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The Importance of Sensing One's Movements in the World for the Sense of Personal Identity

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Riassunto *L'importanza della percezione dei propri movimenti nel mondo per il senso dell'identità personale* - Nell'ambito della filosofia e delle scienze cognitive l'attenzione dedicata al problema dell'identità personale è stata rivolta quasi esclusivamente sul cervello. È nostra convinzione che questo abbia di conseguenza portato a trascurare il ruolo del corpo e dei movimenti corporei nel mondo, impoverendo la comprensione del modo in cui gli esseri viventi sviluppano il senso della loro identità. Esamineremo quindi l'importanza del percepire i propri movimenti per lo sviluppo di un senso del sé di natura basilare e di carattere non-concettuale. Più in dettaglio, noi sosteniamo che all'origine del senso del sé vi sia la capacità di avvertire la propria motilità spontanea. È a partire da questo elemento che l'organismo giunge a sviluppare un senso del "mi muovo" e, infine, del "posso muovermi". La propriocezione e le cinestesi sono elementi essenziali in questa dinamica. Al contempo, sulla scia di Gibson, noi pensiamo che la percezione del sé e dell'ambiente procedano inevitabilmente di pari passo, diversamente da quanto sostiene la tradizionale dicotomia tra i cosiddetti sensi interni ed esterni. Prenderemo in esame una distinzione tradizionale tra due aspetti del sé corporeo: il senso del proprio corpo e l'immagine del proprio corpo. A nostro avviso questi due aspetti colgono elementi differenti del senso del sé e sosterremo nello specifico che il senso del proprio corpo svolge un ruolo di fondamentale importanza per il nostro senso del sé di carattere non-concettuale. Tenteremo infine di indicare alcune conseguenze di questa posizione per la ricerca nel campo delle scienze cognitive, in particolare nel campo della robotica, esaminando un caso di assenza di propriocezione, nella convinzione che questo costituisca un passo in avanti nella comprensione del modo in cui gli esseri viventi agiscono nel mondo, ossia grazie al possesso del senso del sé.

PAROLE CHIAVE: Sé; Identità personale; Propriocezione; Movimento; Corpo.

Abstract Within philosophy and cognitive science, the focus in relation to the problem of personal identi-

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ty has been almost exclusively on the brain. We submit that the resulting neglect of the body and of bodily movements in the world has been detrimental in understanding how organisms develop a sense of identity. We examine the importance of sensing one's own movements for the development of a basic, nonconceptual sense of self. More specifically, we argue that the origin of the sense of self stems from the sensitivity to spontaneous movements. Based on this, the organism develops a sense of "I move" and, finally, a sense of "I can move". Proprioception and kinesthesia are essential in this development. At the same time, we argue against the traditional dichotomy between so-called external and internal senses, agreeing with Gibson that perception of the self and of the environment invariably go together. We discuss a traditional distinction between two aspects of bodily self: the body sense and the body image. We suggest that they capture different aspects of the sense of self. We argue that especially the body sense is of great importance to our nonconceptual sense of self. Finally, we attempt to draw some consequences for research in cognitive science, specifically in the area of robotics, by examining a case of missing proprioception. We make a plea for robots to be equipped not just with external perceptual and motor abilities but also with a sense of proprioception. This, we submit, would constitute one further step towards understanding creatures acting in the world with a sense of themselves.

KEYWORDS: Self; Personal Identity; Proprioception; Movement; Body.



Introduction

WE SUGGEST THAT IN RELATION TO the problem of self and identity the moving body has received too little attention. We will focus on the importance of *sensing our bodily movements* in the world for the establishment of our nonconceptual sense of identity and self. We will argue that this nonconceptual self is more basic than the reflexive, conceptualized, consciously experienced self that is the primary focus of philosophy and most of cognitive science. We will attempt to provide some reasons which explain why it could be important for robotics to incorporate these ideas.

The problem of identity and the self

In a well-known book on personal identity, John Perry¹ reviewed the problem of identity as it has been discussed by the likes of John Locke,² Joseph Butler, Thomas Reid, David Hume, Sydney Shoemaker and Thomas Nagel, to name but a few. As he puts it the main technical problem confronting a theory of personal identity is how to answer questions regarding the relation that obtains between events or stages in order for them to belong to

the same person.³ In the history of Western philosophy, the problem of identity has mainly been a problem regarding the *criteria* of identity.

Identity and brain

Perry's book starts out by a thought experiment (regarding two persons, yourself and a certain Peter Pressher) in which two bodies change brains overnight (by means of clever neuroscience), or, to put it differently, two brains change bodies. As Perry describes it, you wake up the next morning, finding yourself in Peter Pressher's body, and vice versa. Or perhaps, Perry adds, the effect of the brain or body-switch would be that you wake up "*seeming to remember*" being Peter Pressher (since this is the brain now occupying your body), but actually turning out to be yourself, merely having delusions about being Peter Pressher.⁴ In both cases, *the identity goes where the brain goes*, the only difference being the amount of certainty involved in realizing just who you are (i.e. knowing *versus* seeming to remember). Another example of the prominence of the brain in relation to questions about the self is provided by Parfit:

suppose that my brain is transplanted into someone else's (brainless) body, and that the resulting person has my character and apparent memory. Most of us would agree, after thought, that the resulting person is me.⁵

We think that both Perry and Parfit provide good illustrations of the by now almost exclusive attention to the brain in relation to consciousness and identity. For another illustration, see Slors who suggests that in its contemporary guise, psychological continuity (i.e. the traditional hallmark of personal identity) is found ultimately to reside in causally connected brain states.⁶ However, we want to suggest that this approach profoundly neglects the importance of the sense of one's bodily movements in an environment for the experience of one's self and identity. As Bermúdez, Marcel and Eilan say many usages of the term "self-consciousness" seem to imply an awareness of ourselves as purely psychological entities. Largely unexplored is the relation of self-consciousness to bodily awareness.⁷

■ The body and the nonconceptual self

Over the last two decades things have changed, at least a little. One of the theorists who is famous for his focus on the role of the body in relation to identity and the self (and self-consciousness) is Damasio. As he says:

the organism, as represented inside its own brain, is a likely biological forerunner for what eventually becomes the elusive sense of self. The deep roots for the self, including the elaborate self which encompasses identity and personhood, are to be found in the ensemble of brain devices [to be found in the brain stem, hypothalamus, and basal forebrain sections] which continuously represent, nonconsciously, the state of the living body, among its many dimensions. I call the state of activity within the ensemble of such devices the proto-self.⁸

Although we agree with Damasio that the

living body is an essential "deep root" for the self, we think that he too puts too much emphasis on the role of the brain. Indeed, we think that the body is of *primary*, not of secondary importance to the self.

The body is doing more than just translating brain output into movements as if it is executing commands. The body does more than merely selecting sensory information and channeling it back into the brain. Chiel and Beer⁹ provide many examples indicating the importance of the body for cognition. For example, tendons, connecting muscle to bones, are greatly affected by different degrees of stiffness of the tendon as well as by the level of activation of the muscle. The effect of a muscle contraction, and the body's response to it, are a complex function of the geometric relations and positions of other muscles and joints. Chiel and Beer conclude: «motor neuronal output is *transformed significantly* by the properties of the body».¹⁰

Proprioceptive feedback is fundamental in generating normal patterns of motor activity. For instance, phasic feedback from stretch receptors is essential for maintaining normal flying movements in the locust. The swim interneurons of the leech fire too infrequently to provide functional output, but in the presence of normal sensory feedback, the firing is at an effective rate. The same goes for a model of leech crawling: proprioceptive feedback is essential.

In the absence of feedback from an animal's own movements, the nervous system may not generate meaningful activity patterns for behavior.¹¹

■ The nonconceptual self

Having an identity is having the capacity to have "I"-experiences. However, these "I"-experiences need not require linguistic or conceptual capacities. Indeed, we follow Gallagher¹² in suggesting that the moving body provides for a minimal self (at times also called a nonconceptual or "ecological" self, see

Neisser¹³ and Bermudez¹⁴) that is more basic than the reflexive, conceptualized, consciously experienced self that is the primary focus of philosophy and most of cognitive science.

Therefore, what we would like to do here, is to focus on the importance of *sensing* one's *bodily movements* in the world for the establishment of our nonconceptual identity and for our awareness of ourselves. Central to our thesis is the claim that «movement is at the root of our sense of agency».¹⁵ We discover our identity by moving and by perceiving our own movements. Incidentally, by “movement” we do not mean motion as a passive consequence of forces as in the case of stones (or a fainting person) moving towards the ground under the influence of gravity, but active behavior. Thus, we use the word “movement” in the sense of being instrumental to adjustment to the environment.¹⁶

■ Moving into your “I”: Proprioception and kinesthesia

The starting point of our investigation is formed by the idea of Sheets-Johnstone that “move” precedes the “I move” just as this precedes the “I can move”. As she says: «movement forms the I that moves before the I that moves forms movement».¹⁷

It is important to note that the transition from “move” to “I move” is a process of *discovering our bodies* through movement. The basis of our identity arises out of these spontaneous movements that *happen to us before we make them happen*. It is only at a later stage that attention can be focused at controlling the movements.

Of crucial importance to the development of the self is a sense that is often overlooked. Aristotle identified sight, hearing, smell, taste and touch as the five primary senses. Missing from this list is the *sense of proprioception and kinesthesia*.¹⁸

According to Stillman,¹⁹ Bastian introduced the term kinesthesia in 1880 as referring to the body of sensations resulting from or directly occasioned by movements.²⁰ It is the

sense of movement by which we are made acquainted with the position and movements of our limbs, and by which we can discriminate between different degrees of resistance and weight inherent in external objects (*kinein* = move, *aisthesis* = a perceiving). It refers specifically to sense of movement through muscular effort.²¹

Sherrington introduced the term *proprioception* (*proprius* = one's own, *receptio* = receive) for the receptors which lie in the depth of the organism, particularly in the muscles and their accessory organs.²² These receptors excite with changes going on in the organism itself (other than pain and temperature) resulting in a sense of amongst others movement and position of the joints. It refers generally to sense of movement and position, including tactile and kinesthetic information.²³ Despite small differences²⁴ between proprioception and kinesthesia, the terms often are used interchangeably nowadays.

The evolutionary beginnings of proprioception are tied to surface sensitivity, indicating movement in relation to something outside.²⁵ The surface sensitivity in prokaryotic organisms is basically a tactile sensitivity to the physico-chemical environment in which the organism moves, responding to what it senses.²⁶ Similarly the surface sensitivity in eukaryotic forms of life (uni- and multicellular) is in the service of movement.

Proprioceptors seem to have derived from external sensory organs,²⁷ as a result of migration of formerly external bodily structures. The sense of bodily movements evolved from its beginnings in tactility into kinesthesia.²⁸

The sensitivity to movement, posture and balance arises at a very early developmental stage. Prenatally, the semicircular ear canals of the vestibular system start their development already in the 4th week. In a rudimentary form this system for balance is in place around the beginning of the 4th month. Proprioceptors in the muscles (muscle spindles) appear at 9 weeks.²⁹

The 4th month sees the beginning of reflexive movements. At 24 weeks changes in heart

rate in response to sounds can be detected. At 25 weeks the fetus responds to sound by blinking its eyes or movement of its limbs.³⁰ At the fetal stage the receptors in the muscles provide a sense of position and movement.

After birth, babies sense their bodies primarily by attending to the bodily feelings of movement.³¹ The awareness of the body arises from everyday activities such as sucking, grasping, kicking, swallowing, crying, turning, stretching, reaching, smiling, babbling, etc.³² These movements may often seem totally unrelated to any obvious self-related purpose or control. As Thelen and Smith say: «kicking is primarily a manifestation of seemingly non-specific behavioral arousal».³³ Arm movements seem even more “self-less”, being less rhythmic and more random than the movements of the legs.³⁴ Another example of the “move” preceding the “I move” is given by Thelen and Fogel who indicate that communicative expressions appear «in the first weeks and months of life, long before the infant has control over these expressions».³⁵ It is movements such as these that constitute the basis of a prelinguistic, nonconceptual acquaintance with oneself as the center of a spontaneous ability to move. Thus, as Sheets-Johnstone says: we literally discover ourselves in movement, we grow kinetically into our bodies.³⁶ In this sense, spontaneous movement is the constitutive source of agency, of our sense of ourselves as agents, subjects, selves.³⁷

We were apprentices, not would-be masters of our bodies. An infant is not a mind trying to control a body, nor is it an out-of-control body waiting for a mind to catch up with it.³⁸

In the remainder (especially section 6), we will at times speak of a *body sense* that results from the proprioceptive sense of the bodily processes that regulate posture and movement. The body sense can function without conceptual reflective awareness. It does not consist of a representation (*à la* Damasio's proto-self) or of a model. It constitutes the nonconceptual sensing of the ongoing performances of the

body as it moves around, interacting with and adjusting to the environment. As such, it can be contrasted with the *body image* that is a (sometimes conscious) system of intentional states (such as perceptions, attitudes and beliefs) pertaining to one's own body. The body image encompasses the subject's *perceptual experience* of his or her own body in combination with a *conceptual understanding* of bodies in general and the person's *emotional attitude* towards his or her own body.³⁹

■ Against a dichotomy between perception of self-movement and environment

Proprioception, then, is essential to the development of a sense of self. As Bermudez says:

Somatic proprioceptive information provides perhaps the most primitive way of registering the boundary between self and non-self.⁴⁰

We agree that, evolutionary speaking, there seems to be a strong relation between the sense of self and agency and having a bodily boundary. As Damasio indicates:

A simple organism made up of one single cell, say, an amoeba, is not just alive but bent on staying alive [...] If there is no boundary, there is no body, and if there is no body, there is no organism. Life needs a boundary. I believe that minds and consciousness, when they eventually appeared in evolution, were first and foremost about life and the life urge within a boundary.⁴¹

We suggest that this «life urge within a boundary» constitutes a rudimentary form of agency, a nonconceptual form of self. Indeed, Damasio himself suggests that he may be describing «some of the biological antecedents of the sense of self – the sense of a single, bounded, living organism bent on maintaining stability to maintain its life».⁴²

However, there is a danger lurking behind stressing the importance of a body boundary.

Our emphasis on the importance of proprioception does not imply that we consider it to be unrelated, let alone opposed, to the other senses. Indeed we suggest that construing a dichotomy between so-called internal and external senses is false. Of course, we do acknowledge that proprioception is the sensitivity to changes going on within the organism itself, as Sherrington put it. However, we agree with Gibson that «perception and proprioception are not alternatives or opposing tendencies of experience but *complementary* experiences». ⁴³ A dichotomy between internal and external perception would be artificial:

proprioception can be understood as egoreception, as sensitivity to the self, not as one special channel of sensations or as several of them [...] all the perceptual systems are propriosensitive as well as exterosensitive, for they all provide information in their various ways about the observer's activities [...] information about the self is multiple and [...] all kinds are picked up concurrently. ⁴⁴

Thus, egoreception and exteroception are inseparable, ⁴⁵ self-perception and environment-perception go together. ⁴⁶ Perception and proprioception continuously, simultaneously and interrelatedly circle around the two poles of self and environment, they are reciprocal processes. As Lombardo indicates, for Gibson, proprioception involves knowledge of the self (body) *within* the environment. ⁴⁷

Gibson ties together perception and proprioception: the perception of a stable environment based on stimulus invariants is reciprocal to the proprioception of a mobile observer based on stimulus variants. If one breaks down, so does the other. Stability is tied to change, where the environment is the relatively stable “pole” and the observer the relatively variant “pole” of ecological reality. ⁴⁸

Therefore, we suggest that in relation to

the self, a body boundary does not imply a separation between proprioception and the perception of the environment.

■ Implications for robotics and cognitive science

If the above analysis is in the right direction, we think that some implications for the field of robotics in cognitive science deserve consideration. In the current context we are interested in robotics as an aid to our understanding of creatures that act in the world with a sense of self. On the basis of the above analysis, we make a plea that robotics should not focus exclusively on external perception but also incorporate the sense of proprioception. Although we are aware of the fact that proprioception is not always excluded from robots, it seems fair to say that it is an aspect that has received substantially less attention from roboticists than perceptual-motor abilities. ⁴⁹

To indicate why this neglect of proprioception is deplorable it may be useful to take a look at deafferentation patients who have lost all bodily sensation. In terms of the distinction introduced above, these patients present cases of an impaired body sense. ⁵⁰ The most well-known patient, Ian Waterman (IW), is deafferented from below the neck. ⁵¹ IW can experience hot, cold, pain and muscle fatigue, but he has no proprioceptive sense of posture or limb location, and no (light) touch. ⁵² He lost his proprioception at 19 due to a viral infection. ⁵³ He described his thoughts after being hospitalized at that time as follows:

Turned every two hours like a joint of meat, basted with lotions. Unmoving, like a statue. Mind filled with emotion. Limbs dead to the touch, movement impossible. What use an active brain without mobility? ⁵⁴

Impressively, IW has learned to walk. He has achieved this after 3 years of training, on the basis of visual feedback. In order to maintain motor control he must conceptualize his movements and keep certain parts of his body

in his visual field.⁵⁵ Basically, IW walks and moves about on the basis of his body image. Without visual feedback he is unable to walk. If the light suddenly goes out, he crumples to the floor.⁵⁶ If IW sits and is asked to point to his knee with his eyes closed, he can do so with some difficulty, on the basis of his memory. If his leg is moved, he is no longer able to do so. When he writes, he has to pay attention not only to holding his pen, but to his body posture as well.⁵⁷

He sleeps with the light on. «If he woke up in the dark he would have no idea where his body was and would never be able to find the light switch». ⁵⁸ IW describes what happened when his hands moved out of sight:

I could move my hands a bit, but only if they were in vision, and I could control them, if I could see them. But as soon as I looked away, they would float off, and they would do really strange things. I remember people sit beside me, and I'd be turning to someone the other side of the bed, and the arm would wander off and hit someone, or it would knock something off the cabinet. But it was very frustrating. I just... wasn't aware of these things happening, you know. But if I could look and see my hands, I could control them.⁵⁹

It is difficult to get a view on what IW's loss of proprioception has done to his sense of self. It is important to realize that IW lived for 19 years with a completely intact proprioceptive sense, and had every possibility to develop a complete sense of self. Moreover, he continually and consciously uses his body image to remain informed about his bodily whereabouts.

However, IW made a statement that may shed some light on how the loss of proprioception affects the sense of self. When IW is in a position where he is unable to see his body for a prolonged period of time, he describes his sensations as follows:

I feel really quite dizzy. It's very difficult to explain but it's such a long time since I've

been in that position where, you know, for such a long period of time, I haven't seen the rest of me... you get into panic mode, you know, you've got no feedback coming back to you, telling you that you're safe and – and that you're OK.⁶⁰

We suggest that the feeling of dizziness and the sense of panic are related to a growing sense of losing oneself at a very basic, bodily, level. It may perhaps be thought of as an experience of being disembodied.

A first implication of our analysis is that we think that the situation robots without proprioception find “themselves” in can be compared to the situation of IW. That is, they may be equipped with an explicit representation of their physical selves, a body image, but they lack a body sense, allowing them to direct their bodies gracefully and without explicit and detailed attention.

From our perspective it is dismaying to read the report that NASA has expressed interest in how IW uses his fingers because his solutions to dexterity problems are similar to the ones they use to develop and program robotic limbs.⁶¹

To us this seems to be the least attractive way of going about robotics. After all, it is because of proprioception and the body sense that we are able to move as fluently as we do. Furthermore, our basic sense of self resides in our ability to move. To ignore the importance of proprioception and the body scheme is to miss a chance for deepening our understanding of our sense of self. Moreover, it is likely to lead to the production of movement that is as cognitively demanding and as fragile as is the case for IW.

A second implication of our paper is that robots could help to improve our understanding of the development of the sense of self, as they get to know themselves through performing spontaneous movements. If our analysis is correct, the process of self-discovery through movement is important in order to develop a sense of self. Studying robots that progress from proprioceptively sensed uncontrolled moving to more controlled and goal-directed

movements may offer insights into the nature and function of the seemingly random movements observed in young infants.

Conclusion

Cognitive science's understanding of identity and the self, we submit, has much to gain from a greater attention to the body. The almost exclusive focus on the brain precludes a clear view of how we move into our "I". We suggest that the proprioceptive sensing of our movements in the world constitutes the origin of our nonconceptual self. It is the body sense, not the body image, that forms the foundation of our identity. The field of robotics could provide great opportunities to further investigate the fertility of these ideas.

Of course, much regarding the issue of identity and self has been left unsaid. Specifically, we would like to point out that *social interaction* is of great importance to the development of the self. For instance, the capacity of 9 month old infants to interact with others sharing, following and directing their attention,⁶² constitutes an important social stage in the unfolding of the self.

Secondly, our proprioceptive and kinesthetic *expectations* (as highlighted in unexpected moments in everyday experience, e.g. when we lift a surprisingly light suitcase) are worthy of our attention. If we didn't have these expectations, and if they would not be normally right, our sense of ourselves as agents would be compromised. As Sheets-Johnstone says:

reliable kinesthetic expectations, like the kinesthetic regularities on which they are based, are foundational to our sense of agency.⁶³

It would be most interesting to investigate the relation between these kinesthetic expectancies and Gibson's notion of affordances and Turvey's notion of effectivities. All the more so because these notions emphasize the integration of world- and self-perception.

In all, the sequence from "move" to "I

move" to "I can move" is shaped by a great variety of factors, encompassing the multiple facets that form our selves. In this sense, identity may perhaps be likened rather to a multitude than to a unity.

Notes

¹ See J. PERRY, *Personal Identity*, California University Press, Berkeley 1975.

² J. LOCKE, *An Essay on Human Understanding* (1690-1694), edited by P.H. HIDDITCH, Clarendon Press, Oxford 1975: «to find wherein personal identity consists, we must consider what person stands for;- which, I think, is a thinking intelligent being, that has reason and reflection, and can consider itself as itself, the same thinking thing, in different times and places; which it does only by that consciousness which is inseparable from thinking, and, as it seems to me, essential to it: it being impossible for anyone to perceive without perceiving that he does perceive. When we see, hear, smell, taste, feel, meditate, or will anything, we know that we do so. Thus it is always as to our present sensations and perceptions: and by this everyone is to himself that which he calls self: it not being considered, in this case, whether the same self be continued in the same or divers substances. For, since consciousness always accompanies thinking, and it is that which makes everyone to be what he calls self, and thereby distinguishes himself from all other thinking things, in this alone consists personal identity, i.e. the sameness of a rational being: and as far as this consciousness can be extended backwards to any past action or thought, so far reaches the identity of that person; it is the same self now it was then; and it is by the same self with this present one that now reflects on it, that that action was done» (*ivi*, section II, chap. XXVII, § 9). The only thing that does matter, on Locke's view, is that the person self-consciously appropriates actions as its own, e.g. as belonging to the same thinking thing. Locke thought that the "soul of a prince" might enter and inform the body of a cobbler carrying with it the consciousness of the prince's past life, making the cobbler the same person with the prince, though perhaps not the same man (for, as Locke says: «the body too goes to the making of a man») accountable only for the prince's actions (*ivi*, section II, chap. XXVII, § 15).

³ See J. PERRY, *Personal Identity*, cit., pp. 9-11.

⁴ *Ivi*, p. 5.

⁵ D. PARFIT, *Personal Identity*, in: «Philosophical Review», vol. LXXX, n. 1, pp. 3-27, here pp. 4-5.

⁶ See M. SLORS, *Two Conceptions of Psychological Continuity*, in: «Philosophical Explorations», vol. I, n. 1, 1998, pp. 61-80, here p. 64.

⁷ Cfr. J. BERMÚDEZ, A.J. MARCEL, N. EILAN, *Self-Consciousness and the Body: An Interdisciplinary Introduction*, in: J. BERMÚDEZ, A.J. MARCEL, N. EILAN (eds.), *The Body and The Self*, MIT Press, Cambridge (MA) 1995, pp. 1-28.

⁸ A. DAMASIO, *The Feeling of What Happens: Body, Emotion and the Making of Consciousness*, Vintage, London 1999, p. 22. The proto-self is a nonconscious collection of representations of the multiple dimensions of the current organism state, to be distinguished from the core self (a transient but conscious reference to the individual organism in which events are happening) and the autobiographical self (see A. DAMASIO, *The Feeling of What Happens*, cit., p.199).

⁹ See H.J. CHIEL, R.D. BEER, *The Brain Has a Body: Adaptive Behavior Emerges From Interactions of Nervous System, Body and Environment*, in: «Trends in Neurosciences», vol. XX, n. 12, 1997, pp. 553-557.

¹⁰ *Ivi*, p. 553, our emphasis.

¹¹ *Ivi*, p. 555.

¹² See S. GALLAGER, *Philosophical Conceptions of the Self: Implications for Cognitive Science*, in: «Trends in Cognitive Science», vol. IV, n. 1, pp. 14-21; S. GALLAGER, *Phenomenological and Experimental Research on Embodied Experience*, in: T. ZIEMKE, J. ZLATEV, R.M. FRANK (eds.), *Body, Language, and Mind*, vol. I, *Embodiment*, De Gruyter, Berlin 2007, pp. 271-323.

¹³ See U. NEISSER, *Five Kinds of Self-knowledge*, in: «Philosophical Psychology», vol. I, n. 1, 1998, pp. 35-59.

¹⁴ See J. BERMUDEZ, *Precis of Bermudez, The Paradox of Self-consciousness*, p. 20 – URL: <http://www.cogsci.soton.ac.uk/cgi/psyc/newpsy?10.3>

¹⁵ M. SHEETS-JOHNSTONE, *The Primacy of Movement*, John Benjamins, Amsterdam 1999, p. xv.

¹⁶ See T.J. LOMBARDO, *The Reciprocity of Perceiver and Environment: The Evolution of James J. Gibson's Ecological Psychology*, Lawrence Erlbaum Associates, Hillsdale (NJ) 1987, p. 303, who follows Gibson.

¹⁷ M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 59.

¹⁸ *Ivi*, p. 132; see also p. 137.

¹⁹ See B.A. STILLMAN, *An Investigation of the Clinical Assessment of Joint Position Sense*, Ph.D. Thesis, School of Physiotherapy, Victoria, Melbourne, Australia 2000 – URL: <http://thesis.lib.unimelb.edu.au/adt-root/uploads/approved/adt-VU2001.0012/public/front.pdf>

²⁰ See H.C. BASTIAN, *The Muscular Sense: It's Nature and Cortical Localization*, in: «Brain. A Journal of Neurology», vol. x, n. 1, 1887, pp. 1-88, in particular see pp. 5-6. Related words are: kinetics (dealing with forces involved in movements), kinematics (movements).

²¹ See M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 83.

²² C. SHERRINGTON, *The Integrative Action of the Nervous System*, Yale University Press, New Haven, 1906, p. 130.

²³ M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 83.

²⁴ Bastian regarded the skin receptors as a possible source of movement and position sense, whereas Sherrington differentiated skin receptors as being sources of exteroception from musculoskeletal and vestibular receptors (see A. STILLMAN, *An Investigation of the Clinical Assessment of Joint Position Sense*, cit., p. 22).

²⁵ M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 67.

²⁶ *Ivi*, p. 68.

²⁷ *Ivi*, p. 71.

²⁸ *Ivi*, p. 72.

²⁹ See S. GALLAGER, *Phenomenological and Experimental Research on Embodied Experience*, cit., p. 20.

³⁰ *Ivi*, p. 23. Incidentally, the neural development of the motor cortex seems to be stimulated by the body movements of the fetus itself. Movement influences morphology.

³¹ See M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 56; see also pp. 84-85.

³² See *ivi*, p. 134. In terms of the dynamical systems theory, these spontaneous movements may be thought of in terms of the spatial layout of an attractor landscape. Infants do not start with a completely flat landscape, but their terrain of potential movements is already structured because of their intrinsic dynamics (see J.A.S. KELSO, *Dynamic Patterns: The Self-organization of Brain and Behavior*, MIT Press, Cambridge (MA) 1995; E. THELEN, L.B. SMITH, *A Dynamic Systems Approach to the Development of Cognition and Action*,

MIT Press, Cambridge (MA) 1994, p.250; M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 248).

³³ E. THELEN, L.B. SMITH, *A Dynamic Systems Approach to the Development of Cognition and Action*, cit., p. 78; see also M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 266.

³⁴ *Ibidem*.

³⁵ E. THELEN, A. FOGEL, *Toward an Action-based Theory of Infant Development*, in: J.J. LOCKMAN, N.L. HAZEN (eds.), *Action in Social Context*, Plenum Press, New York 1989, pp. 23-63, here see p. 46. See also M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 266.

³⁶ Sheets-Johnstone suggests that we can get a sense of these experiences of movement before memory and language by attending to purely kinetic experiences as in movement improvisation and T'ai Chi. In these cases, the meaning of the kinetic experience is in the movement itself (see M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 151). We have "bare attention" (Buddhism). An interesting aspect that comes to the fore is that all that endures of self-movement is a reverberating felt sense of its dynamics. There is nothing tangible to inspect, nothing audible to which to draw nearer, nothing to hold up to the light and so on. (see *ivi*, p. 154). Merce Cunningham (an American ballet-dancer and choreographer) wrote in 1968: «you have to love dancing to stick to it, it gives you nothing back, no manuscripts to store away, no paintings to show on walls and maybe hang in museums, no poems to be printed and sold, nothing but that single fleeting moment when you feel alive, it is not for unsteady souls» (quoted from M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 175).

³⁷ See M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., pp. 136, 138.

³⁸ *Ivi*, p. 150.

³⁹ See S. GALLAGHER, *Phenomenological and Experimental Research on Embodied Experience*, cit., p. 274.

⁴⁰ J. BERMUDEZ, *Precis*, cit., p. 28.

⁴¹ A. DAMASIO, *The Feeling of What Happens*, cit., pp. 136-137.

⁴² *Ivi*, p. 136.

⁴³ J.J. GIBSON, *The Ecological Approach to Visual Perception*, Lawrence Erlbaum Associates, Hillsdale (NJ) 1979, p. 201.

⁴⁴ *Ivi*, p. 115.

⁴⁵ Gibson differentiated 6 kinds of proprioception:

muscular, articular, vestibular, cutaneous, auditory and visual; see T.J. LOMBARDO, *The Reciprocity of Perceiver and Environment*, cit., p. 279. Let us look at vision for a moment. As Gibson says: «vision is kinesthetic in that it registers movements of the body just as much as does the muscle-joint-skin system and the inner ear system. Vision picks up both movements of the whole body relative to the ground and movement of a member of the body relative to the whole. Visual kinesthesia goes along with muscular kinesthesia. The doctrine that vision is exteroceptive, that it obtains "external" information only, is simply false. Vision obtains information about both the environment and the self. In fact, all the senses do when they are considered as perceptual systems». See J.J. GIBSON, *The Ecological Approach to Visual Perception*, cit., p. 183.

⁴⁶ J.J. GIBSON, *The Ecological Approach to Visual Perception*, cit., p. 116.

⁴⁷ T.J. LOMBARDO, *The Reciprocity of Perceiver and Environment*, cit., p. 227.

⁴⁸ *Ivi*, p. 304; see also p. 323.

⁴⁹ See R.A. BROOKS, *Cambrian Intelligence: The Early History of the New AI*, MIT Press, Cambridge (MA) 1999; here there is hardly any mention of proprioception.

⁵⁰ There are cases of an intact body schema in the absence of a completely intact body image, e.g. unilateral neglect (p. 9). In such cases, patients for example fail to dress the left side of their body or to comb their hair on the left side, while their left side is still functioning motorically (e.g. they can walk, button a garment, tie a knot, or use the left hand to dress the right side of their body).

⁵¹ Another patient, LG, is deafferented from below the jaw. LG did not learn to walk, and remains in a wheelchair. It is interesting that in the mirror drawing task, LG did not need seven tries (which is normal) but only 1; see B. AZAR, *Why Can't This Man Feel Whether or Not he's Standing Up?*, in: «APA Monitor Online», June 1998 (29.6), p. 4. The proprioceptive feedback that normally interferes with what we are seeing is missing in LG and hence did not make the task difficult for her as it did with control subjects. Both IW and LG can accurately estimate the weight of objects they lift. Though normally this is based at least in part on the basis of feedback from the stretch of tendons and muscles, they use vision: the faster and higher their arms move when they pick up an object, the lighter it must be. With their eyes open they can detect 10% weight differences, with their eyes

closed only 50% (see B. AZAR, *Why Can't This Man Feel Whether or Not he's Standing Up?*, cit., p. 3). However, we wish to point out that this reported score of 50% is still very accurate, given the complete absence of proprioception. The report by Horizon speaks of "a loss" of weighing ability.

⁵² See S. GALLAGHER, *Phenomenological and Experimental Research on Embodied Experience*, cit., p. 278.

⁵³ In 1979, Ian's condition was called sensory neuronopathy, which means damaged sensory nerves. No one had ever recovered. As Herb Schaumburg says about Ian: the cells that he's lost are called dorsal route ganglion cells. They're just big neurons that lie, paired, one on either side of the spinal cord, corresponding to every segment of the spinal cord. So there's some thirty-three pairs of these things up and down, and they take all the sensory impulses, all the sensory information in, from your periphery, and feed it into the brain (see Horizon – *The Man Who Lost His Body*, BBC-Television, 1997 – URL: <http://www.bbc.co.uk/science/horizon/lostbodytran.shtml>).

⁵⁴ Horizon – *The Man Who Lost His Body*.

⁵⁵ See S. GALLAGHER, *Phenomenological and Experimental Research on Embodied Experience*, cit.,

pp. 279-279.

⁵⁶ B. AZAR, *Why Can't This Man Feel Whether or Not he's Standing Up?*, cit., p. 1.

⁵⁷ *Ivi*, p. 10.

⁵⁸ J. BERMUDEZ, *Precis*, cit, p. 24.

⁵⁹ Horizon – *The Man Who Lost His Body*.

⁶⁰ Horizon – *The Man Who Lost His Body*.

⁶¹ See B. AZAR, *Why Can't This Man Feel Whether or Not he's Standing Up?*, cit., p. 6; for a particular implementation along these lines, see J. JOSEPH, B. LUDERS, *Modeling and Simulation of Robot Proprioception from Sensor Data*, 2006 – URL http://web.mit.edu/luders/www/work/proprio_paper.pdf; however, for a recent, more promising approach, see J. EVERIST, W.-M. SHEN, *Mapping Opaque and Confined Environments Using Proprioception*, in: *Proceedings of 2009 IEEE International Conference on Robotics and Automation*, Kobe, Japan, May 2009 – URL: http://jacobevert.com/everist2009_mapping_opaque_environments.pdf

⁶² See M. TOMASELLO, *The Cultural Origins of Human Cognition*, Harvard University Press, London 1999.

⁶³ M. SHEETS-JOHNSTONE, *The Primacy of Movement*, cit., p. 145.