What imitation tells us about social cognition: a rapprochement between developmental psychology and cognitive neuroscience

Meltzoff and Decety, 2003

Introduction

- 2 Goals of the review:
  - Discuss similarities between cognitive and neuroscientific findings
  - Propose a theory regarding the connection between the mirror neuron system and the theory of mind

Theory of Mind

- The ability to attribute mental states to oneself and others
- The recognition that each individual possesses their own unique set of mental states
  - Beliefs
  - Intentions
  - Desires
  - Etc.

The Dilemma

- Monkeys have mirror neurons, but no theory of mind
- Humans are proposed to have mirror neurons, **AND** possess theory of mind.

The Link

- Meltzoff suggests that the link between mirror neurons and theory of mind could be motor imitation.

Simple Imitation and its Neural Substrate

- Imitation is Innate
- Proprioception exists at birth and is used in infant imitation

Innate Imitation

Meltzoff and Moore, 1977

Innate Imitation

- Babies knew which body part to use
  - Indicated by movement of the specific body part after perception of congruent stimulus
- However, they did not know how to use the body part properly.

- Take-home message:
  - specific body parts could be neurally represented at birth and serve as a foundation for infant imitation.

Evidence from Neuroscience

- Studies demonstrate activation of the motor cortex during observation of actions
  - Action observation uses neural regions similar to those used for action production

Fadiga et al. 1985

…with-the-intent-to-imitate

- Subjects were instructed to remember actions in order to imitate later
  - Control: …remember actions to recognize them at a later time
- Result: More hemodynamic activation in the SMA, MFG, premotor cortex during intent-to-imitate
  - Top-down effect of intention upon processing of observed action

Decety *et al. 1997*

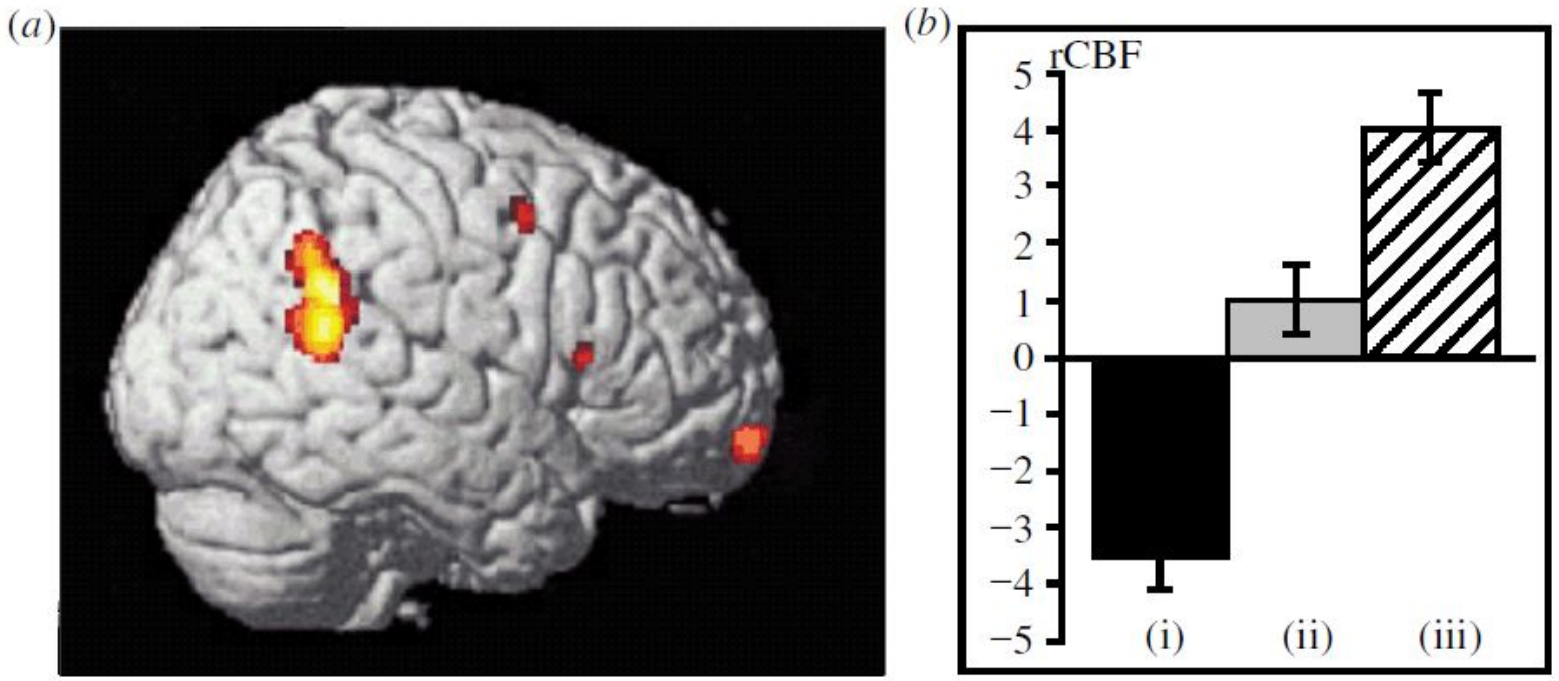
Self-Other Relations

- Imitation seems to be couple with empathy for others.
- Human beings recognize when they are being imitated.
  - Infants also recognize this (Meltzoff 1990)
  - As infants get older, they begin to test the imitator with different motor movements
  - Infants recognize the difference between self and other
    - seem to be exploring the sense of agency involved—
    - who is controlling whom in this situation?

Self-Other Relations

- Decety et al. 2002
  - Activation in **left** Inferior Parietal Lobule when subject imitated
  - Activation in the **right** Inferior Parietal Lobule when subject was being imitated
- Other neuro-studies suggest:
  - Inferior Parietal Cortex is involved in sense of agency

Self-Other Relations



- rCBF indicates regional cerebral blood flow in right inferior parietal lobule
  - i. acted at will
  - ii. direct imitation of experimenter
  - iii. saw actions imitated by experimenter

Reading Others' Goals and Intentions

"Persons are more than dynamic bags of skin that I can imitate and which imitate me."

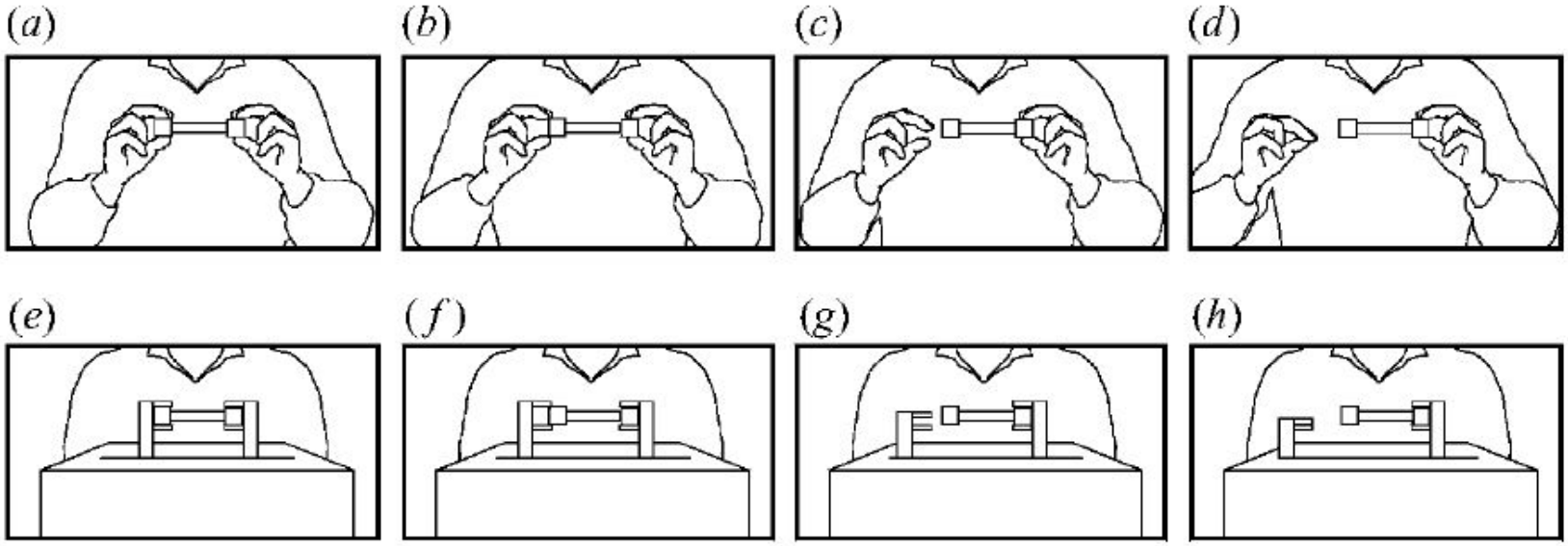
- Meltzoff 1995
  - Infants imitated under 3 conditions:
    - Full action demonstrated
    - Unsuccessful attempt at performing action
    - No attempt
- Results: infants could infer intended goal of unsuccessful attempt
- Ergo, they understand goals even if we fail to fulfill them.

Reading Others' Goals and Intentions

- Experiment:
  - Adult tries to pull apart toy dumbbell and fails.
  - 18 mo. old infant is given a trick dumbbell, glued together, impossible to separate
  - After observing failed attempt,
    - 100% of infants tried to pull apart toy in various ways.
    - 90% looked up at adult, or parents (vocalized/ eye contact) 2 seconds after infant's failed attempt

Meltzoff 1995

Human Intention vs. Machine Intention



- Infants responded to intentions of experimenter but not intentions of inanimate device
  - UNLESS the device succeeded in separating the dumbbell
- Resulting Assumption: Infants can understand successes, but not failures.

Meltzoff 1995

Means and Goals

- Lego Experiment:
  - Subjected had to sequentially move Lego blocks from start position to a specific place
  - Attempted to separate means from goals in order to identify the brain areas involved in each
  - 3 situations:
    - Goal Only: End Lego result was shown.
    - Means Only: Only action process was revealed.
    - Whole action: Action process and end result were shown. (control)

Chaminade *et al. 2002*

Means and Goals

- Lego Experiment:
  - Results:
    - Goal Only & Means Only: Activation in Dorsal Lateral prefrontal area, and cerebellum
    - Means Only: Medial Prefrontal Cortex activation
    - Goal Only: Left Premotor Cortex activation
  - Medial Frontal region activation in Goal Only and Means Only conditions is similar to activation during imitation and mentalizing.

Chaminade *et al. 2002*

So Basically…

- Infant Imitation is Innate
  - Proprioceptive properties help map perception of a body part to the motor representation of that body part
- As infants grow older, they develop a sense of agency, asking “who is imitating whom?”
- This sense of agency helps define the self-other distinction in the human mind

So Basically…

- Human beings therefore can map self-intentions to other-intentions, allowing inference of a goal to be possible early in life
- This essentially is the basis of the theory of mind.

- Ergo, the link between our mirror neurons and the theory of mind can be characterized as **motor imitation**