The mirror neuron system
and the consequences of its dysfunction

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"A key aspect of social interaction is the ability to understand the mental states of other people." [1]
Outline

1. The Mirror Neuron System (MNS)
2. Intention Coding
3. MNS and Speech
The Mirror Neuron System (MNS)

- Found in an experiment in the early 1990’s [2]
- In macaque monkeys
- Later the human MNS has been discovered using fMRI studies
Mirror Neurons in Monkeys

- Recorded activity from 532 neurons in F5 pre-motor cortex area
- The monkey had to perform hand actions
- 92 of the neurons fired when the monkey observed an action
Mirror Neurons in Monkeys

Figure: Discharge of a single cell [3].
No Activation for Object Movement

Figure: Discharge of a single cell [3].
No Activation for Mimic Action

Figure: Neural discharge in mimic condition [4].
Activation in Hidden Condition

Figure: Neural discharge in hidden condition [4].
Properties of Mirror Neurons

- They fire during goal-directed actions
- They fire when observing the same action, or parts of it
- Firing is not modulated by the object that is interacted with
The Mirror Neuron System (MNS)

**Location of the MNS**

- **PMC:** motor dominant neurons
- **IPL:** visual dominant neurons
- **STS:** visual input to MNS

**Figure:** MNS in the human brain [1].

David Kappel The mirror neuron system
Classes of Mirror Neurons

- *strictly congruent*: Respond to one specific action (e.g. precision grip)

- *broadly congruent*: Respond to a more abstract class of actions (e.g. various types of grips)
Other Types of Mirror Neurons

- placing, holding, mouth actions...
- related to sound (breaking peanuts)
- tool usage
- lateraliced neurons
- direction specific neurons
- many more...
What is it good for?

- Important system for imitation
- Crucial for social cognitive skills
- Also involved in emotion recognition from faces
- Children with autism showed reduced activity in MNS
Intention Coding

- Cells that code for intention
- When observing similar actions
- Found in humans and monkeys
Intention Coding

Observing two similar actions, e.g. picking up a cup:

- once with the intention to drink
- once with the intention to take it away
Intention Coding

Figure: Grasping intentions with mirror neurons [1].
MNS and Speech

Arguments that link mirror neurons and speech:

- Anatomical homology between area F5 and Broca area
- Role in creating a *common code*
- Activation of motor speech areas during speech perception
- The laterality of the auditory mirror neuron system
Activation of Motor Speech Areas During Speech Perception

- Listening to words with strong tongue usage activates tongue motor area [5]

- 'Real' words activate these areas more than pseudo-words

- Supports the *motor theory of speech perception*
Activation of Motor Speech Areas During Speech Perception

Figure: Activation of tongue moving neurons during speech perception [5].
The Laterality of the Auditory MNS

- Visual MNS is bilateral
- *But:* Auditory system is mono-lateral
- Action sounds only facilitate left hemisphere
Summary

- The MNS codes very abstract and complex actions in single cells

- Aspects of social cognition can be grounded in a neural system
Thank you for your attention
References

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