Comment

Inference and representations of hand actions through grasping synergies

Comment on “Grasping synergies: A motor-control approach to the mirror neuron mechanism” by D’Ausilio, Bartoli, and Maffongelli

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The concept of synergy, denoting the coordination of multiple elements working together toward a common goal, has been extensively studied to understand how the central nervous system (CNS) controls movement (for review see [5,9]). Although this definition is appealing in its simplicity, ‘multiple elements’, ‘working together’, and ‘common goal’ each take different meanings depending on the scale at which a given sensorimotor system is studied, whether the ‘working together’ is defined in spatial and/or temporal domains, and the hypothesized synergy’s ‘common goal’. For example, the elements involved in a synergy can be defined as single motor units, muscles, or joints. Similarly, the goal of a synergy may be defined as a means available to the CNS to ‘simplify’ the control of multiple elements, or to minimize a given cost function or movement feature — all of which may differ across tasks and tasks conditions. These considerations underscore the fact that a universally accepted definition of synergies and their functional role remains to be established (for review see [6]). Thus, the nature and functional role(s) of synergies is still debated in the literature. Nevertheless, it is generally agreed that the reduction in the number of independent degrees of freedom that is manifested through synergies emerges from the interaction of biomechanical and neural factors constraining the spatial and temporal coordination of multiple muscles.

The theoretical framework of synergies has motivated extensive investigations of fundamental questions in motor neuroscience about neural representations of complex movements (for review see [1,3,4]). In their review [2], D’Ausilio and colleagues propose an additional and novel perspective on the role that synergies might play in the context of movement observation and the mirror neuron system. Their focus is on grasp synergies and, more specifically, on their temporal evolution during the act of reaching towards an object to be grasped and/or manipulated. Grasp synergies in the kinematic domain emerge from the interaction between biomechanical and neural constraints, e.g. tendons spanning multiple joints of the digits and common neural inputs to spinal motor nuclei [6]. The ‘observable’ outcome of this interaction is the spatial and temporal coordination of multiple joints of the digits that is found not
only in hand postures used for grasping a wide variety of imagined, remembered, or real objects, but also during the reach [7,8] (for review of studies on hand kinematic synergies see [6]).

As the review by D’Ausilio and colleagues [2] points out, grasp synergies could be a potential answer to a long-debated issue in the mirror system literature: what are the movement features used by an observer to infer the goal of an agent’s upcoming grasp? In particular, the authors make the important points that the representation of low- and high-level movement goals may co-exist in the mirror system, or are at least highly correlated, and that cannot be objectively distinguished as these belong to a continuum. Grasp synergies would exist within such continuum as they are expressed in the form of multi-joint coordination and could potentially cue the observer about the goal of the upcoming grasp and manipulation. This intriguing view is based on the hypothesized similarity in granularity between the mirror and motor systems. However, testing this proposition is, at present, particularly challenging as it remains to be determined whether the neural representations of grasp synergies in the motor system match their statistical structure as defined through decomposition of multi-joint hand postures or movements.

The thorough and insightful review by D’Ausilio and colleagues [2] opens up a new avenue for research on grasp synergies and the mirror system. To fully address the proposed role of grasp synergies for action observation, future research should address a number of key questions, including the extent to which observers can extract information about the action’s goals from grasp synergies, and the potential contribution of additional observable hand movement features, e.g. trajectories of the fingertips as precursors of where the object will be grasped — a movement parameter that is sensitive to planned grasp action, and the temporal evolution of arm configuration.

References


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