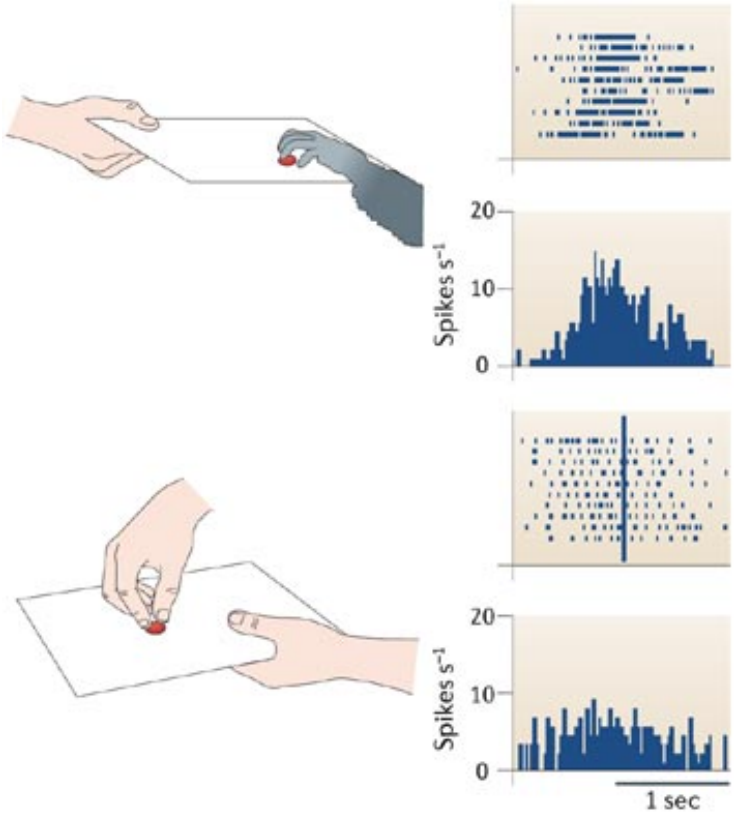
DNM
Dipartimento di
Scienze Neurologiche
e del Movimento

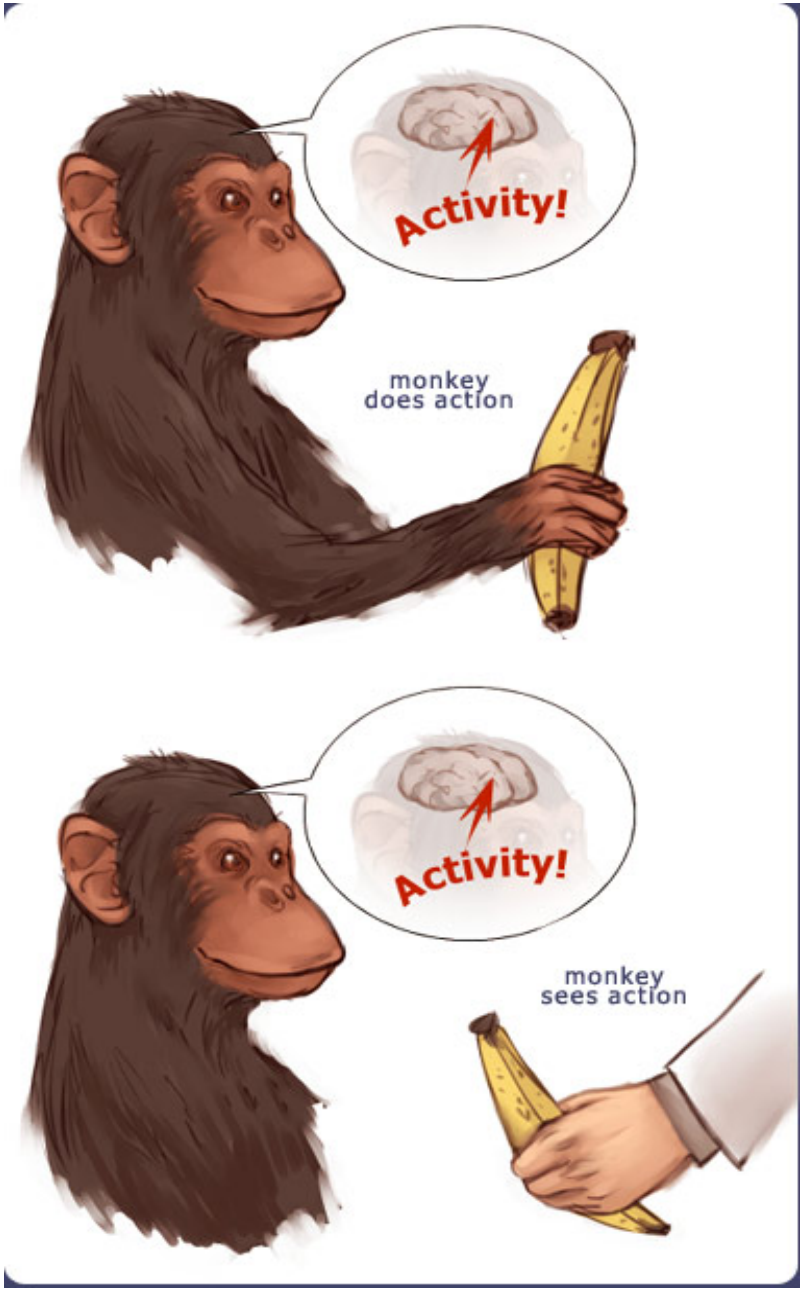
Action observation and action imagination: from pathology to the excellent sport performance

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

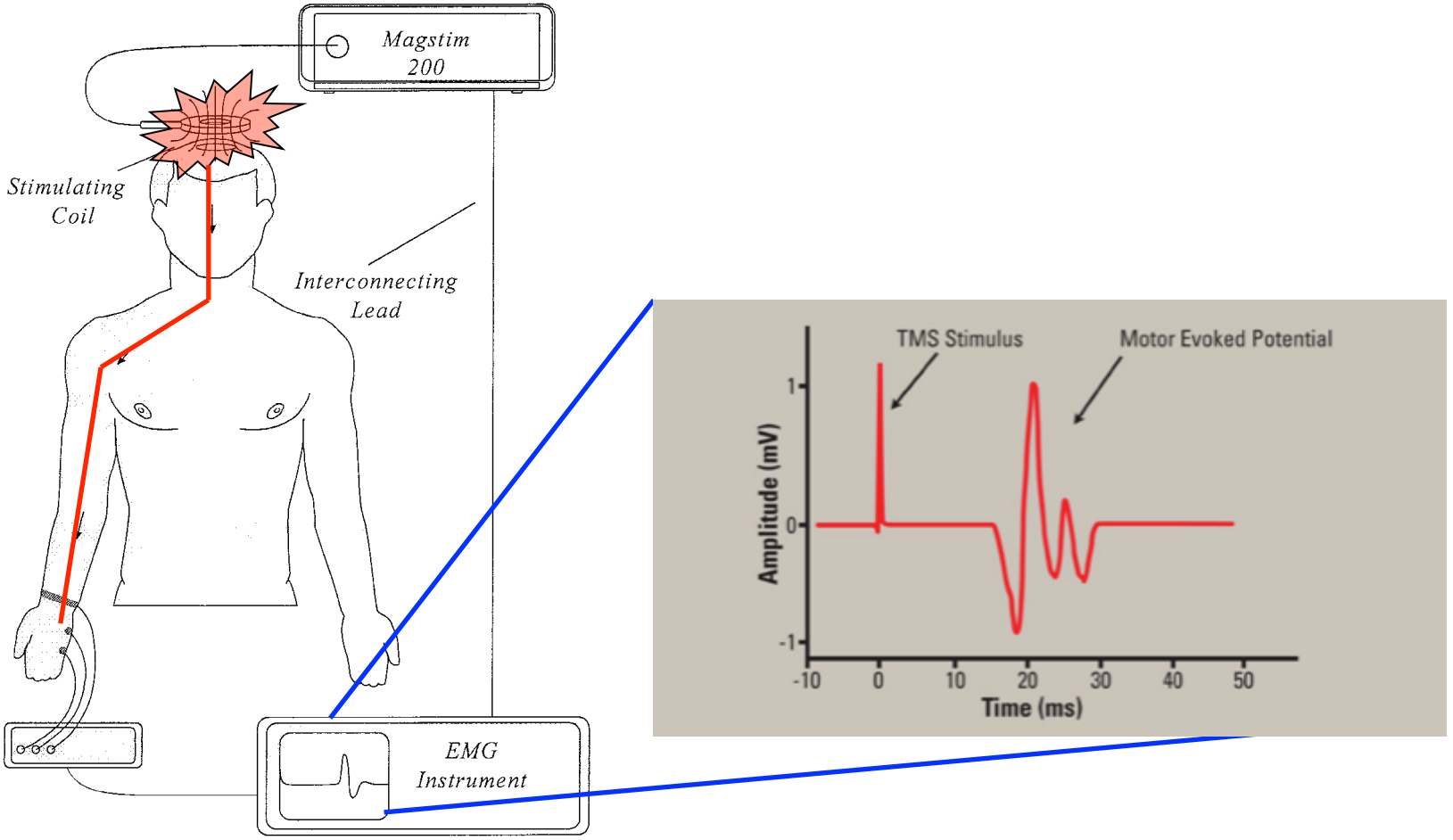
Action observation and imagination

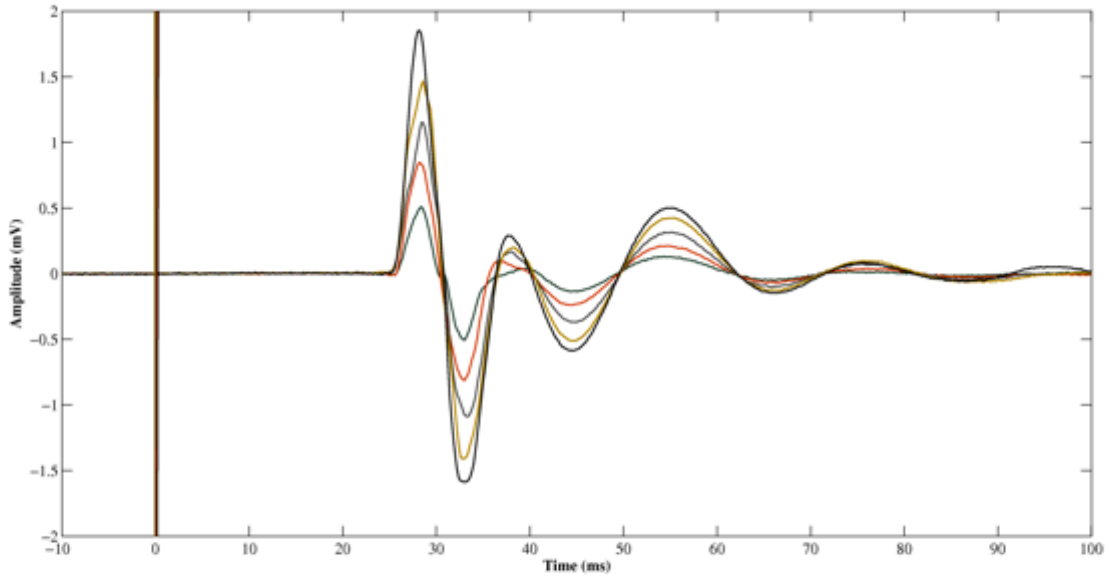
- The motor cortex “resonates” for
- Muscle specific activation
  - Body’s parts
  - Task parameters
    - direction-amplitude, object’s dimensions
- Internal action simulation
  - Action prediction
    - correct vs erroneous
    - fake movements

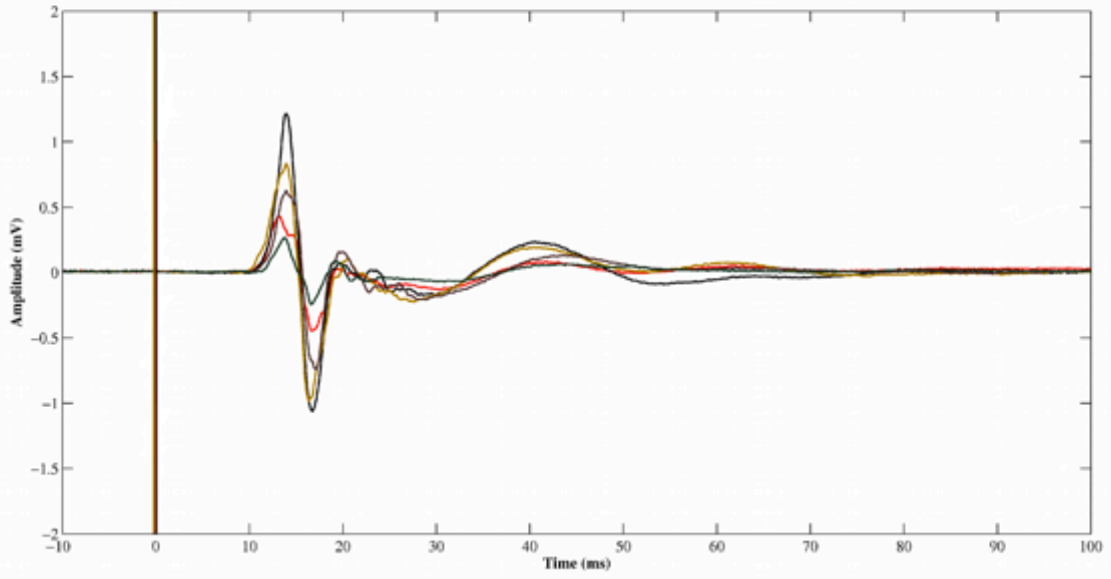
Motor Cortex

To obtain evidence of motor cortex activity during observation and imagination of different movements

TMS-EMG


Magstim
200
Stimulating
Coil
Interconnecting
Lead
EMG
Instrument
TMS Stimulus
Motor Evoked Potential
Amplitude (mV)
1
0
-1
-10
0
10
20
30
40
50
Time (ms)


Amplitude (mV)
Time (ms)


Amplitude (mV)
Time (ms)

Muscle specificity

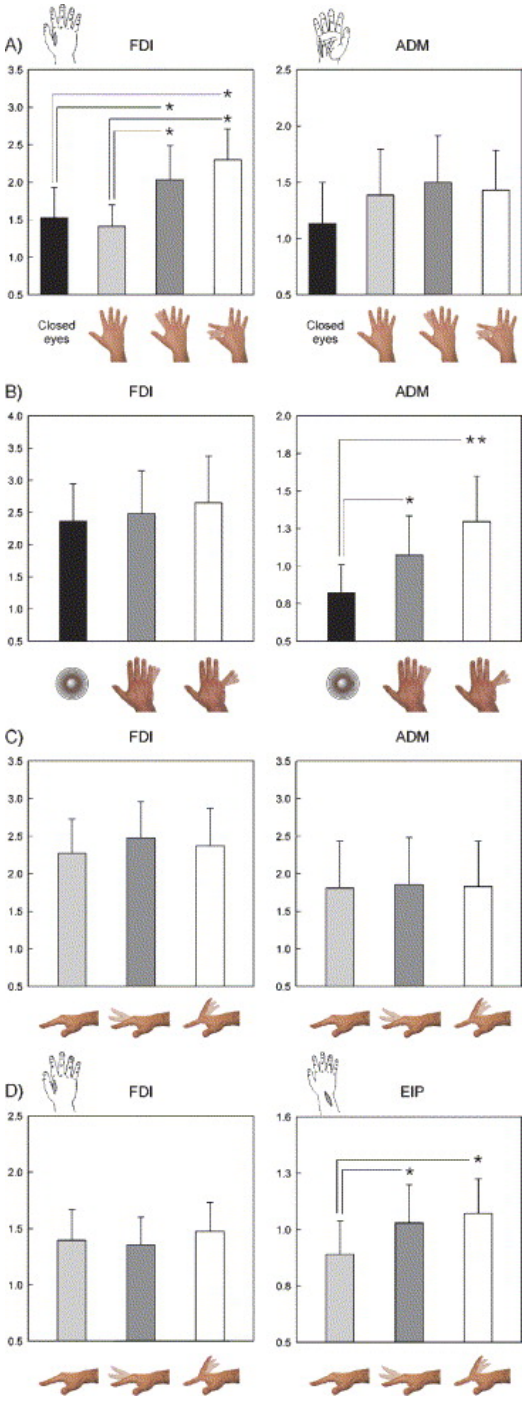
Imagine …Observe…

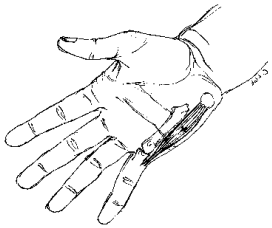
Control

FDI

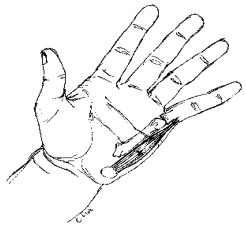
ADM

EIP

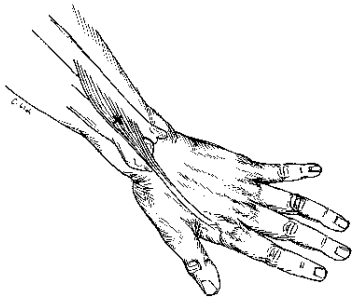




FirstDorsalInterosseus



AbducturDigitiMinimi



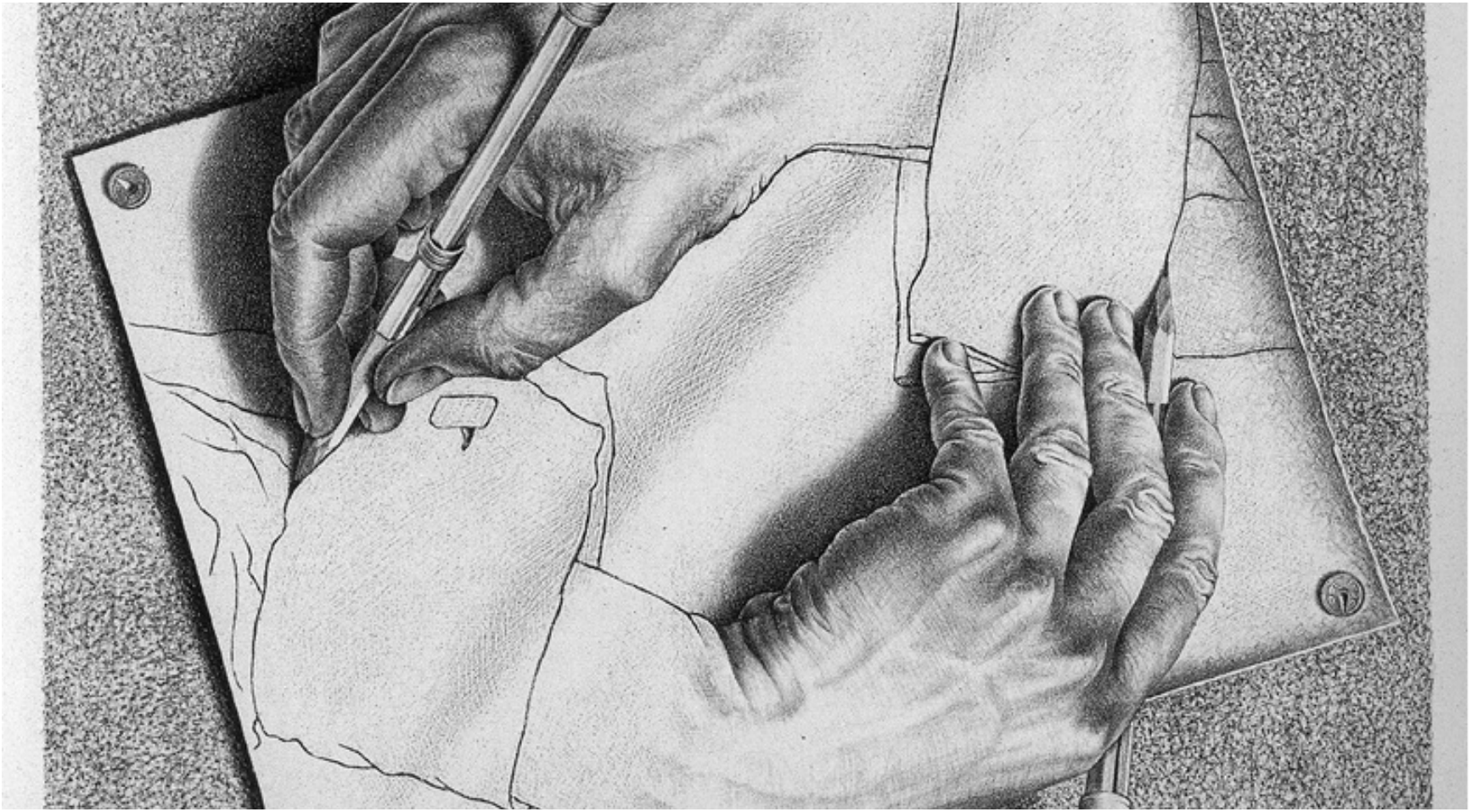
ExtensorIndicisProprius

Muscle-specific for action observation and imagination

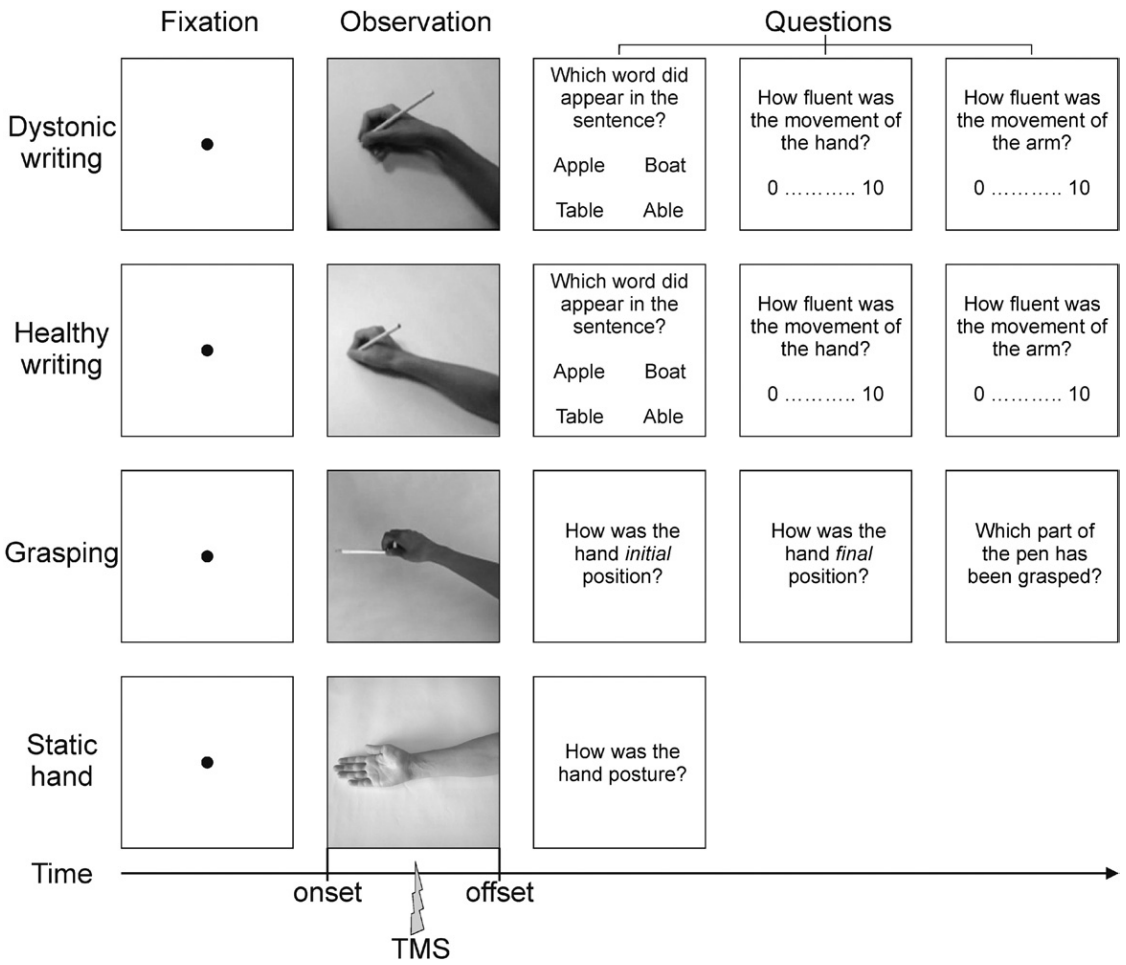
Bufalari et al. Biol. Psych. 2010

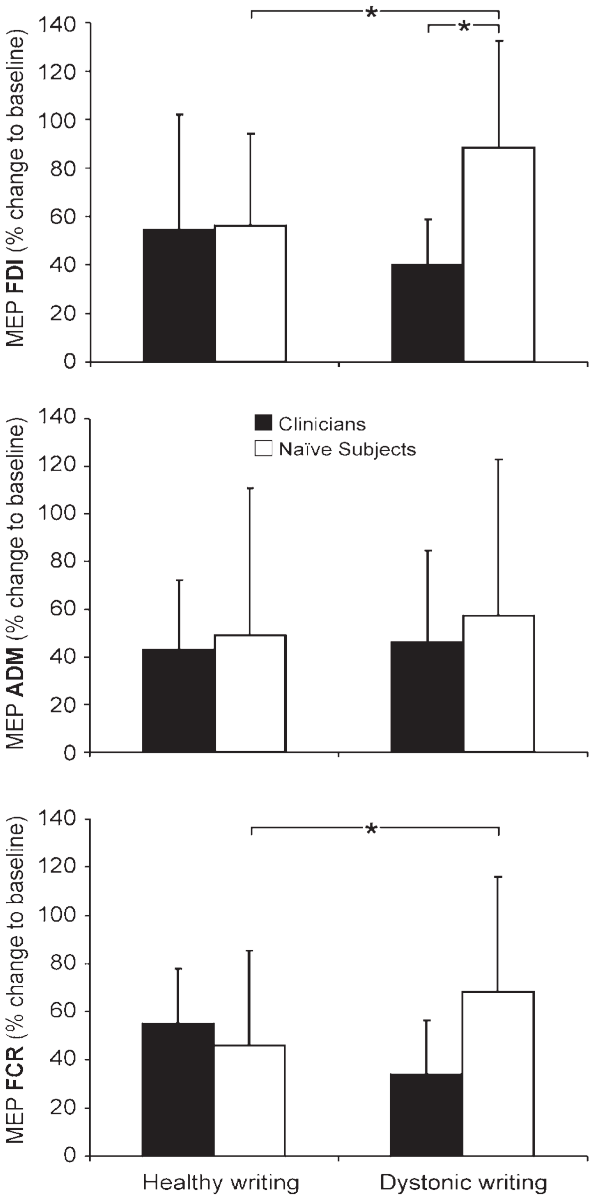
Romani et al., Neuroimage, 2005

Distonic hand



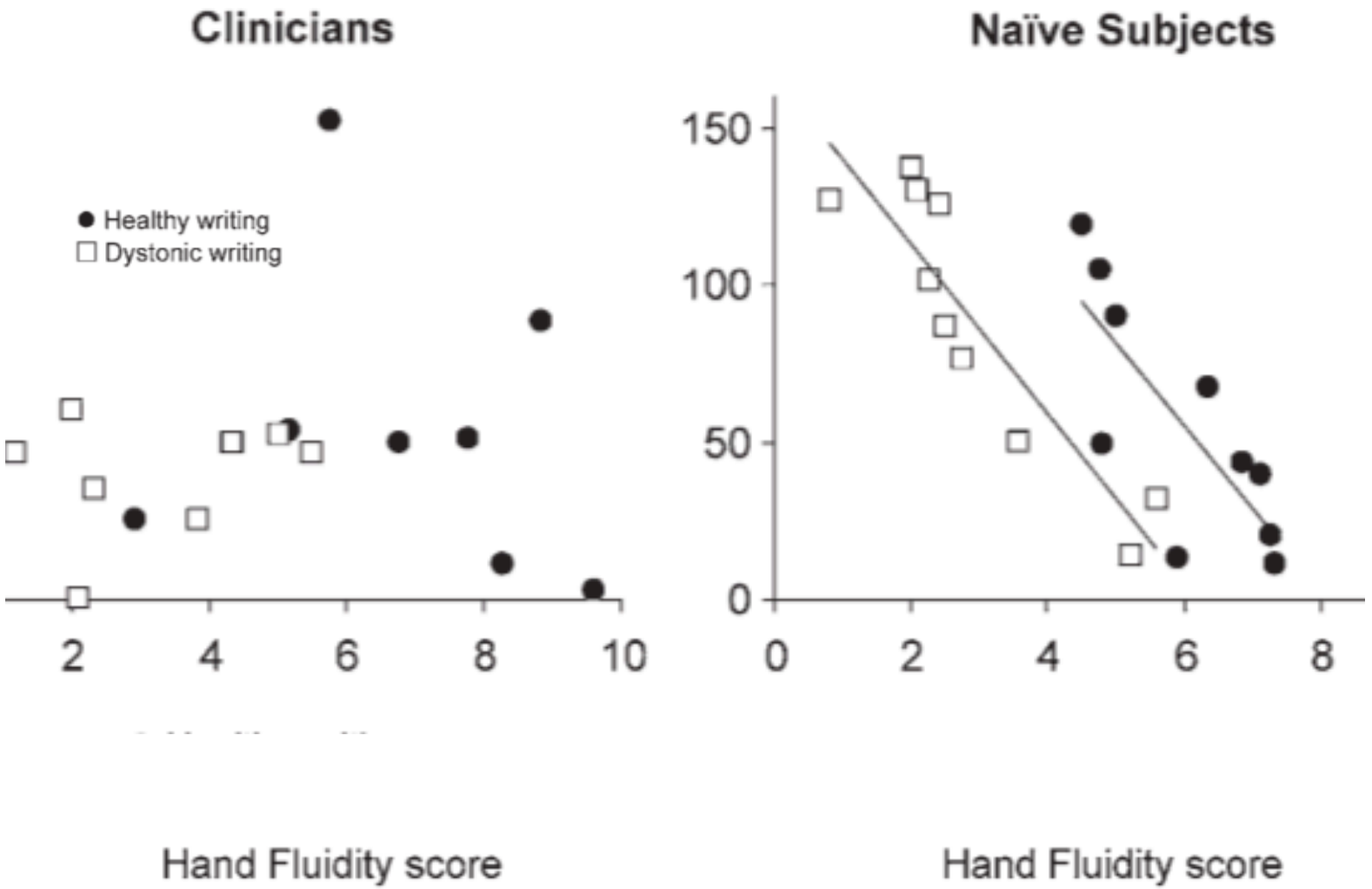
Observing pathological actions





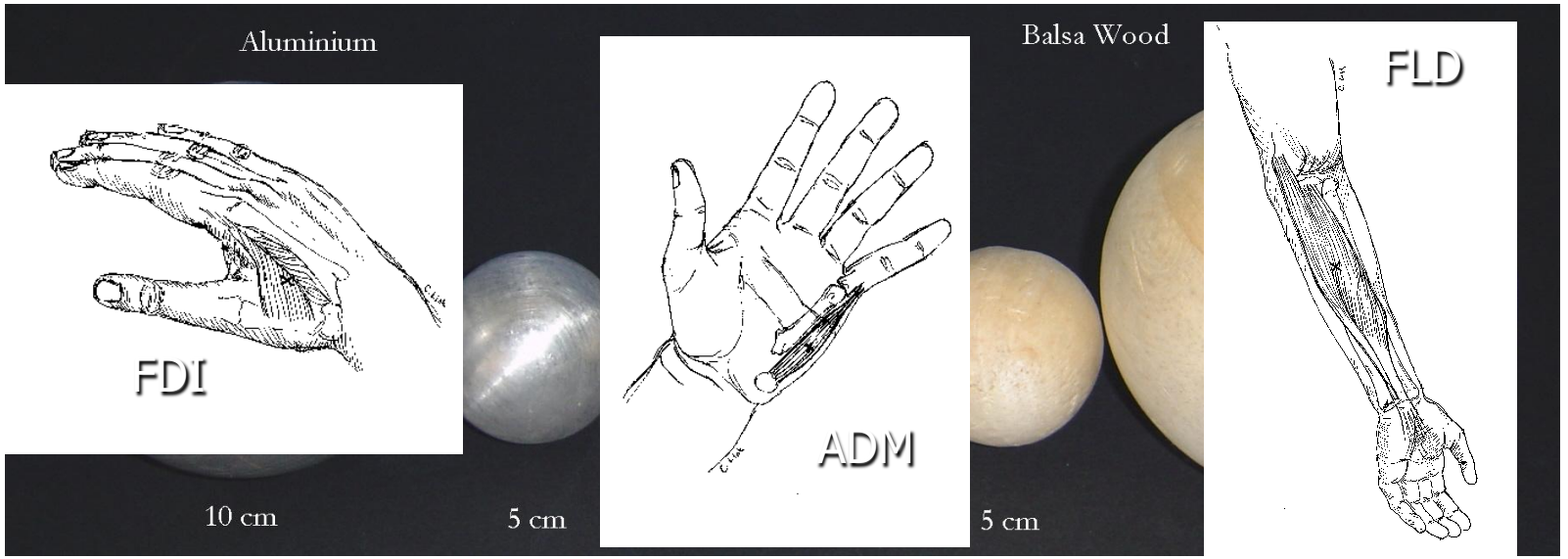
Fiorio et al. Neuroscience, 2010

FDI Muscle



Fiorio et al. Neuroscience, 2010

Task Parameters

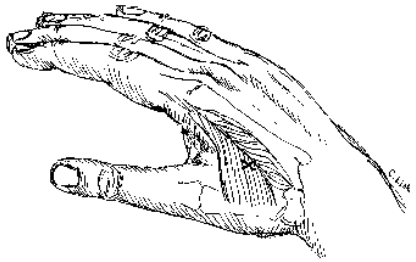


Imagine to hold a sphere

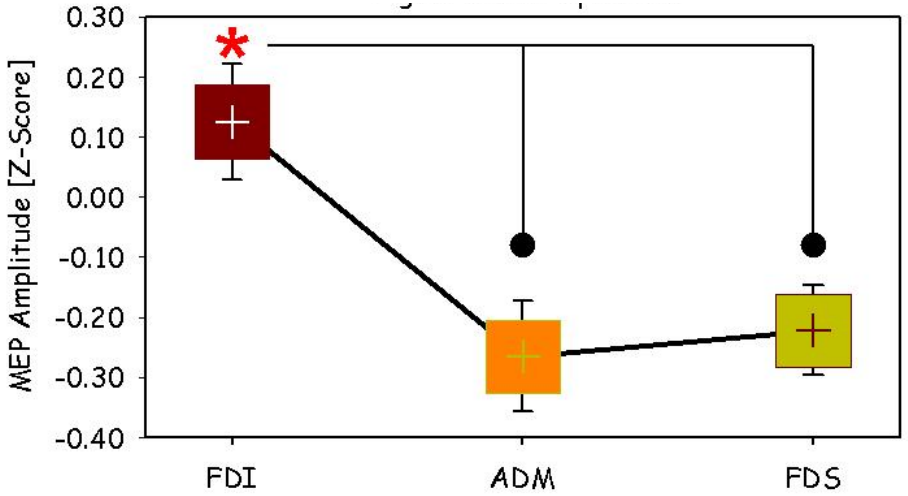
Hold a sphere

Cesari et al. Neuropsychologia 2011

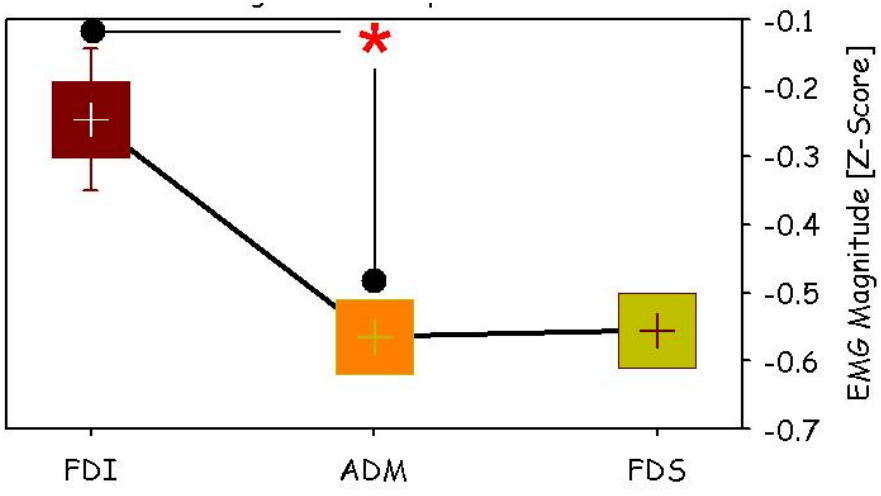
Small Spheres



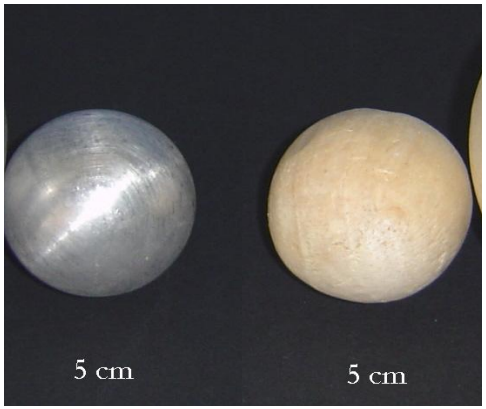
Imagination



Actual Action

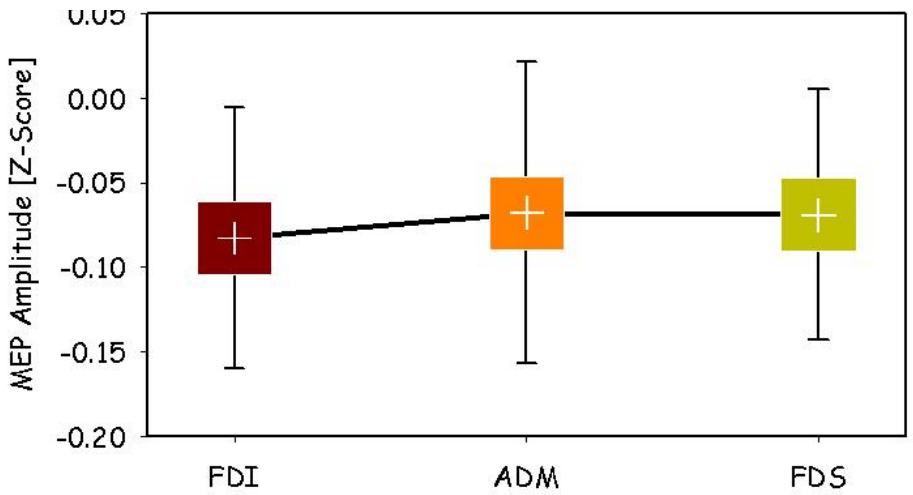


Cesari et al. Neuropsychologia 2011

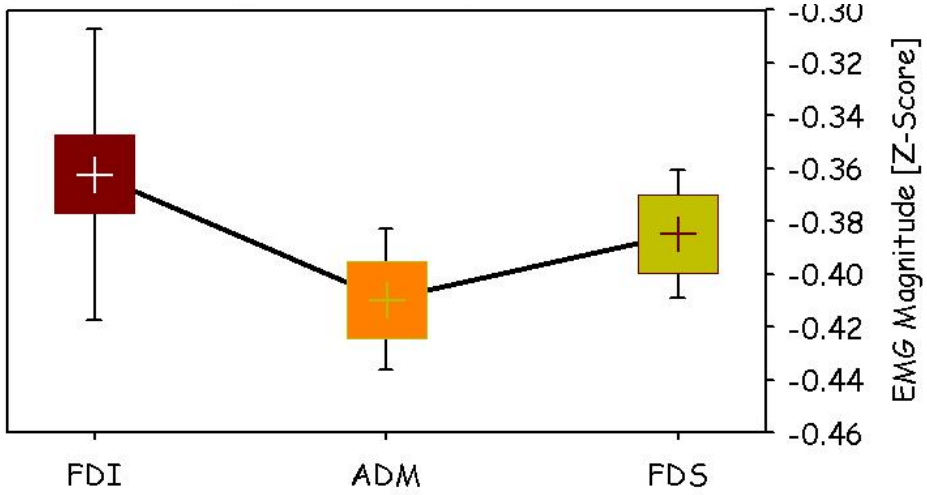


Medium spheres

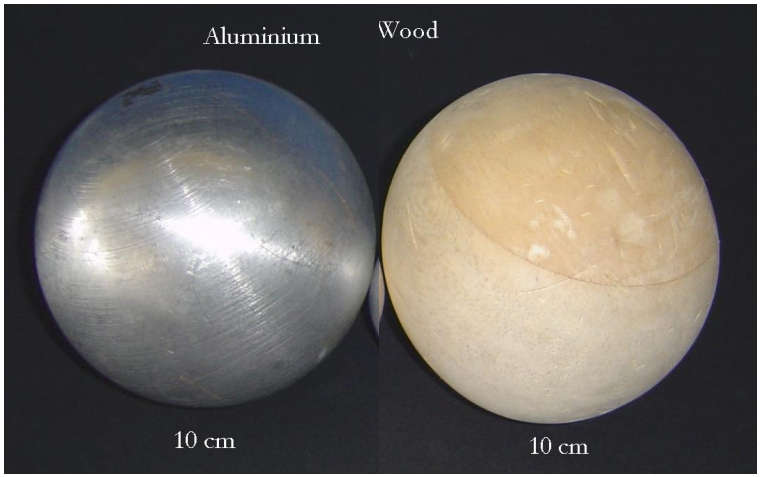
Imagination



Actual Action

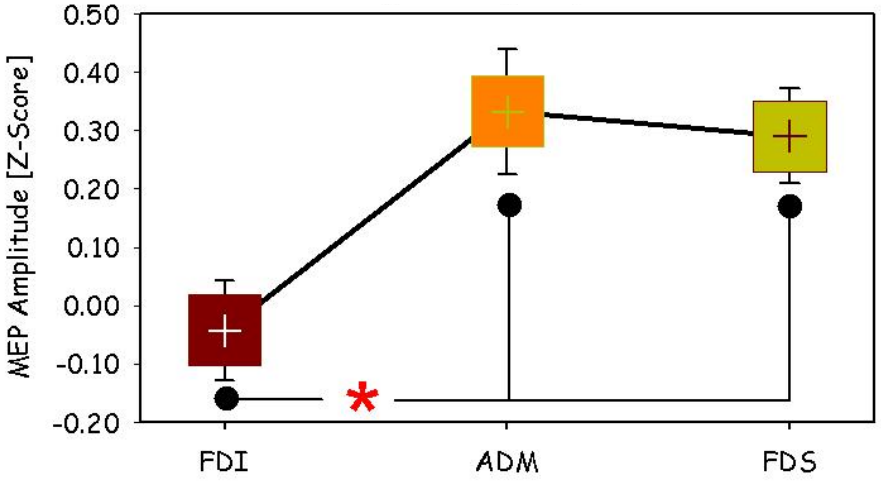


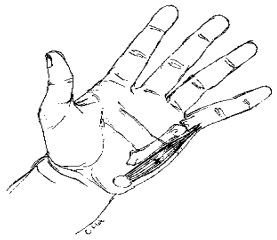
Cesari et al. Neuropsychologia 2011



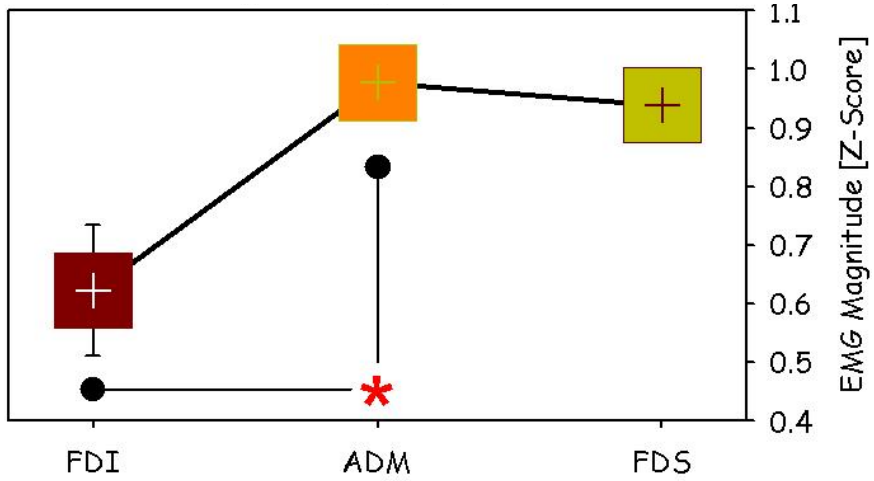
Large Spheres

Imagination





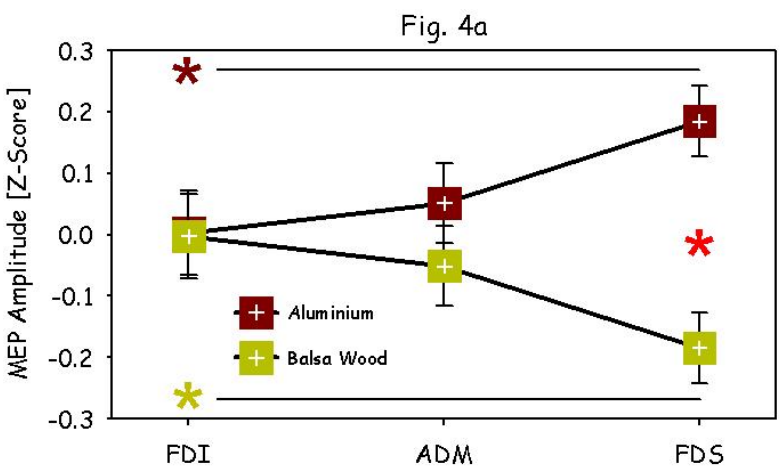
Actual Action



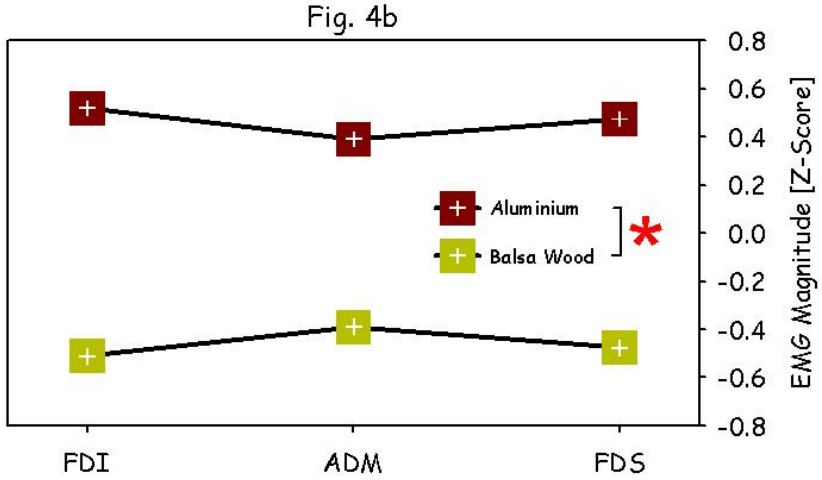
Cesari et al. Neuropsychologia 2011

the density

Imagination

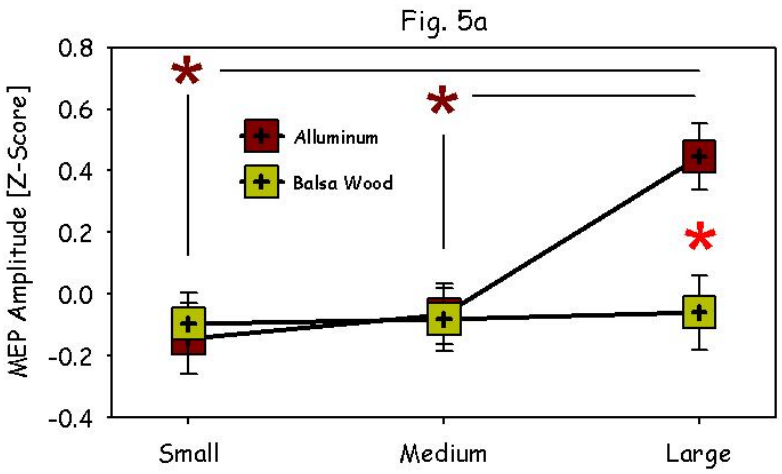


Actual Action

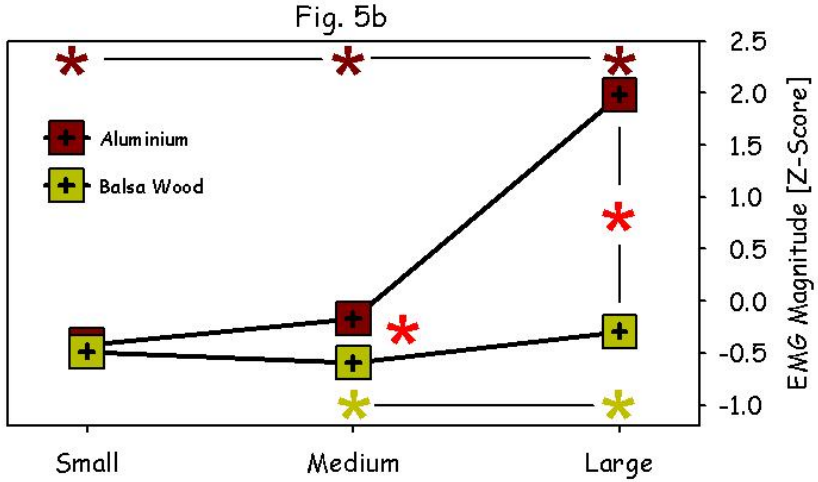


density

Imagination

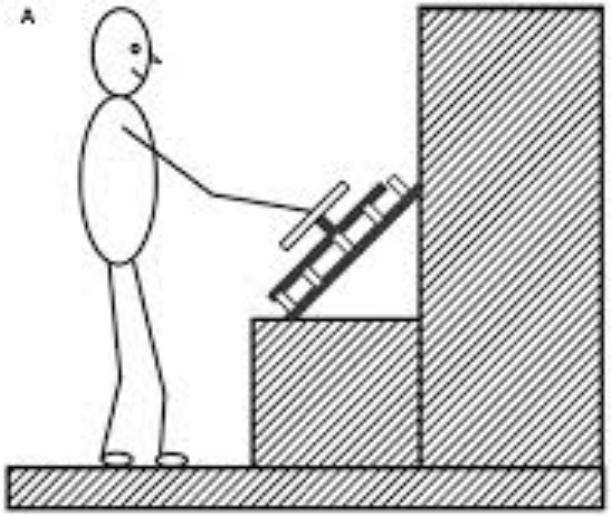


Actual Action



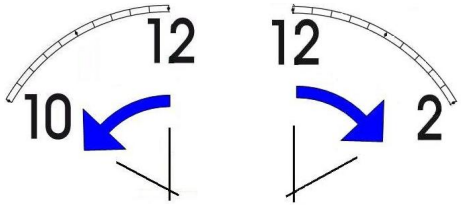
Cesari et al. Neuropsychologia 2011

Movement direction and amplitude

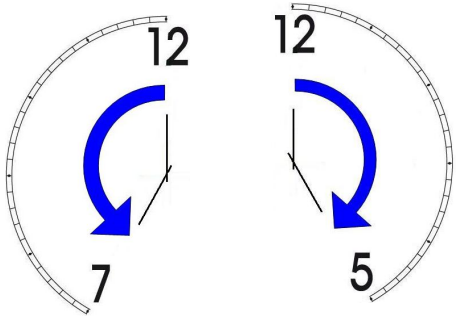


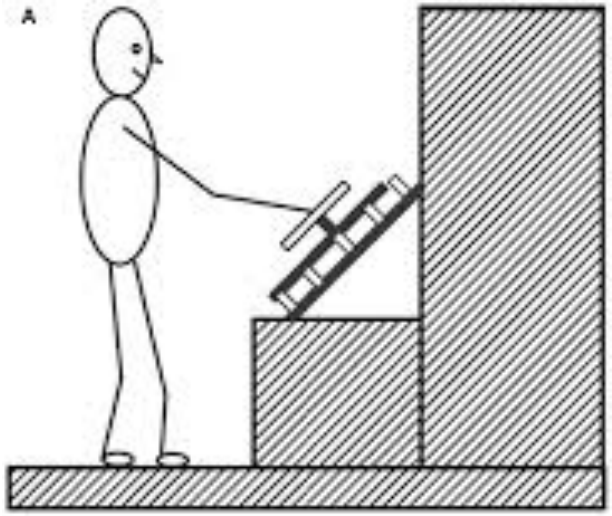
Pizzolato et al. Neuroscience 2012

Small Amplitude

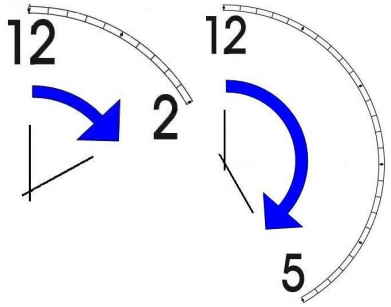


Large Amplitude

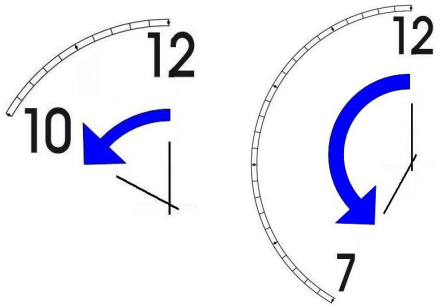




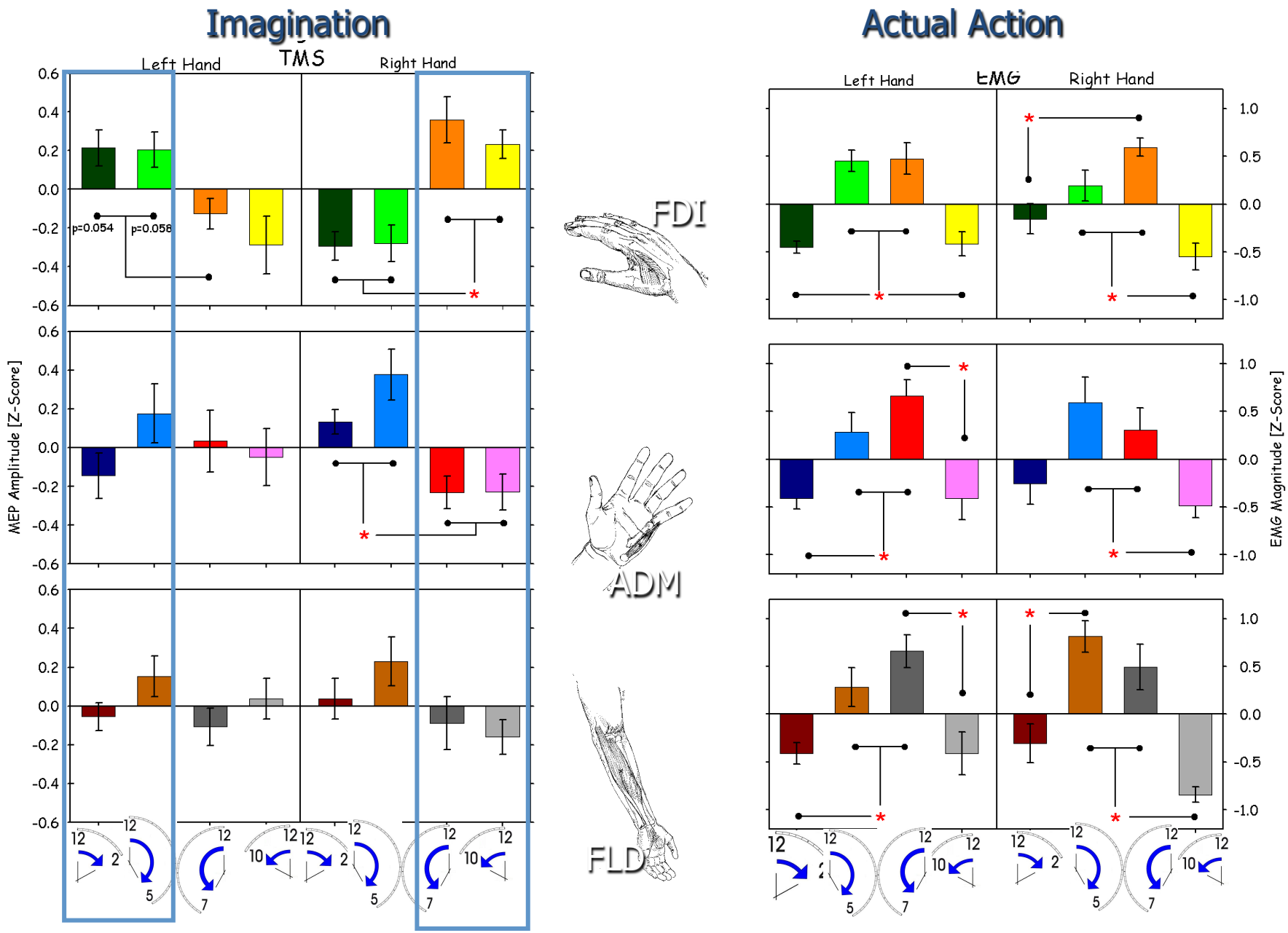
Clockwise Direction



Counter Clockwise Direction

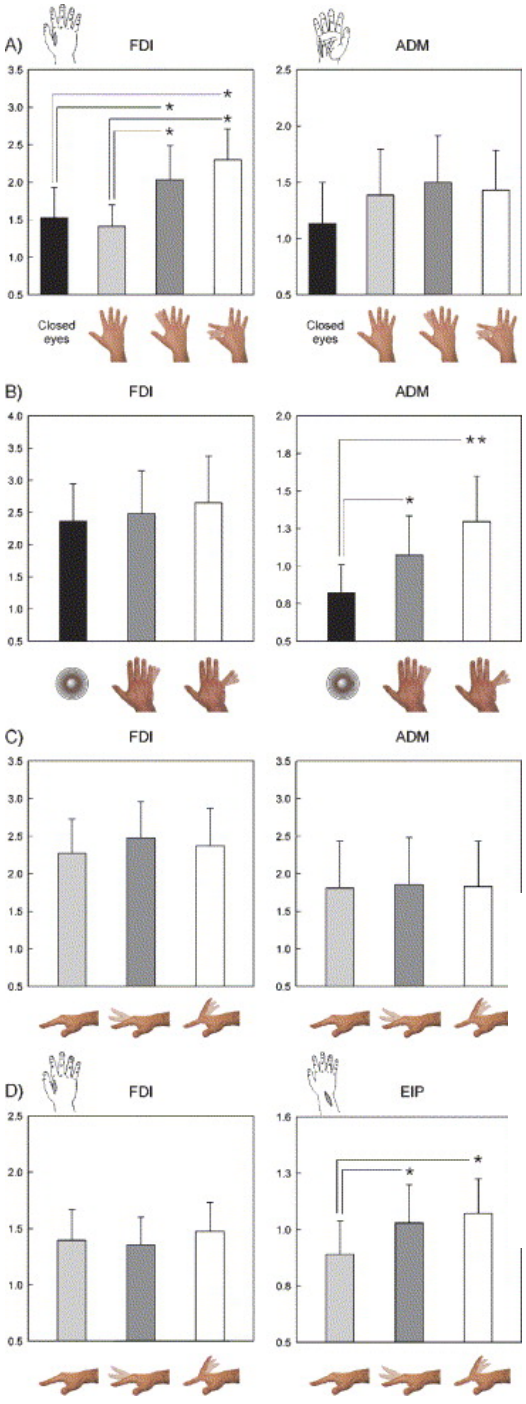


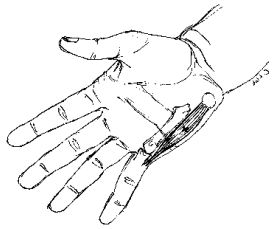
Pizzolato et al. Neuroscience 2012



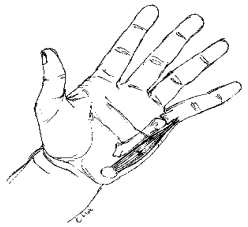
Pizzolato et al. Neuroscience 2010

Muscle specificity





FirstDorsalInterosseus



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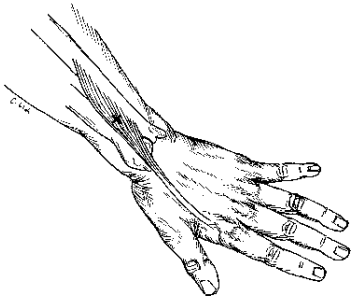
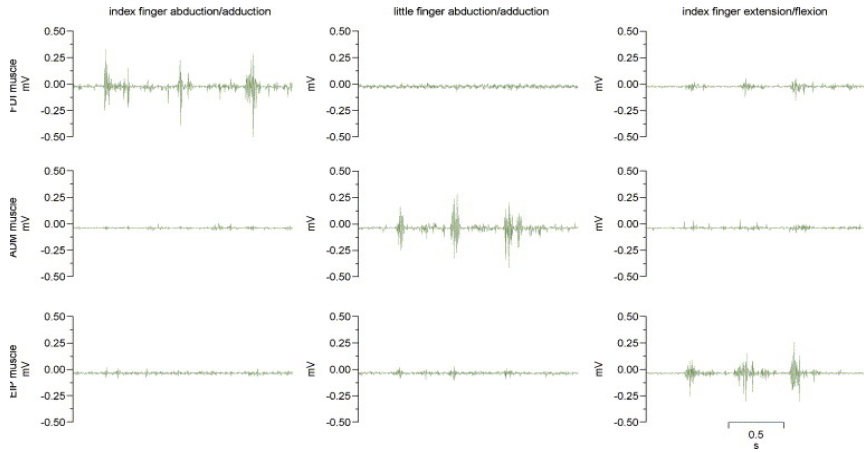


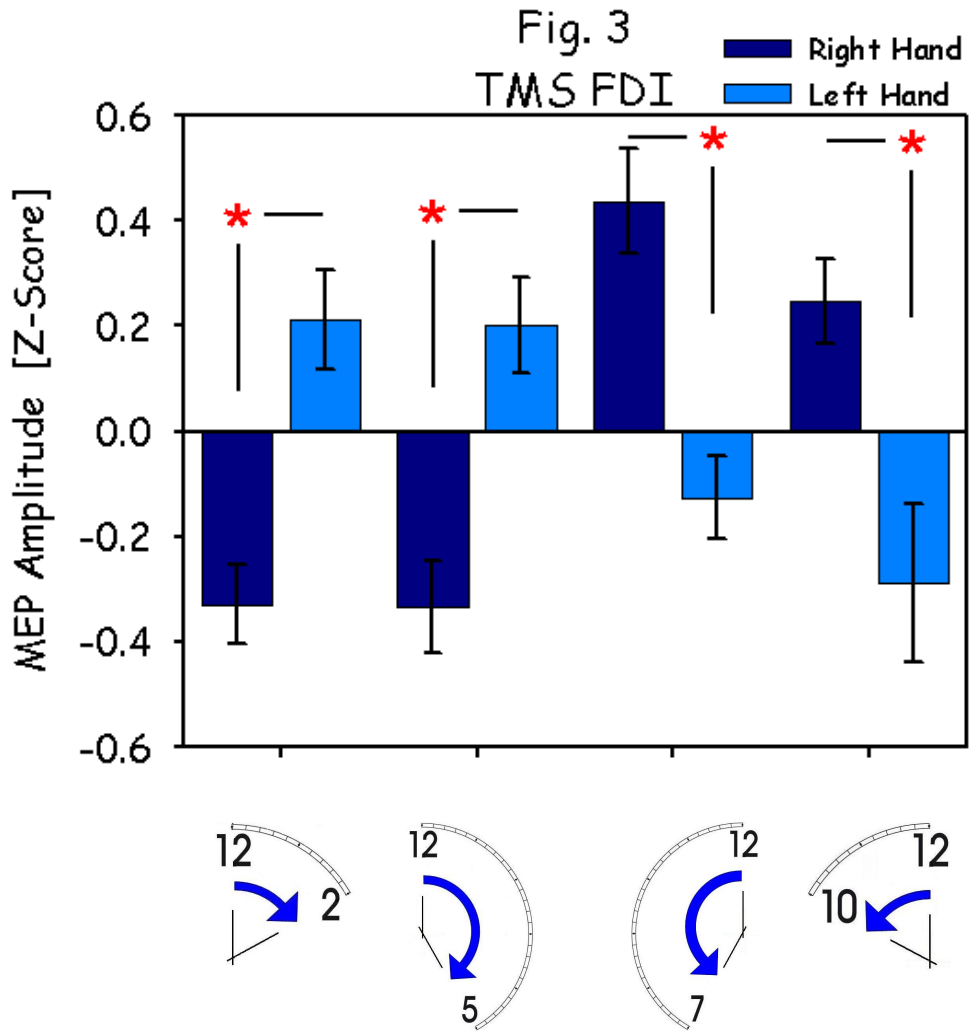
ExtensorIndicisProprius

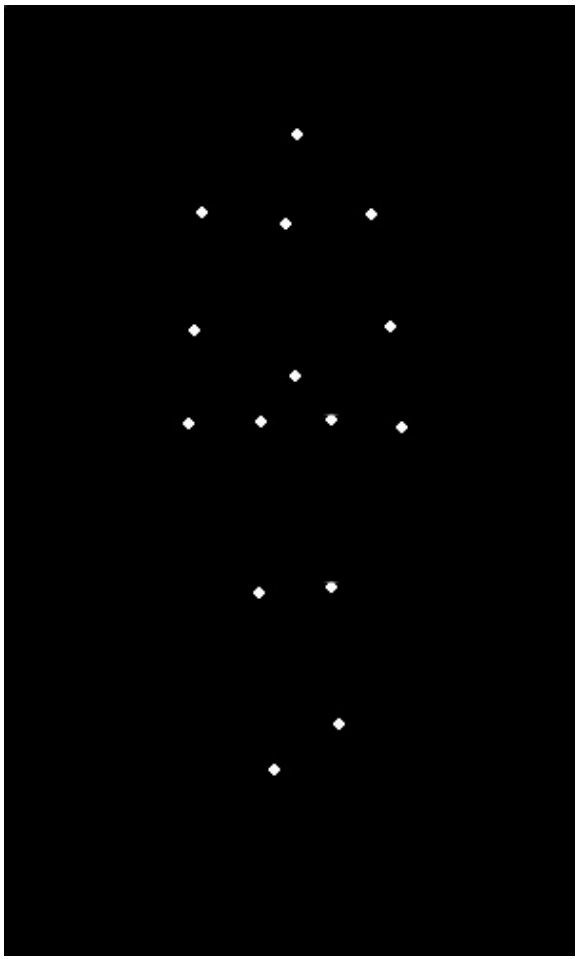


Bufalari et al. Biol. Psych. 2010

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

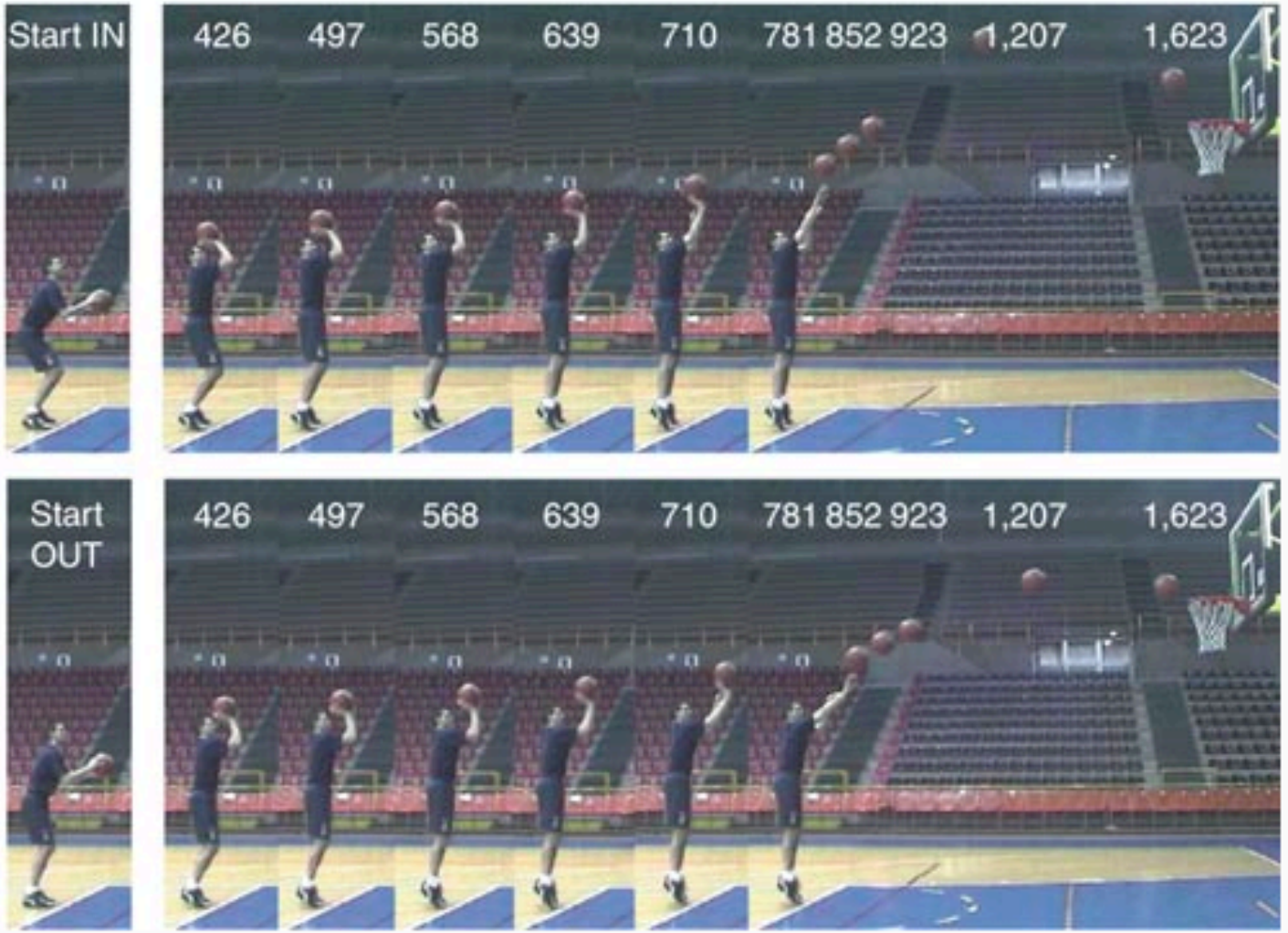
It may be hypothesized that motor knowledge can be used to anticipate a sequence of actions when perceiving human motion. We may use predictive mechanisms which require pre-selection of relevant sensory information -- like athletes do!

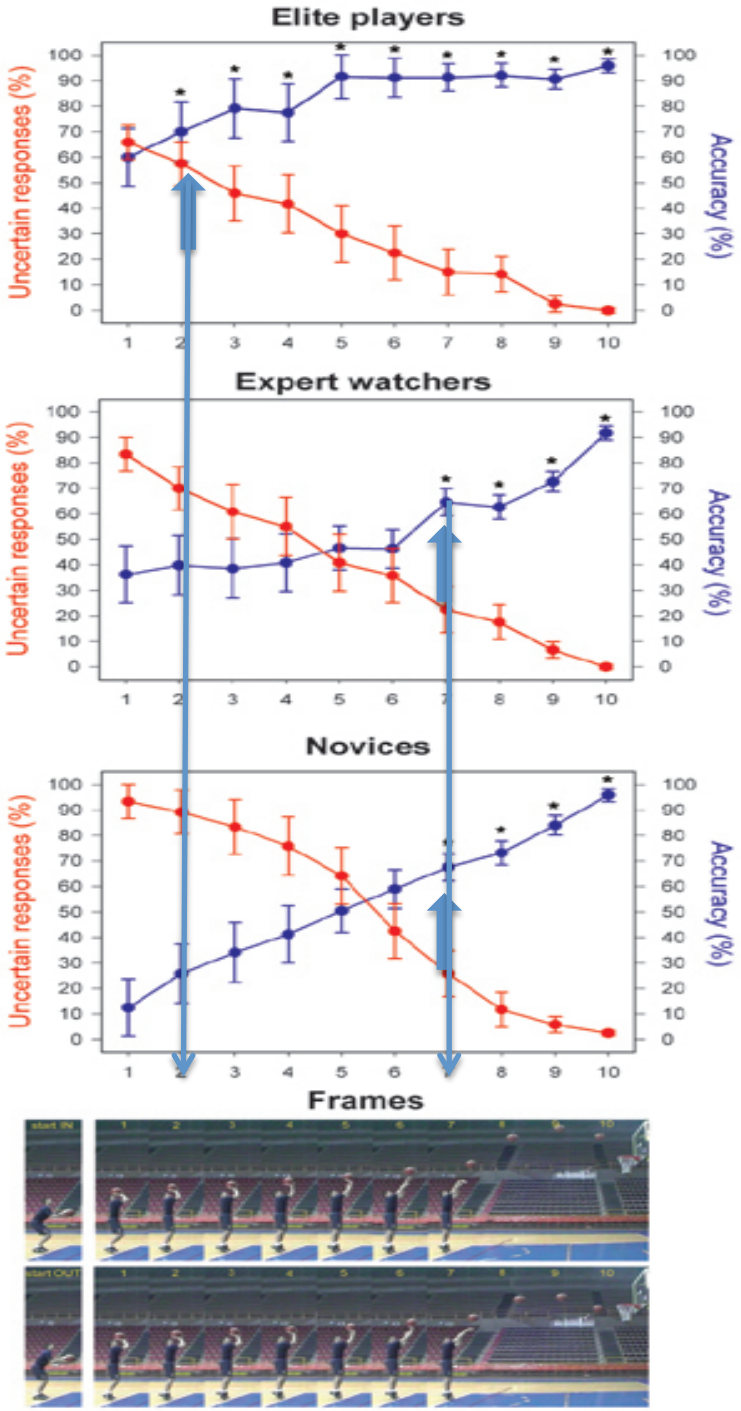
Combining the two areas of research:

Bridging the gap between psychological research on experties and neuroscintific 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

We asked whether there is a correlation between the ability to perform and to recognize an action


Start IN
426
497
568
639
710
781 852 923
1,207
1,623
Start
OUT
426
497
568
639
710
781 852 923
1,207
1,623

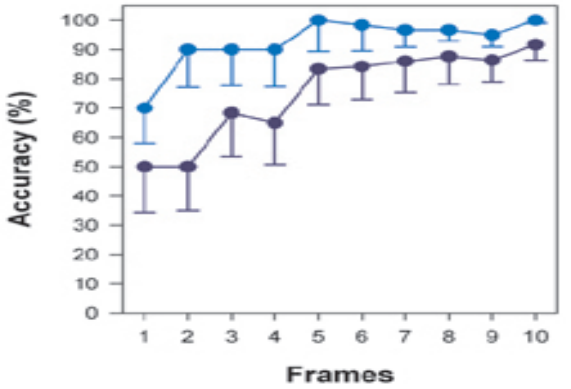


Players

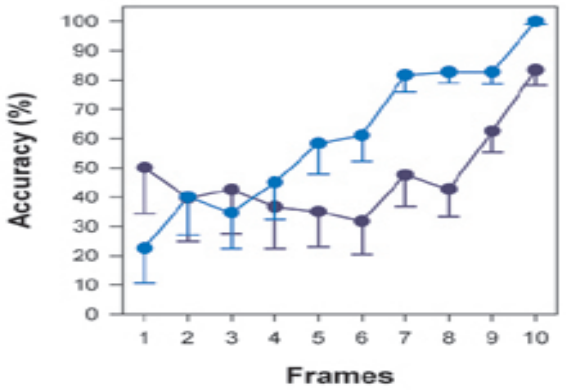
Journalists

Non-Players

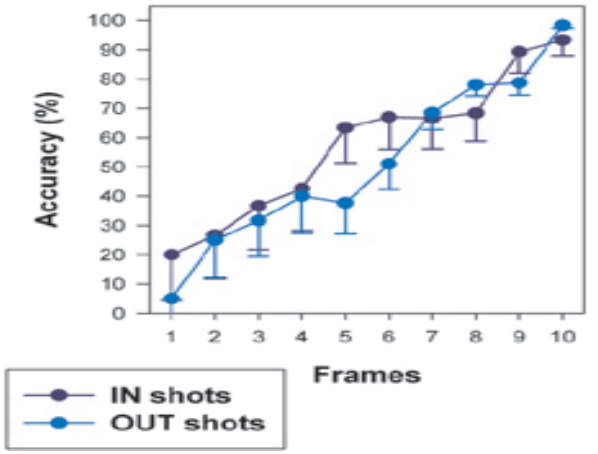
Aglioti et al. Nature Neuroscience 2008



Players

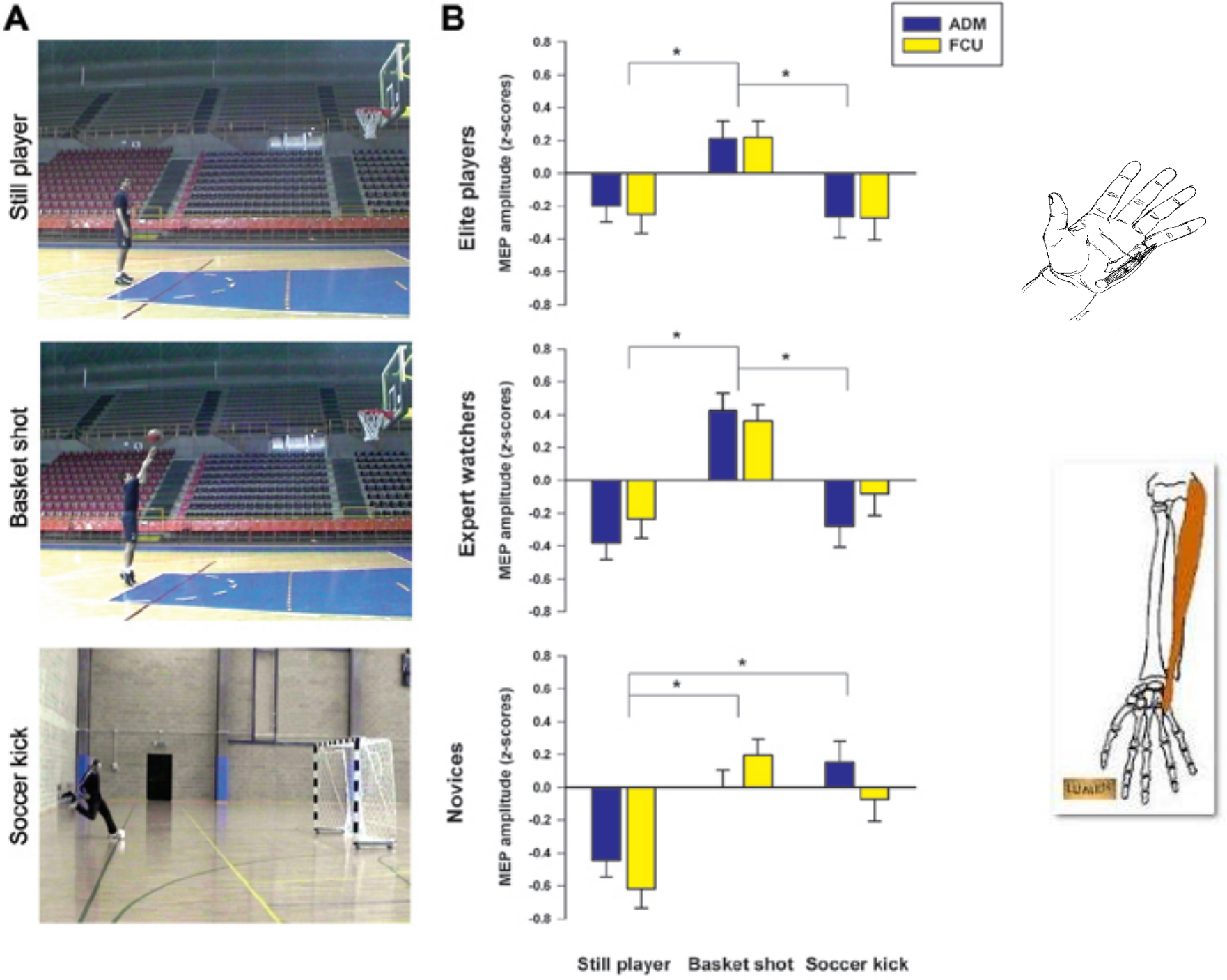


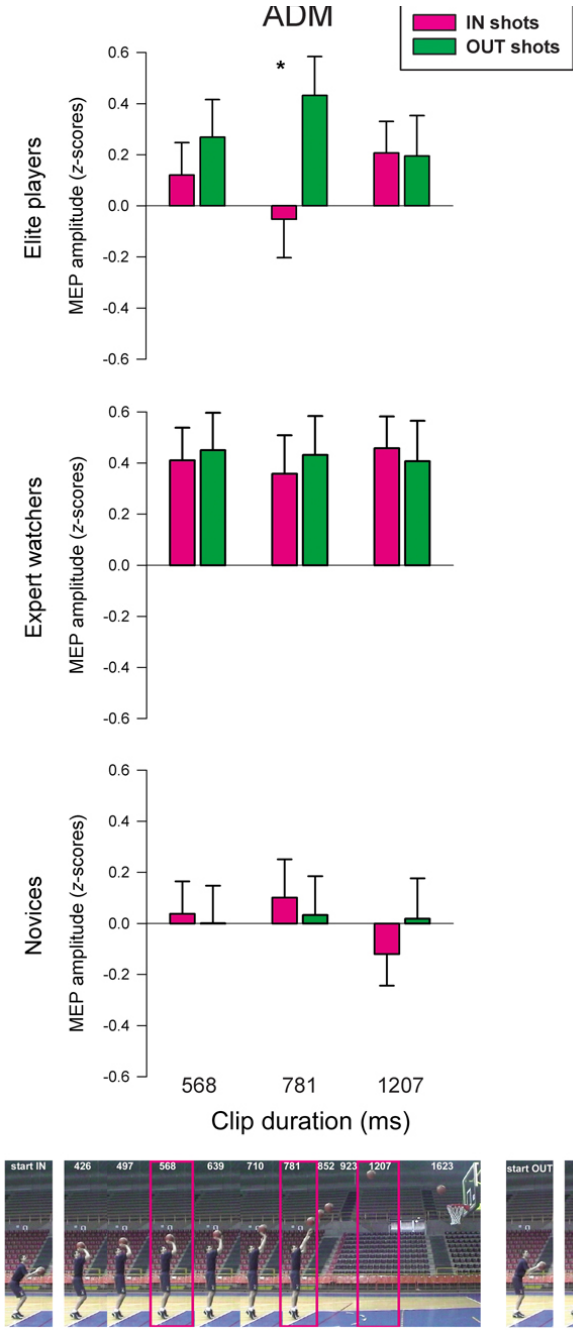
Journalists

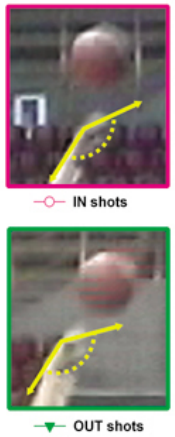


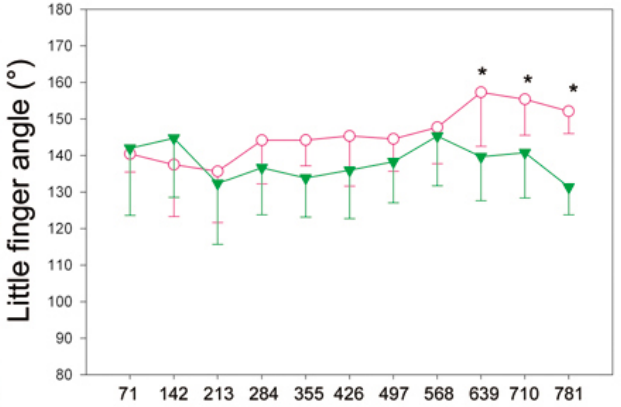
Non-Players

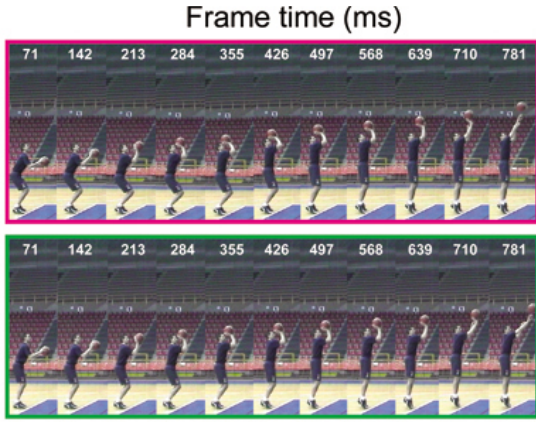
Aglioti et al. Nature Neuroscience 2008


A
Still player
Basket shot
Soccer kick
B
ADM
FCU
Elite players
Expert watchers
Novices
MEP amplitude (z-scores)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
*
Still player
Basket shot
Soccer kick

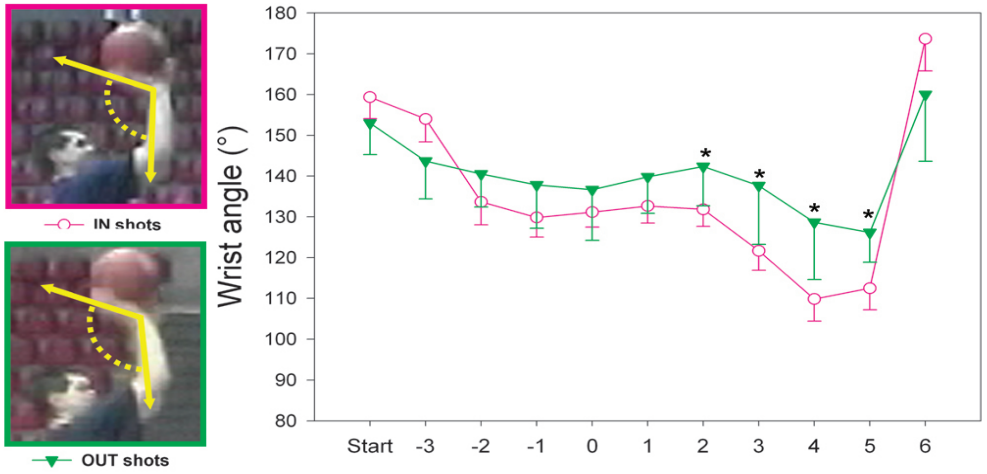




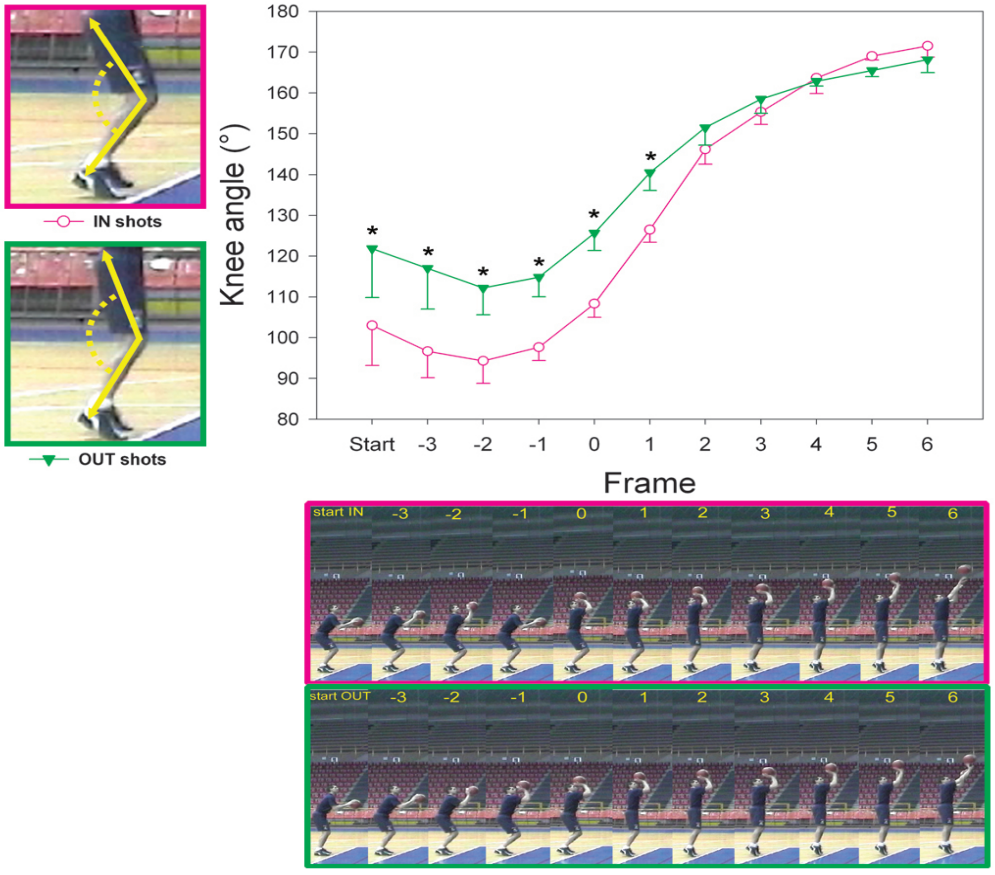




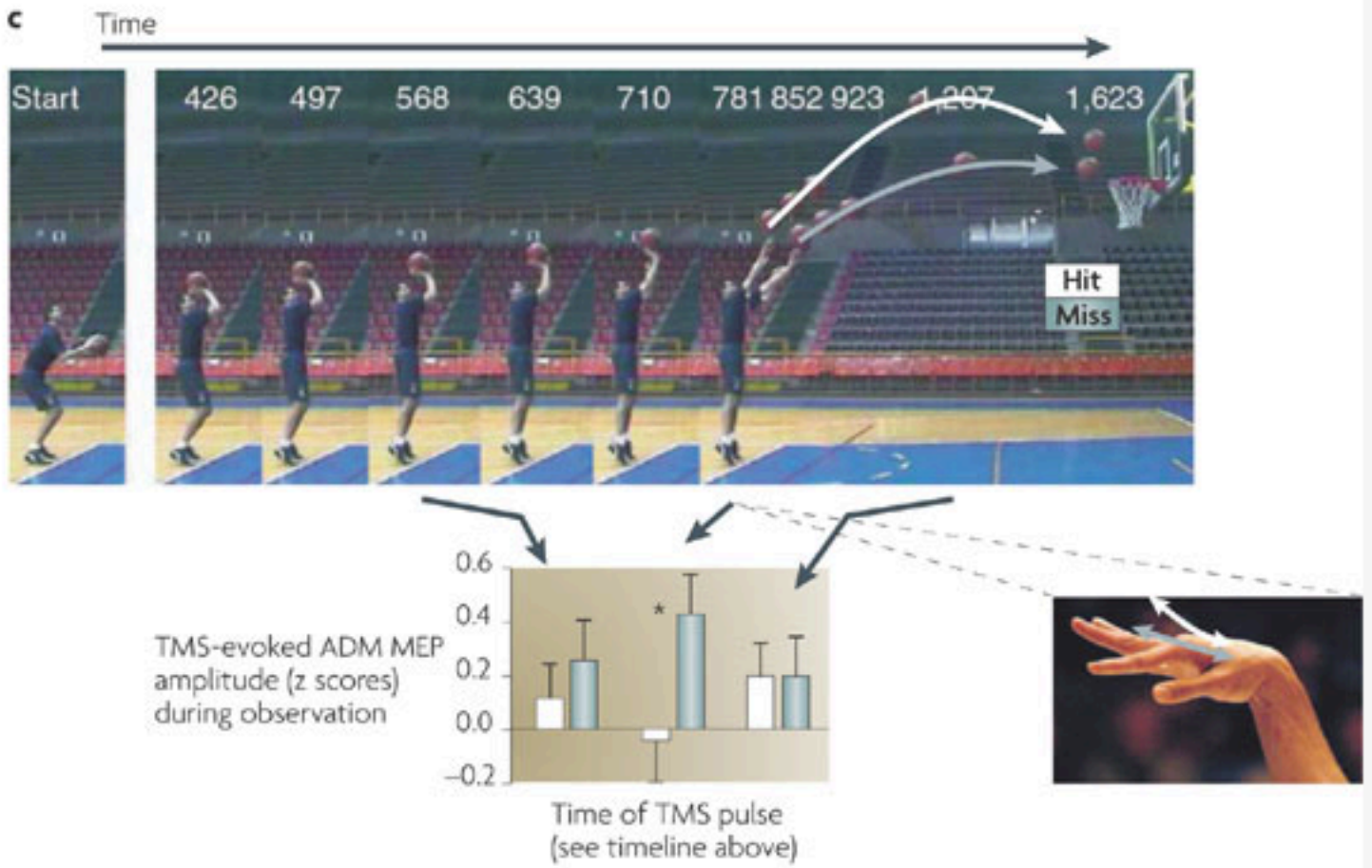
Aglioti et al. Nature Neuroscience 2008



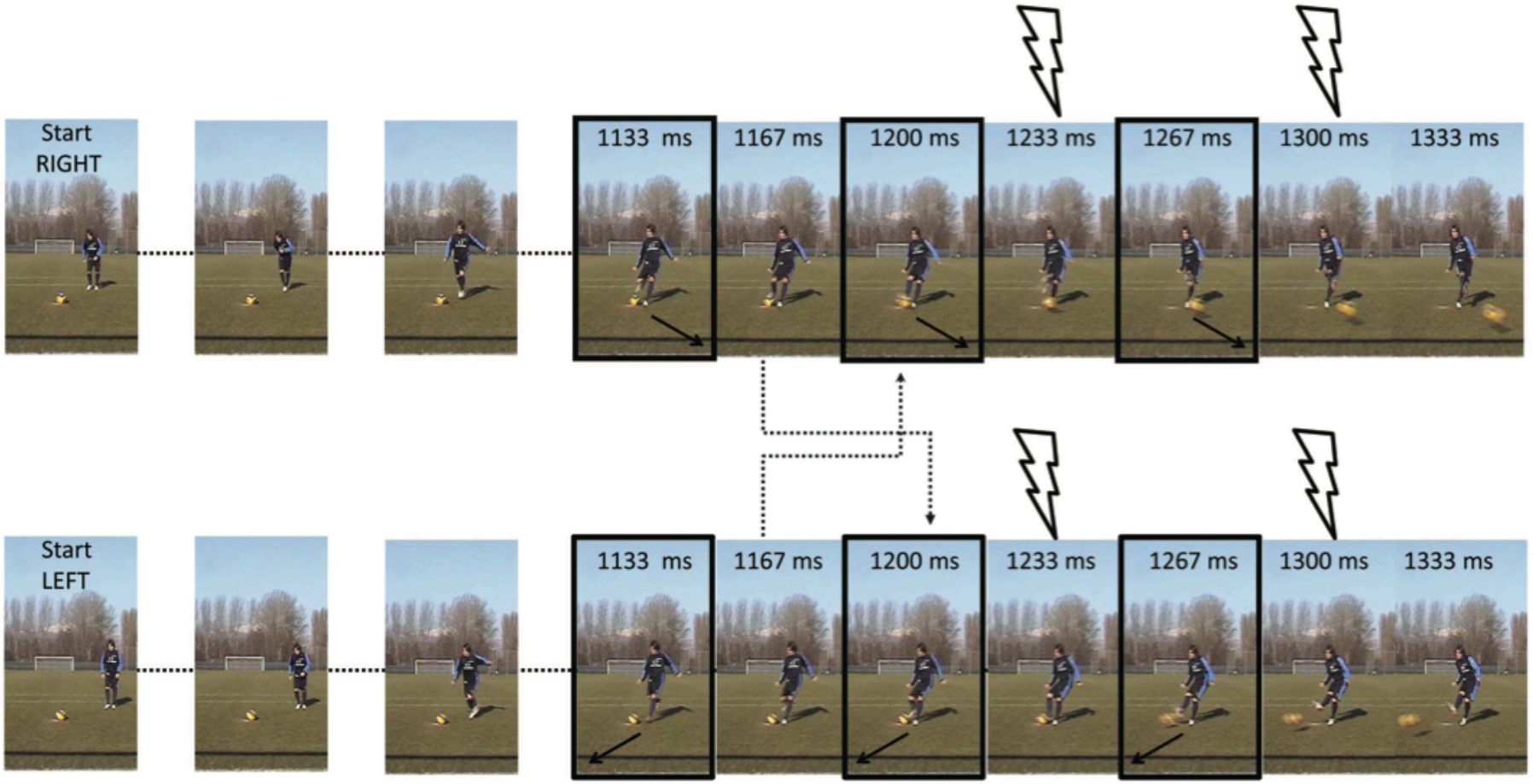
The wrist angle different between IN and OUT at the instant of the ball throw



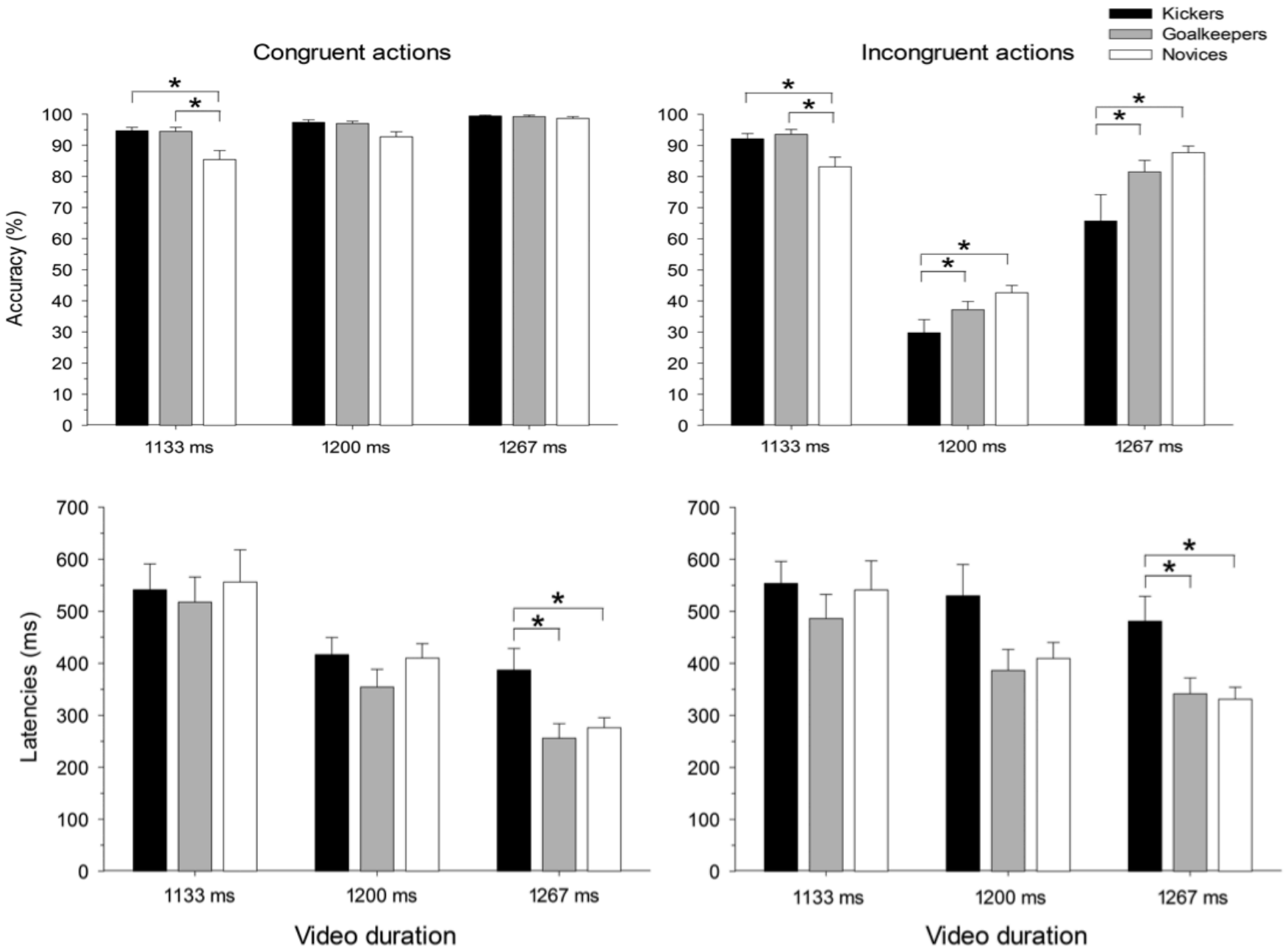
The knee angle different between IN and OUT at the very beginning of the action



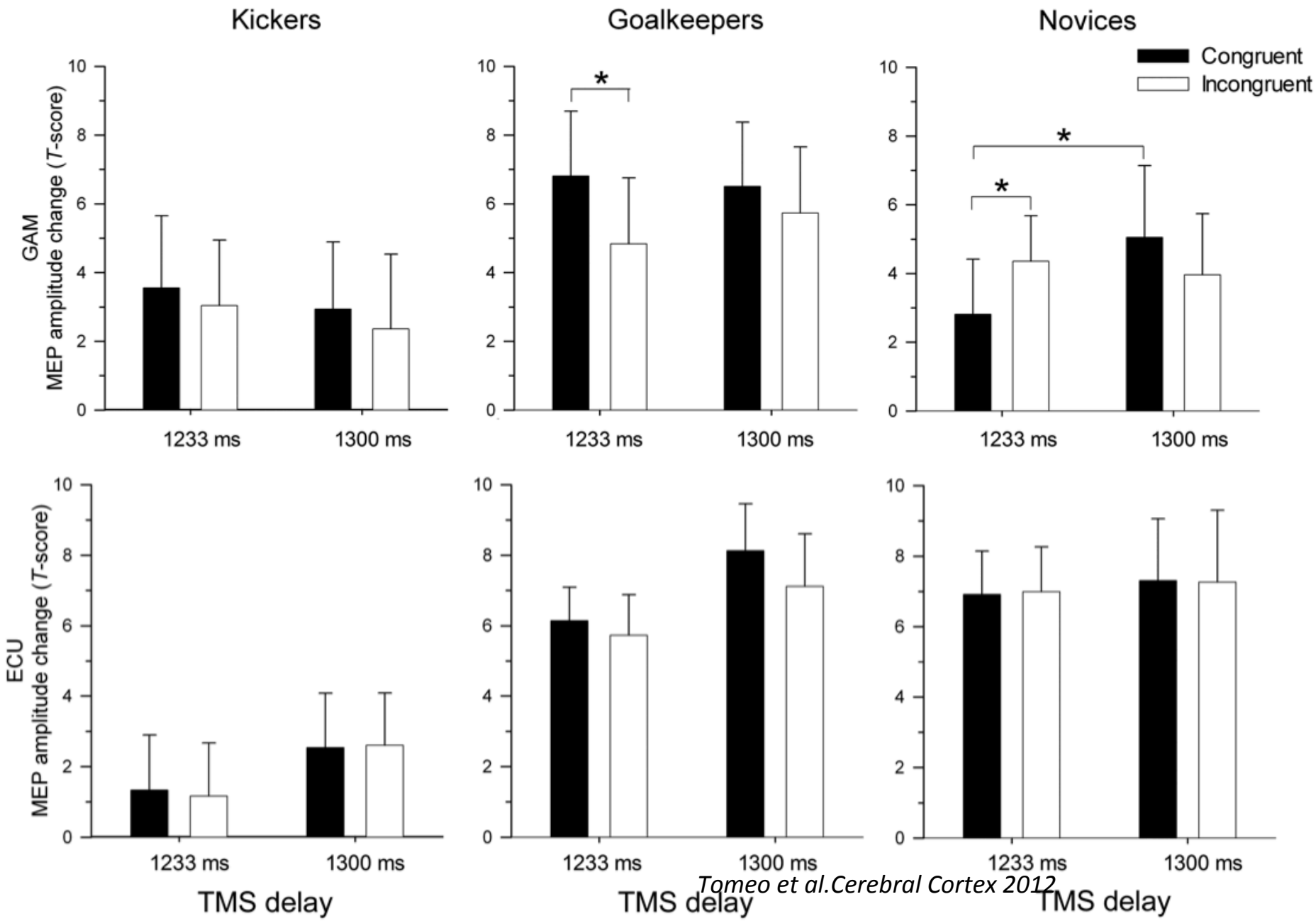
Aglioti et al. Nature Neuroscience 2008



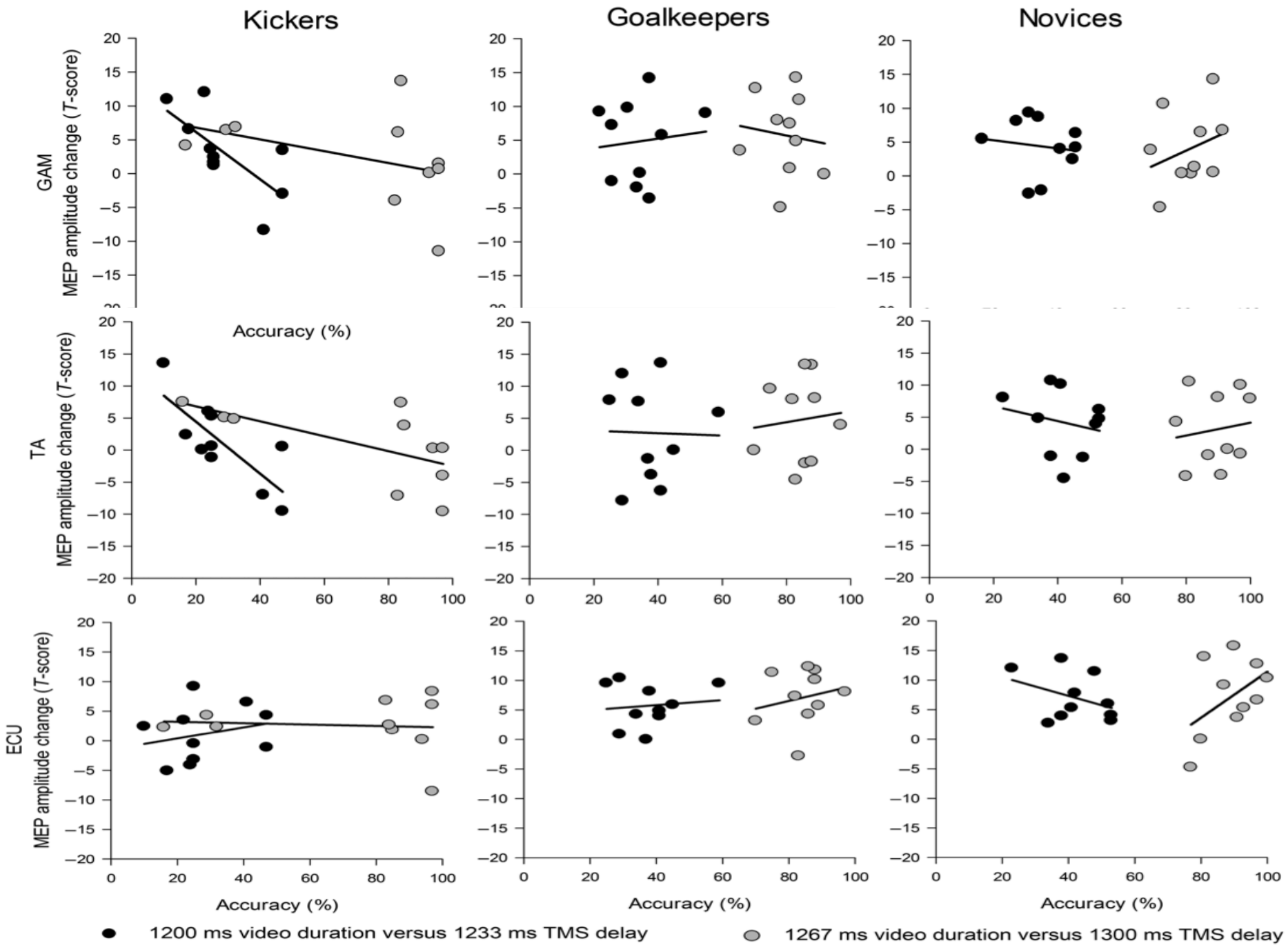
Tomeo et al.Cerebral Cortex 2012

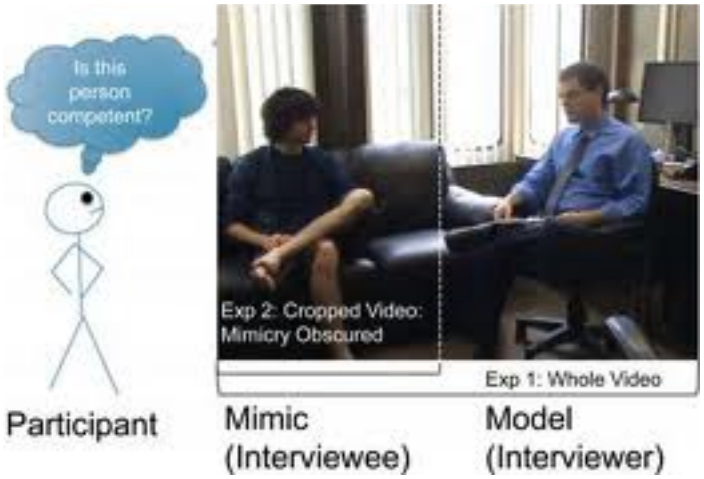


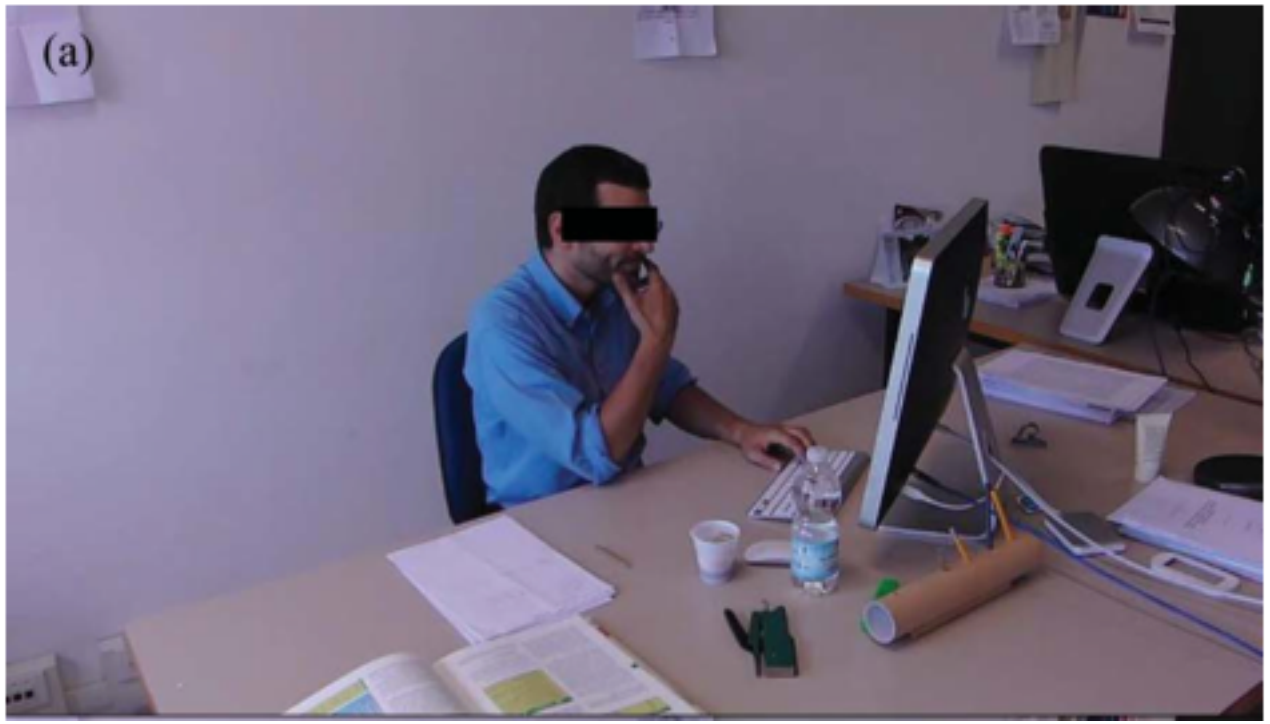
Tomeo et al.Cerebral Cortex 2012



Tomeo et al.Cerebral Cortex 2012


Kickers
Goalkeepers
Novices
GAM
TA
ECU
MEP amplitude change (T-score)
Accuracy (%)
1200 ms video duration versus 1233 ms TMS delay
1267 ms video duration versus 1300 ms TMS delay


Is this person competent?
Exp 2: Cropped Video: Mimicry Obscured
Exp 1: Whole Video
Participant
Mimic (Interviewee)
Model (Interviewer)



van Ulzen et al. Social Neuroscience 2013

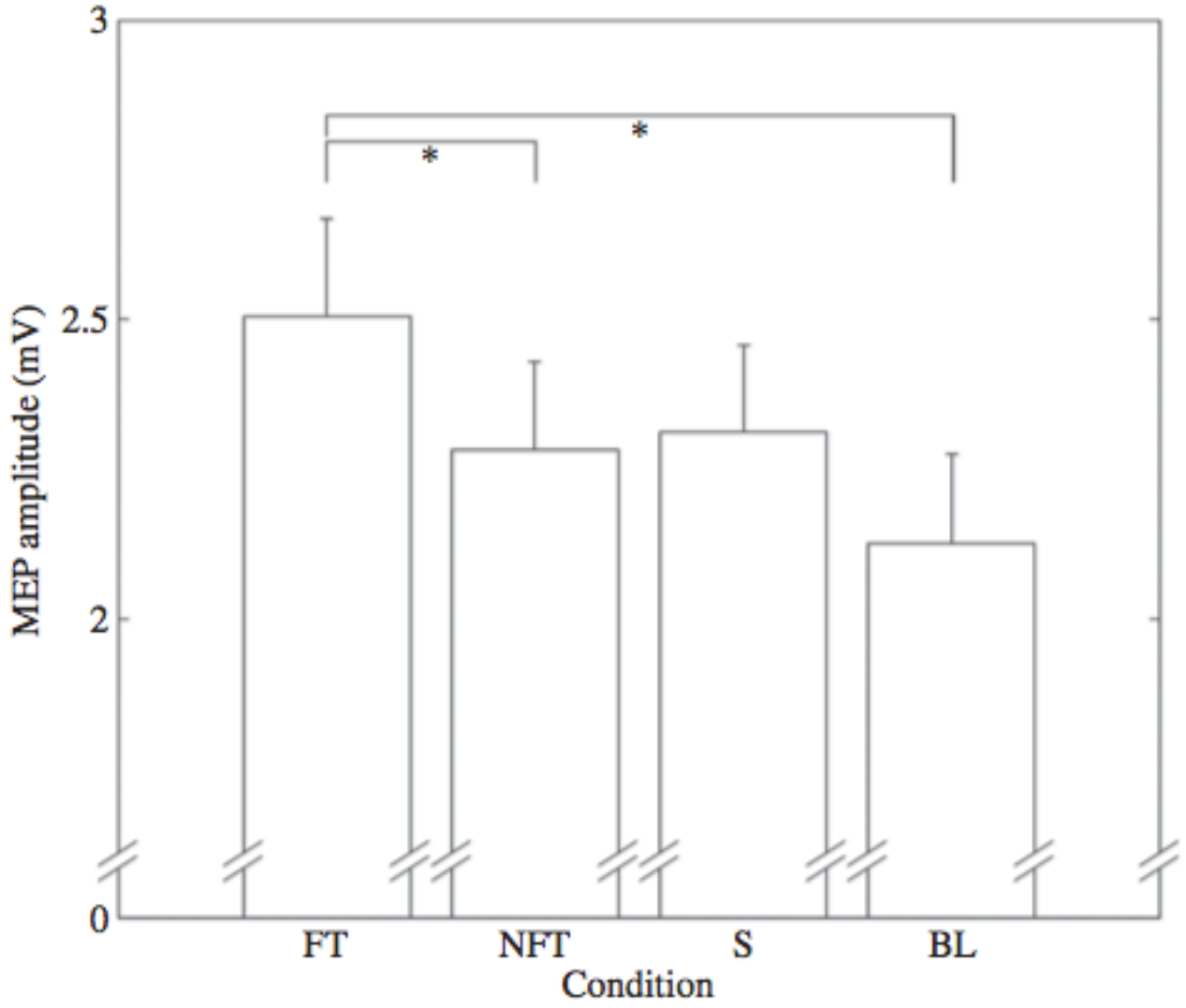


Figure 2. Mean raw MEP amplitudes (+SE) for the face-touching (FT), no face-touching (NFT), static image (S), and baseline (BL) conditions. $^{*}p < .05$.

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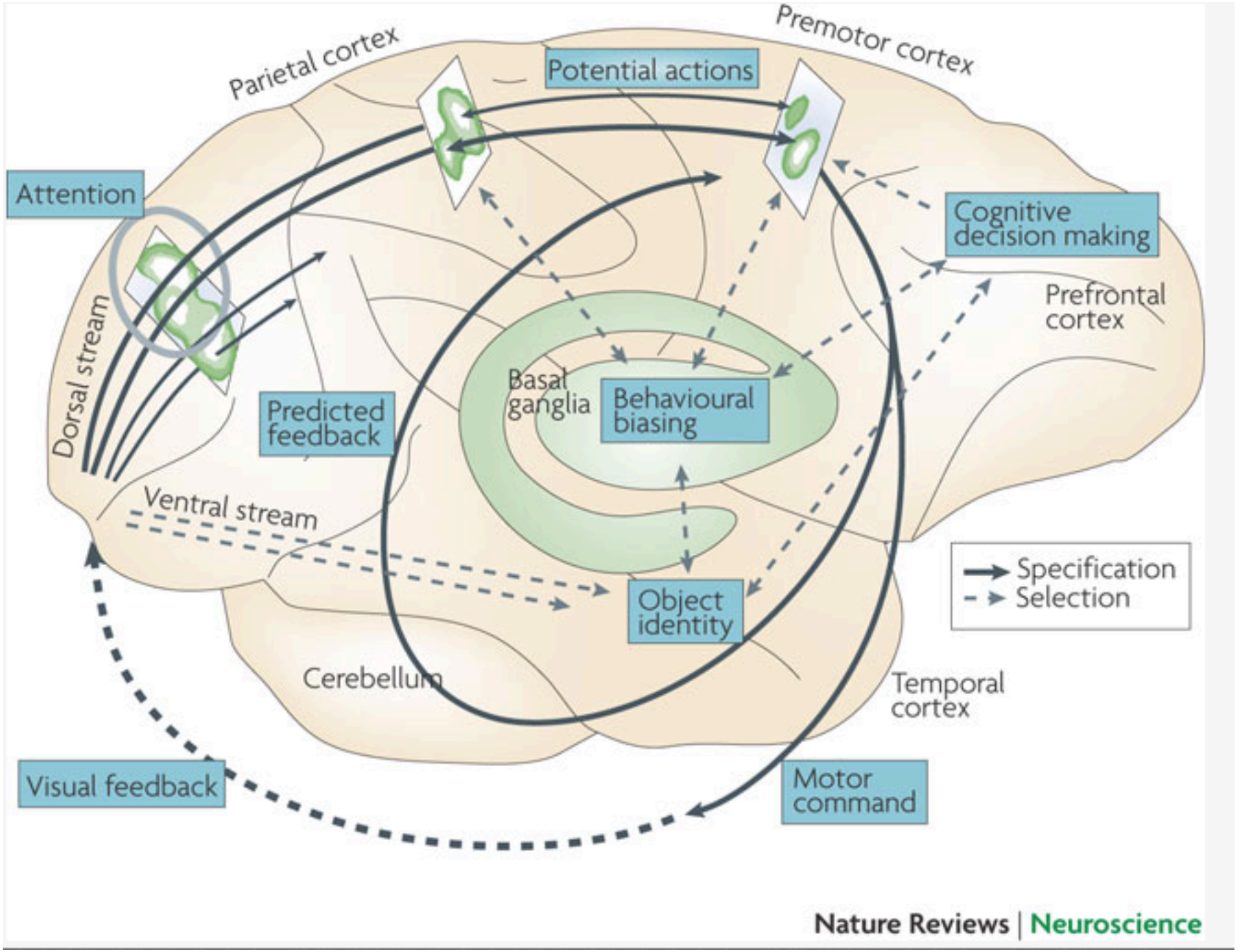
Parietal cortex
Premotor cortex
Potential actions
Attention
Cognitive decision making
Prefrontal cortex
Dorsal stream
Basal ganglia
Behavioural biasing
Predicted feedback
Ventral stream
Specification
Selection
Object identity
Cerebellum
Temporal cortex
Visual feedback
Motor command
Nature Reviews | Neuroscience