

A Reply to Hickok

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Alternative proposals are always welcome, in science and elsewhere. Unfortunately, Hickok's criticisms fail to provide any reasonable alternative account of the function of the mirror mechanism or to suggest new experiments.

It is important to distinguish at the outset between action understanding and imitation. This is ignored by Hickok, who puts them in the same pot to indicate that some properties of action understanding (e.g. generalization) are incompatible with true imitation (precise replica). Although both behaviors may be mediated by the mirror mechanism, this does not imply that they involve *precisely* the same network.

Action understanding. There is a large body of evidence that many mirror neurons of the primate parieto-frontal network selectively encode the goal of an observed action. This occurs regardless of the action's kinematics and the body effectors involved. By contrast, even high-order visual areas such as STS do not respond to action goals *per se*, but their activations requires the vision of a specific body effector (see Cattaneo et al., 2010). This indicates that the mirror mechanism is important when people have to capture the goal-directedness of others' actions.

In his reply, Hickok criticizes a study by Casile and Giese (2006) who showed that motor learning has a direct and highly selective influence on visual action recognition. Hickok suggests that this effect might be due to a "tight" link between proprioception and vision. There is no evidence, however, of proprioceptive neurons that respond to the observation of others' actions.

Imitation. As for imitation, it is not clear why the data cited on this issue (e.g., Catmur et al. 2007) would undermine reasonable claims about the role of mirror mechanism in action understanding. Indeed, the *human* mirror mechanism also provides a neurophysiological counterpart to the ideomotor theory of imitation. It accounts for

imitation both when imitation requires mere replication of the observed movements (Iacoboni et al. 1999) and also when imitation depends on comprehension of the goal of the observed action (Buccino et al. 2004). So, far from being a myth, mirror neurons represent a fundamental discovery in cognitive neuroscience. Although there are unresolved issues, their nature poses a deep challenge to standard views on action and action understanding.

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