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The mirror neuron analogy: Implications for rehabilitation neuroscience:

Comment on “Grasping synergies: A motor-control approach to the mirror neuron mechanism” by A. D’Ausilio et al

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The discovery of individual neurons that respond selectively to both the perception and execution of actions in macaques has had a profound impact on cognitive neuroscience [1]. By demonstrating a neurophysiological mechanism linking perception and motor performance, these mirror neurons have inspired a broad range of research in humans using non-invasive neuroimaging [2,3], and transcranial magnetic stimulation (TMS) [4]. In the present re-view, D’Ausilio and colleagues point out inconsistencies among TMS evidence concerning whether the so-called mirror neuron system (MNS) represents actions as low-level kinematic features, or more abstract goals [5]. They propose instead that actions are represented in the MNS as a modest number of motor synergies, a position arrived at through following propositional reasoning:

If individual mirror neurons must necessarily represent both perceived and executed actions using the same primitives (i.e., at the same level of granularity), and if execution is represented in terms of motor synergies, then perceived actions must also be represented as motor synergies.

The trouble with this logic is that we presently lack any means of testing whether or not mirror neurons exist in the healthy human brain. Both neuroimaging and TMS methods are limited to providing evidence based on the pooled responses of very large populations of neurons. Such evidence is incapable of resolving whether interactions between perception and execution reflect involvement of the very same representational units (i.e., mirror neurons), or distinct yet comingled neural subpopulations coding either perceived *or* executed actions at potentially different levels of granularity. In fact, unit recordings in macaques indicate just such an organization in both F5 and the IPL, where mirror neurons are considerably outnumbered by cells that represent either perceptual stimuli *or* motor execution [1].

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Conflict of interest

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When Rutherford suggested that the atom is *like* the solar system, he was drawing an analogy for purposes of exposition, not proposing a hypothesis. Modulations detected with TMS in the state of corticospinal system activity during action perception might likewise be *analogous* to the responses of mirror neurons. However, these changes should not be mistaken as evidence for the existence of mirror neurons in the human brain. Like Rutherford's analogy to the solar system, the mirror neuron analogy adds value to our understanding of human perception and action by suggesting hypotheses that are testable with current methods. For instance, if activity of the human motor system can be effectively stimulated by action perception, then this can perhaps provide an alternative means to induce activity-dependent plasticity in patients with limited ability to participate in traditional motor therapies (e.g., [6]). The early signs are encouraging and suggest that structured action perception may enhance the effects of physical practice on motor recovery post-stroke [7,8]. Similar interventions inspired by the mirror neuron analogy may have promise in patients with Parkinson's disease [9,10] and cerebral palsy [11]. Whether the effectiveness of these approaches can be enhanced by developing interventions that specifically target representations of motor synergies is a provocative and testable implication of the work by D'Ausilio and colleagues.

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References

1. Kilner JM, Lemon RN. What we know currently about mirror neurons. *Curr Biol*. 2013; 23(23):R1057–R1062. [PubMed: 24309286]
2. Rizzolatti G, Fadiga L, Gallese V, Fogassi L. Premotor cortex and the recognition of motor actions. *Brain Res Cogn Brain Res*. 1996; 3(2):131–141. [PubMed: 8713554]
3. Iacoboni M. Cortical mechanisms of human imitation. *Science*. 1999; 286(5449):2526–2528. [PubMed: 10617472]
4. Fadiga L, Fogassi L, Pavesi G, Rizzolatti G. Motor facilitation during action observation: a magnetic stimulation study. *J Neurophysiol*. 1995; 73(6):2608–2611. [PubMed: 7666169]
5. D'Ausilio A, Bartoli E, Maffongelli L. Grasping synergies: a motor-control approach to the mirror neuron mechanism. *Phys Life Rev*. 2015; 12:91–103. [in this issue]. [PubMed: 25465480]
6. Buccino G. Action observation treatment: a novel tool in neurorehabilitation. *Philos Trans R Soc Lond B, Biol Sci*. 2014; 369(1644):20130185. [PubMed: 24778380]
7. Celnik P, Webster B, Glasser DM, Cohen LG. Effects of action observation on physical training after stroke. *Stroke*. 2008; 39(6):1814–1820. [PubMed: 18403746]
8. Ertelt D, et al. Action observation has a positive impact on rehabilitation of motor deficits after stroke. *NeuroImage*. 2007; 36:T164–T173. [PubMed: 17499164]
9. Buccino G, et al. Action observation treatment improves autonomy in daily activities in Parkinson's disease patients: results from a pilot study. *Mov Disord*. 2011; 26(10):1963–1964. [PubMed: 21547952]
10. Pelosin E, et al. Action observation improves freezing of gait in patients with Parkinson's disease. *Neurorehabil Neural Repair*. 2010; 24(8):746–752. [PubMed: 20453155]
11. Buccino G, et al. Improving upper limb motor functions through action observation treatment: a pilot study in children with cerebral palsy. *Dev Med Child Neurol*. 2012; 54(9):822–828. [PubMed: 22765352]