

Temi ed Eventi

Neurocognitive Dimensions of Self-consciousness

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Abstract Self-consciousness is considered in a framework comprising four dimensions which are theoretically defined and supported by clinical neuropsychological evidence. *Self-monitoring* is defined as the ability to reflect on one's own behaviour, with supporting evidence for deficits in this capacity noted in anosognosia syndrome. *Self-feeling* is defined as the capacity to feel all sensations related to one's own body (interoception and exteroception), with supporting evidence from deficiencies occurring in alexithymia, psychosomatic states and Cotard's delusion. *Identity* refers to the capacity to recognize an object as identical to oneself, based on autobiographic memory; pathological conditions related to this dimension include delusions of identity and the Zelig syndrome. *Ownership* is the capacity to perceive the status of one's own body, and is clinically altered in somatoparaphrenia. All four dimensions are related to specific brain networks.

KEYWORDS: Self-monitoring; Self-feeling; Identity; Ownership; Neurocognitive Dimensions

Riassunto *Le dimensioni neurocognitive dell'autocoscienza* – L'autocoscienza viene inquadrata in base a quattro dimensioni, determinate in via teorica e supportate da evidenze cliniche di carattere neuropsicologico. L'automonitoraggio è definito quale capacità di riflettere sul proprio comportamento ed è sostenuto da evidenze che derivano da quella sindrome denominata anosognosia. Il sentire il proprio sé è la capacità di avvertire tutte le sensazioni del corpo proprio (interocettive ed esteroceettive); questa dimensione è supportata da evidenze derivanti da condizioni cliniche quali l'alessitimia, le affezioni psicosomatiche e il delirio di Cotard. L'identità si riferisce alla capacità di riconoscere come identico a se stesso un oggetto, fondata sulla memoria autobiografica; le condizioni patologiche legate a questa dimensione sono il delirio di identità e la sindrome di Zelig. Il possesso di sé è la capacità di percepire lo stato del proprio corpo, condizione che risulta alterata nella somatoparafrenia. Tutte queste quattro dimensioni sono collegate a specifici network cerebrali.

PAROLE CHIAVE: Automonitoraggio; Sentimento di sé; Identità; Padronanza di sé; Dimensioni neurocognitive



"Homo sum, nihil humani a me alienum puto"
("I am a man, I believe nothing of human nature is extraneous to myself")

SELF-CONSCIOUSNESS IS SOMETHING THAT binds different aspects of a person together, something that includes all the experiences of the subject, giving a sense of unity; on these

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bases we consider how self-consciousness may function and propose a cognitive model containing four “cardinal points” in order to interpret various phenomena attributed to consciousness.

We could, incurring some risk, begin with the concept of consciousness, defining it as the condition in which the mind represents itself in a cognitive act. In this sense, the mind is considered to be a mental representation of the brain, and behaviours are considered as the phenomena of both internal (interoception) and external (exteroception) states, perceived by the subject through sensory modalities. From sensory experience, the subject elaborates cognitive representations as models of knowledge about the world, accessible to consciousness.²

Interoception and exteroception are processes which allow a subject to feel information coming from his own body³ and are correlated with his physical and mental conditions. These ongoing processes work implicitly and form the internal status of a subject. When the signals arising from internal organs exceed a subject’s individual baseline, there is an alteration of internal status, in the direction of greater well-being or malaise. This alteration modifies interoceptive flow and allows the subject to become aware of his own physical condition.

Knowledge is the necessary substrate of awareness that, in turn, is the basic condition for consciousness. Awareness involves representations of objects. When the object of knowledge is one’s self, one experiences consciousness.

As the reader will gather, consciousness is a multifaceted issue, which can be analysed from different points of view. Here, we are interested in classifying the constituent “dimensions” of consciousness. We are going to proceed to examine each dimension of consciousness from a neurocognitive perspective, identifying the brain structures that sustains each dimension and describing disorders in which this dimension is impaired.

We have identified the first dimension as

Self-monitoring, defined as the ability to reflect on one’s own behaviour. Self-monitoring is generated by a sense of agency and allows for control of one’s own physical and cognitive condition.⁴ Both the sense of agency and self-monitoring are born from the concept of “free will” and reflect a capacity to generate actions, control them and affect the environment.⁵ Self-monitoring is above all a medial-prefrontal cortex function and a lesion to this area can cause a domain-specific disorder of awareness. For example, the self-monitoring process is impaired in anosognosia,⁶ a syndrome characterized by denial of deficits, such as post-stroke effects⁷ even in the absence of sensorial and proprioceptive feedback.⁸ Anosognosia for hemiplegia is the most common form of anosognosia and specifically entails unawareness of motor impairment. Anosognosic patients deny their deficit and claim that their paralyzed limbs can still move;⁹ self-monitoring specifically relates to motoric capacities.

Theories concerning the genesis of anosognosia suggest that denial may be the consequence of damage to a central monitoring process.¹⁰ For example, in the model proposed by Spinazzola and colleagues it is hypothesized that after a brain lesion, probably occurring in the premotor frontal region,¹¹ the intentional system for action (the sense of agency) remains intact while the monitoring systems is impaired. For this reason the patient still experiences his intention to move, but the intentional system is no longer controlled by the monitoring system. This results in the patient’s false belief. In this model denial is interpreted as a specific disorder of monitoring, and anosognosia for hemiplegia is attributed to a selective monitoring disorder that specifically affects motor awareness.

Anosognosia can be found in amnesic patients affected by prefrontal damage such as post traumatic patients,¹² in patients with heminattention in prefrontal or parietal areas and in patients with behavioural disorders due to orbitofrontal damage or in psychotic

patients; however, anosognosia can also be observed with cortical blindness due to damage to both occipital lobes.¹³

Disturbances of self-agency and self-monitoring also characterize the *Anarchic Hand Syndrome*, a condition in which a patient performs actions with their anarchic hand but considers this hand to be out of his control, as if the hand was not his own. This disorder, in which the subject is unable to program a motor act, can be ascribed to lesions of the supplementary motor area, cingulate cortex and medial prefrontal cortex¹⁴ and is described as a syndrome that affects agentive self-awareness.¹⁵

In synthesis, *Self-monitoring* is a crucial cerebral function devoted to the control of cognitive processing and motor/behavioural output, and is based on a subject's ability to represent himself in action.

Self-monitoring proceeds "in parallel" with *Self-feeling*, referring to the capacity to feel all sensations related to one's own body. Self-feeling includes interoception, namely attention to internal stimuli, and exteroception, attention to environmental stimuli. Both contribute to maintaining homeostasis and are constituent elements of awareness. Defined cortical and subcortical regions sustain interoceptive and exteroceptive processes. Craig¹⁶ has identified the lamina I spinothalamic pathway of sympathetic afferents which carry information about the physiological condition of the body to be critical for interoception. Interoceptive monitoring is also based on a wide neural network including the insula, the anterior cingulate (ACC), somatosensory and ventromedial prefrontal cortices.¹⁷ Specifically, there is conjoint activity between the insular cortex, which conveys information about the inner body, and the anterior cingulate cortex which collects such information and provides congruent behavioural responses.¹⁸ Although exteroception is generally considered to be a function of the precuneus and posterior cingulate cortex, Farb and colleagues¹⁹ found evidence suggesting that the anterior insula is

also implicated in receiving exteroceptive information. Both interoception and exteroception are processed by cortical midline structures. These structures form part of the default-mode network which, in turn, is involved in monitoring internal states.²⁰ Interoception, exteroception and related brain structures and functions, are reported to be impaired in some psychopathological conditions. Neuroimaging studies have demonstrated structural and functional alteration of several brain areas such as insula, amygdala and cingulate cortex in patients with anxiety disorders associated with increased interoceptive abilities²¹ while patients with Major Depressive Disorder presented reduced fronto-insular connectivity associated with reduced interoceptive abilities.²² Furthermore, Grossi and colleagues²³ found evidence that insular damage can cause interoceptive awareness impairment and impact the self-feeling aspect of interoceptive awareness. Interoception is closely related to emotion (for a review see Gu and colleagues).²⁴ Ernst and colleagues²⁵ observed that the ability to process interoceptive signals (assessed by a self-report index) was positively associated with difficulty in perceiving and recognizing emotions. Our recent study²⁶ confirms this positive relationship between interoceptive awareness (measured by the *Self-Awareness Questionnaire*) and alexithymic traits. Moreover, Grossi and colleagues²⁷ found that high interoceptive awareness in a group of hypochondriac subjects correlated with lower capacity for emotion recognition. On these bases, it is possible to raise the question as to whether excessive focus on one's own body might be related to a sort of emotional "neglect"? Our data seem to suggest that if a person is too much engaged with their own bodily status, they may lose capacity to recognize emotions, and therefore reduce their emotional awareness. Following this interpretation it seems that consciousness may be incomplete. In regard to exteroception, neuroimaging studies, e.g. Tapert and colleagues,²⁸ have found greater connectivity be-

tween regions associated with self-referential processes in cannabis users. This connectivity was positively related to the quantity of drug used, supporting the role of exteroception in addiction.

Disorders of self-feeling can also be found in Cotard's delusion, a psychiatric condition in which patients believe they have lost body parts and /or their soul, or even believe themselves to be dead. This syndrome implies abnormal self-feeling in the sense of a loss of bodily sensations²⁹ and the denial of the existence of the self. As a consequence, body image is incomplete and not integrated because patients lack a body experience.³⁰ On these bases, we can infer that Cotard's syndrome may reflect disrupted interoceptive abilities; in this regard Chatterjee and Mitra³¹ described a patient with dementia and gross atrophy of bilateral insular cortex who complained that she was dead?. The authors concluded that interoceptive feelings in this patient were interpreted in terms of negation and that the insular cortex might have produced "delire de negations". Moreover, Ramachandran³² interpreted Cotard's syndrome as a condition in which the subject feels disconnected from all his senses, therefore lacks emotional experience. The only way that the subject has to explain what has happened is to believe that he is dead.

Identity, the third dimension of consciousness, from the Latin "*identitas*", refers to the identity of an object with respect to itself. Identity is everything that makes a person recognizable, being the bearer of unique features that distinguish him from any other person. Neuroscience interprets identity as a whole of non-continuous components, held together by "something" that integrates interoception, exteroception, autobiography and experiences. The Self is the expression of identity that thinks our thoughts and performs our actions. Jaspers³³ considered identity as a whole of perception, memory, representations, thoughts and feeling that, together, create the psychic reality of a person. Moreover, he introduced the concept of identity con-

sciousness, referring to the awareness of being the same over a period of time.

In psychopathology there are several disorders that affect identity consciousness, e.g. depersonalization in which the patient lives altered self-experience in terms of out-of-body experiences, or losing the certainty of being himself.

Delusion of identity is a further example of an identity disorder, characterized by the patient's belief that he is someone else. Typical of such disturbances is the history of Henry James, brother of William, author of *Principles of Psychology*, who, after a vascular stroke in the right hemisphere (the specific location of the lesion is not available), became convinced he was Napoleon Bonaparte.³⁴ Pirandello³⁵ also described a case of delusion of identity, in his drama *Henry IV* where he describes a nobleman who participated in a ride in costume impersonating Henry IV. Following an injury, caused by a fall from the horse, the protagonist was convinced he really Henry IV. As briefly illustrated, delusional are often caused by right hemisphere damages and might regard self-identity, as in the case of Henry James, or other person's identity as Capgras syndrome, a misidentification delusion in which the patients believes that his relatives and/or friends have been replaced by an identical-looking impostor.

Finally, Grossi's group³⁶ described the case of a patients affected by *Zelig Syndrome* that also belongs to identity disturbances. The patient reported frontal-temporal damage accompanied by behavior disorder represented by environmental dependency. In particular, depending on the social context in which he was, he assumed the identity of the person with whom he was in social relationships in that moment. The patient, thus, overlapped the identity of his interlocutor to his own identity. The authors described this phenomenon as impaired frontal control of his own identity inhibition process resulting in "attraction" for the identity of others.

Ownership, the last dimension, can be defined as the capacity to perceive the status of

one's own body, knowing that the bodily sensations I feel belong to my body, and that my body is ever present in my mental life.³⁷ The sense of ownership also corresponds to the awareness that one's body belongs to one's self and that one's own body parts belong to one's own body.³⁸ Experience of body ownership can be manipulated through an experiment that induces illusory ownership of an artificial hand, the rubber hand illusion.³⁹ Petkova and colleagues⁴⁰ conducted a study in which participants self-identified with a mannequin stroked on the chest, manipulating, in this way, the sense of body ownership. They observed activation of posterior parietal cortex and ventral premotor cortex when the tactile stimulations of participants and the mannequin were perfectly synchronous. Neural activity in ventral premotor cortex was also correlated with the strength of illusory ownership of the virtual body. Activation of a portion of ventral premotor cortex is related to illusory body ownership experience, independently of which body part is stimulated (the authors found activation also during illusory ownership for a virtual hand), suggesting that this brain area is responsible for the multisensory integration of the whole body as one's own experience. Moreover, the insula is a key region for the sense of ownership, and its activation has been positively correlated with the rubber hand illusion. Despite this, Tsakiris and colleagues⁴¹ found a negative correlation between interoceptive awareness, measured by the heartbeat detection task, and the strength of the rubber hand illusion, suggesting that people who are highly "interoceptive" have a strong sense of ownership for their own body and do not feel ownership for extraneous stimuli. Insular damage can cause a delusion called somatoparaphrenia in which the patient believes that one part of one's own body belongs to someone else.⁴² Tsakiris⁴³ proposed a neurocognitive model of body-ownership during the rubber hand illusion according to which right temporo-parietal junction is involved in comparing the visual characteristics of the

rubber hand with a mental model of the body that contains information about visual, anatomical and structural properties of the body;⁴⁴ primary and secondary somatosensory cortices are responsible for a comparison between the state of one's own body and the anatomical features of the rubber hand; finally the posterior parietal cortex integrates visual and tactile information and the insular cortex incorporates the rubber hand into the pre-existing body model modifying the sense of body ownership.⁴⁵

In the range of ownership disorders, somatoparaphrenia, described for the first time by Gerstmann⁴⁶ as a feeling of non-belonging and a tendency to attribute parts of one's own body to someone else, is classified as a delusion of disownership of left-sided body parts, often accompanied by motor and somatosensory deficits. In most cases, right-sided lesions cause these deficits and the resulting pathological factors including proprioceptive disturbances, altered representations of the body related to ownership and deficits in multisensory integration.

Body integrity identity disorder also reflects disownership as manifested by patients who express the desire to amputate one of their healthy limbs because they do not accept this body part and feel themselves to be "incomplete".⁴⁷ Neurofunctional correlates of this disorder include dysfunctional activity of the right parietal lobe,⁴⁸ structural differences in the insula, in the superior parietal lobe and in both somatosensory cortices.⁴⁹ As evidenced, structural and/or functional alterations of brain areas responsible for mental representations of the body and for maintaining a correct sense of self are implicated in ownership disorders.

Serino and colleagues⁵⁰ proposed that bodily self-consciousness comprises two components: body ownership and self-location. Here, we have tried to extend the concept of consciousness also considering other dimensions that integrate with that pre-existing model. In conclusion, right hemisphere damage can impair self-monitoring

and cause inappropriate reactions to external stimuli and the left hemisphere, receiving inappropriate information from the right hemisphere, can produce syndromes such as delusions. In Ramachandran's view,⁵¹ the right and left hemispheres resolve conflicts between sensory inputs and ones' own beliefs in different manners: the left hemisphere ignores the discrepancies and goes on; the right hemisphere does the opposite. If the right hemisphere is damaged and consequently the left side of the body is paralyzed, the left hemisphere ignores the deficit, if the left side of the brain is damaged and the right side of the body is paralyzed, the right hemisphere realizes the discrepancy between the motor command and the impossibility of carrying it out. In this view, the right hemisphere seems to be crucial for all aspects of self-consciousness, and self-consciousness, in turn, appears to be crucial for a person's physical and mental health.

In synthesis we identified four components of Self-consciousness in an intuitive way in order to frame mental phenomena in which a *subject* is also the *object* of his own knowledge; we supported the theoretical analysis by referring to pathological conditions exhibited by brain damaged patients which illustrate disorders of specific components according to the classical neuropsychological method. In this way brain areas involved in self-consciousness were identified, such as the medial prefrontal areas and insular cortex, allowing us to hypothesize *Self-consciousness Networks*. Continuing along this line of thinking, the identified components would be better defined as *Neurocognitive Dimensions*, namely specific perspectives by means of which a person is able to know himself.

Notes

¹ In Terenzio's comedy *Heautontimorùmenos*, Cremete, talking to Menedemo, makes a statement that contains the concept of *humanitas*, intended as the characteristic of belonging to mankind. Cremete is conscious of being part of hu-

man nature and thinks that another person's experience could become his own experiences.

² D. GROSSI, *Come il cervello rappresenta se stesso: alcune considerazioni*, in: «Rivista Internazionale di Filosofia e Psicologia», vol. IV, n. 2, 2013, pp. 204-209.

³ A.D. CRAIG, *How do you Feel? Interoception: The Sense of the Physiological Condition of the Body*, in: «Nature Reviews Neuroscience», vol. III, 2002, pp. 655-666.

⁴ L. SPINAZZOLA, L. PIA, A. FOLEGATTI, C. MARCHETTI, A. BERTI, *Modular Structure of Awareness for Sensorimotor Disorders: Evidence from Anosognosia for Hemiplegia and Anosognosia for Hemi-anesthesia*, in: «Neuropsychologia», vol. XLVI, n. 3, 2008, pp. 915-926.

⁵ P. HAGGARD, S. CLARK, J. KALOGERAS, *Voluntary Action and Conscious Awareness*, in: «Nature Neuroscience», vol. V, 2002, pp. 382-385.

⁶ J. BABINSKI, *Contribution à l'étude des troubles mentaux dans l'hémiplégie organique cérébrale (Anosognosie)*, in: «Revue Neurologique», vol. XII, 1914, pp. 845-848.

⁷ L. SPINAZZOLA, L. PIA, A. FOLEGATTI, C. MARCHETTI, A. BERTI, *Modular Structure of Awareness for Sensorimotor Disorders*, cit.

⁸ A. BERTI, E. LADAVAS, A. STRACCIARI, C. GIANNARELLI, A. OSSOLA, *Anosognosia for Motor Impairment and Dissociations with Patients' Evaluation of the Disorder: Theoretical Considerations*, in: «Cognitive Neuropsychiatry», vol. III, n. 1, 1998, pp. 21-43.

⁹ A. BERTI, G. BOTTINI, M. GANDOLA, L. PIA, N. SMANIA, A. STRACCIARI, I. CASTIGLIONI, G. VALLAR, E. PAULESU, *Shared Cortical Anatomy for Motor Awareness and Motor Control*, in: «Science», vol. CCCIX, n. 5733, 2005, pp. 488-491.

¹⁰ E. GOLDBERG, W.B. BARR, *Three Possible Mechanisms of Unawareness of Deficit*, in: G.P. PRIGATANO, D.L. SCHACTER (eds.), *Awareness of Deficit after Brain Injury*, Oxford University Press, New York 1991, pp. 152-175.

¹¹ A. BERTI, G. BOTTINI, M. GANDOLA, L. PIA, N. SMANIA, A. STRACCIARI, I. CASTIGLIONI, G. VALLAR, E. PAULESU, *Shared Cortical Anatomy for Motor Awareness and Motor Control*, cit.

¹² T. HART, M. SHERER, J. WHYTE, M. POLANSKY, T.A. NOVACK, *Awareness of Behavioral, Cognitive, and Physical Deficits in Acute Traumatic Brain Injury*, in: «Archives of Physical Medicine and Rehabilitation», vol. LXXXV, n. 9, 2004, pp. 1450-1456.

¹³ E. BISIACH, G. VALLAR, D. PERANI, C. PAPAGNO, A.

BERTI, *Unawareness of Disease Following Lesions of the Right Hemisphere: Anosognosia for Hemiplegia and Anosognosia for Hemianopia*, in: «Neuropsychologia», vol. XXIV, n. 4, 1986, pp. 471-482.

¹⁴ A. KRITIKOS, N. BREEN, J. B. MATTINGLEY, *Anarchic Hand Syndrome: Bimanual Coordination and Sensitivity to Irrelevant Information in Unimanual Reaches*, in: «Brain Research Cognitive Brain Research», vol. XXIV, n. 3, 2005, pp. 634-647.

¹⁵ E. PACHERIE, *The Anarchic Hand Syndrome and Utilization Behavior: A Window onto Agentive Self-awareness*, in: «Functional Neurology», vol. XXII, n. 4, 2007, p. 211-217.

¹⁶ A.D. CRAIG, *How do you Feel? Interoception: The Sense of the Physiological Condition of the Body*, cit.

¹⁷ H.D. CRITCHLEY, S. WIENS, P. ROTSHTIEN, A. OHMAN, R.J. DOLAN, *Neural Systems Supporting Interoceptive Awareness*, in: «Nature Neuroscience», vol. VII, n. 2, 2004, pp. 189-195; O. POLLATOS, K. GRAMANN, R. SCHANDRY, *Neural Systems Connecting Interoceptive Awareness and Feelings*, in: «Human Brain Mapping», vol. XXVIII, n. 1, 2007, pp. 9-18; A.D. CRAIG, *How do you Feel - Now? The Anterior Insula and Human Awareness*, in: «Nature Review Neuroscience», vol. X, n. 1, 2009, pp. 59-70; C. DEVEUE, F. COLLETTE, E. BALTEAU, C. DEGUELDRE, A. LUXEN, P. MAQUET, S. BRÉDART, *Here I am: The Cortical Correlates of Visual Self-recognition*, in: «Brain Research» vol. MCXLIII, 2007, pp. 169-182.

¹⁸ N. MEDFORD, H.D. CRITCHLEY, *Conjoint Activity of Anterior Insular and Anterior Cingulate Cortex: Awareness and Response*, in: «Brain Structure and Function», vol. CCXIV, n. 5-6, 2010, pp. 535-549.

¹⁹ N.A. FARB, Z.V. SEGAL, A.K. ANDERSON, *Attentional Modulation of Primary Interoceptive and Exteroceptive Cortices*, in: «Cerebral Cortex», vol. XXIII, n. 1, 2013, pp. 114-126.

²⁰ S.J. DEWITT, A. KETCHERSIDE, T.M. MCQUEENY, J.P. DUNLOP, F.M. FILBEY, *The Hyper-sentient Addict: An Exteroception Model of Addiction*, in: «The American Journal of Drug and Alcohol Abuse», vol. XLI, n. 5, 2015, pp. 374-381.

²¹ B.O. OLATUNJI, B.J. DEACON, J.S. ABRAMOWITZ, D.P. VALENTINER, *Body Vigilance in Nonclinical and Anxiety Disorders Samples: Structure, Correlates and Prediction of Health Concerns*, in: «Behavioral Therapy», vol. XXXVIII, n. 4, 2007, pp. 392-401; V. BAUR, J. HÄNGGI, N. LANGER, L. JÄNKKE, *Resting-state Functional and Structural Connectivity with in an Insula-amygdala Route Specifi-*

cally Index State and Trait Anxiety, in: «Biological Psychiatry», vol. LXXIII, n. 1, 2013, pp. 85-92; M. P. PAULUS, M. B. STEIN, *Interoception in Anxiety and Depression*, in: «Brain Structure and Function», vol. CCXIV, n. 5-6, 2010, pp. 451-463.

²² I. MUTSCHLER, T. BALL, J. WANKERL, I. A. STRIGO, *Pain and Emotion in the Insular Cortex: Evidence for Functional Reorganization in Major Depression*, in: «Neuroscience Letter», vol. DXX, n. 2, 2012, pp. 204-209; D. SLIZ, S. HAYLEY, *Major Expressive Disorder and Alterations in Insular Cortical Activity: A Review of Current Functional Magnetic Imaging Research*, in: «Frontiers in Human Neuroscience», vol. III, 2012, Art. Nr. 323.

²³ D. GROSSI, A. DI VITA, L. PALERMO, U. SABATINI, L. TROJANO, C. GUARIGLIA, *The Brain Network for Self-feeling: A Symptom-lesion Mapping Study*, in: «Neuropsychologia», vol. LXIII, 2014, pp. 92-98.

²⁴ X. GU, P.R. HOF, K. J. FRISTON, J. FAN, *Anterior Insular Cortex and Emotional Awareness*, in: «Journal of Comparative Neurology», vol. DXXI, n. 15, 2013, pp. 3371-3388.

²⁵ J. ERNST, H. BÖKER, J. HÄTTENSCHWILER, D. SCHÜPBACH, G. NORTHOFF, E. SEIFRITZ, S. GRIMM, *The Association of Interoceptive Awareness and Alexithymia with Neurotransmitter Concentrations in Insula and Anterior Cingulate*, in: «Social Cognitive and Affective Neuroscience», vol. IX, n. 6, 2014, pp. 857-863.

²⁶ M. LONGARZO, F. D'OLIMPIO, A. CHIAVAZZO, G. SANTANGELO, L. TROJANO, D. GROSSI, *The Relationships Between Interoception and Alexithymic Trait. The Self-Awareness Questionnaire in Healthy Subjects*, in: «Frontiers in Psychology», vol. VII, 2015, Art. Nr. 1149.

²⁷ D. GROSSI, M. LONGARZO, M. QUARANTELLI, E. SALVATORE, C. CAVALIERE, P. DE LUCA, L. TROJANO, M. AIELLO, *Altered Functional Connectivity of Interoception in Illness Anxiety Disorder* (submitted).

²⁸ S.F. TAPERT, E.H. CHEUNG, G.G. BROWN, L.R. FRANK, M.P. PAULUS, A.D. SCHWEINSBURG, M.J. MELOY, S.A. BROWN, *Neural Response to Alcohol Stimuli in Adolescents with Alcohol Use Disorder*, in: «Archives of General Psychiatry», vol. LX, n. 7, 2003, pp. 727-735.

²⁹ G.E. BERRIOS, R. LUQUE, *Cotard Syndrome: Analysis of 100 Cases*, in: «Acta Psychiatrica Scandinava», vol. XCI, n. 3, 1995, pp. 185-188.

³⁰ G. CONCHIGLIA, G. DELLA ROCCA, D. GROSSI, *When the Body Image becomes "Empty": Cotard's Delusion in a Demented Patient*, in: «Acta Neuro-

psiquiátrica», vol. XX, n. 5, 2008, pp. 283-284.

³¹ S.S. CHATTERJEE, S. MITRA, "I Do Not Exist" – Cotard Syndrome in Insular Cortex Atrophy, in: «Biological Psychiatry», vol. LXXVII, n. 11, 2015, pp. 52-53.

³² V.S. RAMACHANDRAN, *The Emerging Mind: The BBC Reith Lectures 2003*, Profile, London 2003.

³³ K. JASPERS, *General Psychopathology* (1913), edited by J. HÖNIG, M.J. HAMILTON, John Hopkins University Press, Bambridge (MA) 1997.

³⁴ P. BARTOLOMEO, *The Delusion of the Master: The Last Days of Henry James*, in: «Neurological Sciences», vol. XXXIV, n. 11, 2013, pp. 2031-2034.

³⁵ L. PIRANDELLO, *Henry IV* (1922), edited by M. WITT, M.A. FRESE WITT, Ithaca, New York 2016.

³⁶ G. CONCHIGLIA, G. DELLA ROCCA, D. GROSSI, *On a Peculiar Environmental Dependency Syndrome in a Case with Frontal-temporal Damage: Zelig-like Syndrome*, in: «Neurocase», vol. XIII, n. 1, 2007, pp. 1-5.

³⁷ S. GALLAGHER, *Philosophical Conceptions of the Self: Implications for Cognitive Science*, in: «Trends in Cognitive Sciences», vol. IV, n. 1, 2000, pp. 14-21.

³⁸ F. DE VIGNEMONT, *Embodiment, Ownership and Disownership*, in: «Consciousness and Cognition», vol. XX, n. 1, 2011, pp. 82-93.

³⁹ M. BOTVINICK, J. COHEN, *Rubber Hands "Feel" Touch that Eyes See*, in: «Nature», vol. CCCXCI, 1998, Art. Nr. 756.

⁴⁰ V.I. PETKOVA, M. BJÖRNSDOTTER, G. GENTILE, T. JONSSON, T. Q. LI, H.H. EHRSSON, *From Part to Whole-body Ownership in the Multisensory Brain*, in: «Current Biology», vol. XXI, n. 13, 2011, pp. 1118-1122.

⁴¹ M. TSAKIRIS, A. TAJADURA-JIMÉNEZ, M. COSTANTINI, *Just a Heartbeat away from One's Body: Interoceptive Sensitivity Predicts Malleability of Body-representations*, in: «Proceeding of the Royal Society B-Biological Sciences», vol. CCLXXVIII, 2011, pp. 2470-2476.

⁴² G. VALLAR, R. RONCHI, *Somatoparaphrenia: A Bo-*

dy Delusion. A Review of the Neuropsychological Literature, in: «Experimental Brain Research», vol. CXCII, n. 3, 2009, pp. 533-551.

⁴³ M. TSAKIRIS, *My Body in the Brain: A Neurocognitive Model of Body Ownership*, in: «Neuropsychologia», vol. XLVIII, n. 3, 2010, pp. 703-712.

⁴⁴ M. TSAKIRIS, M. COSTANTINI, P. HAGGARD, *The Role of the Right Temporo-parietal Junction in Maintaining a Coherent Sense of One's Body*, in: «Neuropsychologia», vol. XLVI, n. 12, 2008, pp. 3014-3018.

⁴⁵ M. TSAKIRIS, M.D. HESSE, C. BOY, P. HAGGARD, G.R. FINK, *Neural Signatures of Body Ownership: A Sensory Network for Bodily Self-consciousness*, in: «Cerebral Cortex», vol. XVII, n. 10, 2007, pp. 2235-2244.

⁴⁶ J. GERSTMANN, *Problems of Imperception of Disease and of Impaired Body Territories with Organic Lesions, Relations to Body Schema and its Disorders*, in: «Archives of Neurology and Psychiatry», vol. XLVIII, 1942, pp. 890-913.

⁴⁷ D. ROMANO, A. SEDDA, P. BRUGGER, G. BOTTINI, *Body Ownership: When Feeling and Knowing Diverge*, in: «Consciousness and Cognition», vol. XXXIV, 2015, pp. 140-148.

⁴⁸ P.D. MCGEOCH, D. BRANG, T. SONG, R.R. LEE, M. HUANG, V.S. RAMACHANDRAN, *Xenomelia: A New Right Parietal Lobe Syndrome*, in: «Journal of Neurology, Neurosurgery, and Psychiatry», vol. LXXXII, n. 12, 2011, pp. 1314-1319.

⁴⁹ L.M. HILTI, J. HÄNGGI, D.A. VITACCO, B. KRAMER, A. PALLA, R. LUECHINGER, L. JÄNCKE, P. BRUGGER, *The Desire for Healthy Limb Amputation: Structural Brain Correlates and Clinical Features of Xenomelia*, in: «Brain», vol. CXXXVI, Pt. 1, 2013, pp. 318-329.

⁵⁰ A. SERINO, A. ALSMITH, M. COSTANTINI, A. MANDRIGIN, A. TAJADURA-JIMENES, C. LOPEZ, *Bodily Ownership and Self-location: Components of Bodily Self-consciousness*, in: «Consciousness and Cognition», vol. XXII, n. 4, 2013, pp. 1239-1252.

⁵¹ V.S. RAMACHANDRAN, *The Emerging Mind*, cit.