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Explicit and implicit anosognosia or upper limb motor impairment

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ABSTRACT

If asked directly, anosognosic patients deny or seriously underestimate their motor difficulties. However explicit denial of hemiplegia does not necessarily imply a lack of insight of the deficit. In this study we explored explicit and implicit awareness for upper limb motor impairment in a group of 30 right-brain damaged patients. Explicit awareness was assessed using a questionnaire (the VATAm) in which patients are asked to rate their motor abilities, whereas implicit awareness was assessed by means of a newly developed test (BMT – bimanual task). This test requires the performance of a series of bimanual tasks that can be better performed using two hands, but could also be performed using one hand only. With the BMT, patients' performance rather than their verbal reports is evaluated and scored as an index of awareness. Paretic patients with anosognosia tend to approach these tasks as if they could use both hands. Our findings showed that explicit and implicit awareness for motor deficits can be dissociated, and they may be differently affected by feedback suggesting that different underlying mechanisms may account for the multi-factorial phenomenon of anosognosia.

1. Introduction

There is growing agreement amongst researchers to consider anosognosia as a multi-factorial phenomenon (Cocchini, Beschin, Cameron, Fotopoulou, & Della Sala, 2009; Cocchini, Beschin, & Della Sala, 2002; Davies, Davies, & Coltheart, 2005; Marcel, Tegnér, & Nimmo-Smith, 2004; McGlynn & Schacter, 1989; Orfei et al., 2007; Vallar & Ronchi, 2006; Vuilleumier, 2004; see also Prigatano, 2010). This suggests that different mechanisms may be responsible for lack of awareness, and that different aspects of anosognosia should be considered (Heilman, Barrett, & Adair, 1998; Marcel et al., 2004). Despite this possible heterogeneous scenario, most of the researchers' attention has been directed to systematically investigating explicit forms of unawareness, mainly relying on meta-cognition tasks. In this context patients are typically asked to respond to more or less direct questions about their deficit (e.g. Berti, Làdavas, & Della Corte, 1996), rate their ability in performing motor tasks (e.g. Della Sala, Cocchini, Beschin, & Cameron, 2009) or estimate their performance before and after having performed specific tasks (e.g. Marcel et al., 2004).

More subtle aspects of anosognosia, which also may provide relevant information about the nature of patients' unawareness, have received only qualified attention. Implicit processing of the information about one's own condition is one such neglected aspect. Considering patients' incidental comments or their behaviour in specific situations may reveal their actual beliefs (insight) about their conditions. For example, Ramachandran and Blakeslee (1998) anecdotally described a patient oblivious of his severe paresis who nevertheless commented, "I can't wait to go back to two-fisted beer drinking" (Ramachandran & Blakeslee, 1998, p. 143). Similarly Berti, Làdavas, Stracciari, Giannarelli, and Ossola (1998) described a hemiplegic patient who denied any motor impairment but whose "tacit knowledge of her physical condition was apparent in most conversations" (p. 21). Marcel et al. (2004) compared patients' ratings of their own motor abilities with their own ratings in judging how well the examiner would perform the same tasks had he been in the patient's current situation. The authors observed that up to 50% of right-brain damaged patients rated the examiner's ability consistently lower than their own. Nardone, Ward, Fotopoulou, and Turnbull (2007) described 2 anosognosic patients who showed an increment of simple reaction times when a word related to movement was presented with the target. These findings suggest that even patients who firmly deny any motor problem may have access to some type of implicit knowledge about their motor impairment.

A possible dissociation between implicit and explicit knowledge, or "dissociation of knowledge" (Bisiach & Geminiani, 1991), has strong theoretical implications about the nature of anosognosia. Information about implicit awareness is fundamental to provide relevant support to theoretical approaches; indeed some of

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these imply some insight into the deficit. For example, the motivational theory suggests that anosognosia is a psychological defence mechanism (Turnbull & Solms, 2007a,b; Weinstein & Kahn, 1955; Weinstein, 1991); however in order to "trigger" the denial process the patient must have processed some information about the deficit and have some "knowledge" of the deficit. On the contrary, other theories postulate that anosognosic patients lack the necessary information about their motor deficit, or the feedback information is incorrectly interpreted, resulting in lack of explicit and implicit awareness of the deficit. For example, the feed-forward theory by Gold, Adair, Jacobs, and Heilman (1994; see Fotopoulou et al., 2008 for a revised interpretation) identifies in the intention to move the "defective" stage that leads to lack of awareness. According to this interpretation, anosognosics' intentional systems do not formulate expectations about movements and the information about the feedback is correctly processed (i.e. no movement occurred); however since there is no mismatch between intention to move and feedback, the lack of movement is not interpreted as a failure. Other such theories suggest that anosognosia is linked to a malfunction in monitoring the impairment (Jenkinson, Edelstyn, Drakeford, & Ellis, 2009; Rubens & Garrett, 1991) or of the self-evaluation process (Levine, 1990). According to these theories, a lack of explicit knowledge of the motor impairment would be likely associated with lack of insight. Therefore, considering that anosognosia seems to be a multi-factorial phenomenon, different patients' unawareness may underline different causes and further knowledge about patients' implicit knowledge about the motor impairment would contribute to a better understanding of the nature of each patient's anosognosia and guide theoretical interpretation.

Clearly patients' knowledge of the deficit, at an explicit or implicit level, depends on the individual ability to perceive and process information from the surrounding environment and from the internal status of the body (Craig, 2010). Some authors have observed how simple exposure to a failure may considerably increase some patients' explicit awareness. We could call this phenomenon "empirical learning". Berti et al. (1996; see also Marcel et al., 2004) reported that some patients, but not all, tend to update the evaluation of their own motor ability after having performed bimanual or bipedal motor tasks. However, these authors, as many others, have described patients who vigorously denied any motor impairment despite clear evidence to the contrary (see Prigatano, 2010). Yet, some patients may still deny their deficit but react to the examiner's request to move the paretic limb in quite a defensive way (e.g. "You are beginning to ask me too many things!" Berti et al., 1998, p. 29). This suggests that anosognosia cannot be invariably accounted for as due to monitoring deficits or incorrect self-evaluation or lack of motor intention. Indeed, it seems that some patients have some knowledge of their deficit but that this information fails to reach more explicit levels of awareness. More systematic investigations about the effect of empirical learning on explicit and implicit forms of awareness could provide additional understanding of the nature of anosognosia.

The aim of the present study is to identify different levels of awareness and investigate possible factors that may prevent patients from becoming fully aware of their motor impairment.

2. Materials and methods

2.1. Participants

2.1.1. Brain damaged patients

A group of 30 (11 females and 19 males) stroke patients with unilateral right hemisphere damage were recruited for the present study. Demographic and clinical data are reported in Table 1.

To be considered for the experiment, patients had to present with clear left upper limb motor impairment, which was assessed by means of the Motricity Index (Wade, 1992). During this assessment, the patients sat in a chair or a wheelchair. Three left upper limb movements were assessed: "pinch grip", "elbow flexion" and "shoulder abduction". Following published instructions (Wade, 1992), for each of these movements, a score from 0 (no movement) to 33 (normal power) was given. The score for upper limb movement was then calculated by adding the score for the three movements *plus* 1, to give a total score between 1 (severe motor impairment) and 100 (no motor impairment). Poor performance due to apraxia, tremor or ataxia was not considered as evidence of paresis. Details are reported in Table 1.

On a background cognitive assessment, extrapersonal neglect was assessed by means of Line (Albert, 1973) and Star (Wilson, Cockburn, & Halligan, 1987) Cancellation Tests, and by means of a Line Bisection Test (Wilson et al., 1987). Eighteen (60%) patients (of whom 12 of 17 patients had lesions to the frontal and parietal lobes) showed some evidence of left extrapersonal neglect on at least one test. Personal neglect was assessed by means of the Fluff Test (Cocchini, Beschin, & Jehkonen, 2001), the Comb/Razor Test (Beschin & Robertson, 1997) and the One Item Test (Bisiach, Perani, Vallar, & Berti, 1986). Nineteen (63%) patients (of whom 11 of 17 patients had lesions to the fronto-parietal areas) showed some evidence of left personal neglect on at least one test. Reasoning abilities were assessed by means of the Cognitive Estimates Test (Della Sala, MacPherson, Philips, Sacco, & Spinnler, 2003) Only 2 (7%) patients (both with brain lesions limited to the frontal and parietal areas) showed impairment on this test. Finally, data related to short- and long-term verbal memory abilities were collected for 20 patients by means of Digit span and Prose Memory (Spinnler & Tognoni, 1987). One patient (5%) showed short-term and 4 (20%) long-term memory impairment (all but 1 with brain lesions limited to the frontal and parietal areas).

2.2. Control participants

Two groups of volunteers acted as controls. One group (healthy controls) consisted of 19 right-handed healthy participants. See Table 1 for demographic data.

The other group (control patients) consisted of 7 patients with motor disorders of their upper limb (i.e. Motor Index score lower than 85/100) not due to neurological causes (e.g. bone fractures). Five of them had a motor impairment of their left upper limb, and 2 had a motor impairment of their right upper limb. See Table 1 for demographic and clinical data.

Age did not differ significantly (i.e. $F > 1$) across the three groups of participants. A significant effect of years of formal education was found ($F(2,55) = 8.66$; $p < .001$) and Games-Howell post hoc analyses showed that control patients had on average more formal years of education than healthy volunteers and brain damaged patients (both with $p < .001$). The motor impairment of the control patient group was significantly less severe than that of the brain damaged patients ($F(1,36) = 24.17$; $p < .001$). According to some authors (e.g. Levine, 1990) a mild motor deficit is more likely to be associated to unawareness. Therefore, had this difference affected patients' awareness in our study, we should have observed a stronger negative effect on control patients than on brain damaged patients.

All participants gave informed consent prior to taking part in the study.

2.3. Method and procedure

2.3.1. Explicit anosognosia

2.3.1.1. The VATAm. To assess evidence of explicit anosognosia for upper limb motor deficits, all brain damaged patients and control patients underwent the VATAm (Della Sala et al., 2009). In this test, patients are requested to rate (from 0 = no problem to 3 = severe problem), one at a time, their ability to perform a series of simple everyday motor tasks, such as clapping their hands. For the purpose of this study only the 8 bimanual tasks were considered (score range 0–24). There were also 4 check questions, for which the expected ratings lay at one or another extreme of the scale. Performance on the check questions was not considered in the actual score, as these questions were used only to ensure the participants' compliance and reliability. The participants' self-evaluation was compared with the ratings of their caregivers (not part of the control groups) who filled in the questionnaire evaluating the patient's motor skills. The resulting score, i.e. the caregiver–patient discrepancy value, obtained by subtracting the patient's self-rating of the 8 bimanual tasks from those of their caregivers, could be checked against available norms (Della Sala et al., 2009). This score indicates the patient's degree of awareness/unawareness for their upper motor impairment. In the VATAm, the possible discrepancy value for the bimanual actions of the upper limb ranges from −24 (negative values generally indicate patient overestimation of the motor deficit compared to the caregiver's judgment) to +24 (positive values generally indicate patient underestimation of the motor deficit compared to the caregiver's judgment, i.e. unawareness of their own deficits). Following the norms set in Della Sala et al. (2009), values falling between 3.8 and 8.0, 8.1 and 16.0 or 16.1 and 24.0 were taken to indicate mild, moderate or severe anosognosia, respectively.

2.3.2. Implicit anosognosia

2.3.2.1. Experimental bimanual task (BMT). Implicit anosognosia for upper limb motor disorder was assessed by means of the BMT. Participants were asked to perform 8 simple everyday tasks (selected after a series of pilot studies) using real objects (see Table 2 for a list of the tasks). All these tasks are usually better performed using both hands (e.g. holding a two-handle tray with two hands, one at each extremity – see Fig. 1a) but could also be performed using only one hand approach-