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Modular structure of awareness for sensorimotor disorders: Evidence from anosognosia for hemiplegia and anosognosia for hemianaesthesia

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Abstract

In the present paper, we shall review clinical evidence and theoretical models related to anosognosia for sensorimotor impairments that may help in understanding the normal processing underlying conscious self-awareness. The dissociations between anosognosia for hemiplegia and anosognosia for hemianaesthesia are considered to give important clinical evidence supporting the hypothesis that awareness of sensory and motor deficits depends on the functioning of discrete self-monitoring processes. We shall also present clinical and anatomical data on four single case reports of patients selectively affected by anosognosia for hemianaesthesia. The differences in the anatomical localization of lesions causing anosognosia for hemiplegia and anosognosia for hemianaesthesia are taken as evidence that cerebral circuits subserving these monitoring processes are located in separate brain areas, which may be involved both in the execution of primary functions and the emergence of awareness related to the monitoring of the same functions. The implications of these findings for the structure of conscious processes shall be also discussed.

Keywords: Anosognosia; Hemiplegia; Hemianaesthesia; Awareness; Sensorimotor disorders; Consciousness

"Personally, at any rate, had it not been for patients actually forcing me to admit that not only was there a problem, but a fascinating and important one, I probably should have stayed clear of what scientists used to think of as metaphysics, and what philosophers relished as a muddle."

L. Weiskrantz. In Consciousness Lost and Found.

"I think, instead, that one should try elevate one's explanations to the level where they actually give full credence to the importance of awareness. Any patient who has lost his sense of 'seeing' or of 'touch' will understand that: what he has lost is his awareness, not his concept, nor a draft, nor the key to allow him to escape from a Theatre, Cartesian or otherwise."

L. Weiskrantz. In Consciousness Lost and Found.

1. Introduction

Suspicion about consciousness as an object of scientific exploration may lead to the outright dismissal of any subjective report of phenomenal experience, since it is either considered to be impenetrable to external observation or even to be a non-existing problem because 'there is no reason to grant that persons have more of an inside than particles' (Rorty, 1982). However, counterintuitive observations in neuropsychological cases have shown (and *in primis* through subjective reports) that there is an inside and a fascinating and important one (to rephrase Weiskrantz, 1997). Although acknowledging that there cannot be a science for studying those aspects of private feeling that tell us what it is like to be some other subject (Bisiach, 1992), neuropsychologists have nonetheless taken advantage of the subjective component of neuropsychological syndromes. This has resulted in consideration of consciousness as both a private experience that gives rise to personal reports (see Marcel, 2004; Weiskrantz, 1997) and as a functional property of the brain that 'monitors any mental content through the whole spectrum of

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available behaviour open to public observation' (Bisiach, 1999). The study of brain-damaged patients has not only given a more legitimate method by hoe to scientifically study consciousness, but has also contributed in a substantial way to the dismantling of some folk-psychology beliefs, suggesting alternative perspectives on the content and structure of conscious processing. In this respect, years ago, Churchland (1986) noted that when the brain functions normally, the inadequacies of common-sense theories are hidden from view. However, these inadequacies can be unmasked in the counterintuitive behaviour of brain-damaged patients. In particular, the discovery of selective disorders of conscious awareness has provided evidence for a composite nature of conscious processes, as opposite to a unitary one. Indeed, the subjective experience that people have of themselves is reported to be, in normal conditions, a feeling of unity. The 'illusion' of unity of the self, assumed by common-sense theories of consciousness, is evident in the normal experience of correspondence between the actual presence/absence of a stimulus and the presence/absence of a subjective experience of it. An alternative view would suggest that consciousness and self-consciousness do not have a unitary, monolithic structure, but instead have a composite nature, subserved by the activity of different brain mechanisms distributed in specialized brain areas. Such a view would predict that focal brain damage should not cause a generalized impairment of conscious experience or conscious self-monitoring, but should instead result in domain-specific disorders of awareness.

With regards to domain-specific disorders of awareness, we mainly refer to two possibilities. First, brain damage may impair the emergence of awareness for the product of the processing of a specific stimulus, without affecting the elaboration of the sensory/semantic features of the same stimulus. Crucially, the processing and awareness of stimuli presented in different domains is normal. Unilateral neglect and extinction (Berti, 2002; Berti & Rizzolatti, 1992; Marshall & Halligan, 1988; Volpe, Ledoux, & Gazzaniga, 1979), blindsight and blindtouch (Cowey, 2004; Weiskrantz, 1986, 1997) and prosopoagnosia (Tranel & Damasio, 1985) are clear examples of this category of disturbances. Patients are not aware that something has been presented either in the affected field (extinction, neglect and blindsight), or on the affected side of the body (sensory extinction and blindtouch), or do not overtly recognize a familiar face (prosopoagnosi×a), despite the fact that it is possible, in some cases, to demonstrate high level categorical/semantic processing of the ignored items. In these cases, stimuli outside the affected hemifield/hemisoma, or non-face stimuli, are processed normally.

Secondly, with regards to domain-specific disorders of awareness, we also refer to brain damage that can selectively affect specific self-monitoring processes (which, when normal, allow control and awareness of one's physical and cognitive status). Anosognosia in brain-damaged patients seems to be one of the most convincing examples of the latter case. Patients with anosognosia resolutely deny the presence of some of their post-stroke deficits, and/or the consequence that those deficits may have on their behaviour. Denial may therefore affect reading, language or memory disorders (Prigatano & Schacter, 1991), or even contralesional sensorimotor impairments. In these latter cases, patients may deny being blind or plegic, and their false beliefs are strong and often cognitively intractable. However, they are able to monitor their sensorimotor status when it is not related to the affected side of the body.

The discrete, composite structure of conscious awareness proposed above would also predict:

(a) Dissociations of monitoring in relation to sensorimotor symptoms co-occurring on the affected side of the body.
(b) Different anatomical substrates for each form of denial.

In the present paper, we shall review neuropsychological data on anosognosia for sensorimotor deficits, which favors the hypothesis of selective conscious monitoring. In particular, we shall first discuss clinical data on anosognosia for hemiplegia, which suggests adopting a theoretical framework that would explain the motor denial within a model of motor awareness and motor control. We shall then turn to the problem of anosognosia for sensory (tactile and proprioceptive) disorders and to available models of sensory awareness. Finally, we shall discuss recent evidence that suggests a double dissociation between unawareness of motor impairment (anosognosia for hemiplegia, AHP) and unawareness of somatosensory deficits (anosognosia for hemianaesthesia, AHA), arguing, from data collected in single case studies, for potentially different brain localizations for motor and sensory monitoring processes.

2. Anosognosia for hemiplegia

Although anosognosia is a frequent observation in brain-damaged patients (see Orfei et al., 2007; Pia, Neppi-Mòdona, Ricci, & Berti, 2004 for a review), it has not been studied as extensively as other neuropsychological deficits often associated with it, such as spatial neglect. In the last century, this disregard was related to the fact that one of the most accepted interpretations of anosognosia was based on a motivational account, according to which denial is a defensive adaptation against the stress caused by the illness (motivational theories, e.g. Weinstein & Kahn, 1955). The interest in anosognosia in general, and for AHP in particular, increased at the end of the last century, thanks to a seminal paper by Bisiach and Geminiani (1991) in which the former psychodynamic interpretations of the disturbance, which prevented considering AHP as a direct consequence of a damage to a specific cognitive system, were put into question on the basis of clinical observations. For instance, Bisiach and Geminiani (1991) pointed out that the more frequent association of anosognosia with left than with right hemiplegia would not be predicted on the basis of a purely motivational account, since patients are expected to protect themselves against both left and right motor disorders. Furthermore, anosognosia can be temporally eliminated by vestibular stimulation. Cappa, Sterzi, Vallar, and Bisiach (1987) found that the elicitation of the vestibular reflex by introducing cold water into the patient's left ear (thus provoking left side nystagmus), can transitorily ameliorate AHP, whereas a psychodynamic reaction should not be influenced by physiological manipulation. In addition, the temporal course of