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Enacting Interpersonal Space: the Role of the Body in Social Cognition

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The purpose of this article is to bridge the gap between high-level social processes and low-level sensorimotor processes. Specifically, it wants to show that human co-presence and social interactions (high-level social representations), are immediately remapped in spatial representations (low-level sensorimotor processes).

The idea that an embodied cognition is committed in higher-level cognitive processes was developed at the end of the twentieth century. It has been theorised by Maturana and Varela in biology and neuroscience; by Lakoff and Johnson in neurolinguistics. In order to propose an alternative paradigm to computationalist cognitive science, Maturana and Varela conceived cognition as action-oriented and have proved that perception is strongly mediated by embodied (sensory-motor) processes (Maturana and Varela 1998; Varela, Thompson & Rosch 1991). Lakoff and Johnson have shown that the body is able to generate meaning even before a development of self-consciousness. They analyse the several dimensions of signification — images, qualities, metaphors, emotional states — in order to demonstrate that their roots are in the encounters of body with the world (Lakoff & Johnson 1980; Johnson & Lakoff 2007). On the other hand, the role of low-level spatial processing during high-level social representations has not yet been proved, even if space and time are the most basic structures of human cognition. Thus, spatial relationships among individuals might be extremely significant in order to shape and define social dynamics of interactions among people.

Nowadays, an alternative approach to the traditional social cognition is the Interaction Theory (IT). IT focuses on inter-corporal activities occurring during social interactions, in particular coordination and reciprocity conceived as a necessary *medium* to understand the other person's intentions and emotions. IT has introduced the concept of 'we space' in order to point out the importance of another embodied agent physically co-present; surprisingly, it has said nothing about the space and spatial representations between two or more bodies during social interactions.

The present study attempts to provide an interdisciplinary theoretical frame about the importance of spatial representation for social cognition. It refers to research in social psychology, phenomenology and neuroscience. Social psychology has discovered that different social relations are reflected in different interpersonal spatial distances between two partners; phenomenology has identified the embodied aspects of inter-corporality between two agents; neuroscience has defined personal space as a body-centred action space. Bringing together the most important suggestions of those fields of research, this work demonstrates not only that personal space is body-centred but that one's own implicit spatial representation is continuously shaped and transformed by the kind of interactions occurring between two people. In order to prove such a thesis, two experiments are carried out and discussed. The first experiment tests whether the co-presence of a human body modifies one's own spatial representation; the second whether and if so how cooperative or uncooperative interactions reshape the spatial representation between two individuals.

The first two sections of this article will briefly outline the concepts of social cognition through social interaction and interpersonal spatial representation, with particular reference, in the first, to 'Theory Theory' and 'Simulation Theory' and, in the second, Interaction Theory, social psychology and phenomenology. The purpose, methodology and results of the two experiments are discussed in section three, and the interpretation of those results in sections four and five, which deal with Experiment 1 and Experiment 2 respectively. The final section draws conclusions.

1. Social Cognition through social interaction: a different perspective from 'Theory of Mind Theory' and 'Simulation Theory'.

The term 'social brain function' has been often used in social cognitive neurosciences. Here is a current definition of it:

> Social brain function is tightly linked to social context, and social context consists of multimodal social properties including the behaviors of individuals and details in the environment. Social context changes continuously and is often unpredictable. An action that was socially appropriate a few seconds ago is not guaranteed to be appropriate now. Therefore, if social conflict is to be avoided, frequent updates of each agent's internal representation of the social environment must be an essential brain function (Fujii, Hihara & Iriki 2007: e397).

This definition shows some critical points. First of all, it is wrong to reduce the 'social event' to 'behaviors *of* individuals'; in fact, in a social context, behaviours are not only *of* individuals but also *between* individuals. Secondly, people interact with each other and, from the outset, the behaviours between individuals can be defined as actions *with*, *towards* or *against* somebody. Thirdly, individuals live and move in an environment that is characterised spatially and temporally. Lastly, the environment is a '*social* environment', namely, a physical place where interactions among people, physically and temporally co-present, are performed. At this point, Gallagher, as well as De Jaegher and Di Paolo, would introduce the relevance of social interactions to explain and to ground social cognition.

'Interaction Theory' is a theory which has arisen as an alternative paradigm to 'Theory of Mind Theory' (ToM) and 'Simulation Theory' (ST).[1] ToM and ST have been the most important approaches to social cognition. The former claims that an abstract internal theory of mind enables us to develop inferences by which we understand and forecast people's behaviours. Mental states (like desires, beliefs, etc.), cause and justify how individuals usually behave.[2] The latter asserts that we do not need a theory enabling us to make inferences in order to understand people's behaviours. ToM considers the body a crude device of peripheral transmission. ST postulates the use of a first person simulating model that projects third person mental states as if 'we were another person', or as if 'we were in his situation'. ST has been successful since the discovery of mirror neurons in the premotor cortex. In fact, mirror neurons not only fire when we *perform* an action but also when we *perceive* another person performing an action (action is different from movement because the former is goal-oriented).[3] ST is strengthened by the discovery of mirror neurons, a process interpreted as if it would make use of a sort of emulation at level of sensorimotor system through the re-activation of the same neural processes activated during an action. Mirror neurons:

> allow us to directly understand the meaning of actions […] of others by internally replicating ('simulating') them […] The observer understands the action because he know its outcomes when he does it (Gallese, Keysers & Rizolatti 2004: 396).

Nevertheless, ST is criticised by IT because it does not take into account the *reciprocity* of relationship between two or more individuals.[4]

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1 Gallagher first put forward Interaction Theory as an alternative proposal to ToM and ST in *How the body shapes the mind* (2005). In order to define this new field of research, it is necessary to provide IT with an exact definition of 'social interaction' and to identify the possible roles that IT plays in social cognitive performances. For additional information, see: De Jaegher, Di Paolo& Gallagher (2010).

2 The concept of 'Theory of Mind' was first put forward by Leslie and Baron-Cohen in their article 'Does the autistic child have a "theory of mind"?', where they show how children with autism are unable to develop theory of mind mechanisms. It is a capability that enables normal children to attribute mental state to themselves and to other people. The emerging conception of 'Theory of Mind Mechanisms' subsequently achieved significant success also in the understanding of normal human psychology. Today, ToM is employed by neuroscientists (Frith), psychologists (Meltzoff), and philosophers (Fodor, Dennett) to explain the ability to take the-Other's perspective.

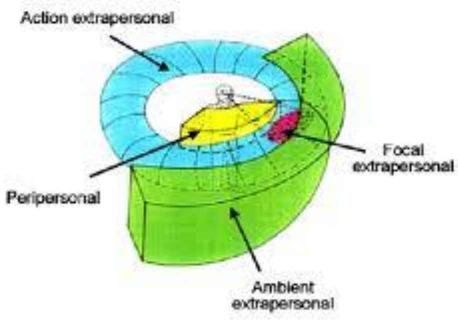
3 The hypothesis of mental simulation was first theorised by Gordon (1986). Today, ST is based almost completely on data from neuroscience (e.g., Barsalou 2003; Decety 1996; Frith & Dolan 1996; Hesslow 2002; Jeannerod 1994, 2001).

4 Such a lack of 'reciprocity' in ST is thoroughly discussed by Fuchs and De Jaegher (Fuchs & De Jaegher 2009: 468).

On its part, IT claims that social cognition is grounded in social interaction. The interaction theorists Gallagher, Di Paolo and De Jaegher focus on the embodied and participatory aspects of social understanding. They aim to demonstrate that 'interactive processes are more than a context for social cognition' (De Jaegher, Di Paolo and Gallagher 2010: 441). Interaction implies the engagement of at least two agents in a complex co-regulated pattern where no agent loses its autonomy. In the context of embodied approaches, social cognition involves the 'know-how' that allows individuals to sustain interactions and act together. Thus, 'understanding' in this context, requires a pragmatic ability to act appropriately in a particular situation. Social interactions demand a reciprocal and joint activity and include an engagement between the participants. 'Joint-activity' is a complex process supported by joint attention, action observation, task sharing, action coordination (Sebanz 2006; Vesper, Butterfill, Knoblich & Sebanz 2010). Engagement can correspond to fluctuating feelings of connectedness with the Other, whose meaning sometimes seems transparent and sometimes opaque, and of increasing and decreasing possibilities for participation. Such a kind of study on acting together paves the way for a conception of social cognition relating to interconnected individuals and not to a mind in an isolated body. Coordination is the most important feature of joint action and it implies a non-accidental correlation of two or more systems that are coupled together to develop a task. Namely, the individuals engaged in this coupling have to adjust their action to those of their partner. Coordinated action can be both emergent and planned. The former occurs spontaneously and without a *plan* to act together. An example of emergent coordination between two people is the synchronisation of speech and bodily movements during a conversation. The latter requires a representation of intentions and desired outcomes in order to plan an activity where the role of the involved agents is defined. In this field of research, Krueger has introduced the interesting notion of 'we space' to point out the social meaning of another's bodily co-presence (Krueger 2010: 2). As the next section shows, such a 'we space' refers to spatial coordination and not to a spatial representation between individuals that is the object of the present research. Thus, after introducing the meaning of Krueger's concept, the section focuses on explaining its limitations and the importance of spatial representation during a social interaction.

2. Interpersonal spatial representation: confronting Interaction Theory, Social Psychology and Phenomenology.

Krueger employs the meaning of 'space' in neurosciences, where recent findings have emphasised its practical feature. In a neuroscientific context, 'space' means body action-centred space'. That is, the spatial representations have been defined and built on the different possibilities of body-centred actions of an embodied agent. Therefore, 'extrapersonal space' is the space beyond the actions of reaching; 'peripersonal space' is the space around one's body within which actions of reaching are possible (it will be central in the following paragraphs); 'personal space' is the space of the body's surface.



The taxonomy of space representations includes at least three main sectors: Personal (i.e., the space defined by the body surface); Peripersonal (the space that encompasses the objects within reach); Extrapersonal space (the space beyond our immediate reach and that one can get close to enough only by locomotion).

FIGURE 1: 'FOUR SPACES': THE TAXONOMY OF SPACE IN NEUROSCIENCE [5]
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As Figure 1 shows, it is one's own body that constitutes the focus of spatial representations, whereas there is no reference about spatial representations between *two* bodies, between the self and the others. Krueger enriches such a meaning of 'space' by taking into account not only the actions of one agent but also the mutual adjustment of actions and intentions occurring *among* individuals. In this perspective, our sensory and motor bodies allow people to perform *face-to-face* interactions with others who are physically co-present. The co-presence is conveyed by coordinated actions, attuned glances and emotional

[5] There have been many studies about this space and its categorisation. See the definition of 'Bodily awareness' in the Stanford Encyclopedia of Philosophy: 'The notion of a special area of space around the body has been first proposed based on the observation of animals by Hediger (1955), the director of the Zurich Zoo. When a threatening object enters a spatial margin of safety around the animal's body (the 'flight zone'), animals engage in a range of protective behaviors (Dosey & Meisels 1969; Cooke and Graziano 2003). Similarly, humans are sensitive to the violation of their peripersonal space, whether it is by a snake or by a mere chair that should be avoided to navigate in the room. Interestingly, it was recently found that neutral visual stimuli close to a part of the body interfere with tactile experiences, if the location of the visual stimuli is incongruent with the location of the tactile stimuli (Spence et al. 2004). There is thus a multisensory attentional mechanism, which relates stimuli in the external space and stimuli on the body (Ladavas and Farne 2004; Makin et al. 2008). One may suggest that the representation of peripersonal space underlies our awareness of our body "within a larger space which can contain other objects" (Martin 1993, 212)' (Encyclopedia of Philosophy <http://plato.stanford.edu/entries/bodily-awareness/#PerSpa>; [accessed 11-Jul-12]).

synchronisations among people. By means of such components, human beings configure and shape an emotionally-featured shared space. However, neither Krueger nor other theorists of IT refer to the space as a space *between* individuals. When they analyse the reciprocal and joint activity among people, the spatial representations of individuals as a result of such interactions is completely overlooked. In summary, the concept of 'we space' introduces the idea of interpersonal activities without making reference to the space. On the contrary, peripersonal space captures the idea of a multisensory interface for inter-actions, but most research in this field has only focused on the representation of *one's own* body. As Donna Lloyd says, if much is known about neural mechanisms that codify the space around one's body, little has been shown about the mechanisms codifying the space between two (or more) bodies. Nevertheless, spatial relationships among individuals are significant because they shape and define social dynamics of our interactions with people (Lloyd 2009).[6]

A different perspective can be found in social psychology, where the social significance of spatial distance between individuals has been theorised. In his *The Hidden Dimension* (1996), E. T. Hall introduced the concept of 'personal space' to mean the closest 'bubble' of space surrounding a person. Entry into this space is acceptable only for closest friends and intimates. Different studies using personal space as a parameter have been carried out, for example by the psychologists Larry M. Dean and Kinzel: the former has determined to what extent the *social* distance among military people belonging to different ranks is a *spatial* distance; the latter has found a correlation between violent people and their overestimated spatial perception. A summary of their findings follows.

Distance and Rank: Dean and his colleagues measured *interaction* distances at the start of a conversation between individuals belonging to various ranks in military settings (Dean, Willis & Hewitt 1975). They found that the distance between military personnel tended to be greater when a person of a lower rank approached a person of higher rank than when peers approached each other or when a person of higher rank approached a person of lower rank. In summary, it is the subordinate who is responsible for spatial distances during social interactions. In this case, spatial representation is a dependent variable of formal organisation.

Body-Buffer-Zone: Kinzel measured the 'body-buffer-zone' in violent prisoners in comparison to that in non-violent prisoners. Body-buffer-zone (BBZ) was identified by Horowitz, Duff and Stratton as the area around a person within which anxiety is produced if another enters. BBZ was conceived as an area surrounding the body which represents the

[6] In this article, Lloyd gives an interesting neurophilosophical frame to the space between individuals.

boundaries of what is felt as 'inner' versus what is felt as 'outer'. Kinzel's comparative measurement showed that in violent prisoners BBZ was almost four times larger than in non-violent prisoners. He suggested that violent prisoners have a permanent abnormality of body image. In fact, they behave 'as if their bodies are extended further into the space around them. Thus, to intrude on their personal space is to intrude on their bodies' (Kinzel 1970: 99).

If the space surrounding a person (i.e. personal space), is a dependent variable of social organisation and if it correlates with specific characteristics of personality, it seems coherent to hypothesise that 'space' is an I-perspective and that it is shaped by our social activity. The two studies referred to above have codified 'personal space' by means of a spatial distance explicitly kept by the subjects in various contexts. That is a different representation in comparison to the neuronal implicit spatial processing. The similarity or correlation between peripersonal space in neuroscience and personal space in social psychology has not yet been proved. The present research does not intend to draw a parallel between the two spatial definitions. The main purpose is to detect and develop the relative components of both, as being useful to endorse the initial thesis about a remapping of social representations in sensorimotor processes. Although psychologists have codified and measured space in a way that is different from neuroscience's practical space, this research extrapolates their respective theoretical suggestions: spatial perception is body-centred and it varies as a function of our social or practical activity. Phenomenologists have pursued the same theoretical principle. Husserl, for instance, in *Ding und Raum* (1907), analysed the importance of body-movements and *kinaesthetic sensations* for the experience of space and the constitution of spatial objects. He claims that spatial objects can only appear for and be constituted by *embodied subjects*. Merleau-Ponty in *Phénoménologie de la perception* (1947) put forward the concept rendered in English as 'body-world relationship', in order to point out that the engagement in a social world is a function of having a body and motility. However, our body is related to other bodies during our entire life (from a family context to a social one); a social event should therefore be added. Social event is the new component of this research that aims to measure the spatial representations *between* two bodies after different social events and will be exemplified by the co-presence of another human being and cooperative and uncooperative interactions during two experiments.

From an embodied perspective, the space between two embodied agents is not an abstract concept or a framework regulated by a code of conduct. On the contrary, the spatial representation occurring between two individuals is enacted by the human sensorimotor system. In other terms, the mere human co-presence and people's social behaviours might enact different inter-personal body-centred space (or, the space between two bodies). This hypothesis suggests a bond between the high level of social interaction and the low level of sensorimotor capability and it has been verified by two experiments that the third section will explain.

3. Experiments: purpose, method and results.

To give substance to an embodied viewpoint concerning spatial representations between two or more bodies, two experiments were designed and peripersonal space (PPS) representation was measured.[7] The experiments were intended to test the following hypotheses:

1) PPS representation varies as a function of the presence of another person (co-presence).

2) PPS representation varies as a function of social interactions.

The choice of measuring PPS was motivated by its features that allow us to verify its modulation. Moreover, PPS has been well codified in neuroscience and experimental evidences have proved the following properties. Representations of PPS are body-centred or body-part centred, restricted to the space immediately surrounding the body (extending to about 20–40 cm from the skin surface in monkeys and up to perhaps 70 cm in humans). It is a multisensory interface between the body and the environment; 'multisensory' because it is represented by neurons that integrate information from multiple sensory modalities (somatosensory, proprioceptive, visual and auditory); an 'interface' because within the limits of PPS the body can directly interact with the environment where one runs into objects and meets up with people. As the external world is characterised by social components and not only by physical objects, it makes sense to conceive of the PPS as an inter-face for social inter-actions. Until now, two main functions of PPS have been detected: it enables involuntary self-defensive movements and it serves voluntary object-oriented actions and nothing has been reported about its social function.[8] Plasticity is another important feature of PPS; in fact, its representation extends to include mirror images, inanimate objects and tools actively held in the hand.[9] Thus, when wondering about the social function of PPS, this

[7] The experiments were carried out in collaboration with Professors G. Di Pellegrino and A. Serino (CNC, Cognitive Neuroscience Center, University of Bologna).

[8] The scientific definition of PPS and its functions can be found in Graziano and Cookee (2006: 845, 859)

[9] In order to read an example of plasticity after tool use, see Holmes and Spencer (2004).

research intends to verify the hypothesis that PPS representation is shaped by social events occurring between two human bodies.

PPS is an implicit representation that occurs at a non-conscious level; it is a non-explicit measurement that takes advantage of its multisensory property. In fact, experimental findings have shown stronger visuo-tactile or audio-tactile interactions in near space than in far space; that is to say, the detection of a tactile stimulus on an area of the body gets faster only when a visual/auditory stimulus occurs *near* that stimulated part of the *body*. For this reason, an audio-tactile interaction task was proposed during the experiments in order to obtain the extent of PPS representation.

3.1 Method

Subjects were asked to respond rapidly to a tactile stimulus administered on their right cheek, while being subjected at the same time to task-irrelevant dynamic and stereophonic sounds which gave the impression of a sound source *approaching* (the 'IN sound' in Figures 1 and 2) the subject's face.

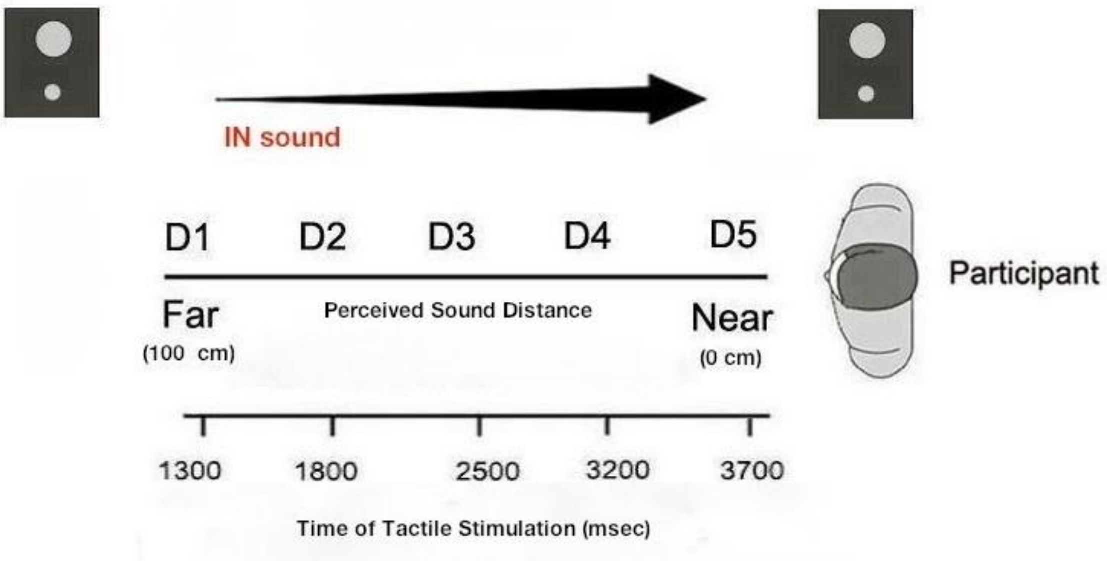

FIGURE 2: THE AUDIO-TACTILE-INTERACTION TASK
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Tactile stimuli were given at five different temporal delays from sound onset, implying that they were processed when sounds were perceived at five possible different distances from the subject's face (ranging from D1, very far, to D5, very close; see Figure 2). Subjects were instructed to ignore the irrelevant sounds and to respond vocally as fast as possible to tactile stimuli. Since task-irrelevant sounds boost tactile reaction time (RT) only if presented within the near space (i.e. PPS),[10] the critical time-point, i.e., the critical distance where a sound affects tactile perception, can be considered as the perceptual limit of the multisensory PPS around the target body part and thus a proxy of the boundaries of PPS representation (Serino et al. 2007; Tajadura-Jimenéz et al. 2010). In such a way, no distance between individuals was varied in order to evaluate their spatial perception and participants were not informed about the real purpose of the experiment (the measure of PPS).[11]

We measured the social modulation of PPS representation by proposing two tasks. In the first one, in order to investigate whether another person's presence modulates the extent of PPS representation, we had participants perform the audio-tactile task in the presence of either a dummy or a person placed in the far space (see Figure 3). The living or inanimate partner was seated facing the participant at a distance of 100 cm, namely at the same distance of the furthest loudspeaker from where approaching sounds originated (i.e. the far space). In the second one, we contrasted a cooperative interaction between two individuals with an uncooperative one during a game for money.

In Experiment 1, we found that the boundary of PPS changes depending on the presence of another human or a dummy. In Experiment 2, we demonstrated that PPS boundaries extend to include the space around the other after performing an economic game with the Other, but only if the Other is cooperative during the game.

4. Interpretation of Experiment 1: recognising a body just as a human-body.

In front of a dummy, participants performed exactly the same task as in front of a person. The order of dummy and partner conditions was counterbalanced; that is to say, half of the participants faced a dummy first and then a person, the other half a person first and then a dummy.

[10] In fact, when approaching sounds enter near space, the RT to a tactile stimulus get easier and consequently faster. See the illustration.
[11] This measure of the extent of PPS was designed by A. Serino.

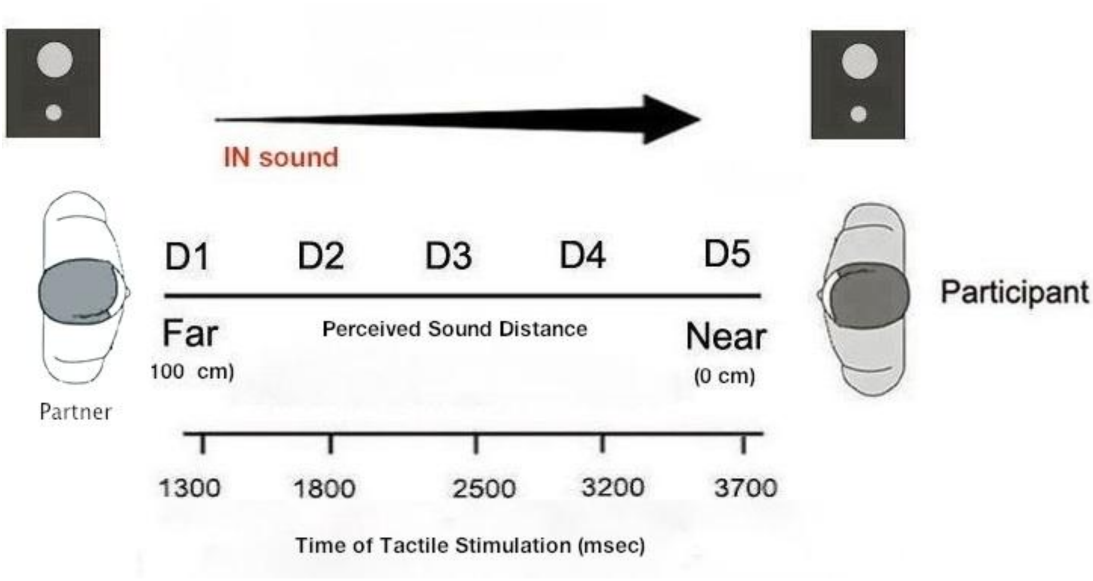

FIGURE 3: TASK WITH A PARTNER[12]
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We found that the boundaries of PPS were closer to participants when they performed the audio-tactile integration task facing a human being (the 'Other-condition') rather than a dummy (the 'dummy-condition').[13] This finding shows that PPS boundaries adapt to the presence of others. In other words, the boundaries of PPS representation shrunk towards one's own space, when the far space was occupied by a human body, as compared to when it was occupied by an artificial body.

Such a result seems to be coherent with the qualitative analysis of social psychologists. They state that when two individuals share the same space, neither of them considers the whole space as their own. On the contrary, both of them tend to shrink the boundaries of the available space. They naturally assign half of the area to the co-present agent. For instance, when two people share a table, they tend to perceive half of the table as a symbolic and spatial representation of their own personal space. However, if two people have a different status, the one with a higher one will take or will be conceded a larger portion of the table.

Such a result is understandable for phenomenologists, too. In fact, they confer the meaning of a person's presence to the human body. When discussing intersubjectivity, Merleau-Ponty does not refer to the body either as an object or as a crude physical entity. The

[12] Partner was either a dummy or an individual in Experiment 1; Partner was always an individual in Experiment 2.

[13] The results are explained in detail in Teneggi, Canzoneri, Pellegrino & Serino (unpbl.). In the dummy condition, the sound approaching the body facilitates (i.e. boosts) the reaction time (RT) to tactile stimulus when it occurs at distance D2. On the other hand, in the Other-condition, the detection of tactile stimulus gets easier and faster only at the distance D3. As D3 is nearer participants than D2 and the boundary of PPS is where sound boosts the RTs, such a finding is interpreted as if the boundary of PPS would shrink towards the participants only in the Other-condition.

human body is a living body and it is the expression of a 'presence' (i.e. my presence, your presence, our presence …). The corporeity of a human body discloses and exposes a living existence to other embodied presences. Quoting the philosopher:

> When my gaze meets another gaze, I re-enact the other existence in a sort of reflection. There is nothing here resembling 'reasoning by analogy'. […] Now the perception of others is anterior to, and a condition of, such observations, the observations don't constitute the perception (Merleau-Ponty 2002: 410).

Following this viewpoint, the result should be interpreted as follows: the material body of another individual is immediately recognised as being different from a lifeless material object. Therefore, another human being, standing in front of us, makes our spatial perception different from that when we are facing a dummy.

This interpretation reminds us of Lévinas' philosophy about the 'face-to-face' encounter with the Other: in his view, the initial and pre-linguistic exposure to the Other corresponds to an ethical command that has no need of any linguistic mediation or inference. Thus, any individual's face immediately drives the Self to take a primordial responsibility for the Other. The Other is recognised as an autonomous individual by means of a pre-reflective, intuitive attentiveness. In order to understand Experiment 1 better, the analysis does not have to be developed as far, since it encompasses the whole of Lévinas' inquiry about the Other. When facing the Other, says Lévinas, the Self is made aware not only of the distinction between the 'I' and the 'You' but also that the Self, like the Other, has finitude; both the Other and the Self occupy a certain time which is closed by death. The possibility of death obliges the 'I', the Self, to be answerable to the 'You', the Other; it is this responsibility felt by the 'I' that is the essence of the Self (Lévinas 1992).

However, something like an 'obligation' towards the Other appears. In fact, if we contrast the participant's PPS representation in the dummy condition with the human body condition, we find that the participants instinctively let the human body have its own space. PPS representation can be formed despite the subject's explicit awareness of it (i.e. it occurs at an implicit level). Thus, one can legitimately say that the participants' PPS representation adapts to the presence of another individual prior to any communicative action and in a pre-reflective way. Furthermore, it is within the limits of PPS that one's actions are performed. Thus, participants might intuitively assign an autonomy of action to the Other (i.e. the partner). In such a case, it is not clear why PPS boundaries reduce towards the participants. As stated above, Lévinas might assert that it deals with an ethical obligation. On the contrary, neuroscientists might infer the following antithetic hypothesis: as PPS may serve as an early detection of a potential threat approaching the body, the human partner might trigger a participant's defensive protective behaviour that is responsible for the derived PPS representation. In such a perspective, the boundaries of PPS were closer to the participants in human condition than in the dummy one, because the participants subliminally monitored the near space. However, the partner did not act in a threatening manner; on the contrary, he stayed still, with a 'neutral' facial expression. Consequently, such a hypothesis is coherent, but it has not been empirically proved yet. In any case, both hypotheses are interesting and they will stimulate further investigation in this field. Moreover, social and cultural components have to be taken into account during further experiments.

5. Interpretation of Experiment 2: do cooperative behaviours enable people to enact a common space?

In order to assess whether a high level of social interactions affects the extent of PPS representation, we had participants perform the previous audio-tactile task, facing a partner before and after a game for money. No dummy was used, only a human partner who faced the participant in the same manner as for Experiment 1. New participants were tested and each of them played only once. During the game, the partners (i.e. actors), were instructed either to be cooperative or not to be cooperative with the participant who had performed the audio-tactile task. All players were told that they were 'randomly assigned' the role of player A or B. Actually, player A was always the one who had the PPS measured and player B was always the actor. The game for money consisted of a decision phase and an outcome phase. During the decision phase, the players A had to decide between two options about an amount of ten euros: 1) to keep the greater part of the amount for themselves and send their partner few euros; 2) to share the ten euros equally with the partner. The first choice made the game end; the second choice introduced the outcomes phase during which the amount doubled in value (so it became twenty euros and each player therefore had ten euros) and player B was given two options: 1) to divide the amount equally; 2) to keep more money for themselves. We had thirty two participants (i.e. the players A during the game) take part in the experiment.

Before the game, PPS boundaries of the participants were near to themselves and not near to the partner, in the same way that Experiment 1 shows (see the human body condition). After the game, we re-measured the extent of PPS representations of participants, while they were facing their partner set in the far space (i.e. the partner was the actor during the previous game). After the cooperative interaction, we found PPS boundaries between near space, at the self-location, and far space, at the location of the Other, had even vanished.[14] We interpret such a finding as if the PPS boundary was so extended that it included the space where the cooperative partner stayed.

On the contrary, after a non-cooperative interaction, the participant's PPS boundary was clearly marked at the distance D3, namely near to themselves as in Experiment 1 (i.e. the Other-condition) and in pre-cooperative condition. Subsequently, no modulation of the extent of PPS representation occurred. However, in comparison to the measure of PPS before the game, we found that the participant's reaction times to tactile stimuli became significantly faster in each trial; namely, when auditory stimuli were presented both far and near from the stimulated cheek. Thus, we have hypothesised an arousal effect after non-cooperative interaction. In fact, the participants behaved as if they were on the alert. Moreover, when the sound entered near space, RTs were absolutely the fastest. Post-cooperative results are meaningful, especially if we consider that only after a cooperative interaction, the PPS boundary shifts towards the partner as far as to include the far space. The psychologist Bakan introduced the definition of the term 'communion' that gives a new slant on the post-cooperative PPS representation. Bakan argues that communion arises from strivings to integrate the self in a larger social unit and it involves such qualities as focus on others and cooperativeness. Finally, communion is important in taking other-perspective (Bakan 1996).[15]

The results reflect Bakan's definition, if it is translated into spatial representations. In this case, the communal (or cooperative) interaction makes the participants behave as if they were spatially in the other-perspective and in connection with the partner's space. If communion makes the person integrate in a larger social unit, cooperative interaction makes the person integrate in a larger and commune space that might be essential to build a social space. If the participants are spatially connected with the partner, probably, after non-cooperative interaction, they felt a sort of 'separateness'. An interesting experiment carried out by Tsugumi Takano supports this possibility.[16] He investigated when or why people feel a sense of isolation in the physical proximity of others. He hypothesised that one may feel a sense of loneliness in the absence of 'trust'. To test it, he also had participants play a 'lend

[14] Before the cooperative interaction, the detection of tactile stimuli is boosted when the sounds occur at the distance D3. After the cooperative interaction, the relevant speeding effect of near-sounds (in comparison to the far-sounds), on the reaction times to tactile stimuli is lost. On the contrary, RTs are boosted also when sounds occur in the farthest space, where the cooperative partner is placed. Consequently, participants' RTs are speeded up both in the farthest space and in the nearest space. For such a reason, it was impossible to detect a difference between I-space and Other-space.

[15] For additional information, see David Bakan (Bakan 1966).

[16] For additional information, see Tsugami Takano (Tsugami 2011).

and pay back money game'; their partners, in some cases, were instructed by the experimenter to betray them. The results show that the participants felt loneliness when they were betrayed by the partner after trusting him (i.e. after lending money). This study concludes that one can feel a sense of isolation in the absence of trust. Although the sense of isolation or loneliness is not detected in Experiment 2, non-cooperative interaction nonetheless significantly boosts the participants' reaction time, so that the boundary fell in near space where their own body is. The resulting effect is as if they are monitoring the space near the body in order to protect themselves. In comparison to the situation the cooperative condition, there appears to be no connection with Other space; probably, they felt themselves detached from the partner. Following these considerations, the presence or the lack of a 'larger and commune space' might be an essential component in order to increase or decrease the sense of belonging to a social community.

In such a way, Experiment 2 can stimulate Interaction Theory, proposing a new perspective and a new field of research. When IT theorises about the phenomenon of cooperation, it analyses coordination and joint actions. In fact, cooperation is renamed 'embodied coordination' in order to 'contrast [it] with the methods of traditional game-theory approaches to cooperation, which examine strategic decisions made to cooperate or to defect' (Marsh, Richardson & Schmidt 2009: 325). Experiment 2 shows that even Interaction Theory can deal with a high-level cooperation as Game Theory does, without reducing such an event to the sensorimotor coordination. If Game Theory approaches do not *require* that individuals have bodies (as claimed by some interaction theorists), certainly it *implies* that individuals are embodied and situated.

6. General Conclusions

In summary, Experiment 1 shows that the mere presence of another human being directly shapes and structures one's spatial representation. Experiment 2 shows that a high level of social cognition (i.e. a personal choice about an amount of money) can affect low level audio-tactile integrations between near and far space. Thus, the experiments reveal that the spatial representation between two bodies variously functions as an indicator of both co-presence and social interaction, a factor which illuminates the sense of Deleuze's observation that:

> Le tort des théories philosophiques, c'est de le réduire tantôt à un objet particulier, tantôt à un autre sujet [...] faisant d'autrui un objet sous mon regard. Mais autrui n'est ni un objet dans le champ de ma perception, ni un sujet qui me perçoit, c'est d'abord une structure du champ

perceptif, sans laquelle ce champ dans son ensemble ne fonctionnerait pas comme il le fait. (Deleuze 1969: 356–57).[17]

Reading the findings through the Deleuzian theoretical construct, one can state that the Other and the interaction with the Other is going to structure our spatial perceptual field. In such a way, both hypotheses have been demonstrated as giving substance to the embodied perspective and enriching Interaction Theory. Finally, these results reveal that low-level multisensory processing used to construct spatial representations is prone to social modulation. Such new findings suggest a link between high-level cognition, such as social cognition, and low-level sensorimotor representations, such as peripersonal space.

Bibliography

Bakan, David, *The Duality of Human Existence. Isolation and Communion in Western Man* (Chicago: Rand McNally, 1966)

—— *The duality of human existence: an essay on psychology and religion*, (Chicago: Rand McNally, 1996)

Baron-Cohen S, A.M. Leslie and U. Frith, 'Does the autistic child have a "theory of mind"?', *Cognition*, Vol.21, No. 1 (October, 1985), 37–46

Barsalou, L.W. (2003). 'Situated simulation in the human conceptual system', *Language and Cognitive Processes, 18*, 513-562.

Bassolino, M., Serino, A., et al., 'Everyday Use of Computer Mouse Extends Peripersonal Space Representation', *Neuropsychologia*, 48 (2010), 803–11

Decety, J. (1996). 'Do imagined and executed actions share the same neural substrate?'; *Cognitive Brain Res*., 3, 87–93.

De Jaegher, Hanne, Ezequiel Di Paolo and Shaun Gallagher, 'Can social interaction constitute social cognition?', *Trends in Cognitive Sciences*, Vol. 14, No. 10 (2010), 441–47

Dean, L.M., F. N. Willis and J. Hewitt, 'Initial Interaction Distance among Individuals Equal and Unequal in Military Rank', *Journal of Personality and Social Psychology*, Vol. 32, No. 2 (1975), 294–99

Deleuze, Gilles, *Logique du sens*, (Paris: Minuit, 1969)

Frith, C. and Dolan, R., 'The role of the prefrontal cortex in higher cognitive functions', *Cognitive Brain Research*, 5 (1996), 175–81

Fuchs T., and H. De Jaegher, 'Enactive intersubjectivity: Participatory sense-making and mutual incorporation', *Phenomenology and the Cognitive Sciences* Vol. 8 (2009), 465–86

Fujii N., S. Hihara and A. Iriki, 'Dynamic Social Adaptation of Motion-Related Neurons in Primate Parietal Cortex', *PLoS ONE*. Vol. 2, No. 4, (2007): e397 <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0000397> [accessed: 10-Jul-12]

Gallagher, S., *How the Body Shapes the Mind* (Oxford: Oxford University Press, 2005)

Gallese, V., C. Keysers and G. Rizzolatti, 'A unifying view of the basis of social cognition', *Trends in Cognitive Science*. Vol. 8, (2004). 396–403

Gordon, R., 'Folk Psychology as Simulation', *Mind and Language*, Vol. 1, (1986), 158–71. Reprinted in *Folk Psychology: The Theory of Mind Debate*, edited by M. Davies and T. Stone (Oxford: Blackwell, 1995), pp. 100–22.

Graziano M. S., and D. F. Cookee, 'Parieto-frontal interactions, personal space, and defensive behaviour', *Neuropsychologia*, Vol. 44 (2006), 845–59.

Hesslow, G. 'Conscious thought as simulation of behaviour and perception', *Trends in Cognitive Sciences, 6* (2002), 224–42

[17] '[t]he mistake of philosophical theories of the Other is to reduce him either to a particular object or to another subject […] [that] transforms me into an object. But the Other is neither an object in my field of perception, nor a subject who perceives me: it is initially a structure of the perceptual field, without which the entire field could not function as it does' (translation by Constantin V. Boundas in Logic of Sense by Gilles Deleuze, ed. by Constantin V. Boundas (London & New York: Continuum International Publishing, 2005), p. 346).

Holmes, N.P, and C. Spencer, ‘The body schema and the multisensory representation(s) of peripersonal space’, *Cognitive Processing*, Vol. 5, No. 2 (June, 2004), 94–105

Husserl, Edmund, *Ding und Raum: Vorlesung 1907* (Hamburg: Felix Meiner Verlag, 1991)

Jeannerod, M., ‘The representing brain’ *Behavioral and Brain Sciences,* 17 (2) (1994), 187–245

—— Neural simulation of action. *NeuroImage,* 14, (2001), 103–09.

Johnson, M., and G. Lakoff, *The Meaning of the Body*: *Aesthetics of Human Understanding* (Chicago: The University of Chicago Press: 2007)

Kinzel, F. A., ‘Body-Buffer Zone in Violent Prisoners’, *The American Journal of Psychiatry*, Vol. 127 (1970), 99–104

Krueguer, J., ‘Extended Cognition and the Space of Social Interaction’, *Consciousness and Cognition*, Vol. 20, No. 3 (2010), 643–57

Lakoff, G., and M. Johnson, *Metaphors We Live By* (Chicago and London: The University of Chicago Press, c1980)

Lévinas, Emmanuel, *La mort et le temps* (Paris: Librairie Générale française, 1992)

Lloyd, D., ‘The space between us: A Neurophilosophical Framework for the Investigation of Human Interpersonal Space’, *Neuroscience and Behavioral Reviews*, Vol. 33 (2009), 297–304

Marsh, K. L., M. J. Richardson and R. C. Schmidt, ‘Social Connection Through Joint Action and Interpersonal Coordination’, *Topics in Cognitive Science* (2009), 320–38

Maturana, H. R., and J. F. Varela, *The tree of knowledge: the biological roots of human understanding*, translated by Roberto Paolucci, foreword by J. Z. Young, revised ed. (Boston and London: Shambhala, 1998)

Merleau-Ponty, M., *Phenomenology of Perception*, translated by Colin Smith,(Psychology Press: 2002)

Sebanz, N., ‘Joint Action: Bodies and Minds Moving Together’, *Trends Cogn Sci*., Vol.10, no. 2 (February, 2006), 70–76.

Serino, A., M. Bassolino, A. Farné and E. Ladavas, ‘Extended multisensory space in blind cane users’, *Psychological Science*., Vol. 18 (2007), 642–48

Tajadura-Jiménez, A., N. Kitagawa, A. Väljamäe, M. Zampini, M. Murray and C. Spence, ‘Auditory-tactile multisensory interactions are spatially modulated by stimulated body surface and acoustic spectra’, *Neuropsychologia*. Vol. 47 (2009), 195–203

Teneggi, C., E. Canzoneri, G. Di Pellegrino and A. Serino, ‘Social modulation of Peripersonal Space’ (article submitted for publication)

Tsugami, T., ‘The feeling on what happens in a game’, *IPEDR*, Vol. 5 (2011), VI-151–55.

Varela, J. F., E. Thompson and E. Rosch, *The embodied mind: cognitive science and human experience*, (Cambridge, Mass. and London: The MIT Press, 1991)

Vesper, C., S. Butterfill, G. Knoblich and Sebanz, ‘A minimal architecture for joint action’, *Natural Networks*, Vol 23, Nos. 8–9 (October/November, 2010), 998–1003