



Research report

Modulating anosognosia for hemiplegia: The role of dangerous actions in emergent awareness

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ABSTRACT

Anosognosia for hemiplegia is a lack of awareness of motor deficits following a right hemisphere lesion. Residual forms of awareness co-occur with an explicit denial of hemiplegia. The term emergent awareness refers to a condition in which awareness of motor deficits is reported verbally during the actual performance of an action involving the affected body part. In this study, two tasks were used to explore the potential effects of i) attempting actions which are impossible for sufferers of hemiplegia and ii) attempting actions which are potentially dangerous. Sixteen hemiplegic patients (8 anosognosic, and 8 non-anosognosic) were asked to perform both potentially dangerous and neutral actions. Our results confirm an increase in emergent awareness in anosognosic patients during the execution of both of these types of action. Moreover, actions that are potentially dangerous improved the degree of awareness. However, lesions in the fronto-temporal areas appear to be associated with a reduced effect of action execution (emergent awareness) while lesions in the basal ganglia and amygdala and the white matter underlying the insula and fronto-temporal areas are associated with a lesser degree of improvement resulting from attempting to perform dangerous actions.

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1. Introduction

The term anosognosia (from the Greek, α = without, νόσος = disease, γνώσις = knowledge) refers to a lack of awareness of sensory, motor or cognitive (i.e., language, memory) deficits. Babinski (1914) described a specific form of unawareness known as Anosognosia for hemiplegia (AHP) that selectively involves an incapacity to admit motor deficits and that mainly occurs as a consequence of right hemisphere

lesions (Pia, Neppi-Modona, Ricci, & Berti, 2004; Vocat, Staub, Stroppini, & Vuilleumier, 2010; but see also Cocchini, Beschin, Cameron, Fotopoulou, & Della Sala, 2009; Jehkonen, Laihosalo, & Kettunen, 2006a). Anosognosic patients fail to acknowledge or recognize their paralysis and they claim that they are able to carry out everyday activities which are in reality impossible for them.

Sensory loss, intellectual impairment or a combination of these cannot fully explain the syndrome (Marcel, Tegnér, & Nimmo-Smith, 2004). Furthermore, double dissociations

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have been demonstrated between AHP and proprioceptive impairment (Cocchini, Beschin, Fotopoulou, & Della Sala, 2010), spatial or personal neglect (Vocat et al., 2010), confabulation and deficits in frontal lobe functions (Heilman & Harciarek, 2010 for review) and other disorders in body representation, in particular somatoparaphrenia and feelings of disownership relating to affected limbs (Moro, Pernigo et al., 2016; Moro, Zampini, & Aglioti, 2004).

AHP is in fact a heterogeneous, multicomponential syndrome which may be influenced by a combination of partially different causes and which may manifest partially different symptoms (Davies, Davies, & Coltheart, 2005; Marcel et al., 2004; Vocat et al., 2010).

A crucial role in the syndrome was initially attributed to lesions in the parietal lobe (Bisiach, Vallar, Perani, Papagno, & Berti, 1986; Heilman, 1991) and in the wide networks of fronto-temporo-parietal integration (Pia, Neppi-Modona, Ricci, & Berti, 2004). More recently, the premotor cortex (Berti et al., 2005) and the insula (Karnath, Baier, & Nägele, 2005) have been identified as the core systems in AHP, with lesions associated with the symptoms in subcortical structures (the basal ganglia and amygdale) and in white matter tracts (Fotopoulou, Pernigo, Maeda, Rudd, & Kopelman, 2010; Moro, Pernigo et al., 2016; Moro, Pernigo, Zapparoli, Cordioli, & Aglioti, 2011; Vocat et al., 2010).

Damage to different parts of these networks has been linked to various expressions of the syndrome, with specific anosognosic symptoms occurring along with residual forms of awareness. For example, in the case of explicit anosognosia and implicit awareness, patients verbally deny their paralysis but act as if they know about their paralyzed body parts (Cocchini et al., 2010; Fotopoulou et al., 2010; Moro et al., 2011). This may have a significant impact as these implicitly aware patients will not try to stand up or act alone (as they risk hurting themselves) and will ask for help when necessary. In these cases rehabilitation is generally more efficacious (Gialanella, Monguzzi, Santoro, & Rocchi, 2005; Jehkonen, Laihosalo, & Kettunen, 2006b).

Another dissociation has been reported between deficits in awareness which refer to the self and to other people. Although the majority of people suffering from AHP fail to acknowledge paralysis both in themselves and in other people, some patients deny the motor deficits only when answering questions which refer to themselves. This may indicate that in the former situation the motor awareness deficits relate to the actions per se, while in the latter they are specific to the patient's own body actions (Marcel et al., 2004; Moro et al., 2011; Ramachandran & Rogers-Ramachandran, 1996; Ramachandran, 1996).

A form of Emergent Awareness has been previously described (Moro, 2013; Moro, Scandola, Bulgarelli, Avesani, & Fotopoulou, 2015; Moro et al., 2011). In this condition, when the anosognosic patients are asked to actually perform an action using the affected body parts they are able to verbally state that they cannot perform the action due to their motor deficits (Moro et al., 2011). This indicates that the intention to act (and/or actually acting) may modify any explicit, verbal knowledge of the deficits. More generally, this suggests that a modulation in AHP may be induced by ad-hoc experimental manipulation.

We investigated this topic by means of an experiment in order to establish whether there is a relationship between the top-down processes required to carry out specific actions and the effects of the characteristics pertaining to that action, in particular if they are of an emotional as compared to neutral nature. In fact, fluctuations in awareness in AHP are influenced by both sensory-motor and high cognitive functions (Fotopoulou, 2015 for review) and the role of emotional components has been previously reported (Besharati et al., 2014; Nardone, Ward, Fotopoulou, & Turnbull, 2008).

In the present study, anosognosic and hemiplegic non-anosognosic patients (HP) were asked to execute a number of everyday actions, which were impossible for them due to their paralysis. Their judgment regarding their proficiency in carrying out the actions (Della Sala, Cocchini, Beschin, & Cameron, 2009; Moro et al., 2011) was asked at various times: i) in a preliminary interview which focused on the specific actions to be performed (Semantic awareness); ii) before starting to execute the action (Anticipatory awareness); iii) during execution (Emergent awareness) and iv) after the attempt to act (Post-error awareness) (Moro et al., 2011). Moreover, the experiment was devised to determine whether the nature of the action had in itself an impact on awareness. To this end, half of the actions were neutral (i.e., they could be executed in safety, without risk of injury) and the other half were dangerous (i.e., patients could potentially hurt themselves).

We expected that real attempts to carry out actions would increase awareness in the AHP patients, with more realistic judgments being expressed during the execution of the action and/or after failing. Moreover, we expected that the Emergent Awareness effect would be stronger in dangerous as compared to neutral actions. A detailed analysis of the patients' lesions (Bates et al., 2003; Rorden, Karnath, & Bonilha, 2007) was also carried out in order to integrate behavioral and anatomical data associated with AHP, and in particular to investigate any modulations due to emergent awareness and the characteristics of the actions they performed.

2. Materials and methods

2.1. Participants

Sixteen patients suffering from left hemiplegia (absence of movement, MRC scale – Medical Research Council, 1986; see Table 1) as a consequence of a right hemisphere stroke were recruited at the Rehabilitation Unit, Sacro Cuore Hospital (Negrar, Verona) over a period of one year. They were divided into two groups based on the presence or otherwise of AHP. This was assessed by means of the Bisiach scale (Bisiach et al., 1986) and the Berti interview which investigates symptoms related to upper and lower limbs separately (Berti, Ládavas, & Della Corte, 1996). For the Bisiach scale, a partially modified version of the scoring was used (Bisiach et al., 1986) in which 0 = the disorder is spontaneously reported or mentioned by the patient following a general question about his/her complaint; 1 = the disorder is reported only after a specific question about the strength of his/her left limbs; 1.5 (not reported in the original version of the scale) = general deficits

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