Paired-pulse on two brain regions

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Plans for the afternoon

• Introduce ourselves

• Physiological and technical aspects

• Practice TMS!

• Clinical aspects and applications
Basic concepts

- Paired-pulse protocols
  - Intracortical
  - Intrahemisheric
  - Interhemispheric
  - Different brain structures

- Paired-pulse in two brain regions

  - Test pulse \((TP)\) \(\rightarrow\) MEP on target muscle

  - Conditioning pulse \((CP)\)

  - Inter stimulus interval \((ISI)\) (ms)
Physiological aspects: **Transcallosal inhibition**, but also…

**INHIBITION**: ISI 6-30ms → Transcallosal inhibition (IHI)
- To avoid mirror movement, allow unilateral movement, and hemispheric specialization
- To allow exchange of unilaterally represented information

But also **FACILITATION** at ISI 3-5 ms (inconsistent):
- To allow transfer of information via the CC between the two hemispheres?
Physiological aspects:

Corpus callosum:
- 200 million fibers
- largest white matter structure
- \( \text{GABA}_B \) interneurons

Transcallosal pathway: short latency

- studies in total or partial callostomy
- \( \pm \) direct ipsilateral pathway (?)

IHI has intracortical origin \( \rightarrow \) TES vs TMS (Ferbert et al. 1992)

\( \rightarrow \) I waves (Di Lazzaro et al. 1999)
Different parameters...

IHI dependent on:

- Intensity of CS (↑ duration), TS (↑ depth) and increasing ISI (↑ 5-15 ms)

- State of target muscle (→ control for muscle contraction!)
  - Contraction of muscle contralateral to the CS ↑ IHI
  - Effect disappears if the muscle contralateral to TS is also activated

And...

- Hand dominance (studies are contradicting)
- Gender differences (IHI women > men; ISI range well circumscribed in women)
Test pulse alone (RH)
Procedure to measure IHI

- 1 right-handed subject
- 2 to prepare the electrodes over the two hands
- 1-2 to prepare the cap and the marking on the two hemispheres
- 2 to find RMT on LH and RH
- 2 to measure RH baseline (TS alone) (120% of RMT, with the two coils)
- 2 to apply the paired pulses from L→R CP on LH and TS on RH (120 % of RMT) ISI of 8-12 ms (12 ms women, 10 ms men)

Always monitor the relaxation of the muscle!

\[ IHI = 100 \times \frac{\text{PP MEP} - \text{TS alone MEP}}{(\text{TS alone MEP})} \]

We expect a decrease of 20 to 40% but it may not work today!
How to find FDI hotspot with a standard Magstim figure-of-eight coil

- Monophasic coil
- Handle pointed backwards 45°
- Current directed posterior-anterior
- Perpendicular to central sulcus

Safe coil and machine handling!
What are we going to do?

• Mapping both M1 to find hotspot to determine RMT (FDI)

• Baseline (TP alone, monophasic coil) at 120% of RMT

• Paired-pulse: Conditioning pulse (CP) followed by test pulse (TP) (on optimal MEP site)
  - TP at 120% of RMT
  - CP at 120% of RMT
  - ISI = 8 - 12 ms

• What do we get?
From a historical point of view

- Various contradictory studies about callosotomies ("split-brain")
- Ferbert et al., 1992: first description
- Vuilleumier et al., 1996: right parietal stroke followed by a left frontal stroke
- Geschwind & Kaplan, 1962: "deconnection syndrome" due to callosal lesions
Clinical aspects
How could we use it?

- PD (↓)? Mirror movements? Dystonia? Cortical myoclonus (↓)?

- MS: prolonged transcallosal conduction time

- Stroke
  - IHI ↓ from affected to unaffected side (balance model)
  - IHI ↑ before movement onset (from unaffected to affected side)

- Assess the efficiency of brain stimulation and/or rehabilitation?

- Deconnection syndrome? Assess integrity of CC? (Chen et al., 2008)
Outside M1…
Be aware of network effects!

• Cerebellum - M1: Suppression of MEPs at ISIs of 5-8 ms (Ugawa et al., 1995)

• FEF and extrastriate visual cortex (MT/V5): stimulation of FEF 20-40 ms prior to stimulation of MT/V5 decreases the intensity needed to evoke a phosphene (Silvanto et al., 2006)

• PPC and contralateral M1: stimulation of right caudal IPS facilitates MEPs but stimulation of anterior IPS suppresses them. Directly or via homologous areas (Koch et al., 2009)