The role of the mirror neuron system in action understanding, imitation learning, and language.

Giovanni Buccino
Department of Neuroscience, University of Parma
e-mail:giovanni.buccino@unipr.it

Mirror neurons, first described in the rostral part of monkey ventral premotor cortex (area F5), discharge both when the animal performs a goal-directed hand action and when it observes another individual performing the same or a similar action. More recently, in area F5 mirror neurons coding the observation as well as the execution of mouth actions have been also found. As for humans, through an fMRI study, it has been shown that the observation of goal-directed as well as mimicked actions performed with the hand, the mouth and the foot leads to the activation of different sectors of the premotor cortex, including Broca's area, according to the effector involved in the observed action. These results strongly support the existence of an execution-observation matching system (mirror neuron system) similar to that described in the monkey also in humans and the notion that this system has a somatotopic organization, which resembles the classical motor cortex homunculus. A further fMRI study has shown that the mirror neuron system plays a fundamental role in action recognition, even in the case of actions performed by non conspecifics. There is increasing evidence that this system may constitute the neural substrate for imitation learning and the processing of language material. In a recent event-related fMRI, while being scanned, musically naïve participants were required to imitate guitar chords, after a model. This study has shown that the mirror neuron system is recruited from the observation of the model till its execution, thus suggesting a specific role of this system in imitating novel, complex hand actions. As for language, in two distinct fMRI studies it has been demonstrated that processing language material (written or verbally presented sentences) expressing mouth, hand/arm and foot/leg actions leads to the activation of different sectors of the premotor cortex, depending on the effector involved in the processed language material. Interestingly, these sectors largely overlap those active during the observation of mouth, hand/arm and foot/leg, respectively. This evidence strongly suggests that the mirror neuron system is indeed involved also in processing action related language material.