



Editorial: How Do Motivational States Influence Motor Resonance?

Cosimo Urgesi^{1,2*}, Kaat Alaerts³ and Laila Craighero⁴

¹ Laboratory of Cognitive Neuroscience, Department of Languages and Literatures, Communication, Education and Society, University of Udine, Udine, Italy, ² Scientific Institute, IRCCS E. Medea, Bosisio Parini, Italy, ³ Research Group for Neuromotor Rehabilitation, KU Leuven, Leuven, Belgium, ⁴ Department of Biomedical and Specialty Surgical Sciences, University of Ferrara, Ferrara, Italy

Keywords: action observation, imagery, motivational state, motor resonance, top-down modulation

Editorial on the Research Topic

How Do Motivational States Influence Motor Resonance?

Viewing or imagining actions triggers an activation of the observer's motor system that overlaps the representations of executed actions (Rizzolatti and Craighero, 2004). This "vicarious" motor activation has been referred to as *motor resonance* and it can be directly gauged by recording brain activity in the observer or imager, for example by recording with electroencephalography (EEG) a suppression of the mu rhythm from central scalp regions (Pineda, 2005) or by recording motor evoked potentials (MEPs) in response to transcranial magnetic stimulation (TMS) of the primary motor cortex (Fadiga et al., 2005). Furthermore, it can be also indirectly assessed by considering the influence that the action has on its execution or evaluation (e.g., facilitated mimicry of corresponding actions, but motor interference during the simultaneous observation and execution of incompatible actions; Craighero et al., 2002, 2014) or the influence that action observation has on the execution of similar actions (e.g., during observational learning; Urgesi et al., 2012). Using these methods, many experiments have shown that motor resonance occurs in a muscle-specific fashion according to somatotopic rules (Urgesi et al., 2006; Alaerts et al., 2009), that it is time-locked to the movement phases (Borroni et al., 2005; Alaerts et al., 2012), and that it follows the pattern of facilitation or inhibition of motor activity involved in selecting or refraining from performing a particular action (Romani et al., 2005; Schütz-Bosbach et al., 2009; Alaerts et al., 2010a). Based on these somatotopic, time-locked and direction-specific features, motor resonance has been commonly considered to reflect a fine-grained encoding of action kinematic aspects (Naish et al., 2014). This motor replica may support action perception and conception, since the automatically induced, sensorimotor representation of the perceived or imagined action corresponds to what is spontaneously generated during action execution and whose outcome is known to the agent.

However, even if a butcher knows exactly how to use a knife to slaughter a cow he probably does not know what it really means to use the same knife to infer a fatal stab to a person: motivations and consequences are totally different. As well, watching someone devouring a greasy hamburger can arouse envy or disgust depending on the level of satiety of the observer or on his diet. Therefore, if mapping others' actions onto one's own sensorimotor representation cues the goal and, possibly, the ultimate intention of the agent, motor resonance must necessarily encode also aspects not simply related to the kinematics of the movement.

This Research Topic includes original research and review contributions aimed at assessing which cognitive processes and neural mechanisms are involved in exerting a top down modulation of motor resonance according to stimulus features and task requirements, as well as according to actor's and observer's motivational states.

OPEN ACCESS

Edited and reviewed by:

Lutz Jäncke,
University of Zurich, Switzerland

*Correspondence:

Cosimo Urgesi
cosimo.urgesi@uniud.it

Specialty section:

This article was submitted to
Cognitive Neuroscience,
a section of the journal
Frontiers in Human Neuroscience

Received: 16 December 2019

Accepted: 21 January 2020

Published: 14 February 2020

Citation:

Urgesi C, Alaerts K and Craighero L
(2020) Editorial: How Do Motivational
States Influence Motor Resonance?
Front. Hum. Neurosci. 14:27.
doi: 10.3389/fnhum.2020.00027

Amoruso and Finisguerra provided a comprehensive overview of the various pieces of evidence that have challenged the view of an automatic motor resonance by showing that motor resonance is pervious to top-down modulation. In particular, by examining TMS studies that have measured modulation of MEPs amplitudes during action observation, they have shown that, when the experimental stimuli stop displaying only aseptic moving body parts, but include more complex information on the actor, object and environment, motor resonance goes beyond the low-level mapping of the observed kinematics. In fact, it may be shaped by the intended goal (Cattaneo et al., 2009; Alaerts et al., 2010b; Senot et al., 2011; Finisguerra et al., 2015), the underlying intention (Tidoni et al., 2013; Amoruso and Urgesi, 2016b; Craighero and Mele, 2018; Finisguerra et al., 2018) and/or the embedding context (Amoruso and Urgesi, 2016a; Amoruso et al., 2016, 2018) of observed actions. Accordingly, the empirical contribution of Rens and Davare found that observing object lifting movements improved the force scaling of successively performed lifting movements, since observing the kinematics differences between actions directed to objects of different weights updates internal sensorimotor representations and anticipatory motor control. Crucially, however, these effects were modulated by the situational context in which the actions took place, with greater effects when the model actor intended to commit an error in object lifting than when he intended to perform skillful movements.

Moving to more direct measures of motor resonance, Karakale et al. reported that suppression of the mu rhythm recorded from central electrodes was modulated by the emotional content of observed facial gestures, with greater suppression for biological than non-biological stimuli only for neutral movements void of any emotional meaning (i.e., mouth opening-closing movements), but not for emotional (i.e., happy or sad) expressions. In a similar vein, Maegherman et al. failed to find an amplitude increase of MEPs evoked by TMS in finger and facial muscles during imagery of simple squeezing movements involving the fingers or the lips, respectively. This finding

contrasts with previous evidence of imagery-related facilitation of the motor cortex for more complex movements (e.g., Fourkas et al., 2006, 2008), and suggests that the recruitment of the primary motor cortex during imagery is conditional on task difficulty and requirements. Finally, the contribution of Farwaha and Obi further supported top-down modulation of motor resonance by highlighting the correlation between the degree of motor resonance during action observation and the online status of the observer. They found that individuals who have fewer Instagram followers than they follow (i.e., followers) show greater motor resonance than individuals who have more followers than they follow (i.e., leaders). This finding converges with similar evidence that observer's sense of power (Hogeveen et al., 2014) or socioeconomical status (Varnum et al., 2016) in the real world also affects motor activation during action observation and supports the flexible nature of motor resonance according to not only external stimulus and task complexity, but also internal observer's factors.

In conclusion, this Research Topic has collected initial evidence supporting the hypothesis that motor resonance can be modulated by actor's and observer's intentions, needs, values, emotions, and attitudes. However, further studies are required to clarify which cognitive processes and neural mechanisms are involved in exerting this top-down modulation.

AUTHOR CONTRIBUTIONS

CU wrote the first draft of the manuscript. KA and LC revised it critically. All authors approved the submitted version.

FUNDING

CU was supported by the Italian Ministry of University, Research and Education (PRIN 2017, no. 2017N7WCLP) and by the Italian Ministry of Health (Bando Ricerca Finalizzata 2016, no. GR-2016-02363640).

REFERENCES

- Alaerts, K., de Beukelaar, T. T., Swinnen, S. P., and Wenderoth, N. (2012). Observing how others lift light or heavy objects: time-dependent encoding of grip force in the primary motor cortex. *Psychol. Res.* 76, 503–513. doi: 10.1007/s00426-011-0380-1
- Alaerts, K., Heremans, E., Swinnen, S., and Wenderoth, N. (2009). How are observed actions mapped to the observer's motor system? Influence of posture and perspective. *Neuropsychologia* 47, 415–422. doi: 10.1016/j.neuropsychologia.2008.09.012
- Alaerts, K., Senot, P., Swinnen, S. P., Craighero, L., Wenderoth, N., and Fadiga, L. (2010a). Force requirements of observed object lifting are encoded by the observer's motor system: a TMS study. *Eur. J. Neurosci.* 31, 1144–1153. doi: 10.1111/j.1460-9568.2010.07124.x
- Alaerts, K., Swinnen, S. P., and Wenderoth, N. (2010b). Observing how others lift light or heavy objects: which visual cues mediate the encoding of muscular force in the primary motor cortex? *Neuropsychologia* 48, 2082–2090. doi: 10.1016/j.neuropsychologia.2010.03.029
- Amoruso, L., Finisguerra, A., and Urgesi, C. (2016). Tracking the time course of top-down contextual effects on motor responses during action comprehension. *J. Neurosci.* 36, 11590–11600. doi: 10.1523/JNEUROSCI.4340-15.2016
- Amoruso, L., Finisguerra, A., and Urgesi, C. (2018). NeuroImage Contextualizing action observation in the predictive brain: causal contributions of prefrontal and middle temporal areas. *Neuroimage* 177, 68–78. doi: 10.1016/j.neuroimage.2018.05.020
- Amoruso, L., and Urgesi, C. (2016a). Contextual modulation of motor resonance during the observation of everyday actions. *Neuroimage* 134, 74–84. doi: 10.1016/j.neuroimage.2016.03.060
- Amoruso, L., and Urgesi, C. (2016b). Familiarity modulates motor activation while other species' actions are observed: a magnetic stimulation study. *Eur. J. Neurosci.* 43, 765–772. doi: 10.1111/ejn.13154
- Borroni, P., Montagna, M., Cerri, G., and Baldissera, F. (2005). Cyclic time course of motor excitability modulation during the observation of a cyclic hand movement. *Brain Res.* 1065, 115–124. doi: 10.1016/j.brainres.2005.10.034
- Cattaneo, L., Caruana, F., Jezzini, A., and Rizzolatti, G. (2009). Representation of goal and movements without overt motor behavior in the human motor cortex: a transcranial magnetic stimulation study. *J. Neurosci.* 29, 11134–11138. doi: 10.1523/JNEUROSCI.2605-09.2009

- Craigheo, L., Bello, A., Fadiga, L., and Rizzolatti, G. (2002). Hand action preparation influences the responses to hand pictures. *Neuropsychologia* 40, 492–502. doi: 10.1016/s0028-3932(01)00134-8
- Craigheo, L., and Mele, S. (2018). Equal kinematics and visual context but different purposes: observer's moral rules modulate motor resonance. *Cereb. Cortex* 104, 1–11. doi: 10.1016/j.cortex.2018.03.032
- Craigheo, L., Zorzi, V., Canto, R., and Franca, M. (2014). Same kinematics but different objects during action observation: detection times and motor evoked potentials. *Vis. Cogn.* 22, 653–671. doi: 10.1080/13506285.2014.904460
- Fadiga, L., Craigheo, L., and Olivier, E. (2005). Human motor cortex excitability during the perception of others' action. *Curr. Opin. Neurobiol.* 15, 213–218. doi: 10.1016/j.conb.2005.03.013
- Finisguerra, A., Amoruso, L., Makris, S., and Urgesi, C. (2018). Dissociated Representations of deceptive intentions and kinematic adaptations in the observer's motor system. *Cereb. Cortex* 28, 33–47. doi: 10.1093/cercor/bhw346
- Finisguerra, A., Maffongelli, L., Bassolino, M., Jacono, M., Pozzo, T., and D'Ausilio, A. (2015). Generalization of motor resonance during the observation of hand, mouth, and eye movements. *J. Neurophysiol.* 114, 2295–2304. doi: 10.1152/jn.00433.2015
- Fourkas, A. D. A. D., Avenanti, A., Urgesi, C., and Aglioti, S. M. S. M. (2006). Corticospinal facilitation during first and third person imagery. *Exp. Brain Res.* 168, 143–151. doi: 10.1007/s00221-005-0076-0
- Fourkas, A. D. A. D., Bonavolontà, V., Avenanti, A., and Aglioti, S. M. (2008). Kinesthetic imagery and tool-specific modulation of corticospinal representations in expert tennis players. *Cereb. Cortex* 18, 2382–2390. doi: 10.1093/cercor/bhn005
- Hogeveen, J., Inzlicht, M., and Obhi, S. S. (2014). Power changes how the brain responds to others. *J. Exp. Psychol. Gen.* 143, 755–762. doi: 10.1037/a0033477
- Naish, K. R., Houston-Price, C., Bremner, A. J., and Holmes, N. P. (2014). Effects of action observation on corticospinal excitability: muscle specificity, direction, and timing of the mirror response. *Neuropsychologia* 64, 331–348. doi: 10.1016/j.neuropsychologia.2014.09.034
- Pineda, J. (2005). The functional significance of mu rhythms: translating “seeing” and “hearing” into “doing”. *Brain Res. Brain Res. Rev.* 50, 57–68. doi: 10.1016/j.brainresrev.2005.04.005
- Rizzolatti, G., and Craigheo, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci.* 27, 169–192. doi: 10.1146/annurev.neuro.27.070203.144230
- Romani, M., Cesari, P., Urgesi, C., Facchini, S., and Aglioti, S. M. S. M. (2005). Motor facilitation of the human cortico-spinal system during observation of bio-mechanically impossible movements. *Neuroimage* 26, 755–763. doi: 10.1016/j.neuroimage.2005.02.027
- Schütz-Bosbach, S., Avenanti, A., Aglioti, S. M., Haggard, P., and Schu, S. (2009). Don't do it! Cortical inhibition and self-attribution during action observation. *J. Cogn. Neurosci.* 21, 1215–1227. doi: 10.1162/jocn.2009.21068
- Senot, P., D'Ausilio, A., Franca, M., Caselli, L., Craigheo, L., and Fadiga, L. (2011). Effect of weight-related labels on corticospinal excitability during observation of grasping: a TMS study. *Exp. Brain Res.* 211, 161–167. doi: 10.1007/s00221-011-2635-x
- Tidoni, E., Borgomaneri, S., di Pellegrino, G., and Avenanti, A. (2013). Action simulation plays a critical role in deceptive action recognition. *J. Neurosci.* 33, 611–623. doi: 10.1523/JNEUROSCI.2228-11.2013
- Urgesi, C., Candidi, M., Fabbro, F., Romani, M., and Aglioti, S. M. S. M. (2006). Motor facilitation during action observation: topographic mapping of the target muscle and influence of the onlooker's posture. *Eur. J. Neurosci.* 23, 2522–2530. doi: 10.1111/j.1460-9568.2006.04772.x
- Urgesi, C., Savonitto, M. M. M. M., Fabbro, F., and Aglioti, S. M. S. M. (2012). Long- and short-term plastic modeling of action prediction abilities in volleyball. *Psychol. Res.* 76, 542–560. doi: 10.1007/s00426-011-0383-y
- Varnum, M. E. W., Blais, C., and Brewer, G. A. (2016). Social class affects Mu-suppression during action observation. *Soc. Neurosci.* 11, 449–454. doi: 10.1080/17470919.2015.1105865

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2020 Urgesi, Alaerts and Craigheo. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.