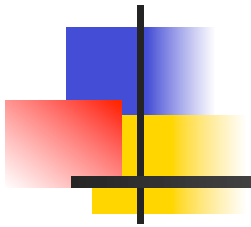


Mirroring and Social Cognition: An Introduction

COGS171

FALL Quarter 2011

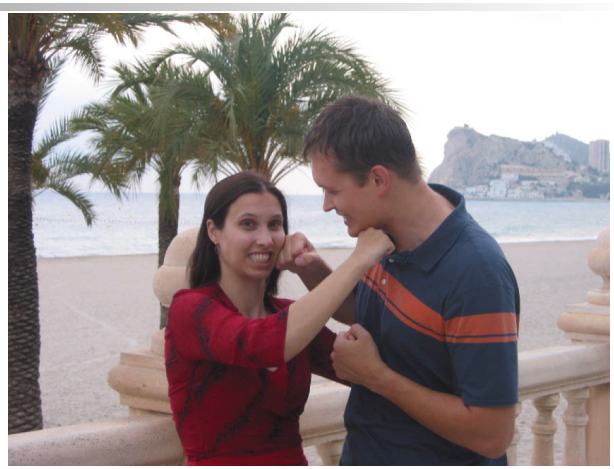
J. A. Pineda

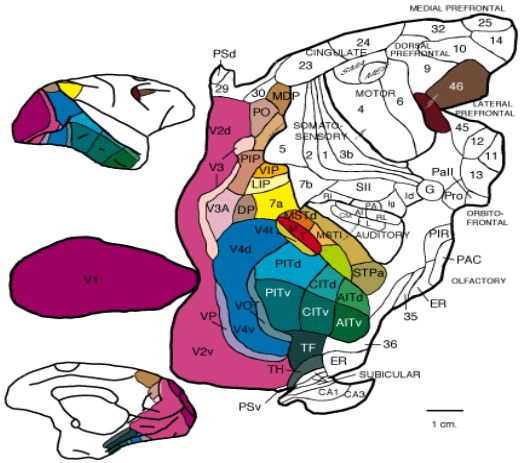
Social Cognition

- Social cognition refers to the mental processes by which we make sense of our social world(s).
- Accounting for these complex dynamics requires an understanding of the cognitive structures and processes that shape the individual's understanding of the social situation
- A core assumption of how humans understand and infer the intentions and beliefs of others is the existence of a functional self-other distinction.

Classic Explanation

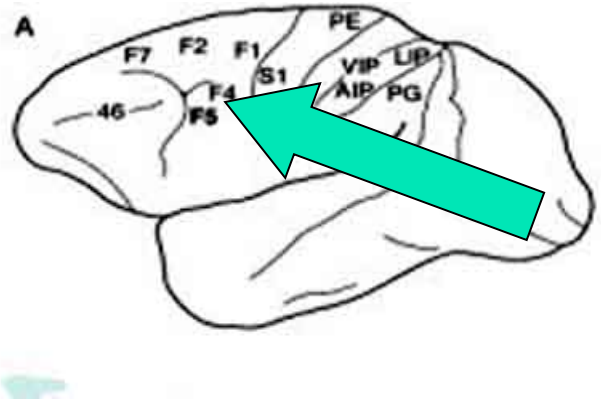
- Theory-Theory
  - argument from analogy
  - disembodied knowledge
  - visual hypothesis





A Different Perspective

- Simulation Theory
  - Direct-matching hypothesis
  - Embodied knowledge
    - Map visual information onto motor representations of the same action
- Mirroring systems
  - Bridges between perception and action that allow for simulation
    - Mirror neurons
    - EEG Mu rhythms



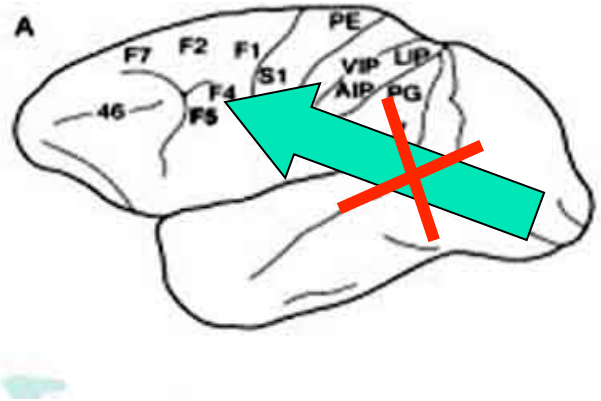
Ideomotor action

"every mental representation of a movement awakens to some degree the actual movement which is its object"

William James

A Different Perspective

- Simulation Theory
  - Direct-matching hypothesis
  - Embodied knowledge
    - Map visual information onto motor representations of the same action
- Mirroring systems
  - Bridges between perception and action that allow for simulation
    - Mirror neurons
    - EEG Mu rhythms



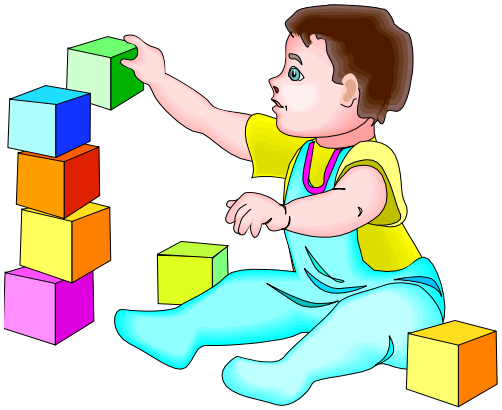
Ideomotor action

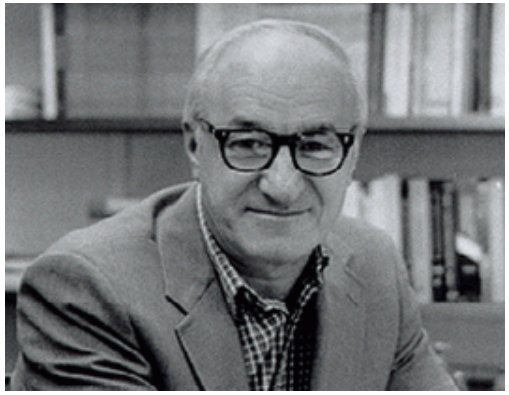
"every mental representation of a movement awakens to some degree the actual movement which is its object"

William James

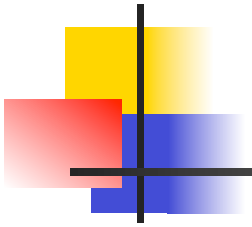
Bandura's (early) Social Learning Theory

- Emphasized the means by which we acquire behavior or **Learning…**
  - Operant Conditioning
  - Classical (Pavlovian) Conditioning
  - But especially, via observational learning or **Imitation**





Albert Bandura



Imitation

"The capability to acquire new skills by observation, based on the imitator's existing behavioral repertoire"

"Learning by observing and mimicking the behavior of others"

This form of learning is not limited to a sensitive period

- Many predators, including cats and coyotes, seem to learn some of their basic hunting tactics by observing and imitating their mother

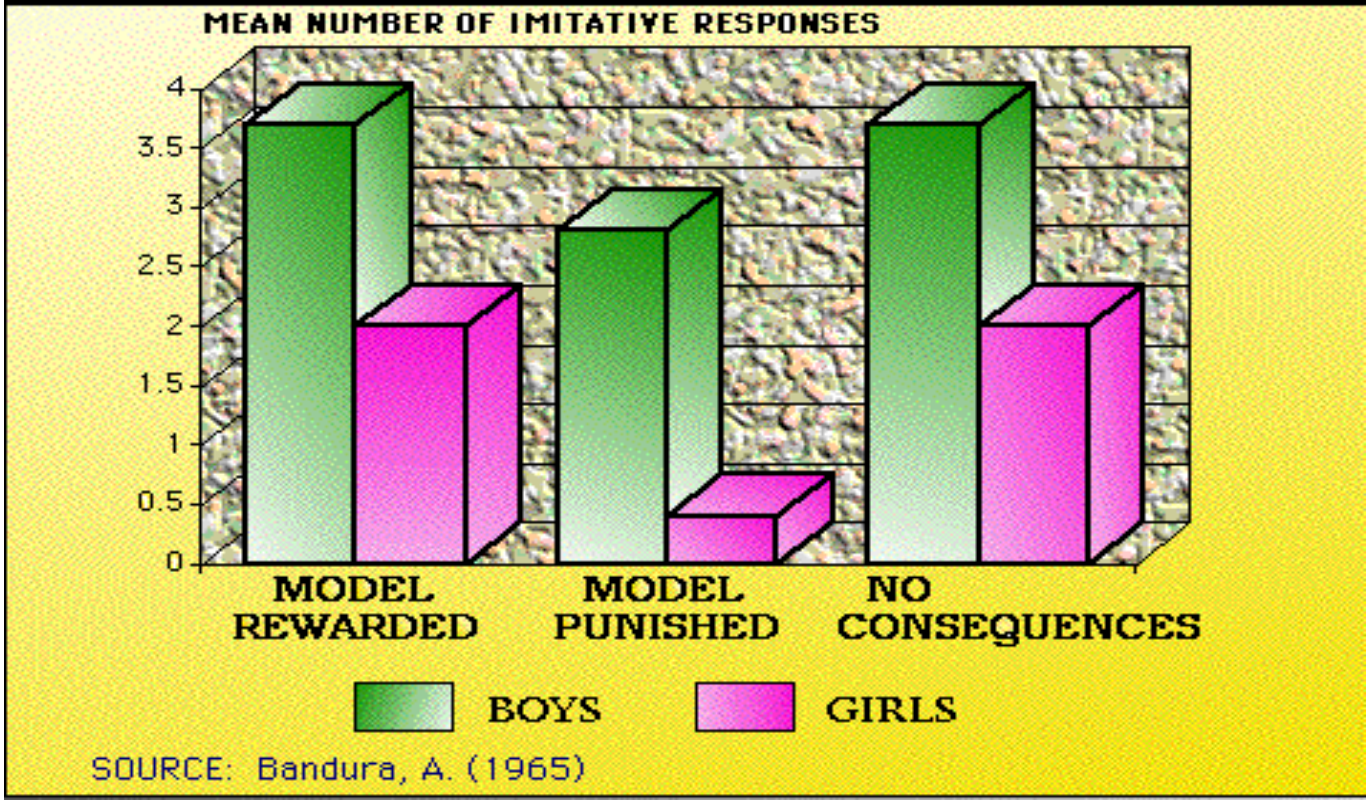
Imitation (cont)

In his "Bobo doll" studies, Bandura showed that children (ages to 6) would change their behavior by simply watching others.

He observed three different groups of children:

- One group of children saw a child praised for aggressive behavior (rewarded)
- A second group saw the child told to go sit down in a corner and was not allowed to play with the toys (punished)
- A third group saw a film with the child simply walking out of the room (no consequence)

EFFECT OF OBSERVED CONSEQUENCE ON IMITATIVE BEHAVIOR

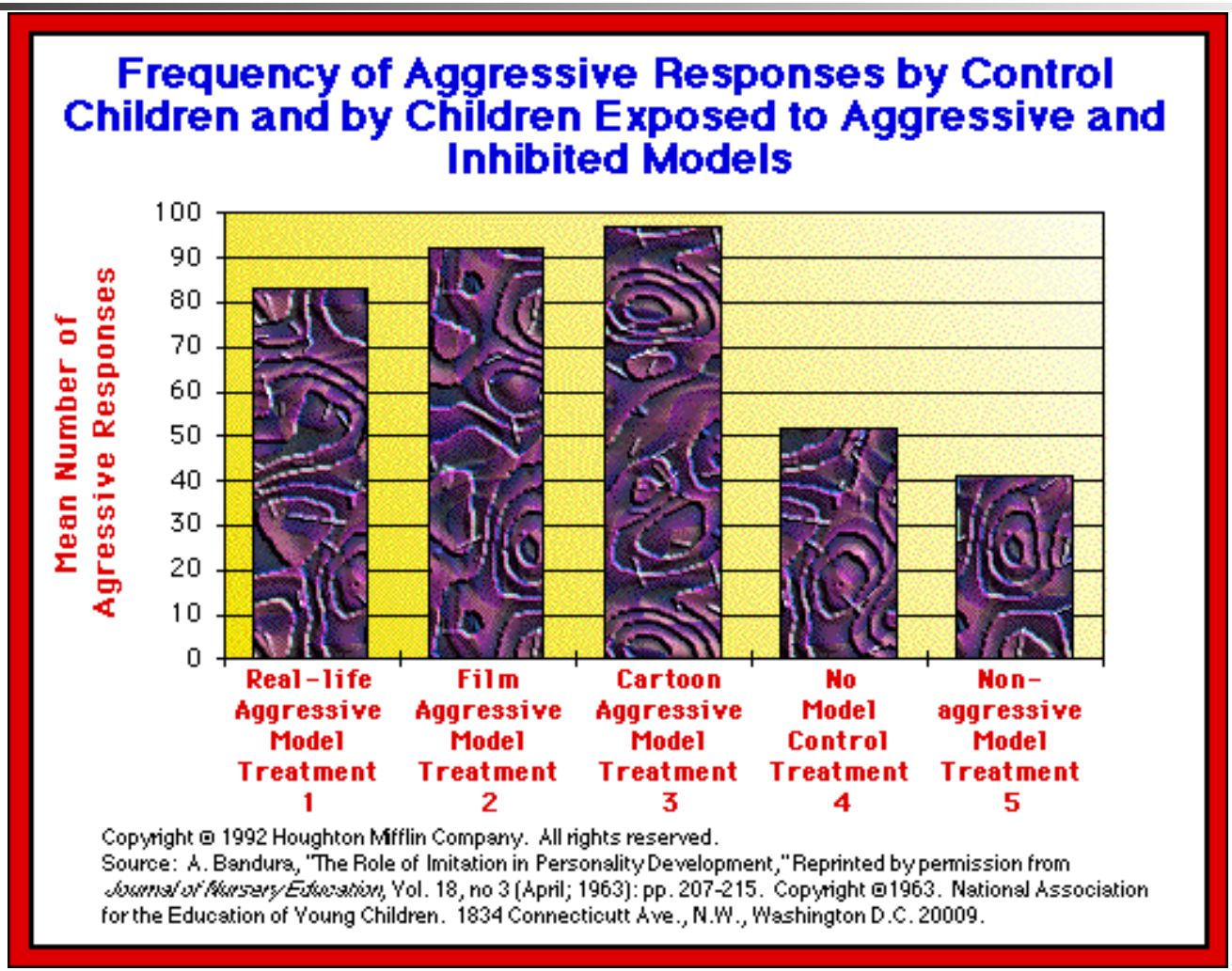


Imitation (cont)

Bandura also demonstrated that viewing aggression by cartoon characters produces more aggressive behavior than viewing live or filmed aggressive behavior by adults.

Furthermore, they showed that having children view prosocial behavior can reduce displays of aggressive behavior.

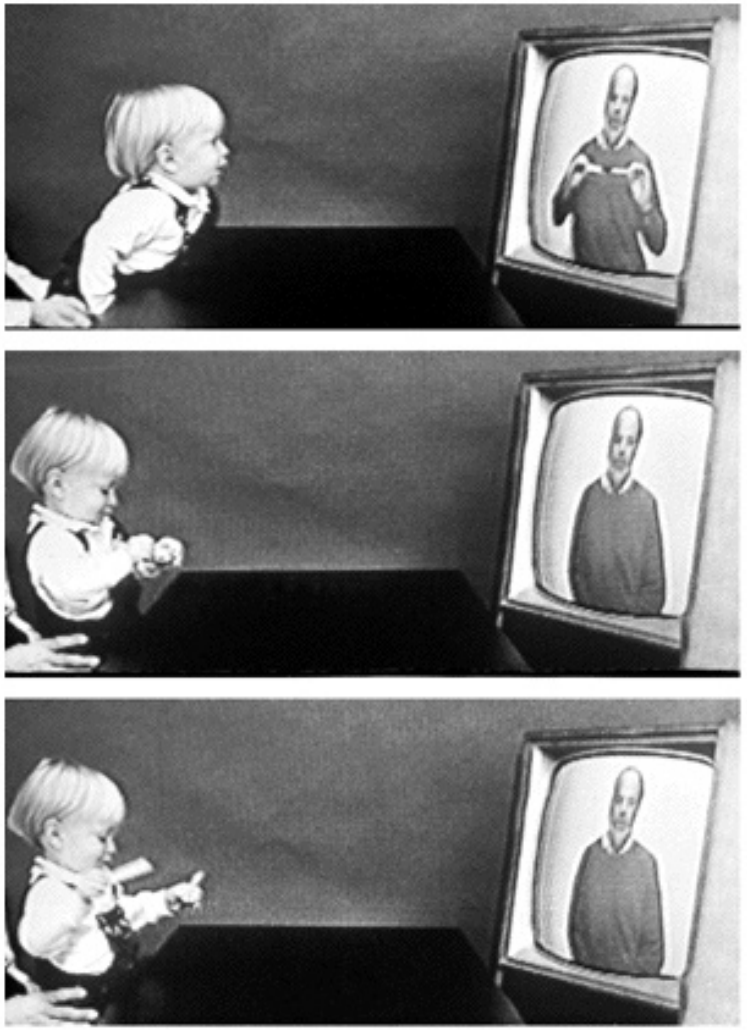
Learning Aggressiveness



Copyright © 1992 Houghton Mifflin Company. All rights reserved.
Source: A. Bandura, "The Role of Imitation in Personality Development," Reprinted by permission from *Journal of Nursery Education*, Vol. 18, no 3 (April; 1963): pp. 207-215. Copyright ©1963. National Association for the Education of Young Children. 1834 Connecticutt Ave., N.W., Washington D.C. 20009.

Imitation via Television

- This 14-month-old boy is imitating behavior he has seen on TV
- Does imitation require a theory of mind or does it create it?

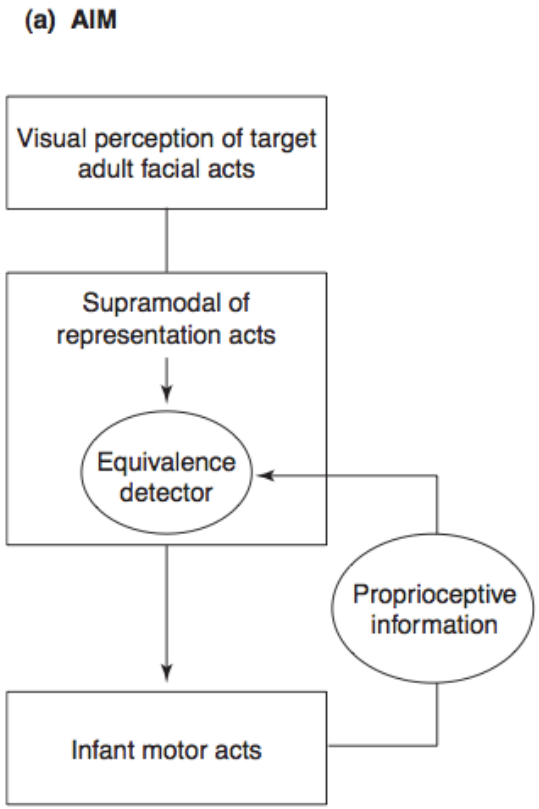


Is Imitation innate?

- Piaget, 1951
  - imitation is learned by 2yrs
- Meltzoff & Moore 1977, 1983
  - Newborns can imitate facial and manual gestures

Interpretations of Neonatal Imitation

- Innate Releasing Mechanisms
  - A reflex mechanism that evolved specifically *for* neonatal imitation of specific gestures
- Coincidence
  - Neonatal imitation "results from a coincidental matching of interesting visual stimuli with infants' behavioral expressions of interest" (p. 1968)
- Active Intermodal Matching (AIM)
  - (Meltzoff & Moore, 1977, 1997)



Emergence of understanding other minds

(Meltzoff, 2005)

Imitation

Intrinsic connection between observed and executed acts, as manifest by newborn imitation (Meltzoff & Moore, 1997).

↓

First-person experience

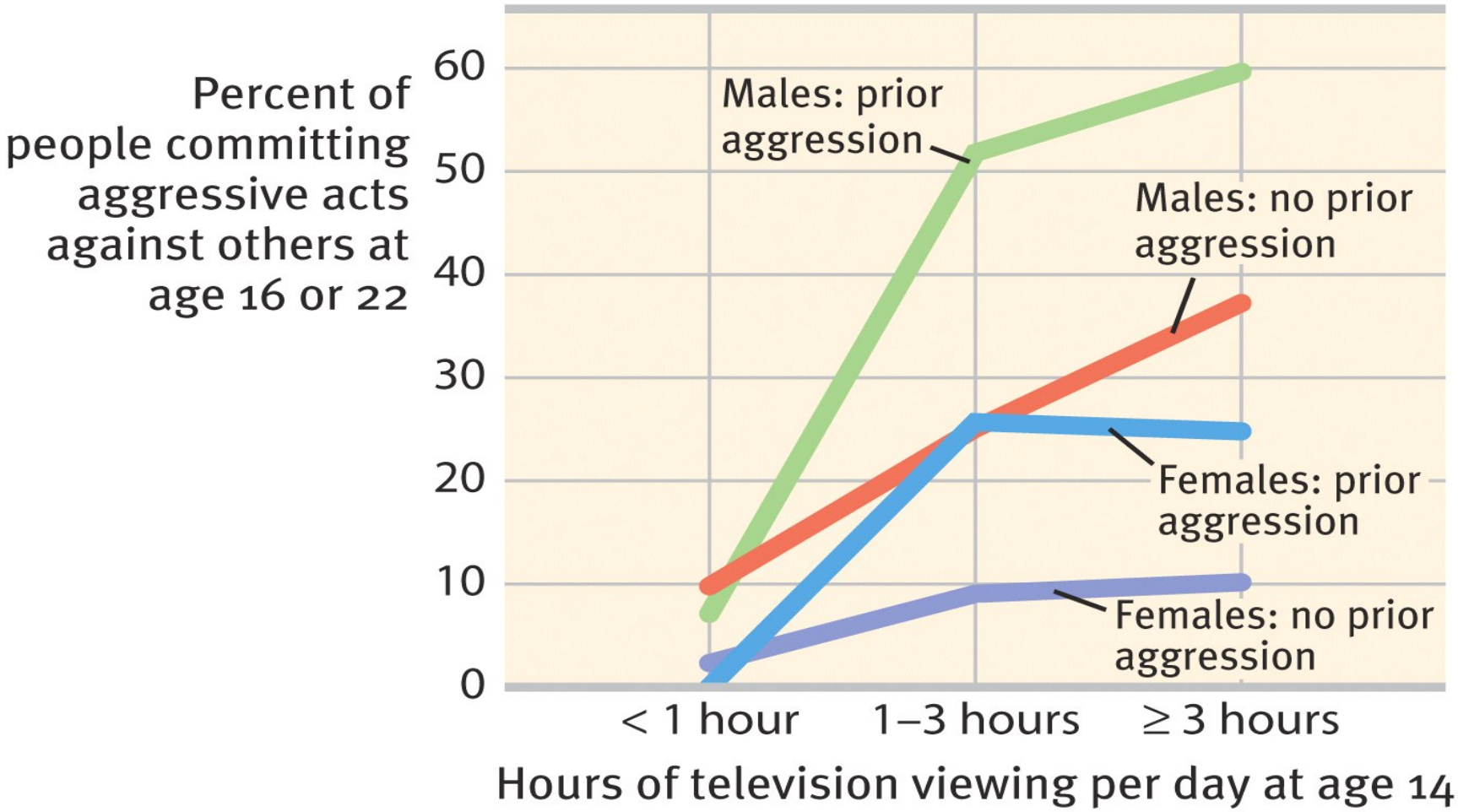
Infants experience the regular relationship between their own acts and underlying mental states.

↓

Understanding Other Minds

Others who act "like me" have internal states "like me."

TV, Imitation, and Prior Experience



Why do we imitate?

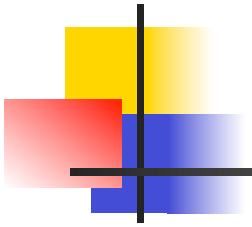
- It is rewarding
  - dopamine release?
- To learn about the world
  - Is it the same for infants and adults?
- A prelude and the facilitator of verbal communication among children
- Facilitates an embodied 'intimacy' between self and others during social relations
  - an intersubjectivity; empathy; mind reading

Echopraxia

- The involuntary repetition or imitation of the observed movements of another.
- Echopraxia as a released behavior (Dromard, 1905; Stengel, 1947; Ford, 1989)
  - Observed in Autism, Tourette's syndrome, 'idiocy', hypnosis, fatigue
- Compulsive imitation observed in patients with Utilization behaviors (Lhermitte et al., 1986): a frontal lobe disorder in which the patient has difficulty resisting the impulse to operate or manipulate objects which are in their visual field and within reach.

What is the basis for this social learning?

- Selective attention
- Motor primitives
- Classification-based learning system
- Specialized neurons



Neural Systems

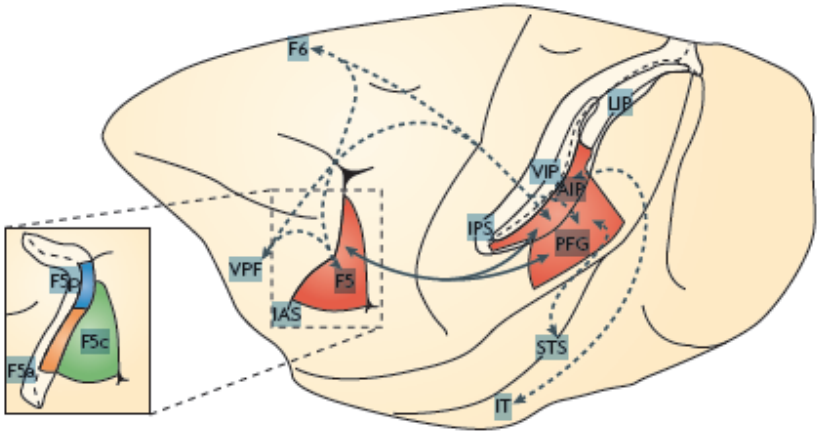
- At least two neural systems have been proposed to manage self/other distinction
  - **Classic motor system**: specialized for the preparation and execution of motor actions that are self realized and voluntary,
  - **Mirroring system**:
    - primarily involved in capturing and understanding the actions of non-self or others.
    - Evolved to share many of the same circuits involved in motor control.
    - Bridge between perception and action that allows for simulation

Mirroring System

- Mirroring or 'shared circuit systems' are assumed to be involved in
  - Resonating
  - Imitating
  - Simulating the actions of others
- Shared representations of motor actions may form a foundational cornerstone for higher order social processes
  - Each time an individual observes another individual performing an action, a set of neurons that encode that action is activated in the observer's cortical motor system.

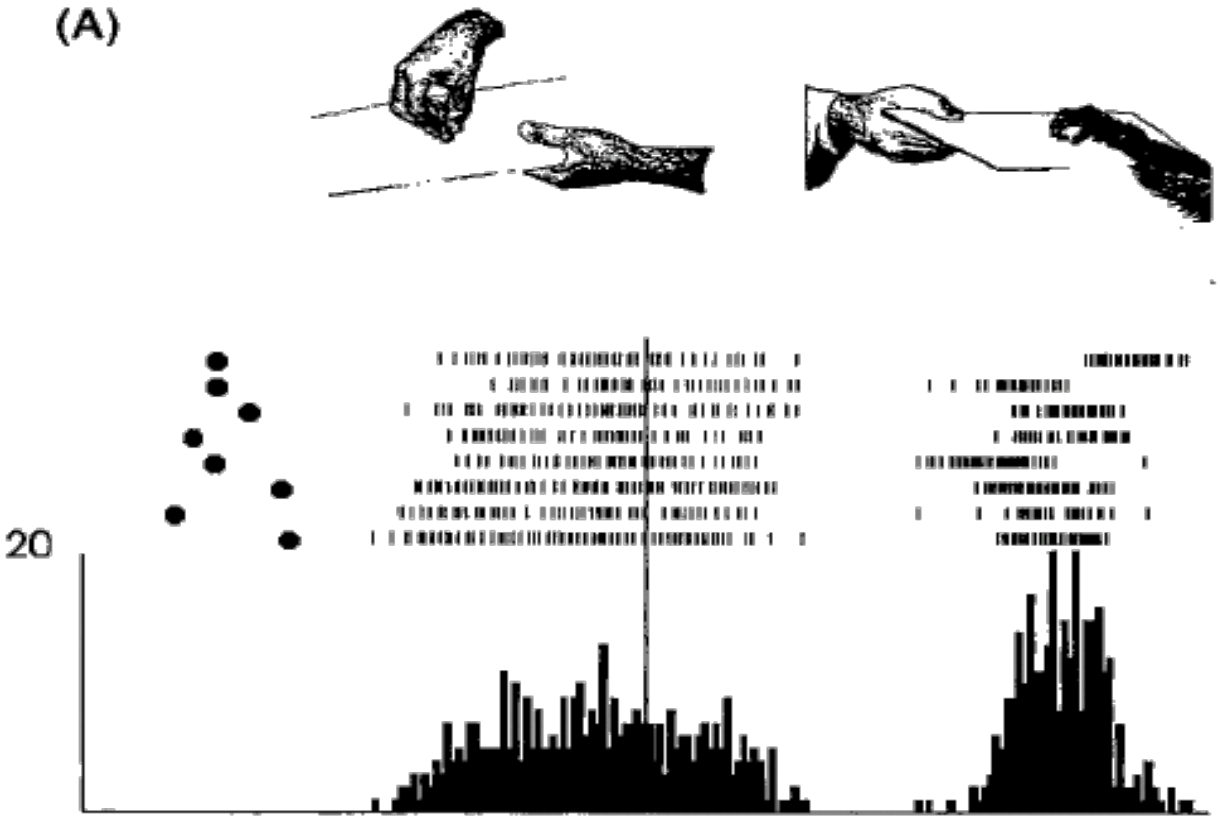
Mirror Neurons in Parietal-Frontal Circuit

- Discharge both when the monkey performs an action and when it observes a similar action done by another monkey or an experimenter
  - **Found in:**
    - area F5 (homolog of Broca's area); 10-20%
    - inferior parietal cortex (PF/7b)
  - **Activated by:**
    - Goal directed actions (reaching, grasping, holding)
    - Observation of similar actions performed by "biological" agents



Rizzolatti and Sinigaglia, Nature Reviews Neurosci, 2010

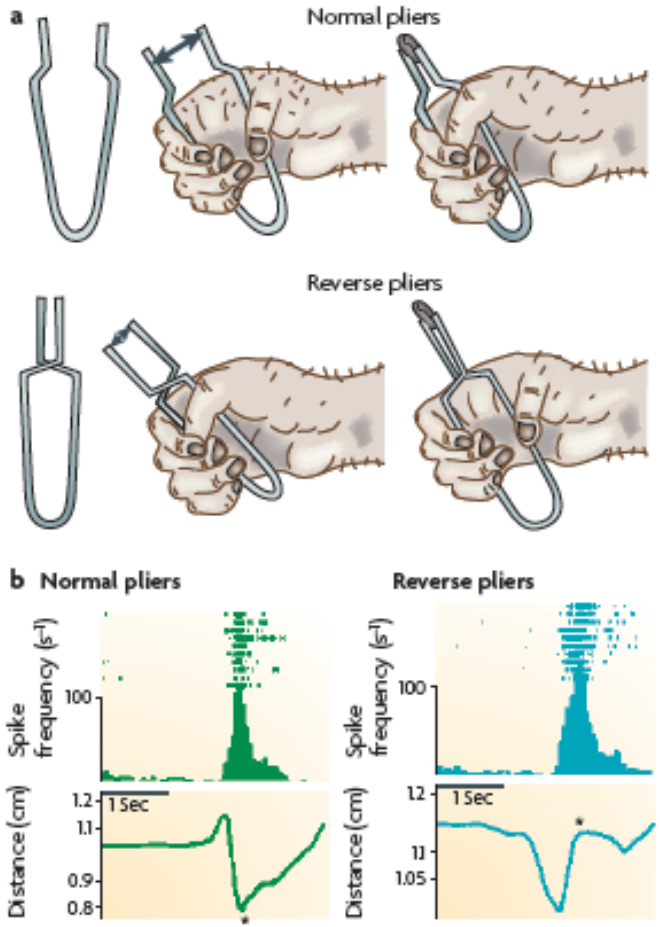
Mirror Neuron Activity



Rizzolatti et al., Cogn. Brain Res., 1996, 3:131-141

What do mirror neurons encode during movement?

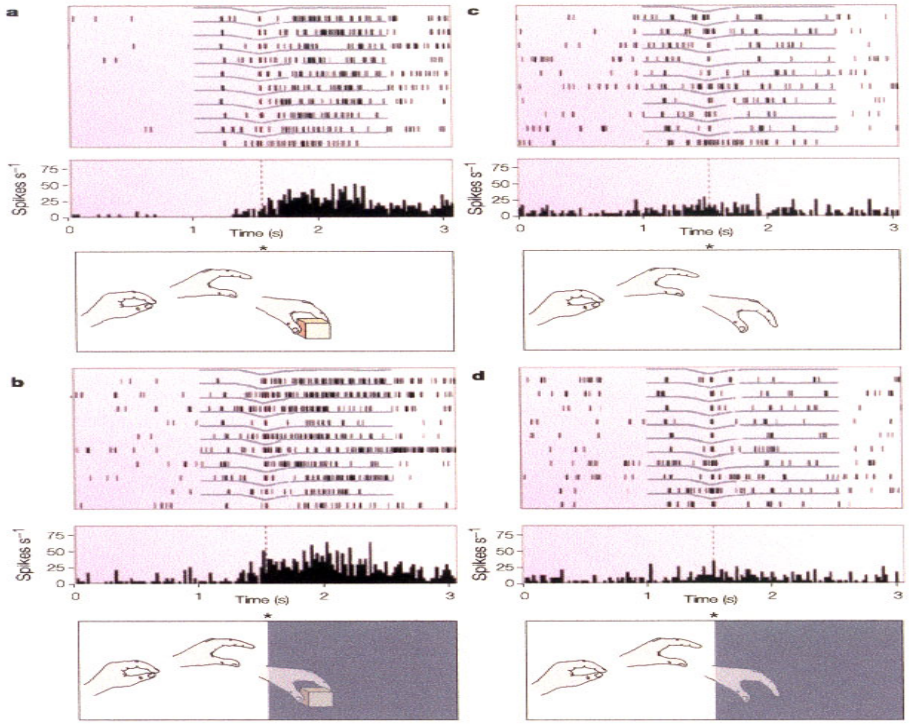
F5 neurons discharged during the same phase of grasping in both conditions, regardless of whether this involved opening or closing of the hand



Umiltà, M. A. *et al. Proc. Natl Acad. Sci. USA,* 2008.

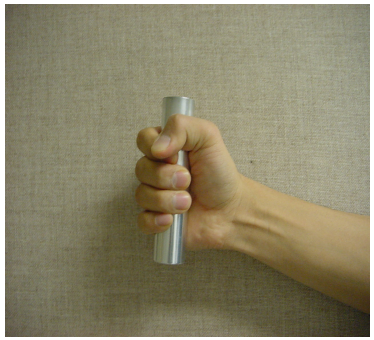
What do mirror neurons encode during observation?

Grasping Mimicking

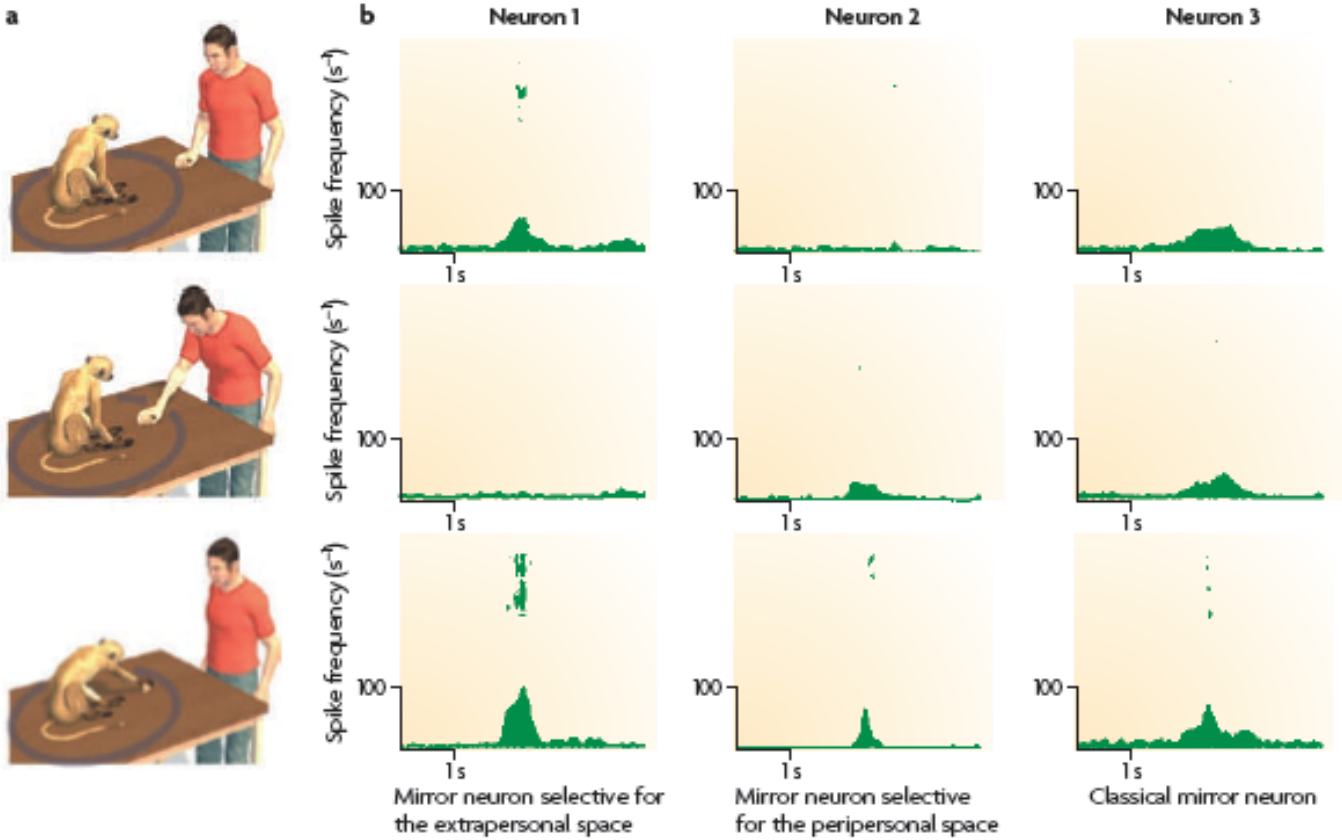


Umiltà et al. Neuron, 2001

Perception-to-Action Mapping Selectivity

	Congruent (effector dependent)	Logically-Related (effector independent; 2X)
Perception		
Action		

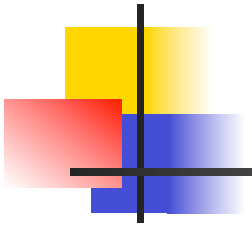
Encoding goal in an observer-centered spatial framework



Why does the motor system encode the goal of actions performed by others?

- Allow the observer to understand directly the goal of the actions of others without needing inferential processing
- …although there are several mechanisms through which one can understand the behaviour of other individuals, the parieto-frontal mechanism is the only one that allows an individual to understand the action of others 'from the inside' and gives the observer a first-person grasp of the motor goals and intentions of other individuals.

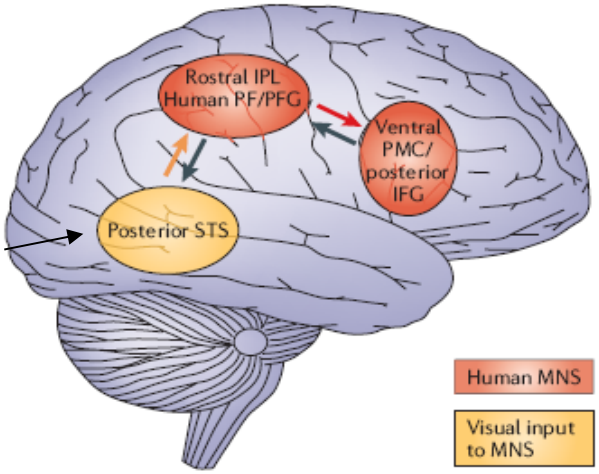
Rizzolatti and Sinigaglia, 2010

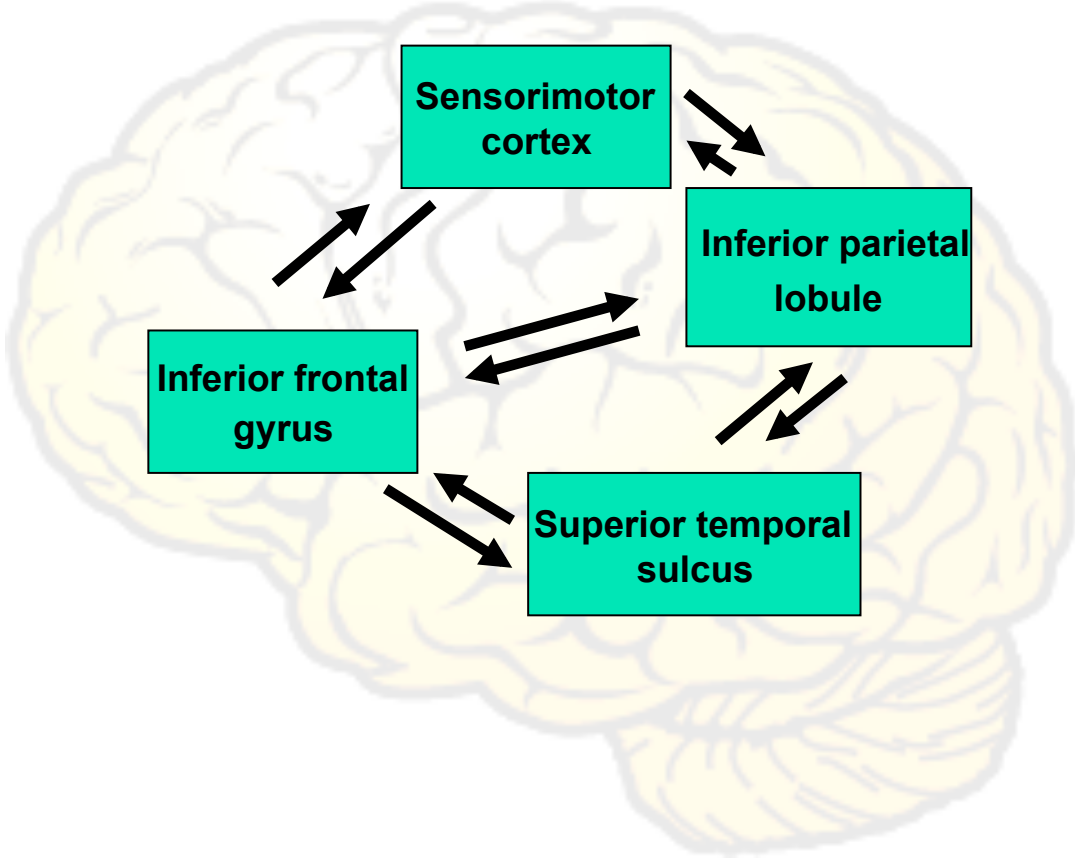


Differences Between Monkey/Humans

- Monkeys imitate the goal and not the individual movements;
- In humans, the mirroring system also becomes active during the observation of individual movements
- Mirror neurons seem tailor-made for imitation; yet monkeys (at least) are rotten imitators (monkeys aren't chimps)
  - maybe necessary element but not sufficient

The Mirror Neuron System





Iacoboni and Dapretto, Nature Reviews, 2006,7:942-951

Pineda, Beh & Brain Functions, 2008, 4, 47

Functional Significance

- Response facilitation
- Mimicry
- Simulation
- Imitation learning
- Understanding actions
- Understanding intentions
- Empathy
- Theory of Mind
- Language

Controversy: Do human MNs exist?

- Some have argued that the activation of the same areas during action observation and action execution via fMRI is not sufficient to prove the existence of the mirror mechanism in humans
- Motor areas have distinct, segregated populations of visual and motor neurons, the visual neurons discharging during action observation and the motor neurons during action execution.

Repetition–Suppression Technique

- If mirror neurons exist in humans, they should ‘adapt’ when the observation of a motor act is followed by the execution of that motor act, and *vice versa.*
- True only when information repeatedly reaches a neuron through the same or largely common pathways

Other Controversies/Questions

- Do MNs reflect understanding?
- Do they reflect intention?
- Are they born or made?
- Is the system broken in patients with social deficits?
- Are they the basis for theory of mind, empathy, language?

Watching actions you can do or can't do…
Imitating what we know

Dance videos

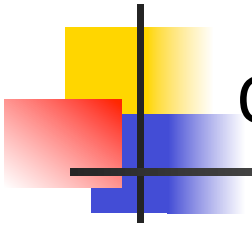
	Ballet	Capoeira
Subjects		
Ballet dancers	Expert	Non-expert
Capoeira dancers	Non-expert	Expert

Expert vs non-expert

Mirror neuron areas

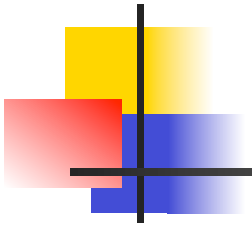
Experts show more mirror system brain activity than non-experts

Calvo-Merino et al., Cerebral Cortex (2005)



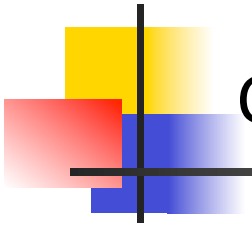
Other Problems

- Mirroring systems present at least three problems
  - Correspondence
  - Development
  - Control problem



Problems (cont)

- Correspondence
  - How does the observer agent know what the observed agent's resonance activation pattern is?
  - How does the matching of motor activation patterns occur?



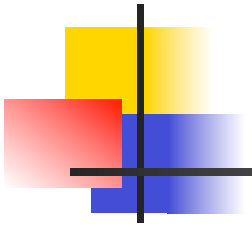
Correspondence Problem

- **Common coding** facilitates imitation, avoiding the correspondence problem and the need for translation between input and output codes

- What are the neural mechanisms possible for common coding?

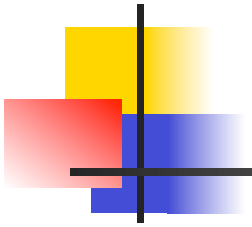
  - **Canonical neurons**: fire when an animal perceives an object that affords a certain type of action and when the animal performs the afforded action

  - **Mirror neurons**: fire when an animal perceives another agent performing a type of action, and also when the animal performs that type of action itself



Problems (cont)

- Developmentally
  - How does a mirroring system arise?
  - How do humans acquire the ability to simulate through mapping observed onto executed actions?
  - Are mirror neurons innate and therefore genetically programmed?
  - To what extent is learning necessary?



Problems (cont)

- Control
  - How to efficiently control a mirroring system when it is turned on automatically through observation?
  - Or, as others have stated the problem more succinctly: “Why don’t we imitate all the time?”

What Is It Like To Be…?

Can aspects of subjective experience be reduced to brain activity?

Thomas Nagel, The Philosophical Review 83 (1974).

Mirroring: A Fundamental Organizational Feature of the Brain?

"Understanding others as intentional agents may be grounded in the relational nature of our interactions with the world"

- Beyond understanding actions
  - What's the role of experience?
  - Context?
  - Attention?
  - Emotions and the root of empathy?
  - Sounds and other senses?
  - Relationship to Language?

- Problems in "mirroring"
  - Consequences of mirroring dysfunction?
  - Aberrant imitation learning: addiction?