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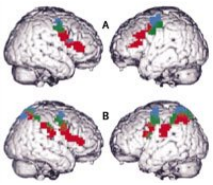

How Do Mirror Neurons Work?

Where does empathy come from and how do we understand the goals of others

The mirror neurons are the brain feature that makes empathy possible. Some neurologists have hailed their discovery in the 1990s as the equivalent for the science of the mind of what the discovery of DNA has been for biology. Mirror neurons are activated both when one does something and when one observes somebody else doing the same thing. Thus, they represent the neurological mechanism that allows us to put ourselves in the shoes of others.Philosophers have wondered for a long time about what is known as "the problem of other minds". Why are we so certain that all the other people are conscious? It was usually assumed that we inferred somehow the others' consciousnesses from their behavior. They look and behave like us and so they must also have an "inner self" and feelings similar to our own. One problem with such an idea is that we are experiencing consciousness only as a private feeling and we are hardly experiencing our body from an outsider's perspective. Think about how it feels when you see yourself videotaped; the person you observe on film doesn't really feel the same way as you feel yourself. In other words, on one hand, we see others moving but we don't experience their minds, and on the other hand, we experience our minds but we don't see ourselves moving (from an external point of view). Moreover, how much time have you spent trying to learn how you look like when you have certain emotions? How many times when you felt disgust for instance have you ran to a mirror to see how an expression of disgust looks like - so you will be able to recognize it in others? Even so, you are able to acknowledge what others feel pretty easily. How can this be done? There is not much "empiric data" on which we could really base our inference from our own mind to others' minds. Nonetheless, this is one of the things about which we feel most confident about. Where does this confidence come from?The discovery of mirror neurons solves this issue and the details of how they work show that we don't actually make such complex and improbable inferences as philosophers have assumed. Nature's way of building empathic creatures capable of complex socialization is much more straightforward and simple. "When I see the facial expression of someone else, and this perception leads me to experience that expression as a particular affective state, I do not accomplish this type of understanding through an argument by analogy. The other's emotion is constituted, experienced and therefore directly understood by means of an embodied simulation producing a shared body state. It is the activation of a neural mechanism shared by the observer and the observed to enable direct experiential understanding," explained Vittorio Gallese from the Department of Neurosciences at Parma University, Italy.**Embodied simulation**Since the 1990s, neuroscientists have studied both the mechanism behind empathy (understanding other's emotions) and the mechanism by which we understand others as goal-driven agents. In both cases it seems that the act of internally simulating what others feel or desire involves very basic and unconscious neurological mechanisms. Gallese called this type of basic simulation mechanism "embodied simulation"."I employ the term 'embodied simulation' as an automatic, unconscious, and pre-reflexive functional mechanism, whose function is the modeling of objects, agents, and events," he wrote. "Simulation ... is therefore not necessarily the result of a willed and conscious cognitive effort, aimed at interpreting the intentions hidden in the overt behavior of others, but rather a basic functional mechanism of our brain.""However, because it also generates representational content, this functional mechanism seems to play a major role in our epistemic approach to the world," he added. "It represents the outcome of possible actions, emotions, or sensations one could take or experience, and serves to attribute this outcome to another organism as a real goal-state it is trying to bring about, or as a real emotion or

sensation it is experiencing."This generation of "representational content" doesn't happen in the mirror neurons themselves, but it is caused in other parts of the brain by signals coming from the mirror neurons. "Indeed, before they can reason about beliefs, young children can represent goals and intentions," wrote Pierre Jacob and Marc Jeannerod from the Institut Nicod. "...infants represent the goal of the action and the agent's motor intention by matching the observed hand movement onto their own motor repertoire, i.e., by motor simulation."The transition from understanding emotions and desires to having thoughts, beliefs, moral views and so on is marked by the transition from the mirror neurons to the workings of other parts of the brain. As Jacob and Jeannerod observe, this transition has the very important consequence of making us capable of understanding the *relevance of context*. The mirror neurons cannot provide us with different reactions to the same stimuli in different external situations. This type of higher understanding comes from somewhere else. "Our most sophisticated mind reading abilities likely require the activation of large regions of our brain," wrote Galesse. "As correctly pointed out by Jacob and Jeannerod, the same actions performed by others in different contexts can lead the observer to radically different interpretations. Thus, social stimuli are also understood on the basis of the explicit cognitive elaboration of their contextual aspects and of previous information."But all these higher cognitive abilities are built on the systems designed to detect emotions and intentions.

Understanding sensations and emotions"With this mechanism we do not just 'see' an action, an emotion, or a sensation. Side by side with the sensory description of the observed social stimuli, internal representations of the body states associated with these actions, emotions, and sensations are evoked in the observer, 'as if' he/she would be doing a similar action or experiencing a similar emotion or sensation," Gallese wrote.For example, Bruno Wicker from the Institut de Neurosciences Physiologiques et Cognitives de la Mediterranée, in Marseille, France, and his colleagues have conducted fMRI brain scans of people experiencing odors, pleasant, neutral and disgusting and then of the same people watching a video of other people experiencing disgust. They found that "observing such faces and feeling disgust activated the same sites in the anterior insula and to a lesser extent in the anterior cingulate cortex. Thus, as observing hand actions activates the observer's motor representation of that action, observing an emotion activates the neural representation of that emotion." (Somewhat surprisingly, the study also showed a certain overlapping between the brain areas involved with pleasure and with disgust.)In another study led by Christian Keysers from University of Groningen, Netherlands and involving among others both Wicker and Gallese, scientists have analyzed the sense of touch. While in the fMRI machine, the subject experienced a tactile sensation and then he viewed a movie of somebody else being touched. "Watching the movie scene in which a tarantula crawls on James Bond's chest can make us literally shiver - as if the spider crawled on our own chest," they wrote. This is also why we have such stark responses when we see others in pain.This means that we understand sensations and emotions in a fairly direct way and not via some complex cognitive process. Gallese interprets such experiments in the following way: "the first- and third-person experiences of a given emotion are underpinned by the activity of a shared neural substrate. When I see the facial expression of someone else, and this perception leads me to experience that expression as a particular affective state, I do not accomplish this type of understanding through an argument by analogy. The other's emotion is constituted, experienced and therefore directly understood by means of an embodied simulation producing a shared body state."**Understanding intentions**Jacob and Jeannerod have argued that intentions are of different degrees of complexity. They refer as an example to the task of turning on the light. If one has this goal than one employs the sub-goals of moving a finger to the switch and of pushing the switch. To what do mirror neurons react? Just to the sub-goals or to the bigger goal as well? Do mirror neurons react just to the elementary sub-goals and than send the information to some other part of the brain that processes the information and infers the existence of the bigger goal? Experiments show that mirror neurons are actually more deeply involved. We can

understand what we can predict. In fact, in its most fundamental and basic form, understanding is just sensing the consequences of some action. In other words, if one is able to perform the task of turning on the light, which has a hierarchical structure as mentioned, then one's brain functions in a certain way. When one watches somebody else doing the same action the brain is again activated in approximately the same way as before. This is why one can understand even the bigger goal without any complex conceptual reasoning *about the other person*."When a given action is planned, its expected motor consequences are forecast," Gallese wrote. "This means that when we are going to execute a given action we can also predict its consequences. The action model enables this prediction. Given the shared sub-personal neural mapping between what is acted and what is perceived - constituted by mirror neurons - the action model can also be used to predict the consequences of actions performed by others."The only difference between the two cases (action and perception) is that when we perceive something there is an external stimulus while when we act there is no such stimulus. "The main difference is what triggers the simulation process: an internal event - a deliberate act of will - in the case of motor imagery, and an external event, in the case of action observation."But how does the brain know how to distinguish between the two? It can because "this difference leads to slightly different and non-overlapping patterns of brain activation," Gallese explained."However, both conditions share a common mechanism: the simulation of actions by means of the activation of parietal and premotor cortical networks," he added. "I submit that this simulation process also constitutes a basic level of experiential understanding, a level that does not entail the explicit use of any theory or declarative representation."Indeed, explicit representations come only later with thoughts, beliefs, systems of beliefs and so on.The exact process by which we understand intentions is interesting as well. Apparently, we're not doing it top-down by seeing the entire individual as a "self" with goals, but we recognize each of its particular motions as intentional motions. The criterion we use is whether or not we ourselves are usually involved in doing such motions. Giovanni Buccino, also from the University of Parma, and his colleagues from several other Italian universities scanned the brains of various subjects while they were observing things like another person speaking or biting something, a monkey lip-smacking and a dog barking. The mirror neurons were not activated by the sight of the barking dog, which was understood visually and not empathically, but were activated by the sight of other people as well as of monkeys. Moreover, a certain action was identified as belonging to a goal-driven agent only if it was successful. This offers the neurological basis of how we are able to make the distinction between an error and an intended action - we judge something as un-intended (as an error) when our mirror neurons don't light up. So this means that when you feel that, say, somebody has intended to offend you, it means that in his or her situation you would have had such an intention. Interestingly, this also means that if we will ever build human-looking robots that simulate our behavior sufficiently well our brains will automatically feel empathy towards them.**From individuals to society**All these studies point out to the fact that we are instinctively social to a much higher degree than previously thought. This increased understanding fills many gaps but it is also somewhat paradoxical: For one thing, our social life is not entirely manufactured by education and interpersonal relationships but it has a biological cause. On the other hand the very differences that exist between various cultures, and which make human behavior much more heterogeneous than any other kind of animal behavior of one species, are made possible by the same biological mechanism. The development of these brain structures had opened the doors for this huge diversity. Our diversity today is so huge that these very mechanisms that have created it seem to be unable to cope with it. The reason why people feel threatened by other people's habits and ways of life and have a "gut reaction" against such diversity is due to the fact that their mirror neurons are less unable to understand the "stranger". His or her intentions and emotions are to a certain extent clouded by one's cultural identity and made inaccessible to others."Our brains, and those of other primates, appear to have developed a basic

functional mechanism, embodied simulation, which gives us an experiential insight of other minds," wrote Gallese. "The shareability of the phenomenal content of the intentional relations of others, by means of the shared neural underpinnings, produces intentional attunement. Intentional attunement, in turn, by collapsing the others' intentions into the observer's ones, produces the peculiar quality of familiarity we entertain with other individuals. This is what 'being empathic' is about."