



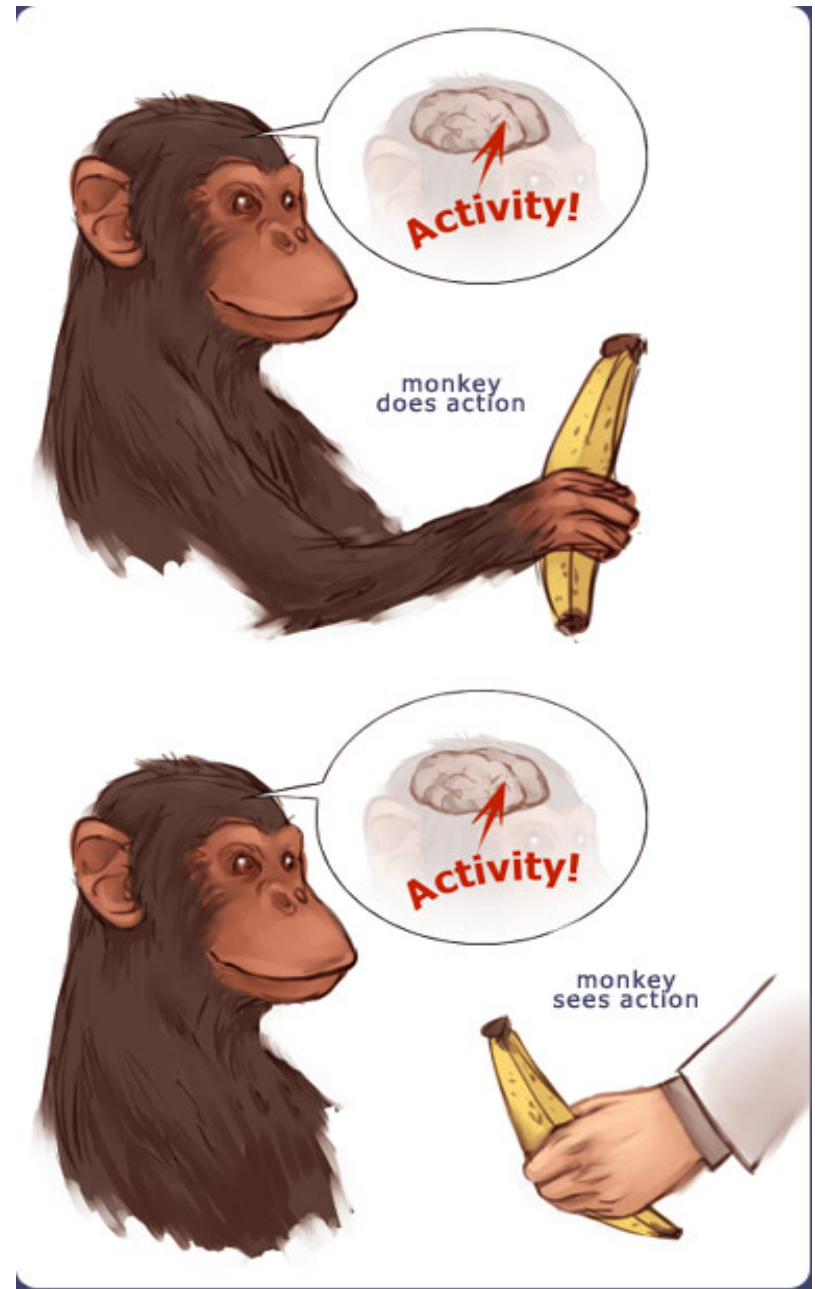
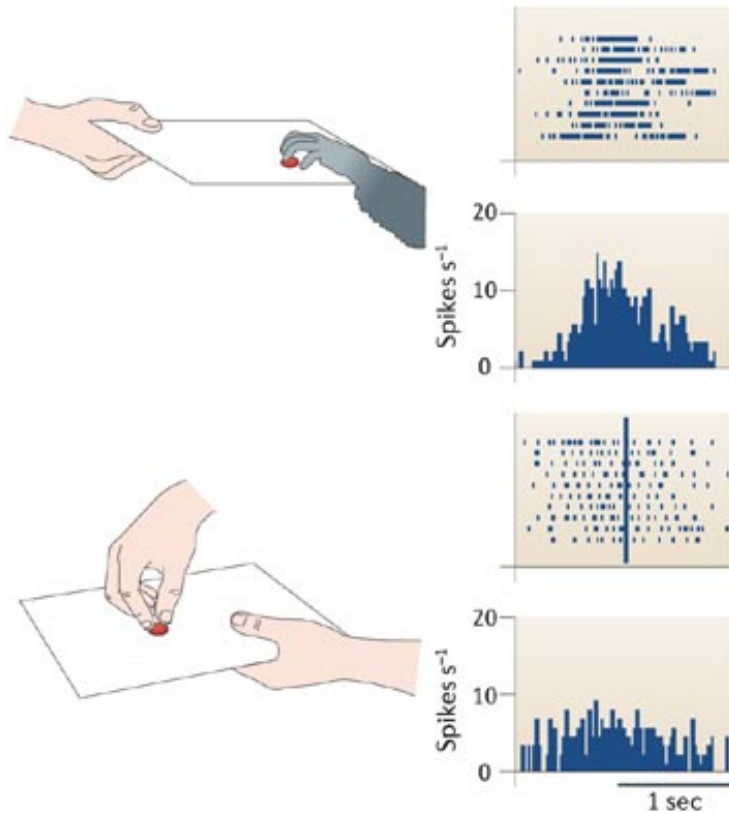
Action observation and action imagination: from pathology to the excellent sport performance

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

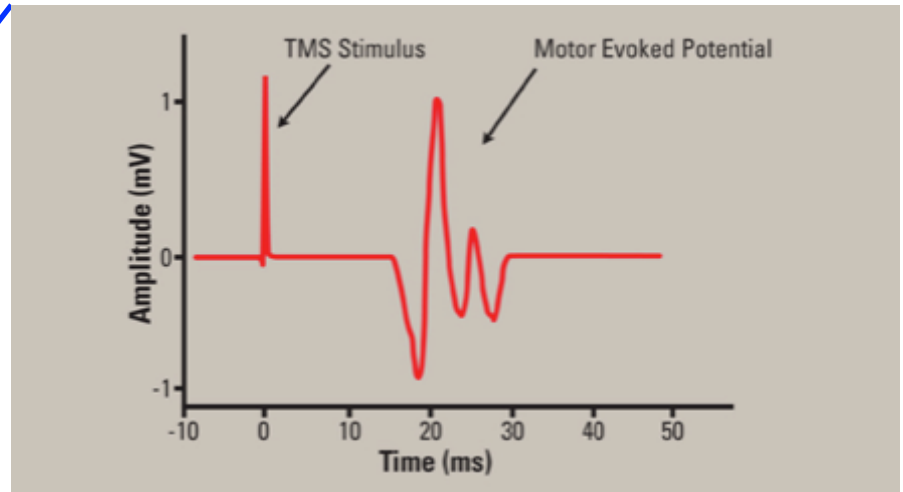
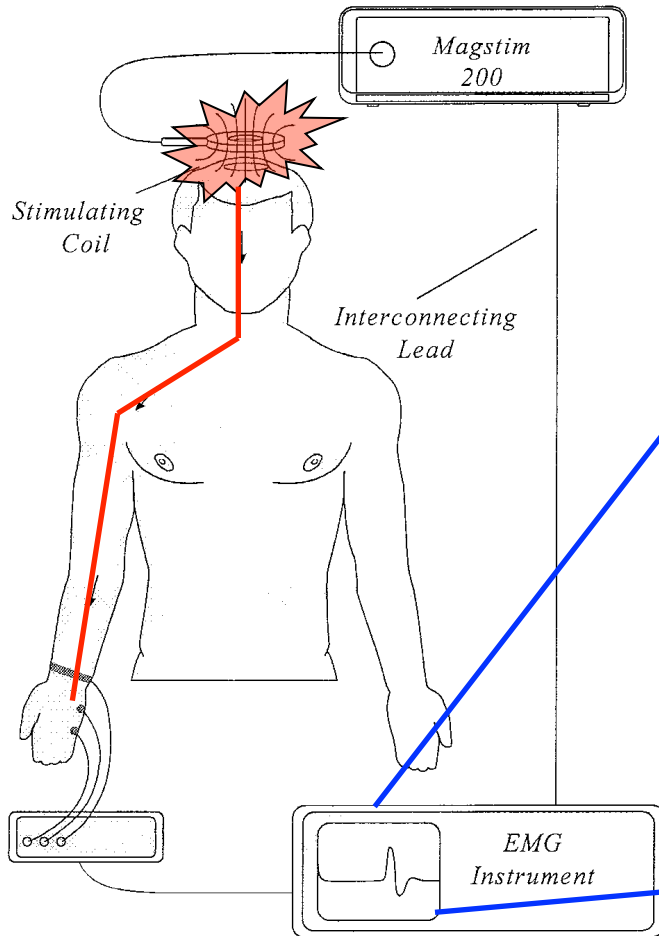
Action observation and imagination

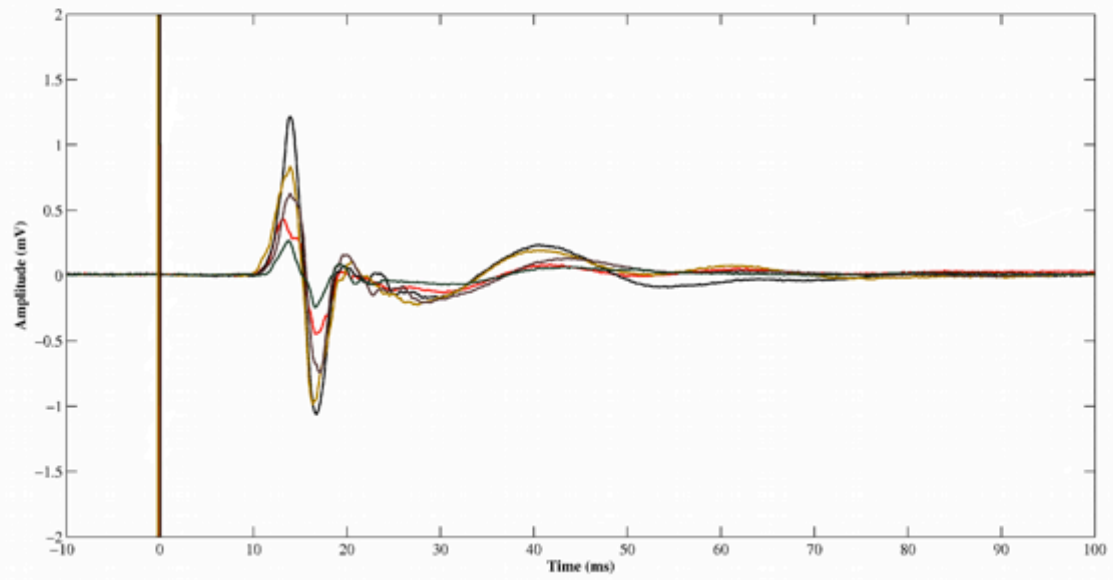
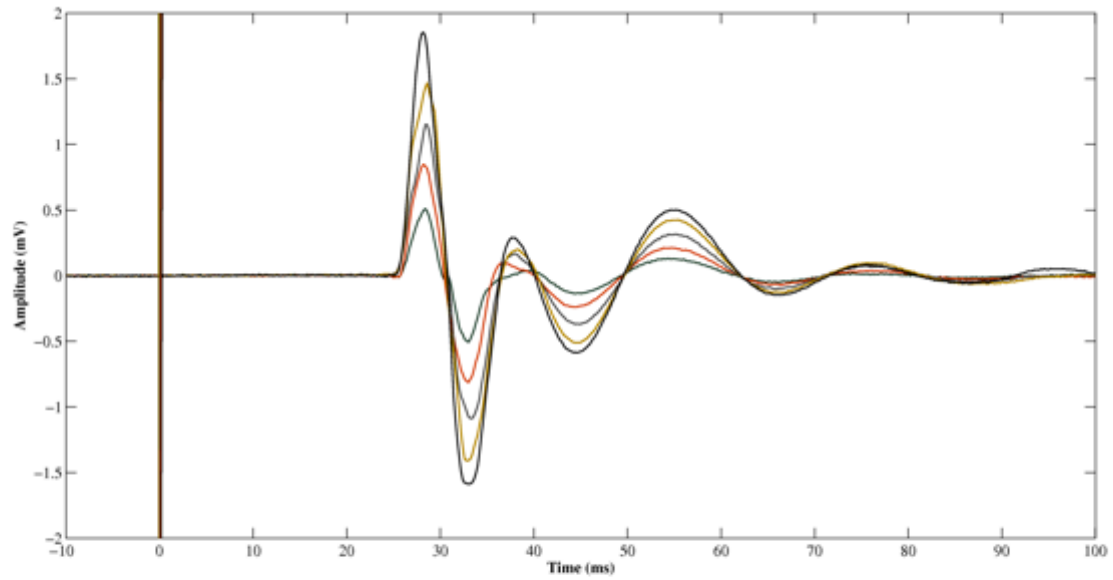
- The motor cortex “resonates” for
- Muscle specific activation
 - Body’s parts
 - Task parameters
 - direction-amplitude, object’s dimensions
- Internal action simulation
 - Action prediction
 - correct vs erroneous
 - fake movements

Motor Cortex

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

TMS-EMG





Muscle specificity

Imagine ...Observe...

Control



FDI

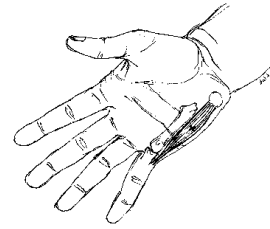
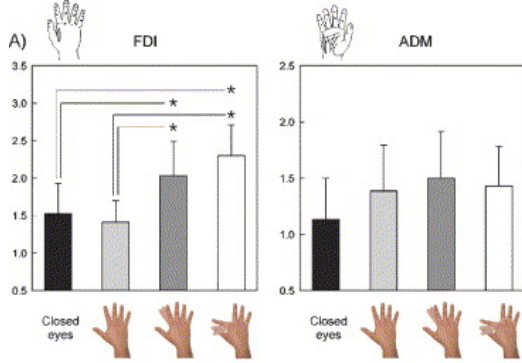


ADM

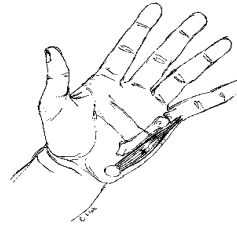
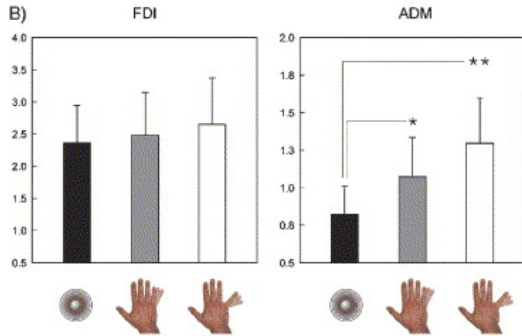


EIP

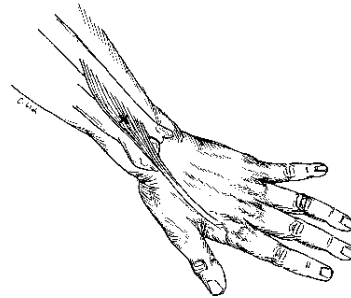
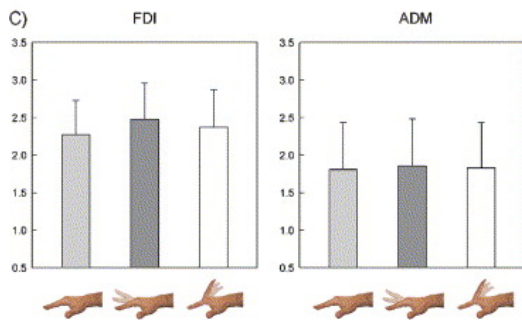




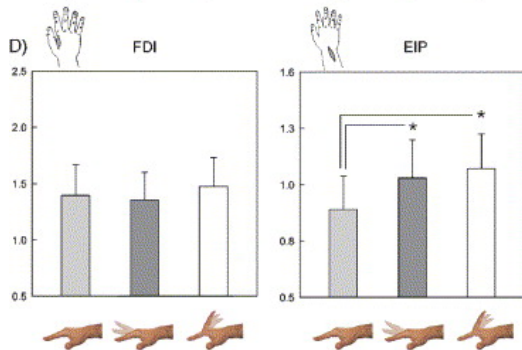
FirstDorsalInterosseus



AbducturDigitiMinimi



ExtensorIndicisProprius

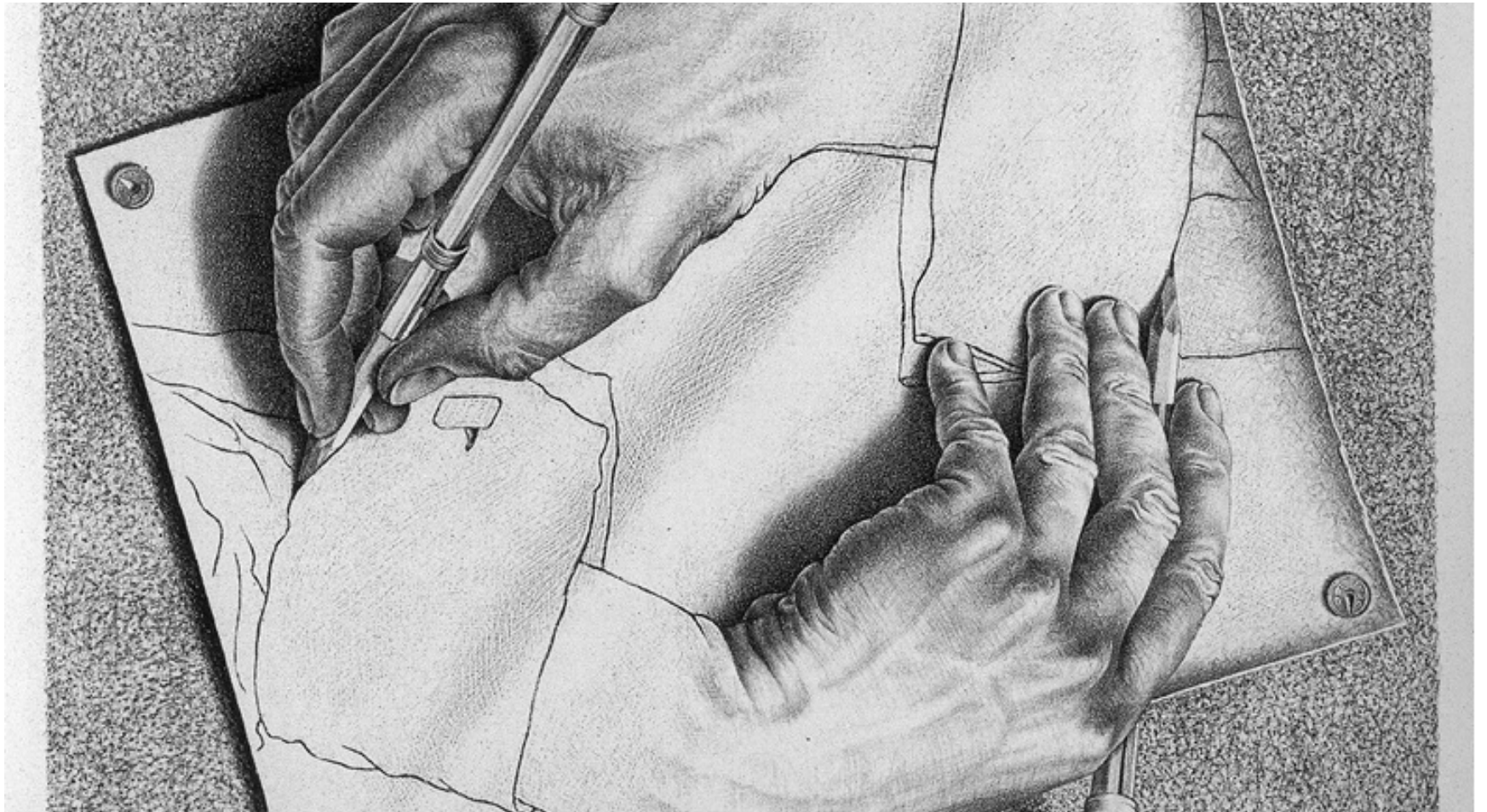


Muscle-specific for
action observation
and imagination

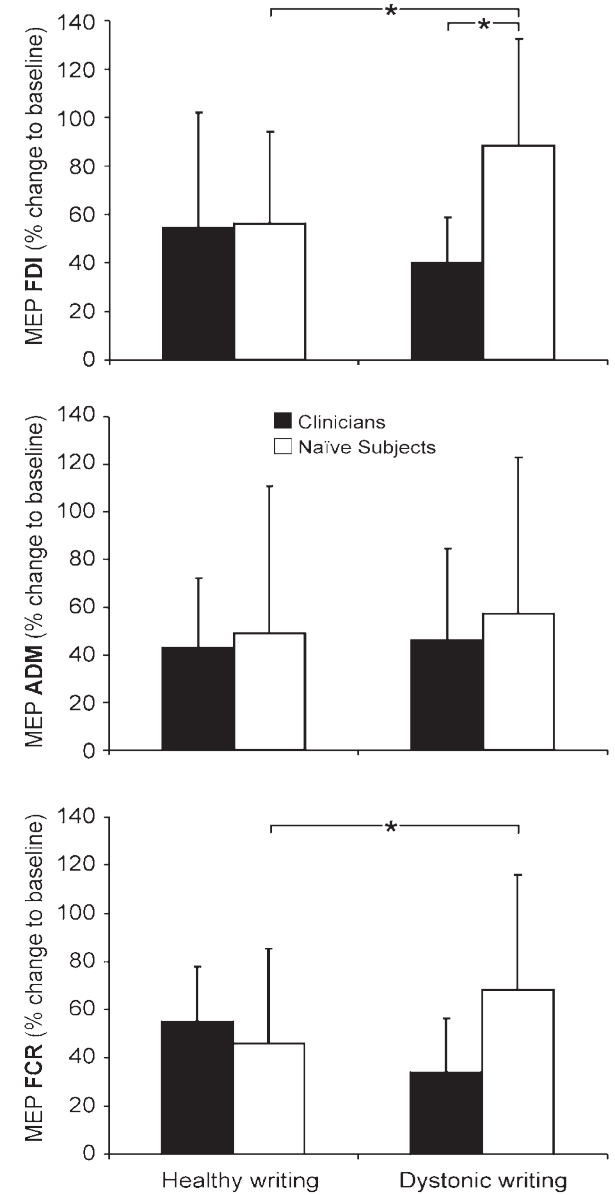
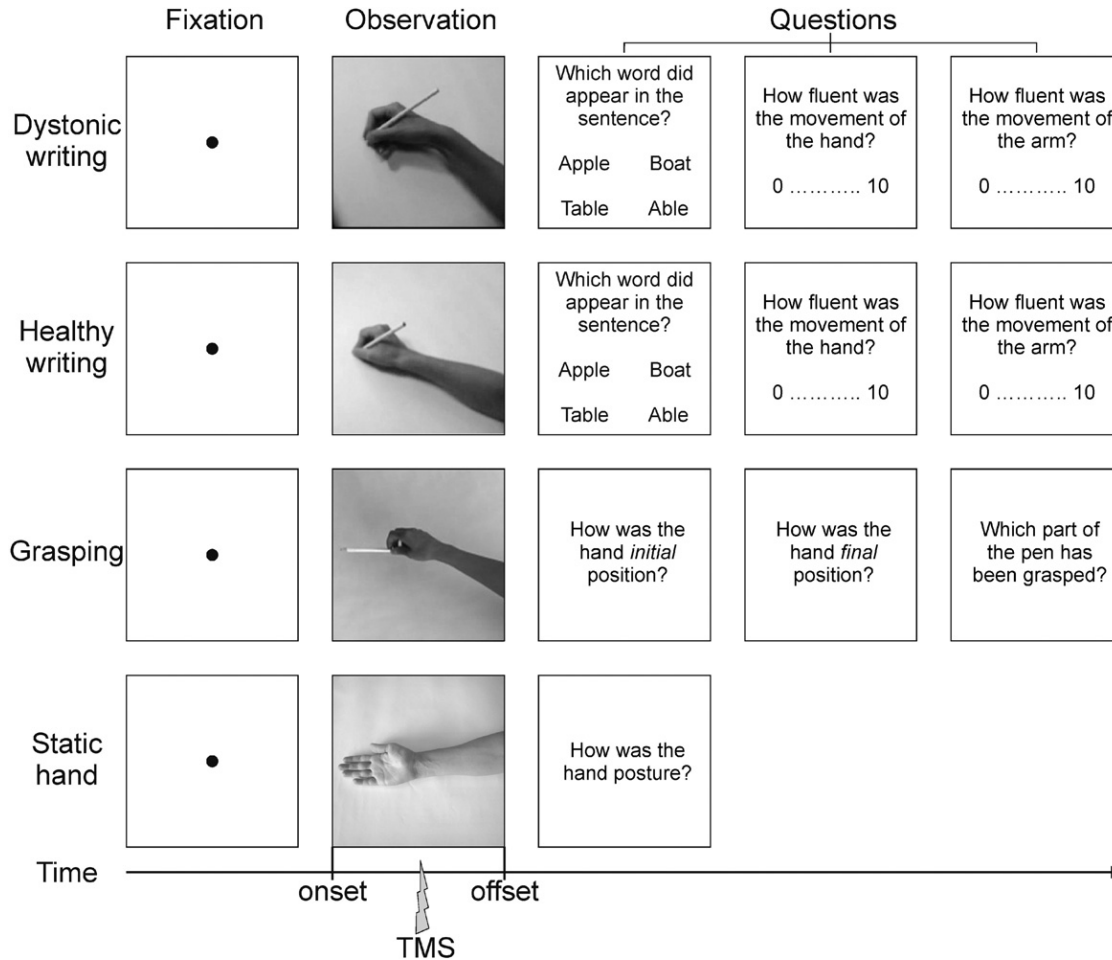
Bufalari et al. Biol. Psych. 2010

Romani et al., Neuroimage, 2005

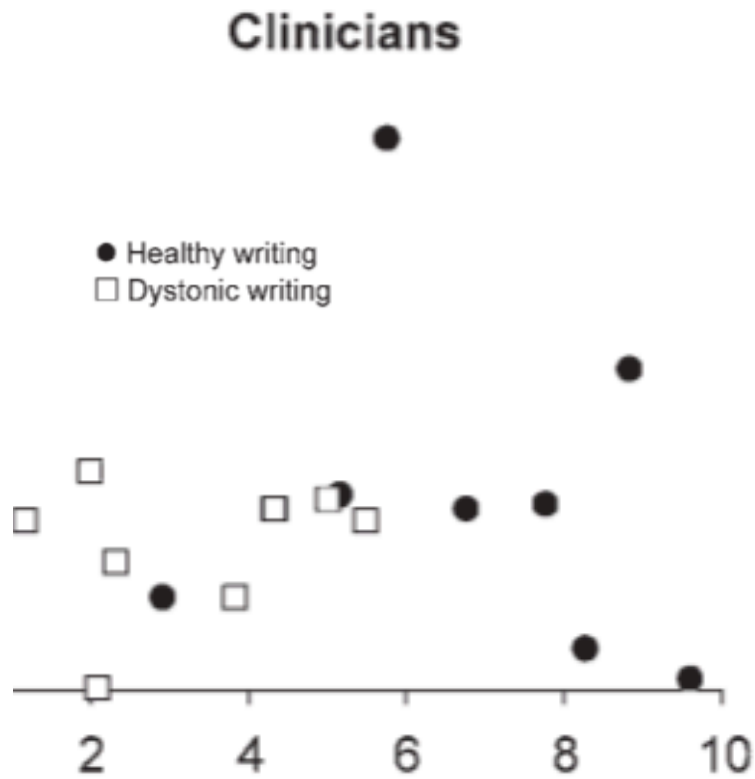
Distonic hand



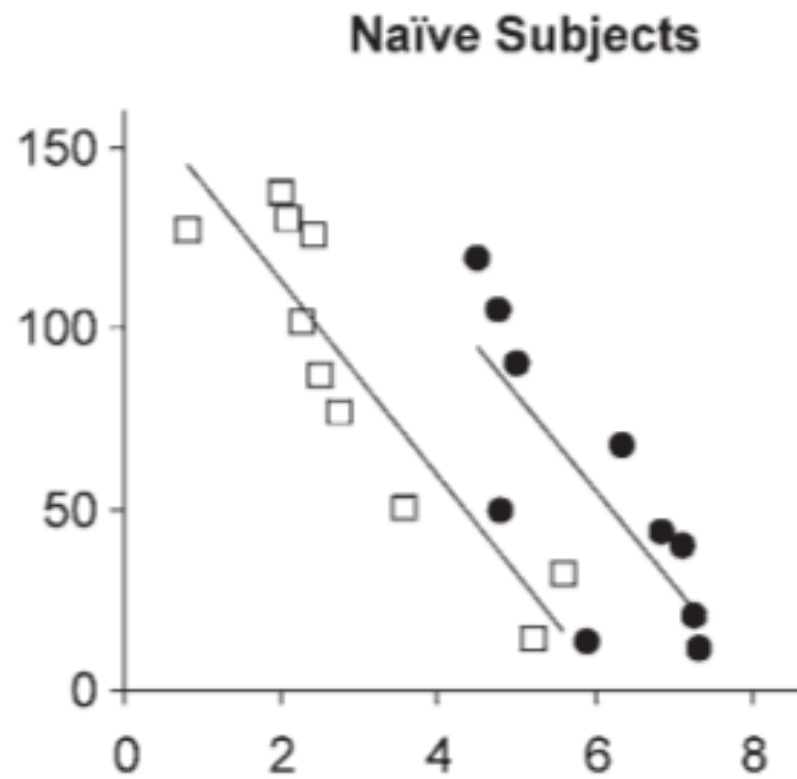
Observing pathological actions



FDI Muscle

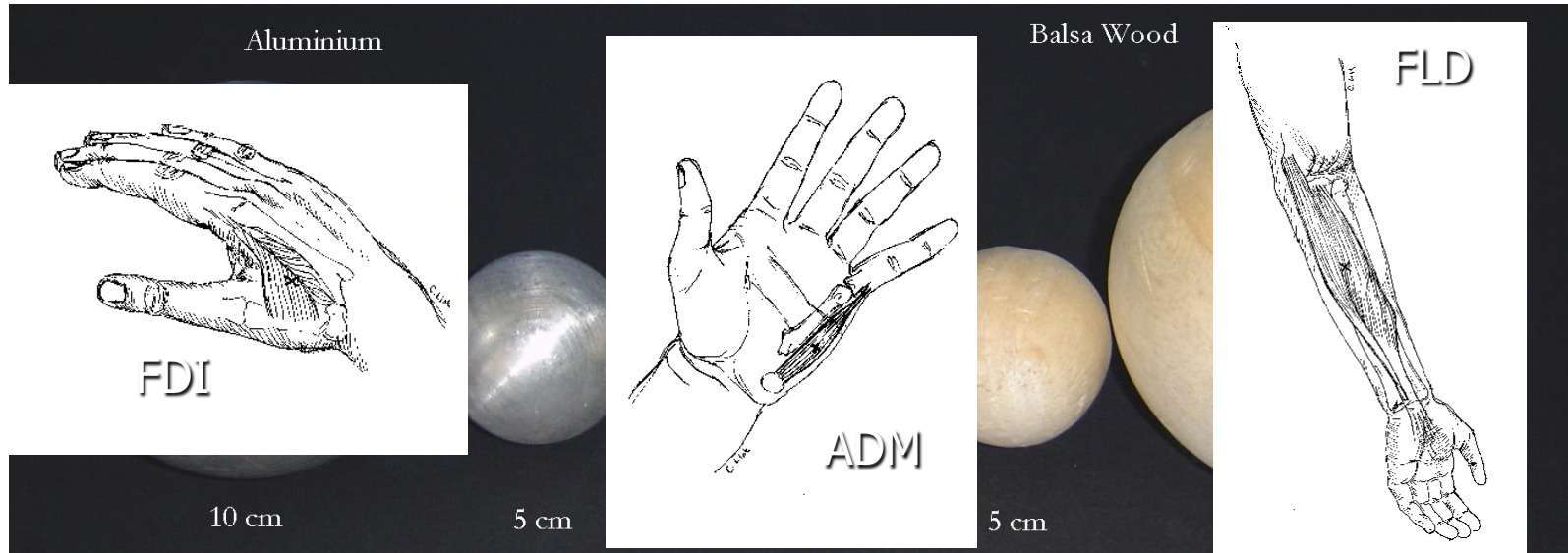


Hand Fluidity score



Hand Fluidity score

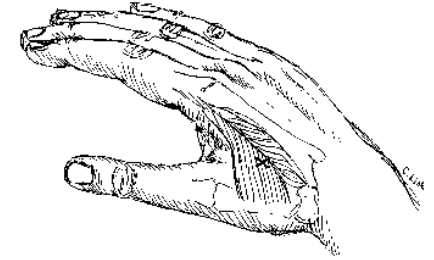
Task Parameters



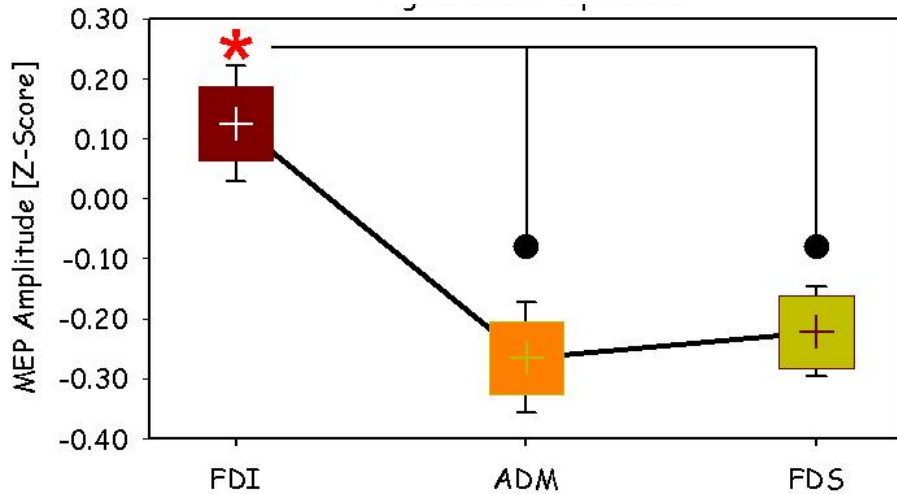
Imagine to hold a sphere

Hold a sphere

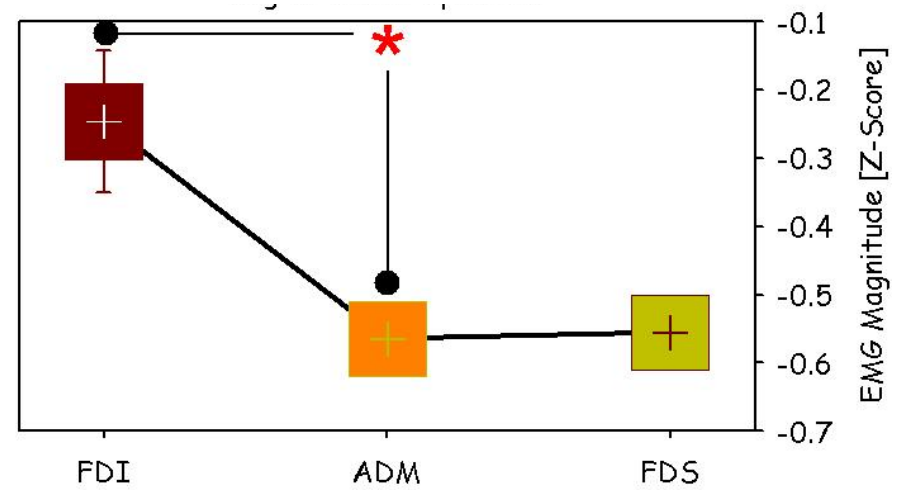
Small Spheres

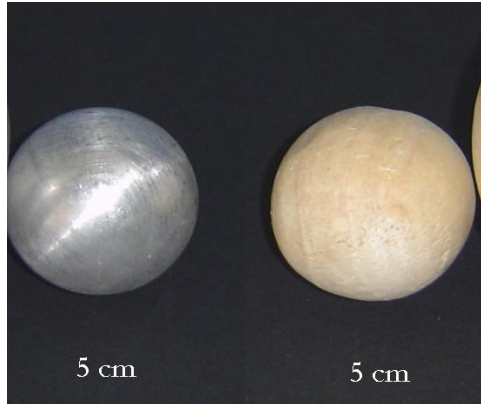


Imagination



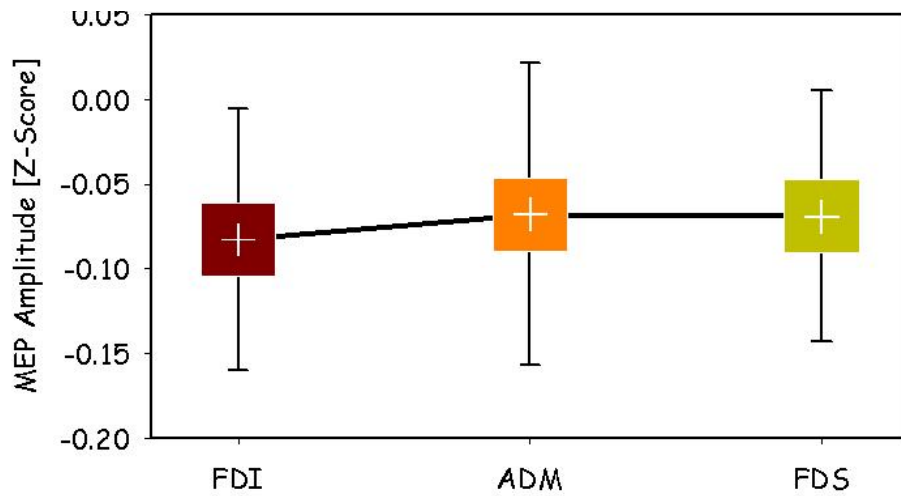
Actual Action



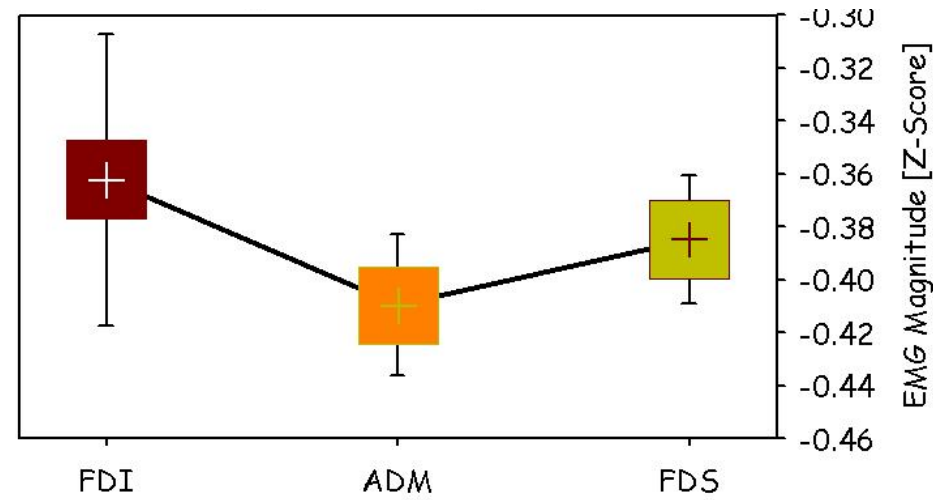


Medium spheres

Imagination



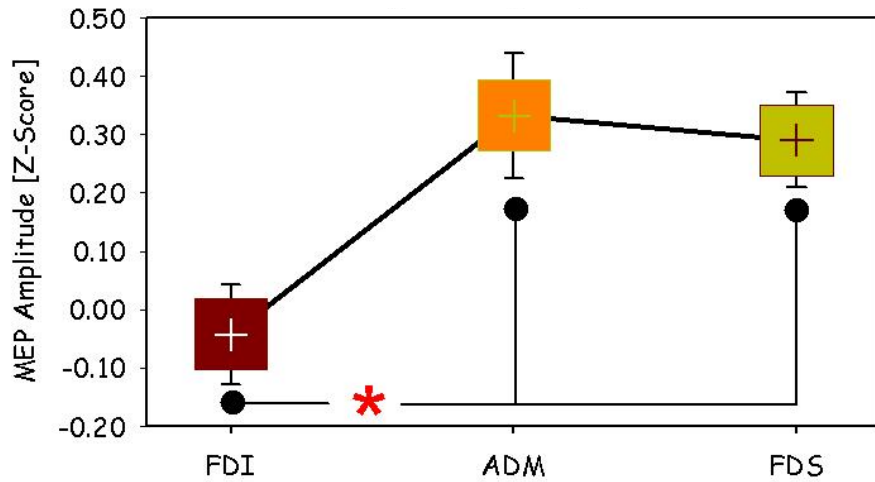
Actual Action



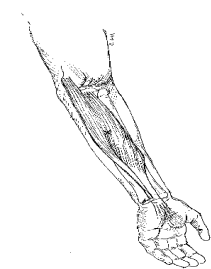
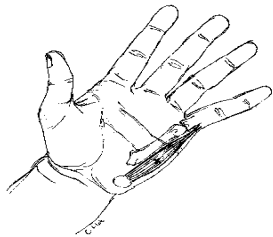
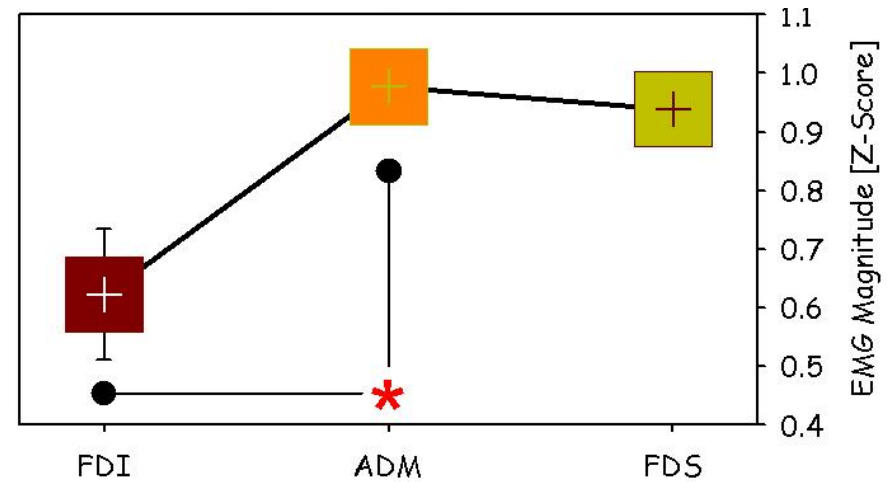


Large Spheres

Imagination

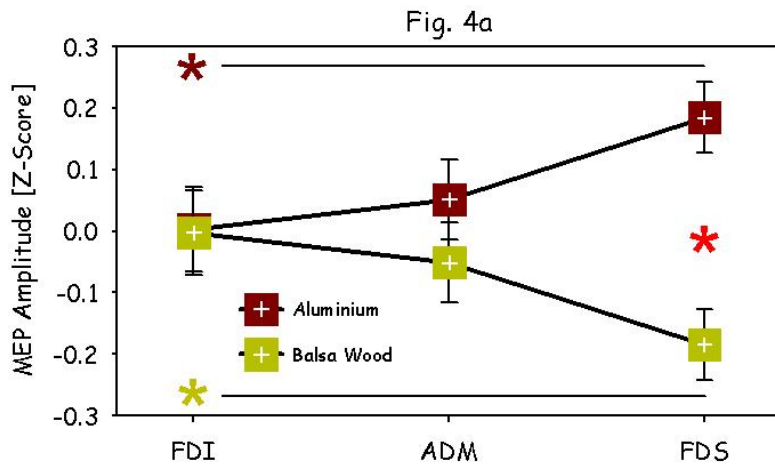


Actual Action

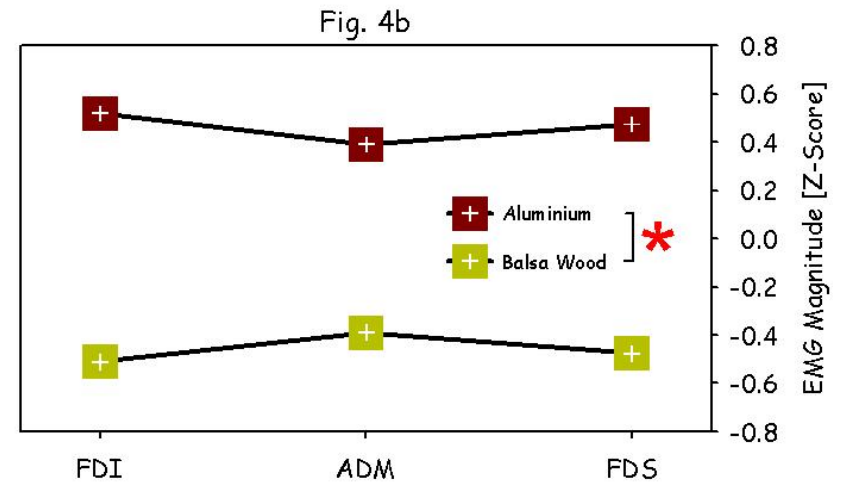


the density

Imagination

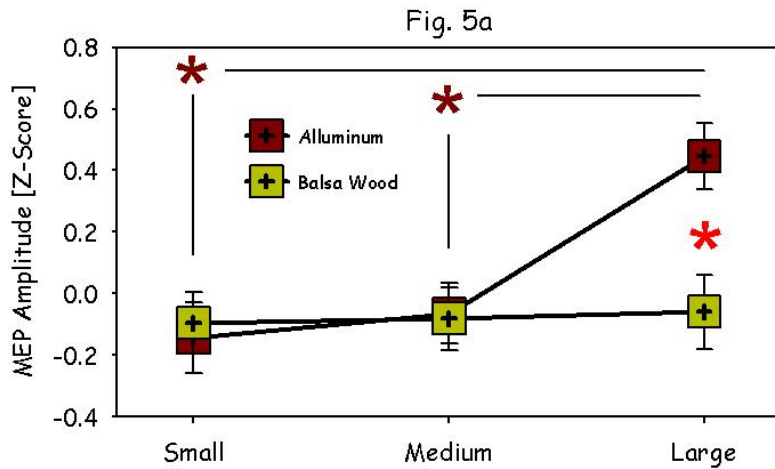


Actual Action

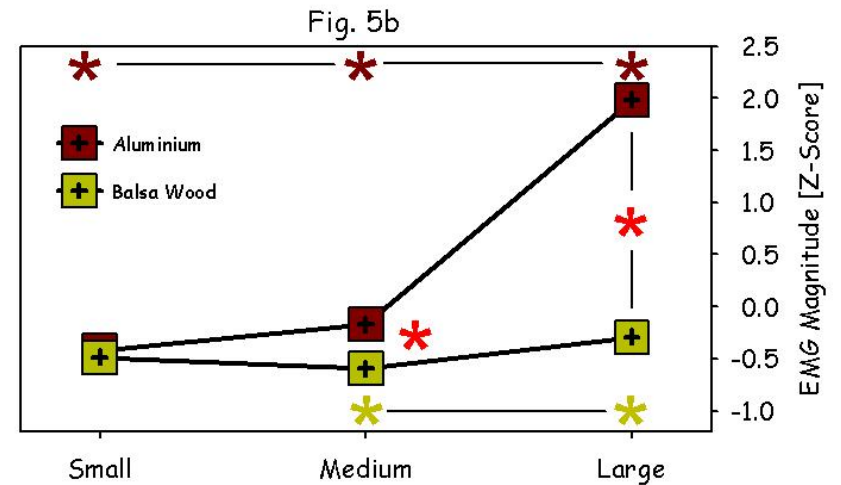


density

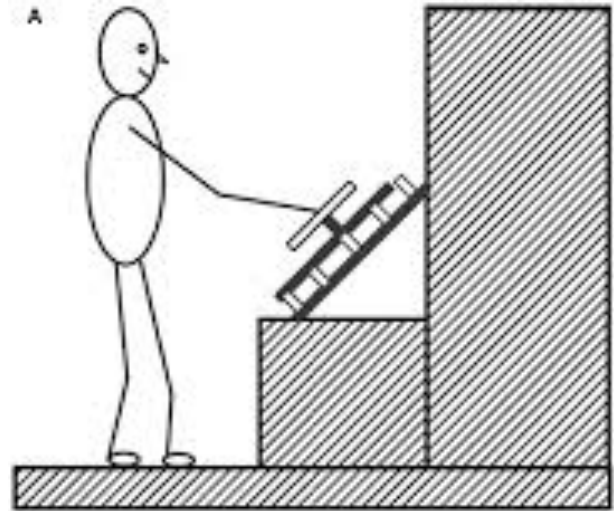
Imagination



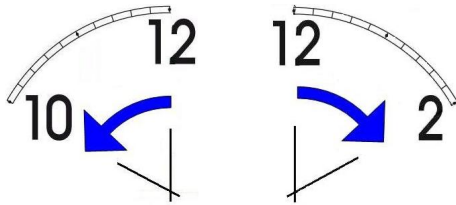
Actual Action



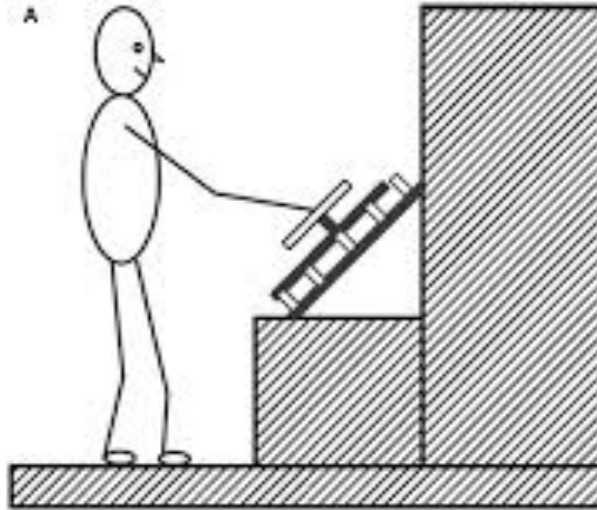
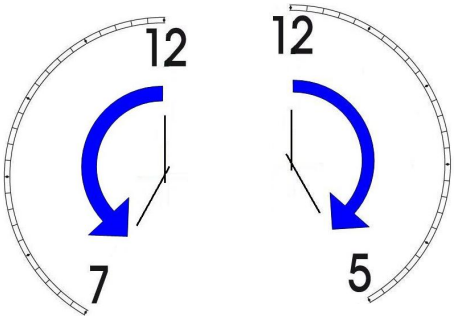
Movement direction and amplitude



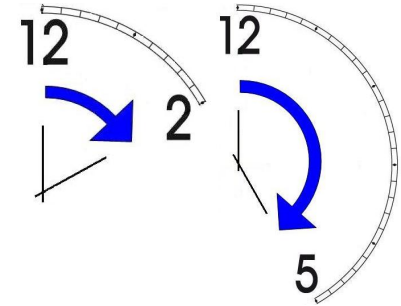
Small Amplitude



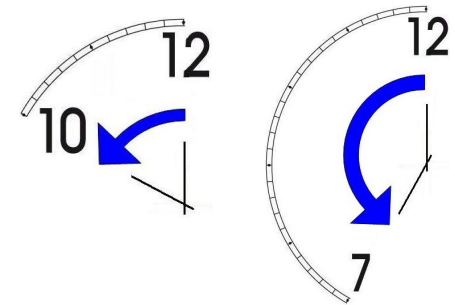
Large Amplitude



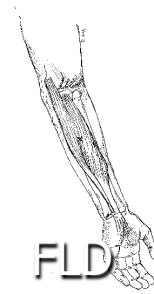
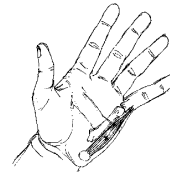
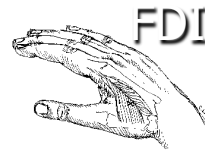
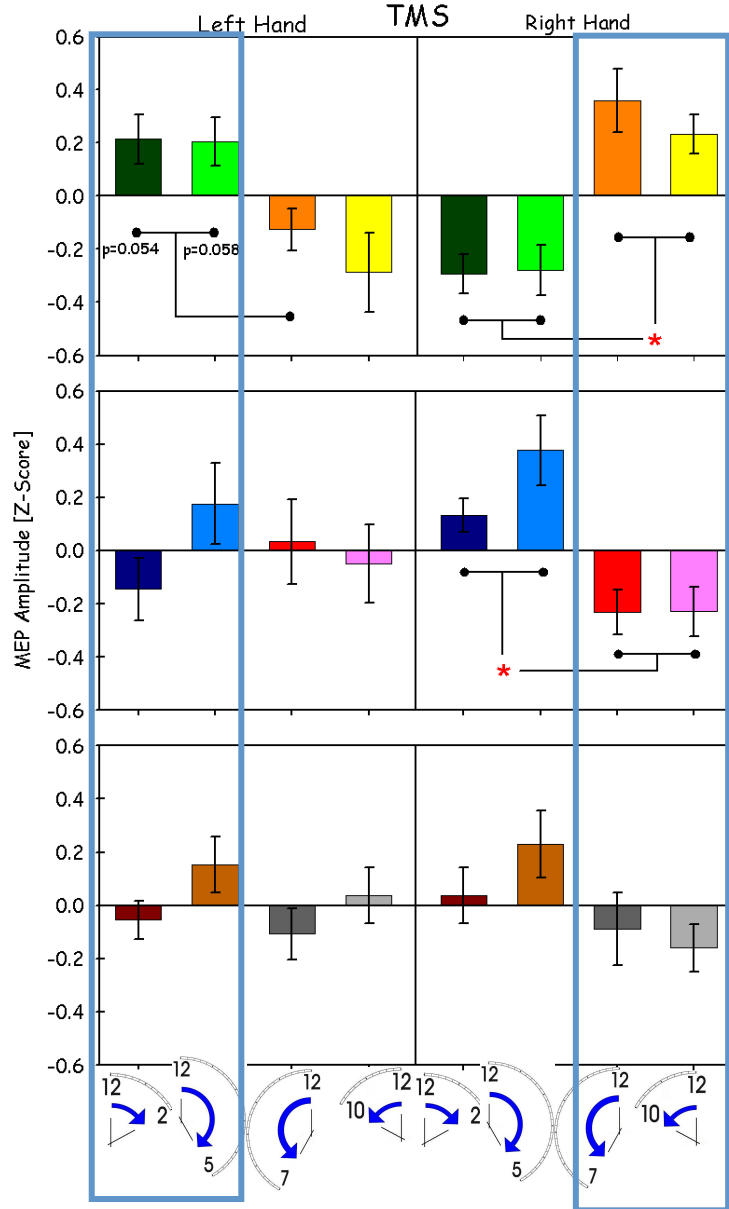
Clockwise Direction



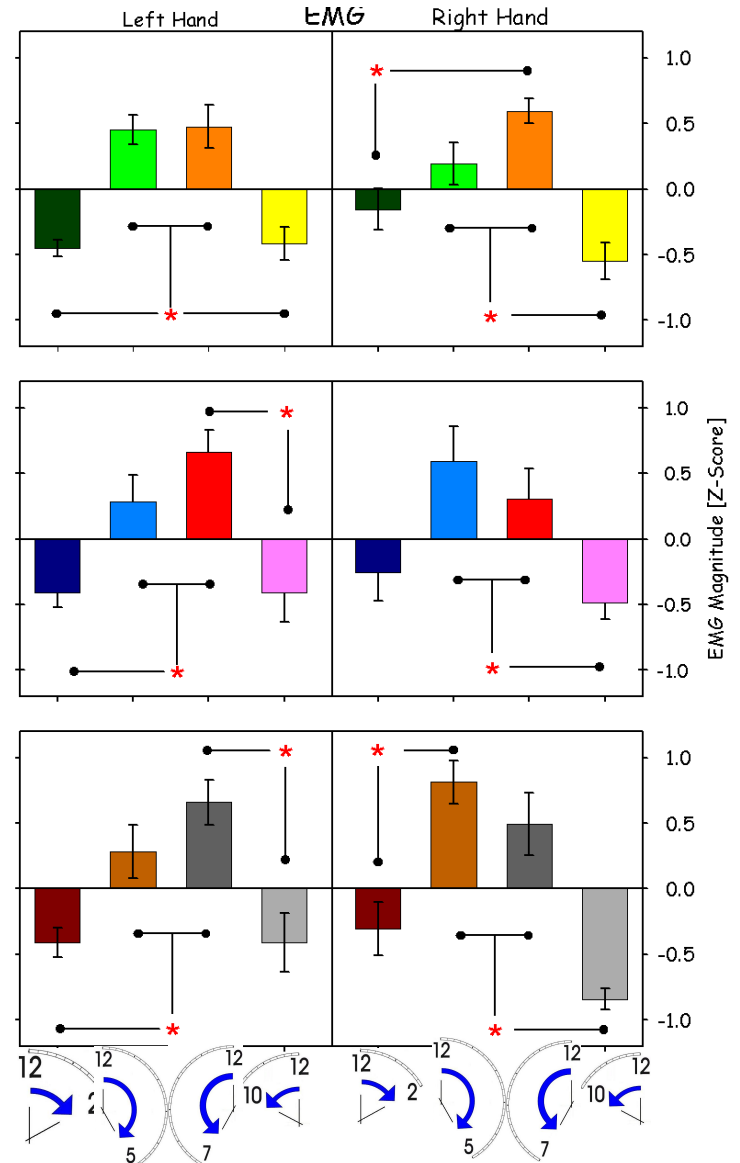
Counter Clockwise Direction



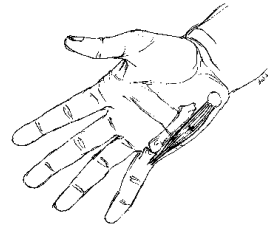
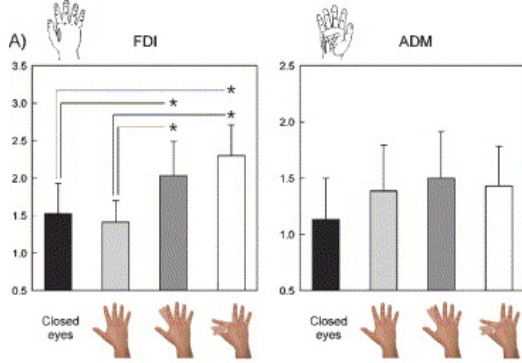
Imagination



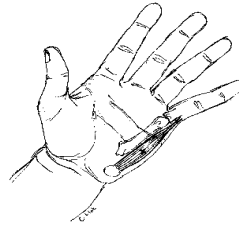
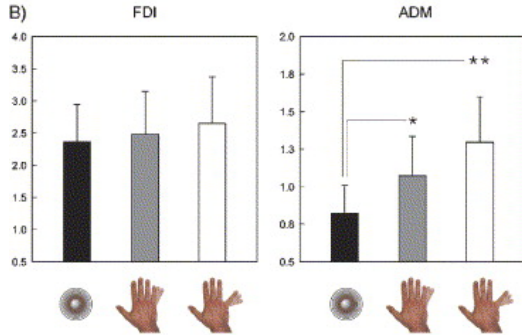
Actual Action



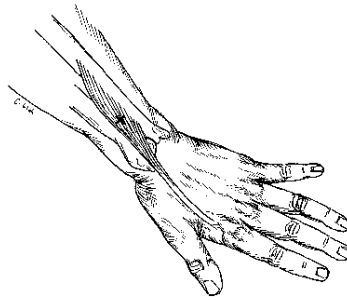
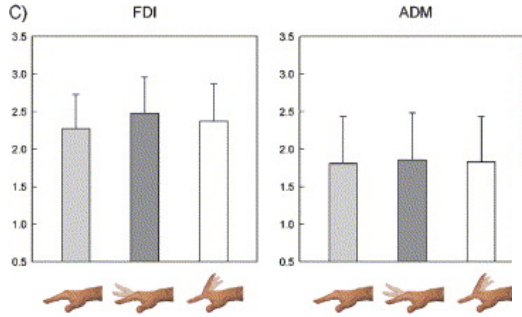
Muscle specificity



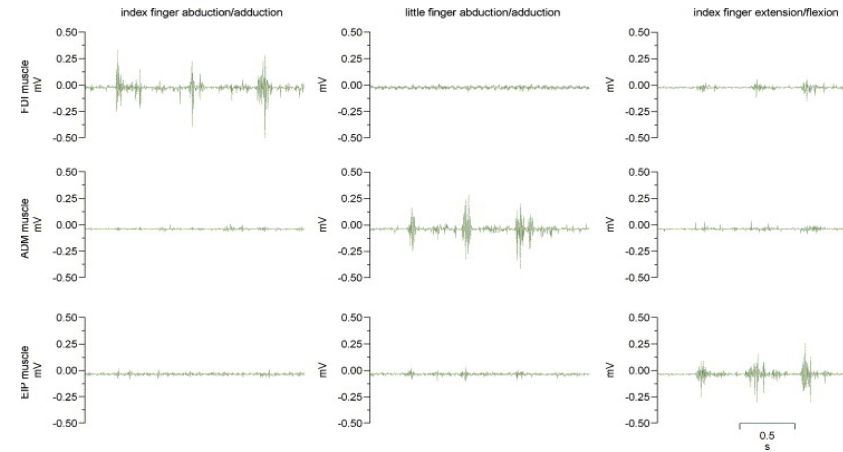
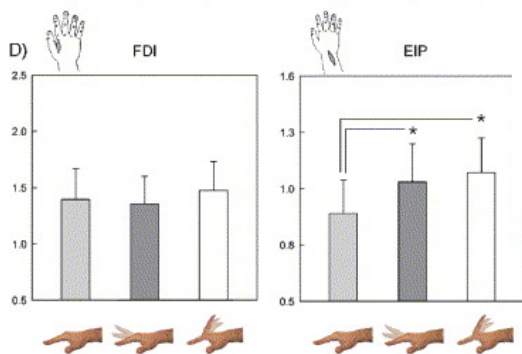
FirstDorsalInterosseus



AbductorDigitiMinimi

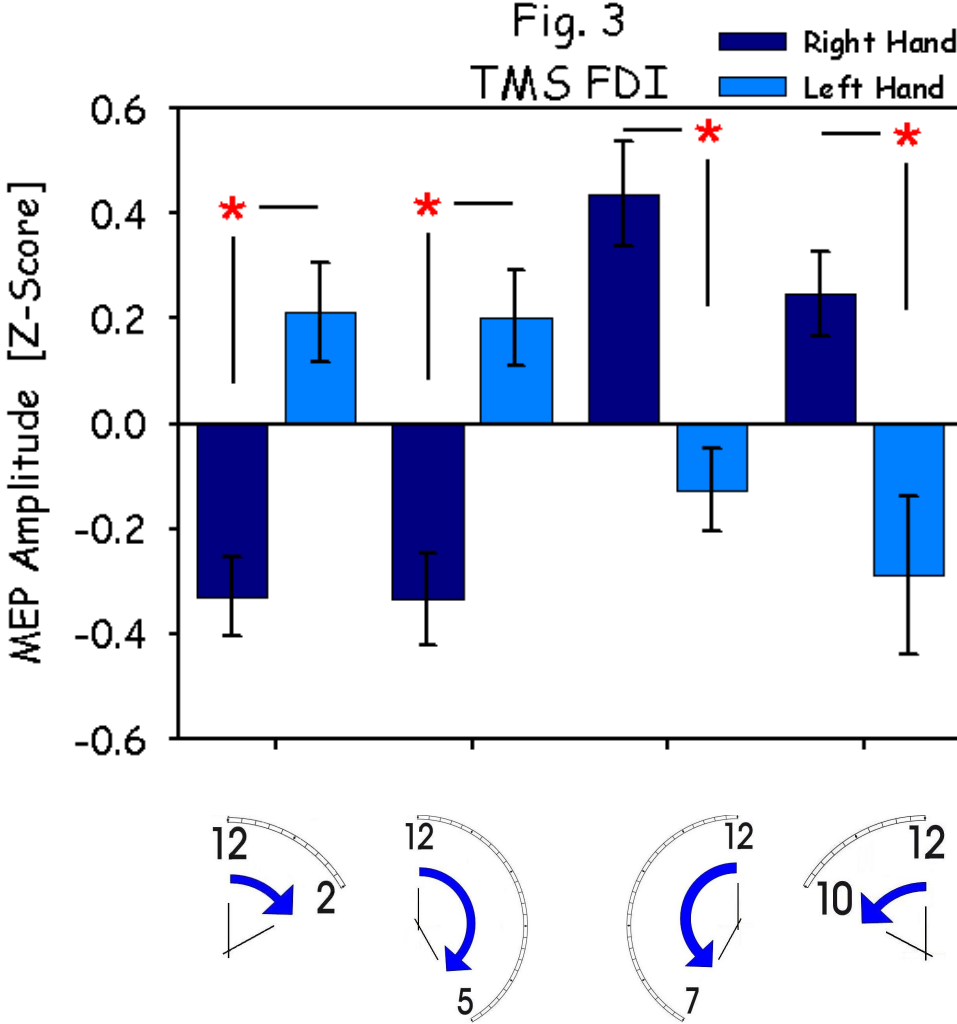


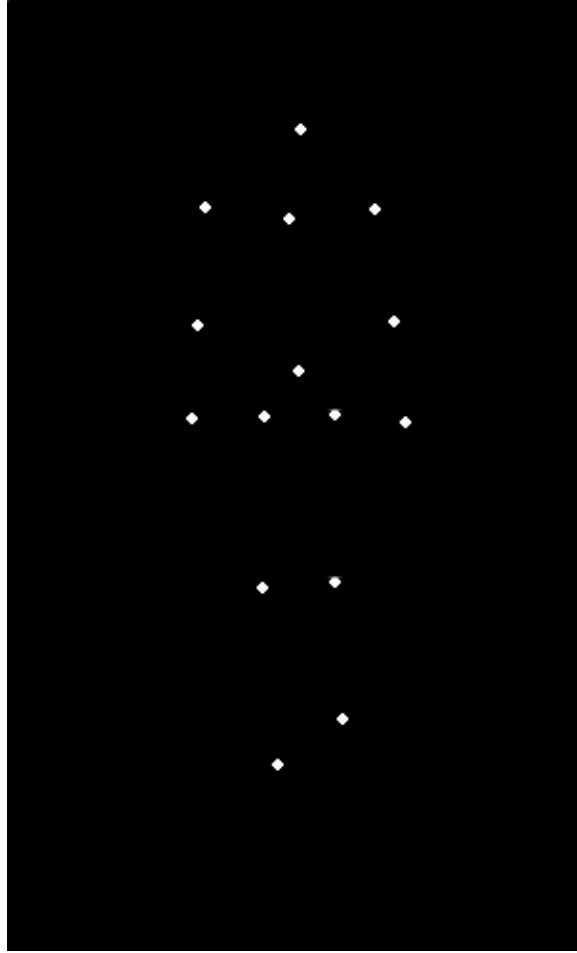
ExtensorIndicisProprius



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 expertise and neuroscientific models of the basic mechanism that support sporting success

Observer → Athletes vs sport-journalist/non-athletes

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



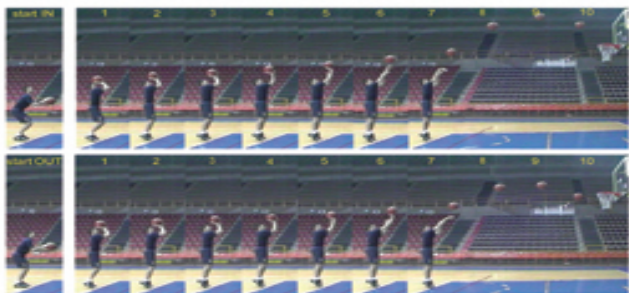
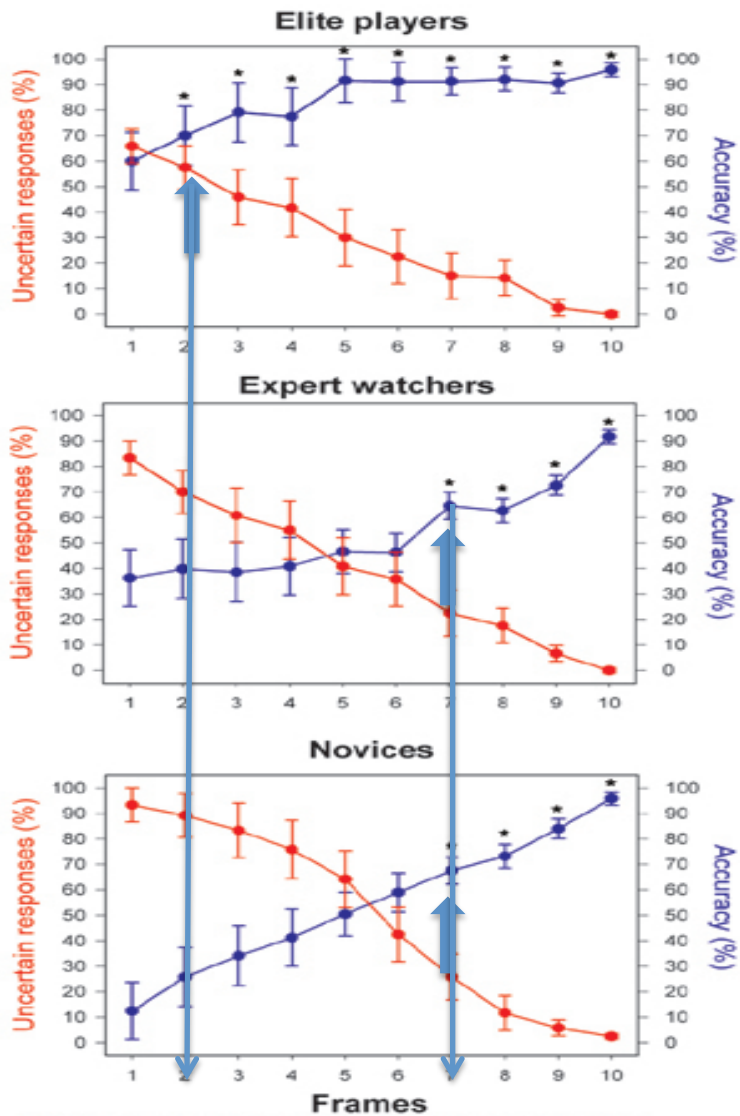
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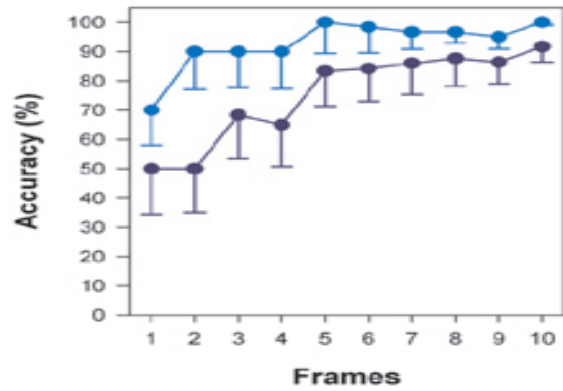


Players

Journalists

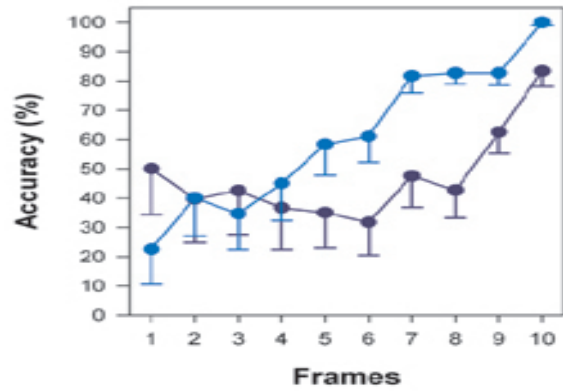
Non-Players



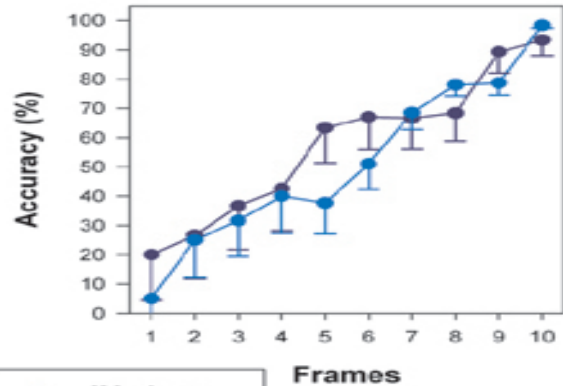


Players

Ex

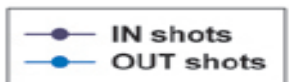


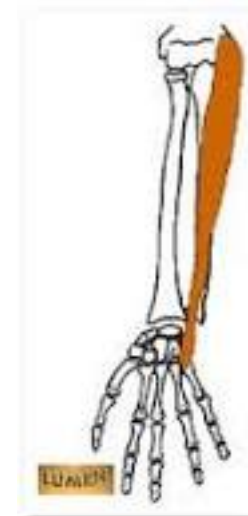
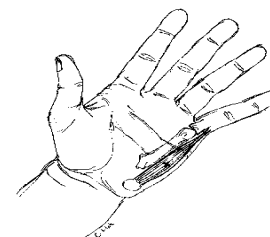
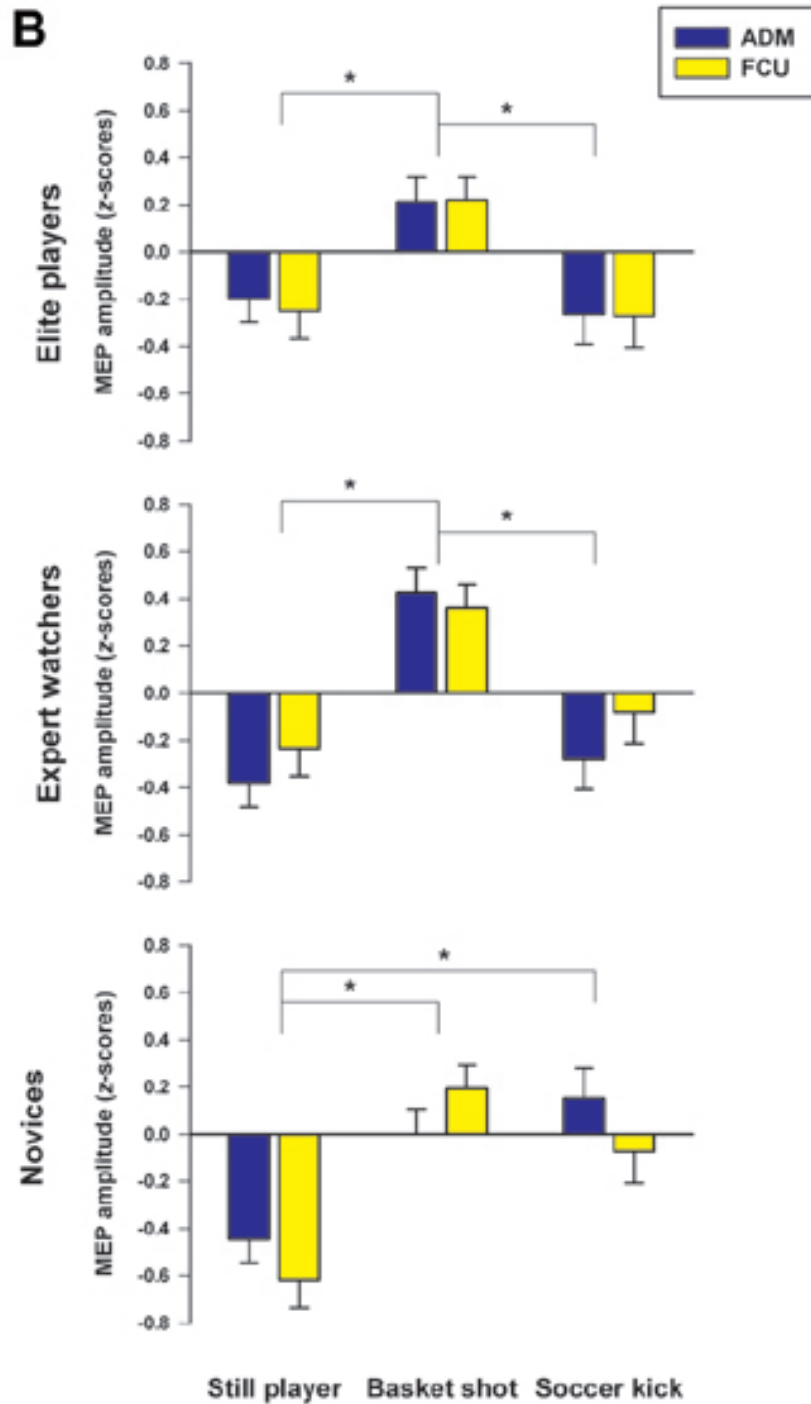
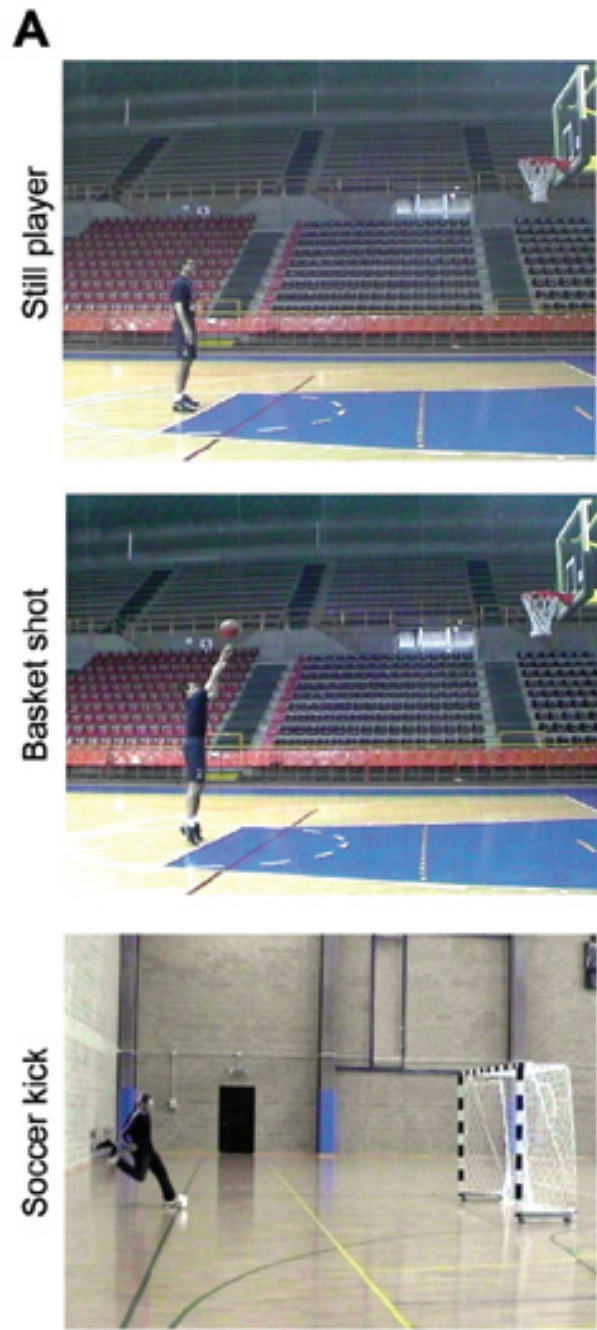
Journalists

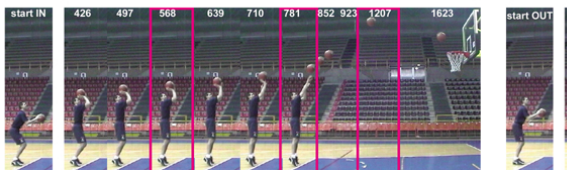
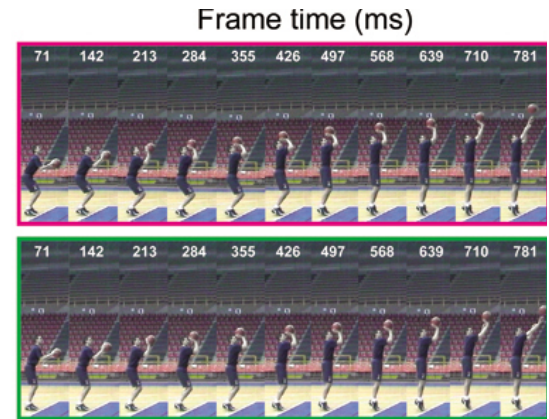
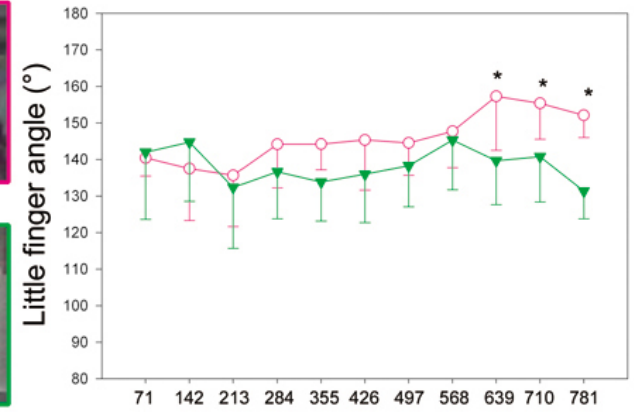
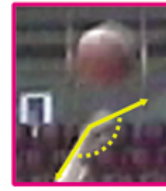
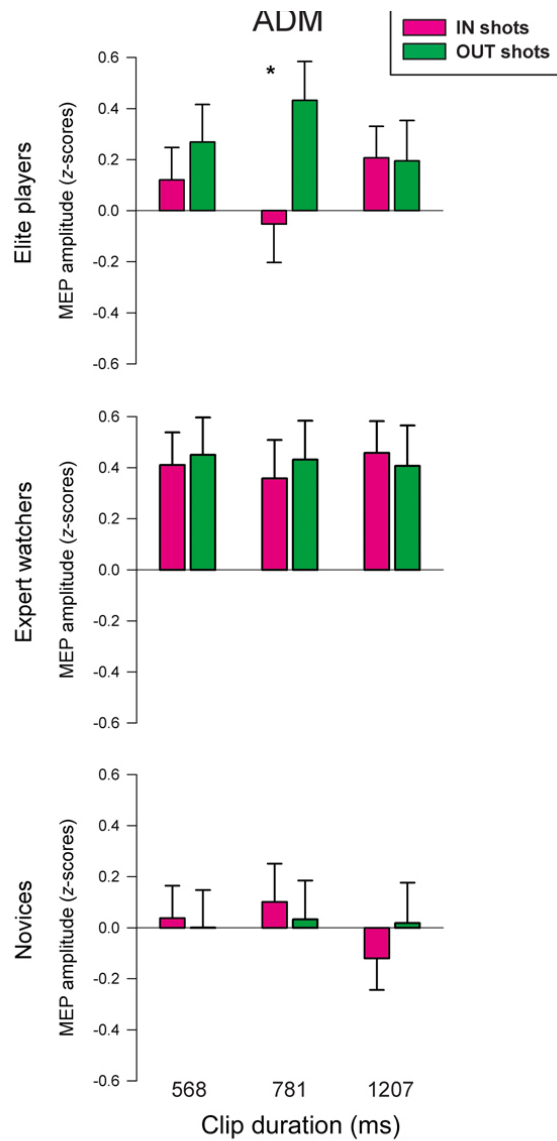


Non-Players

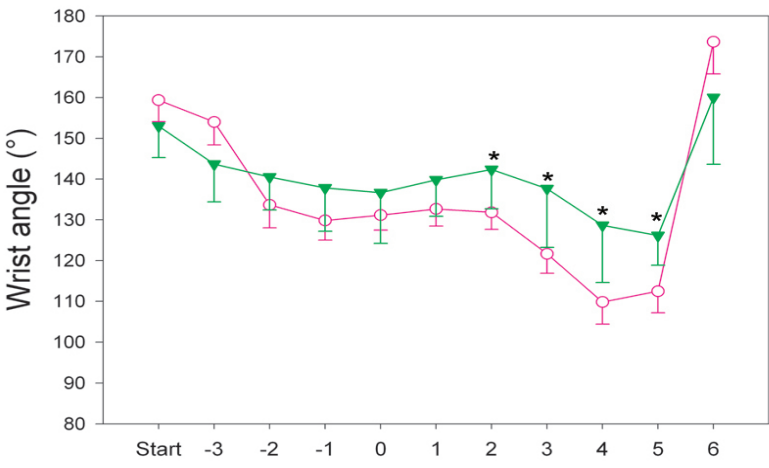
Aglioti et al. Nature Neuroscience 2008



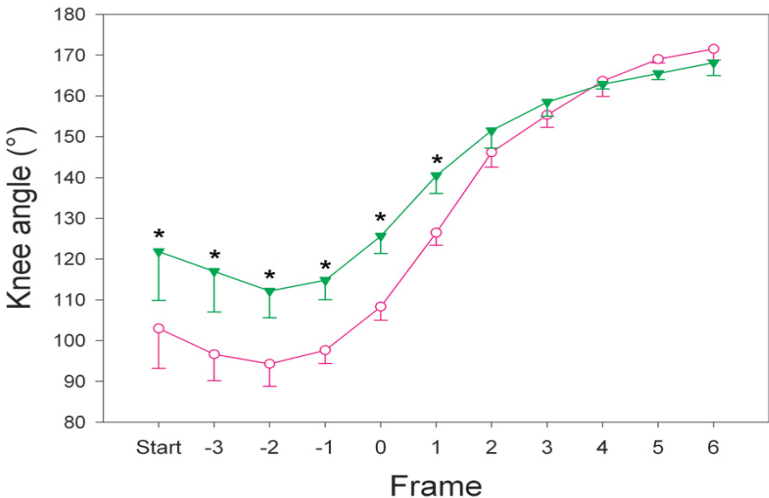




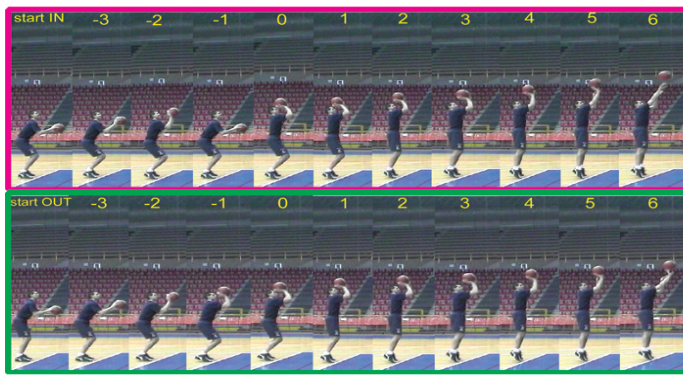
Aglioti et al. Nature Neuroscience 2008

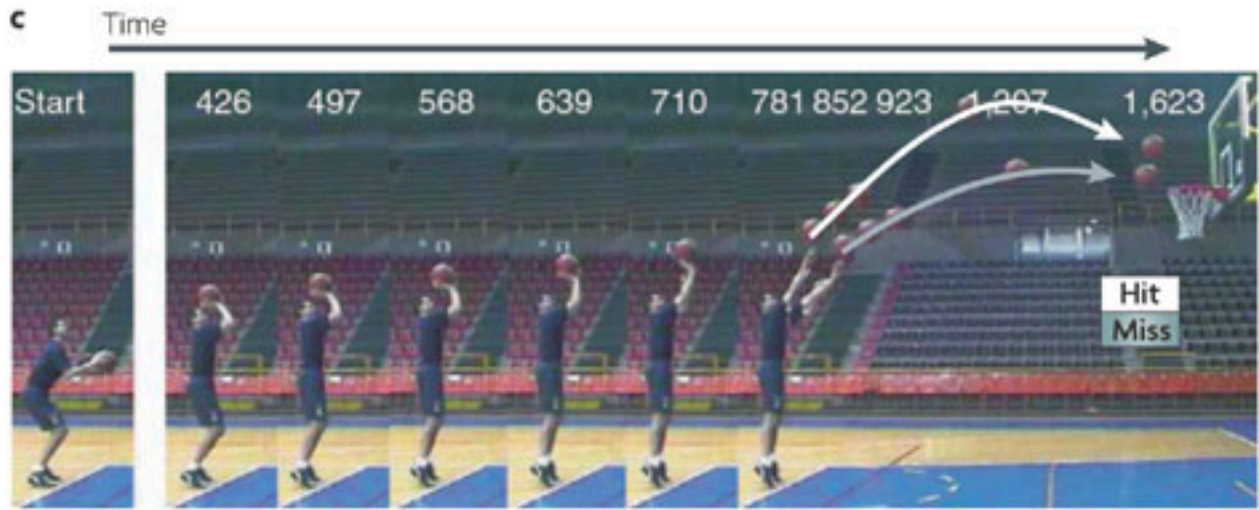


The wrist angle different between IN and OUT at the instant of the ball throw

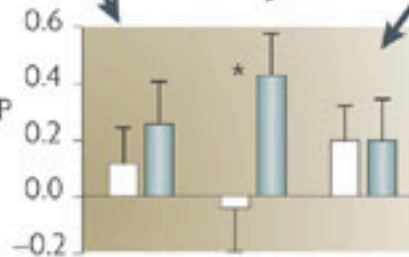


The knee angle different between IN and OUT at the very beginning of the action



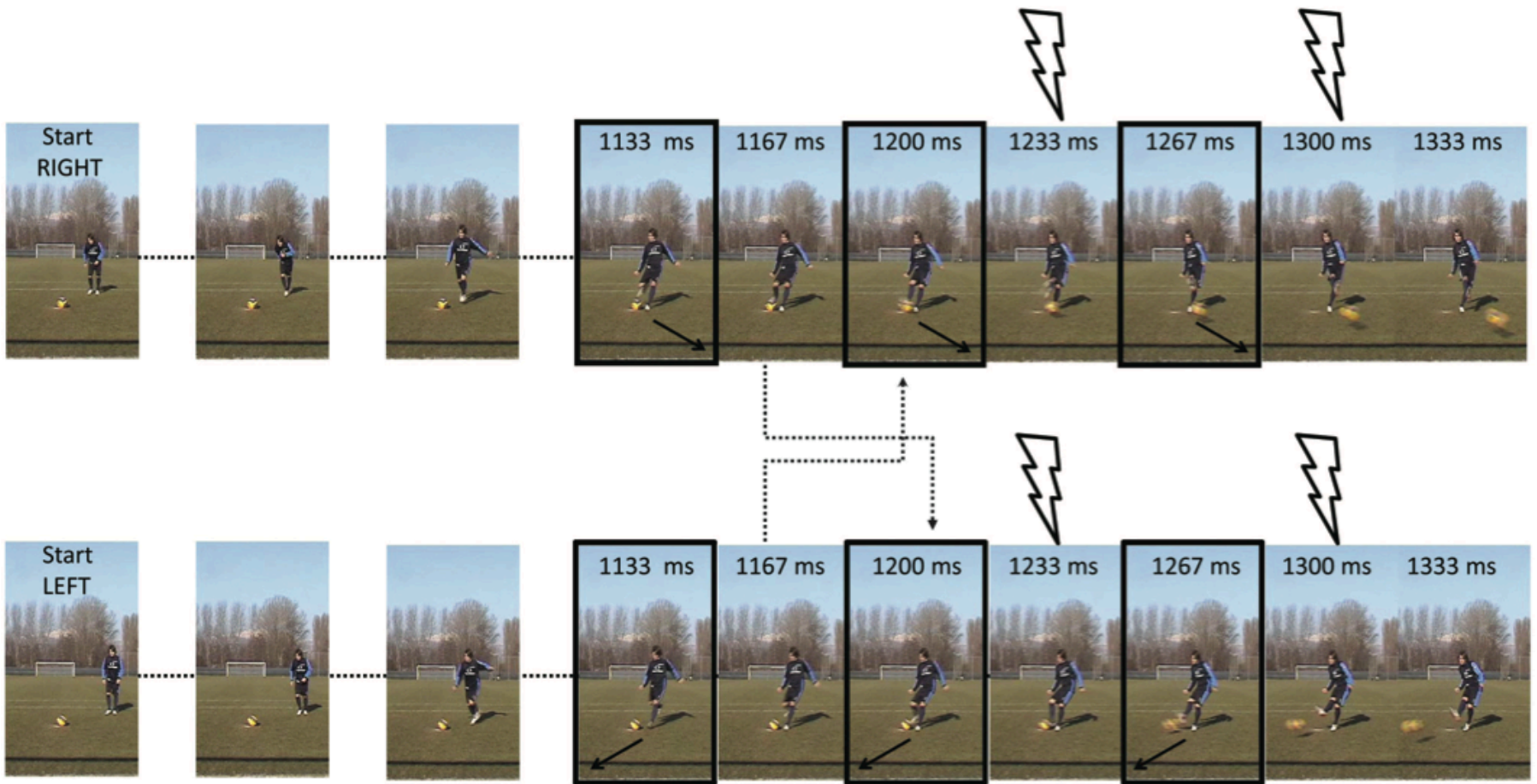


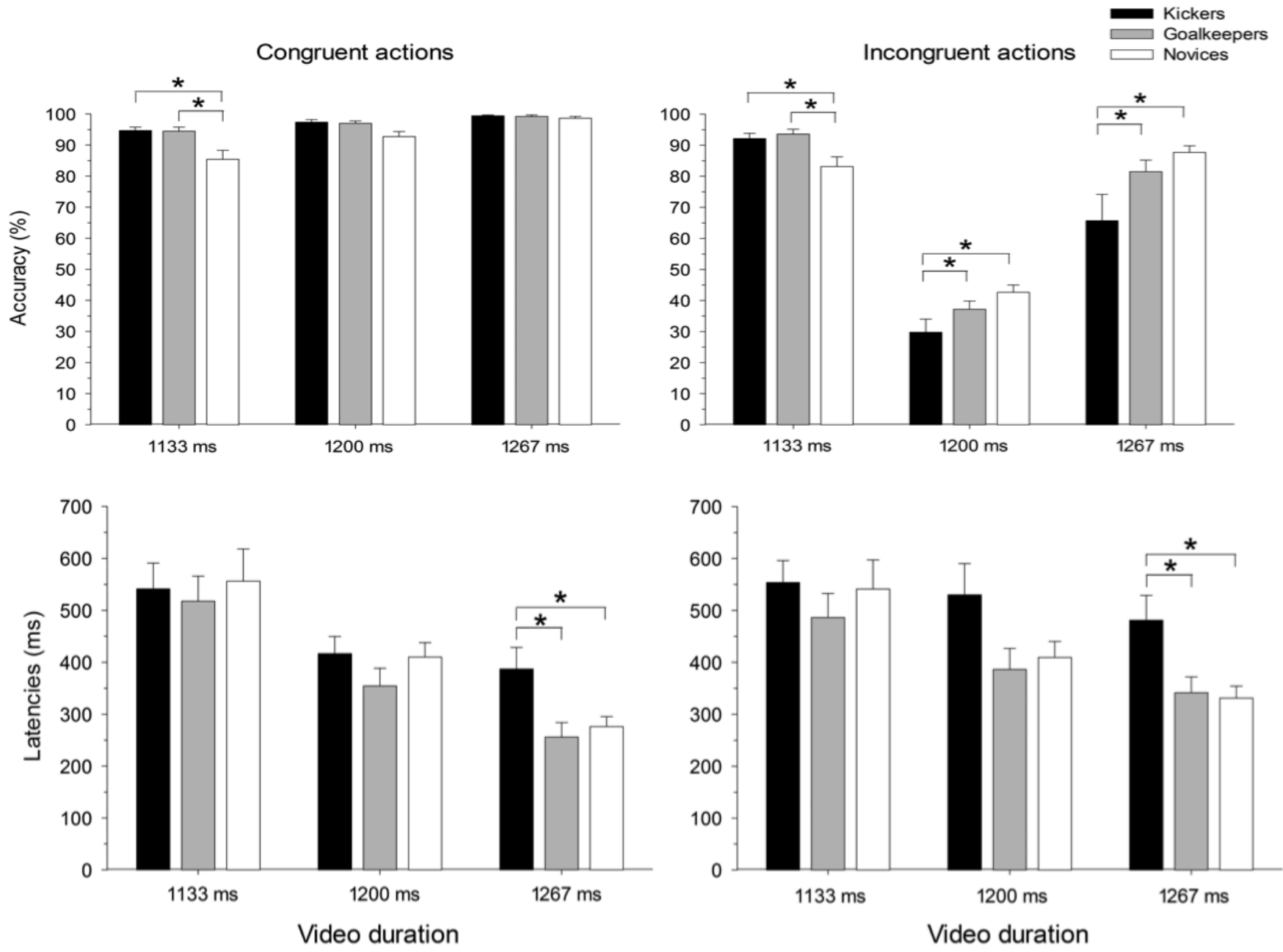
TMS-evoked ADM MEP amplitude (z scores) during observation



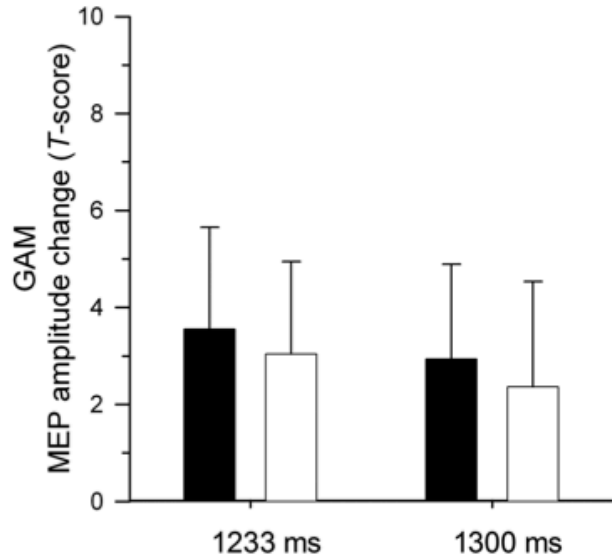
Time of TMS pulse (see timeline above)



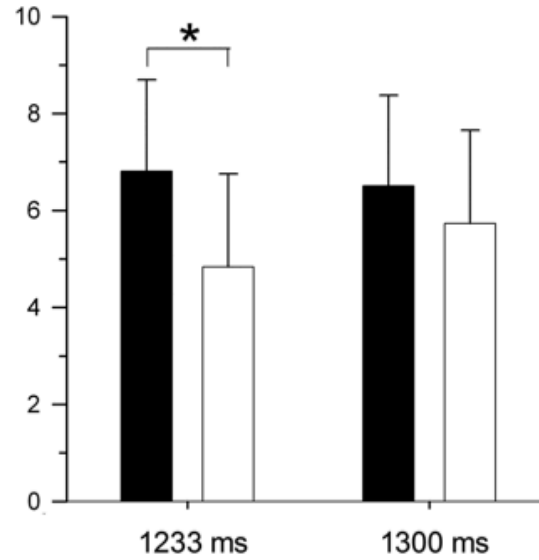




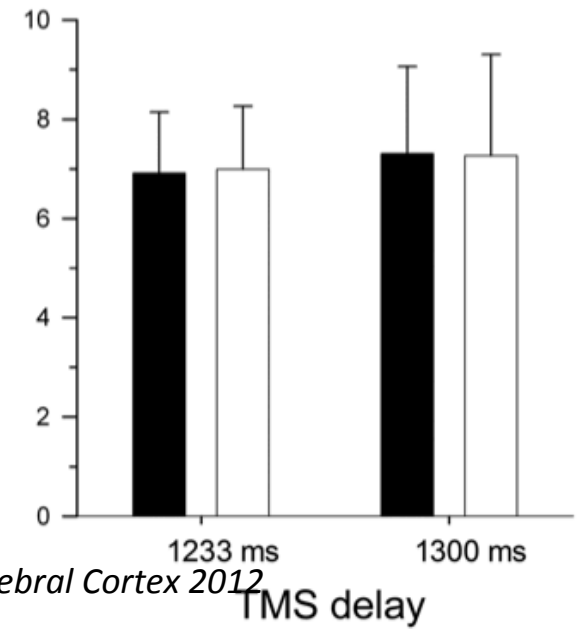
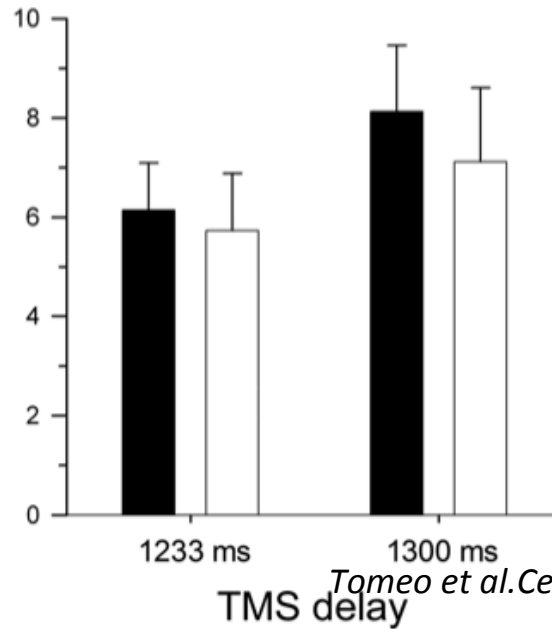
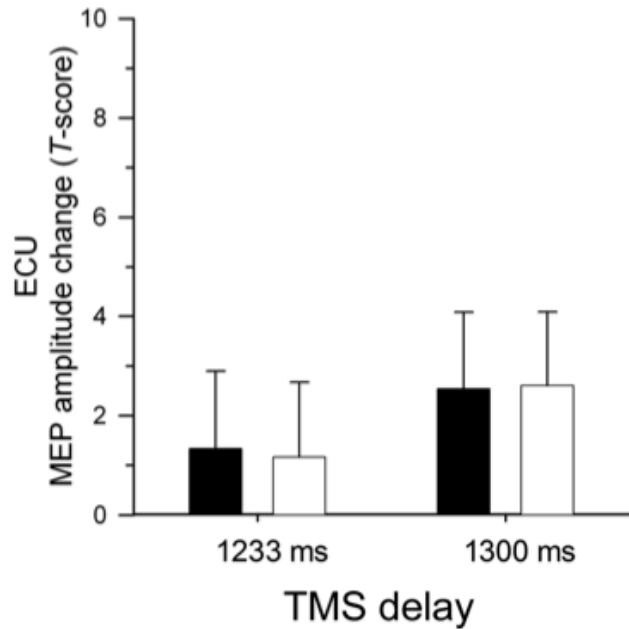
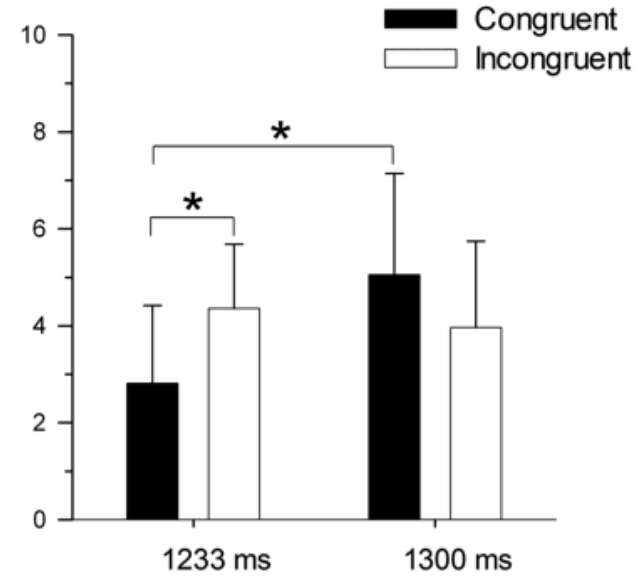
Kickers



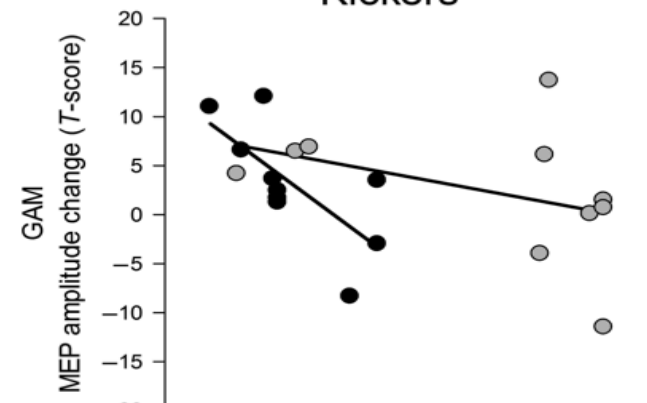
Goalkeepers



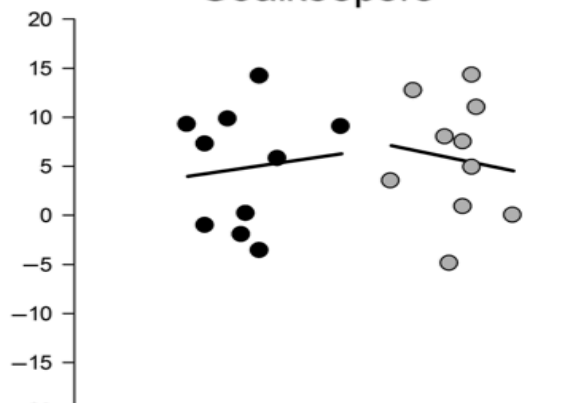
Novices



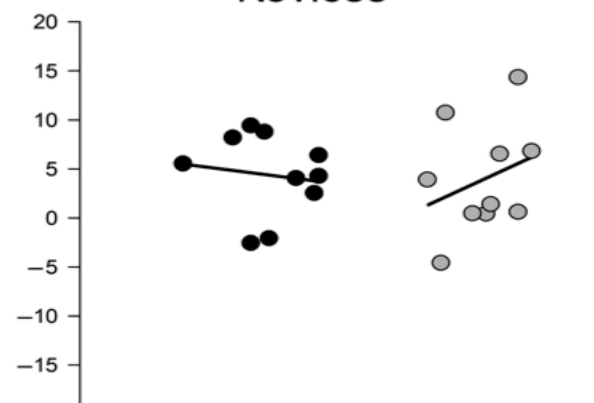
Kickers



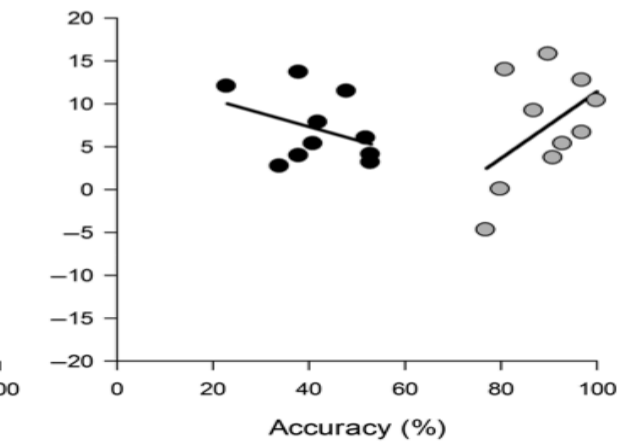
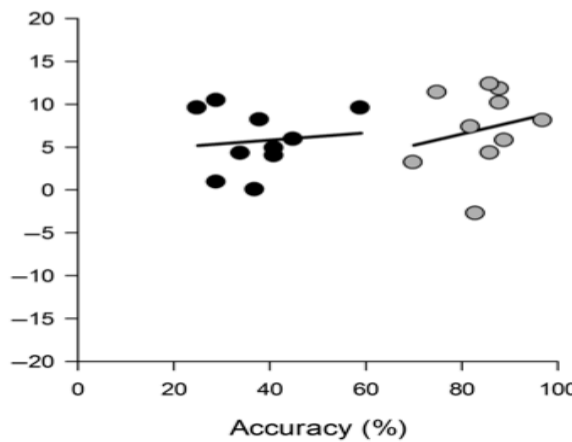
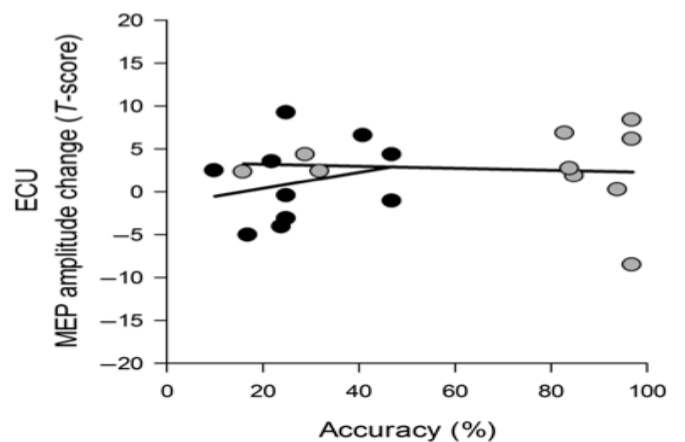
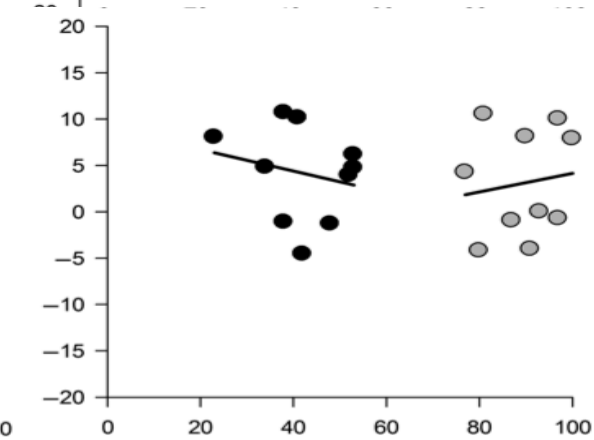
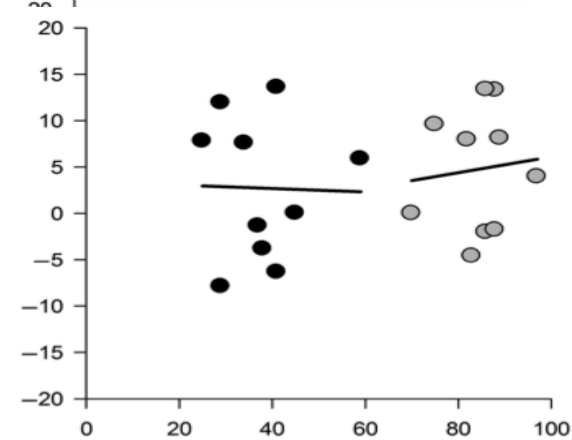
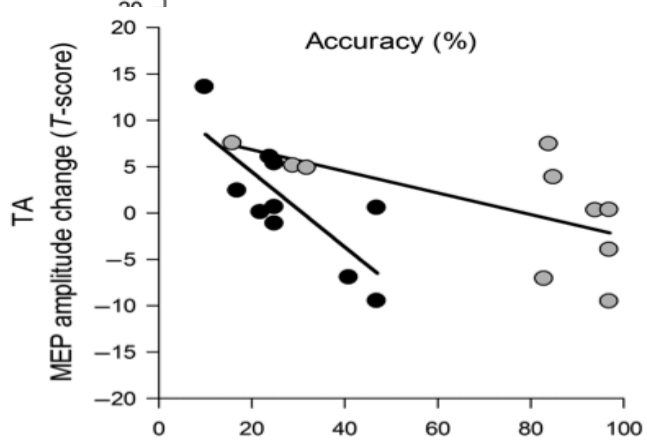
Goalkeepers



Novices



Accuracy (%)



● 1200 ms video duration versus 1233 ms TMS delay

● 1267 ms video duration versus 1300 ms TMS delay



Is this person competent?



Participant



Mimic
(Interviewee)

Model
(Interviewer)





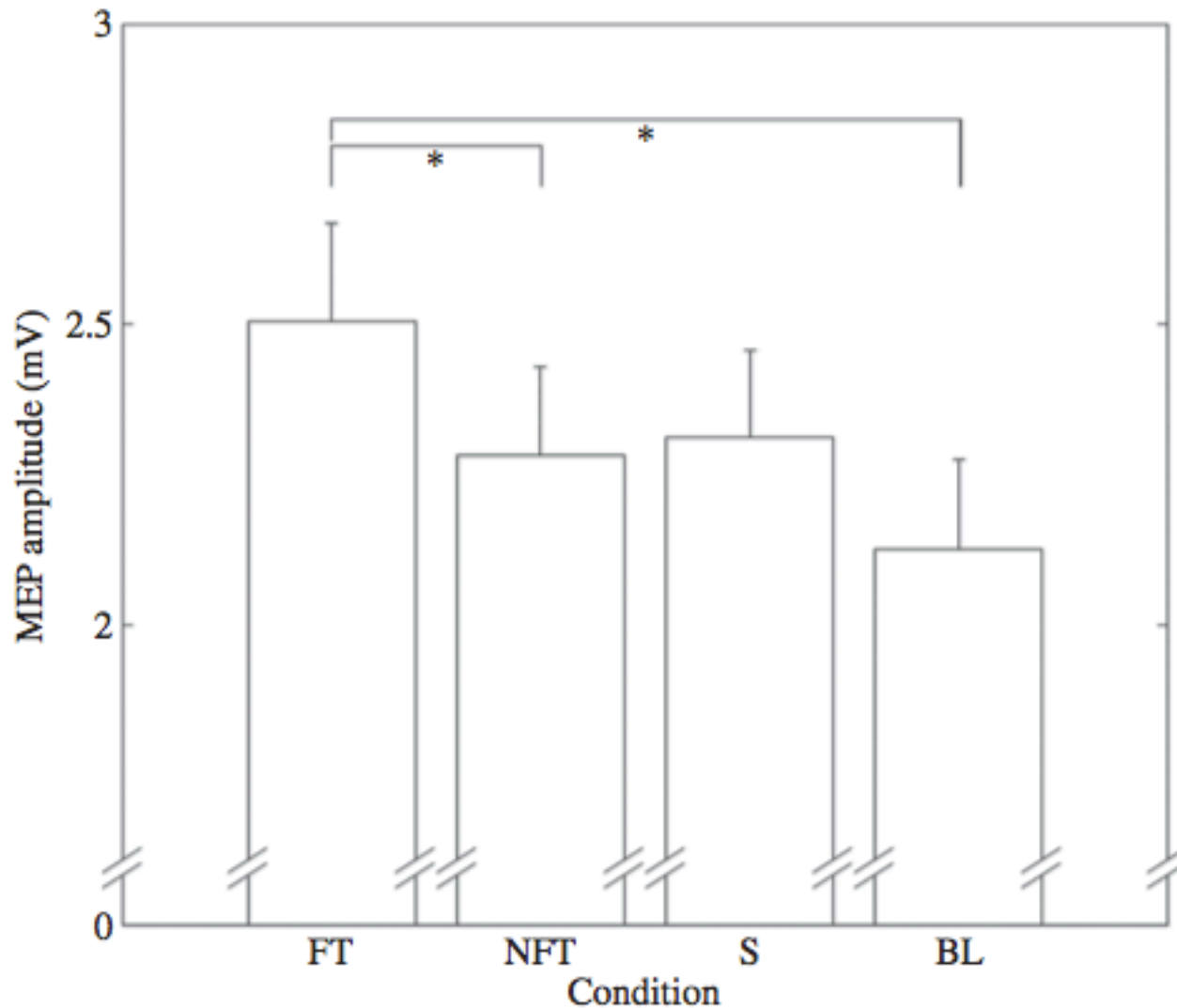


Figure 2. Mean raw MEP amplitudes (+SE) for the face-touching (FT), no face-touching (NFT), static image (S), and baseline (BL) conditions. * $p < .05$.

