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Comment

The granularity of grasping
Comment on "Grasping synergies: A motor-control approach to the mirror neuron mechanism" by A. D'Ausilio et al.

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The idea that mirror neuron systems in the human and the macaque monkey could provide a link between perceiving an action and performing it has spurred intense research [1,2]. Hundreds of papers now examine if this link exists and what it might contribute to human behaviour. The review article from D'Ausilio et al. [3] highlights how relatively few papers have considered the granularity of coding with mirror neuron systems, and even fewer have directly tested different possibilities. Granularity refers to the critical question of what actually is encoded within the mirror system – are neurons selective for low level kinematic features such as joint angle, or for postural synergies, or for action goals? Focusing on studies of single neurons in macaques and on studies measuring the excitability of primary motor cortex with TMS, the review suggests that it is very hard to distinguish low-level kinematic from goal representations. Furthermore, these two levels are often highly correlated in real-life contexts – the kinematics needed to grasp an apple are defined by the shape of the goal (an apple tends to be a large sphere) and these kinematics differ for other possible goals (a pencil which is a narrow cylinder). In some cases, kinematics may be enough to define a goal [4]. The review suggests that it is therefore arbitrary to distinguish these levels, and that a synergy level might be a better way to understand the mirror system. Synergies are a form of coding based on commonly used hand-shapes or hand postures, which take into account the fact that some joint angles are more likely to co-occur than others. Evidence that different grasp shapes are represented separately in premotor cortex has been found [5]. These could provide an intermediate level of representation between muscle activity and goals. The review proposes that a synergy level of granularity provides the best way to consider both the motor system and the role of the mirror system in understanding actions.

This is a useful proposal, but has some limitations. The proposed synergies seem much closer to a kinematic representation than to goals, and do not necessarily resolve the problem of if/how the mirror neuron system could contribute to understanding goals. Just because it is not easy to separate cognitive concepts such as kinematics and goals, does not mean it should not be done. A small number of carefully designed fMRI experiments have been able to show distinct patterns of brain activity for goals and kinematics. For example, grasping a tennis ball and grasping an apple both involve the same hand kinematics and the same hand synergies, but quite different goals. Anterior intraparietal sulcus can distinguish these actions [6] and shows cross-modal sensitivity to other action goals too [7].

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There are also important theoretical reasons to distinguish between action goals [8] – in different contexts, the same action may have very different social meanings. An approach based solely on synergies is unlikely to solve this problem.

The review from D'Ausilio et al. is valuable in highlighting the issue of granularity, and for pointing out that the question of what precisely is represented in human mirror neuron systems remains unknown after over 20 years of research. Low level kinematic features, postural synergies and action goals may all make a contribution. What is needed now is precise, well designed experiments which separate these different options, and test what is really going on within the intriguing mirror neuron network.

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