Consciousness and Cognition 21 (2012) 383–392

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Short Communication

Kids observing other kids' hands: Visuomotor priming in children

Marco Tullio Liuzza [a,*], Annalisa Setti [b], Anna M. Borghi [c,d]

[a] Department of Psychology, Sapienza University of Rome, Italy
[b] Institute of Neuroscience, Trinity College Dublin, Ireland
[c] EMbodied COgnition lab, Department of Psychology, University of Bologna, Italy
[d] Institute of Cognitive Sciences and Technologies, National Research Council, Rome, Italy

ARTICLE INFO

Article history:
Received 22 December 2010
Available online 19 October 2011

Keywords:
Motor resonance
Motor simulation
Visuomotor priming
Body schema
Body ownership
Embodied cognition

ABSTRACT

We investigated motor resonance in children using a priming paradigm. Participants were asked to judge the weight of an object shortly primed by a hand in an action-related posture (grasp) or a non action-related one (fist). The hand prime could belong to a child or to an adult. We found faster response times when the object was preceded by a grasp hand posture (motor resonance effect). More crucially, participants were faster when the prime was a child's hand, suggesting that it could belong to their body schema, particularly when the child's hand was followed by a light object (motor simulation effect). A control experiment helped us to clarify the role of the hand prime. To our knowledge this is the first behavioral evidence of motor simulation and motor resonance in children. Implications of the results for the development of the sense of body ownership and for conceptual development are discussed.

1. Introduction

The body mediates all the interactions we have with objects and other organisms in our world. Our own body determines our perception of objects, for example perception of slant and distance change if we are carrying a heavy backpack (Proffitt, Stefanucci, Banton, & Epstein, 2003). We also use our body to perceive and understand other people's actions, for example we process perceived actions that we can perform and ones that we cannot perform differently (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006). Highly important for our sense of body is the capability to differentiate our own body from the body of others (Borghi & Cimatti, 2010). There is evidence that our brain "resonates" when we see others performing actions. This 'resonance' mechanism is modulated by the similarity between the actions we observe and the actions we are able to perform. The neural underpinnings of motor resonance are thought to reside in the mirror neuron system (MNS) and canonical neuron system, discovered originally in the monkey premotor cortex (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Murata et al., 1997). Mirror neurons fire both when a grasping action is perceived and performed; canonical neurons fire when a given action is performed and when the subject sees an object that the action can be performed upon. Neurophysiological and neuroimaging studies suggest that a similar system and resonant mechanisms are also present in humans (for a review see Rizzolatti & Craighero, 2004). These mechanisms are modulated by the similarity between the perceived actions and the actions we are able to execute. Brain imaging and behavioral studies have shown that, when participants observe others dancing, climbing, or playing basketball, resonant mechanisms are evoked, and that this motor resonance is stronger when expert athletes rather than novices observe other experts (e.g. Aglioti, Cesari, Romani, & Urgesi, 2008; Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009; Pezzulo, Barca, Bocconi, & Borghi, 2010). Behavioral

* Corresponding author. Address: Dipartimento di Psicologia, Via dei Marsi, 78, 00185 Roma, Italy. Fax: +39 06 49917635.
E-mail address: marcotullio.liuzza@uniroma1.it (M.T. Liuzza).

1053-8100/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.concog.2011.09.015

evidence has shown that, when the actions observed are part of the motor repertoire of the perceiver, actions are recognized more easily (Knoblich & Flach, 2001). These findings are in line with the ideomotor theories (Hommel, Muesseler, Aschersleben, & Prinz, 2001; Prinz, 1997), according to which perceptual features and motor plans rely on a common representational code: in other words, the more similar the action we see and the action we can perform are, the easier we simulate.

Bruzzo, Borghi, and Ghirlanda (2008) investigated whether observing actions similar to the actions that are part of our motor repertoire influences processing perceived actions. They used a priming paradigm and found that participants were faster to decide whether an action made sense or not when they observed a hand interacting with an object (e.g. grasping an orange) in the actor (egocentric) perspective rather than in an allocentric perspective. This shows that it is easier to put ourselves in others' shoes and to resonate while perceiving an action when we share action-relevant characteristics, such as the viewpoint (egocentric or allocentric) with the actor.

We think it would be worth to distinguish between motor resonance and motor simulation, given that in the literature contrasting definitions have been provided (for a brief overview see Borghi & Cimatti, 2010; for different definitions see Gallese, 2009; Jeannerod, 2007).

In this paper we will use the term "motor simulation" to refer to the fact that observing objects activates a simulated motor action. In other words, observation of graspable objects, such as notebooks and dictionaries, should activate a motor simulation, the underlying neural basis of which is probably the canonical neuron system. Motor simulation refers to the process of internally simulating an action when perceiving an object that can be acted upon (first person perspective). Motor resonance, the neural basis of which is the mirror neuron system, instead, would be activated during observation of others interacting with objects – for example, when we observe somebody lifting a dictionary with the hand. Our mirror neuron system seems to resonate with differing intensity depending on the similarity between the actions we observe and the actions that are part of our motor competence. For example, Calvo-Merino et al. (2006) have shown that dancers' mirror neuron system resonated more when observing dancers of their own gender. Motor resonance refers to the overlap of characteristics between the perceiver's actions and the perceived actions.

In spite of the large body of evidence obtained (Aglioti et al., 2008; Buccino et al., 2001; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Urgesi, Moro, Candidi, & Aglioti, 2006), some mechanisms underlying motor resonance are still poorly understood. Results have shown that motor resonance increases when participants and the observed actor share the same culture (Molnar-Szakacs, Wu, Robles, & Iacoboni, 2007) and perspective (Bruzzo et al., 2008), and when they have a similar motor competence (Calvo-Merino et al., 2006). So far, however, few studies (Cattaneo et al., 2007; Lepage & Théoret, 2006; Martineau, Cochin, Magne, & Barthelemy, 2008) investigated the extent to which this motor resonance process changes during the lifespan, in conjunction with our bodily modifications. The present study aims to fill this gap, investigating to what extent motor simulation and motor resonance processes occur in children.

We addressed this issue using a visuo-motor priming paradigm, in which a hand prime was followed by a target-object. Behavioral evidence with visuomotor priming paradigms has shown that observing an effector in potential interaction with an object re-activates our perceptual and action experience with it (Borghi, Bonfiglioli, Lugli, et al., 2007; Borghi, Bonfiglioli, Ricciardelli, et al., 2007; Vainio, Symes, Ellis, Tucker, & Ottoboni, 2008): for example, Borghi and colleagues (Borghi, Bonfiglioli, Lugli, et al., 2007; Borghi, Bonfiglioli, Ricciardelli, et al., 2007; Setti, Borghi, & Tessari, 2009) have demonstrated that an action-related prime (i.e. a static grasping hand) can activate information regarding how to manipulate (e.g. using an unimanual or a bimanual grasp; a precision or a power grip) target objects or nouns referring to them. Along the same line, neuroimaging studies have shown that observing static pictures of the same objects being grasped or touched is sufficient to selectively activate the frontal mirror region (Johnson-Frey et al., 2003); further TMS evidence confirms that a grasping hand in (implied) motion affects the primary motor area (Urgesi et al., 2006). In a developmental study, Kalenine, Bonthoux, and Borghi (2009) have shown how action primes (e.g. a hand in grasping posture) can prime basic level concepts (e.g. 'saw') more effectively than superordinate concepts (e.g. 'tool') in children from the age of 7 (even if the developmental pattern is not clear).

In a previous study Setti, Liuzza, Burke, Borghi, and Newell (in preparation) investigated to what extent motor resonance increases when participants share the same age. The authors used a priming paradigm. A hand prime was followed by heavy vs. light manipulable objects; participants were required to decide whether the target-object was heavy or light. They found that both young adults and older adults responded faster to hand primes of their same gender, but overall they did not respond faster when they observed hands of actors of their same age compared to a different age. This suggests they did not resonate to others' actions. A possible reason for the absence of the motor resonance effect with people of the same age could be due to the simple fact that humans are not sensitive to the age differences. An alternative reason is that age matters and impacts motor resonance, but only when the body schema changes substantially. Given that from youth to older adulthood only partial changes in body schema occur, the difference between the younger and older hand may have been too subtle for a difference in motor resonance to be found. In addition, the lifting actions alluded to in Setti et al. (in preparation) study may be too simple to be susceptible to a different motor simulation between younger and older (see also Poliakoff, Galpin, Dick, & Tipper, 2009), i.e. both older and younger adults can easily simulate lifting of the objects used as stimuli.

In the present study we used a similar paradigm to investigate the extent to which children were sensitive to the difference between children's and adults hands. Few studies have investigated if the MNS is at play since childhood. Among them Lepage and Théoret (2006), for example, have demonstrated that, in children aged between 4 and 11 years, action observation reduces the magnitude of the mu (8–13 Hz) rhythm which is considered to reflect the activation of the mirror fronto-parietal system. Martineau et al. (2008) compared EEG activity during the observation of videos showing actions or still scenes in autistic children and neurotypical children between 5 and 7 years of age (3 girls and 11 boys, aged 5 years 3 months–7 years