DESIGN OF A GENERIC QUESTIONNAIRE FOR REFLECTIVE EVALUATION OF A VIRTUAL REALITY-BASED INTERVENTION USING VIRTUAL DOLPHINS FOR CHILDREN WITH AUTISM

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There is an alarming increase in more Singaporean children diagnosed with special needs and it could be attributed to higher awareness and better screening procedure. However, research and development on various intervention strategies for children with special needs is still very lacking. With the introduction of information and communication technology, a wide range of useful intervention tools are now available to both special education professionals and parents with disabled children. In particular, interest in virtual reality (VR) within the domain of special education community is on the rise as reflected in a growing number of special issues of journals on this subject. VR offers a new channel to reach out to individuals with special needs such as cerebral palsy and autism. However, its effectiveness in intervention for such individuals has not been fully explored. In this paper, the authors have collaborated with a research team of the Pink Dolphin Simulation project at the Institute for Media Innovation, Singapore, to design a generic questionnaire for VR researchers and special education professionals to use in evaluating reflectively the possible benefits a VR-based intervention can offer. In this case, the VR-based intervention using the specially designed virtual dolphins was used for reflective evaluation.

Introduction

Autism, also known as autism spectrum disorder with its various subtypes, is a generic term first coined by Bleuler (1908) to describe schizophrenic patients, who screened themselves off and were self-absorbed. Kanner (1943), an American child psychiatrist, used the term *autistic* to describe this syndrome with the following common traits: impairments in social interaction and communication, manifestation of stereotyped behaviour, anguish for disrupted daily routines, belated echolalia, hyper-sensitivity to certain stimuli, limitations in spontaneous activity, and the list or traits is long. A year later, Asperger (1944), independent of Kanner (1943), wrote about a group of children he called *autistic psychopaths*. In most aspects they resembled the children of Kanner's (1943) description. The difference was that Asperger (1944) did not mention echolalia as a linguistic problem but that the children talked like little grown-ups. In addition, Asperger (1944) noted that his children‘s motor activity was more clumsy and different from normal children.

Since then, more research studies have been done to understand the enigma of autism (Jeste & Neslon III, 2009). Chia (2008) and Chia, Kee and Shaifudin (2010) have reviewed existing definitions of autism and proposed the following definition as *[A] neuro-developmental syndrome of constitutional origin (genetic)* and whose cause could also be epigenetic*, and its onset is usually around first three years of birth, with empathizing or mentalizing deficits that result in a triad of impairments in communication, social interaction, and imagination (or presence of stereotyped behaviours), but may, on the other hand, display (especially by autistic savants) or hide (especially by crypto-savants) a strong systemizing drive that accounts for a distinct triad of strengths in good attention to detail, deep narrow interests, and islets of ability* (Chia, 2008, p.10; words not italicized are a recent addition to the definition, see Chia, Kee, & Shaifudin, 2010, p.8).

Recently, more media attention has been drawn on the alarming increase in diagnosed cases worldwide of autism (Carpenter, Soorya, & Halpern, 2009; Lawrence & Karen, 2009; Poon, 2009) as well as in Singapore (Kee & Loh, 2009; Lim, 2011; Tan, 2011). This *increase in the number of children diagnosed with autism could be attributed to higher awareness and better screening procedure* (Chia, 2011, p.38).

However, the development of interventions and treatments for children with autism is still lagging behind the advancement made in the design of better screening procedure and public education through talks, forums and seminars for both professionals and parents. Today there are many so-called effective strategies, such as facilitated communication, gluten-free/casein-free diet and chelation therapy, and claims made about them with the promise that such approaches can help children with autism. It is extremely important and timely to identify scientifically validated methods in order to provide an effective early intervention program to young children with autism.

Simpson (2005) has classified the interventions and treatments for children and youth with autism into five broad categories: (1) interpersonal relationship interventions and treatments; (2) skill-based interventions and treatments; (3) cognitive interventions and treatments; (4) physiological, biological and/or neurological interventions and treatments; and (5) other miscellaneous interventions and treatments.

In this paper, the authors have chosen to focus on the dolphin-assisted therapy (DAT), which according to Simpson (2005), falls under the category of interpersonal relationship interventions and treatments, and then shifting to some form of computer-assisted intervention involving virtual reality (VR). The dolphins, which are partially or indirectly involved in this study, have been raised in captivity in the Dolphin Lagoon, Sentosa, managed by the Underwater World Singapore. The rationale behind this paper is threefold: Firstly, it is to avoid using or relying on the real dolphins because of current ethical issues arising from animal-assisted programs (Chandler, 2005; Iannuzzi & Rowan, 1991); secondly, it is also to avoid being drawn into persistent protests from or any debate with pro-animal rights activists (Chua, 2011; Ho, 2011; Loi, 2011), especially from the Animal Concerns Research and Education Society (Lee, 2011); and thirdly, it is to evaluate the effectiveness of a VR-based intervention and in this case, the use of virtual dolphins instead of real dolphins in the virtual dolphin-assisted therapy.

Dolphin-Assisted Therapy

There has always been something special about the dolphins. To the Minoans as far back as 1500 BCE, dolphins are symbols of joy and music. The ancient Greeks even dedicated a temple at Delphi to a dolphin god. This special relationship between humans and dolphins has gone beyond just religious belief, moving into scientific and medical domains (Chia & Kee, 2010).

In the early 1970s, dolphins have been the subjects of interests in research investigation relating to the understanding of effects of dolphin-human interaction on human behaviour. Dolphins have been trained to assist individuals with disabilities, and this form of intervention approach became popularly known as dolphin-assisted therapy (DAT). Several experimental studies (e.g., Humphries, 2003; Nathanson & de Faria, 1993; Nathanson, 1998; Servais, 1999) have been done to investigate the effectiveness of DAT with children with various disabilities, mental retardation, and autism. Cochrane and Callen (1992) reported one study on how autistic children were relieved of their characteristic anxiety (e.g., vocal and motor self-stimulations and rocking movement) and stress through positive interactions with dolphins, and subsequently they also improved in their communication and learning. Another study reported that DAT helped to motivate an autistic child to communicate (Smith, 1981).

In Singapore, Chia, Kee, Watanabe and Poh (2009) reported on the efficacy of DAT on reduction of stereotyped behaviour in non-verbal children with autism and these subjects also began to hand-signal in their attempt to communicate with others. In another study, Chia and Kee (2010) reported an increase in self-awareness and self-regulation and all their five autistic subjects *awarized* – a term coined by the researchers to refer to *an action rather than to be aware of, a passive reaction* (Chia & Kee, 2010, p.44).

There are many different forms of DAT. The simplest form can involve a child swimming with, touching or taking care of dolphins, while the more complex one is based on an individualized structured program designed to meet the needs of the child concerned. According to Nathanson (1998), the DAT is based on the theory that children with disabilities will increase their attention to relevant stimuli in the environment as a result of their desire to interact with dolphins. *The general purpose of DAT is to*

encourage children with disabilities to engage to desired responses in accordance with their individual education or therapy plan (Chia & Kee, 2010, p.43).

To date, there are mixed reactions regarding whether dolphin-assisted therapy actually benefits individuals with autism or other disabilities. Apparently anecdotal reports from parents and those working with dolphins and disabled people suggest that this intervention may be beneficial for some individuals, especially in reducing stress and anxiety, alleviation of depression and pain prevention (McKinney, Dustin, & Wolff, 2001). One possible reason why DAT works could be the primate relationship an individual establishes emotionally with the nature (Verbeek & de Waal, 2002). Wilson (1984) and Kellert and Wilson (1993) have termed this relationship as *biophilia* and described this as a form of adaptive learning ability with rules that govern how one can learn about and from nature. It involves emotional experiences ranging from *attraction to aversion, from awe to indifference, and from peacefulness to fear-driven anxiety* (Wilson, 1993, p.31).

However, according to Cole (2009), *holding a non-domesticated mammal captive to serve people is often controversial. Those against this form of therapy often point to the limitations in the research, the often exorbitant expense incurred by clients and family members, and the general welfare of the animals in captivity* (Beck & Katcher, 1996) (p.20). Researchers such as Humphries (2003) and Marino and Lilienfeld (2007), who have reviewed DAT studies over the last decade, revealed inherent methodological flaws in these studies resulting in unreliable outcomes. In other words, no conclusive evidence has yet been found to suggest DAT can stand alone as a legitimate therapy.

Moreover, with more frequent and more persistent protests from pro-animal activists and environmentalists being reported in mass media and also being circulated in the social media, dolphin-assisted therapy has come under closer scrutiny than before. As a result, there is a need to explore an alternative approach that can tap on biophilia – an innate tendency to affiliate with natural or living things such as hamsters, dolphins and horses – through information and communication technology (ICT).

Virtual Reality: From Biophilia to Technophilia

According to Alers and Barakova (2009), children with autism like technological gadgets and logical thinking since they are stimulated and challenged to communicate using them. One explanation for their technophilic behavior is their high systemizing ability, i.e., *the drive to analyze and build systems in order to understand and predict the behaviour of impersonal events or inanimate or abstract entities* (Myers, Baron-Cohen, & Wheelwright, 2004, p.18), perhaps with particular preferences for mechanical (e.g., machines and tools) and abstract (e.g., mathematics or computer programs) systems. Hence, ICT can benefit them greatly. For example, since the introduction of the Apple iPad, there has been some excitement in special education and autism communities. The iPad, like other computers, is an effective tool for many on the autism spectrum (Chi, 2010). With its flexibility and portability, the iPad offers additional advantages over laptops or PCs. With its touch screen and layout, the iPad becomes more accessible for children with coordination or learning difficulties (see Today, 2011, Dec 12, for more detail). These children may find sliding and tapping easier than either typing or writing. Moreover, the iPad can be easily carried. It is helpful for calming and focusing hyperactive children. In another example, robots have been used for behavioural training for children with autism for obvious reasons: firstly, they like computerized games; secondly, predictable behaviour can be expected in playing the games; and thirdly, there are repeating movements (Billard, Robins, Dautenhahn, & Nadel, 2006; Dautenhahn & Werry, 2004).

As a result, the authors of this paper embarked on exploring ICT but eventually narrowing their focus on virtual reality (VR) (also known as virtuality) as a new techno-channel to reach out to children with autism. The term *virtual reality* refers to computer-simulated environments that can simulate physical presence in places in the real world as well as in imaginary worlds (also known as multiverses or metaworlds). The simulated environment can be similar to the real world in order to create a life-like experience for a user (e.g., simulated training for pilot) or gamer (e.g., playing a VR game).

There has been a growing interest in VR technology within the domain of special education community. However, the field is currently under-theorized, with most of the initial work being exploratory, descriptive and often technologically driven (see Savin-Baden, Gourlay, Tombs, Steils, Tombs, & Mawer, 2010, for more detail). It seems, throughout much of the literature (see White & Le Cornu, 2010, for more detail) the authors have reviewed, that what happens in virtual worlds is not real and thus, to

most special education professionals, not useful in real life applications, especially for children and youth with autism. The problem lies in the usage of the term *virtual world* that juxtaposes with *real world*. Hence, it denies the reality of virtual world experiences. White and Le Cornu (2010) argue that virtual world experiences are real *in which participants' experience is actually secondary, mediated through vision, yet such is the power to draw in and engage that, together with the human ability to project and imagine, participants have the impression of learning through primary experience* (p.192). With additional inputs of other sensory information, such as sound through speakers or headphones, and touch through some advanced haptic systems generally known as force feedback, virtual experiences can become more real than ever.

In the same way, the DAT that involves real dolphins working with children with autism in a big deep pool at the Dolphin Lagoon, Sentosa, could be reproduced in their respective virtual forms. The authors worked with a research team led by Professor Cai Yiyu (cited in Guo, 2011; see Cai & Chia, 2011, for detail) of the Institute for Media Innovation (IMI), Nanyang Technological University, in the Pink Dolphin Simulation project resulting in the creation of three-dimensional virtual dolphins that can swim and perform acrobatic acts in a virtual dolphinarium. These virtual dolphins (see Figure 1) are computer-based or virtual robots (also known as bots) that have been designed to interact with the participants, i.e., children with autism, in the same way as what the real dolphins would do.

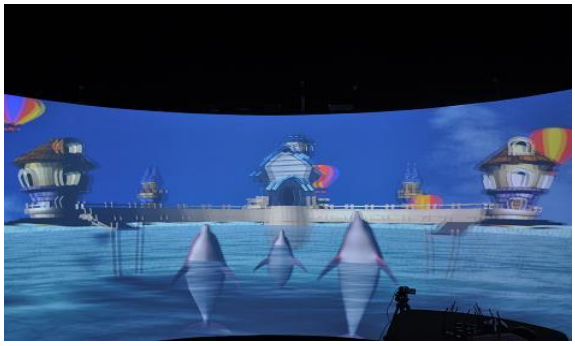

Figure 1. Virtual Dolphins in the 3-D Virtual Dolphinarium

In addition, among the four different dolphin sounds tested on ten participating children with autism, Chia and Kee (2011) found that buzzing-clicks (see Figure 2) made by bottlenose dolphins were preferred by seven out ten participants who felt more ambient, and these buzzing-clicks were also added into the design of virtual dolphins.

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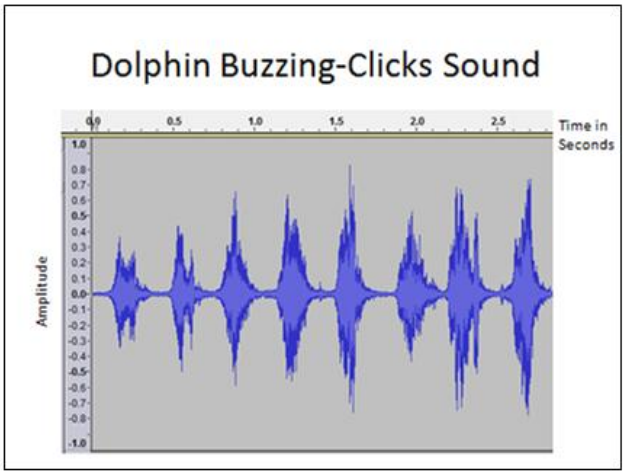

Figure 2. An Audacity Graph of Dolphin Buzzing-Clicks (Chia & Kee, 2011)

Unlike the physical robots, bots are software applications that run automated tasks over the computer games or Internet. Typically, bots perform task that are both simple and structurally repetitive, at a much higher rate than would be possible for a human alone. A bot can be a virtual being in form of either a non-player character (sometimes known as a non-person character or non-playable character) not controlled by a user or player (e.g., the virtual dolphins in the Pink Dolphin Simulation project) or an

avatar, which is the graphical representation of a user or the user's alter ego or player character. Be it a non-player or player character, the virtual being may take either a three-dimensional form, as in cyber-games or virtual worlds, or a two-dimensional form as an icon in Internet forums and other online communities.

The authors have chosen to focus on the technological-pedagogical-psychological framework of the Pink Dolphin Simulation in order to design a generic questionnaire to evaluate reflectively the possible benefits that can be derived from its computer-assisted intervention using virtual dolphins – specially designed static bots (also known as *delphisbots*) – based on the indo-pacific humpback dolphins raised in captivity and trained to interact with non-verbal children with autism at the Dolphin Lagoon, Sentosa.

Technological-Pedagogical-Psychological Framework of Virtual Dolphin-Assisted Intervention: A Reflective Questionnaire

According to Zhou (2011), the Pink Dolphin Simulation project, a joint effort between IMI researchers and the Underwater World Singapore, involved the use of the Immersive Room system that is *equipped with infrared emitters, high-end projectors, stereoscopic lightweight 3D glasses, position trackers and computer graphics* (p.6). Using Kinect technology that is also used in Xbox consoles, the dolphins in the simulation move according to a user's hand movements in the same way a dolphin trainer hand-signals to a live dolphin to perform a certain act at the Dolphin Lagoon. The main goal of the simulation is to help children with autism to improve their communication and learning skills through interaction with virtual dolphins, as research (e.g., Chia & Kee, 2010; Dobbs, 1990; Nathanson, 1998) has shown that they respond and interact well with dolphins.

The main question that most special education professionals have often asked the authors is *How effective or successful can a virtual dolphin be than a real dolphin as an intervention tool?* To answer this question, there are three important areas that need to be examined: (1) the technological dimension; (2) the pedagogical dimension; and (3) the psychological dimension. In other words, the triangulation of these three dimensions can offer us a better understanding to decide if a virtual dolphin is as effective as a real dolphin as an intervention tool through how the VR technology can enhance pedagogy in special education to improve the life and daily activities of a child with autism (see Figure 3). A further discussion on this issue will bring us delving into the learning activity system involving the three dimensions and how they interact with each other and are interrelated. It is beyond the scope of this paper. Besides, it has already been covered elsewhere (see Chia, 2011, for more detail).

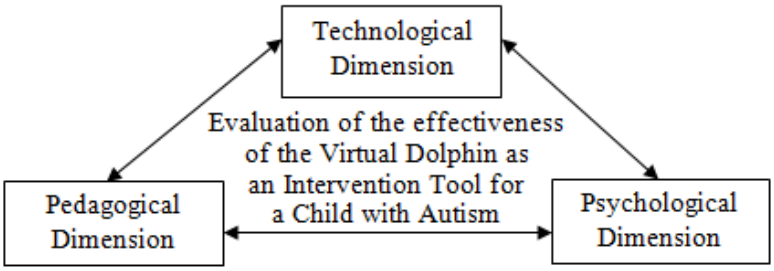

Figure 3. Triangulation of the Three Dimensions

The main question has prompted the authors to design a generic questionnaire for both VR researchers and special education professionals to evaluate reflectively the effectiveness of a VR-based intervention approach designed to help children with autism or any other learning disorders.

The Technological Dimension

In VR, there are many different types of virtual worlds with the largest type of virtual world being the Massively Multi-player Online Role Playing Game (MMORPG). They are created for different purposes such as commercial gaming, online community building, military training, and education. However, all the virtual worlds share six common features (i.e., shared space, graphical user interface, immediacy, persistence, and socialization/community) (Virtual World Review, n.d.) which are adapted and presented in the following questions:

1. Does the VR-based intervention allow many participants (of same or different learning challenges) to be involved at any one time? Any minimum or maximum number of participants allowed in taking part?

2. Does the virtual world depict space visually, ranging in style from a two-dimensional imagery to a more immersive three-dimensional environment?
3. Do the interactive exchanges between the participant and the non-player and/or player characters/avatars take place in real time? Who does the initiation of the social exchanges?
4. Does the VR-based intervention allow the participant to alter, develop, construct or submit customized content?
5. Does the virtual world continue to exist with its on-going activities regardless of whether the participant is logged in?
6. Does the VR-based intervention allow and encourage the formation of virtual social groups such as teams, guilds or cliques?

The Pedagogical Dimension

As far as education is concerned, virtual worlds are unclaimed spaces that educators have yet to establish the norms of (1) how to tap on the abaundant resources available in those multiverses or metaworlds, and (2) how to support learning within them (Twining, 2009). VR provides many good opportunities for participants to engage in various activities in different virtual worlds, where an activity can be more real than anything they normally experience in this physical world. Twining (2010) has provided the following pedagogical dimension (see Figure 4):

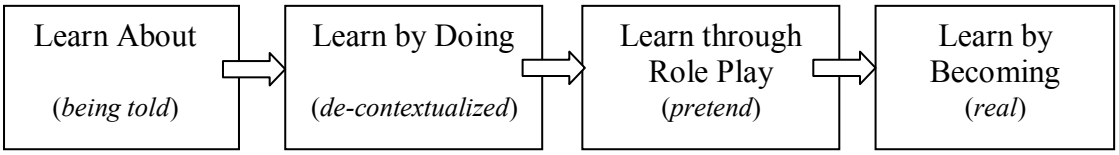

Figure 4. The Pedagogy Dimension (adapted from Twining, 2010)

Twining (2009, 2010) suggests that VR allows *learning by becoming* which, in turn, involves a greater depth of engagement for a participant than any other categories on the Pedagogy Dimension. Apparently, the reality of virtual worlds provides an ideal mode for participants coming from different experiential backgrounds and prior knowledge to *learn by becoming* according to the following five core aspects of an education system (Twining, Broadie, Cook, Ford, Morris, & Twiner, 2006) are expressed in the interrogative format:

1. Aim(s): What is/are the aim(s) of the VR-based intervention? The focus is on enhancing learning, motivation and lifelong learning as important elements.
2. Learning environment: How is the VR-based intervention relevant to the learning environment of the participant? The learning environment refers to the whole environment of a learner that is relevant to him/her in terms of two components (Twining, 2009):

a. Spatial environment, i.e., where learning takes place; and
b. Temporal environment, i.e., when learning takes place.

Both components work across physical settings and virtual settings and even extend the school day. *This is all summed up in the phrase anywhere/anytime learning* (Twining, 2009, p.500).

3. Actors: Who are the actors involved in the VR-based intervention? These actors refer to people and/or organizations that are supporting learning. They include teachers, parents, peers as well as the learners themselves, whose *involvement and availability depend on the facilities that ICT offers* (Twining, 2009, p.500).
4. Curriculum: What are the subjects to be offered in the VR-based intervention? The curriculum includes everything that learners learn, i.e., *in terms of the subjects available and in learner choice* (Twining, 2009, p.500).
5. Support: What kind of support is provided by the VR-based intervention? According to Twining (2009), *[T]he range and nature of support, which includes teaching, will increase and diversify as the learning environments, actors and curriculum expand* (p.500).

In addition, VR researchers and special education professionals need to reflect on the following two essential questions:

1. Does the VR-based intervention (as in a virtual world) allow a participant to do things which it would have been difficult or impossible to do in the physical world, literally and pragmatically?

a. Literal sense: Are there things a participant can do in a virtual world that are not possible in the physical world?

b. Pragmatic sense: Would it be more difficult and expensive or easier and cheap to set up a new learning community in the physical world than in a virtual world?

2. Does the VR-based intervention create spaces that allow a participant to experience playfulness and test boundaries?

The Psychological Dimension

The following questions have been adapted from Cline's (2005) arguments that VR can lead to important positive changes to take place in an individual's life and daily activities:

1. Is VR integrated into the participant's daily life and activity and being applied in various human ways? How and what ways?
2. Are the techniques developed in this VR-based intervention approach impacting on the participant's behaviour, interpersonal communication and cognition? How?
3. Is the participant spending more time in the virtual space? How much time and/or for how long? This might result in a gradual transmigration from this real space to virtual space and can cause important changes in the way an individual perceives the world (Castranova, 2007).
4. Does the design of the virtual environment allow the participant to extend his/her own existence and activities into virtual space, to engage with other player and non-player characters rather than the immediate real people around him/her? How and in what way?
5. Is the participant affected by VR that might induce body transfer illusions? How? This is known as *hyper-reality, which is a hypothetical inability of the mind to distinguish reality from fantasy* (Chia & Tan, 2011, p.33).

Conclusion

The purpose of developing this generic questionnaire is intended to raise the awareness among VR researchers and special education professionals of the essential elements (from technological, pedagogical and psychological dimensions) that they need to reflect on and use to evaluate the effectiveness of a VR-based intervention, such as the use of virtual dolphins described here. VR has provided a new frontier in special education and it can be used in many ways to aid children with autism and other disorders. As in the case of the Pink Dolphin Simulation project, the use of virtual dolphins as intervention tool has provided the potential to enhance delphisbot-human interaction as a vehicle for learning support and behaviour modification for children with autism.

What that remains to be seen is whether or not VR researchers and special education professionals in their trans-disciplinary collaboration will take full advantage of the potential that VR offers, and use this generic questionnaire to evaluate reflectively its impact on treatment and intervention for children with autism and other disorders in their physical world.

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