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Selective improvement of anosognosia for hemiplegia during transcranial direct current stimulation: A case report

Martina Gandola [a,*], *Anna Sedda* [a], *Marina Manera* [b], *Valeria Pingue* [c], *Gerardo Salvato* [a], *Grazia F. Spitoni* [d,e], *Caterina Pistarini* [c], *Ines Giorgi* [b], *Luigi Pizzamiglio* [d,e] *and Gabriella Bottini* [a,f]

[a] *Department of Brain and Behavioural Sciences, University of Pavia, Pavia, Italy*
[b] *Psychology Service, Salvatore Maugeri Foundation, IRCCS, Scientific Institute of Pavia, Pavia, Italy*
[c] *Neurorehabilitation Unit, Salvatore Maugeri Foundation, IRCCS, Scientific Institute of Pavia, Pavia, Italy*
[d] *Department of Psychology, Sapienza University of Rome, Rome, Italy*
[e] *Neuropsychology Laboratory, IRCCS Santa Lucia Foundation, Rome, Italy*
[f] *Cognitive Neuropsychology Centre, Niguarda Ca' Granda Hospital, Milano, Italy*

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ABSTRACT

Right brain damage patients may not complain of a left sided paralysis up to the point of denying it or even claiming of having just moved an otherwise paralyzed limb. This condition is known as anosognosia for hemiplegia (AHP). Recent behavioural experiments suggest that some residual intentionality might be preserved in patients with anosognosia and that the false belief of having moved originates from a failure to notice discrepancies between movement expectancies and the actual state of the motor system. This failure may be caused by a lack of afferent sensory information concerning the movement or alternatively by a direct dysfunction of the brain regions involved in actions' motor monitoring (i.e., the comparator system). Here we examined the effect of anodal transcranial direct current stimulation (tDCS) of the right premotor cortex in a patient with a bilateral lesion, involving predominantly the right hemisphere, and a dense unawareness for his left hemiplegia. During sham or anodal tDCS the patient was requested to judge his ability to perform simple motor actions (i) without actually executing the movement itself ("offline" condition) and after having performed a series of verbally cued finger opposition movements ("online" condition) with (i) eyes-closed or (ii) eyes-open. We found that anodal tDCS induces a significant remission of the false experience of movement only when the patient is requested to actually perform the movement with eyes open. Conversely, the patient's awareness does not improve in both the "offline" condition (in which the patient does not attempt to perform the movement) and in the "online" condition, when vision is precluded ("online" condition, eyes-closed). We conclude that the stimulation of the premotor cortex by tDCS activates brain regions involved in motor monitoring, temporary

* *Corresponding author*. Department of Brain and Behavioural Sciences, University of Pavia, Piazza Botta 11, 27100 Pavia, Italy.
E-mail addresses: martina.gandola@unipv.it, gandola.martina@gmail.com (M. Gandola).
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restoring the ability of the motor comparator system to correctly appreciate afferent information and build up a veridical motor awareness.

1. Introduction

We are normally able to judge whether we have performed or not a movement even if many aspects of motor control occur without conscious awareness (Blakemore & Frith, 2003). However, there are neurological diseases, such as anosognosia for hemiplegia (AHP), in which patients are unaware of their motor inabilities (Babinski, 1914). Patients with AHP do not spontaneously complain about their contralesional motor deficit and in most severe cases they continue to deny their hemiplegia even after clear demonstration of it through the neurological examination. These patients have such a strong false experience (false beliefs of movement; Fotopoulou, 2012) that they claim to have performed the actions requested by the examiner, typically clapping hands or raising arms, although no movement actually occurred with the paretic arm (Ramachandran, 1996).

The clinical observation of patients with AHP clearly reveals that motor unawareness is a heterogeneous phenomenon rather than a unitary entity and that diverse levels of motor awareness may be differently affected, even in the same patient (Marcel, Tegner, & Nimmo-Smith, 2004).

A first distinction between different forms of AHP has been introduced by Bisiach and collaborators (Bisiach, Vallar, Perani, Papagno, & Berti, 1986). They differentiate between "moderate" anosognosia, when the patient recognizes the inability after its demonstration through the neurological examination (score: 2/3), and severe anosognosia, when the patient remains anosognosic after the demonstration of the failure (score: 3/3). A further distinction has been recently proposed by Moro, Pernigo, Zapparoli, Cordioli, and Aglioti (2011) that used the term "emergent awareness" to indicate a condition in which the patient denies the deficit but becomes declarative aware of it when invited to execute the action with the affected limb. Moreover, double dissociations between verbal (explicit) and non-verbal behaviour have been described (Berti, Ladavas, & Della Corte, 1996; Bisiach & Geminiani, 1991). Some patients, although explicitly able to recognize the presence of the motor impairment, do not refrain from performing infeasible actions (e.g., a patient with a complete lower limb left hemiplegia may attempt to walk; Bisiach & Geminiani, 1991). By contrast, other patients verbally deny their motor deficit but act coherently with the presence of the paralysis: implicit awareness or tacit knowledge (Ramachandran, 1996; for example a patient with a complete lower limb hemiplegia remains in bed, without trying to walk; Bisiach & Geminiani, 1991).

Further, even if AHP is frequently associated with unilateral spatial neglect and sensory impairments (tactile imperception and loss of position sense), double dissociations have been described in literature (see review in Vallar & Ronchi, 2006), suggesting the independence of AHP from these deficits.

The presence of such a complex semiology has important implications at both the clinical and theoretical level and clear consequences for the treatment of AHP. The development of instruments to assess all these different forms should rely on different theoretical frameworks taking into account this heterogeneity. In this view, focused rehabilitation treatments might allow to better target the multifaceted clinical manifestations of AHP. More recently, it has been suggested that various forms of unawareness do not correspond to a mere different degree of severity of the same symptom (see for example Bisiach et al., 1986), rather they represent different clinical phenomena with discrete underlying mechanisms and anatomical substrates (Fotopoulou, Pernigo, Maeda, Rudd, & Kopelman, 2010; Moro et al., 2011; Vocat, Staub, Stroppini, & Vuilleumier, 2010).

Despite the presence of AHP being a negative prognostic factor for motor recovery (Gialanella, Monguzzi, Santoro, & Rocchi, 2005), evidence concerning the efficacy of rehabilitative treatments is scarce (see review in Besharati, Crucianelli, & Fotopoulou, 2014; Kortte & Hillis, 2011). Seminal studies demonstrate a recovery of AHP after caloric vestibular stimulation (Cappa, Sterzi, Vallar, & Bisiach, 1987; case 5 and 3 in Geminiani & Bottini, 1992; Rode, Perenin, Honore, & Boisson, 1998; Vallar, Bottini, & Sterzi, 2003; Vallar, Sterzi, Bottini, Cappa, & Rusconi, 1990). In most of these studies the remission of AHP during CVS is generally transient (see review in Bottini et al., 2010), although in two cases described by Cappa and colleagues the remission outlasted the period of vestibular stimulation (Cappa et al., 1987).

Beschin and collaborators (Beschin, Cocchini, Allen, & Della Sala, 2012) have recently tested the efficacy of a number of treatments including prism adaptation, optokinetic stimulation and transcutaneous electrical stimulation. All these manipulations were transiently effective (within 48 h) although with different responses by patients (Beschin et al., 2012).

More recently, a case of *permanent* recovery of motor unawareness has been described in a patient (case LM) when she was observing her motor performance in a video replay (e.g., in a 3rd person perspective) and in a time subsequent to the attempt to execute the movement (e.g., off-line; Fotopoulou, Rudd, Holmes, & Kopelman, 2009). Two alternative explanations have been proposed by the authors to explain this remission: the first argues that body observation from a 1st or 3rd perspective involves distinct brain regions (Corradi-Dell'acqua et al., 2008; Saxe, Jamal, & Powell, 2006) that might be differently damaged in anosognosic patients. The second interpretation is that when the patient is observing himself in an off-line condition (e.g., when the action is