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Presence and Social Presence: From Agency to Self and Others

Giuseppe Riva

Applied Technology for Neuro-Psychology Lab., Istituto Auxologico Italiano, Milan, Italy
Interactive Communication and Ergonomics of New Technologies Lab
Università Cattolica del Sacro Cuore, Milan, Italy
{giuseppe.riva@unicatt.it}

Abstract

In its more general use the term "Presence" has referred to a widely reported sensation experienced during the use of virtual reality or other media. However, a growing number of researchers consider Presence as a general neuropsychological phenomenon, whose goal is to produce a strong sense of agency and control. This paper presents a general framework based on this concept: subjects are "present" if they are able to enact in an external world their intentions. Within this view, any behavior is driven by an intentional cascade, with higher-level intentions causally generating lower-level ones: the more are the intentional levels supported by a tool, the more is the presence in the tool (e.g., Wii Tennis gives more presence than PS3 or Xbox Virtua Tennis because it supports motor intentions, too). This approach works also for Social Presence: others are "present" to us if we are able to recognize their intentions through a tool (e.g., text can convey more Social Presence than a 3D image because it reveals writer's intentions). This framework suggests that any environment, virtual or real, does not provide undifferentiated information, ready-made objects equal for everyone. It offers different opportunities and produces Presence according to its ability in supporting the users and their intentions.

Keywords--- **Media Presence, Inner Presence, Action, Intentions, Agency**

1. Introduction

The paper presents a conceptual framework that links the enaction of our intentions to the understanding of other people's intentions through the concepts of Presence and Social Presence. Specifically [1]:

– "Presence" is defined as *the non mediated (prereflexive) perception of successfully transforming intentions in action (enaction) within an external world*;

– "Social Presence" is defined as *the non mediated perception of an enacting other (I can recognize his/her intentions) within an external world.*

Within this framework, based on the ecological/ethnographic approach [2-8], any environment, virtual or real, does not provide undifferentiated information, ready-made objects equal for everyone. It offers different opportunities and produces Presence according to its ability in supporting the users and their intentions.

2. Is physical presence real?

I'm aware that this framework is complex and controversial, as showed by the critical comments from the reviewers. For instance, one of them wrote: "*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? If so, then it would seem (to me) that the ability to act in an environment is unrelated to Presence*".

The main assumption of this vision, shared by many presence researchers, is that the core of Presence is "Physical Presence" [9]. According to Schloerb [9], physical presence is an "objective" feature of things and designates ''the existence of an object in some particular region of space and time. For example, this text (in some form) is physically present in front of you now'' (p. 68).

In this view, virtual reality research should focus on creating a sense of physical presence by simulating as closely as possible the range and intensity of stimuli human senses detect and interpret in perceiving the natural world [10, 11].

This vision is based on a philosophical position that is known as "ingenuous realism" [2, 3, 12]: reality is a set of objects located outside the mind and has a set of well-defined characteristics. From the viewpoint of ingenuous realism, "physical" presence is "real" because it designates a state of things, the way an object is, the fact that something or someone exists within a certain physical environment.

Unfortunately, the results from one century of neuroscience research undermined the distinction between

"physical" and "mental" and the link between presence and the physical body. Here are some examples:

1. *Autopagnosia*: it is a neurological disease characterized by the inability to recognize or to orient any part of one's own body, caused by a parietal lobe lesion [13]. A patient with autopagnosia will not be present in the 20' by 20' by 20' room suggested by the reviewer;
2. *Hemispatial Neglect*: it is a neurological disease characterized by a deficit in attention to and awareness of one side of space. For example, a stroke affecting the right parietal lobe of the brain can lead to neglect for the left side of the visual field, causing a patient with neglect to behave as if the left side of sensory space is nonexistent. A patient with left neglect will not be present in the left part of the room suggested by the reviewer;
3. *Anarchic Hand*: it is a neurological disease in which patients are aware of the actions of their anarchic hand but do not attribute its intentional behavior to themselves (it is not "owned" by them) [14]: The hand of the patient with anarchic hand will not be present in the reviewer's room;
4. *Isolation tanks*: an isolation tank is a lightless, soundproof thank in which subjects float in salty water at skin temperature (see on You Tube at http://www.youtube.com/watch?v=YEjTXX2rHgA). The darkness and silence during the experience have the effect of reducing sensory input from the external environment and within 15/20 minutes physical presence disappears [15]. So, if the reviewer's room is an isolation tank, after some time the person's physical presence will disappear.

The challenge of this paper is to provide a conceptual framework able to explain both these experiences and technology-mediated experiences. I will start this attempt from the analysis of the link between action and presence.

3. The link between presence and action

Recent neuropsychological research showed that the contents of subject's perception guide action in space and locate the subject in the perceived world [16, 17]. In other words, as suggested previously by Piaget (*assimilation*) and Gibson (*affordance*), **we conceive places in terms of the actions we could take towards them**: the subject has not a separate knowledge of the place's location relative to him/her, what he/she can do in it, and his/her purposes. Extending this vision, Waskan [18] suggests that *we represent phenomena by thinking in terms of the mechanisms by which the phenomena may be produced*.

An example can help in understanding this point. Retrieving an occluded object – e.g. when we lift a book to retrieve a pen from under it – is an action taken on the basis of a belief about where the pen is located relative to the self. In sum [18], "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 pen exists when it is occluded is a matter of knowing what can be done to make the pen visible. More, if I want to grab the pen, 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.

More, recent studies on peripersonal space demonstrated that tool-mediated actions modify the multisensory coding of near peripersonal space [19, 20]: the active use of a tool to physically and effectively interact with objects in the distant space appears to produce a spatial extension of the multisensory peri-hand space corresponding to the whole length of the tool: **in other words, through the successful enaction of him/her intentions using the tool, the subject become physically present in the tool**.

These studies confirm that the subject locates himself/herself in an external space according to the action he can do in it. As suggested by Zahoric and Jenison [21]: *''presence is tantamount to successfully supported action in the environment''* (p. 87, italics in the original).

In other words, the subject is "*present*" in a space if he/she can act in it. More, the subject is "*present*" in the space – real or virtual – where he/she can act in.

From a practical viewpoint, these reflections suggest that in the creation of a virtual world, **action is more important than perception**: I'm more present in a perceptually poor virtual environment (e.g. a textual MUD) where I can act successfully than in a real-like virtual environment where I cannot do anything.

3.1. Behind action: Intentions

Another consequence of the above reflections is the need to understand more what "acting successfully" means. We can start from the definition of "Agency": "the power to alter at will one's perceptual inputs" [22]. But how can we define our will?

A simple answer to this question is: **through intentions**.

For this reason we suggest that "*Presence" can be defined as the non mediated (prereflexive) perception of successfully transforming intentions in action (enaction).*

A second reviewer criticized the above definition in this way: *"I may be asked to repair an engine, and I may be unable to fix it. This does not mean that I am not present in the environment (real or virtual) where the engine and I are."*

This objection makes sense if we use the folk psychology definition of intention: the intention of an agent performing an action is his/her specific purpose in doing so. However, the latest cognitive studies clearly show that **any behavior is the result of a complex intentional chain that cannot be analyzed at a single level** [23, 24].

According to the *Dynamic Theory of Intentions* presented by Pacherie [24, 25] and to the *Activity Theory* introduced by Leont'ev and disseminated by Kaptelinin, & Nardi [26, 27], repairing an engine is driven by an above objective (e.g.,

obtaining the money for paying a new car) and is the result of lower-level operations (e.g., removing the candles, cleaning them, etc.) each driven by specific purposes. So, for an intention that failed (repairing the engine) many others were successful (removing the candle, cleaning it) inducing Presence.

More in detail, Pacherie identifies three different "levels" or "forms" of intentions (see Figure 1), characterized by different roles and contents: distal intentions (D-intentions), proximal intentions (P-intentions) and motor intentions (M-intentions):

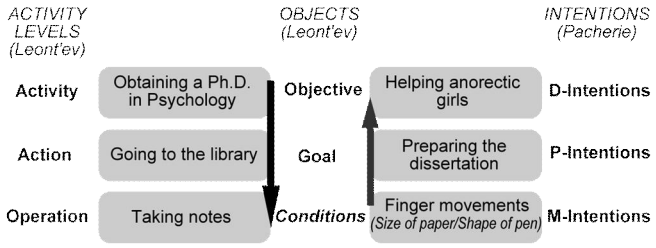

Figure 1 The intentional chain of the activity "obtaining a Ph.D. in Psychology"

- *D-intentions (Future-directed intentions).* These high-level intentions act both as intra- and interpersonal coordinators, and as prompters of practical reasoning about means and plans: in the activity "obtaining a Ph.D. in psychology" described in Figure 1, "helping anorectic girls" is a D-intention, the object that drives the activity of the subject.
- *P-intentions (Present-directed intentions).* These intentions are responsible for high-level (conscious) forms of guidance and monitoring. More in detail, they have to ensure that the imagined actions become current through situational control of their unfolding: in the activity described in Figure 1, "preparing the dissertation" is a P-intention.
- *M-intentions (Motor intentions).* These intentions are responsible for low-level (unconscious) forms of guidance and monitoring: we may not be aware of them and have only partial access to their content. Further, their contents are not propositional: in the activity described in Figure 1, the motor representations required to move the pen are M-intentions.

In sum, any intentional level has its own role: *the rational (D-intentions), situational (P-Intention) and motor (M-Intention) guidance and control of action.* More, as suggested by the Activity Theory, they form an intentional cascade [24, 25]: *higher intentions generate lower intentions.*

3.2. From intentions to presence

Given its link with action and intentions, Presence is not separated by the experience of the subject but *it is directly related to it*. It corresponds to what Heidegger [28] defined "the interrupted moment of our habitual standard, comfortable *being-in-the-world*". In fact, a higher level of Presence is experienced by the Self as a better quality of action and experience [21]. More, the agent perceives directly only *the variations* in the level of Presence: *breakdowns* and *optimal experiences* [1].

From a computational viewpoint, the experience of Presence is achieved through a forward-inverse model:

- First, the agent produces the motor command for achieving a desired state given the current state of the system and the current state of the environment;
- Second, an efference copy of the motor command is fed to a forward dynamic model that generates a prediction of the consequences of performing this motor command;
- Third, the predicted state is compared with the actual sensory feedback. Errors derived from the difference between the desired state and the actual state can be used to update the model and improve performance.

At this point we can argue that *Presence provides to the agent a feedback about the status of its activity*: the agent perceives the variations in Presence and tunes its activity accordingly. Specifically, the agent tries to overcome any breakdown in its activity and searches for engaging and rewarding activities (optimal experiences).

From a practical viewpoint, these reflections suggest that:

a) **subjects with different intentions will *not* experience the same level of Presence, even when immersed in the *same* virtual environment**: this means that understanding and supporting the intentions of the user will improve his/her Presence in the virtual world.

b) **the more the task is complex, the more are the intentional levels that have to be supported by the virtual environment to induce a high level of presence**: it is easier to induce presence during simple tasks.

c) **we have the highest level of Presence when the environment is able to support the full intentional chain of the user**: this can explain i) the success of the Nintendo Wii over competing consoles (it is the only one to fully support M-intentions); ii) the need of a long-term goal to induce a high level of Presence after many experiences of the same virtual environment.

4. Intentions: The link between presence and social presence

In the previous section we connected action and intentions to Presence. Recent studies suggest that a similar link exists in

Social Presence, the ability of recognizing others in an external environment. Specifically, is through the recognition of the Other's intentions that he/she becomes present to us.

4.1. Social presence: Understanding the intentions of the other

There is a large body of evidence underlying that infants, even in the first months of life, show a special sensitivity to communication and participate in emotional sharing with their caregivers [29]. Trevarthen [30, 31] argues that an infant is conscious, from birth, of others' subjectivity: he/she is conscious of other's mental states and reacts in communicative, emotional ways so to link each other's subjectivity. Meltzoff goes further [32-35] proposing the existence of a *biological mechanism allowing infants to perceive others "like them" at birth*.

In our view, this ability can be defined as *"Social Presence": the non mediated (prereflexive) perception of an enacting other within an external world*.

It is important to note, however, that this ability evolves in time and it is related to the intentional skills of the subject: **a subject can recognize only the intentions that he/she is able to enact**. As underlined by Meltzoff and Brook [36]:

> Evidently, infants construe human acts in goal-directed ways. But when does it start? We favor the hypothesis that it begins at birth… The hypothesis is not that neonates represent goal directedness in the same way as adults do. In fact, neonates probably begin by coding the goals of pure body acts and only later enrich the notion of goals to encompass object directed acts (p. 188).

In fact, newborns are able to detect *intentionality* (there is an other) – they recognize that a M-intention is being enacted by another self – but neither to detect higher level intentions – they do not recognize D-intentions and P-intentions – nor to identify the *motives* of motor behaviors – they do not recognize why the specific M-intention is being enacted. However, this simple ability has a critical role for the newborn: the more he/she is able to identify other selves, the more it is the possibility of starting an interaction, thus increasing his/her probability of surviving.

The next step in the development of Social Presence skills is the identification of communicative intentions in other selves (the intention of the other is toward the self). The more the infant is able to identify a communicative intention in other selves, the more it is the possibility of starting an interaction, thus increasing its probability of surviving. This skill requires the ability of enacting P-intentions and usually appears after 4-9 months from birth.

The highest level of Social Presence is the identification of intentional congruence and attunement in other selves (the self and the other share the same intention). The more the self is able to identify intentional attunement in other selves, the more it is the possibility of conducting an interaction, thus increasing its probability of surviving. This skill requires the ability of enacting P-intentions and usually appears only at the age of 11.

From a practical viewpoint, these reflections lead to new suggestions for the developers of a virtual world:

a) **action and its intentions are more important than perception also for Social Presence**: In this view text, if it is able to convey the intention of the writer, can induce more Social Presence than a static 3D photo of the same writer.

b) **Social Presence in children is different from Social Presence in adults**: their different ability of enacting intentions also influences their ability of recognizing intentions. So networked virtual environments for children have to be simpler.

4.2. Social presence: The cognitive process

How does a subject learn to recognize and explain the full intentional chain of the other? Following Csibra and Gergely [37], I suggest that this processes is a *predictive* one: it emulates the action needed to achieve a hypothesized goal. From the computational viewpoint, it follows the same approach used by Presence:

- First, the agent recognizes the motor command, the current state of the other agent and the current state of the environment;
- Second, an efference copy of the motor command is fed to a forward dynamic model that generates a prediction of the consequences of performing this motor command;
- Third, the predicted state is compared with the actual sensory feedback. Errors derived from the difference between the predicted state and the actual state can be used to update the model and improve performance.

Supporting this vision, Oztop, Wolpert, and Kawato [38] showed that the motor modules of the observer can be used in a "predictive mode" to infer the mental state of the actor. According to their model, mirror neurons [39, 40] can be involved in the sensory forward prediction of goal-directed movements, which are activated *both* for mental simulation during action observation and for feedback-delay compensation during movement.

From an evolutive viewpoint this approach has two strengths. First, it can be seen as the brain's attempt to minimize the free energy induced by a stimulus by encoding its most likely cause [41]. More, the recognition of others' intentions using a forward model allows interpretation without prior experience since, as long as an intentional movement or behavior is in the repertoire of the Self, it will be interpretable without any training.

If Social Presence is the result of predicting Other's intentions through an internal simulation, it is not separated by the experience of the subject but it is related to the quality of his/her social interactions. In fact the subject experiences reflexively the feeling of Social Presence only when the quality of his experience is modified during a social interaction: according to the level of Social Presence experienced by the subjects, they will experience *intentional opacity* on one side

(break in Social Presence), and *communicative attuning and synchrony* (optimal social experiences) on the other side [42].

New suggestions for the developers of a virtual world are:

a) **We have the highest level of Social Presence when the environment is able to support the full intentional chain of the other**: if the other is not able to express and enact fully his/her intentions through the medium the level of Social Presence will be low.

b) **The more the communicative task is complex, the more are the intentional levels that have to be supported by the virtual environment to induce a high level of presence**: it is difficult to induce social presence during complex cooperative tasks.

c) **The best avatars are those whom can express fully the intentions of the user**: it is not critical to have a human-like avatar. Is more important to have the possibility to express intentions through them. According to communication and cognitive psychology nonverbal cues (facial expressions and body movements) are critical to provide intentional cues.

5. Inner presence vs. media presence

How does this vision of presence refer to the classical one [43] that describes the sense of presence as a function of the experience of a given medium (*Media Presence*)?

Lombard and Ditton define the sense of presence as the *perceptual illusion of non-mediation* [44], produced by means of the disappearance of the medium from the conscious attention of the subject. We defined the sense of presence as the "non-mediated (prereflexive) perception that an intention is being enacted successfully". Where is the difference?

Apparently the main difference is in what is "non-mediated" by presence. In this paper we clearly indicated **successful intentions** as the non-mediated content. Lombard and Ditton suggest that a person is present when his/her response to the medium is not mediated [44]:

An illusion of nonmediation occurs when a person fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there. ... Presence in this view cannot occur unless a person is using a medium.

Are these positions so far? According to Searle and Pacherie [23, 24] the answer maybe no. As we have seen before, any complex behavior (obtaining a Ph.D.) is the result of an intentional chain that cannot be analyzed at a single level. Within this chain, any single action is composed of two parts: an intention, and a movement.

When the action is premeditated, it is caused by a "prior intention": an intention to act formed in advance of the action (P-Intentions and D-Intentions). However, many body movements are caused by an "intention-in-action" (M-Intentions), which drives the movement prereflexively, without the need of a prior intention.

What is the link between them? Any higher-level intention (P-Intentions and D-Intentions) is enacted through chains of M-intentions that are not under the direct control of the subject.

This is the typical case of synchronous mediated communication when the user masters the medium: the fingers of an expert chatter or the hands of a Doom III cooperative player are prereflexively driven by M-intentions. Following Heidegger [45], the medium is "ready-to-hand". Only when there is a breakdown, a problem - the keyboard is no more responsive or the screen disappears – the user needs to plan a new action (P-intention or D-Intention according to the context) to solve the problem.

For Lombard and Ditton the Doom cooperative players are present in the game "if this does not draw attention to itself reminding them that they are having a mediated experience". For me, the players are present in the virtual environment if they are able to drive successfully and prereflexively their interaction. If I substitute in my definition of presence the word "intention" with the one "intention-in-action" I have an almost perfect match with the Lombard and Ditton's position: *the non mediated (prereflexive) perception of successful intentions-in action.* The main difference is that this definition works for experiences not related to media, too.

To make this concept clearer some examples may help. A stroke patient with a left hemiplegia is no more "present" in the left part of his body: using his left hand he is not able to translate an intention-in-action in a purposeful behavior.

An anarchic hand patient is no more present in his/her hand because he/she is not able to use the hand to enact his/her intentions.

But it is not only the body to be not "present" – or not "ready-to-hand" - to the self. I'm in a restaurant for a formal dinner with my boss and some colleagues, but I don't know how to directly use the many different strange forks I have around my dish. In this situation I'm physically there, but the lack of knowledge puts me outside, at least partially, from the social and cultural space of the "formal dinner". The result is a reduced presence and a limitation in my agency: I don't use the forks to avoid mistakes. These examples show clearly how both physical boundaries (body, wall, obstacles, etc.) and social and cultural boundaries have a strong influence on the possibility of action and the experienced presence of the subject.

In this context, *a breakdown* occurs when, during our activity, we are forced to stop our intentional chain. To illustrate, imagine sitting in a balcony engrossed in reading a book on a pleasant evening. As the sun sets and the light diminishes one continues reading, engrossed in the story until one becomes aware that the light is no longer suitable for reading. In such conditions, before any overt change in behavior, what we experience is a breakdown in reading and a shift of attention from the book to the light illuminating the book. At that stage we are not present anymore in the reading and we have to reflexively plan an action to switch on the light on the balcony.

Conclusions

In this paper we tried to show that the concepts of "Presence" – *the non mediated (prereflexive) perception of successfully transforming intentions in action (enaction) within an external world* - and "Social Presence" - *the non mediated perception of an enacting Other within an external world* – can offer a conceptual framework for understanding the link between the enaction and the recognition of intentions. Through Presence, the agent *prereflexively* controls his/her action through a forward-inverse model: the prediction of the action is compared with perceptual inputs to verify its enaction. Through Social Presence, the agent *prereflexively* recognizes and evaluates the action of others using the same forward-inverse model: the prediction of the action is compared with perceptual inputs to verify its enaction.

I believe that this model makes sense in terms of cognitive psychology and is beginning to be supported by evidence of the neural and other physical correlates of action, imitation and self-monitoring. From a more practical viewpoint, the model suggests that any environment, virtual or real, does not provide undifferentiated information, ready-made objects equal for everyone. It offers different opportunities and produces Presence according to its ability in supporting the users and their intentions.

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References

[1] G. Riva. Being-in-the-world-with: Presence meets social and cognitive neuroscience. In: G. Riva, M. T. Anguera, B. K. Wiederhold, F. Mantovani (Eds.) *From Communication to Presence: Cognition, emotions and culture towards the ultimate communicative experience. Festschrift in honor of Luigi Anolli*. Amsterdam: IOS Press, pp. 47-80. 2006. URL: http://www.emergingcommunication.com/volume8.html.

[2] G. Mantovani, G. Riva. Real presence: How different ontologies generate different criteria for presence, telepresence, and virtual presence. *Presence: Teleoperators, and Virtual Environments*, 8, 538-548. 1999.

[3] G. Mantovani, G. Riva. Building a bridge between different scientific communities: on Sheridan's eclectic ontology of presence. *Presence: Teleoperators and Virtual Environments*, 8, 538-548. 2001.

[4] J. J. Gibson. *The Ecological Approach to Visual Perception*. Hillsdale, NJ: Erlbaum. 1979.

[5] A. Spagnolli, L. Gamberini. A Place for presence. Understanding the human involvement in mediated interactive Environments. *PsychNology Journal*, 3, 6-15. 2005. URL: www.psychnology.org/article801.htm.

[6] A. Spagnolli, D. Varotto, G. Mantovani. An ethnographic action-based approach to human experience in virtual environments. *International Journal of Human-Computer Studies*, 59, 797-822. 2003.

[7] L. Gamberini, A. Spagnolli. On the relationship between presence and usability: a situated, action-based approach to virtual environments. In: G. Riva, W. A. IJsselsteijn, F. Davide (Eds.) *Being There: Concepts, effects and measurement of user presence in synthetic environments*. Amsterdam: IOS Press, pp. 97-107. 2003.

[8] J. A. Waterworth, E. L. Waterworth. Presence as a dimension of communication: Context of use and the person. In: G. Riva, M. T. Anguera, B. K. Wiederhold, F. Mantovani (Eds.) *From Communication to Presence: Cognition, emotions and culture towards the ultimate communicative experience*. Amsterdam: IOS Press, pp. 80-95. 2006. URL: http://www.emergingcommunication.com/volume8.html.

[9] D. Schloerb. A quantitative measure of telepresence. *Presence: Tteleoperators, and Virtual Environments*, 4, 64-80. 1995.

[10] C. Heeter. Being There: The subjective experience of presence. *Presence: Teleoperators and Virtual Environments*, 1, 262-271. 1992.

[11] M. V. Sanchez-Vives, M. Slater. From presence to consciousness through virtual reality. *Nature Review Neuroscience*, 6, 332-9. 2005.

[12] G. Mantovani. *New Communication Environments: From Everyday to Virtual*. London: Taylor & Francis. 1996.

[13] A. Sirigu, J. Grafman, K. Bressler, T. Sunderland. Multiple representations contribute to body knowledge processing: Evidence from a case of autotopagnosia. *Brain*, 114, 629-642. 1991.

[14] S. Della Sala. The anarchic hand. *The Psychologist*, 8, 606-609. 2006.

[15] A. Kjellgren, U. Sundequist, U. Sundholm, T. Norlander, T. Archer. Altered consciousness in flotation-REST and chamber-REST: Experience of experimental pain and subjective stress. *Social Behaviour and Personality*, 32, 103-115. 2004.

[16] M. Matelli, G. Luppino. Parietofrontal circuits for action and space perception in the macaque monkey. *Neuroimage*, 14, 27-32. 2001.

[17] A. Postma. Space: From perception to action. *Acta Psychologica*, 118, 1-6. 2005.

[18] J. Waskan. *Models and Cognition*. Cambridge, MA: MIT Press. 2006.

[19] L. Gamberini, B. Seraglia, K. Priftis. Processing of peripersonal and extrapersonal space using tools: Evidence from visual line bisection in real and virtual environments. *Neuropsychologia*, 46, 1298-1304. 2008.

[20] A. Farné, A. Serino, E. Làdavas. Dynamic size-change of perihand space following tool-use: Determinants and spatial characteristics revealed through cross-modal extinction. *Cortex*, 43, 436-443. 2007.

[21] P. Zahoric, R. L. Jenison. Presence as being-in-the-world. *Presence, Teleoperators, and Virtual Environments*, 7, 78-89. 1998.

[22] J. A. Russell. *Agency: Its Role in Mental Development*. Hove: Erlbaum. 1996.

[23] J. Searle. *Intentionality: An Essay in the Philosophy of Mind*. New York: Cambridge University Press. 1983.

[24] E. Pacherie. Toward a dynamic theory of intentions. In: S. Pockett, W. P. Banks, S. Gallagher (Eds.) *Does Consciousness cause Behavior?* Cambridge, MA: MIT Press, pp. 145-167. 2006.

[25] E. Pacherie. The phenomenology of action: A conceptual framework. *Cognition*, 107, 179-217. 2008.

[26] A. N. Leontjev. *Activity, consciousness, and personality*. Englewood, NJ: Prentice-Hall. 1978. URL: http://marxists.org/archive/leontev/works/1978/ch3.htm,

[27] V. Kaptelinin, B. Nardi. *Acting with technology: Activity Theory and Dnteraction Design*. Cambridge, MA: MIT Press. 2006.

[28] M. Heidegger. *Unterwegs zur Sprache*. Neske: Pfullingen. 1959.

[29] M. Legerstee. *Infants' Sense of People: Precursors to a Theory of Mind*. Cambridge: Cambridge University Press. 2005.

[30] C. Trevarthen. The neurobiology of early communication: Intersubjective regulations in human brain development. In: A. F. Kalverboer, A. Gramsbergen (Eds.) *Handbook on Brain and Behavior in Human Development*. Dordrecht, Netherlands: Klewer Academic publisher. 2001.

[31] C. Trevarthen, K. Aitken. Infant intersubjectivity: Research, theory and clinical applications. *Journal of Psychological Psychiatry*, 42, 3-48. 2001.

[32] A. N. Meltzoff, W. Prinz, G. Butterworth, G. Hatano, K. W. Fischer, P. M. Greenfield, P. Harris, D. Stern. The imitative mind: Development, evolution, and brain bases. Cambridge: Cambridge University Press. 2002.

[33] A. N. Meltzoff, M. K. Moore. Imitation of facial and manual gestures by human neonates. *Science*, 198, 702-709. 1977.

[34] A. N. Meltzoff, J. Decety. What imitation tells us about social cognition: a rapprochement between developmental psychology and cognitive neuroscience. *Philosophical Transactions of the Royal Society*, 358, 491-500. 2003.

[35] A. N. Meltzoff. Origins of theory of mind, cognition and communication. *Journal of Communicative Disorders*, 32, 251-269. 1999.

[36] A. N. Meltzoff, R. Brooks. "Like me" as a building block for understanding other minds: Bodily acts, attention and intention. In: B. F. Malle, L. J. Moses, D.A. Baldwin (Eds.) *Intentions and Intentionality: Foundation of Social Cognition*. Cambridge, MA: MIT Press. pp. 171-191.2001.

[37] G. Csibra, G. Gergely. Social learning and social cognition: The case for pedagogy. In: Y. Munakata, M. H. Johnson (Eds.) *Process of Change in Brain and Cognitive Development. Attention and Performance XXI*. Oxford: Oxford University Press. pp. 249-274. 2006.

[38] E. Oztop, D. Wolpert, M. Kawato. Mental state inference using visual control parameters. *Cognitive Brain Research*, 22, 129-151. 2005.

[39] G. Rizzolatti, L. Fogassi, V. Gallese. Cortical mechanisms subserving object grasping and action recognition: A new view on the cortical functions. In: M. S. Gazzaniga (Eds.) *The Cognitive Neurosciences, 2nd Edition*. Cambridge, MA: MIT Press. pp. 539-552. 2000.

[40] G. Rizzolatti, G. Luppino, M. Matelli. The organization of the cortical motor system: new concepts. *Electroencephalography and Clinical Neurophysiology*, 106, 283-296. 1998.

[41] J. M. Kilner, K. J. Friston, C. D. Frith. The mirror-neuron system: A Bayesian perspective. *Neuroreport*, 18, 619-23. 2007.

[42] L. Anolli, R. Ciceri, G. Riva. *Say not to Say: New persectives on Miscommunication*. Amsterdam: Ios Press, 2002. URL: http://www.emergingcommunication.com/volume3.html.

[43] C. Coelho, J. Tichon, T. J. Hine, G. Wallis, G. Riva. Media presence and inner presence: The sense of presence in virtual reality technologies. In: G. Riva, M. T. Anguera, B. K. Wiederhold, F. Mantovani (Eds.) *From Communication to Presence: Cognition, emotions and culture towards the ultimate communicative experience. Festschrift in honor of Luigi Anolli*. Amsterdam: IOS Press, pp. 25-45. 2006. URL: http://www.emergingcommunication.com/volume8.html,

[44] M. Lombard, T. Ditton. At the heart of it all: The concept of presence. *Journal of Computer Mediated-Communication*, 3. 1997. URL: http://www.ascusc.org/jcmc/vol3/issue2/lombard.html,

[45] M. Heidegger. *Being and Time*. New York: Harper & Row. 1962.