SILVIA OTTE/GETTY

It is not necessary to mimic another's actions in order to understand them.

NEUROSCIENCE

Looking-glass wars

Patricia Smith Churchland welcomes a critique of the mirror-neuron theory linking brain and behaviour.

Well-grounded theories that connect neurons with behaviour are highly prized but in short supply. One behaviour we would dearly love to explain is how humans, along with some birds and mammals, 'mind-read' — that is, attribute mental states such as goals, intentions and feelings to others, to predict and understand their actions. Because others' motivations are not directly observable, the capacity to intuit them has seemed to require some special explanation.

The discovery several decades ago of 'mirror' neurons in the premotor cortex of macaque monkeys spawned the idea that these neurons provide that special explanation. As described by neuroscientists Giacomo Rizzolatti and Laila Craighero, mirror neurons respond both when one monkey sees another make a certain movement and when the animals make the same movements themselves.

The idea that a brain's capacity to mind-read emerges more or less automatically from the activity of mirror neurons was articulated thus by neuroscientist Marco Iacoboni in *Mirroring People* (Farrar, Straus and Giroux, 2008): "Mirror neurons undoubtedly provide, for the first time in history, a plausible neurophysiological explanation for complex forms of social cognition and interaction." Examples of such social cognition might be my knowing what you intend when I see you head for the chicken coop with an axe in hand, or my understanding what a baseball player feels when he strikes out in the last inning. In *The Myth of Mirror Neurons*, cognitive scientist Gregory Hickok undertakes a balanced and detailed examination of claims that have flourished in the past ten years — that mirror neurons are the key to explaining our capacity for reading other minds.

The Myth of Mirror Neurons: The Real Neuroscience of Communication and Cognition
GREGORY HICKOK
W. W. Norton: 2014.

The mirror-neuron approach to mind-reading depends on the assumption that our own neural activity is transparently revealed to our own minds. So when we see someone holding an axe while heading to the hen house, that observation activates in us not only the motor programme for that movement, but also the mental state that is its normal antecedent — intent to slaughter a chicken. Simulation of observed behaviour, so this argument goes, allows us to identify others' intentions. Iacoboni declares that mirror neurons "are at the heart of how we navigate through our lives".

These are bold and promising ideas, and Hickok wants to know whether the research makes good on the promise. One basic problem that he sees is this: the evidence shows that mirror neurons respond to movements, one's own and others'. The claim is that mirror neurons reflect high-level understanding of goals. But how? Rizzolatti and his colleagues tried to address this matter by designing an experiment in which the monkey is trained either to put food in its mouth or to put an object in a cup stationed near its mouth: similar movements, different goals.

When other monkeys witness these actions, the responses of mirror neurons in their inferior parietal lobes vary depending on whether the action-performer grasps to eat or to place. So are these neurons sensitive to observing similar movements with different goals? Here things get complicated because the nonfood object was taken from a jar, but the food was not. In Hickok's view, this leaves open the question of whether the mirror neurons are reading the goal or merely responding to different movements.

As Hickok sizes it up, the responses of the witness monkeys' mirror neurons seem to be explicable in terms of past associations, implying that the claim of mind-reading through simulation is superfluous. Likewise with my expectations regarding the unfortunate hen: my brain does not need to produce a simulation of your behaviour to know your motive, because in the past I have detected axe-wielding in the vicinity of chickens before they are slaughtered. Adding to the scepticism, Hickok points out that you can understand many actions that you never perform. Hickok's dog, who never throws the ball himself and thus cannot simulate ball-throwing, nevertheless reliably predicts the ball's trajectory by watching Hickok's arm. As for simulating feelings, I may know that a baseball player is disappointed after striking out, but feel only joy if it means my team is winning.

Some scientists sought to draw support for the simulation hypothesis from the motor theory of speech perception (MTSP). In brief, the idea of MTSP, popular in the 1950s, is that I can understand what you

mean when you say, "The cat is swimming" by recreating that bit of speech in my brain's speech area. Language is Hickok's area of expertise, and he reminds us of the experiments that saw MTSP shelved. For example, people with a disorder called Broca's aphasia are unable to produce speech, but they can still understand it, as can children in the pre-speech language-learning phase of development and people born with cerebral palsy who have severely impaired speech production. Some researchers dismiss those flaws in MTSP on the grounds that the mirror-neuron story explains language understanding. The circularity here is not reassuring.

Not least of the problems with the mirror-neuron approach is that learning mind-reading skills cannot be just a matter of simulation, because such skills depend on a co-evolution of understanding of the self and of others. Recognition of one's own inner states is not a computational freebie.

How fares the hypothesis that autism is fundamentally a mirror-neuron disorder? So far, it is mixed. A deeper perspective derives from post-mortem studies of the brains of youngsters with autism. These show patches of laminar disorganization — types of neuron in the wrong layer making the wrong connections — in wide swathes of the prefrontal cortex, including areas important for executive function, motor control and social cognition, as well as areas that probably contain some mirror neurons. This suggests that autism is not primarily or essentially a disorder of a hypothetical mirror-neuron system, but a broader disorder that affects many aspects of normal brain function, including cognition.

Hickok does not for a moment deny that we mind-read. Rather, his point is that the roles of mirror neurons and simulation have been oversold. The upshot of his inquiry is an analogue of the familiar warning: if it seems too good to be true, it probably is.

Hickok's critique deserves to be widely discussed, especially because many scientists have bought into the mirror-neuron theory of action understanding, perhaps because they lack the time or inclination to peer into its workings themselves. Hickok performs a valuable service by laying out the pros and cons clearly and fairly. He ends by agreeing that although mirror neurons may well have a role in explaining communication and empathy, many other neural networks with complex responses are undoubtedly involved. Those networks and their roles are still to be clarified. ■

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