Action observation and action imagination: from pathology to the excellent sport performance
Imitation

Meltzoff & Moore, Science 1977
Rizzolatti and the Parma’s group: The mirror system
Open problems for Mirror neurons

• Normally is not possible to study single neurons in the human brain, so most evidence for mirror neurons in humans is indirect.
• The function of the mirror system is a subject of much speculation:
  – Are the neurons active when the observed action is goal-directed? Or is a pantomime of a goal-directed action?
  – How do they “know” that the definite action is goal-directed or is a pantomime of the goal-directed action?
The primary motor cortex (M1)

• M1 may have a role in action recognition and skill acquisition

• Imagery (a cognitive process that involves multiple areas) may lead to potentiation of output from M1 (which is involved directly in execution)

• We may expand the knowledge about the role for forward models
Action observation and imagination

• The motor cortex “resonates” for
• Muscle specific activation
  – Body’s parts
  – Task parameters
    • direction-amplitude, object’s dimensions
• Internal action simulation
  – Action prediction
    • correct vs erroneous
    • fake movements
Motor Cortex

To obtain evidence of motor cortex activity during observation and imagination of different movements
TMS-EMG
Muscle specificity
Imagine ...Observe...

Control  FDI  ADM

EIP
Muscle-specific for action observation and imagination

FirstDorsalInterosseus
AbducturDigitiiMinimi
ExtensorIndicisProprius

Bufalari et al. Biol. Psych. 2010
Romani et al., Neuroimage, 2005
Distonic hand
Observing pathological actions

Fiorio et al. Neuroscience, 2010
FDI Muscle

Fiorio et al. Neuroscience, 2010
Imagine to hold a sphere
Hold a sphere

Cesari et al. Neuropsychologia 2011
Small Spheres

Imagination

Actual Action

Cesari et al. Neuropsychologia 2011
Medium spheres

**Imagination**

**Actual Action**

*Cesari et al. Neuropsychologia 2011*
Large Spheres

Cesari et al. Neuropsychologia 2011
the density
density

**Imagination**

**Actual Action**

---

Cesari et al. Neuropsychologia 2011
Movement direction and amplitude

Pizzolato et al. Neuroscience 2012
Small Amplitude

Large Amplitude

Clockwise Direction

Counter Clockwise Direction

Pizzolato et al. Neuroscience 2012
Imagination

Actual Action

Pizzolato et al. Neuroscience 2010
Muscle specificity

FirstDorsalInterosseus

AbducturDigitiminimi

ExtensorIndicisProprius

Bufalari et al. Biol. Psych. 2010
Romani et al., Neuroimage, 2005
Results: the two hemispheres
Inherent capacity to recognize other people’s actions

Observing

Performing

Perfectioning
These motor ideas may provide the neurobiological basis for space representation and understanding of actions made by others.

It may be hypothesized that motor knowledge can be used to anticipate a sequence of actions when perceiving human motion. We may use predictive mechanisms which require pre-selection of relevant sensory information -- like athletes do!
We asked whether there is a correlation between the ability to perform and to recognize an action.

Combining the two areas of research:

Bridging the gap between psychological research on expertsies and neuroscientifc models of the basic mechanism that support sporting success

Observer → Athletes vs sport-journalist/non-athlets

Action Observed → Specific vs non-specific Sport action

Measures → Psychophysics/TMS
Players

Journalists

Non-Players

Players

Journalists

Non-Players

The wrist angle different between IN and OUT at the instant of the ball throw.

The knee angle different between IN and OUT at the very beginning of the action.
Figure 2. Mean raw MEP amplitudes (+SE) for the face-touching (FT), no face-touching (NFT), static image (S), and baseline (BL) conditions. *p < .05.