

A Synthesis of Literature on Mirror Neurons

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In this paper I synthesize the literature on “mirror neurons” and discuss the implications of the reviewed studies in regard to (a) action understanding, b) imitation and (c) evolution of brain, communication and language.

What are the Mirror Neurons?

Mirror neurons (MN) are a group of visuo-motor neurons discovered in the F5 area of the macaque monkey premotor cortex. These neurons are fired whenever the monkey executes an action or observes another individual (monkey or human) executing the action.

Why is the mirror neuron system important?

The mirror neuron system is found to be functional in *action understanding*, *imitation*, and *verbal communication*. Mirror neurons could provide a framework to understand how humans (and to some extent monkeys) make sense of others' actions for the communication purposes.

It is a common view that both monkeys and humans have to *understand* the purpose of others' *actions* for socialization and communication. *Imitation* is a unique characteristic of humans and it is possibly the basis of most of the human learning process. *Verbal communication* is necessary for the formation and sustainability of culture. *Action understanding*, *imitation*, and *verbal communication*, three interrelated concepts, are all dependent on the observation of others. If mirror neurons provide a framework to explain the interrelations among *action understanding*, *imitation*, and *verbal communication*, then we will explore how humans make sense of others' actions more effectively that would eventually help us understand many concepts related to cognition and learning.

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Evolution of brain, communication and language

In his article named, “The mirror system, imitation, and the evolution of language” (2000) Micheal Arbib hypothesizes seven stages of evolution starting from the simple grasping movement and ending with the development of the complex human languages. These stages are:

- 1) Grasping
- 2) A mirror system, matching observation and execution, for grasping
- 3) A simple imitation system for grasping
- 4) A complex imitation system for grasping
- 5) A manual-based communication system

- 6) Simple speech, which includes a vocabulary of vocal gestures matching with meanings without constituting a language
- 7) Language

Naming his hypothesis as “Mirror system hypothesis”, Arbib (2000) claims that the ability to imitate is the key leap in evolution of humans leading to the complex languages. Rizzolatti and Arbib (1998) explain how the mirror system in monkeys is homologous to the Broca’s region, a crucial speech area in humans. They claim that the common ancestor of humans and monkeys had the precursor system for the mirror neuron system. This system evolved resulting with increased complexity and functionality, as it is shown in the 7 stages above. Like Rizzolatti and Arbib, Studdert (2002) also argues that a manual mode of expression, supported by a facial mode of expression, is likely the immediate antecedent of speech. However Rizzolatti believes that there is a discontinuity in the evolutionary path from the gesticulation to speech; from intrinsic meanings to extrinsic and socially constructed meanings. He proposes four stages of evolution of mirror systems in humans, again with increasing complexity and functionality, from imitation to vocal imitation (Studdert 2002).

- 1) Recognition and replication (imitation) of the actions of a conspecific (??).
- 2) Facial imitation
- 3) Vocal imitation
- 4) Organization of a mirror system in a way that certain anatomical parts of the mirror system engage in certain functions.

Studdert’s stages assume the first four stages of Arbib’s stages. He separates the mechanisms for facial and vocal imitation and in the fourth stage gives a bigger emphasis to the reorganization of the mirror system.

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