Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Research Report

Equal kinematics and visual context but different purposes: Observer's moral rules modulate motor resonance

Laila Craighero * *and Sonia Mele*

Dipartimento di Scienze Biomediche e Chirurgico Specialistiche, Università di Ferrara, Ferrara, Italy

ARTICLE INFO

Article history:
Received 29 November 2017
Reviewed 10 February 2018
Revised 19 February 2018
Accepted 30 March 2018
Action editor Stephen Jackson
Published online 9 April 2018

Keywords:
Action observation
Motor resonance
Action intention
MEPs
Embodied cognition

ABSTRACT

Motor resonance is considered to be an index of the automatic under threshold motor replica of the observed action. Similar actions may be quite different in terms of long-term goals (e.g., grasp to eat *vs* grasp to throw) and, recently, it has been proposed that the distal goal subtly modulates movements execution, and that observers automatically use these differences in kinematics to discriminate between different intentions. This interpretation is in line with computational approaches proposing that in the agent the generative process causes that intention shapes the kinematics, and in the observer the recognition process causes that the kinematics cues the intention. Given the close entanglement between the two processes, here we investigated whether the mere knowledge of agent's intentions induces in the observer a generative process able to modulate motor resonance. We used transcranial magnetic stimulation to examine motor evoked potentials in the *Opponens Pollicis* muscle to verify if observer's knowledge of agent's positive, negative, or neutral intentions on a third person influences corticospinal excitability during observation of the same action performed with equal kinematics, and in the same visual context. Results showed that the observation of an action executed with the intention to induce negative effects determined a reduction of motor resonance, revealing the presence of a specific inhibition to reenact an action that results in unpleasant consequences in the other. These data suggest that the information at the intention level activates a generative process which overcomes the replica of kinematics at the goal level, and shapes motor resonance according with observer's mind and not with agent's intention, revealing the possibility of a mere cognitive influence on motor resonance based on individual's ethical values.

* *Corresponding author*. Dipartimento di Scienze Biomediche e Chirurgico Specialistiche, Università di Ferrara, via Fossato di Mortara 17/19, 44100, Ferrara, Italy.
E-mail address: crh@unife.it (L. Craighero).

https://doi.org/10.1016/j.cortex.2018.03.032

1. Introduction

To ring a door bell is a socially accepted action whenever the agent is a respectful person interested in meeting the house inhabitants and having as purpose a friendly interaction. However, exactly the same action on the same bell, executed by the same person, and performed with the same kinematics, may be considered unfair by most people if the agent has the purpose to make a joke and get away immediately after ringing. The question posed in the present study concerns the possibility that the knowledge of the agent's intentions can modulate motor resonance in the observer, even when the action and the visual context are maintained constant. Motor resonance is considered to be an index of the automatic motor replica of the observed action, typically measured by recording motor evoked potentials (MEPs) from a given muscle in response to single-pulse transcranial magnetic stimulation (TMS) of the primary motor cortex (M1) (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995). MEPs modulation is considered to reflect changes in corticospinal (CS) excitability induced by the activity of various brain regions connected with M1 and involved in the concomitant task. Many experiments have shown that motor resonance is fine-grained and occurs according to somatotopic rules (Borroni & Baldissera, 2008; Brighina, La Bua, Oliveri, Piazza, & Fierro, 2000; Clark, Tremblay, & Ste-Marie, 2004; Gangitano, Mottaghy, & Pascual-Leone, 2001; Montagna, Cerri, Borroni, & Baldissera, 2005). Furthermore, studies indicated that the motor replica is automatic, since somatotopic specificity is present even when the individual is not aware of the use of muscles necessary to perform the action (see Fadiga et al., 1995). Embodied theories of cognition (Decety & Chaminade, 2004; Gallese, 2003, 2008; Keysers & Gazzola, 2007), claim that this motor replica supports action perception and recognition since this automatically induced, motor representation of the observed action corresponds to that which is spontaneously generated during active action and whose outcome is known to the acting individual (Rizzolatti & Craighero, 2004). Indeed, studies investigating the perception of intransitive actions, such as phoneme discrimination (Ito, Tiede, & Ostry, 2009), and categorization of facial expressions (Mele, Ghirardi, & Craighero, 2017), clearly showed that the sensorimotor system is involved in action perception, given that the implementation in the observer of low-level movement details influences the discrimination of ambiguous stimuli differing for a specific involvement of those movement details. The possibility to demonstrate that the sensorimotor system is similarly involved during the perception of transitive actions is, however, more difficult, since on the same object, the same goal may be achieved by using different effectors, or by using the same effector in different ways (Borroni, Gorini, Riva, Bouchard, & Cerri, 2011; Cattaneo, Caruana, Jezzini, & Rizzolatti, 2009; Cattaneo, Maule, Barchiesi, & Rizzolatti, 2013; Cavallo, Becchio, Sartori, Bucchioni, & Castiello, 2012; Cavallo, Sartori, & Castiello, 2011; Sartori, Bucchioni, & Castiello, 2012; Sartori, Xompero, Bucchioni, & Castiello, 2012). Moreover, in real life situations, the goal of the action is never restricted to "grasp an object", and grasping is usually executed to move the object from one position to another, to give it to someone, to eat it, or to do something else, and, therefore, similar actions may be quite different in terms of higher order goals. Consequently, Kilner, Friston, and Frith (2007), inspired by Grafton and colleagues (cf., Hamilton & Grafton, 2008), proposed that actions can be described at four levels: "(1) The intention level that defines the long-term goal of an action. (2) The goal level that describes short-term goals that are necessary to achieve the long-term intention. (3) The kinematic level that describes the shape of the hand and the movement of the arm in space and time. (4) The muscle level that describes the pattern of muscle activity required to execute the action. Therefore, to understand the intentions or goals of an observed action, the observer must be able to describe the observed movement at either the goal level or the intention level having only access to a visual representation of the kinematic level". A series of kinematic and behavioural studies has indeed proven that this possibility is feasible. In fact, several findings showed that the distal goal of the action influences movements execution (Ansuini, Giosa, Turella, Altoè, & Castiello, 2008; Armbrüster & Spijkers, 2006; Marteniuk, MacKenzie, Jeannerod, Athenes, & Dugas, 1987; Naish, Reader, Houston-Price, Bremner, & Holmes, 2013; Sartori, Becchio, Bara, & Castiello, 2009), and indicated that observers are sensitive to these differences in kinematics, and use them to discriminate between movements performed with different intentions (Ansuini et al., 2016; Manera, Becchio, Cavallo, Sartori, & Castiello, 2011; Sartori, Becchio, & Castiello, 2011). Further results have also proven that, during action observation, motor resonance is modulated by the subtle differences in movement kinematics characterizing similar actions performed with different intentions (Finisguerra, Amoruso, Makris, & Urgesi, 2016; Tidoni, Borgomaneri, di Pellegrino, & Avenanti, 2013). It has been proposed that this kinematically consistent replica of the observed action allows the cueing of the agent's intention, prompted by the knowledge of the sensory consequences of that specific kinematics (Ansuini, Cavallo, Bertone, & Becchio, 2014). This interpretation is in accord with computational approaches to action execution and recognition (Craighero, Metta, Sandini, & Fadiga, 2007; Kilner et al., 2007; Wolpert, Doya, & Kawato, 2003; Wolpert, Ghahramani, & Flanagan, 2001) claiming that, in the recognition model, visual information "is passed by forward connections … from low-level representations of the movement kinematics to high-level representations of intentions subtending the action", and that this model operates by the inversion of a generative model, where "the generative model produces a sensory representation of the kinematic level of an action given the information at the goals or intentions level" (quoted sentences from Kilner et al., 2007). Therefore, while in the agent the generative process causes that intention shapes the kinematics, in the observer the recognition process causes that the observed kinematics cues the intention. However, consistent with this close entanglement between the two processes, it is also possible that contextual cues can trigger a generative process (i.e., a covert motor program) in the observer, consequently modulating motor resonance. This is suggested by a series of studies that showed that, during observation of the same action, different visual contexts modulate corticospinal excitability. Specifically, motor facilitation increased during