Determining motor threshold

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Questions this session will answer

1. What is motor threshold (MT)?
2. Why do we determine MT?
3. What types of MT can be determined?
4. What are the available methods to determine MT?
5. What are the key steps for determining resting MT with electromyography (EMG)?
What is motor threshold (MT)?

- The minimum intensity (% of maximum machine output) to elicit a motor response in at least 50% of all attempts.
- Reflects excitability (reactivity) of the motor cortex:
  - Voltage-dependent ion channel function
  - Inter- and intra-individual variance
- Physical parameters:
  - Device (stimulator and coil)
  - Pulse waveform/shape/direction
  - Activity of brain/muscle
  - Method of determination (visual inspection vs. EMG)
Why do we determine MT?

- Easy to observe
- Objective measure of relative cortical excitability
- A way of calibrating TMS intensity to inter- and intraindividual physiologic variability in experimental designs and therapeutic applications
- Consistent with safety limits (Rossini et al., 2009)
What types of MT can be determined?

Resting motor threshold (RMT) > Active motor threshold (AMT)

Proper Hand Position

right↑

wrong
What are the available methods to determine MT?

- Visual inspection
- Electromyography (EMG)
RMT with EMG

- Rossini-Rothwell method:
  Minimum single-pulse stimulator output intensity to elicit motor-evoked potentials (MEPs) ≥50 µV peak-to-peak amplitude in ≥50% of n consecutive trials (typically n = 10)
What are the key steps for determining RMT with EMG?

1. Safety first
2. Choosing an output target
3. Locating the motor “hot spot” (adjusting location)
4. Finding the MT (adjusting intensity)
Safety first

- Screen for contraindications and side effects
- Earplugs must be worn by participant/patient and operator
Choosing an output target

Determining motor threshold
Choosing an output target

Determining motor threshold
Attaching EMG electrodes

Identify

Clean

Attach

Determining motor threshold
Locating the motor “hot spot”

≈5 cm lateral from the vertex

(Jaspers, 1958)
Locating the motor “hot spot”

≈5 cm lateral from the vertex

(Jaspers, 1958)
Locating the motor “hot spot”
Locating the motor “hot spot”

1. Set intensity to 30% and deliver 3 pulses (6-10 s apart)
2. Go up in steps of 5-10% until MEP is observed
3. Deliver several pulses to ensure a consistent response (MEP) is evident (suprathreshold)
4. Test four points around the location of the MEP
   - 1 cm north, east, south, and west
   - Deliver 3 pulses at each location
5. Repeat Step 4 until the individual’s “hot spot” is identified
6. The location that elicits the largest peak-to-peak MEP amplitude is the motor “hot spot”
Locating the motor “hot spot”

- Keep in mind:
  - The hotspot is **not** at the interior curve of the TMS coil
  - The distance between center and the interior curve of a figure-of-eight coil varies across vendors/coil types
Finding the MT

1. Record 10 MEPs
2. Progressively lower intensity (1-2%) until <5/10 show an MEP of \( \geq 50 \, \mu V \)
3. Always test one intensity lower
4. The lowest intensity that elicits MEPs in \( \geq 5/10 \) pulses is your MT
Finding the MT

- Alternatives under time constraints:
  - ≥3/6
  - Adaptive MT determination/Parameter estimation by sequential testing (PEST) with the TMS Motor Threshold Assessment Tool (clinicalresearcher.org)

- Trouble shooting:
  - No MEP detected (relaxation, AMT, silence period)
  - MEP latencies >150 instead of 20-30 ms
  - Expectation