Let your left hand know what your right hand is doing

Trans-callosal inhibition explains contralateral motor learning transfer

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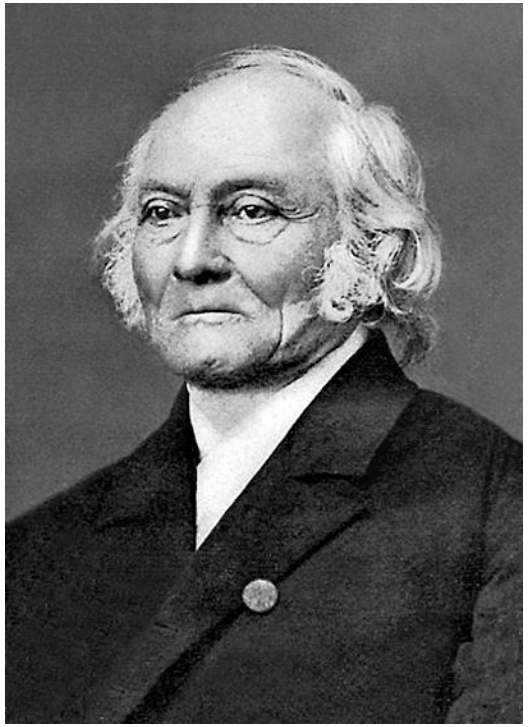
Background



G. Th. Fechner. Leipzig, 1858

E. H. Weber hatte schon früher nach einigen, bei den Schreibübungen seiner Kinder gemachten, Erfahrungen mündlich gegen mich bemerkt, dass die Uebung des Schreibens mit der rechten Hand sich in gewisser Weise auf die linke zu übertragen vermöge, aber in Rücksicht auf die symmetrische Anord-

«[...] the practice of writing with the right hand could be transferred in a certain way to the left»

Journal of Experimental Psychology, 1928

TRANSFER OF LEARNING

BY CHARLES W. BRAY

Princeton University[1]

It has long been known that practice of one part of the body in performing a skilled act increases the ability of the bilaterally symmetrical part in the same act. The effects of practice are transferred from one hand or one arm to the other, and from one toe to the similar toe of the other foot. This phenomenon has been called cross-education.[2] There are also indications that a similar transfer takes place to all parts of the body, not merely to bilaterally symmetrical parts.

erlangt hat. Eines Tages, nachdem ich den Satz von 100 Versuchen vollendet hatte, ergriff ich zu guter Letzt die Feder mit der nun frei gewordenen rechten Hand, um die letzte 9 mit dieser aufzuschreiben, und war höchlich überrascht, als sie dastand, zu sehen, dass ich sie verkehrt, als ϱ geschrieben hatte, so wie es uns sonst geläufiger ist, mit der Linken zu schreiben. Diese hatte also ihre richtige Uebung nun in verkehrtem Sinne auf die rechte Hand übertragen.

«[...]the left hand had now transferred her attitude to the right hand, in the wrong sense».

Background

Neurophysiological Mechanisms Involved in Transfer of Procedural Knowledge

The Journal of Neuroscience, January 31, 2007 · 27(5):1045–1053

Monica A. Perez,[1] Steven P. Wise,[2] Daniel T. Willingham,[3] and Leonardo G. Cohen[1]

Interhemispheric transfer of visuomotor conditional learning via the anterior corpus callosum of monkeys

M.J. Eacott and David Gaffan

Behavioural Brain Research, 38 (1990)

Relationship between the interlimb transfer of a visuomotor learning task and interhemispheric inhibition in healthy humans

Cerebral Cortex, 2023, 33, 7335–7346

Giulia Paparella[1], Martina De Riggi[2], Antonio Cannavacciuolo[1], Donato Colella[2], Davide Costa[2], Daniele Birreci[2], Massimiliano Passaretti[2], Luca Angelini[2], Andrea Guerra[1,2], Alfredo Berardelli[1,2], Matteo Bologna[1,2,*]

Unilateral practice of a ballistic movement causes bilateral increase in performance and corticospinal excitability

J Appl Physiol 104: 1656–1664, 20

Timothy J. Carroll,[1,2] Michael Lee,[1] Marlene Hsu,[1] and Janel Sayde[1]

Transfer of Motor Learning Is More Pronounced in Proximal Compared to Distal Effectors in Upper Extremities

Tore K. Aune[1], Morten A. Aune[1], Rolf P. Ingvaldsen[1] and Beatrix Vereijken[2]*

Gregor Thut · Ulrike Halsband · Marianne Regard
Eugène Mayer · Klaus L. Leenders · Theodor Landis

Exp Brain Res (1997) 113:365–370

What is the role of the corpus callosum in intermanual transfer of motor skills? A study of three cases with callosal pathology

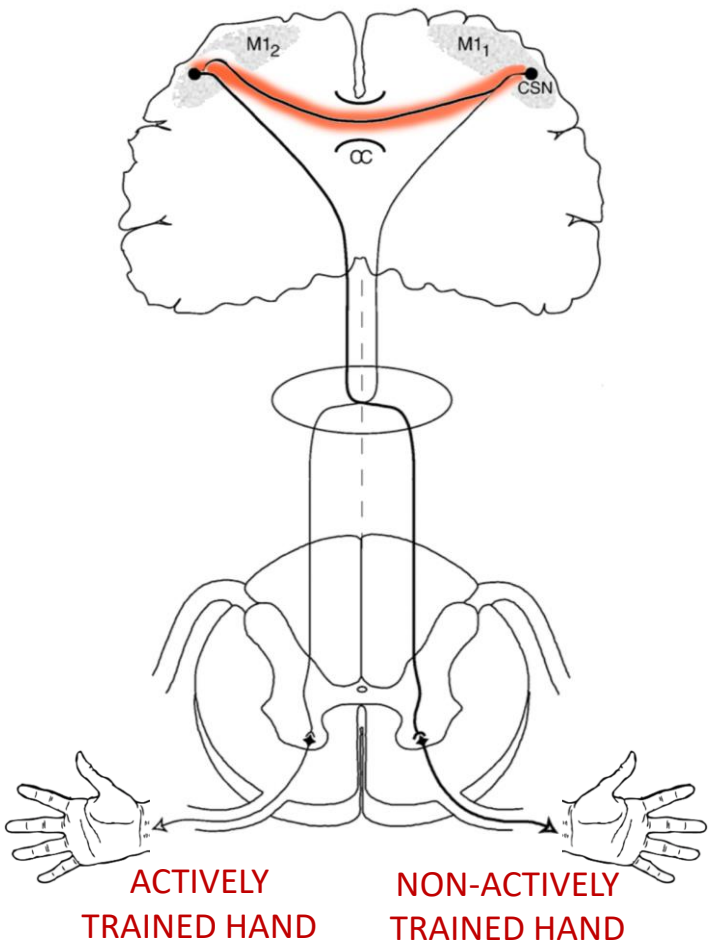
J Appl Physiol 101: 1514–1522, 2006;

Contralateral effects of unilateral strength training: evidence and possible mechanisms

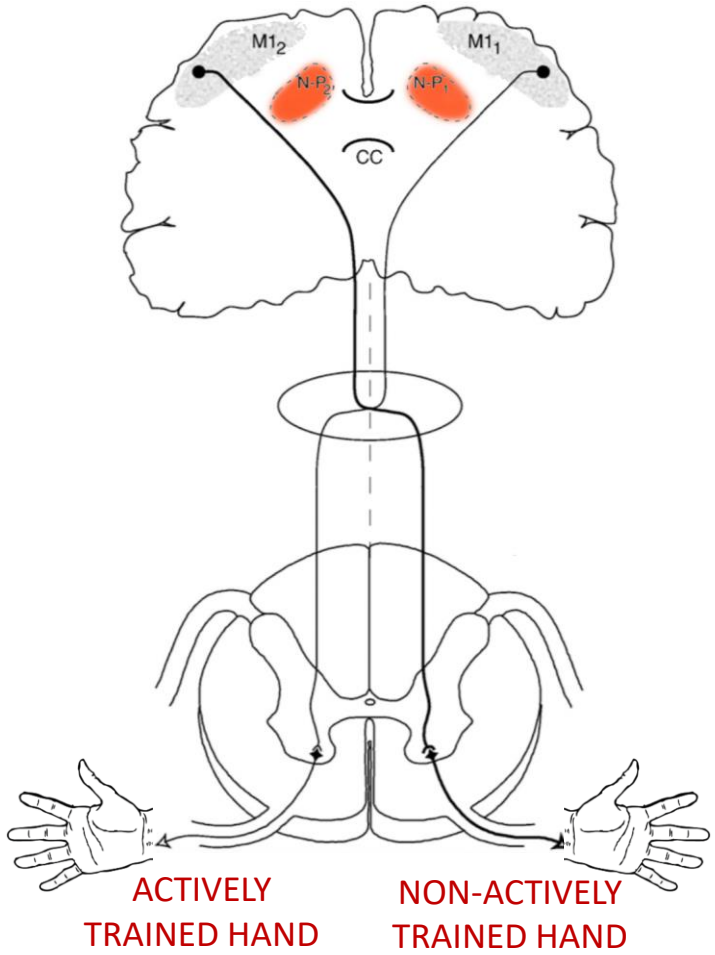
Timothy J. Carroll,[1] Robert D. Herbert,[2] Joanne Munn,[2] Michael Lee,[1] and Simon C. Gandevia[3]

Neuroanatomical models explaining CLT

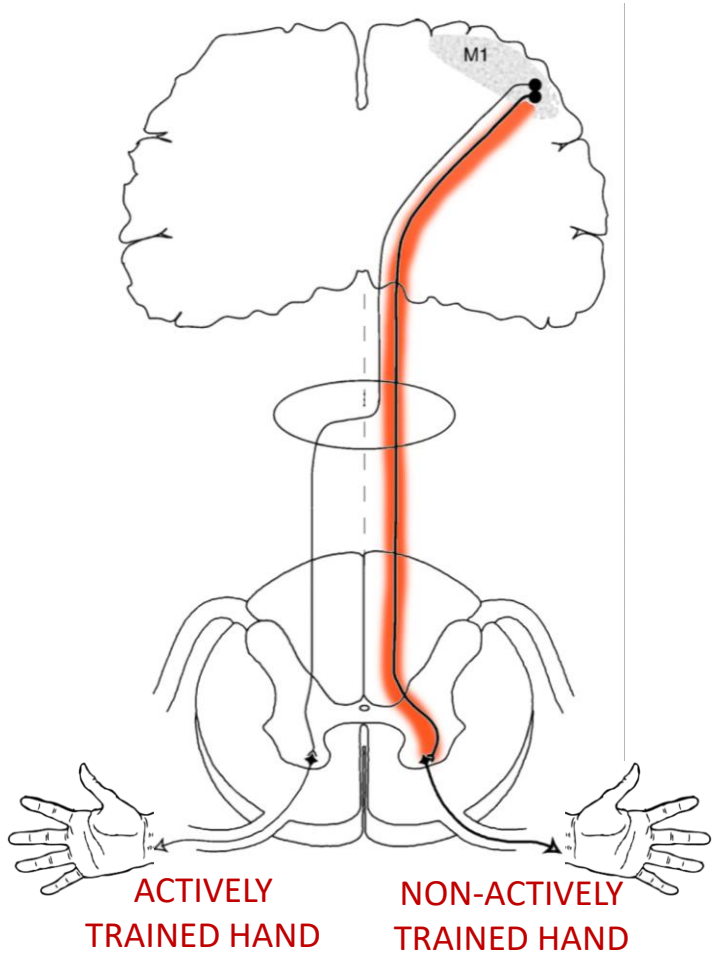
Callosal «spill over» model



Bihemispheric model

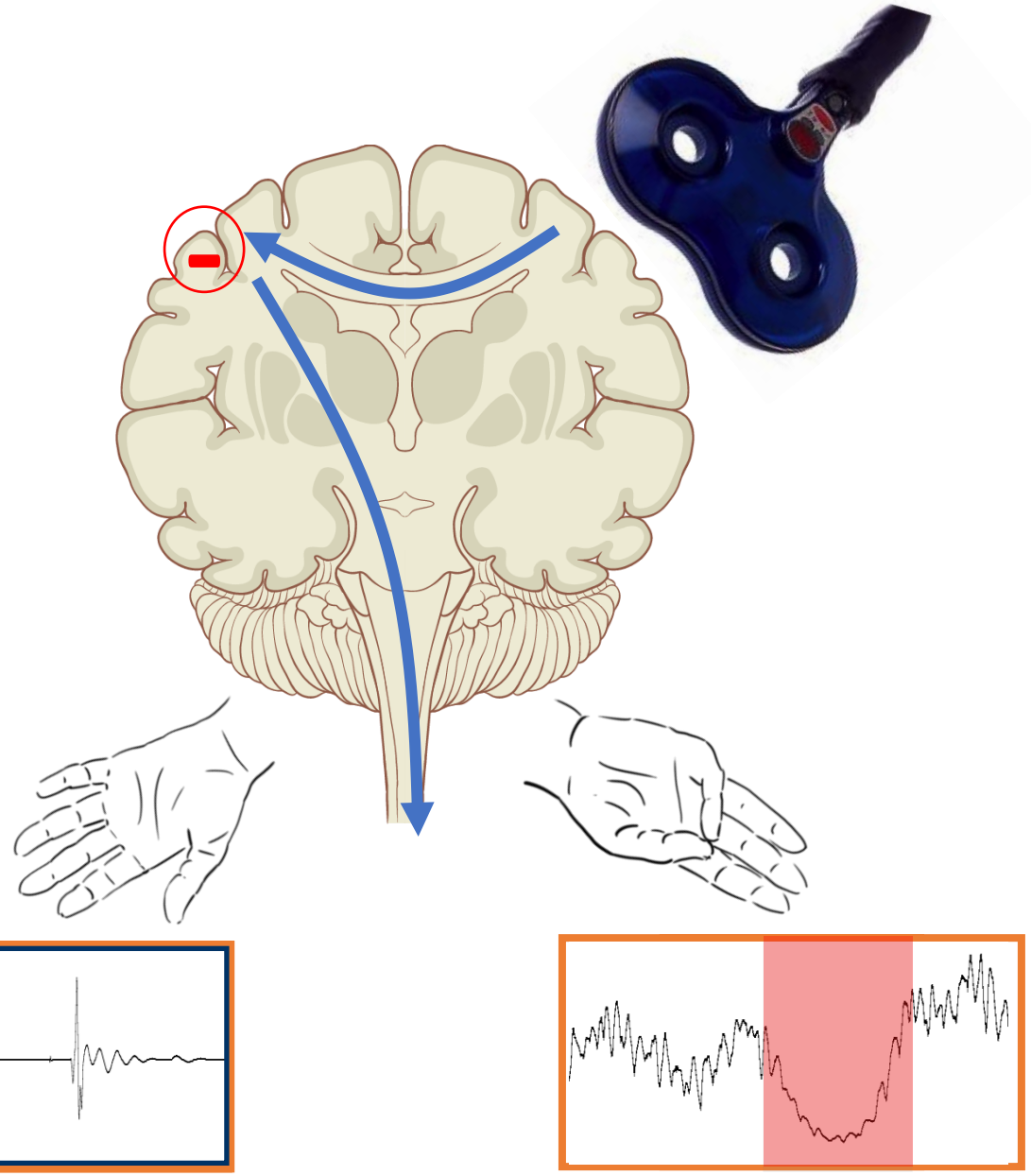


Ipsilateral CST model



CONTRALATERAL LEARNING TRANSFER ? TRANSCALLOSAL CONNECTIVITY

Ipsilateral Silent Period (ISP)

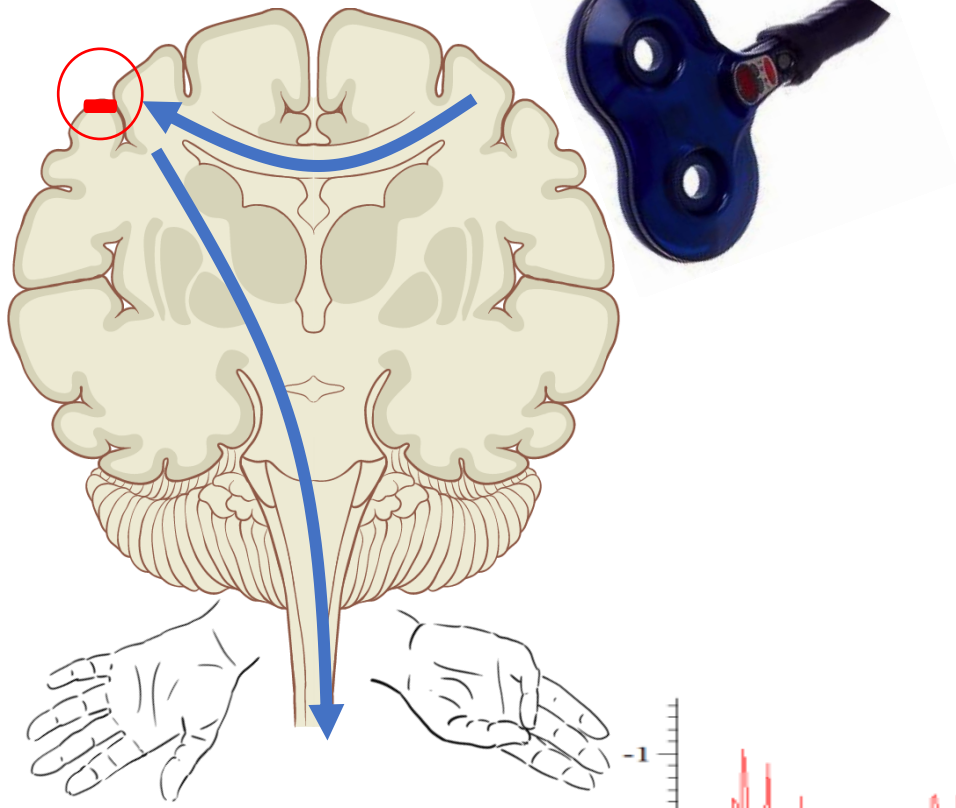


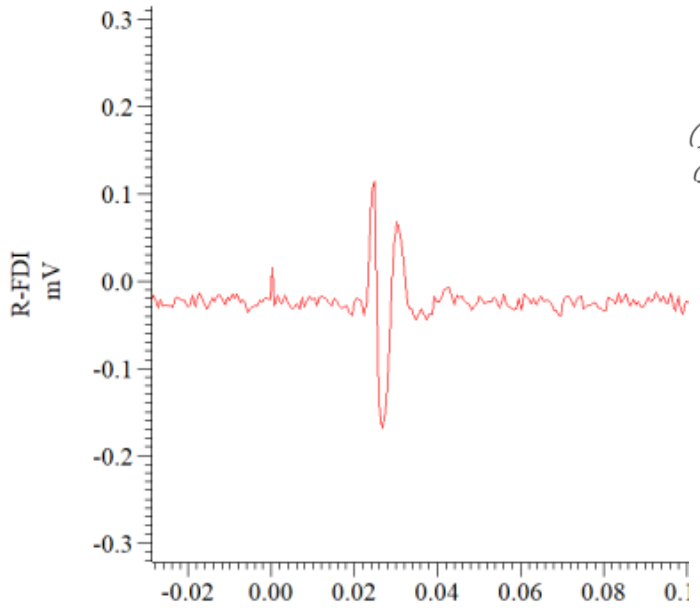
- Suppression of voluntary tonic EMG activity by TMS of the ipsilateral hemisphere

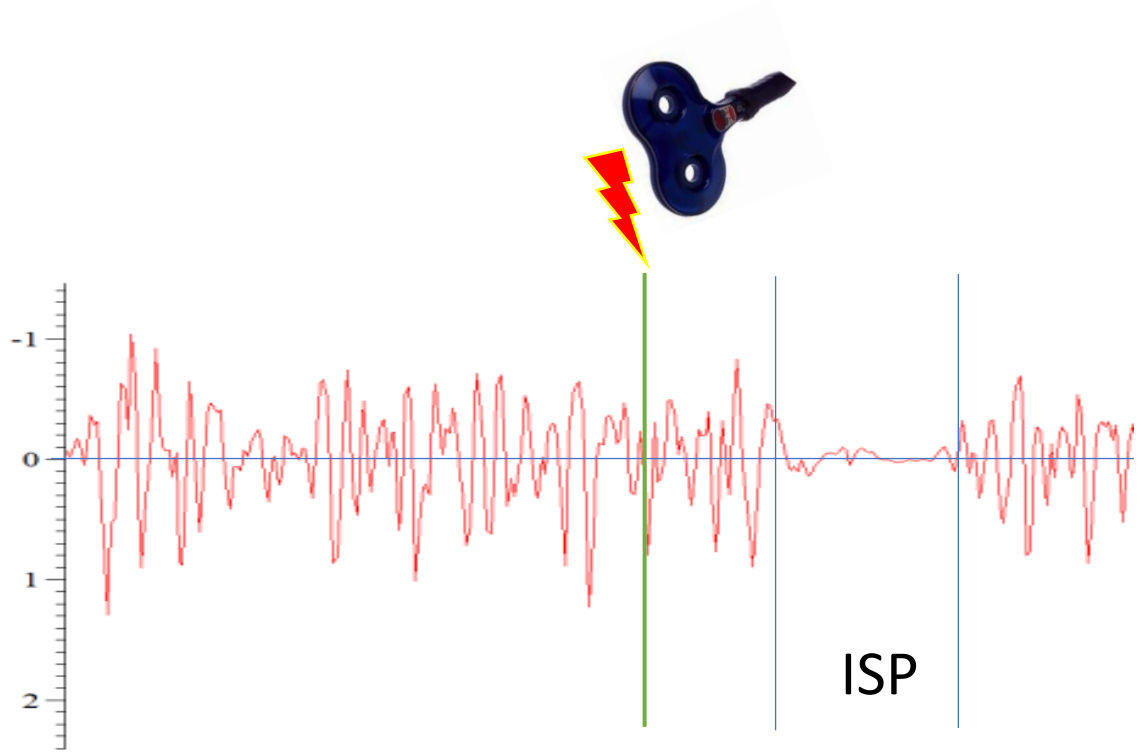
- Cortical origin *(Wassermann et al. 1991)*

- Driven by excitatory (glutamatergic) transcallosal motor fibers synapsing on inhibitory (GABAergic) interneurons in the contralateral primary motor cortex (*Ferbert et al., 1992; Meyer et al., 1995*)

Ipsilateral Silent Period (ISP)







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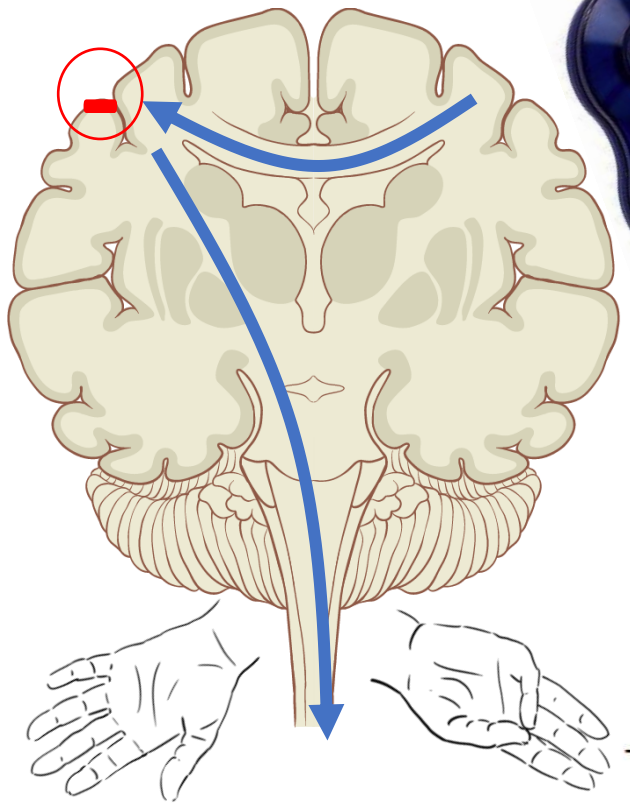
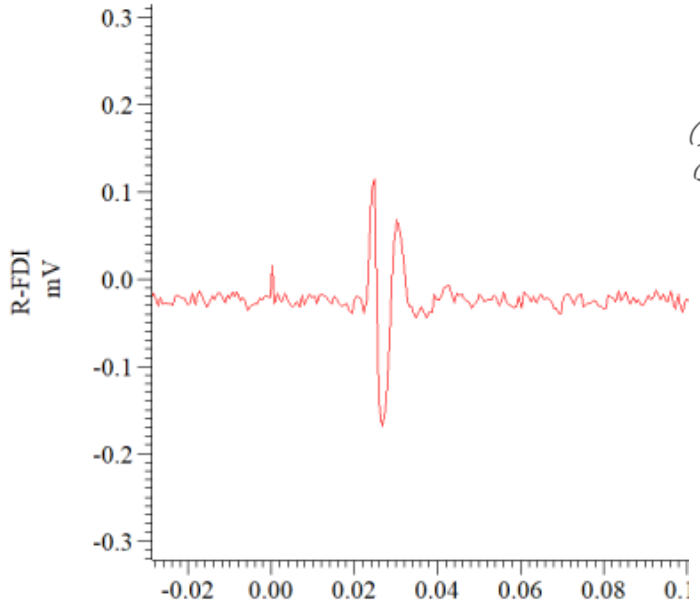
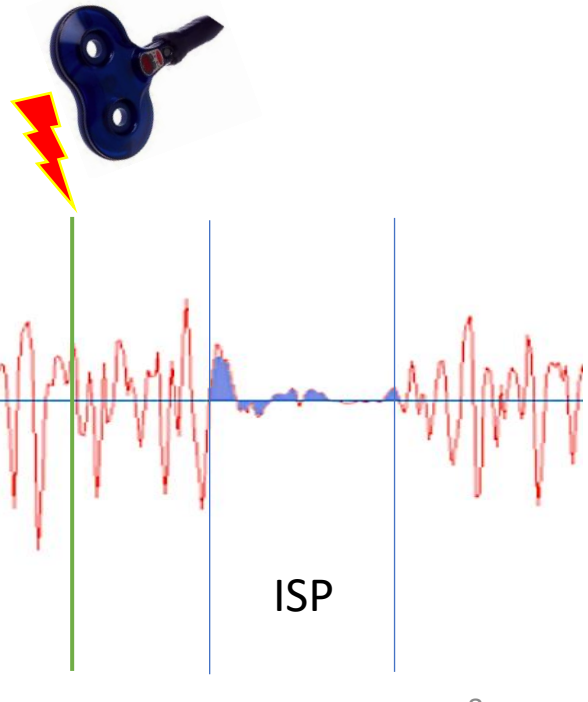


$ISP_{inhibition}\% = (1 - ISP_{AREA}/Baseline_{AREA}) \times 100$



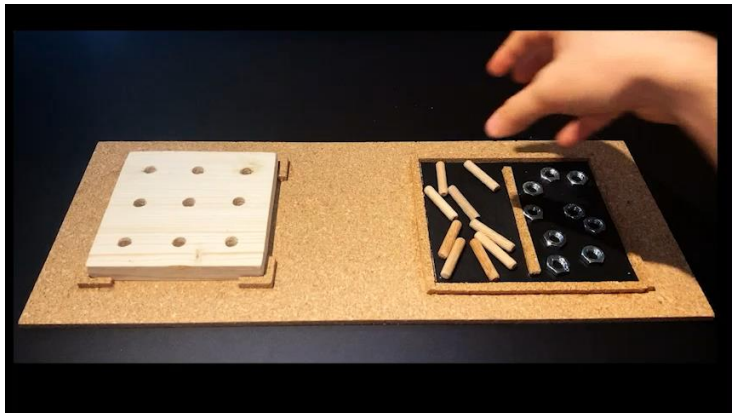


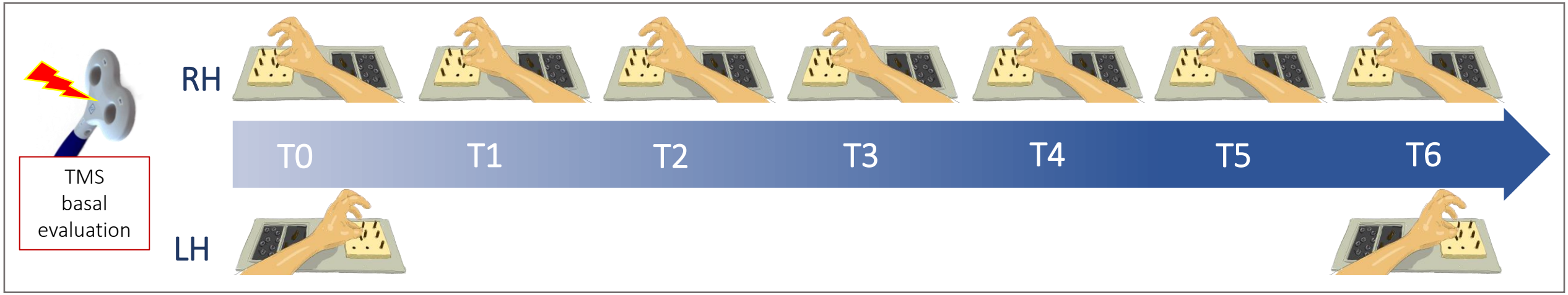
Experimental design

POPULATION: 22 healthy subjects (age32 ± 8 y.o.; 16 F)

MOTOR TASK: Modified Nine-Hole Peg Test (mNHPT) (Nuara et al, 2019)

- Performance depends on frontoparietal network functioning (Uggetti et al. 2016; Fiori et al. 2018)
- Performance improves with repetition over time (Solari et al. 2005)

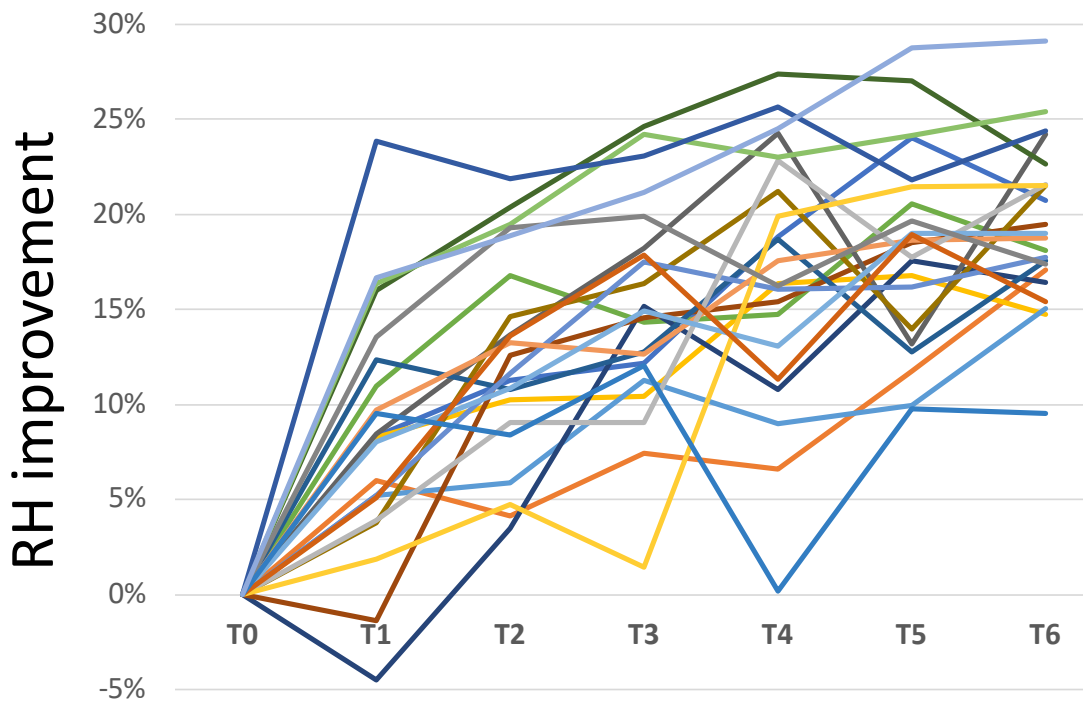




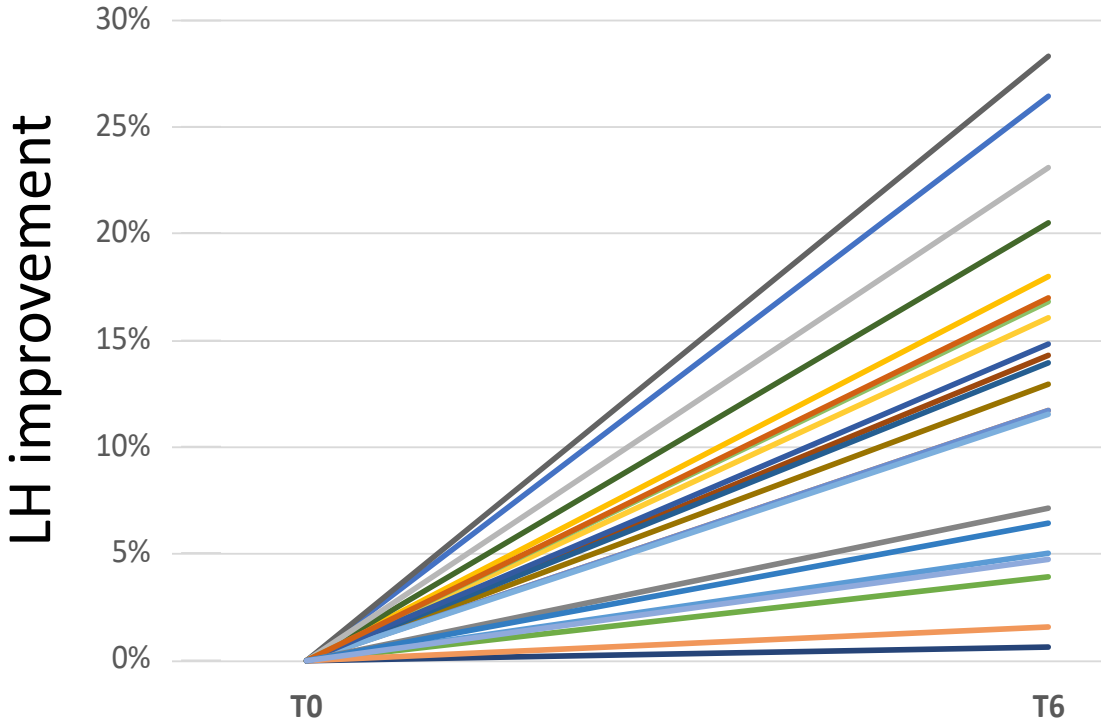
NEUROPHYSIOLOGICAL REGRESSOR		MAIN BEHAVIOURAL OUTCOME
Ipsilateral Silent Period	?	**Contralateral Learning Transfer**
ISP% = $(1 - ISP_{AREA}/Baseline_{AREA}) \times 100$		CLT = $(\Delta_{T0\text{-}T6}\,LH - \Delta_{T0\text{-}T6}\,RH)/\,\Delta_{T0\text{-}T6}\,RH$

Results (1)

Behavioral endpoints

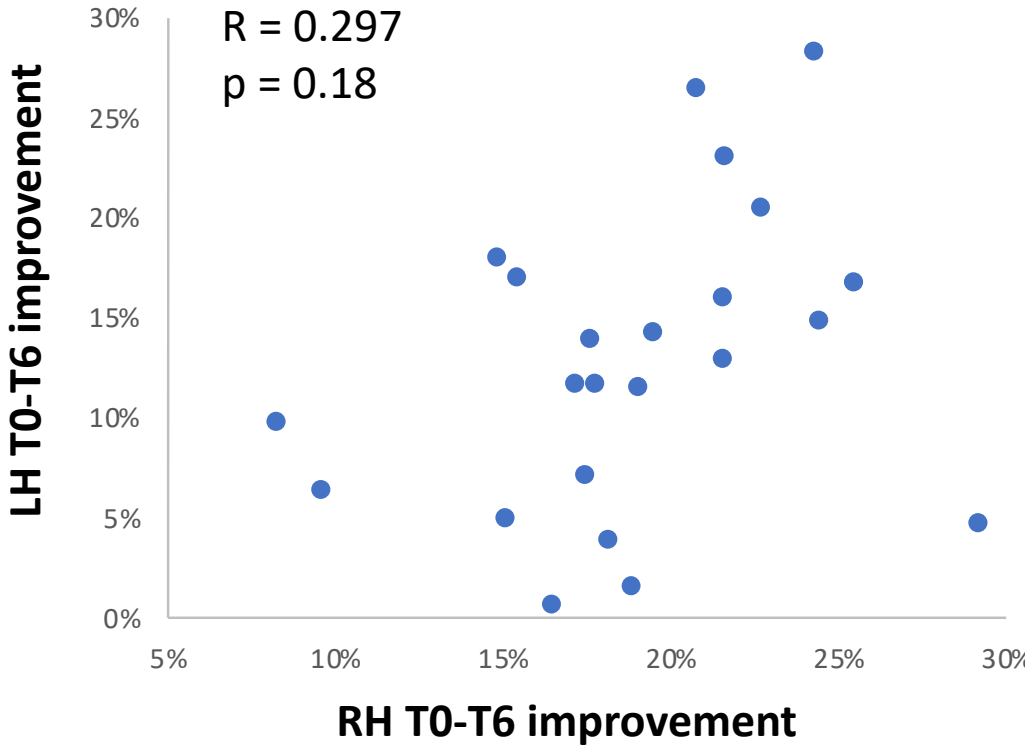


?

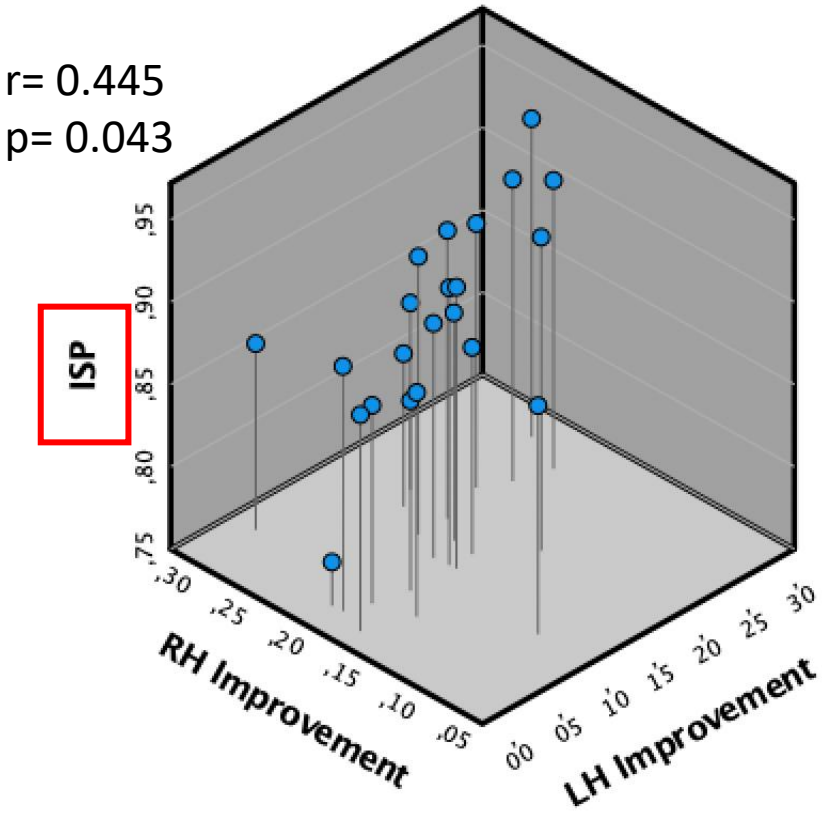


Results (2)

No correlation between RH and LH improvement



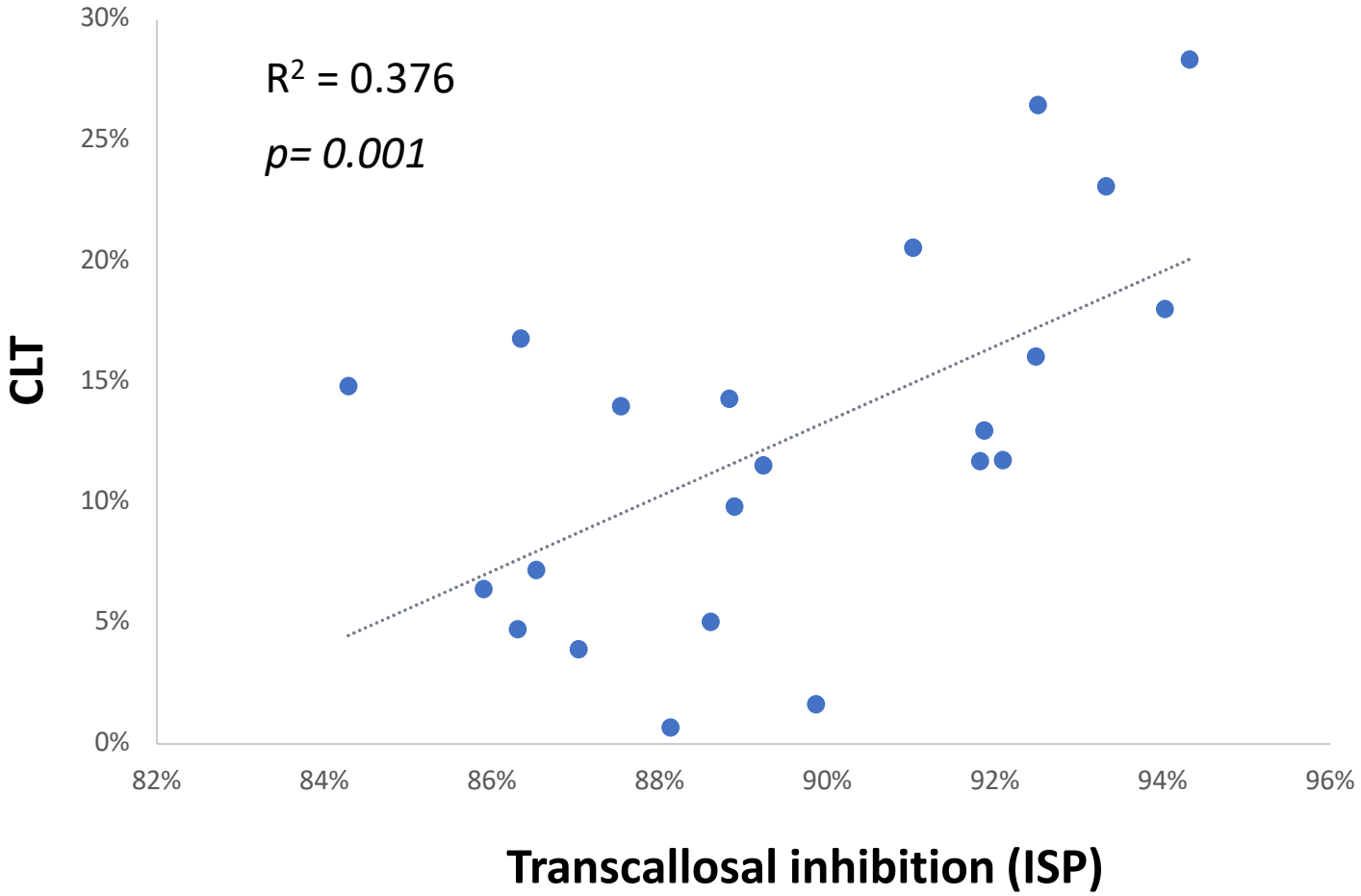
Significant partial correlation (**ISP** as control variable)



Transcallosal inhibition makes significant the interplay between RH and LH learning

Results (3)

Transcallosal inhibition explains contralateral learning transfer



$BF_{1|0} = 8.329$

Substantial level of evidence in favor of the alternative hypothesis

(Kass and Raftery, 1995)

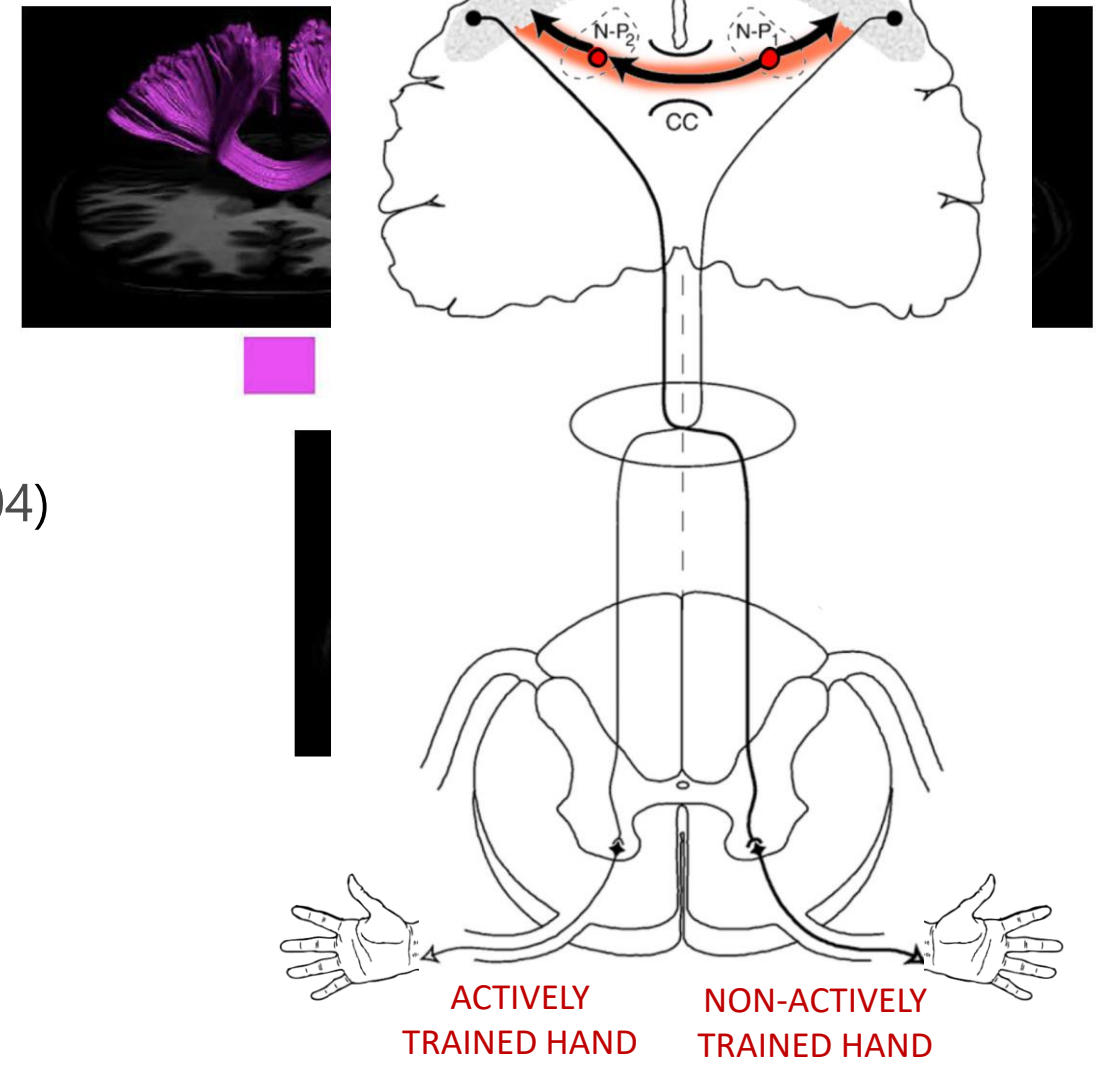
Conclusion

- Trans-callosal connections between brain motor structures drives CLT

- Direct M1-to-M1 interplay?
  - PM-PM and S1-S1 > M1-M1 connections

    (Ruddy et al, 2017)
  - M1-to-M1 proximal>distal motor connectivity

    (Pandya and Vignolo, 1971; Jenny, 1979; Brodal, 2004)



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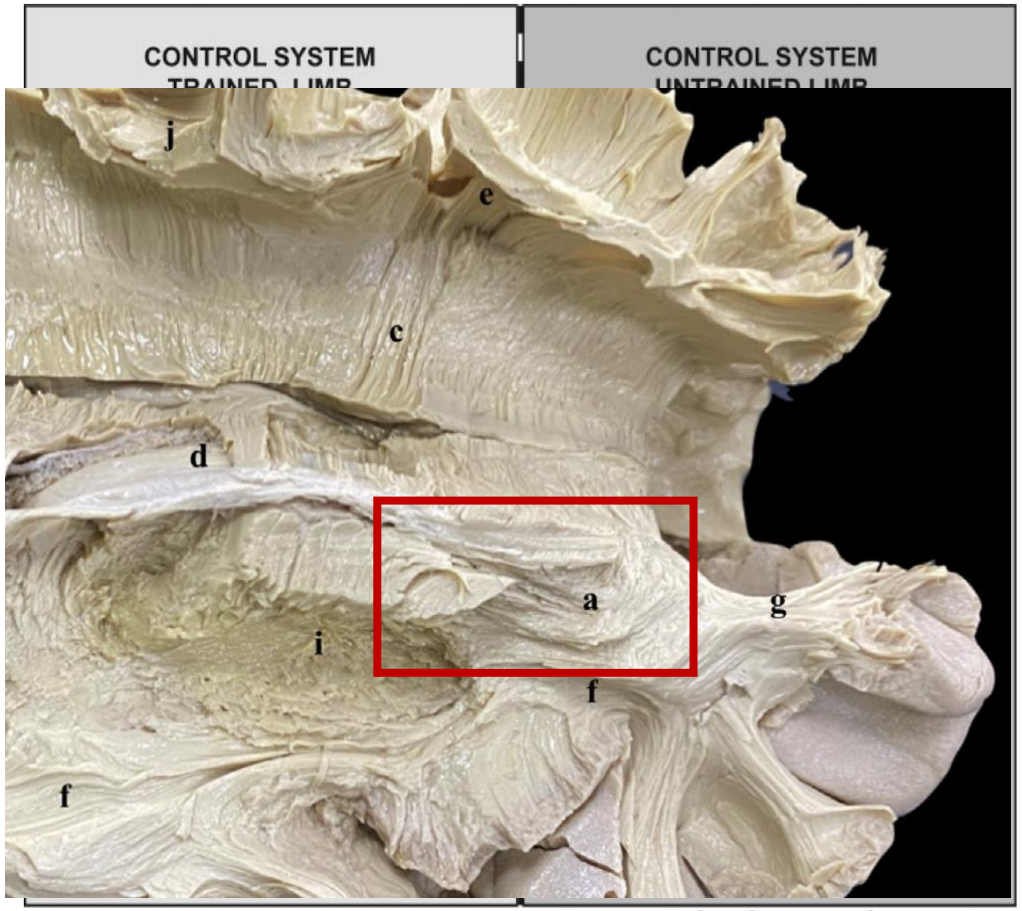
- Role of *underground* callosal connections?

Carrol et al. 2006



Shah et al. 2021

PFC: Prefrontal Cortex; BG: Basal Ganglia; CB: Cerebellum; PM: pre-motor cortex; SMA: supplementary motor area; B Stem: brainstem nuclei

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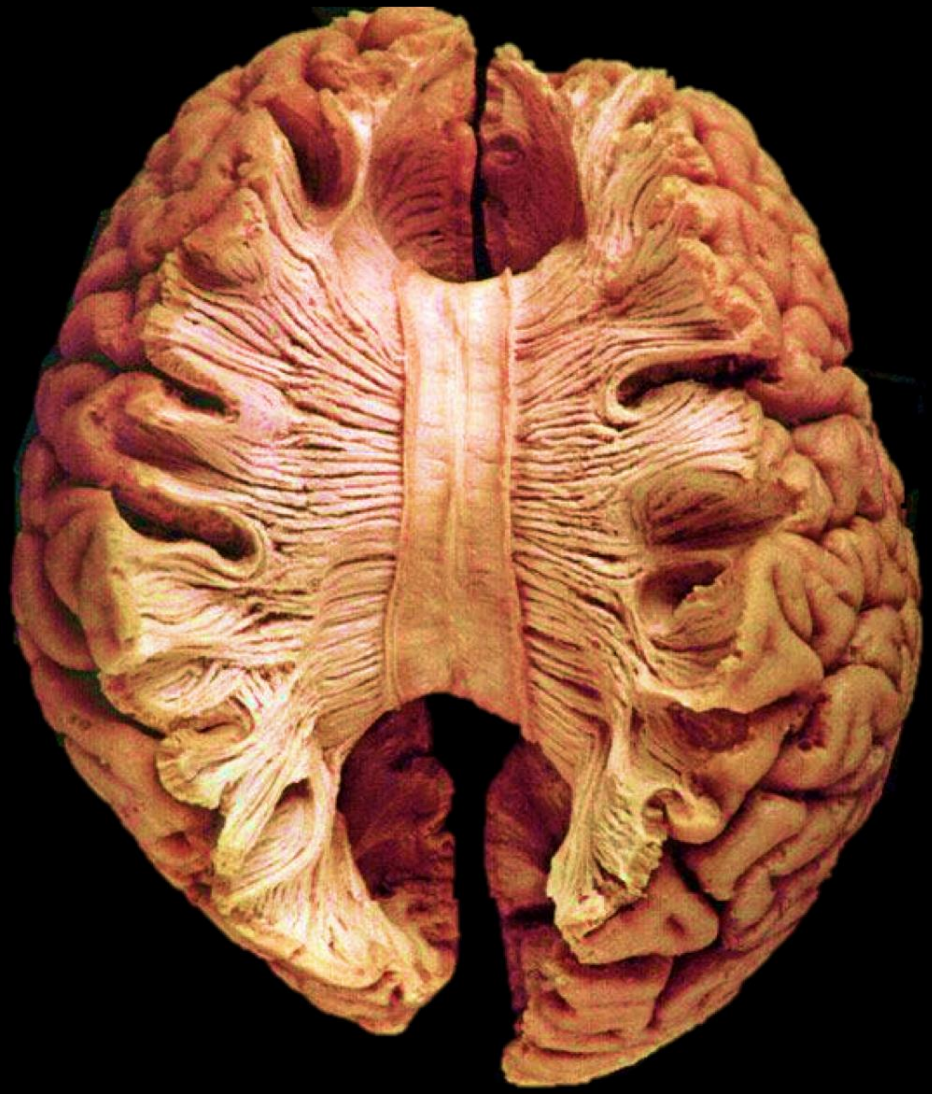
- Role of *underground* callosal connections?

- Potential for motor rehabilitation

«[…] non sappia la tua sinistra quel che fa la destra» *Matteo 6 ,1-4*



Thank you for your attention!

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Recruiting in progress!

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