A brief review: assistive technology and autism, a proposal for virtual tools for improved communication and emotional recognition

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Abstract: Autism is a condition that affects over one percent of the population, and is a condition that has varying degrees of severity. There currently exist various therapies to help people with autism communicate effectively. As a result some researchers and schools have expanded this provision by creating virtual tools to assist the communication process and allow a greater level of independence and generalization. Therefore, this brief paper aims to present a review of literature surrounding assistive technology, augmentative and alternative communication and autism, and how these fields of knowledge can be better understood to help develop virtual tools – more specifically a virtual world.

Introduction

Assistive technologies (AT) have been used to aid communication for children and adults with autism for some years and some specific studies have shown how extending this provision, through technology, can help improve communication using a variety of means: virtual reality, collaborative virtual environments, 3D avatars and 3D animation, for example. As technology has become more readily available more studies have been conducted to explore and assess ways virtual spaces can be used as a method to enhance and reinforce communication. Assistive technologies, more generally, have been used as a way to help many people with disabilities and as such are seen as a way to help people move, talk and communicate. This study will review the use of AT used to help people with autism better understand communication, to explore interactions with others, and even to explore the use of gestures and facial movements, as a means to help generalise within social scenarios.

Autism

Autism is described as a *spectrum* disorder, ranging from *classic* autism, with severe learning difficulties, to high functioning autism and Asperger's Syndrome where normal levels of cognitive ability can be expected (Kerr 2002). However, either condition can mean children and adults lack social-understanding and communication skills. Baron-Cohen & Bolton (1993) state that autism is a condition that can affect children from birth or early childhood, and is a condition that leaves the child unable to form normal social relationships or normal communication (Baron-Cohen & Bolton 1993; Scott 2002; Bolton et al. 1994; Kerr 2002). As a result of this, the child may become isolated from human contact and absorb the world in a repetitive, obsessive manner (Baron-Cohen & Bolton 1993). Moreover Baird et al (2003), highlight autism as a; "behaviorally defined disorder, characterized by qualitative impairments in social communication, social interaction and social imagination" (Baird et al. 2003: 1) , while Haswell et al (2009: 970) define children with autism as having "defects in motor control, imitation and social function". Autism also has a range, in terms of diagnostic, and can be classified as high or low functioning and as such can be located within the broader boundary of spectrum disorders (Bolton et al. 1994). This is further reinforced by Baird et al. (2003) who highlight that 75% of children diagnosed as having autism will have some form of learning difficulty, while the other 25%, have a higher-functioning autism, that will allow for a normal language development range and some social interactions.

There are many different reports to the number of children with autism with it being something once considered quite rare (Lotter, 1996 cited Howlin, 1998). Studies and research in the late 1990s puts the number at

approximately 3-4 individuals in every 10,000 (0.03% – 0.04%). However this compares with studies carried out by Baird et al (2006) and Green et al (2005) who both consider a figure closer to 100 for every 10,000 (1%), a more accurate representation. Furthermore this figure of 1% relates to autism spectrum disorders, so covers a broader array of special needs. In terms of autism specific conditions, the numbers are considerably lower and represent a figure closer to 40 in every 10,000 (0.4%) for childhood autism (Baird et al., 2006).

Augmentative and Alternative Communication and Assistive Technology

An initial and important distinction to make is the difference between augmentative and alternative communication (AAC) and assistive technology (AT). Although there is some commonality between the two terms, there are also some clear differences. Mirenda (2001), for example provides a definition of AT stating that this can include:

> …voice output communication aids (VOCAs), as well as computer hardware and software applications that produce writing and/or spelling assistance, support various aspects of learning, and/or facilitate classroom participation in general (Mirenda 2001: 147).

So one difference between AAC and AT is that while AAC provides a way for users to communicate through speech and/or writing [for individuals would not normally be able to], AT that provides a way for individuals to improve their ability through assisted means. However, the University of Washington (2006) provides a definition of AT that could be considered an overlap into what AAC provides. Here they state:

> Assistive technology is technology used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible. Assistive technology can include mobility devices such as walkers and wheelchairs, as well as hardware, software, and peripherals that assist people with disabilities in accessing computers or other information technologies. (University of Washington 2006: 1)

Furthermore, the Federal Register of the United States (US), provide a formal, legal definition stating that: "Any item, piece of equipment, or system, whether acquired commercially, modified, or customized, that is commonly used to increase, maintain, or improve functional capabilities of individuals with disabilities" [emphasis added] (Federal Register 2000: 5). It is interesting to note the terms *increase*, *maintain* and *improve*, in the context that they are used, as they help to differentiate AAC with AT. Within AT this [increase, maintain, improve] can mean any part of the body and for many disabilities, motor and cognitive, compared to AAC that specifically deals with communication needs. However, one might argue that the use the term communication methods could be extended across to AT, in that this also deals with communication and being able develop such skills. Furthermore, with more technology being used in AAC it is reasonable to expect the two terms (AAC and AT) to become closer aligned.

Assistive Technology and Autism

During the late 1990s and into the 2000s many studies were conducted and have since helped to identify ways that computer aided learning (CAL) can be used as a way to facilitate, promote and encourage learning and communication in people (specifically children) with autism. In Particular, Virtual Environments (VEs) have been identified as an advantageous way for people with autism to communicate (Strickland et al 1996). Strickland et al (1996), presents an early study that assesses the effect Virtual Reality (VR) as a learning tool to engage children with autism. Here they consider the differences between VR and computer programs, as the level of interaction with computer-generate images, independence in determining motion and objects in a VR world and a way to present real life experiences (Strickland et al 1996). The use of VR with children with autism was considered based on: sensory problems, lack of generalisation, visual thought patterns, individualised treatment and responsive to computer technology (Strickland et al 1996). The aim of the study was to raise awareness of, and help children with autism, cross a road safely. They used VR helmets to help immerse the users in a 3D environment that meant users could identify cars, the colour of objects and where they had travelled. Furthermore the children were presented with difference scenarios to determine generalisation, as well as being asked to walk into the scene and interact with signs. As a result some conclusions and lesson learned included: (1) Children with autism are able (and happy) to use virtual helmets, (2) the participants immersed themselves in the virtual scenes and verbally labeled objects and colours of objects, (3) response was similar across three different scenes, (4) hand controls were used in conjunction

with the helmet on a couple of occasions, (5) participants tracked moving objects with eyes, head and body turning and located objects (stop signs) and walked towards them, more often than not.

In addition, Strickland et al (1996) conclude that VR can be taken forward and advantages afforded to children with autism are far reaching, including interaction, exploring, immersing and learning. A weakness of the study was the small group of participants used to validate the product, and while two children accepted the use of VR devices (helmet, joystick, gloves, etc), it does not conclusively prove others would. Furthermore details pertaining to the way participants reacted in the VE, by no means validates this use of technology for children with autism, although it does provide a sound basis for which others can work.

Further studies exploring the use of Virtual Environments (VEs) have also shown improved communication for children with autism. In particular, Fabri & Moore (2005) discuss the use of Collaborative Virtual Environments (CVEs) with reference to users who have autism. Fabri & Moore (2005) discuss the use of CVEs to enhance and improve communication and emotional recognition in people with autism. They put forward the case for introducing emotional expressiveness in CVEs as a way to aid inter-personal communication, generally and specifically, for children with autism (Fabri & Moore 2005). Part of this project involved creating an interface that included a 3D avatar, that could express emotion to help communicate through a text based 2-way tool. Here they implemented the theories of Ekman & Friesen (1978) and used the six "universal" facial expressions of emotion: happiness, surprise, anger, fear, sadness and disgust – and a neutral pose. In using CVEs, Fabri & Moore (2005) also propose reasons for involving a virtual head in their work. A previous study (Fabri et al 2004) highlights three points that relate to virtual faces and emotions: (1) emotions can be visualized with limited facial features, (2) recognition rates (of virtual faces) are comparable to real-life images, and (3) some expressions are easily recognizable and potentially build a basis for emotionally expressive avatars in CVEs (Fabri et al 2004). However, Fabri et al (2004) also conclude this is not the case for all emotions. For example, disgust was not well understood in their study, mainly due to the fact this emotion requires wrinkling of the nose – and thus more detailed avatar models. Fabri and Moore (2005) also argue that this form of interaction could benefit children with autism and present three areas where this could be of particular benefit; (1) an assistive technology, (2) an educational technology, and (3) as a means of helping address any Theory of Mind (ToM) impairment (Fabri & Moore 2005). Finally, Fabri & Moore (2005) conclude that the use of virtual tools is being understood emotionally, and used appropriately by individuals with autism.

Elsewhere, Moore et al (2005) argue the case for using CVEs to help people with autism understand emotion. Here they have developed a simple platform that integrates the use of images (avatar representations) and animated facial expression sequences to help understanding of facial emotion and communication. Here Moore et al (2005) present three stages to their product: (1) avatar representations in isolation, to help initial emotional understanding, (2) prediction of emotions in contextual situations – own feelings and feelings of others and (3) avatar emotional representation, paired with a selection of events. The user at stage three is required to select an event that may have caused an emotional response, and asks the user to infer their own emotion to that of another (cause and effect). In order to identify whether participants were successful in selecting emotional avatars for each section of their program Moore et al (2005) compared the observed responses of the participants to the questions against the responses that would be expected were they to be selected by chance. The outcome of the study shows that over 88% performed above a threshold of 7.3, and indeed many of the 88% way above this. Therefore, Moore et al (2005) concludes that the study offered evidence that the majority of participants involved were able to interpret and/or understand the emotions of the avatars appropriately. More specifically the tasks involved recognition of an emotion from an expression, selection of an expression to represent and emotion and prediction of an expression (Moore et al 2005). What this study really highlights is that people with autism have both the ability and prerequisites to use CVEs, in that they can, via this medium, identify emotion, apply emotion, and recognise emotion from expression (Moore et al 2005). Some areas that are a little unclear are the demographic of the participants, the settings in which the study was carried out, and whether the skills gained could be generalised. Some details of the age range are presented (age range 7-16), however no details are presented for where the children sat on the autism spectrum, the mental age or IQ - all areas that Mirenda (2009) attribute to this type of evidence-based practice (EBP). In contrast, this study does offer clear evidence that using virtual animated facial expression can help users with autism understand and recognise emotion/s on a personal level and in that of others (although not generalised). This study also recognises that a small minority of the participants found it very difficult to understand the emotional representation of the avatars (Moore et al 2005), and something that could have been better understood if the range of participants were further explored and maybe allowing further insight into whom CVEs could be most beneficial for. In a similar fashion Cheng & Fan (2008), also use a CVE to experiment with the use of emotions in children with autism. This study includes 2D images rather than 3D, something Moore et al (2005) had already identified as a contributory factor in the successful design of CVEs used with children with

autism. However, Cheng & Fan (2008) do provide some further evidence that this format – communicating through a mixture of text and visuals – allows children with autism to better communicate their emotions. Here they provide a simple interface that allows users to talk to each other (one-one) through the medium of text and visual representations of faces. Each of these faces displays a different emotion, and were modeled in 3D, rendered and exported as a 2D image. Cheng & Fan (2008) conclude that 80% of the participants were able to successfully use the system as a way to identify their emotion, as a representation of a graphic. Moreover the participants were able to interpret the emotions others through such a system (Cheng & Fane 2008). This study considers the work of Moore et al (2005) and Fabri et al (2004) and as such fails to build significantly on this; furthermore they also present their work mainly as an observational study, where evidence based practice and/or intervention methods would have added a contextual dimension to their work. However, the work of Cheng & Fan (2008) does help in a way that shows this work (using CVEs) is being continued, further developed, and implemented. However further evidence and a greater use in context would help this area of research associated with augmenting communication in people with autism.

In addition to using Collaborative Virtual Environments to help people with autism, Schmidt & Schmidt (2008) highlight why and how Virtual Environments can be successful for people with autism. Here they state why individuals with Autism Spectrum Disorders (ASD) are suited to using computers, chiefly as they provide an ideal platform to help people with ASD improve their core defects, social skills. Moreover the use of computers can help as they are predicable, routine, free from social demands, provide immediate feedback and set clear expectations (Moore 1998 cited Schmidt & Schmidt 2008) and are visual by their nature, all going some way to provide ways to help children learn and develop social and emotional skills (Schmidt & Schmidt 2008). Within this review Schmidt & Schmidt (2008) note that VEs can help because they allow users to make mistakes, and in the case of children with autism, make mistakes without suffering real consequences (Cromby et al 1995 cited Schmidt & Schmidt 2008). In addition to this the use of VEs can be modified and customized (simplified) to suit individual needs (Schmidt & Schmidt 2008). As a precursor to the work of Schmidt & Schmidt 2008), Cromby et al (1996) identified the use of VEs for a more generic use to help aid people with learning difficulties (which include people with autism). Here they consider the use of a VE to help people with severe disabilities learn how to shop independently, through the use of a pre-programmed VE. Their methods for this involved a group of participants who were tasked with shopping for a selection of items, putting in a trolley and taking to the checkout. While the other participants would do the same but using a VE. The mean age was 15 years old, with 5 male and 6 female participants. Results of this study highlight how the experimental group performed better than the control group when shopping for real after the VE intervention. Moreover, the experimental group correctly identified more items on the shopping list, when repeating the task a second time (Cromby et al 1996). What this study fails to make clear from the outset are the participant's issues with performing the task in the 'real' world, other than having "mental retardation" (Cromby et al 1996: 104).

Another study that reinforces some of the work carried out by Schmidt & Schmidt (2008) and Cromby et al (1996) is that of Parsons et al (2006) and Parsons et al (2005). Here they created a Virtual Environment (VE) with the intention of improving social skills in two children with autism. This study used 2 children within a high-functioning range, as Fabri & Moore (2005); Fabri et al (2004) do, but Parsons et al (2006) consider the use of VEs, with users who are encouraged to navigate through the scene (a café and bus stop), rather than using a one-on-one approach. The scene is a simply generated one that includes other characters (passive, but who are pre-programmed to respond to user input). As a result of the study Parsons et al, consider five areas for review and discussion, (1) repetition of response, (2) physical and literal interpretations, (3) treating the VE like a game, (4) putting learning into practice and (5) recognizing changes and usefulness. Repetition of response was an area of the research that provided mixed results. Both users would navigate through the café scene in exactly the same way each time they approached the task. Moreover, one of the participants would maintain their path/route through the scene, despite encounters with chairs, tables and other objects. Parsons et al, also report some repetitive statements/verbal responses, however the participants did change more general responses in the VE. In particular, the choice of food ordered and when asking if they could sit down to eat their food.

Further reinforcing the use of Virtual Environments to help teach people with autism (and Autism Spectrum Disorders) Rutten et al (2003) explore the use of Single-User Virtual Environments (SVEs). Within this study they considered the use of SVEs to help teach support learning and enhance social skills in people with autistic disorders. This study used the same infrastructure and software as a previous study (Parsons et al 2005) and as such considers some of the same issues. However Rutten et al (2003) conclude that the use of SVEs can be used successfully to help teach transferable skills, but in such a way that needs support from facilitators/teachers to enable constant reflection and learning. Moreover, the safety that SVEs and CVEs both provide and the opportunity to practice skills away from real-life contexts, mean that they both offer valuable tools for ASD individuals. Rutten et

al (2003) also compare the difference in CVEs and SVEs concluding that CVEs provide less structure and are more challenging to use, but conversely they offer increased flexibility for social skills training that do not rely of fixed protocol and they can be used cross-cultures. Finally Rutten (2003) suggest that SVEs would be better employed as a progressive training package, whereby users learn a particular skill, followed by CVE use, where learnt skills can be practiced in a real-life setting.

Conclusions and future directions

Having considered virtual environments and reality with relation to helping people with autism communicate and understand the world around them, albeit a virtual space, it seems a logical and potentially useful step to take this further still. What this brief literature review has shown is that virtual spaces can be used to good effect in allowing people, and specifically children, to explore, interact, express and communicate with one another. The studies considered above cover mainly virtual environments, whereas virtual worlds are becoming more commonplace, easier to use, and less bespoke. For example, Second Life is an online community where users can join for free, and within minutes be interacting with others in this 'virtual world'. Moreover, some studies are already using such spaces to enable: "intensive, interactive therapies to deal with problems they encounter everyday but in a safe setting to practice their social skills" (Chapman 2007: 2). However, much of this work is being considered for and with people with Asperger's. This author, on the other hand, sees no reason why a virtual world can't be considered for use in a school setting to help aid children with mid-high functioning autism. The literature reviewed above provides a sound basis in which to consider the use, of say Teen Grid (http:teen.secondlife.com) in a classroom setting as both a therapy and way to provide children a chance to test a variety of social scenarios. This is the next stage to this project, where a virtual world is being created in collaboration with a school (children from 13-19 with autism) in the suburbs of London (UK) where it will be trialed and evaluated. However as a way forward in the consideration and design of a virtual world, we need to carefully devise: the design of avatars, provide appropriate input interfaces, present engaging (and sometimes focused) tasks, build group tasks, and most importantly embed the use of a virtual world into classroom teaching. In doing so, there is every chance that users will become engaged, familiar, and prepared to become immersed within the virtual worlds. However this needs to done in close collaboration with real-world activities to help generalize information, as pointed out by Max & Burke (1997). The next direction of this work is to evaluate the use of a virtual world in a school setting for people with autism, and to work collaboratively with the students, teachers and facilitators to empower and enable a successful product that can be taken forward positively. The results of this study will be presented in due course.

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