufficiently advanced to provide the kind of perspective taking in 'social' situations described above, this is certainly an aspirational goal for the future development of VEs.

4.3. The importance of behavioural realism

Although VEs have progressed a great deal in terms of how realistic the scenes appear there is still further development required if VEs are to maximise the potential they offer for social skills training. Whilst the physical aspects of the café and bus VEs were realistic in their appearance, our users commented on the lack of realism of our virtual figures in the scenes:

Mike: I think they could make it look more detailed, maybe.

F: A bit more human?

Mike: A bit more human.

This lack of 'humanness' also seemed to influence Mike's behaviour in the VEs. In the following example Mike is talking about asking someone if they could move their bags from the seat in a bus:

> Mike: These have got no personalities... some [people] might be quite nervous, asking that, and maybe leave it. But these have got no personalities, so you know they're not going to say anything back to you. They're not going to say 'no you can't'.

It was clear to Mike that the virtual people were pre-programmed to behave in particular ways and so he responded accordingly. This lack of 'humanness' is one consequence of single-user VEs in which only one person can navigate the scene at any time, thus rendering virtual people in the scene rather 'blocky' and mannequin-like in appearance. By contrast, CVEs could potentially allow greater behavioural realism through the incorporation of 'embodied avatars' (those under the control of another user), and improved features such as gaze direction and facial expressions, which allow a user to respond contingently to ongoing interactions in the scene. Blascovich et al. (2002) suggest that these features of interpersonal behaviour, afforded by certain types of virtual reality systems, could offer the possibility that '...social psychologists could systematically determine the critical aspects of successful and unsuccessful

social interactions, at least within specified domains and interaction tasks'. For people with ASDs, with known difficulties in social interactions and communication, this type of approach could stand to tell us a great deal about social behaviours in a clearly defined and controlled environment.

5. Conclusions

Despite some concerns over certain aspects of VEs, comments and observations from these two users with ASDs are encouraging. Generally, there was a very positive response to the VEs from the users and evidence that they had remembered social knowledge gained during their VE sessions. In addition, John and Mike appeared to have a good understanding of the purpose of the VEs and were able to offer specific examples of how it had helped them now, and could help them in the future. These observations suggest VEs could offer an additional tool for useful and meaningful social skills training opportunities in the classroom, perhaps as an augmentation to existing methods and approaches. A systematic study with a larger group is needed to confirm the direction of these findings as well as a longer follow-up period after VE use to investigate the longevity of any effects demonstrated.

The single-user VEs were suitable for certain types of use such as learning to solve social problems and scaffolding learning through a facilitator. However, there were some limitations, in particular, the visual representation of people was blocky and unrealistic, and 'tricky' situations had to be specified and programmed beforehand. This meant there was a finite number of problems and responses the user could encounter, with a lack of spontaneity in the resulting interactions. CVEs may offer an improvement in spontaneity and 'realism', although the current level of technology may not yet be sufficiently advanced to offer the ideal environment in which to practise social skills. However, this is likely to improve dramatically and rapidly in the next few years, potentially allowing more powerful insights into (autistic) behaviour and sophistication in social skills training in the future.

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