Agency and Presence: a Common Dependence on Subjectivity?

Gerardo Herrera[1], Rita Jordan[2] and Lucía Vera[1]
[1]Autism and Learning Difficulties Group. Robotics Institute. University of Valencia,
[2]Autism Team. School of Education. University of Birmingham
{Gerardo.Herrera@uv.es, r.r.jordan@bham.ac.uk, Lucia.Vera@uv.es}

Abstract

The analysis of agency, a very close concept to presence, is of great help for acquiring insights into how the sense of presence is acquired in the developing child and also about the experience of presence itself. Empirical evidence coming from Cognitive Developmental Research together with the positive outcome of people with autism (who are not generally able to act "as if") when participating in Virtual Environments suggests that presence is more about 'experiencing agency' than 'Pretending to be there' or than constructing and reconstructing mental models in real time. It is considered that these phenomena shed some light on the current issues of Presence Research and open up new fascinating philosophical and psychological ones, both in relation to Presence and Autism.

Keywords --- **agency, presence development, autism, interaction, affordances, subjectivity**.

1. Introduction

1.1. Agency, action perception, imitation and autism

From the point of view of the user of Virtual Reality (VR) systems, agency has been referred to by Murray [1] (p.126) as "the satisfying power to take meaningful action and see the results of our decisions and choices". The individual-environment relationship and the potential for action of the environments, very close concepts to agency, have been the focus of attention of other researchers in this field such as Spagnoli et al. [2], and also Zahorik et al. [3].

The field of cognitive developmental and autism research provides other more complete attempts to define agency as in that of Russell [4], who defines agency as the exercise of a capacity for first person experience that has four integral features: the first two describe types of information-processing and control that the agent must achieve, and the other two describe the kind of self-knowledge that is available to agents and to agents alone. These features (that will be analysed in the third section of this paper) are:

A. Locating the cause of altered inputs in one's body rather than in the world –"action-monitoring".
B. The perceptual sequences brought about by acting are reversible; but those experienced in perceiving environmental change are irreversible.
C. Our actions are known non-observationally whereas the world is known by observation.
D. Agents have a privileged knowledge of their own "tryings" which they lack when observing the "tryings" of others (although the existence of 'mirror neurons' (Rizzolatti)[5] provides a possible mechanism through which the linkage between one's own and others' actions might be made apparent).

Brewer [6] used the term 'experiencing self' (akin to 'Presence') to characterise our typical moment to moment awareness of ourselves in the process of perception of the world, which is a more comprehensive conceptualisation than that of Steuer [7] (p.73) who characterised presence just as the *sense of being in a place*. The understanding of presence that emerges from Brewer's conceptualisation fits better with Russell's definition of agency and puts both concepts very close to each other. Therefore, we will use presence in that way throughout this paper.

We understand that what we will call 'Tangible Presence' can occur in natural/physical Realities (where natural presence takes place), in Technologically Mediated Realities (such as Augmented/Mixed Reality or Real Environments equipped with Ambient Intelligence) and in Virtual Realities. Tangible Presence is possible both remotely (as in Telecommunications and Teleoperations, i.e. *Telepresence*) and locally (as in Augmented Realities), and both alone or in social contexts (Co-Presence).

1.2. Hypothesis about the role of Agency in Presence

Analysing how the sense of presence is acquired through typical development and in autism offers some insights into the concept of presence concept and leads towards understanding of the role of agency both in the development and in the experiencing of presence in any environment and by any individual.

Several authors such as Biocca & Delaney [8]; Kalawsky [9]; Sheridan [10,11]; Welch, Blackmon, Liu, Mellers, & Stark [12] have reached consensus in seen presence as a multidimensional concept. We argue further that there is a multidimensional continuum that goes from Absence to Presence of this sense of being engaged in the

perceived environment and that agency is a regulating variable that usually correlates with the level and type of presence obtained.

We also argue that presence is a subjective measure and, as a consequence, it adopts different forms for each person in different moments or situations and with different technologies.

Finally, we propose that the agency based model (which is more connected with experience) is a better model than *constructivism* (proposed by Nunez [13) for describing and explaining the experience of participating in Virtual and Real Environments, since it has greater potential to be an empirically (rather than metaphorically) based model.

2. Agency and the development of a natural sense of presence

Agency and presence cannot be understood fully by paying attention solely to the environment or to the individual; it is necessary to consider the relationship between them. As individuals with autism find it difficult to cope with the environment (perceptually, culturally and socially) we will also analyse this human condition within this section.

For obtaining more insight into that feeling of presence that we have in natural settings, it is useful to separate the 'sense of presence' from the child's '*development* of a sense of presence' for which exercising agency is fundamental, and this will help us to know more about presence in Technology-Mediated and Virtual Realities.

2.1. The case of typical developing children

There are different mechanisms in which the development of a sense of presence is supported. Without the intention of being exhaustive, we outline those that we find more relevant for the scope of this paper.

The role of sensory perception in the development of a sense of presence: The perceptions we receive from our senses have a very important role in the configuration of the sense of being there as they keep us 'connected' with reality at every moment. Relevant here is the concept of *affordances* as noted by Zahorik et al. [3]. *Affordances*, as Gibson suggested [14, define the opportunities for perception and action offered by the environment in the context of the individual's capacities: they are things that one perceives directly (without the need of a mental representation process). This is characterised by Valenti [15] (p.90) as '*It is more of something we live in rather than we think*'. Loveland [16] claims that discovering and acting upon available *affordances* is an essential process in development. In general, people suffering from learning difficulties (with or without autism) will also have an impoverished exercise of agency as their knowledge of the *affordances* (physical, cultural or social) of the environment will be very limited and so they have a limited range of actions to execute through agency. Gibson's [14] passive view of perception, as derived from the *affordances* of the world around, has been challenged by the view of those like Russell [4] who claim that the infant must become aware of his/her own actions in order to truly 'perceive' (i.e. to make sense of sensory information).

The role of exercising agency in the development of a sense of presence: The development and continuous update of our mental world, then, is fully connected with our interaction with the environment (exercising our agency). Russell (op cit.) shows how sensory perception is bound up with action and that presence comes from agency, through the capacity thus afforded of distinguishing self from other perceptions. Mirror neurons, a subset of action-coding neurons identified in the premotor cortex in monkeys by Rizzolatti [5], show activity both in relation to specific actions performed by self and in matching actions performed by others (see the work of Williams [17] for further explanation and implications in humans). This work also contributes to our understanding of how the distinction of the self from others (and the notion of others) is fostered further through reciprocal imitation. However, in typical development at least, the child does not act autonomously on the world but does so initially as a 'social unit' with those who help tutor the sense of both personal and social agency. As Hobson [18] makes clear, the sense of self and of others and the capacity to make human sense of the world depend on the quality of social interactions through which such understandings develop. The claim is that it is through inter-subjectivity that we are enabled to take a subjective stance and thus have a sense of presence. As Halliday [19] suggests, the baby is taught how to mean, and so missed opportunities to engage in these acts of emotionally charged mutual agency (as happens in autism) lead to a failure in culturally appropriate perception.

The role of connecting the experience with feelings and emotions: The work of Damasio [20] on the biological representation of emotion in the brain, gives further insight into the development of 'the sense of what is' as Damasio phrases it. Damasio sees the subjective experience of the world as being the root of consciousness. He characterises emotions as being represented in the brain at three different levels, occurring in a timed sequence during a single emotional event. The initial stage (called 'emotions' by Damasio) is purely represented at sub-cortical levels of arousal and there is no subjective consciousness of this stage. The next stage (Feelings 1) is represented also subcortically but reflects reactions to the first stage and is mediated through the hormonal system; this stage is also unconscious. It is only at the third stage (Feelings 2) where emotion processing subcortical areas are linked, via the hypothalamus and amygdala loop, to the cortex that the individual becomes aware of his/her emotion and is able to name it and control its expression. Thus, conscious experience of the world and the sense of oneself as an agent within it, are linked to this emotional level of representation. The relationship to the development of first order presence is not clear, but it is clear that conscious awareness is a necessary condition of presence.

2.2 The case of autism

Autism is a pervasive developmental disorder of brain functioning (definition of American Psychiatry Association [21]). According to Wing [22], the main symptoms of autism are:

- Deficits in social reciprocal interaction
- Deficits in verbal and non verbal communication
- Limited range of activities and interests

2.2.1. Why consider Autism?

In developmental psychology, it is common to study people with developmental disorders to find out about the existence of very basic abilities of typical human development. Studying people who have differences in their interaction with the environment (perceptually, culturally and socially), as occurs with people with Autism Spectrum Disorders (ASD)[1], would help us to understand both our and their relation to the real or virtual world better. This is especially the case if take into account the work referred to above that links autism with deficits in the basic mechanisms that might lead to a sense of agency and hence, of presence. Individuals with autism (possibly all those with ASD, although it is clearer in those with classical autism defined by Kanner [23]) also appear to have problems with 'first-order' presence i.e. with a subjective experience of the world in which they act as agents (see Grandin [24]; Powell & Jordan [25]).

There are a number of studies aimed at educational intervention for people with autism where VR settings have been used as a medium for developing this sense of agency, as in that of Herrera et al [26] or Parsons [27]. As we will examine later, the data collected from the experience of people with autism facing VR situations is a very useful secondary result of those studies in the sense that they help us to better understand the experience of typical developing people and people with autism when participating in these settings.

Recent work on 'mirror neurons' from Nishitani et al. [28] and from Oberman et al. [29] suggests that this mechanism, which affords the final aspect of agency (feature D above), may be missing or at least dysfunctional in autism. Oberman et al. (ibid) and Williams et al. [17] make the case for such a fundamental deficit being the basis for the sequalae of social and interpersonal problems that characterise autism.

Sensory disability is also a source for obtaining some insight about presence. Oliver Sacks [30] describes the case of a man whose sight was restored after 45 years of blindness. After such a long period, his world had been built up through other senses (cited, Bogdashina [31]) and thus visual stimuli still did not play a major role in his understanding of the world even after his sight was restored. He was able to see but not to decipher what he was seeing [30]. This is only an extreme case of how the same environment (even with the same perceptual inputs) can produce different kinds of presence depending on the previous experience of each individual; it is an example of the subjective nature of presence. The difficulties suffered by people with hearing difficulties in hearing themselves, in order to modulate their speaking, also supports the perception/action cycle view of agency.

2.2.2 Autism and Presence

Nadel [32] makes the case for a connection between early imitation and a sense of agency, citing the psychological and neuroimaging experiments that have demonstrated that there are some common neural and cognitive mechanisms underlying perception of action, action generation, action simulation, action recognition and action imitation. She further points out that human beings as young as 2 months are selective in their imitation of biological agents as opposed to mechanical actions with similar perceptual qualities. She suggests, using Russell's characterisation of agency above, that this kind of imitation may be the basis for distinguishing self from other agency.

Rogers et al. [33] claim that children with autism have difficulties with spontaneous imitation of others but Nadel was able to enhance the capacity to imitate other children, in children with autism, by first giving them experience of synchronous imitation of their actions by a robot.

Jordan has described the problems of 'first-order' presence of people with autism as lacking an 'experiencing self' (see Jordan [34]; Jordan & Powell [35]; Powell & Jordan [25]), after Brewer's [6] use of this term to characterise our typical moment to moment awareness of ourselves in the process of perception of the world. This theoretical notion is allied to (although not identical with) Russell's [4] characterization of autism as a failure to develop 'social agency' and Hobson's [18] account of how early failures in social and emotional processing lead to later failures to differentiate the self (and other) from the experience. People with autism have themselves described their experience of the world as like watching a video (as in Grandin [24]). The result is a unique 'objective' view of life, which makes it easier (unlike any other group) to recall what they have witnessed than what they have experienced (Millward et al. [36]), poor spontaneous recall of personal episodes alongside phenomenal cued, rote and procedural memory and a world view that Baron-Cohen [37] suggests is at the extreme end of systemetising as opposed to empathising.

The reasons for the failure in first order presence in autism may be manifold. At one level it may relate to the way emotions are processed in the brain. We know that the areas of brain functioning linking emotional with cognitive processing are disturbed in autism and we know that there is often (always?) extreme delay in developing understanding of their own emotional states (and thus the emotional states of others). It may be that, without that cognitive emotional link, it is not only that it is hard to be consciously aware of emotions but also to be emotionally aware of cognition i.e. to develop a subjective 'presence' in the world.

We also know that people with autism have difficulty in becoming aware of their own intentions (perhaps through failures in 'efference copying' –see next section for an

[1] All along this document, in many instances, we talk about autism to refer briefly to Autism Spectrum Disorders

explanation of this concept: Frith & Frith [38]) and that this is one of the breakdowns in neural functioning that also occurs in schizophrenia. In the latter condition there has been a stage of normal development before the illness so that a loss of that awareness is interpreted, by the individual, as what we might call 'false secondary mediation'. Thus, the person who is used to the feeling of intending his/her own actions reacts to the lack of that feeling by imputing technological or 'other' agency in their own actions (they feel 'controlled' by radio waves, extra terrestrials and so on). The person with a developmental disorder like autism, however, may never have experienced that sense of agency or intention so they do not react with delusions and paranoia to its loss, but instead are far less engaged in the world and far less aware of their own engagement when it does happen.

If mirror neurons are absent or dysfunctional in autism and Asperger syndrome, as growing evidence suggests (see above), then there is a further barrier to developing that sense of an 'experiencing self' (i.e. presence). The capacity to engage in reciprocal imitation not only leads to bonding but to the capacity to distinguish ones own actions from those of others and to learn the difference between being a passive viewer of life and someone who is emotionally and physically engaged.

3. Agency in Technology-Mediated and Virtual Realities

Here we will review the implication of agency in Technology-Mediated and Virtual Realities and, for this analysis, we will first adopt the limitations of the state-of-the-art technology and then we will adopt a focus that anticipates a future position where there are no such technological limitations. We will do this in order to outline a model that may last through time, not restricted to the current state-of-the-art.

We will also propose ways of obtaining an 'augmented agency' by augmenting the potential of each core feature of Russell's model of agency. This will be done, respecting those features by manipulating them in the natural dimension (that goes from non agency to natural agency) but going beyond natural limits to reach augmented agency. Examples of other non-natural possible ways of manipulating agency will also be examined.

3.1. Types of information and control that the agent must achieve.

As indicated above, Russell [4] grouped those features of agency into two pairs: The first pair (A and B) describe kinds of information-processing and control that the agent must achieve.

Manipulating Feature A: Locating the cause of altered inputs in one's body rather than in the world: "action-monitoring".

To illustrate some of the limitations of some of the state-of-the-art technologies for obtaining a natural-like ("natural") agency in relation to this feature, we find that when a VR helmet is used, there may be efficiency limitations in the head tracking system used –in some low frequency electromagnetic trackers– since the changes in our visual input are not naturally correlated to head movements (which is a cause of altered input that comes from one's body). In this case, it would be difficult to solve the problem of self-ascription versus world-ascription of the changes in the visual input (a natural ability that is called 'efference copying' by Host and Mittelstaedt, cited Gallistel [39]). Given the fact that, according to Russell [4], visual experiences are, to some extent, a function of what we do, if there are interferences in this action monitoring, this will lead to a disturbed sense of agency.

Another problem is the imperfection of the available representations of the user's body in VR. Some authors such as Tang, Biocca & Lim [40] have already suggested that the absence of representations of the user's body in the VR environment may lessen the sense of spatial presence compared to the Augmented Reality environment. In fact, the variety of Augmented Reality that consists of seeing oneself (with a VR helmet with embedded subjective video-camera and real-time video processing and reproduction in the helmet displays) allows the participants to experience agency in a natural way, although it also includes artificial additions. A variety of VR that includes body representation is that of Fernandez and Gimeno [41] where an infrared motion tracking system and a Cave Automatic Virtual Environment (CAVE) have been used for obtaining the information about the user's body and drawing it in a virtual mirror, thus increasing the body perception of the user.

Using Joysticks for moving around the virtual environment (VE) is not a way of promoting a natural sense of agency, although there are examples of adapted joysticks that are natural for certain applications (such as a steering wheel controller of a driving simulator). Thus, there are implications in the particular interfaces used, if a "natural" presence is the goal.

We can believe that, at some time in the future, these limitations will be completely solved in Virtual Environments and then we would be able to configure this Feature of agency in a way that produces a natural sense of agency and presence. We would also be able to exploit the potential of technology by manipulating this feature in a way that produces other kinds of artificial agency and presence. For example, we can modify this feature of agency just by inverting the positive and negative (x, y) values of the movements of our head and then produce an inversed efference copy that would lead to a different (and perhaps uncomfortable) artificial agency. An example in the direction of augmented agency would be augmenting the visual perception of our body, such as having transparency in the skin of our virtual body and being able to see our heart beating when the physiological measure of our heart rate exceeds a given value. This would be similar to the visual effect recreated in the film 'Amelie Poulain' of Jean Pierre Jeunet (min 38) [42], with the difference that in

this film the director uses this effect to communicate something to the audience, whereas the combined use of virtual and electrophysiological technologies could be a way to use visual information to augment proprioception of the user him/herself.

The kind of agency that will be generated in this way will be artificial (i.e. not natural) in the same sense that the agency that is generated with the limitations in the efficiency of some head trackers of the current state-of-the-art technologies is artificial. Nevertheless, as the 'Amelie' example is situated beyond the natural limit of feature A, the perception of ourselves when interacting with the environment would be augmented and we could call this 'augmented agency'.

Manipulating Feature B: The perceptual sequences brought about by acting are reversible; but those experienced in perceiving environmental changes are irreversible.

State-of-the-art VR environments (such as 3D games) perfectly incorporate this possibility, so it is not necessary to wait to have natural agency in relation to this feature in the future. Again, it is possible to manipulate this possibility to obtain an artificial experience of agency. As an example of this, we could say that in reality we can 'undo' our stream of visual input just by going back again with our eyes over the previously seen stimuli and that, thanks to Gaze Tracking Technologies, even currently it is possible to construct a gaze-contingent virtual environment that is voluntarily configured in a way that the user cannot pass his eyes back over and find what he/she had previously seen in his/her visual perceptual sequence again (for example, putting an apple where he/she has just seen an orange or even, at a more basic level, manipulating colours and shapes).

A way of promoting 'augmented agency' by manipulating this variable would be to increase our capacity to reverse our perceptual sequences going backwards further than the natural limits of our short term memory (reviewing our perceptual sequences of previously lived minutes, hours, days, months or years).

3.2. Self- knowledge that is available to agents and to agents alone.

The second and final pair of features (C and D) pointed out by Russell [4] describes the kind of self-knowledge that is available to agents and to agents alone:

Manipulating Feature C: Our actions are known non-observationally whereas the world is known by observation.

Shopenhauer [43] claimed that we know everything representationally except facts about our will. Russell [4] explains that the representations about our actions (e.g. I am doing X) are not gleaned from self-observation: they are known immediately, in the sense of "without inference".

This feature is fully related to the degree of sensory immersion in VEs. If we want to obtain a "natural" sense of agency in a virtual environment, we should always act in the first-person. However, the state-of-the-art technologies do not allow us to obtain a Quality of Immersion comparable to the one we have naturally in the real world (although that is not the case with Augmented Reality). Quality of Immersion (Schubert et al. [44]) refers to immersion that includes sensory factors (Witmer & Singer, [45]), multimodal presentation and consistency of multimodal information (Held & Durlach, [46]), but (we suggest) not necessarily to the environmental richness or other non-sensory related features.

With the advance of technology, these difficulties will be solved at some time in the future and then it will be possible to obtain a natural first-person experience of interaction with the VR world. Once again, potential manipulation of this agency variable can be outlined. A possible example would emerge if we distort the way our actions modify the virtual world (i.e. producing inverted effects to those of the same action in the real world, such as making it necessary to grasp a VR object if we want to release it), then this feature would also be challenged by forcing us to know our actions through observation or inference and thus obtaining an agency that, at least at first, will be really different to the natural one.

An example of augmented agency would be just giving the user more potential for interaction than what he/she has in reality by allowing him/her to move VR objects with his/her eyes using a gaze tracking system. In this line also is the work of Duncan et al. [47] where they use electroencephalogram signals for what they call 'thought-controlled music systems'.

Another example would be to let the user obtain knowledge of the world non-observationally by allowing him/her to adopt the subjective points of view of others (and swapping these with his/her own at his/her will).

Manipulating Feature D: Agents have a privileged knowledge of their own "tryings", which they lack when observing the "tryings" of others.

O'Shaughnessy [48] defines strong knowledge of agents as knowledge whose falseness is impossible to imagine. Russell [4] explains that the agent's knowledge of what he or she is trying to do in goal-directed action has a degree of first-person authority similar to the first-person authority of an experiencer of a sensation (such as pain) and claims that, through the exercise of agency, one gains the conception that agents have immediate and incorrigible knowledge of some aspects of their mental life.

In order to widen the field of view and interaction with the user's body, some existing VR games (such as Tomb Raider [49]) include an avatar that is fully managed by the user in what it is called the *third-person mode* of controlling the game. Although it is a third-person perceptual point of view, the user does not establish differences between him/her and the avatar he/she controls, so the user adopts the same first-person conceptual point of view. Even with this, the sense of agency in relation to this feature would be artificial rather than natural because of these perceptual differences and because of the requirement

for the user to identify him/herself with the avatar he/she is controlling in a third-person perceptual point of view.

For obtaining augmented agency and presence here, we may want to give the user access to the privileged knowledge of the "tryings" of others by constructing what we may call a 'shared subjectivity' in which a user can transfer him/herself to (and acquire some control over) the subjectivity of another. This could be as simple as remotely controlling someone else's computer mouse and keyboard, or as complex as controlling some movements and actions of another's virtual body.

In a virtual social framework where several agents participate in a 'shared subjectivity' basis it would be possible, for example, to have a face to face conversation with other agents also knowing that behind the eyes of that agent there can be several human people. The deeper into our cycle of perception/action technologies we go the greater the possibilities in this direction.

4. Discussion

4.1. Agency and it's correlation with Presence

Once agency and its potential have been analysed, in order to clarify the differences between presence and agency we start by going back to the role of agency in the development of a sense of presence.

As we stated in the second section, exercising agency is a necessary companion in the journey that enables us to take a subjective stance and thus have a sense of presence but, once the capacity of experiencing presence has been developed, do we still need agency to experience presence?

4.1.1. Affordances, Agency and Presence

One consideration is the state-of-the-art limitations to the realism of stimuli and perception (the cycle of ourselves perceiving the environment and the environment perceiving us). Another is the potentiality of the environment itself for interacting with us. This is a good complementary concept to presence in that it has the potential of putting together many of the other components of presence.

Defined by Gibson [14] and previously approached in presence research by Zahorik et al. [3] *affordances* relate to the action-supportive information of the content of a given environment. Experiencing agency also means being able to put all our repertoire for action into practice and, if we do not perceive this possibility, then our agency is impoverished.

If we have expectations about the contents of a given environment and the objects we find fit those expectations, then the affordances provided by those objects can be seen as enriching our sense of presence. If those objects are tools through which we gain access to the affordances of other (different) objects then, once we have them in our hands, they will act as an extension of ourselves increasing or modifying our potential Agency in that environment. We may say that in relation to the sense of being 'there', finding what we expect to find is something that brings us 'nearer there' and not finding it moves us further away 'from there'.

Zahorik et al. [3] claim (p. 87) that '*Presence is tied to action in the environment*' and further that '*Successfully supported action in the environment is a necessary and sufficient condition for presence*'.

Although we believe that Zahorik et al.'s assertions are generally right, without taking away importance from the role of agency in presence, we may say that even in reality the demands for action vary from one environment to another and depend also on the previous experiences and individual profile of the participant. For example, the employee of a repair shop would feel a high intensity demand for action in that environment but if he/she is not used to eating popcorn (or some similar activity) while watching a film, the demands for action he/she will receive in the cinema will be kept to a minimum. A clearer example occurs when someone with paralysis is in a non-accessible environment where he/she cannot do any single action. Both examples illustrate how, at least in some situations, there can be presence without potential for action.

Agency, as well as attention and other variables, helps very much to fill up our '*moment to moment awareness of ourselves in the process of perception of the world*' (i.e. presence) [6] but in certain situations it is not a necessary condition for this. As indicated in the second section, individual differences deviate more from the typical in those who cannot typically 'perceive' because they do not have the typical awareness of their actions [4] (those who have not acquired a typical sense of presence).

4.1.2. Tangible presence vs. Imaginary Presence

The imaginary experience of being in another place that we experience when we read a book or in daydreams has been claimed to be a form of presence that it is known as 'the book problem' (Schubert [50]). Although it can metaphorically be considered as presence, this kind of experience is certainly not about '*our moment to moment awareness of ourselves in the process of perception of the world*' (Brewer [6]) as this world would be imaginary rather than real or even artificial. As the main component in this kind of "presence" is provided by imagination, we prefer to label this experience as being 'imaginary presence'. In the borderline of tangible and imaginary presence we would find those films or those non agency-able contents where perception still plays an important role and conspires with imagination to obtain that feeling of being there.

When we are using state-of-the-art VEs that include interferences from the real world, we can also fill those lapses of agency or presence with our imagination. This would be similar to when there is a power cut and the lights are turned off, and we have to move in the darkness to find a candle or a lighter. We will go back to this 'power cut' problem in the next section.

The amount of working memory dedicated to the task would also contribute to a higher involvement and then to a higher sense of presence (Nunez [51]), but this would only be necessary in those situations in which the state-of-the-art

technologies still have failed to obtain a "natural" presence (if a natural-like presence is pursued).

Even in relation to social presence (feeling or being there with other people) there can be a high component of 'imaginary presence'. A very well experimented situation in developmental psychology is the 'Sally Ann' Test from Wimmer and Perner [52], where participants' abilities for attributing false beliefs are assessed. In this test the participant sees how a doll (Sally) puts her toy in a box and, while she is out of that room, the other doll (Ann) changes the location of the toy putting it into a basket. The aim of this test is to ask the participant about Sally's belief as to the location of the toy while going back to recover it (the false belief of thinking she will find it where she left it).

Modifying the previous experimental situation slightly, we can have a hypothetical virtual environment with several rooms, each containing several objects distributed in a given order that we can alter. If we are the participants and the experimenter tells us that it is a collaborative environment (where other people are supposed to be –but they are not– participating in the same way), then after altering the order or distribution of the objects in one of the rooms, if we go to another room and back to the previous one a few minutes later, finding a different distribution than the one we set up, then we may have a feeling of social presence (suspecting that another participant has changed our distribution), but again this will only be a product of our imagination.

We can say that in Presence Research where we have to set up the technology for obtaining a sense of presence: the more an experience rests on our imagination, the less robust and consistent is the presence it provides.

4.2. Social Agency supports the development of Presence and the experience of Social Presence

In the second section we reviewed the role of experiencing social agency in the development of the 'experiencing self'. In early ages, the simple situation of being imitated by an adult can be seen as a form of socially-mediated agency. Features C and D of Russell's Model of agency reflect the contrast between our knowledge about ourselves and our knowledge about others.

Extending Brewer's conception of presence [6], we can understand social presence as our moment-to-moment awareness of ourselves in the process of perception of the *social* world (the word *social* is ours), which again would include both directions of the perception/action cycle: awareness and inferences about the subjectivity of the others *and* feeling that the others are aware of ourselves.

Going back again over autism, some authors (such as Russell [4]) propose that the deficits of Social Agency of these people have their origin in an impaired development of the sense of self or self-awareness. As we mentioned before, people with autism have themselves described their experience of the world as something like watching a video (Grandin [24]). If they cannot experience their feelings and reactions to the world in the first person, then it would be difficult to empathise with the feeling of others (putting themselves in the same shoes as another person).

Hobson [18] suggests that early failures in social and emotional processing lead to later failures in differentiating the self (and other) from experience, and thus their sense of presence (experiencing self) can be impaired.

Social awareness has been the focus of attention in some educational intervention with VR. In the research carried out by Parsons et al. [27], whether or not individuals with autism adhere to particular social conventions (in a Café and a Bus) in Virtual Environments was assessed. Different degrees of success were found, with results suggesting that some individuals with an ASD, low verbal IQ and weak executive ability require the most support to complete tasks successfully in the Virtual Environment. Participants in the research developed by Herrera et al [26] have also re-created (within the VE) a limited and basic range of social routines they can manage (such as greeting and saying goodbye to the employees in the Virtual Supermarket).

The origin of these appropriate behaviours towards unfamiliar (virtual) people might only be in the context of that predictable and structured way of socially interacting. The repertoire of behaviours of virtual characters in these experiments is very limited and thus predictable. Perhaps in both situations (real and virtual), people with autism are challenged to interact with social stimuli by putting their impaired (but not null) capacity for experiencing agency into practice, and differences in performance arise as a consequence of the differences in the degree of predictability and structure of those stimuli with unfamiliar people.

Social Presence is being studied in several research works on presence. The kind of measures of social presence that came from some authors of Presence Research (Garau et al. [53]) fits well with this, as they include co-presence feeling, participant behaviour in response to other agents and other agents' awareness of the participant.

Given the fact that the children of today are becoming more and more familiarised with technology from the very beginning, and that social agency drives 'self awareness' development (see second section), it seems appropriate to include as many opportunities for social agency as possible in any technological product designed for children.

With co-presence being obtained from avatars or from artificial intelligence agents, our action in any environment should trigger others' reactions and this can be adapted for each individual. Together with this, the effect of our activity must persist throughout time, not only physically but also socially: endurably affecting our relationships with other co-participants or agents.

4.3. Exercising Agency or Constructing Mental Models: Experiencing Presence or Pretending to be there?

The moment-to-moment experience of interacting in real or virtual environments can be understood in different ways, with some of them based on empirical evidence and others being just metaphorical, although they are useful for understanding some concepts.

In the research field of developmental psychology, some authors (such as Baron Cohen [54]; Leslie [55]) have proposed modular models of the mind (and theoretical conceptions of autism) that have been demonstrated to be useful for developing autonomous robots (Adams et al. [56]) but, as pointed out by Russell [57], they fail to correspond with human functioning partly because of their empirical inconsistency. Russell [4] suggested that these positions are more like philosophical doctrines rather than empirical hypotheses. Loveland [16] argues that, from an ecological psychology perspective, those tests of 'Theory of Mind' actually measure the subject's ability to perceive what a particular situation affords to another person directly, thus indicating the varied interpretation of the findings and the failure of testability in many studies.

The usefulness of these meta-representational models of mind, however, is not restricted to the development of autonomous robots or to give a view about minds. It has been demonstrated to be useful for teaching people with autism about mental states (Herrera et al [26]), by using think bubbles where mental content about imagination was represented.

In the Presence Research field, some publications have emerged around 'cognitive constructions' (Nunez [13]) and also around 'spatial constructions' (Wirth et al [58]). They consider their proposals to be attempts to understand the role of cognition in presence. The Cognitive Constructivist view (Nunez, ob cited) also includes a higher level of meaning about the environment within the model and can be useful for that possible research proximate to social psychology where constructivism plays a major role.

But does interacting with VR environments (as Nunez suggested [13]) consist of constructing and reconstructing mental models? If we were immersed in a completely novel environment (such as a virtual environment of complex molecules and DNA strings without being biochemical experts), would we quickly construct and reconstruct mental models about these 'strange things'? Even if we were experts in a given environment (such as reality), would we continuously construct and reconstruct mental models (spatial and meaningful) about everything? Would, for example, an expert car driver who is used to driving on the right side of the road (as in Spain) continuously imagine how it would be to drive this way when driving on the left side of the road (as in the UK or Ireland)?

Or, on the contrary, does this continuous construction and reconstruction of mental models (or of some of its parts) only occur in such situations as the 'power cut' where imagination plays a major role?

To answer this question, the experience of people with autism participating in VE is of great help.

Difficulties and delay in understanding symbolism, especially in relation to symbolic play, have long been documented as characteristic of people with ASDs. It is not clear whether such difficulties and delays represent a core deficit in imagination, as some have proposed, or whether they result from other aspects of autism (Jordan [59]) such as communication or social difficulties. Whether it is one origin or the other, it is commonly accepted that people with autism obtain low scores when they are asked to "act as if…" that can be measured with psychological tests such as the Test of Pretend Play (ToPP:Lewis & Boucher [60]).

There was an experiment carried out by Labajo et al [61], with a sample of 34 participants with autism (mean age: 13·6 years; mean score ABC [62] Test 63·85 points), aimed at assessing the acceptance of VR devices (VR Helmet, data-gloves and positioning-trackers) and the VR environment by people with autism. In that study, after following a period of using analogous materials (ski glasses and gloves) and providing structured information in advance, 86 per cent of the participants accepted VR and interacted naturally with the environment. With smaller samples, other studies (Strickland [63]; Herrera et al [26]; Parsons et al [27]) have also found good levels of management within virtual environments by people with autism using a variety of devices (from mere flat screens to immersive helmets).

Some authors of Presence Research (Nunez [13]; Slater [64]) have compared Presence and Pretence in the sense that presence *is taken as when the subject is acting and thinking "as if"* in the virtual environment. Although this can be accepted metaphorically speaking, if we consider that people with autism (who are not generally able to act "as if") do not find it difficult to manage in VR settings, then it seems that when we are participating in a Virtual Environment we are not pretending (at least in the sense of second-order meta-representing referred to by Leslie [55]), it seems more likely that we are just exercising our agency in relation to an approximate version of that reality we know (i.e. it is intuitive) but on a first-order (i.e. non meta representational) basis.

When participating in a VE where the experience appears to be 100% natural, this interpretation does not prevent us from rationally knowing (analytically) that it is not "real" in the sense proposed by Biocca [65] and Slater & Steed [66]. Thus, as occurs sometimes when we are dreaming, we can ask ourselves whether or not we are living a dream and then rationally analyse all the information available to obtain an answer (How did we get there?, Is that possible?, etc.).

5. Conclusions

Considering and analysing agency in the field of Presence Research has consequences both for Presence itself and for Autism research.

5.1. Conclusions for Presence Research

5.1.1. Presence is about experiencing Agency

Constructivism offers a theoretical frame for understanding presence but has the disadvantage of diverting the focus of Presence Research towards aspects that are more related to imaginary presence than to the kind of tangible presence that seems to be pursued in Presence Research. Empirical evidence coming from Cognitive Developmental Research and from the participation of people with autism in Virtual Environments suggests that presence is more related to experiencing agency than to pretending to be there.

5.1.2. Presence is a subjective concept

As a product of our individual features and our accumulated experience in relation to the world, all of us have different conceptual systems and, therefore, the same stimuli can have a different effect or meaning for any of us: presence is a subjective concept. The enormous variety of presence measures proposed by different authors or groups of people may be a consequence of this subjective characterisation.

As perception is a core component of the sense of presence, analysing presence in certain collectives such as people with sensory disability (e.g. blind or deaf people) or people with impairments in sensory perception (people with autism) helps us to better understand how presence can vary from one person to another. As concluded in the fourth section, individual differences show more deviation from the typical in those who cannot typically 'perceive' because they do not have the typical awareness of their actions [4] (those who have not acquired a typical sense of presence).

5.1.3. Agency generally correlates with Presence

As presence is partially rooted into agency, manipulating variables associated with agency is a way of obtaining different kinds of presence (such as "natural" or artificial presence) that offer some insight into their nature. To say there are different kinds of presence is not to make evaluations judgements. There is no kind of presence better than another; every kind of presence has its own pros and cons depending on the objectives we have. For example, the situation of experiencing a "natural" agency and presence in a VE would not be an advantage in a future where augmented agency existed, especially in those competitive collaborative virtual environments where other participants would enjoy the advantages that augmented agency would bring when compared to the natural one.

5.1.4. Implications for measuring Presence

If we accept that agency is a component or a regulating variable of presence, then we can think about adapting Agency Psychological Measures to obtain partial measures of presence.

Some authors have already established subjective measures that, although they are not specifically designed for this, slightly relate to agency. Among them we can find Rice [67] who speaks about assessing a medium's "capacity for *immediate feedback*" (the italics are ours) which is very related to the perception/action cycle involved in exercising agency.

Any possible psychological instrument that would emerge in the future for assessing an individual's agency could be reversed in order to assess the potentiality of a given environment for experiencing agency inside it. Instruments aimed at assessing individual relationships with the environment could be used as well.

If there is Potentiality for Agency, even with one's arms folded, the environment should make us feel our potentiality for action; there must be technological elements to support our Perception/Action cycle in the VE. For this to happen, the system must respond to our exploratory initiations, we have to see the effects of our actions and our emotional state, we have to be felt by the other co-participants and the effect of our activity must persist throughout time both physically (persistence of the changes we produce) and socially (endurably affecting our relationships with other co-participants).

Accurately knowing what natural agency means (Russell's features) would help us to measure the existence of "natural" presence in VE when we wish to obtain such a feeling. For this purpose, experiments that compare base-line natural presence with artificial presence would be of help. The use of Functional Magnetic Resonance would also be of help for this when used to check if the same areas of the brain are being activated when exercising agency in reality and in VE. Those technologies will also be useful to obtain more insight into the implications of presence.

As we stated before, autism can be considered as an interesting condition for Presence Research. If the researcher wants people with autism to participate in his/her experiments, whether Presence Research is the primary objective or not, then ethical concerns should be considered and collaboration of accredited professionals in autism should be ensured.

5.2. Conclusions for Autism Understanding and Intervention

Our interest in these phenomena is not just at a theoretical and philosophical level; we are concerned with establishing the conditions that can help people with autism increase their capacity to become aware of themselves and others and to learn more effectively from their experiences.

There is already evidence that high emotional involvement in a task does seem to 'work' in putting people with autism in touch with their own experiences (Grandin [24]; Sherratt [68]) and that explicit structure can help them interpret and deal with their experiences (Peeters [69]). There is also evidence that computer assisted learning is an effective medium for them, for a variety of reasons (Murray [70]). This fits with the work developed in the past few years by Herrera et al [71] where they have developed a VR environment for individuals with autism which has already had some success (Herrera et al [26]) in teaching individuals with autism about mental states during an intensive period of three months. If we look at this in relation to secondary mediation and the role of 'artificial presence' then we have the interesting case of the individual with autism being seemingly *more* involved in the virtual environment and better able to participate in it than in the 'real' environment. The previous experiences of people with autism participating in VR settings suggest that participating in these environments was facilitatory in developing a sense of agency and thus presence. Can they be said to show 'presence' in this virtual situation when they do not show 'presence' in reality? How can we measure '*Presence*' in such cases when we have no baseline 'presence' with which to compare? Are the examples of agency in the virtual environment transferring to the real environment, examples of the secondary mediation drawing attention to primary mediation and in

that way helping the individual develop their sense of agency and intention? Is the 'artificial' situation more 'real' to people with autism because they are more engaged in it?

The analysis of how Russell's agency features can be manipulated (third section) leads to some other possible future developments for helping people with autism to develop agency. The possibility of obtaining a "shared subjectivity" (by modifying feature D) would be of great help for the teacher and the individual with autism to share a subjectivity and then, under the guidance of the teacher, let the user with autism increase his/her participation gradually until he/she becomes the main protagonist of that shared subjectivity.

Some authors, such as Vygotski [72,73] or Rivière [74], have suggested an interpersonal origin of some intrapersonal functions such as those in which imagination is supported. In fact, some theories such as the one of Jordan [59] suggest that social play, impaired in the condition of autism, is the confluence of two development paths that are affected in autism: the social and emotional development, and the cognitive development of play. Both paths influence each other and so it can be expected that improvements in one of the components also will have repercussions on the other. In consonance with these conceptions are the empirical results obtained by Herrera et al. (in press) when assessing the educational benefit of their VR tool for promoting play in a small sample of participants, which suggest a key role for the child's ability to initiate social contact in the development and generalisation of cognitive play. The framework of 'shared subjectivity' outlined above would be a unique and valuable opportunity to teach individuals with autism to redirect their agency towards social sources. Exercises for connecting the experience with feelings and emotions should also be an intervention goal. For this aim, the work developed by Rey et al. [75] can be a base for how virtual environments can be used to induce emotions and then for teaching people with autism about contingencies between what they perceive and what they feel.

Finally, can studying the unique way that people with autism respond to secondary mediation help us understand the process in general and the factors that lead to natural or artificial presence? In autism it appears that making the environment clear and structured and giving the individual control over the speed at which it is processed, makes it accessible. Adding to this, visual cues to the thought processes underlying the person's own agency (distinguishing functional acts, playful acts and imagination) seems to enable the person to pay attention to their own role and thus become involved in a more subjective way. The fact that the virtual environment is attractive and enjoyed by the participants may also play a role but that is hard to quantify at present. It may be that the 'presence' then displayed by people with autism under these conditions is not the same as others who are 'neglecting' the (secondary) mediation rather than (as in autism) 'discovering' the whole aspect of mediation. Yet it might be that this neglect is mediated by the same variables (accessibility, involvement, enjoyment) as its obverse. These are empirical questions that nevertheless lead to fascinating philosophical and psychological questions.

5.3. General conclusions: Beyond natural Presence

The experience of people with autism participating in technology-mediated and virtual realities is of double benefit: the positive outcome of each educational intervention and the insights into the implications of those technologies for the Presence Research community. As we have seen in the third section, it is possible to obtain Augmented Agency through technologies but is it possible to augment presence? Is it possible to obtain a sense of 'being there' that is more intense than our everyday sense of presence? Naming it *Hyperpresence*, Biocca [65] has already pointed to new alternatives for communication between individuals for obtaining it. Again, the knowledge coming from developmental psychology suggests other aspects to consider and gives fundamental cues about how to obtain such a sense of presence: As babies, when we come into the World we are not equipped with a (full) sense of presence. It is through development that we acquire such a capacity and the extension to which we develop it depends both on the environment opportunities (cultural and social) and on our personal intellectual potential. With Technology-Mediated and Virtual Realities we can improve our potential in all the variables involved in presence and we can think that, by augmenting them, we can go beyond the natural limits to acquire an Augmented Sense of Presence, as the moment-to-moment awareness of ourselves in relation to the world will be augmented.

If, while departing from null presence, we have successfully travelled across the developmental journey to reach the sense of presence that we know, could we develop it –with the appropriate stimuli– beyond the natural limits? Would the differences to our current sense of presence then be as big as the differences we have when we compare our typical experience of presence with that (still incomplete) provided by technology?

We have seen how people suffering from sensory disabilities have a sense of presence that is qualitatively different to the typical, and that the sense of presence of people with autism (who fail on interpersonal experiences) is quantitatively minor (what we may call *hypopresence*). If the sense of presence develops interpersonally, we may suspect that the way of leading it beyond its natural limits (hyperpresence) is, again, interpersonal.

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