Peripheral and Central Stimulation

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Investigating Hebbian principles of neural plasticity in humans
"Cells that fire together, wire together"

How can we induce plastic changes at the brain level?

*Paired Associative Stimulation (PAS)*
*Or when the peripheral stimulation meets the MEP*

How can we induce plastic changes at the spinal level?

*Spinal Associative Stimulation (SAS)*
*Or when the central stimulation meets the H-reflex*
How do we measure cortical excitability? The MEP
Induction of plasticity in the human motor cortex by paired associative stimulation

Katja Stefan, Erwin Kunesch, Leonardo G. Cohen, Reiner Benecke and Joseph Classen

Electrical stimulation of right median nerve

TMS of left M1 hand representation

PAS protocol:
Induction of time-dependent plasticity in the motor cortex

(A) 
ISI 25 ms
ISI 100 ms
ISI 525 ms
ISI 5000 ms

(B) 
Amplitude (mV)

pre  post

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<th>ISI (ms)</th>
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(C) 
Amplitude change (percent of baseline)

Interstimulus interval (ms)

(D) 
Silent period duration (ms)

Stefan et al, Brain, 2000
Changes in cortical excitability were no due to changes in spinal excitability: MEPs and F-waves

(A) TMS-evoked MEPs

(B) F-waves

Brain, 2000

Stefan et al., E
• The increase of cortical excitability (MEP amplitude) was dependent on the synchronous **timing** between the afferent and the magnetic stimulation.

• Plasticity induced by PAS 1. evolved rapidly (within 30 min), 2. was persistent (minimum duration 30-60 min) yet reversible, and 3. was topographically specific – properties signature of associative **long-term potentiation (LTP)**.
How do we measure spinal excitability? The H-REFLEX
Effect of Stimulus Intensity - M Response & H Reflex

Low Intensity PNS

M-Response

H-Reflex

Increased Intensity PNS

Smaller H-Reflex

Larger M Response
SAS protocol:

Spinal associative stimulation: A non-invasive stimulation paradigm to modulate spinal excitability

Mar Cortes a, Gary W. Thickbroom b, Josep Valls-Sole c, Alvaro Pascual-Leone d,e, Dylan J. Edwards a,b,d,e

PRE
H-Reflex RC

INTERVENTION (15 min)

POST
H-Reflex RC

0.1 Hz

20ms

90 paired stimuli

sec
Peripheral stimulation of somatosensory afferents conditioned by low frequency TMS increases spinal excitability.
Repetitive paired stimulation can induce changes in spinal excitability.

Cortes et al, Clin Neurophysiology, 2011
Left shift of the RC post-intervention

Amplitude

PRE H-Reflex Recruitment Curve

Individual POST Recruitment Curves

Standard Deviation

Cortes et al, Clin Neurophysiology, 2011
SAS experimental setup

Figure-8 TMS Coil (vertex)

Posterior Tibial nerve Stimulation

Soleus EMG
REFERENCES:


