Engaging the Anomalous Self of Individuals with Autism through Digital Doppelgangers: Transcendence from Self to i-Self

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Abstract— **The aim of this paper is fivefold: firstly, it provides a brief introduction to the latest criteria that have been used to define autism spectrum disorder (ASD); secondly, it examines the concept of *Self* that constitutes one of the dominant aspects of human experience, which, in turn, expresses an individual's unique existence and hence, an object of the individual's own reflective consciousness; thirdly, it explores the altered *Self* known as *i-Self* that can be represented by virtual icons such as mii, avatar and digital doppelganger within the context of the virtual world; fourthly, it also briefly examines the anomalous Self of an individual with ASD; and lastly, it illustrates how the transformational transition (also known as transcendence) of the digital Self from Self to i-Self can be attained by using an eclectic framework that is based on the underpinnings of social learning, information richness and self-perception theories placed within the authors' proposed interactive model of psychosocial-physical-internet Selves. This paper attempts to explain how the avatar image-based virtual reality technology (AIbVRT) approach can help engage the anomalous Self of individuals with ASD through self-referential encoding and protean shaping processes and their resultant effects.**

Keywords — **Autism Spectrum Disorder, Avatar, Digital Doppelganger, Human User-Avatar Interaction, Self, Virtual Reality Technology**

I. INTRODUCTION

The perceived increase in the number of cases in autism spectrum disorder (ASD), which knows no racial, ethnic, or social boundaries, has captured the imagination of the general public about the disorder through mass media and heightened the interest in ASD amongst the experts in the research community has risen in the last decade. More research funding has been given out to studies on ASD and there is also more public education to raise the awareness of ASD. In this way, individuals with ASD as well as their families can be helped through better support services to meet their challenging needs.

With the revised criteria of ASD in the fifth edition of the Diagnostic and Statistical Manual (DSM-5) [1], Asperger Syndrome and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) have been excluded. Under the new criteria, an individual must manifest three deficits in social interaction, communication and at least two repetitive behaviors. Apparently, the narrower definition of ASD puts an end to the autism epidemic. The international prevalence rate of ASD is estimated to be 60 per 10,000 across all cultures, and the ratio of boys to girls diagnosed with ASD is 4:1 [2]. However, "today's prevalence rate is an average of 1 in 110 children in the United States diagnosed with autism, while it is about 1 in 100 children in the United Kingdom" (p.235) [2]. In Singapore, it has been reported that the number of children diagnosed with ASD has gone up in the last decade. In 2005, 361 ASD cases were reported but in 2010, it went up to 528 ASD cases, an increase by 46 per cent [3].

Many theories and hypotheses have been postulated to explain the causes of ASD. For instance, according to the central coherence theory first advanced by Frith [4], there are some individuals with ASD whose specific perceptual-cognitive style cause them to process at local detail over global processing. In other words, these individuals manifest a limited ability to understand context or to see the big picture, which underlies the central disturbance in autism. Another example is the theory that explains ASD could be the result of neuronal apoptosis before the age of three years [5].

More recently, several studies [6] [7] [8] have shown that ASD can arise from rare highly penetrant mutations and genomic imbalance. As a result of the rare nature of these variants, it becomes very difficult to appreciate the extent to which progress has been made in understanding the genetic etiology of ASD.

There are also many unfounded claims that attempt to explain the causes of ASD. One debunked theory is about MMR (mumps-measles-rubella) vaccination that causes ASD in many young children [9]. Another unproven theory explains that it is due to delayed so-called *bpoptosis* – supposedly to occur between birth and four months of age – of spindle neurons to contact the other nerve cells and thus, resulting in developmental delay syndrome that leads to the cause of ASD [10]. However, one thing for certain is that the chance of ASD's occurrence is not due to family income, lifestyle, and educational levels.

Among the many theories and hypotheses about ASD, it is the theory of mind – "the ability to attribute mental states and predict behavior accordingly" (p.1) [11] – in relation to the Self, especially on one aspect of the Self concerning the ability to reflect on one's own inner mental states [12], that has captured our attention. This is because current studies [13] [14] [15] have found evidence of an altered Self-representation or intrapersonal cognition in individuals with ASD.

II. UNDERSTANDING SELF

Our current understanding of the term *Self* is based on past and present extensive examination and discussion amongst the many professionals in different fields such as philosophy and psychology as well as coming from different religions. Hence, it is not surprising to note that there are many models of Self. According to the Oxford online dictionary meaning, Self refers to "a person's essential being that distinguishes them from others, especially considered as the object of introspection or reflexive action" (para.1) [16].

Self is not a single primordial entity [17]. According to Neisser [18], there are five kinds of Self: the ecological Self as perceived within the physical context; the interpersonal Self as seen to depend on emotional and other species-specific forms of interaction; the temporally extended Self, i.e., based on memory and anticipation; the private Self, i.e., based on personal reflection and experiences; and the conceptual Self, i.e., based on socio-cultural experience.

Fig.1. Socio-Psychological Model of Self

This is a socio-psychological perspective that regards Self as a whole person whose most fundamental form consists of Self-knowledge and Self-awareness (see Figure 1).

However, according to Chia [19], there are three kinds of Self. First, there is the philosophical Self. It refers "to any individual as an object of one's own reflective consciousness" (p.30) [19]. Second, there is the psychological Self. It consists of "cognitive, conative, affective and sensory representations of an individual's identity and/or experience" (p.30) [19]. Jeannerod [20] argued that the key component of the recognition of Self is recognizing oneself as the owner of a body as well as the agent of actions through the sensory ownership and agency come from congruence of proprioceptive feedback and sensory signals from different parts of the body. These signals also contribute to the production of locomotive and manipulative actions. According to Jeannerod [20], the sense of agency paves a way for Self to create an identity independent of the external world. Third, there is the doppelganger Self. It represents the unique existence of an individual in terms of "any double or look-alike of a person" (p.32). In short, Chia [19] defines Self as the conscious totality of personal experience and expression, an organized, personalized whole as a unique existing or living being (see Figure 2).

Fig.2. Expression of the Self Model

According to James [21] in his classical definition of Self, he distinguished Self in two forms: the *Self of Me*, i.e., Self as an object of reflection and the *Self of I*, i.e., Self as a conscious agent. The Self of Me (Me-Self) is also described as accusative Self; the Self of I (I-Self), nominative Self.

The Me-Self is "the sum total of all that an individual can call his/her own" (p.518) [22]. This Me-Self can be further sub-divided into three smaller Me-Self categories, i.e., physical, psychological and social, which will be described further below (see Figure 3).
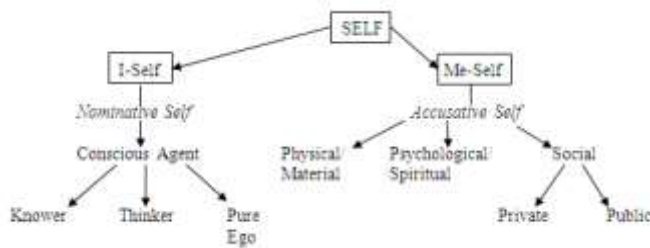

Fig.3. James' (1892) Classical Model of Self

Physical Self of Me

According to Singh [23], the physical Self refers to

"[t]he body, this marvelous container and complex, finely tuned, machine with which we interface with our environment and fellow beings. The physical Self is the concrete dimension, the tangible aspect of the person that can be directly observed and examined." (para.1)

Another way to describe the physical Self is through its physical manifestation in terms of ownership of action or sense of agency, which is described as follows:

"the sense that I am the one who is causing or generating an action … that I am the one who is causing something to move, or that I am the one who is generating a certain thought in my stream of consciousness" (p.15) [24].

According to Chia [25], the physical or material Self of Me (or Me-Self) refers to "a single entity that consists of a person's physical being and possessions" (p.13).

This involves an explanation of one's actions in terms of underlying intentional states. Hence, this brings us into the psychological or spiritual Self of Me.

Psychological Self of Me

According to James [21], the psychological or spiritual Self of Me is a single entity that incorporates psychological

faculties (e.g., personality traits, verbal skills, aptitudes, attitudes and social perceptions). Among them, social perceptions – also known as theory of mind – constitute a special challenge to individuals with ASD. This is because an individual with ASD displays faulty social perceptual ability "to create an impression or judgment of others, individually or a s a group, through observation and understanding existing information about an individual or group and drawing out conclusion from the information" (p.13) [25].

Social Self of Me

The social Self of Me is the biggest among the Me-Self categories and can be further divided into private social Me-Self, which an individual engages in private speech or thoughts (as in a reflective mood), and public Me-Self, which varies for different people and can be either reactive positively or negatively depending on how the individual is coping with the Self in the public (see [25] for detail). The positive reactive public social Me-Self, also known as the capacitated public social Me-Self, is to look good in success which, in turn, positively reinforced him/her to maximize his/her potential. The negative reactive public social Me-Self, also known as the handicapped public social Me-Self, is to attempt to look good in failure.

Self of I

Unlike the Self of Me, this Self of I (also the nominative Self) is an on-going process of consciousness. According to Chia [25], "[i]t is the conscious agent who is the knower, the thinker as well as the pure ego. It can reflect on the contents of the Me-Self (or accusative Self), but it is separate from them" (p.14). In other words, according to Shaver and Tarpy [22], the Self of I "can direct a person's purposive behavior, but it is separate from that behavior" (p.518).

III. UNDERSTANDING THE INTERNET SELF

There is another Self that exists in the cyber or virtual world. It is termed as i-Self. The letter *i* in i-Self represents internet – a worldwide system of inter-connected computer networks – that provides an extensive online range of information resources and services for the purpose of communication. Hence, i-Self is also known as the *internet Self*. "The i-Self exists in the cyber world and without it, there is no i-Self" (p.14) [25].

Like the classical definition of Self, i-Self, too, can be divided into the i-Self of Me (Me i-Self) and the i-Self of I (I i-Self), where the former is accusative i-Self and the

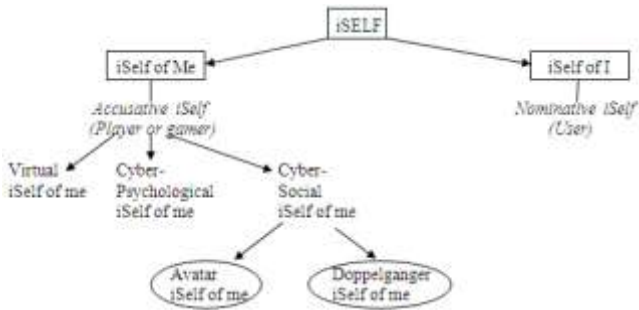latter, nominative i-Self. Figure 4 illustrates the model of i-Self.

Fig.4. Model of Internet Self (i-Self)

The i-Self of Me can be defined as the sum total of all that an individual who takes the role of a player or gamer in the virtual or cyber world. Like the Self of Me in the classical psychology, i-Self of Me can be sub-divided into three smaller forms of i-Self of Me: virtual, cyber-psychological and cyber-social [25]. Each of these will be described briefly below.

Virtual i-Self of Me

According to Chia [25], this refers to a single entity that consists of a user's virtual being (or avatar or digital doppelganger in the cyber world) and cyber or virtual possessions (e.g., apps, i-gadgets, virtual spouse and virtual currency such as Bitcoins).

Cyber-psychological i-Self of Me

This is also another single entity that includes cyber-psychological faculties (e.g., the player/gamer traits, gaming skills, aptitudes, attitudes and cyber-social perceptions). These cyber-psychological faculties influence a user's choice of action or response as a player or gamer, avatar or digital doppelganger, to cyber or virtual stimuli such as challenges, incentives and rewards [25].

Cyber-social i-Self of Me

According to Chia [25], this i-Self of Me can be further divided into the avatar i-Self of Me or the digital doppelganger i-Self of Me. In the former, the user can impersonate anyone or anything. This is the user's hidden or implicit i-Self – the persona that the user prefers to be known in the cyber or virtual world. The latter is the user's double that resembles him or her in the look and may include his or her personality. This is the user's explicit i-Self of Me. These two forms of cyber-social i-Self of Me will be discussed further later on.

i-Self of I

Finally, like the classical Self of I, i-Self of I is also an on-going process of consciousness. According to Chia [25], i-Self of I is described as the persona of a user of ICT, also the conscious agent who knows, thinks and manages what he/she does when engaging some form of activities (e.g, surfing the internet or cyber gaming) in the cyber or virtual world. The i-Self of I directs a person's purpose behavior as a user (player or gamer), but it remains separate from that behavior.

IV. FROM SELF TO I-SELF

In this paper, we have proposed a three interacting forms of Self as illustrated in Figure 5: psychosocial Self (i.e., in the combination of psychological/mental and social/cultural domains), physical Self (i.e., as it is in this real physical domain) and i-Self (i.e., in the virtual or cyber domain). Each of these forms of Self has already been described earlier as in terms of Self of Me and Self of I as well as i-Self of Me and i-Self of I.
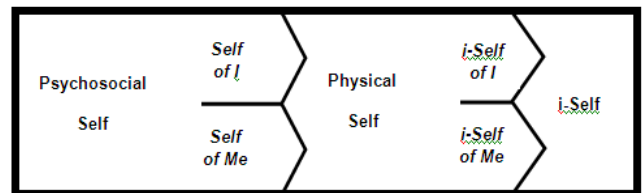

Fig.5. Interactive Model of Psychosocial-Physical-Internet Selves

When an individual engages others in the community (i.e., the physical world), he/she will portray what he/she perceives himself/herself (psychosocial Self) to be and what he/she wants others to see him/her as such (physical Self) in the physical world. When the individual goes online to engage in some kind of virtual activities (e.g., gaming) or watching a movie in an IMAX theatre, either his/her i-Self of Me or i-Self of I will be involved during the engagement. The digital Self is the *transformational transition* (also termed as *transcendence*) from physical Self to i-Self.

Generally, there are three types of digital Self: mii, avatar and digital doppelganger. Each of them will be briefly described below and all three do possess what Chia [25] has termed as *i-Self* described earlier and it should not be confused with techno-Self, advanced by Luppicini [26], to denote evolving human identity within a technological society focusing on the dynamic nature of relationships between the human users and the new technologies adopted. Terms such as cyborgs [27], trans-human [28],

homotechnicus [29], bio-electric human (*beman* for short, i.e., a robot in the human form), avatar [30], techno-human (i.e., a hybrid creature between human and machine), techno-sapien (a slang to describe someone familiar and cozy with technology) and digital identity (i.e., data that uniquely describes a person and his/her relationships) fall under techno-Self.

However, avatar, which represents an individual, his/her alter ego or character within the virtual worlds controlled by a human user [30], comes under i-Self. The other one is digital identity, but it is not within the scope of this paper to discuss about it.

Mii

The term *mii* is a portmanteau of me and *Wii*. It is a free-form digital icon or avatar that a user can create a caricature of himself or herself, other people (users) or even invented characters to be used as a playable character in various titles for each of the following Nintendo consoles: Wii, Wii U as well as Nintendo 3DS. Mii involves i-Self of I in full control and management of the virtual character.

Avatar

In computing and cyber gaming, the word *avatar* – first coined in 1985 by Richard Garriott, a British video game developer, for the computer game *Ultima IV: Quest of the Avatar* – refers to a 2D or 3D graphical representation [31] or digital icon of a user in virtual worlds as well as Internet forums and other online communities (e.g., Facebook, Twitter, Instagram and Whatsapp). In the past, avatar images were known as "picons" (derived from the term *personal icons*) but the term is rarely used today [32].

Avatars driven by artificial intelligence (AI) have been used as virtual embodiments of embodied agents by organizations as a part of automated customer services in order to interact with customers and users of services. They are also commonly known as *bots*. An example is the avatar Anna, an automated online assistant, designed to provide a virtual tour around the Ikea website. There are also other avatars such as Cleverbot, Boibot and Evie that are powered by a digital conversation – a scripted dialogue written by a human – to take place between a person and a computer via any digital medium. They are also known as *chatbots*.

Avatars can also include persona in online communities and games or virtual life simulations such as Second Life.

Avatars involve the cyber-psychosocial (i.e., a combination of both cyber-psychological and cyber-social forms) i-Self of Me. When fully engaged in a cyber game activity, a user becomes in full suspension of disbelief in that cyber or virtual world, especially in the Massively Multiplayer Online (MMO) games.

Digital Doppelganger

The term *doppelganger* is derived from the German language and is defined as "any double or look-alike of a person" (p.176) [33]. In computing and cyber gaming, a loose definition of digital doppelganger refers to virtual versions of the Self.

Avatars are created by users to resemble themselves and who control them in the virtual worlds. In other words, they provide a unique opportunity for the users (relying on i-Self of I) to experiment with their own identity (i.e., i-Self of Me) construction within virtual worlds [30]. However, according to Bailesnson and Segovia [33], "in many cases, users are not in control of their look-alike avatars; sometimes other players or algorithms take control. This is the case in which avatars become doppelgangers" (p.176). In other words, this happens when a doppelganger begins to behave autonomously or independently of the user whom it is modeled after.

V. THE ANOMALOUS SELF OF INDIVIDUALS WITH ASD

Observations as well as a diagnostic assessment of individuals with ASD found them to display an anomalous Self in terms of both physical Self and psychosocial Self.

In the physical Self, young children with ASD display a delayed developmental turbulence in their acquisition of recognizing themselves in front of a mirror [34]. They lack the shared neural representations for self and others that typically developing children seem to possess [35]. In fact, in a study done by Jemel et al. [13], children with ASD have been found to display face-processing deficits, which could be explained by the findings of another study done by Behrmann et al. [36] showing such individuals have altered perceptual processes.

However, individuals with ASD do not show deficits in their sense of agency (i.e., ownership of action) or action monitoring and attribution despite known significant impairments in empathizing – also known as mentalizing (i.e., the ascription of mental states to other people) [37]. In fact, individuals with ASD construct internal models of action (e.g., when they learn a motor task) that create more-than-normal or superior associations between Self-

generated psychomotor commands and proprioception [38]. This is known as systemizing ability.

In the psychosocial Self of individuals with ASD, studies [39] [40] [41] have found that such individuals display altered psychosocial and self-related evaluative processing which is the result of functional abnormalities in the ventromedial Pre-Frontal Cortex (vmPFC), which forms part of a larger default mode network that supports Self-knowledge and autobiographical memory (see [42] for detail). Hence, there is a reduced functional connectivity between vmPFC and ventral premotor and somatosensory cortex resulting in the poor or faulty ability to mentalize (i.e., deficit in theory of mind) [43].

With a better understanding of the anomalous Self observed in individuals with ASD, this knowledge can be used to harness the potential of virtual reality technology (VRT) to create a better intervention design to treat ASD.

VI. ENGAGING INDIVIDUALS WITH ASD THROUGH AVATARS AND DIGITAL DOPPELGANGERS

As a result of functionally abnormal vmPFC, individuals with ASD display significant difficulties in their social interaction and communication with others, resulting in an anomalous Self. This concerns interpersonal interaction that individuals with ASD find it most challenging to remain in socially appropriate engagement with other people.

According to Uddin [44], current empirical and theoretical research has begun to reveal increasing evidence for altered Self-representation or intrapersonal cognition in individuals with ASD. Uddin [44] reviewed literature of recent studies of the Self in individuals with ASD, focusing on paradigms examining physical aspects of their Self, including Self-recognition, agency and perspective taking, and psychological aspects of the Self, including Self-knowledge and autobiographical memory. From the review, Uddin [44] suggests that psychological, but not physical, aspects of Self-representation are altered in ASD. One key cortical region that has emerged as a potential locus of Self-related cognition deficits, including difficulties in accessing specific autobiographical memories [45], in ASD is the vmPFC which constitutes a significant part of a larger default mode network.

There has been an increase of interest in potential impact of new technologies used in autism treatment. One of these new technologies is the augmented reality technology, more popularly known as virtual reality technology (VRT). The term *virtual reality* was popularized by Jaron Lanier in

1985 (see [46] for detail). With the introduction of avatar image-based virtual reality technology (AIbVRT), the treatment approach for individuals with ASD has also taken a new turn in an attempt to circumvent the dysfunctional vmPFC.

In order for this VRT-based autism treatment to work well, there are two major factors to be considered. Firstly, there is a need for a *H*uman user-socially assistive *A*vatar *I*nteraction (HAI) framework to be created. There are several HAI-based models. One of them is the User-Avatar Social Engagement model (see [47] for detail). Secondly, there is also a need to select an appropriate theory that can best explain how a user with ASD might be affected by the experience of being confronted by a virtual version of one's Self in the VRT-based autism treatment.

Currently, there are three theories that can explain how a VRT user might be affected when he/she is confronted by a virtual version of his/her Self (see [33] for detail). These three theories are briefly described below.

The first one is the theory of social learning [48] which explains that an individual learns by observing the behavior of models. Digital doppelgangers are the best model of the Self that can be used in VRT-based autism treatment. In other words, it assumes that if individuals with ASD see their digital doppelgangers performing certain tasks, they will observe and learn to perform the same tasks. It has a similar effect like video modeling in which an observed behavior is learned by watching a video demonstration and then imitating of the behavior of the model..

The second one is the information richness theory developed by Daft and Lengel [49] to explain that digital doppelgangers are rich forms of media in immersive virtual environments. They (doppelgangers) can provide immediate feedback, language variety and personal focus as well as transmit multiple cues to individuals with ASD. Whether a user chooses to interact or not with his/her doppelganger in that environment, the doppelganger itself "is a rich form of media in its own right as it maximizes more than any other existing medium" (p.178) [49].

The third and last one is the self-perception theory developed by Bem [50] to explain that an individual develops his/her attitudes by observing his/her own behaviors and then concluding what attitudes must have caused them. In other words, the behavior of a user within the online virtual world is changed by the visual characteristics and traits of his/her avatar or digital doppelganger associated with specific behavioral

stereotypes and expectations. This phenomenon has been termed as Proteus Effect [51].

Whichever theory one's preference is, an eclectic choice of the three theories is the best, by putting them together in the interactive model of psychosocial-physical-internet selves, to explain and show the transcendence of the Self of a typical individual to i-Self via the AIbVRT (see Figure 6).
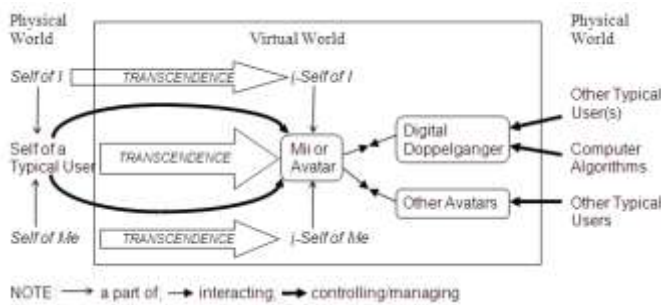

Fig.6. User Control/Management of Avatars and Interactions

Figure 6 illustrates a typical user's control or management of his/her designed mii/avatar in an interaction with other avatars controlled/managed by other users. When the user loses control of his/her avatar, which becomes somewhat autonomous from its user and comes under the control of the computer algorithms or other user(s), the avatar has become a doppelganger, free from its original user who designed or created it. When that happens to an individual with ASD, two possible processes may happen and take place simultaneously: self-referential encoding (SRE) and protean shaping (PS) of the individual.

Self-Referential Encoding (SRE)

In the SRE process (see Figure 7), an individual learns and remembers information better when it is related to the Self because the information would be preferentially encoded and organized above other types of information [52]. This phenomenon is also known as the SRE effect. In AIbVRT approach, a user with ASD may process information that his/her avatar/doppelganger is used to convey to him/her over information that is presented to him/her via other users or avatars. For example, the doppelganger of a teenage girl with ASD is presented a list of pictures of supermarket items "belonging" to her or another person. She watches her doppelganger picking up all those items in the virtual supermarket. Later, the girl later conducts a recognition task to determine if the presented items belonged to her or another person. She can perform the same task at a real supermarket picking up only those items that "belong" to

her. In this VRT-based activity, the memory advantage is resulted from self-referentially encoding the owned items, suggesting preferential information encoding in relation to the person concerned. According to Bailenson and Segovia [33], "autonomous avatar (or digital doppelgangers) that merely look like their users (even if they do not act like their user or share similar beliefs with their user) will activate preferential information encoding" (p.14).
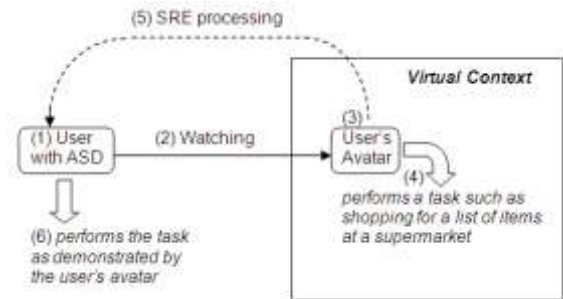

Fig.7. An Illustration of Steps taken during the SRE Processing

Protean Shaping (PS)

In the PS process, a user's behavior, within the online virtual world (e.g., SimCity), is shaped by his/her avatar's (or doppelganger's) visual characteristics and traits that are associated with specific behavioral stereotypes and expectations. This change is due to the user's knowledge about the behaviors that other users, who are part of that virtual environment, typically associated with those characteristics. This phenomenon is known as Proteus effect. In the AIbVRT approach, the behavior of an individual with ASD can conform to or be shaped by his/her digital self-representation independent of how others perceive him/her. For example, a boy with ASD took his usual long route to get to his school now changes to take a shorter route after watching his avatar walking down the street that is the shortest link between his house to the school on the Google Street View.

VII. CONCLUSION

In AIbVRT, avatars and/or digital doppelgangers may offer powerful intervention tools in autism treatment. Digital representations of individuals with ASD can be used to serve as a model via SRE process to teach appropriate social interaction and communication skills. They can also be used to shape the behaviors of these individuals via PS process so that they can engage appropriately with others in any social events.

However, in order for any VRT-based autism treatment to work successfully, there are three important factors to be carefully considered in creating such an intervention design to treat ASD. They are summarized as below:

Firstly, autism must be understood as a spectrum disorder (and hence, it is often known as autism spectrum disorder or ASD for short) with its various subtypes and it ranges from mild to profound level of severity. There is no one best strategy to treat ASD. Using avatars or digital doppelgangers is just one of the many promising innovative techno-strategies to treat ASD currently being tried out in many research laboratories worldwide. An example is the Virtual Reality Technology Lab in Nanyang Technological University, Singapore, where the first author has been working collaboratively with other researchers in the fields of innovative engineering technology and special needs education.

Secondly, the anomalous Self of individuals with ASD must not be ignored if interventionists hope to engage these individuals, understand them and make a difference in their learning and behavior. The anomalous Self needs to be carefully addressed in terms of the Self of I and the Self of Me in both physical and psychosocial entities.

Finally, a good *H*uman user-socially assistive *A*vatar *I*nteraction (HAI) framework is needed to create a VRT-based intervention design such as the User-Avatar Social Engagement [47] to treat individuals with ASD. To do so, a clear understanding of the i-Self of users with ASD (in terms of their i-Self of Me and i-Self of I) and their responses to the use of their virtual representations (in terms of mii, avatars and/or digital doppelgangers) is required, while, at the same time, tapping into the self-referential encoding (SRE) and protean shaping (PS) processes to engage their anomalous Self.

Acknowledgment

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