

Mirror Neuron

A mirror neuron [1] is a neuron that fires both when an animal performs an action and when the animal observes the same action being performed by another animal. Thus, this neuron "mirrors" or reflects the behavior of the other being, as if the observer were itself acting. Such neurons have been directly observed in primates and other species including birds.

Many researchers in cognitive neuroscience and cognitive psychology argue that mirror neurons can provide us the key to observing and understanding the intentions and actions of other people, and for learning new skills by imitation. For instance, mirror neurons can help identify if another person who was picking up a cup of tea planned to drink from it or clear it from the table. In addition, mirror neurons form the neural basis of the human capacity for emotions such as compassion and empathy.

Discovery in monkeys

The first animal in which mirror neurons have been studied is the macaque monkey. In the 1980s and 1990s, neurophysiologists at the University of Parma, Italy conducted experiments where they studied neurons specialized for the control of hand and mouth actions in the macaque monkey; for example, taking hold of an object and manipulating it. During each experiment, the researchers allowed the monkey to reach for pieces of food and recorded activity from a single neuron in the monkey's brain, thus measuring the neuron's response to certain movements. They found that some of the neurons that they observed exhibited some response even when the monkey saw a person perform the same action i.e. pick up a piece of food.



Figure 1. A macaque baby monkey imitating a human's facial expression

Recent experiments suggest that infant macaques can imitate a human's facial movements, though only as babies and during a limited temporal window. Figure 1 shows a macaque infant imitating a human's facial expressions. Adult macaques do not seem to learn by imitation.

In Humans

It is not normally possible to study single neurons in the human brain, so most evidence for mirror neurons in humans is indirect. Brain imaging experiments using functional magnetic resonance imaging (fMRI) have shown that the parts of the human brain such as inferior frontal cortex and superior parietal lobe are active when the person performs an action and also when the person sees another individual performing that action. It has been suggested that these brain regions contain mirror neurons, and they have been defined as the human mirror neuron system.

Possible functions of the mirror neuron

- Understanding intentions - Many studies link mirror neurons to understanding goals and intentions.
- Empathy - A large number of experiments using fMRI, electroencephalography (EEG) and magnetoencephalography (MEG) have shown that certain brain regions are active when people

experience emotions such as disgust, happiness, sorrow, etc. and when they see another person experiencing an emotion.

- Human self-awareness – It has been speculated that mirror neurons may provide the neurological basis for human self-awareness
- Language - Mirror neurons have been postulated to have the potential to provide a mechanism for understanding actions, learning through imitation, and the simulation of other people's behaviour. For instance, the rate of vocabulary expansion can be associated with the ability of children to vocally mirror non-words and to acquire the new word pronunciations.
- Automatic Imitation - The term is commonly used to refer to cases in which an individual, having observed a body movement, deliberately performs a topographically similar body movement.

The Mirror Test

The mirror test [2] is a measure of self-awareness and gauges it by determining whether an animal can recognize its own reflection in a mirror as an image of itself. This is done by marking the animal with an odorless dye, and observing how the animal reacts to it - whether the animal is aware that the dye is located on its own body or it thinks that there is another animal in the mirror. Acknowledging that the dye is on its own body includes behavior such as turning and adjusting of the body in order to better view the marking in the mirror, or poking at the marking on its own body with a finger while viewing the mirror. Animals that have passed the mirror test are common chimpanzees, orangutans, dolphins, elephants, humans and possibly pigeons.

Doubts about mirror neurons

Although many researchers in the scientific community have expressed excitement about the discovery of mirror neurons, there are scientists who have expressed doubts about both the existence and role of mirror neurons in humans. The main cause of disagreement is that whether mirror neurons really form a distinct class of cells or are they a manifestation of an occasional phenomenon seen in cells that have other functions.

Mirror Neurons in Robotics

Self-other distinction is a hard and challenging problem in robotics and researchers have employed mirror neurons to address this challenge. Nagai and colleagues [3] propose a computational model for the development of a mirror neuron system (MNS) in robots. Their robot observes motion of self and others and is able to make the distinction between them with increasing spatiotemporal resolution.

References:

1. http://en.wikipedia.org/wiki/Mirror_neuron
2. http://www.sciencedaily.com/articles/m/mirror_test.htm
3. Y. Nagai, Y. Kawai and M. Asada, "Emergence of Mirror Neuron System: Immature vision leads to self-other correspondence", 2011 IEEE International Conference on Development and Learning (ICDL)