SIPF

Società Italiana di Psicofisiologia e Neuroscienze Cognitive

XXIX CONGRESSO NAZIONALE

PALERMO, 30 SETTEMBRE • 2 OTTOBRE 2021

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BEYOND THE LOCKDOWN OF THE BRAIN

Giovedì 30 Settembre 2021

----------SIMPOSIO ----------

Bodily self-perception in healthy and pathological conditions

Chairs: Angela Marotta - Emiliano Ricciardi

How the central processing of sensory information shapes bodily self-perception

Angela Marotta
Dipartimento di Neuroscienze, Biomedicina e Movimento –
Università di Verona

How the effects of actions become our own: the sense of agency and its neural correlates in healthy and pathological populations

Laura Zapparoli
Dipartimento di Psicologia
Università degli Studi di Milano Bicocca

Does the belief of owning a body gate tactile awareness?

Carlotta Fossataro
Dipartimento di Psicologia
Università degli Studi di Torino

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XXIX CONGRESSO NAZIONALE

How the central processing of sensory information shapes bodily self-perception

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Bodily self-perception

- Two main components of bodily self-perception are the sense of agency and the sense of body ownership.

- **Sense of agency** -> feeling of voluntarily controlling our body movements and their effects in the external environment.

- **Sense of body ownership** -> feeling that the body belongs to oneself

Sense of agency and sense of body ownership

- Both these aspects of bodily self-perception involve central processing of sensory information coming from the body

- The **sense of agency** is thought to arise when there is a match between the predicted and the actual sensory outcome of a generated action (Frith, et al., 2000; Khalighinejad & Haggard, 2015).

- The **sense of body ownership** arises from the multisensory integration of visual, tactile, and proprioceptive inputs from the body (Ehrsson et al., 2005; Ehrsson et al., 2004).

Neural underpinnings of agency and body ownership

PM cortex

Subjective experience
of agency and body ownership

- Higher-order cognitive aspects related to motor control (e.g., Haggard, 2017; Lau et al., 2007)
- Body-centered representation of peripersonal space (e.g., Ehrsson & Chancel, 2019; Ehrsson et al., 2004, 2005; Gentile et al., 2013; Guterstam et al., 2019)

Cerebellum

Implicit components
of agency and body ownership

- Sensory prediction (e.g., Blakemore et al., 2001; Roth et al., Lindner, 2013)
- Sensorimotor integration (e.g., Huang et al., 2013; Requarth et al., 2014)
- Visual, tactile, and proprioceptive processing (e.g.,Baumann et al., 2015; Therrien & Bastian, 2015; Ehrsson, 2021)

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Research Report

Bodily self-perception during voluntary actions: The causal contribution of premotor cortex and cerebellum

Angela Marotta [a,*], *Anna Re* [b], *Massimiliano Zampini* [c,d] *and Mirta Fiorio* [a,**]

Aim. To investigate the causal role of the premotor cortex (PM) and the cerebellum, in modulating the relation between body ownership and agency

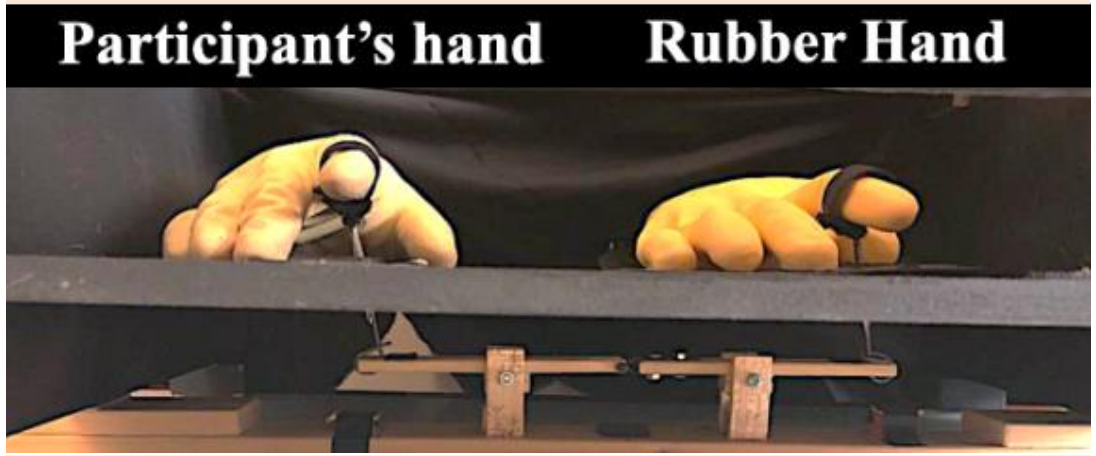
The moving RHI

- Sensations of agency and/or body ownership are referred to a rubber hand.

The moving RHI

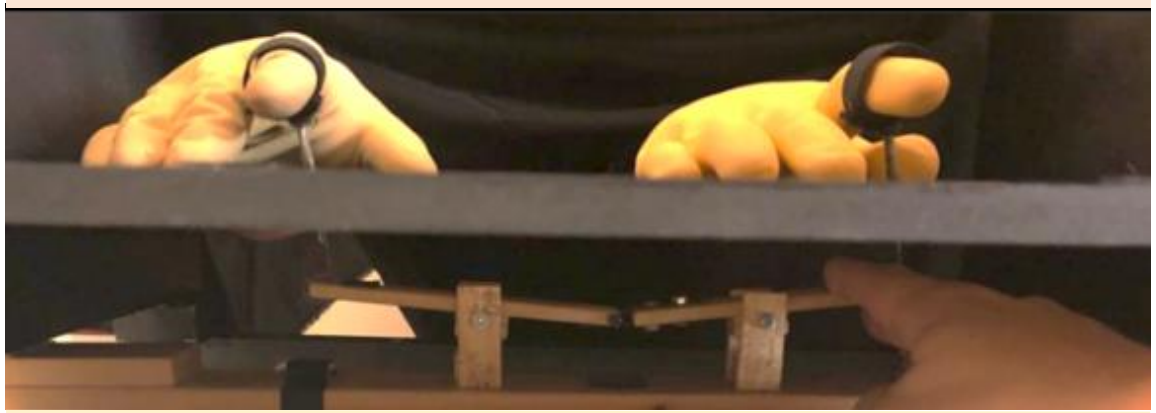
Conditions

ACTIVE CONGRUENT



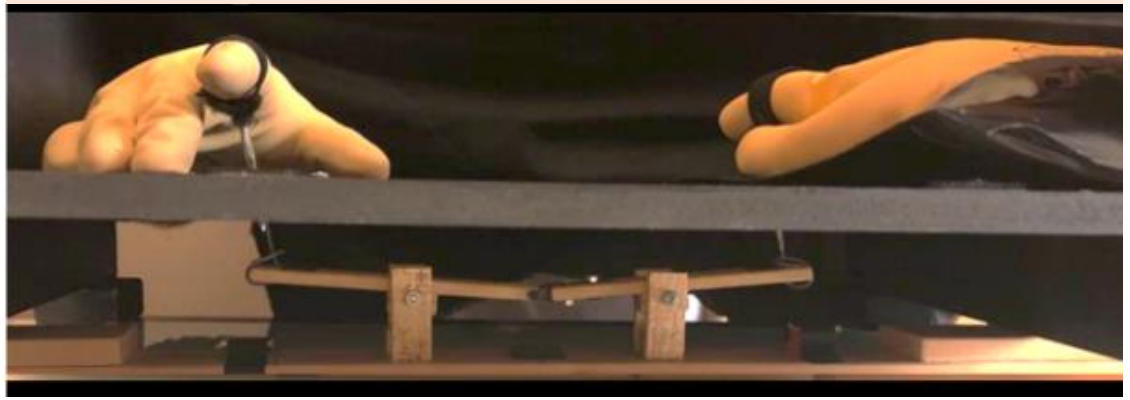
Agency & Ownership

PASSIVE CONGRUENT



Ownership

ACTIVE INCONGRUENT



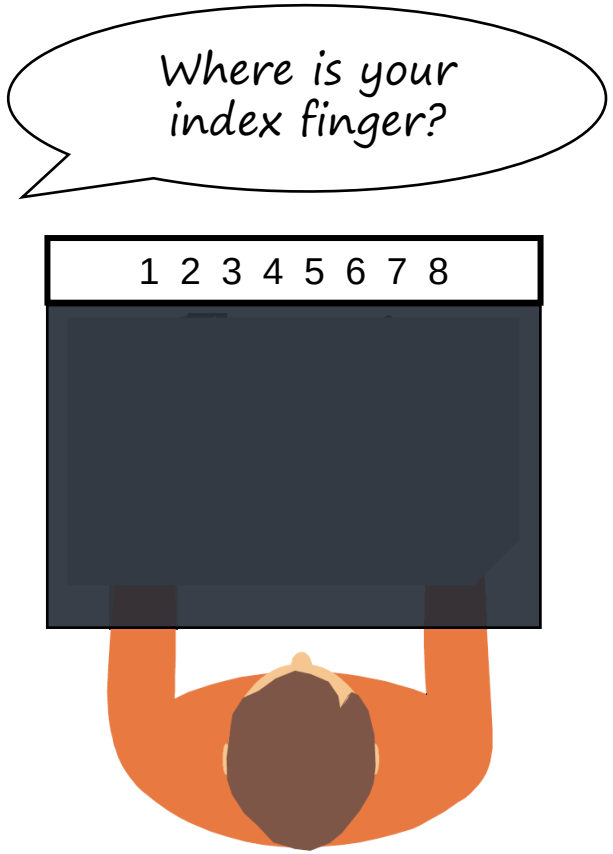
Agency

The moving RHI
Measures

The moving RHI questionnaire
(Kalckert and Ehrsson, 2012)

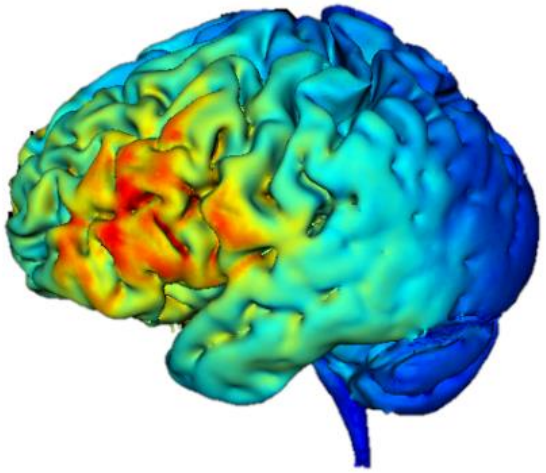
Agency	Ownership
The rubber hand moved just like I wanted it to, as if it was obeying my will	I felt as if I was looking at my own hand
I felt as if I was controlling the movements of the rubber hand	I felt as if the rubber hand was part of my body

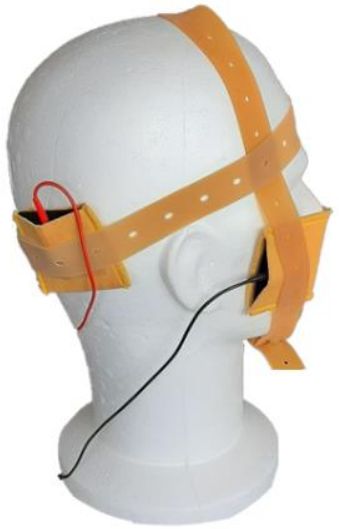
Proprioceptive drift

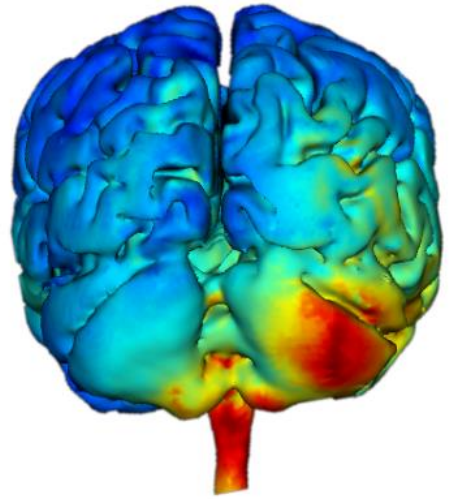


tDCS protocol

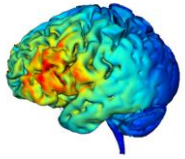
PM cortex (n=20)	Cerebellum (n=25)





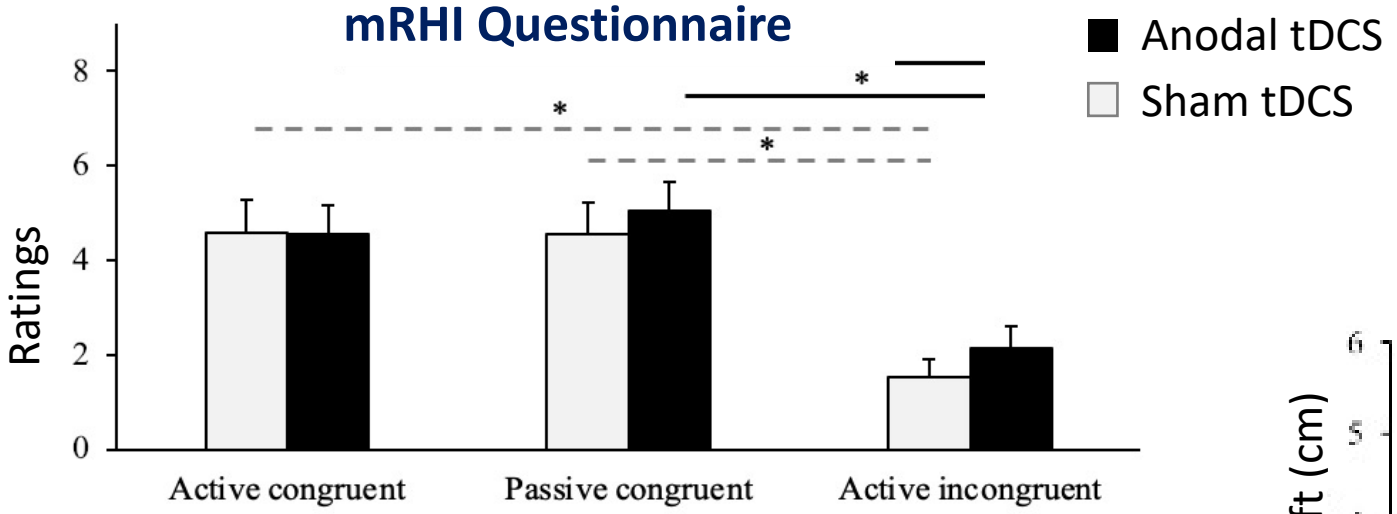


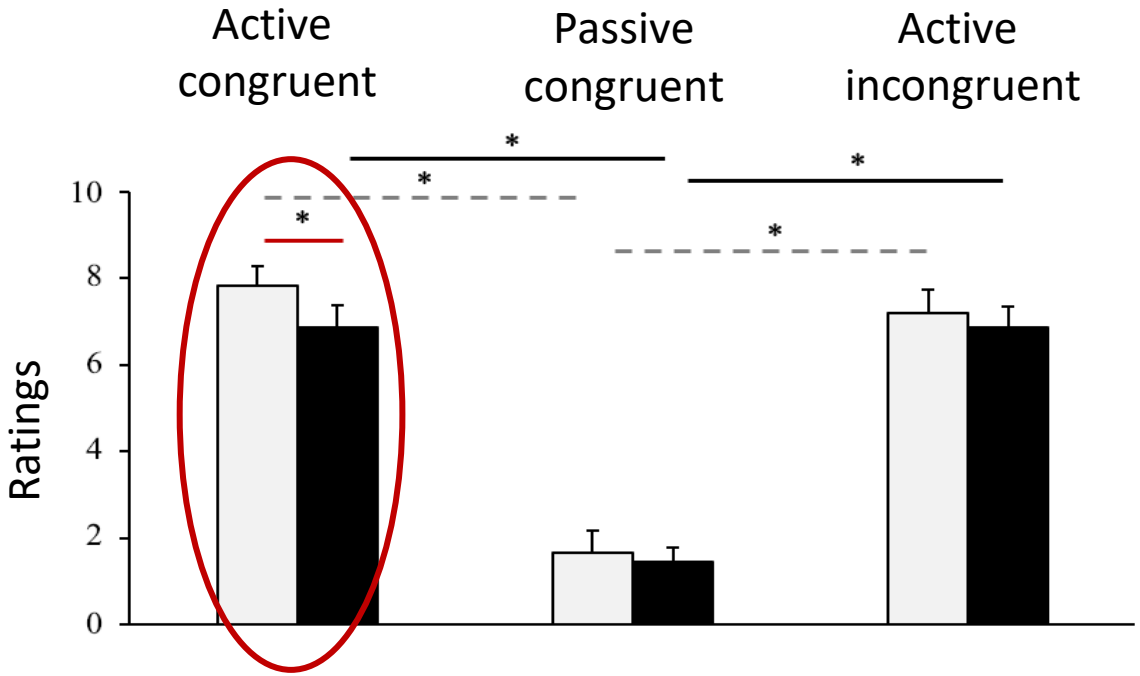
- **Two sessions** (Anodal tDCS and Sham tDCS) for each experiment
- **tDCS** before mRHI induction (25 minute *off-line stimulation*)
- **Anodal tDCS**: 1mA (PMc) or 2mA (Cerebellum)
- **Sham tDCS:** electrical current was applied for only 30 sec at the beginning and at the end of stimulation
- **Within subject design**



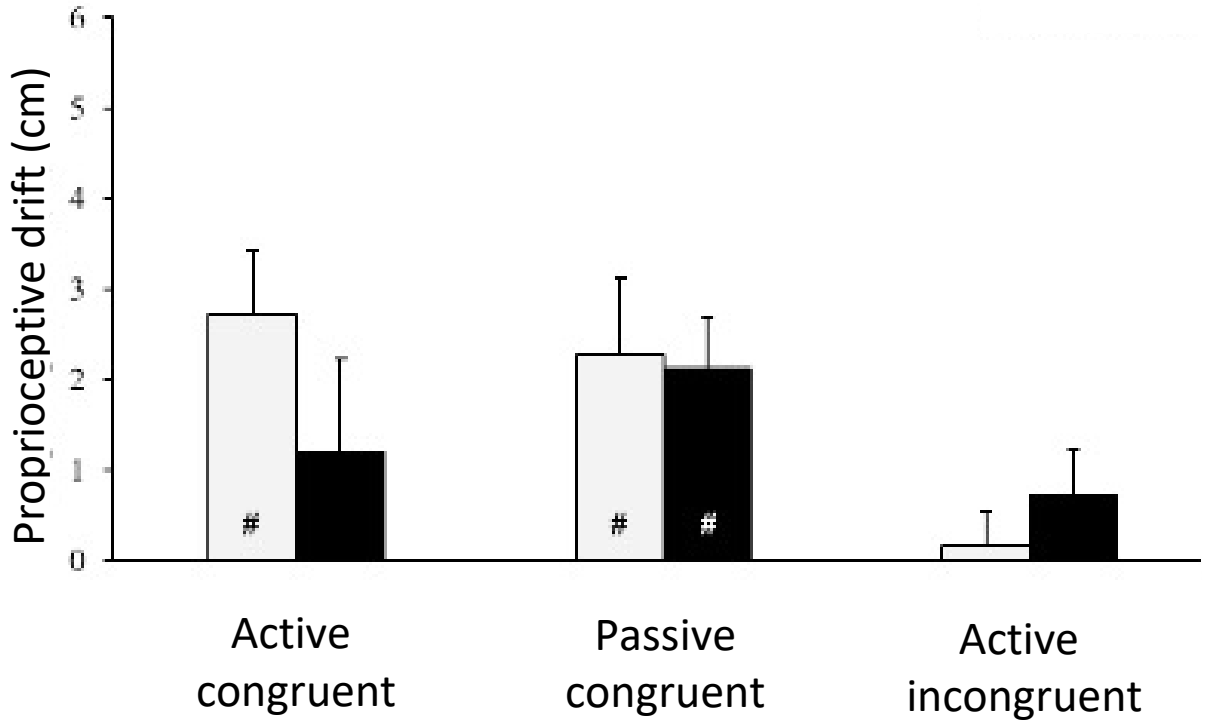
Results: Experiment 1 (PMc)

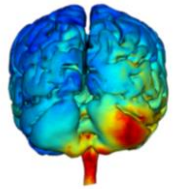
mRHI Questionnaire





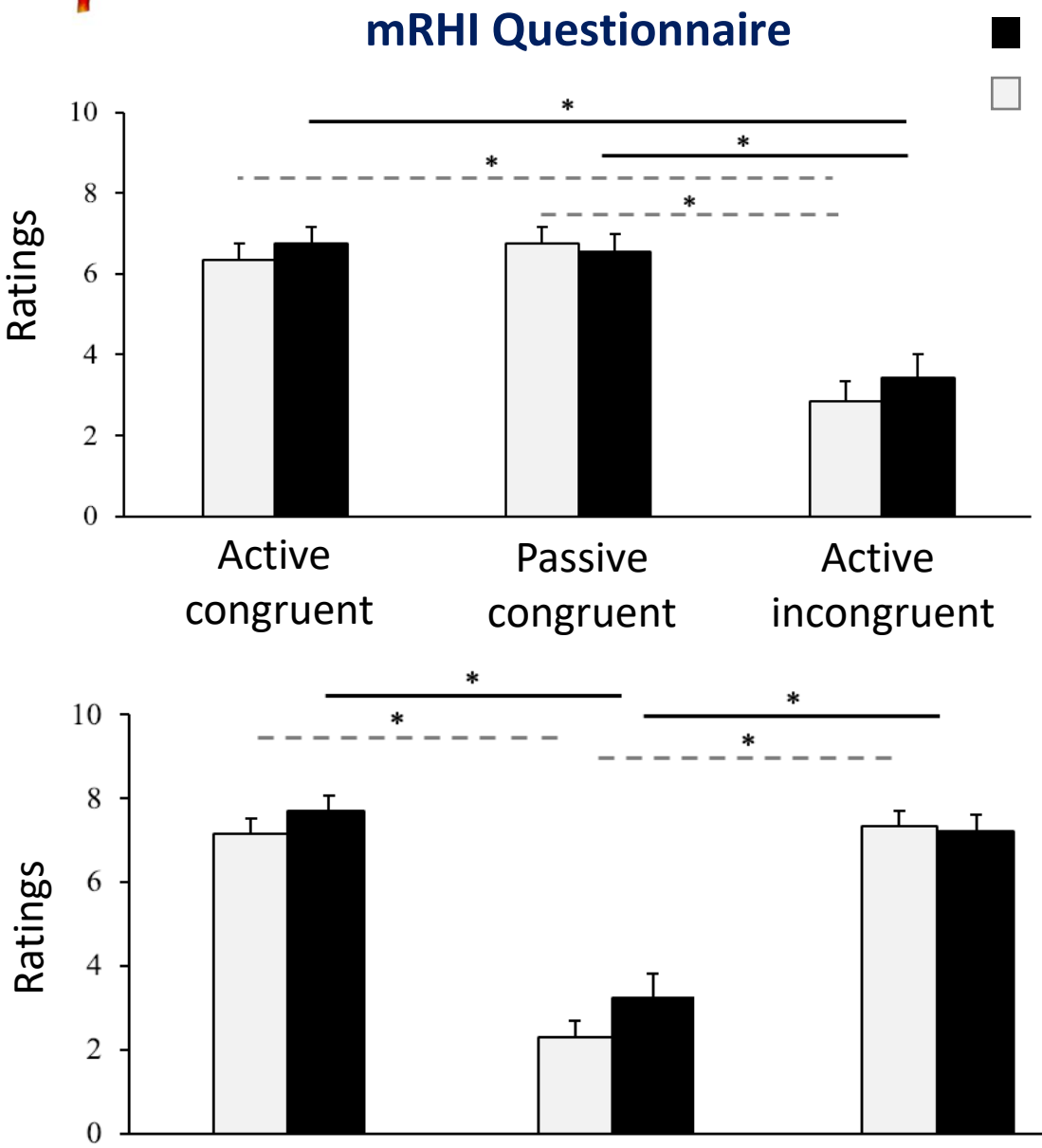
Proprioceptive drift



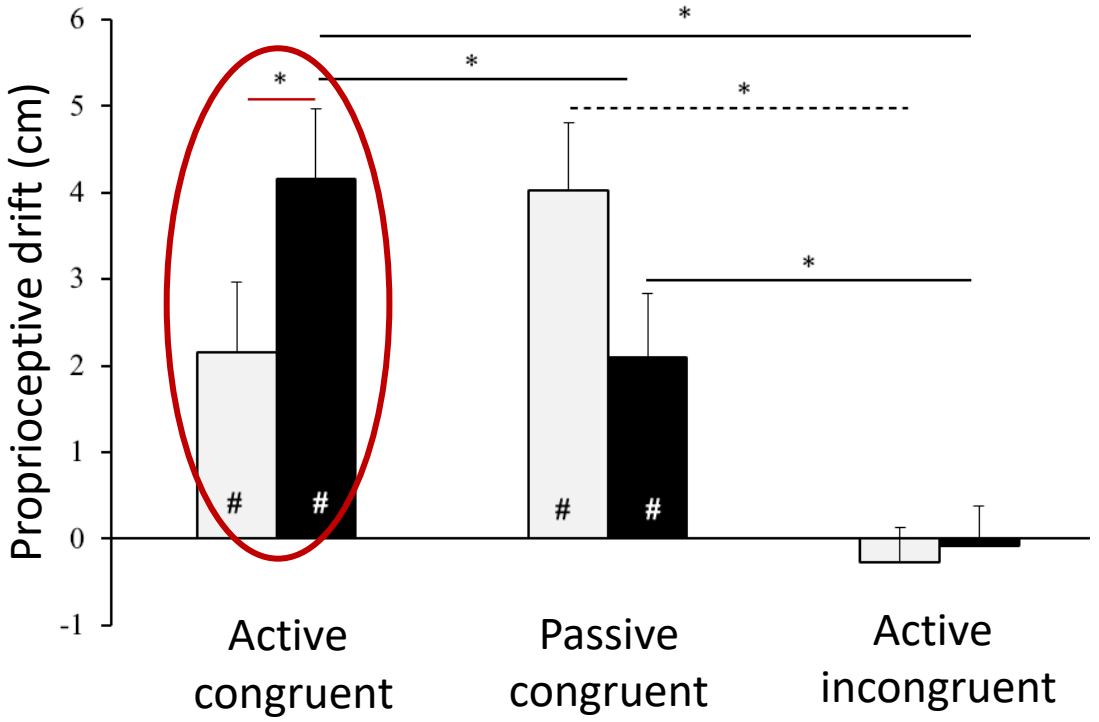


Results: Experiment 2 (Cerebellum)

mRHI Questionnaire



Proprioceptive drift



Conclusion

In case of active movements…

- Facilitating the activity of PM decreased the **subjective feeling of agency**
- Facilitating the activity of the cerebellum increased the **proprioceptive recalibration** of the participants' hand toward the rubber hand
- Specific causal contribution of the PMc and the cerebellum to bodily self-perception during voluntary movement, with the PMc mainly involved in awareness of action and the cerebellum in proprioceptive adaptation of body position in space.

What happens in case of abnormal central processing of sensory information?

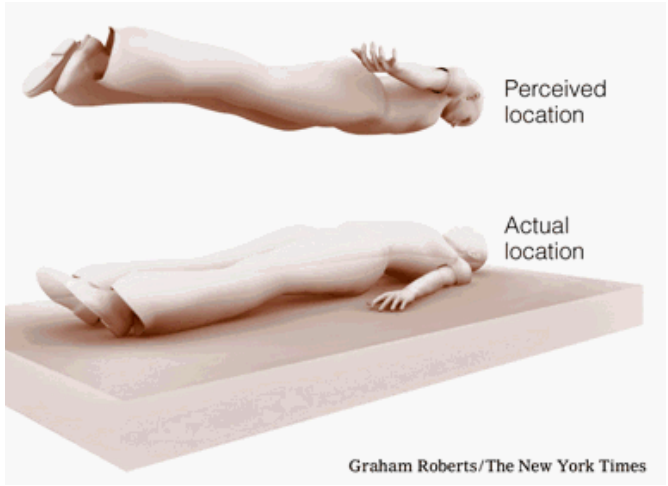
Phantom limb

I still feel my limb

Somatoparaphrenia

This is not my arm

Out-of-body experience



I was floating from the ceiling, looking down at myself

Failure in integrating multisensory inputs from the body

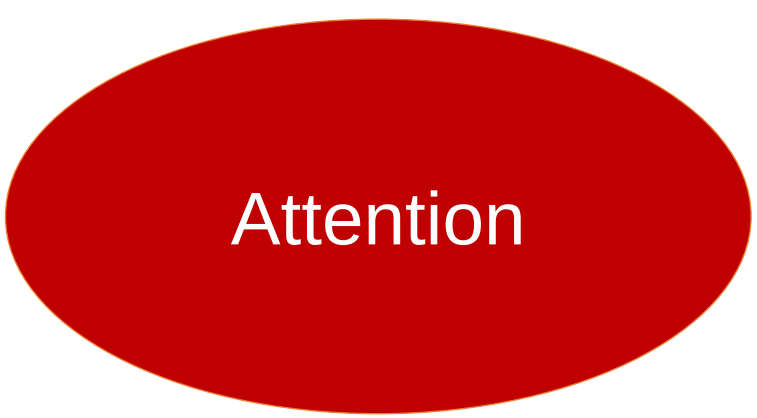
What happens in case of abnormal central processing of sensory information?

Functional movement disorders (FMD)

Functional vs. Structural

Motor symptoms (e.g., tremor, gait disturbances, dystonia)
are **related to a functional rather than structural damage of the brain**

Functional movement disorders



Distraction reduces motor symptoms

Motor symptoms are perceived as involuntary movements

Voon et al., 2010, 2011; Edwards et al., 2011; Kranick et al., 2013; Pareés et al., 2014; Macerollo et al.,2015

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Movement perception of the tonic vibration reflex is abnormal in functional limb weakness

Michele Tinazzi [a,**], Angela Marotta [a], Mara Zenorini [b], Marianna Riello [a], Angelo Antonini [b], Mirta Fiorio [a,*]

Proprioception and movement control

- Proprioception is essential for correct control of body position and movement in the environment.

- It plays an important role in self-awareness

? Is Functional limb weakness associated with a disorder of the central processing of proprioceptive information?

Proske et al., 2009; Stone et al., 2012; Lackner et al., 1988

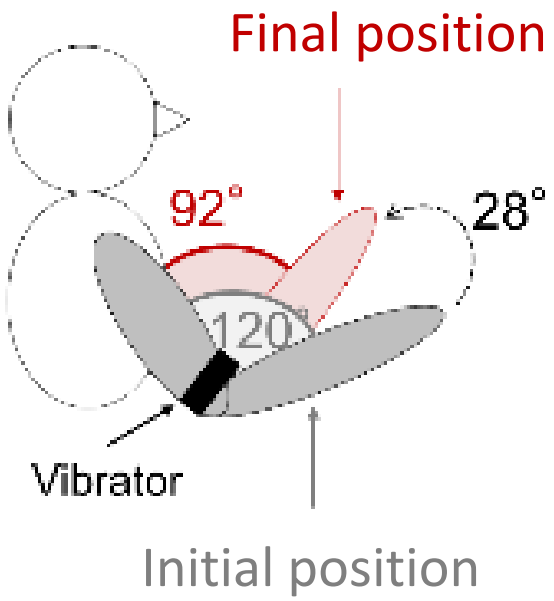
The tonic vibration reflex

- Widely employed to experimentally assess proprioception.
- Mechanical vibration applied to the biceps brachii tendon of the arm elicits elbow flexion (tonic vibration reflex, TVR).
- The TVR is not a simple spinal reflex but rather a combination of both spinal and supra-spinal reflex arc mechanisms.

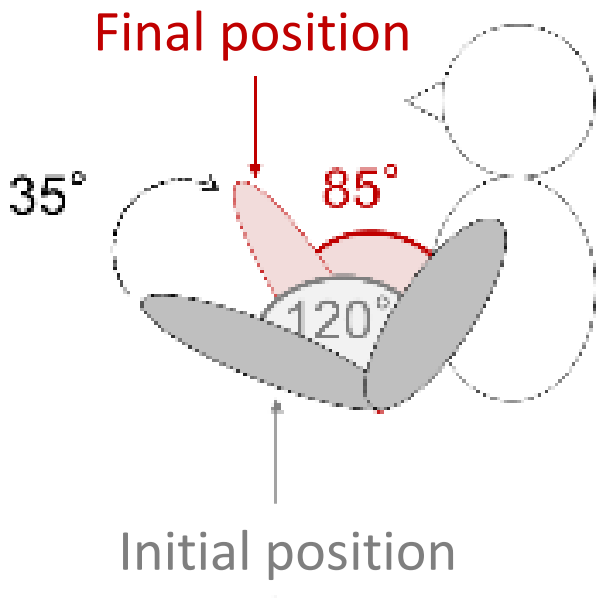
Grünewald et al., 1997; Yoneda et al., 2000

Method
Position matching task

Vibrated Arm



Tracking Arm



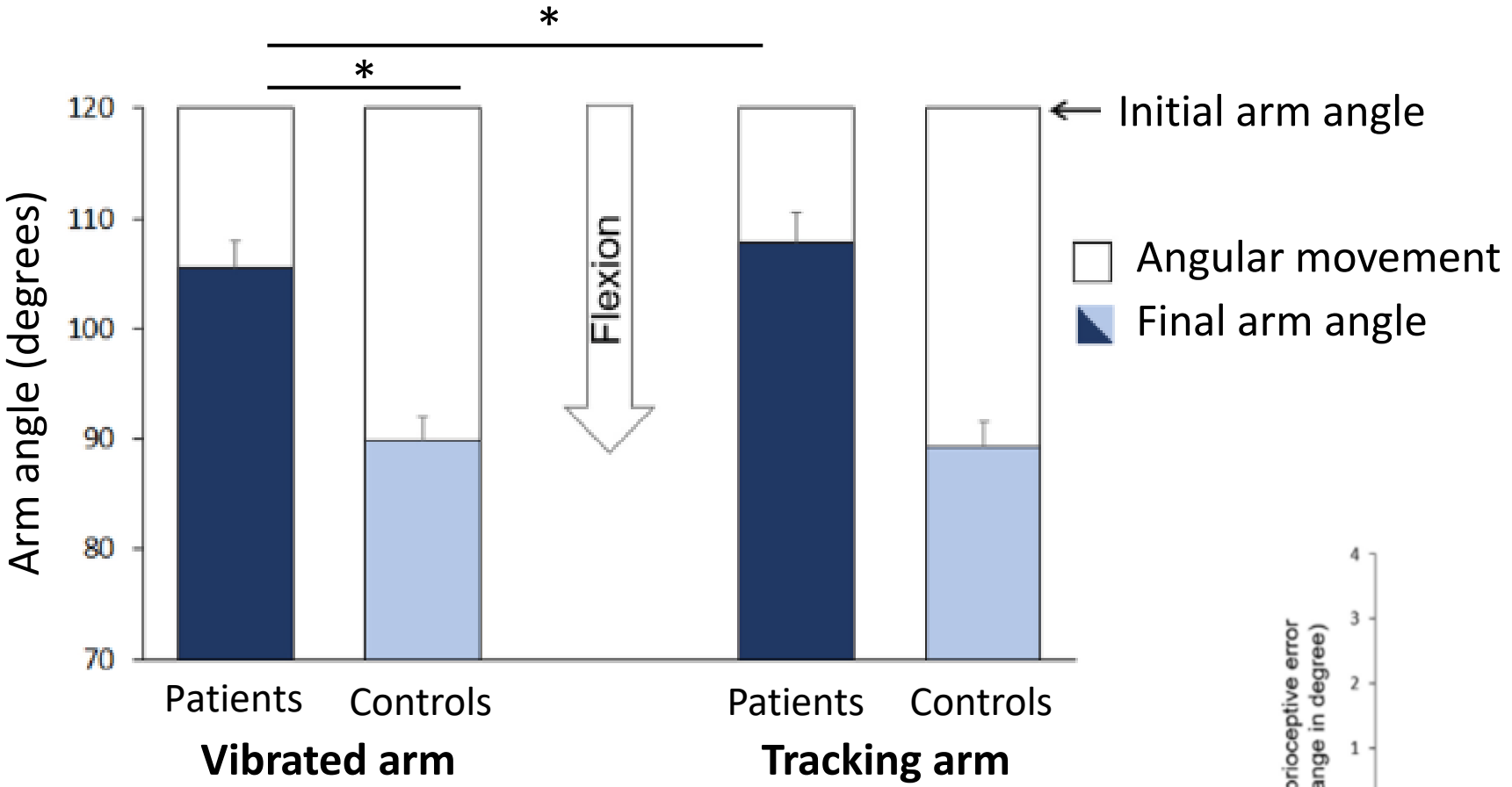
Participants

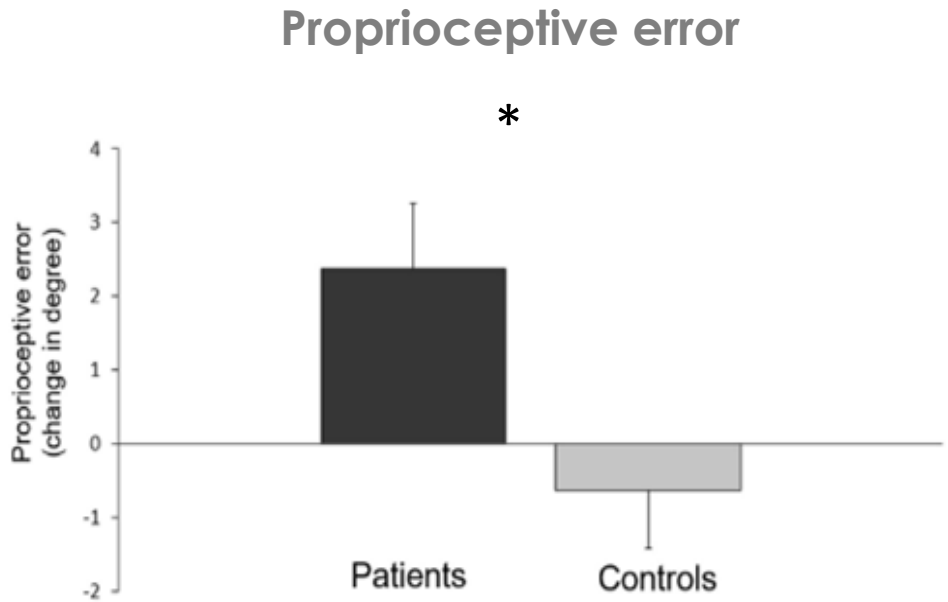
20 patients with functional limb weackness

25 age-matched healthy controls

Results

Tonic Vibration Reflex and Position matching task





Conlcusion

- **Movement perception** of the TVR is **abnormal** in patients with functional limb weakness.

- Proprioceptive dysfunction potentially underlies alterations in body movement and posture, as well as in the sense of agency in FMD

Overall conclusions

- Multisensory brain regions are **differently involved in subjective and proprioceptive components** of bodily self-perception

- **Proprioception** emerges as an important component of **self-perception** during **active movements**

- **Abnormal central processing of proprioceptive signals** might lead to altered sense of agency in a specific pathological condition, that is the FMD

Thank you

Mirta Fiorio

Michele Tinazzi

Mehran Emadi Andani

Diletta Barbiani