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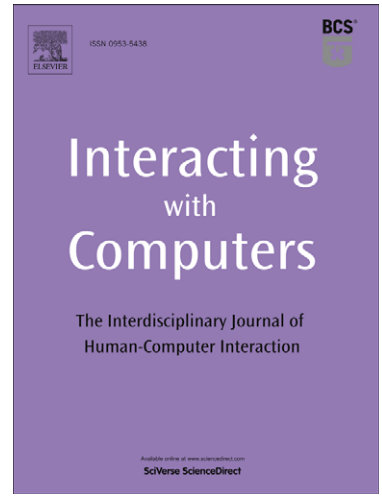

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From the body to the tools and back: a general framework for presence in mediated interactions

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From the body to the tools and back: a general framework for presence in mediated interactions

Abstract. Different neuropsychological studies clearly show that the perception of our body and its surrounding space is not a given fact but it is influenced by the outcome of our actions (both direct and mediated by the use of tools). In this view, a possible starting point for a better understanding of Presence in computer-mediated interactions is the study of mediated action and its effects on our spatial experience.

Following a cognitive perspective, the presented framework describes Presence as an intuitive feeling which is the outcome of an experience-based metacognitive judgment that controls our action. This process monitors pre-reflexively our activity by using an embodied intuitive simulation of the intended action developed through practice (implicit learning).

When actions are implemented using one or more tools, it is possible to distinguish between two different types of mediated action: first-order (I use the body to control a proximal artifact, e.g. a tennis player striking the ball with the racquet) or second-order (I use the body to control a proximal artifact that controls a different distal one, e.g. a cranemen using a lever to move a mechanical boom to lift materials). These two mediated actions, when produced intuitively, have different effects on our experience of body and space: a successfully learned first-order mediated action produces incorporation - the proximal tool extends the peripersonal space of the subject – while a successfully learned second-order mediated action produces also incarnation – a second peripersonal space centered on the distal tool.

1. Introduction

I'm now writing this paper using the keyboard in front of the monitor of my PC in my office. I can transparently transform my thoughts in finger movements on the keyboard that become a meaningful sentence through a word processor on the screen in front of my eyes. Pressing the keys I feel my hands present on the keyboard. I'm prereflexively sure – no reasoning is required - that I'm in the space in front of the monitor, that my fingers are over the keyboard.

This example shows clearly how in our daily life the experience of presence is strictly related to the one of space [1]: I'm present *in* a space. This concept is well reflected by the definitions provided by the Merriam Webster dictionary: "presence" is both "the fact or condition of being present" and "the part of space within one's immediate vicinity"; "present" is "being in view or at hand" [2].

Unfortunately, the link between space, presence and telepresence is little explored in the recent scientific literature about this topic. A few exceptions come from Baumgarten and colleagues [3], Jäncke and colleagues [4], Lee and colleagues [5]; Schloerb [6] and Wirth and colleagues [7]. For example, the International Society of Presence Research, defines "Presence" (a shortened version of the term "telepresence") as a "psychological state in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience"[8]. But am I present only when I'm experiencing a virtual reality environment?

In this paper we will try to present and discuss a related but different theoretical stance based on following four pillars emerging from the recent work of cognitive sciences:

1. *Cognitive processes can be either rational or intuitive*: Starting from this premise we will try to argue that Presence is an intuitive feeling that is the outcome of an experience-based metacognitive judgment;
2. *Skills become intuitive when our brain is able to simulate their outcome*: Starting from this premise we will try to argue that Presence monitors intuitively our activity processes using embodied intuitive simulations;
3. *Space is perceived in terms of the actions we could take towards them*: Starting from this premise we will try to argue that the feeling of Presence in a real or virtual space is directly correlated to the outcome of the actions the subject can enact in it;
4. *The use of tools shapes our spatial experience*: Starting from this premise we will try to argue that the intuitive and effective use of tools shapes both our perception of space and our feeling of presence.

2. Intuition vs. Reasoning

A first problem related to the research about presence is its role in cognitive science: what is its foundation in terms of the cognitive processes involved in it? In this paragraph we suggest that presence is an intuitive metacognitive judgment that monitors our actions.

Recent research in cognitive psychology underlines the role of nonconscious mental structures and processes in driving the subject's experience, and action. For example Daniel Kahneman, a psychologist who in 2002 was awarded the Nobel Prize in Economics for his work on the psychology of intuitive beliefs and choices, identified two generic modes of cognitive function [9]: "In the terminology that became accepted much later, we held a two-system view, which distinguished intuition from reasoning… an intuitive mode in which judgments and decisions are made automatically and rapidly, and a controlled mode, which is deliberate and slower." (pp. 449-450).

As noted by Stanovich & West, [10] in the last forty years, different authors from different disciplines suggested a two-process theory of reasoning. Even if the details and specific features of these theories do not always match perfectly, nevertheless they share the following properties (see Table 1).

Insert Table 1 here

In sum, intuitive operations are faster, automatic, effortless, associative, and difficult to control or modify. Rational operations, instead, are slower, serial, effortful, and consciously controlled. As underlined by Koriat [11] this distintion "… implies a separation between two components
or states of consciousness – on the one hand, sheer subjective feelings and intuitions that have a perceptual-like quality and, on the other hand, reasoned cognitions that are grounded in a network of beliefs and explicit memories. It is a distinction between what one feels and senses and what one knows or thinks." (p. 301).

Contrary to common thought, however, Intuition is not innate only. Research on perceptual-cognitive and motor skills shows that they are automatized through experience and thus rendered intuitive [12]. In the case of motor skill learning, the process is initially rational and controlled by consciousness, as shown, for example, by the novice driver's rehearsal of the steps involved in parking a car: check the mirrors and blind spots; signal to the side of the space; position the car beside the vehicle I'm parking behind, etc. However, later the skill becomes intuitive and consciously unaccessible by virtue of practice, as shown, for example, by the difficulty of expert drivers to describe how to perform a complex manoeuvre to others, and by the fact that conscious attention to it actually interferes with their driving performance.

In sum, perceptual-motor skills that are not innate – e.g. driving a car - may become automatic through practice, and their operations thereby rendered intuitive. Using a metaphor derived from computer science, this process can be described as "*knowledge compilation*" [12, 13]: a knowledge given in a general representation format (linguistic-semantic) is translated into a different one, more usable and less computationally demanding (perceptual-motor).

Are Presence and Telepresence intuitive or rational cognitive processes? On one side, it is evident that presence is the *outcome* of an intuitive cognitive process: no rational effort is required to experience a feeling of presence. On the other side, however, presence is *different* from an acquired motor skill or a behavioral disposition.

A possible path to find a better answer comes from the concept of metacognition. Koriat [11] defines "metacognition" as "the processes by which people self-reflect on their own cognitive and memory processes (monitoring) and how they put their metaknowledge to use in regulating their information processing and behavior (control)." (p. 289). Following the distinction between Intuition and Reasoning, researchers in this area distinguish between *information-based* (or theory-based) and *experience-based* metacognitive judgments [11, 14]. Information-based metacognitive judgements are based on a deliberate use of one's beliefs and theories to reach an evaluation about one's competence and cognitions: they are deliberate and largely conscious, and draw on the contents of declarative information in long term memory.

By contrast, experience-based metacognitive judgments are subjective feelings that are product of an inferential intuitive process: they operate unconsciously and give rise to a "sheer subjective experience". An example of these metacognitive judgment are [15]: the "*feeling of knowing*" (knowing that we are able to recognize the correct answer to a question that we cannot currently recall), or the "*feeling of familiarity*" (knowing that we have encountered a given situation before, even if we don't have an explicit memory of it).

As Koriat and Levy-Sadot [14] argued, "The cues [for these metacognitive judgments] lie in structural aspects of the information processing system. This system, so to speak, engages in a self-reflective inspection of its own operation and uses the ensuing information as a basis for metacognitive judgments" (p. 496).

In other words, we can try to describe presence as the sheer subjective experience of being in a given environment (the feeling of "being there") that is the product of an intuitive experience-based metacognitive judgment.

3. Intuition as Simulation

At this point a critical question is "What is intuitively judged by Presence?". Different authors have suggested a role of presence in the monitoring of action. For example, Zahoric and Jenison [16] underlined that ''presence is tantamount to successfully supported action in the environment'' (p. 87); Riva and colleagues [17]: suggested that "…the evolutionary role of presence is the control of agency" (p. 24); finally, Slater and colleagues [18] argued that "humans have a propensity to find correlations between their activity and internal state and their sense perceptions of what is going on out there" (p. 208).

But, how may this work? And how this process is related to intuition?

As suggested by Reber [19]: "To have an intuitive sense of what is right and proper, to have a vague feeling of the goal of an extended process of thought, to "get the point" without really being able to verbalize what it is that one has gotten, is to have gone through an implicit learning experience and have built up the requisite representative knowledge base to allow for such judgement." (p. 233).

In simpler words, through implicit learning the subject is able to represent complex actions using perceptual-motor data and enact/monitor them intuitively. As suggested by the *Covert Imitation Theory* [20, 21], the brain instantiates a sophisticated simulation, based on motor codes, of the outcome of an action and uses this to evaluate its course. This can be achieved through a simulative forward model [22, 23]: during the enaction of a learned skill a sensory prediction of the outcome of the action (simulation) is produced along with the actual motor command. The results of the comparison (which occurs intuitively) between the sensory prediction and the sensory consequences of the act can then be utilized to determine both the agent of the action and to track any possible variation in its course (see Figure 1). If no variations are perceived, the subject is able to concentrate on the action and not on its monitoring.

Insert Figure 1 here

In this view, presence is unconscious in the sense that we do not have detailed conscious access to its processing antecedents. It is conscious, too, in that it is a distinct phenomenology — something it feels like to have the feeling. And it is metacognitive since it conveys information about our spatial experience that permits to monitor and eventually regulate our action. In summary, Presence is an intuitive experience-based metacognitive judgment:

- It monitors pre-reflexively our activity processes;
- It is achieved using an embodied intuitive simulation of the intended action;
- Only when the subject acquires a motor skill he/she is able to simulate its outcome intuitively (implicit learning);
- A break in presence is a violation of our intuitive simulation. As consequence the subject is forced to shift to reasoning to understand and cope with the causes of the violation.

A possible criticism to this vision is the following [23]: "*What about this thought experiment: paint a 20' by 20' by 20' room completely white, there are no windows, have a person sit in the middle of the room, there is nothing to interact with, is the person not present there? " (p.* 61).

The key to answer to this criticism is the word "intuitive". Even to stand sit, or to lay down on a floor, the involvement of different intuitive postural processes that we learned in our first months of life, is required. For example, a newborn learns to sit independently only between the ages of 4 and 7 months. When these intuitive postural processes do not work as it happens, for example, experiencing an *isolation tank* - a lightless, soundproof thank in which subjects float in salty water at skin temperature (see an example on You Tube at http://www.youtube.com/watch?v=YEjTXX2rHgA) - within 15/20 minutes the feeling of presence totally disappears [24].

A second possible criticism is the following: "*System 1 or intuitive thinking is error prone yet my experience of in the world being is not, how can we account for this*?".

A first answer to this point is related to the simulative forward model described in Figure 1. According to it our brain represents sensory information probabilistically [25, 26], in the form of probability distributions. As underlined by Knill and Pouget [26]: "This allows the system to integrate information efficiently over space and time, to integrate information from different sensory cues and sensory modalities, and to propagate information from one stage of processing to another without committing too early to particular interpretations… [In sum], humans behave near-optimally even when the sensory information is characterized by highly non-Gaussian density functions, leading to complex patterns of predicted behavior" (pp. 712 and 718).

A second answer is that our experience of the world is error prone, too, even if we are not aware of it. In their book "*The invisible gorilla: how our intuitions decieve us*" Chabris and Simons [27] describe how our experience is full of "gaps" or "illusions" in six different areas: attention, memory, confidence, knowledge, cause and potential. The most significant example for the goals of this paper is the one described in the title of the book: *the invisible gorilla*. In an experiment the two authors asked their sample to watch a one-minute video of a basketball game and to count the number of passes made by the team wearing white. During the video a woman wearing a gorilla costume walked into the scene, stopped, faced the camera and walked off. Astonishingly, half the sample did not see the gorilla: the gorilla was not present to them. Moreover, when asked later on, "Did you notice a gorilla?," they were unable to believe that they had missed it, and they were astonished when they watched the video again and saw it.

4. Neuropsychology of subjective space

At this point, a new question is the following: how is a metacognitive judgment related to the outcome of our actions able to produce the feeling of being in an environment? A possible answer comes from neuropsychological research: research data show a clear link between spatial perception, our bodily experience and action.

On one side, we conceive places in terms of the actions we could take towards them: subjects have not a separate knowledge of the place's location relative to them, what they can do in it, and their purposes. An example can help in understanding this point. Retrieving an occluded object – e.g. when we lift a box to retrieve a pencil from under it – is an action taken on the basis of a belief about where the object (pencil) is located relative to the self. As noted by Waskan [28], "one cannot see a place as being there1 rather than there2 *without knowing what it would be to act* there1 rather than there2." (p. 170, our italics). It follows that to know that the pencil exists when it is occluded is a matter of knowing what can be done to make the pencil visible. More, if I want to grab the pencil, its spatial position will be represented in terms of the movements needed to reach for it. Further, its shape and size will be represented in terms of the type of handgrip it affords.

On the other side, our spatial experience is the outcome of the interaction of different spatial representations whose integrated activity give rise to spatial awareness [29]. For example, the proprioceptive knowledge of our own body's location in external space (*the feeling of being in a given space*) requires that information about the angles of each joint be combined with information about the size and shape of the body segments between joints. However, as noted by Longo and Haggard [30] the metric properties of different body parts are not directly provided by sensory signals. In other words, the experience of presence in the external space requires that the on-line proprioceptive information (i.e. body posture) are integrated by stored data related to a body model (*intrinsic body representation*) constructed by the brain. This model, which is coarse-grained and relatively inaccurate - as shown by both the "phantom limb" experience and the "rubber hand" illusion – is the pillar that defines our whole spatial experience.

In fact, evidence from clinical and experimental studies indicates that our spatial experience involves the integration of different sensory inputs within two different reference frames defined by our body model and related to its possibility of action [31-33]:

- *Subjective/near space* (body as reference of first-person experience). It is shaped around the *egocentric frame* and its primary source are *somatoperceptions*: representations of the present state of the body and tactile stimuli from sensory inputs [33]. In fact, it is based on the body of the observer: it is defined by its three axes: front-back, left-righ, head-feet and within this frame the position of an object changes if the subject moves [34]. More, this frame defines the "*peripersonal space*", the space immediately surrounding our bodies [31]. Within this space the subject can directly grasp and manipulate objects and tools. The subjects learn to interact with external objects in this frame using two different strategies [35]:
    - *Sensorimotor coding*: through the exact repetition of an acquired pattern of actions/movements;
    - *Inertial navigation*: through the coding in terms of distance and direction from a starting position.
- *Objective/far space (*body as object in a world*).* It is shaped around the "*extrapersonal space*", the space that occurs outside the reach of an individual [31]. This space is defined by the spatial relations between the objects (*landmarks*) included in it: the subjects learn the position of the objects in this frame using two different strategies [35]:
    - *Cue learning*: remembering an object as located within a given area;
    - *Place learning*: through the coding in terms of distance and direction from a landmark.

The extrapersonal space shapes the allocentric frame: within this frame the position of an object does not change if the subject moves, and the object exists even if there is no relation with the self or another person [34]. In this frame the body is an object like the other ones and its representation is the outcome of abstract knowledge, beliefs, and attitudes related to it as an object of third-person perception (looking at it from outside).

This picture suggests that, even if we have a unitary spatial experience, we do not have a single global representation of space. This is immediately evident in "*hemispatial neglect*", a neurological disease characterized by a deficit in attention to and awareness of one side of space. More, it underlines that manipulating our body model we can change the way we perceive objects in the external world and viceversa [36].

5. Action, presence and use of tools

In the previous paragraph, we have seen that spatial perception is a dynamic operation that can be continuously modified and updated by the actions carried out by the subject. But what does it happen when these actions are implemented using a tool?

According to the Merriam Webster dictionary a "tool" is both "a handheld device that aids in accomplishing a task" and "something (as an instrument or apparatus) used in performing an operation" [2]. These definitions underline that tools are controlled by human action and that they exert an action upon external objects [37]. But, as reflected by the two different definitions, the relationship between the human action, the tool and its final effect is not always the same.

For this reason, in this context we can distinguish between two different types of mediated action: *first-order or second-order (see Figure 2):*

- In *first-order* mediated actions the subject use the body to control a proximal tool (an artifact present and manipulable in the peripersonal space) to exert an action upon an external object. In practice, there is a direct spatial connection between the body of the subject, the tool and the external object. An example of first-order mediated action is the one of the tennis player striking the ball (external object) with the racquet (proximal tool).
- In *second-order* mediated action the subject use the body to control a proximal tool that controls a different distal one (a tool present and visible in the extrapersonal space) to exert an action upon an external object. In this situation there is a spatial disconnection between the peripersonal (near) space that contains both the body of the subject and the proximal tool, and the extrapersonal (far) space, that may be either real or virtual, where are located both the distal tool and the external object. An example of second-order mediated action is the one of the cranemen using a lever (proximal tool) to move a mechanical boom (distal tool in the real space) to lift materials (external real objects). Another example, more related to technology, is the one of the videogame player using a joystick (proximal tool) to move an avatar (distal tool in a virtual space) to pick up a sword (external virtual object). A possible, simpler variant of second-order mediated action is the direct use of the body to control a distal tool that exerts an action upon an external object. An example of this variant is the interaction with the Microsoft Kinect system: I move my body to move an avatar (distal tool) to pick up objects.

Insert Figure 2 here

Here we suggest that these two mediated actions have different effects on our experience: a successfully learned *first-order* mediated action produces *incorporation* - the proximal tool extends the peripersonal space of the subject (the subject is present in the tool) – while a successfully learned *second-order* mediated action produces also *incarnation* – a second peripersonal space centered on the distal tool. Let's try to deepen these two points.

Since the seminal work of Atsushi Iriki on macaques [38], many different studies demonstrated that, after a successful training, a proximal tool (*first-order mediated action*) is incorporated in the bodily experience of the subject [39-42]. As explained by Maravita and Iriki [39], "Recent neurophysiological, psychological and neuropsychological research suggests that this extended motor capability [the acquired ability of manipulating the tool] is followed by changes in specific neural networks that hold an updated map of body shape and posture (the putative 'Body Schema' of classical neurology). These changes are compatible with the notion of the inclusion of tools in the 'Body Schema', as if our own effector (e.g. the hand) were elongated to the tip of the tool." (p. 79).

In other words, the acquisition of a motor skill related to the use of a proximal tool extends the body model we use to define the near and far space. From a neuropsychological view point the tool is incorporated in our body schema, prolonging it till the end point of the tool. From a phenomenological view point, instead, *we are now present* in the tool and we can use it intuitively as we use our hands and our fingers.

But what does it happen when we learn to use a distal tool (*second-order mediated action*)? In a different experiment Iriki and colleagues trained macaques to retrieve food by watching their hand/arm movements through a real-time video monitor [43]. In other words, the monkey used the self-image in the monitor as a distal reference of hand movement, as it happens using the Microsoft Kinect. The study showed that the identical neurons, which code the image of the hand in normal condition, responded in a similar manner to the image in the video monitor: here, again, the image of the hand is experienced as a direct an extension of the self. And this happened only after the acquisition of the new motor skill: before training no neuron responded to visual stimuli presented in the monitor screen. This requires an integration of the visual data (the distal tool) with the proprioceptive/tactile data (the real hand moving the proximal tool): how are they integrated?

Van Beers and colleagues [44, 45] suggest that our brain uses simultaneously the available visual and proprioceptive information to control the movement of the hand. Specifically, in cases of mismatches the role of the different data varies with direction [45, 46]: in azimuth (left-right), vision is more precise than proprioception; in depth (near-far), however, proprioception is more precise than vision.

This suggests that, in agreement with Wirth and colleagues [7] and Jäncke and colleagues [4], *second-order* mediated action is based on the simultaneous handling of two different body models – one centered on the real body (based on proprioceptive data) and a second centered on the distal tool (visual data) – that are weighted in a way that minimizes the uncertainty during the mediated action.

Interestingly, the passage between them is not experienced as a possible breakdown. And this is confirmed by the experimental data presented by Gamberini and Spagnolli [47, 48]. Describing the result of their analysis of 15 technical dysfunctions (e.g. to disentangle from the head mounted wires) experienced during the use of a virtual environment they conclude: "A sudden emersion from the virtual environment seems to be a rather inappropriate way to describe what happens. Participants remain focused on the navigation in the virtual environment, even though the environment they address with their actions is an expanded one." (p. 1).

In other words, in second-order mediated actions the distal tool is the core of a second peripersonal space that extends the space of action and competes with the one centered on the body to drive action and experience. Specifically, when the distal-centered peripersonal space becomes the prevalent one, it also shifts the extrapersonal space to the one surrounding the distal tool. From an experiential viewpoint the outcome is simple: the subject experiences presence in the distal environment (telepresence).

6. Conclusions

Even if in our daily life the experience of presence is strictly related to the one of space - we are present *in* a space - the link between space and presence is little explored in the recent scientific literature about this topic. In this paper we used the outcome of the recent work of cognitive sciences to present a framework able to link mediated action, space and presence.

The starting point was describing presence as the sheer subjective experience of being in a given environment (the feeling of "being there") that is the product of an intuitive experience-based metacognitive judgment related to the outcome of our actions.

But how is a metacognitive judgment able to produce the feeling of being in an environment? Neuropsychological research identified a clear link between spatial perception and action. On one side, we conceive places in terms of the actions we could take towards them: we do not have a separate knowledge of the place's location relative to them, what they can do in it, and their purposes. On the other side, our spatial experience is the outcome of the interaction of different spatial representations whose integrated activity gives rise to spatial awareness. Specifically our spatial experience involves the integration of different sensory inputs within two different reference frames defined by our body model and related to its possibility of action:

- *Subjective/near space (body as reference of first-person experience)*: this frame defines the "peripersonal space", the space immediately surrounding our bodies;
- *Objective/far space (body as object in a world)*: this frame is shaped around the "extrapersonal space", the space that occurs outside the reach of an individual.

But what does it happen when an action is implemented using a tool? To answer this question we distinguished between two different types of mediated action: *first-order* or *second-order*:

- *First-order mediated action:* the subject uses the body to control a proximal tool (an artifact present and manipulable in the peripersonal space) to exert an action upon an external object. An example is the videogame player using a joystick (proximal tool) to move an avatar (distal tool) to pick up a sword (external object).
- *Second-order mediated action*: the subject use the body to control a proximal tool that controls a different distal one (a tool present and visible in the extrapersonal space, either real or virtual) to exert an action upon an external object. An example is the cranemen using a lever (proximal tool) to move a mechanical boom (distal tool) to lift materials (external objects).

In the paper we suggested that these two mediated actions have different effects on our spatial and bodily experience. A successfully learned first-order mediated action produces incorporation - the proximal tool extends the peripersonal space of the acting subject. In other words, the acquisition of a motor skill related to the use of a proximal tool extends the body model we use to define the near and far space. From a neuropsychological view point the tool is incorporated in the near space, prolonging it till the end point of the tool. From a phenomenological view point, instead, we are now present in the tool and we can use it intuitively as we use our hands and our fingers.

A successfully learned second-order mediated action, produces incarnation, too – a second body representation centered on the distal tool. In fact, second-order mediated actions are based on the simultaneous handling of two different body models – one centered on the real body (based on proprioceptive data) and a second centered on the distal tool (visual data) – that are weighted in a way that minimizes the uncertainty during the mediated action. In other words, this second peripersonal space centered on the distal tool competes with the one centered on the body to drive action and experience. Specifically, when the distal-centered peripersonal space becomes the prevalent one, it also shifts the extrapersonal space to the one surrounding the distal tool. From an experiential viewpoint the outcome is simple: the subject experiences presence in the distal environment (telepresence).

At the end, a first conclusion is the link between action and presence : The feeling of presence can be described as the outcome an intuitive metacognitive process that allows us to control our actions through the comparison between intentions and perceptions. As suggested by many authors [1, 17, 49-53] and effectively summarized by Zahoric and Jenison [16]: *''presence is tantamount to successfully supported action in the environment'' (p. 87).*

One of the reviewer of this paper, reading this conclusion noted: "*I think an equally valid conclusion is that presence is an unnecessary construct. What does presence add?".* In our view presence has three critical features that cannot be explained by other cognitive processes:

- First, *presence "locates" the Self in an external physical and/or cultural space:* the Self is "present" in a space if he/she can act in it.
- Second, *presence provides feedback to the Self about the status of its activity*: the Self perceives the variations in presence and tunes its activity accordingly.
- Third *presence allows the evolution of the Self through the incorporation of tools*: tools do not enable us only to extend our reaching space, but when successfully mastered become part of a plastic neural representation of our body that allows their use without further cognitive effort (intuitively). In this way we can focus our cognitive resources on actions that are not only related to the here-and-now, improving the complexity of our goals [54-56]. As suggested by Andy Clark [57], we are "natural born cyborgs" that are able "…to continually restructure and rebuild our own mental circuitry, courtesy of an empowering web of culture, education, technology, and artifacts… It is our natural proclivity for tool-based extension, and profound and repeated self-transformation, that explains how we humans can be so very special while at the same time being not so very different, biologically speaking, from the other animals with whom we share both the planet and most of our genes." (p. 10).

Second, the framework suggests a possible cognitive explanation for the difference between "presence" (intended as "spatial presence", the intuitive impression of being where I'm using a proximal tool, for example the keyboard) and "telepresence" (the intuitive impression of being where I'm using a distal tool, for example the avatar in a virtual environment) in mediated action. In presence our peripersonal space is extended by the proximal tool: we are present in it. In telepresence, when the distal-centered peripersonal space becomes the prevalent one, it also shifts the extrapersonal space to the one surrounding the distal tool: we are present in the distal tool and in the space surrounding it.

Finally, this framework underlines the critical role of intuition in the experience of presence: only when we are able to use a tool intuitively we can be present in it and/or in the space surrounding it. In other words, "intuition" can be the psychological translation of the concept of "transparency" that is behind a significant part of the theoretical reflection on presence. However, if transparency is a property of the medium, intuition is a property of the subject that can be acquired with practice.

On one side, the shift from transparency to intuition challenges the assumption that the only path for improving presence in mediated interactions is the use of already available intuitive knowledge (e.g., touch technology). On the other side, it underlines the critical role of experience and training for the effectiveness of mediated interaction: with the right training even the most opaque technology (do you remember MS-DOS?) may become totally intuitive for its user; without a relevant training the subject may experience a lack of presence in the interaction with even the most transparent medium (for example, if you are new to using a mouse, it may take a little practice to get the hang of it). More, the same technology may be experienced either as opaque or transparent according to the intuitive skills of the user.

An open issue not discussed in this paper is "social presence". What does this model tell us about it? We can say that social presence is similar to presence - an intuitive process tracking the enaction of intentions using embodied simulations – but with a different focus: the Other. In the view of one of the two authors of this paper, social presence can be defined as [23, 58] "the non-mediated perception of an enacting Other within an external world". In other words, using Social Presence, the Self prereflexively recognizes and evaluates the action of the Other using the same simulative forward model: the prediction of the action is compared with perceptual inputs to verify its enaction. A critical role in this process is probably played by mirror neurons, a class of neurons that are activated both during the execution of purposeful, goal-related actions, and during the observation of similar actions performed by another individual [59, 60].

7. Acknowledgments

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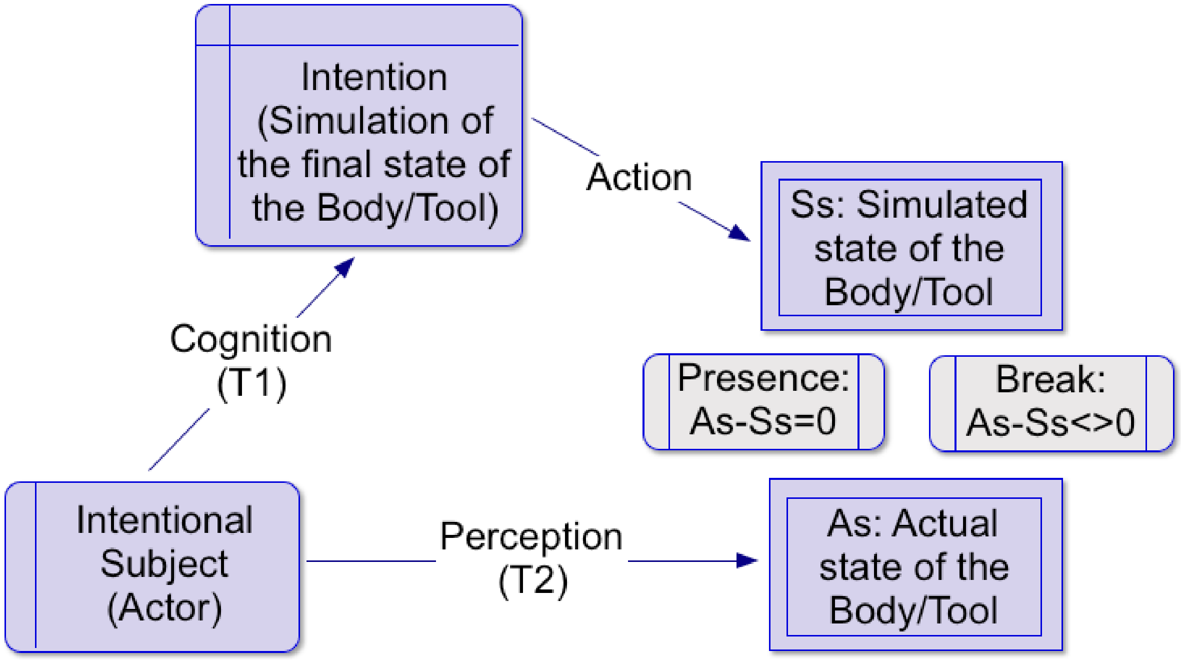

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Figure 2: Mediated action and its effects on the experience of the subject

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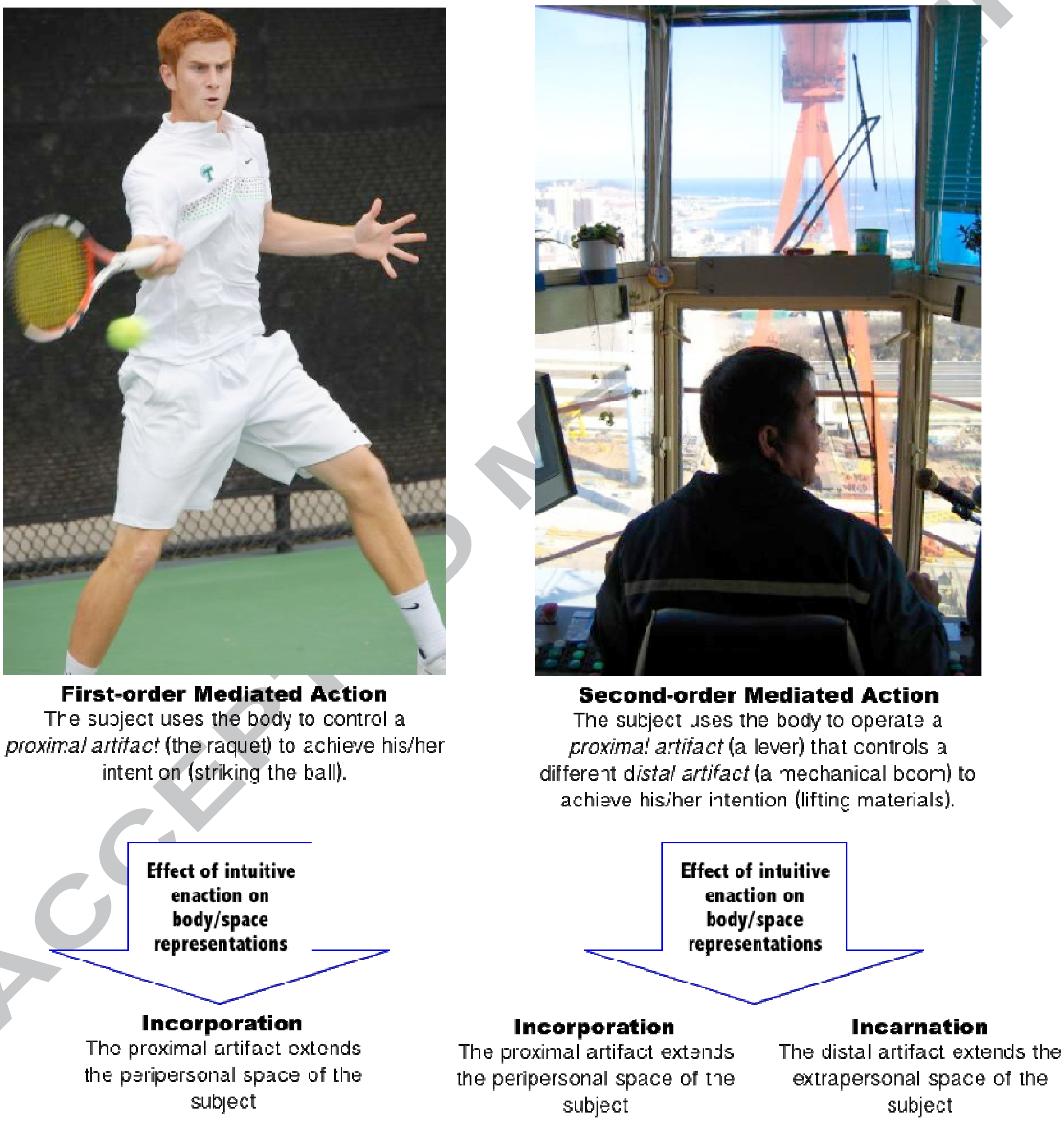
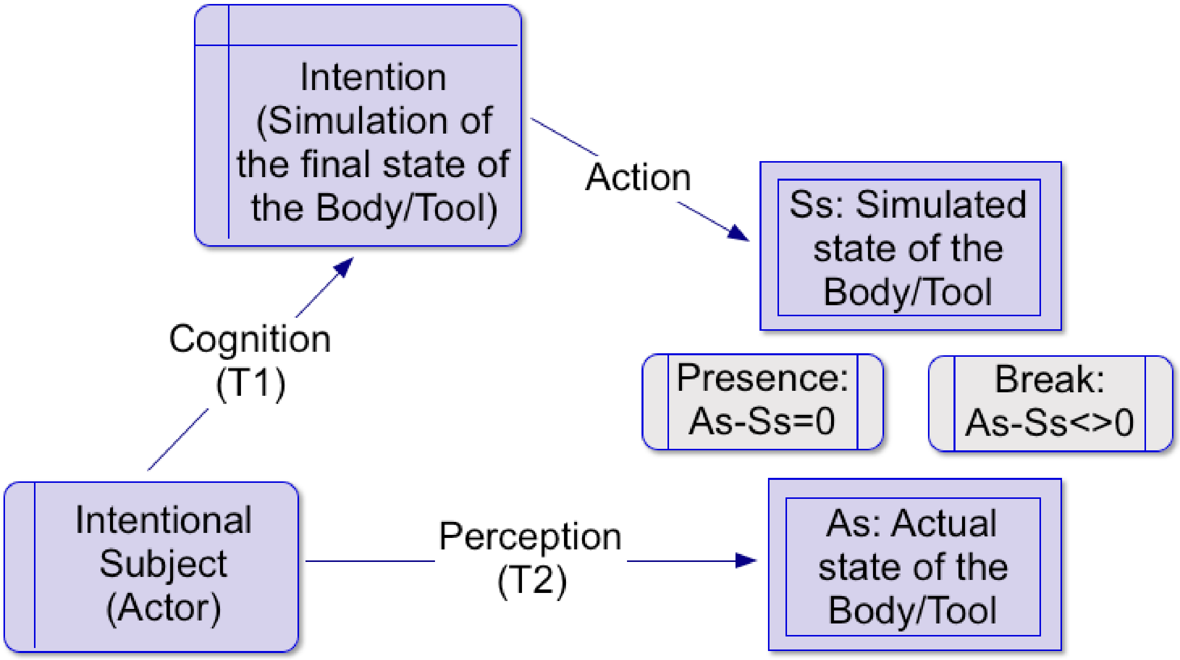
Highlights

1. We outline a model for understanding Presence using the outcome of cognitive sciences;
2. Presence is the product of an intuitive experience-based metacognitive judgment;
3. This process monitors our activity by using embodied intuitive simulations;
4. It is possible to distinguish between first-order and second-order mediated actions;
5. They differ for their effect on our bodily experience: incorporation and incarnation.





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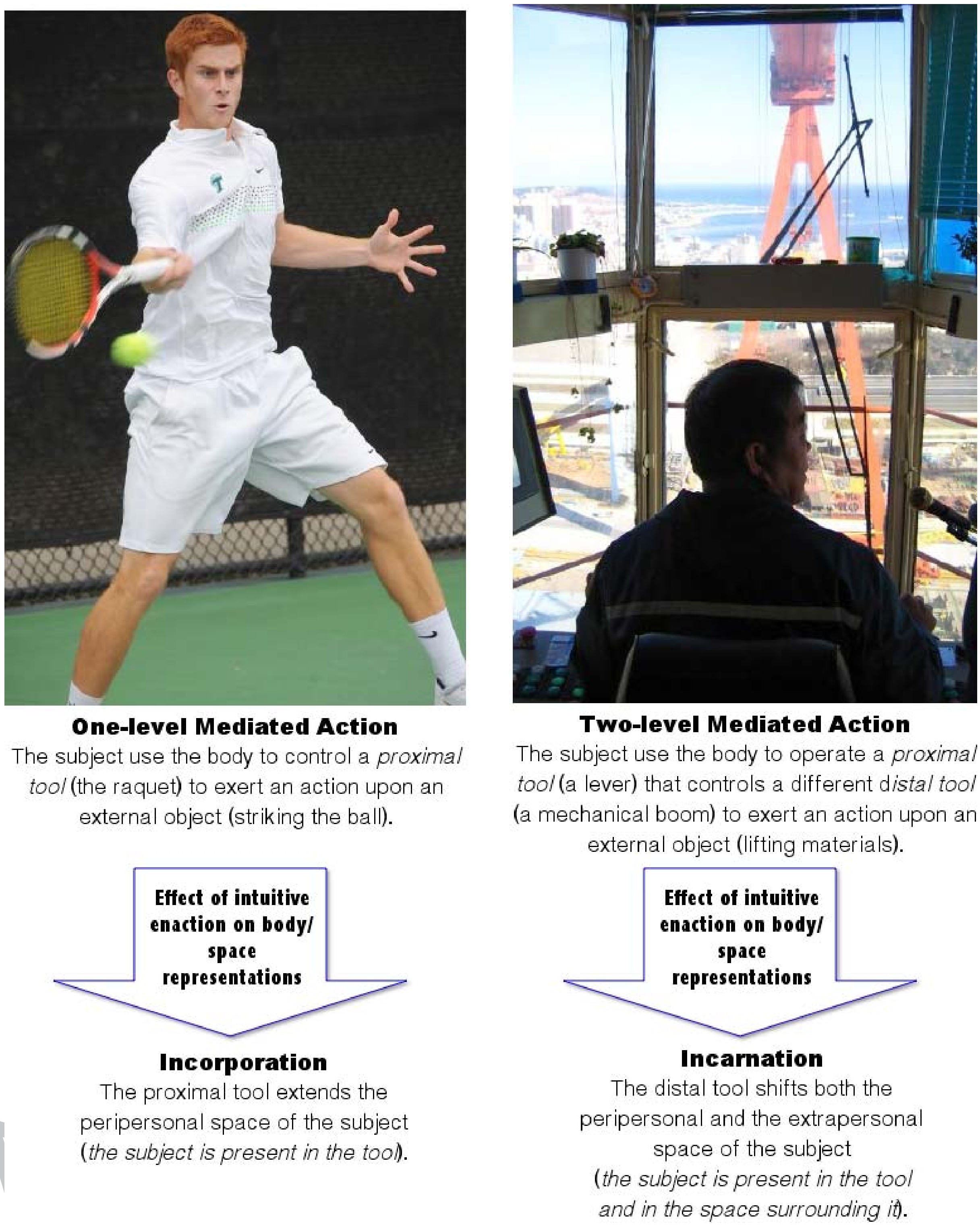

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