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Determining Motor Hotspot/Threshold

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Intensive Course in Transcranial Magnetic Stimulation

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Overview

- Review of safety
- Definitions
- Motor Threshold background
- Attaching EMG electrodes
- Finding the hotspot
- Assessing the motor threshold
- Phosphene hotspot/threshold
- Hands-on



Safety First!!!



- Screen for contraindications and side-effects
- Earplugs must be worn by subject and operator

Motor threshold (MT) definition

- The minimum intensity (% of maximum machine output) to elicit a motor response in at least 50% of trials

Role of MT

- Objective measure of relative cortical excitability/reactivity
 - Reflects voltage-dependent ion channel function
 - Highest test-retest reliability of any TMS measure
- Used to individualize intensity of further TMS
- Consistent with safety limits (Rossini et al., 2009)

Factors that influence MT

- **Subject factors:**
 - Inter- and intra-individual variance
 - Activity of brain/muscle
 - Coil-to-cortex distance
 - CNS drugs

- **Physical Parameters:**
 - Device (stimulator and coil)
 - Pulse waveform/shape/direction
 - Navigated vs. Non-navigated TMS
 - Method of determination (visible/EMG)

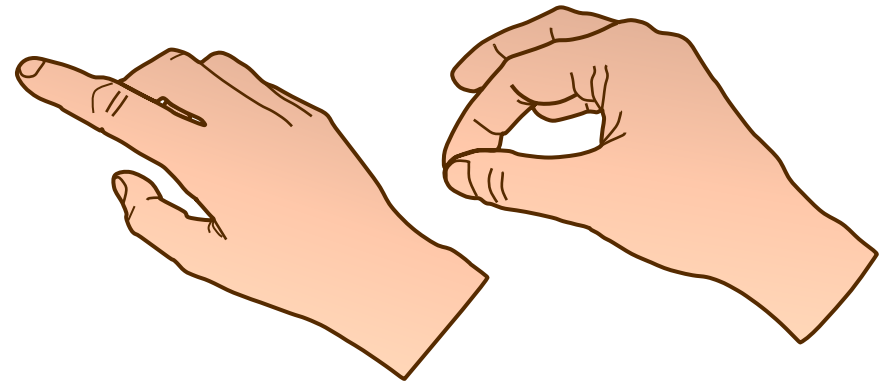
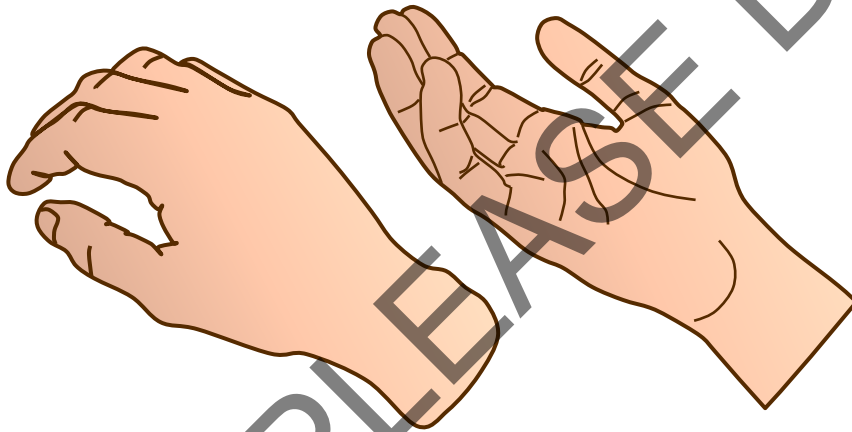
Types of MT

Resting motor threshold (RMT)



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Active motor threshold (AMT)

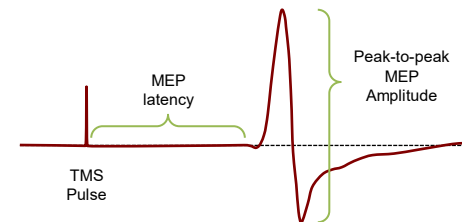
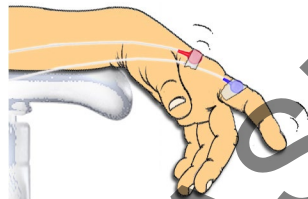
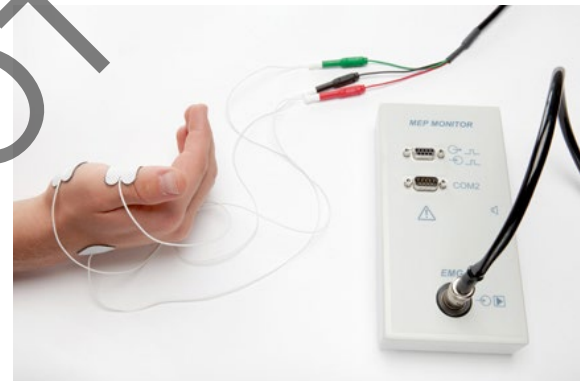


Methods of determining MT

Visual inspection



Electromyography (EMG)

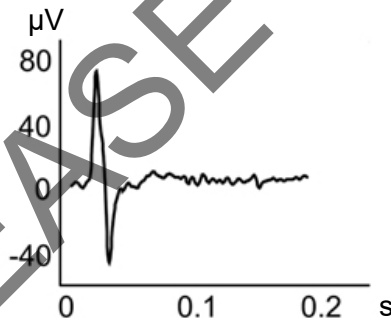


RMT with EMG

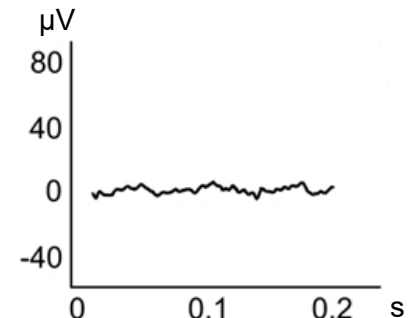
Rossini-Rothwell method:

- Minimum intensity to elicit motor evoked potentials (MEPs) of $\geq 50 \mu\text{V}$ **peak-to-peak** amplitude in $\geq 50\%$ of consecutive trials (typically 10)

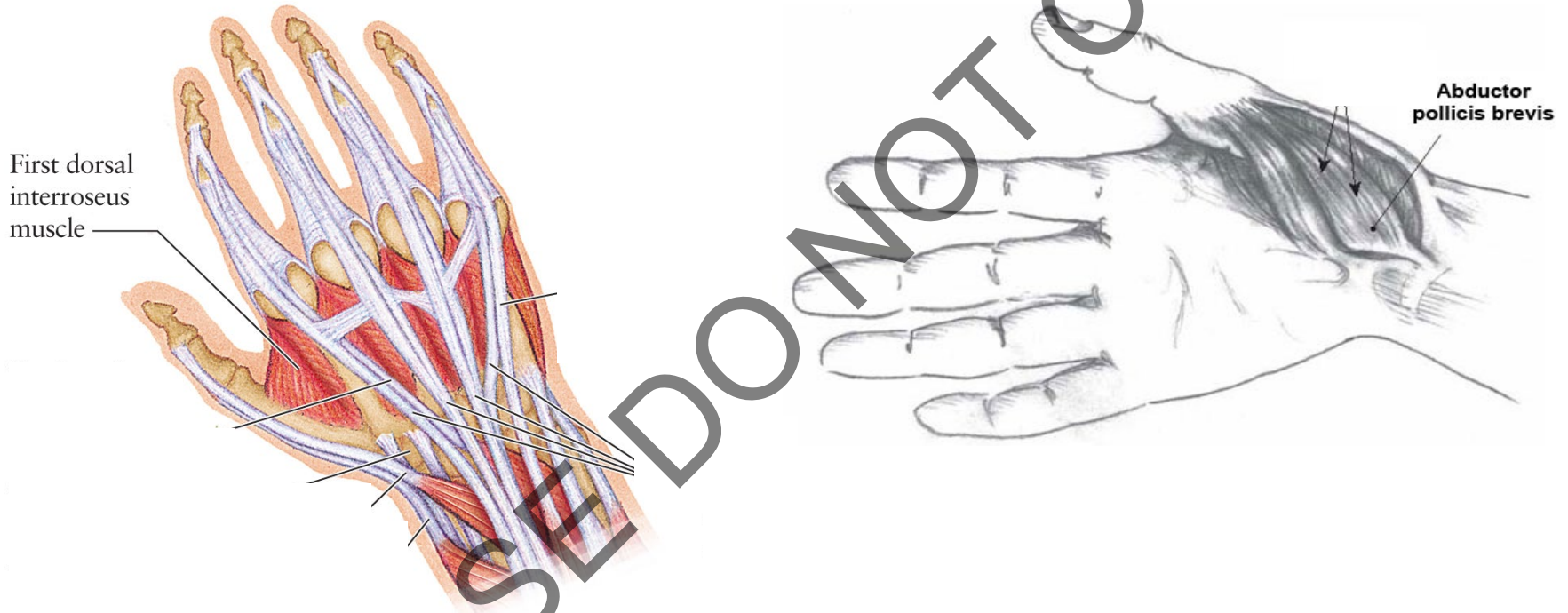
MEP found



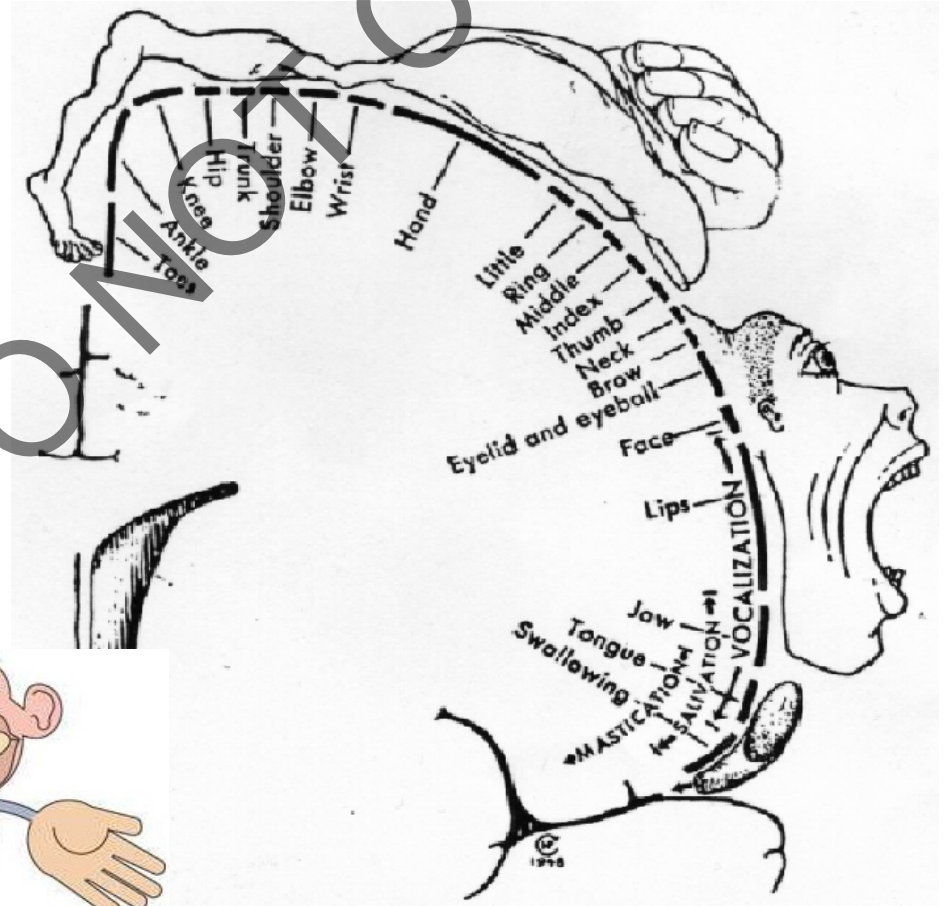
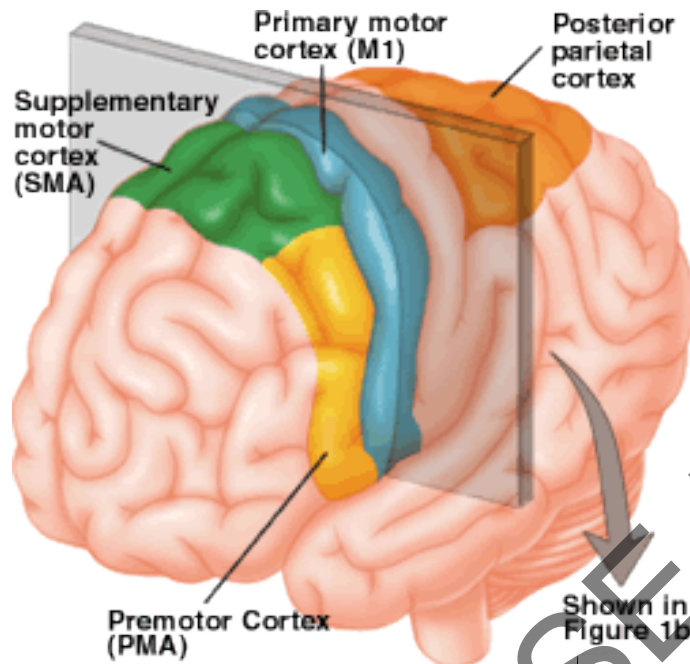
MEP not found



Target muscle

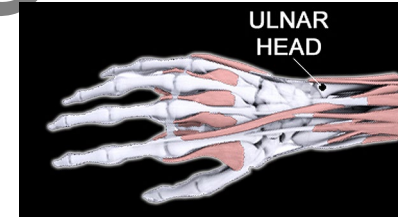
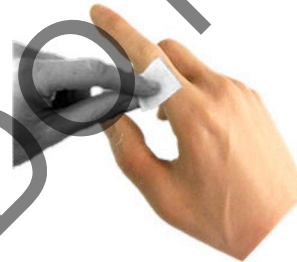
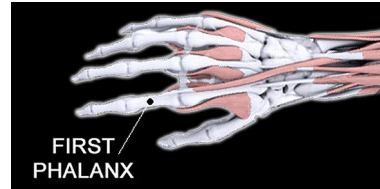
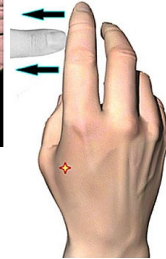
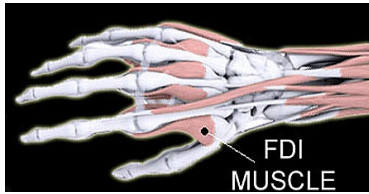


Penfield's motor homonculus

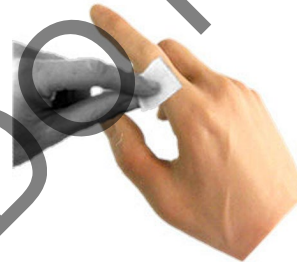


Attaching EMG electrodes

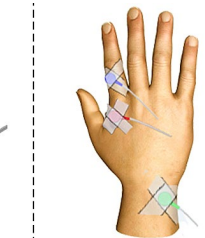
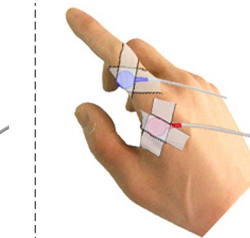
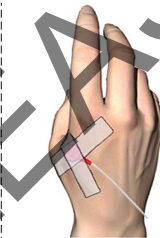
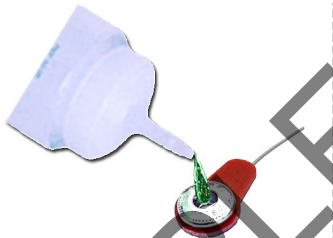
Identify



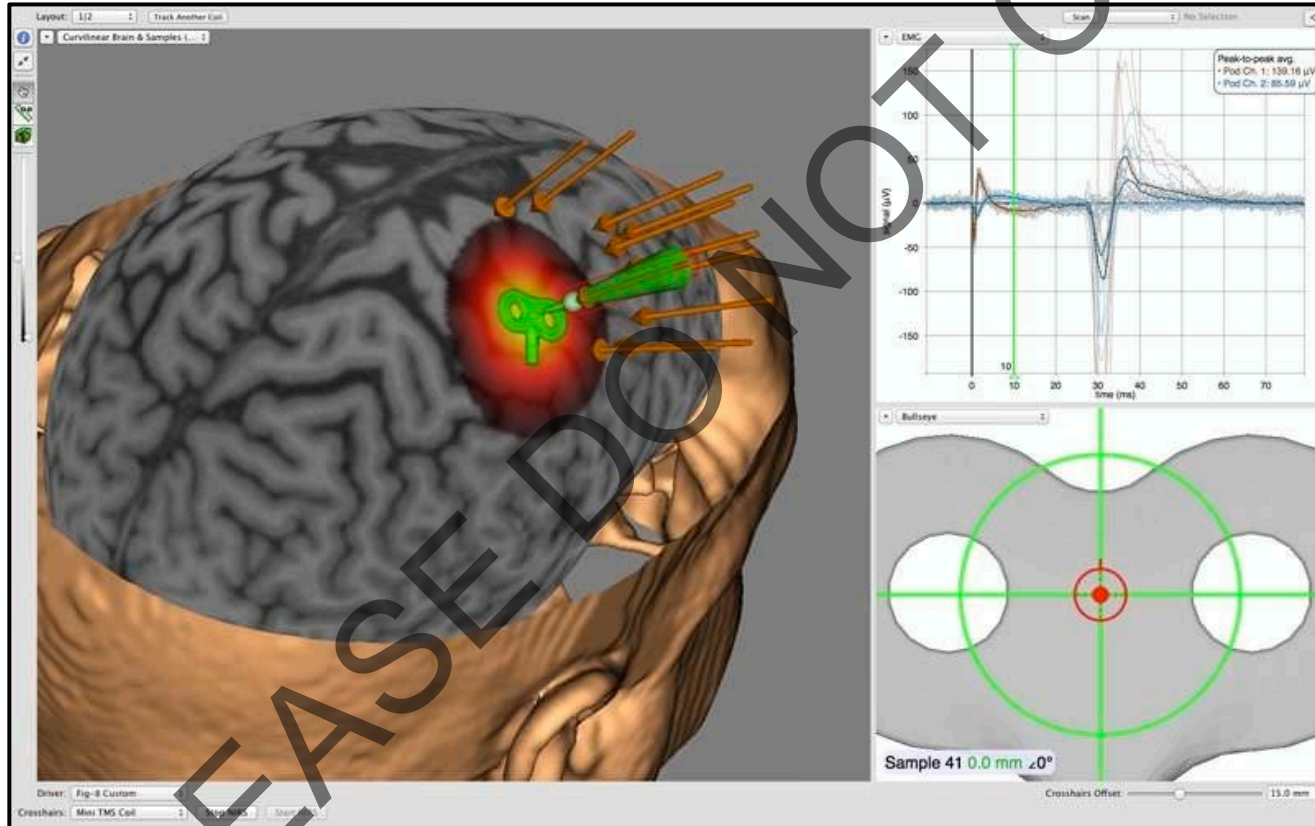
Clean



Attach

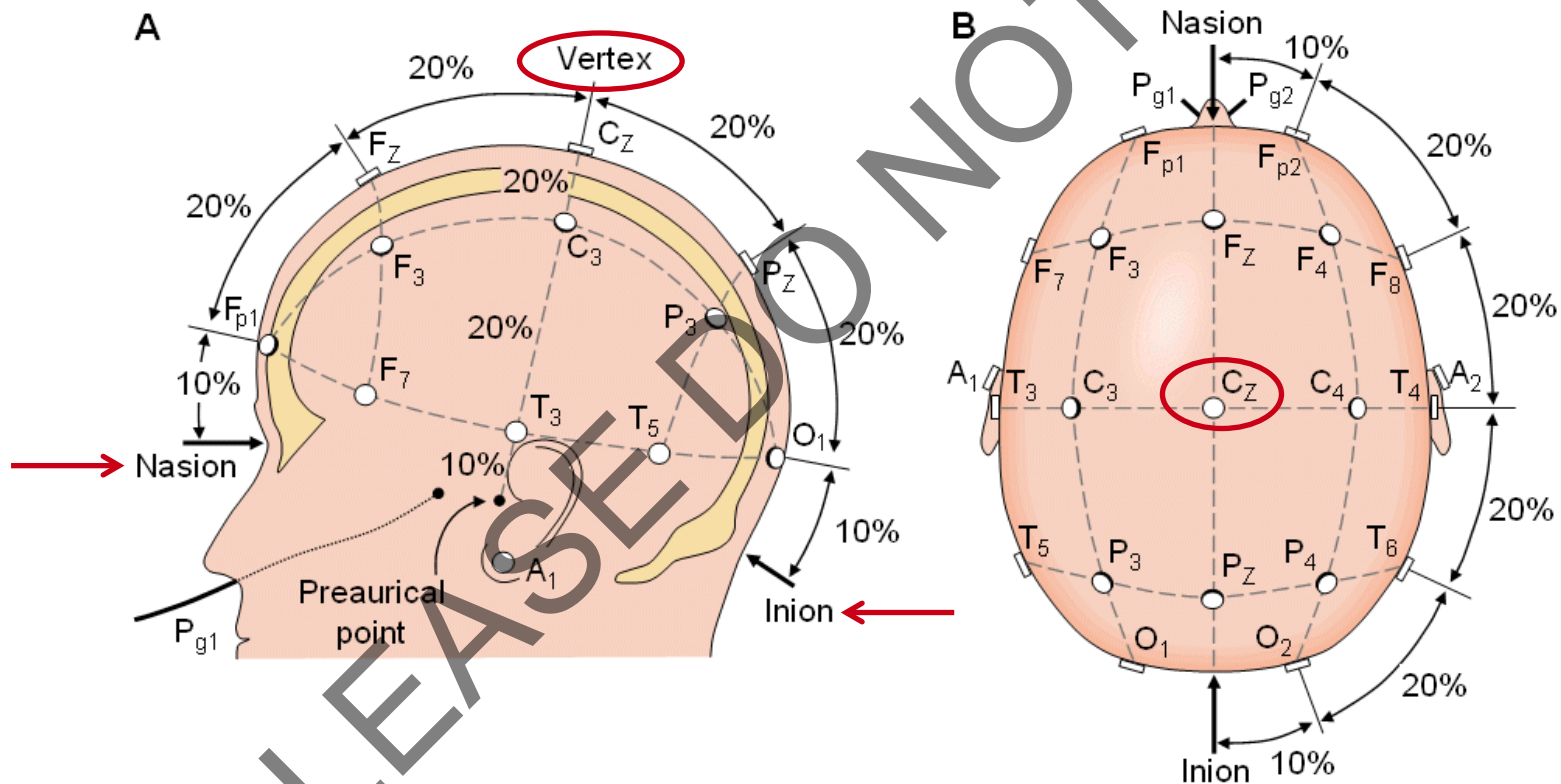


Finding the “hot spot” with neuronavigation



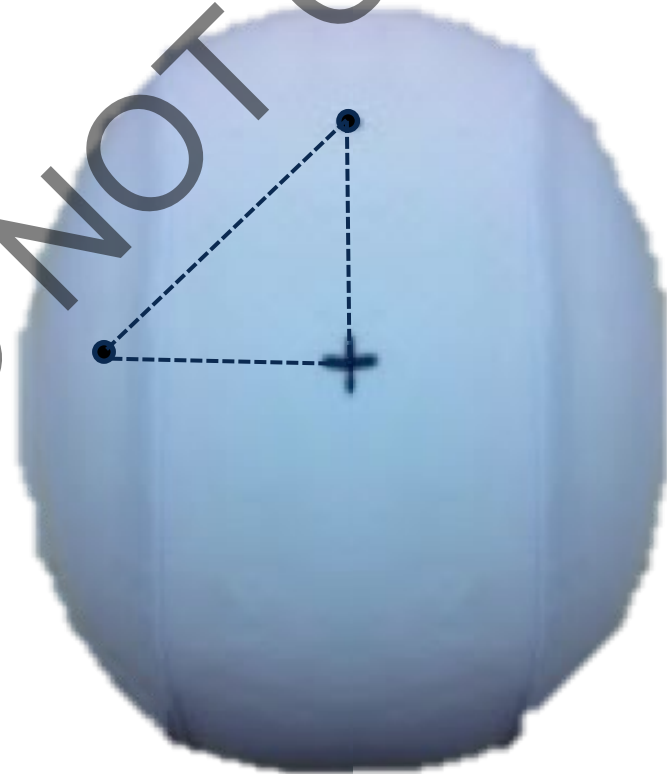
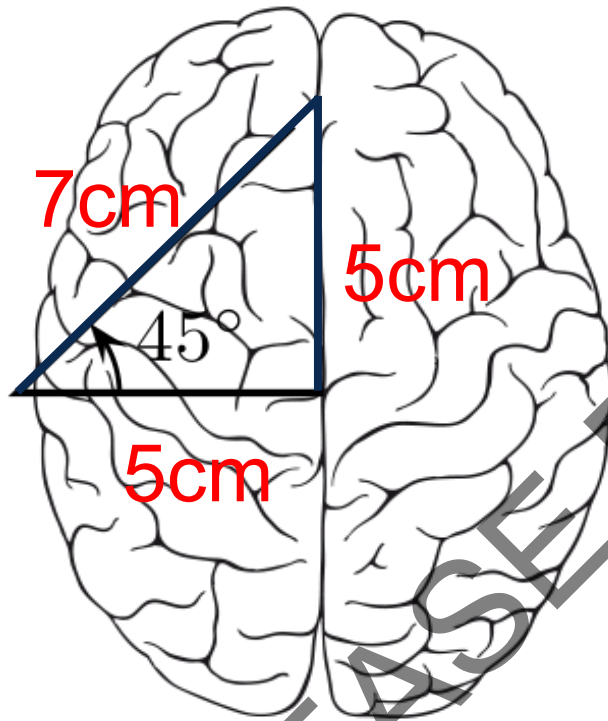
Finding the “hot spot” without neuronavigation

≈5 cm lateral from the vertex



(Jaspers, 1958)

Finding a starting location



Finding the “hot spot”

1. Set intensity to 30% and deliver a couple of pulses
2. Go up in steps of 5-10% until MEPs are observed
3. Deliver several pulses to ensure a consistent response is evident (**suprathreshold**)
4. Test **four** spots around the location of the MEP (**north, east, south, west**)
5. Repeat Step 4 until the individual’s “hot spot” is identified



Whatever you do, do it consistently.

Finding the MT

1. Record 10 MEPs
2. Progressively lower intensity (1-2%) until $\geq 5/10$ trials elicit an MEP of $\geq 50 \mu V$ (or visible twitch)
3. Always check 1 intensity lower

Finding the MT

- Alternatives under time constraints:
 - $\geq 3/6$
 - 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, silent period)
 - MEP latencies = 20-30 ms

Phosphenes

- Visual percept not triggered by phototransduction (i.e., rubbing your eyes, blow to the head, TMS to visual cortex)



Eyes closed: phosphene

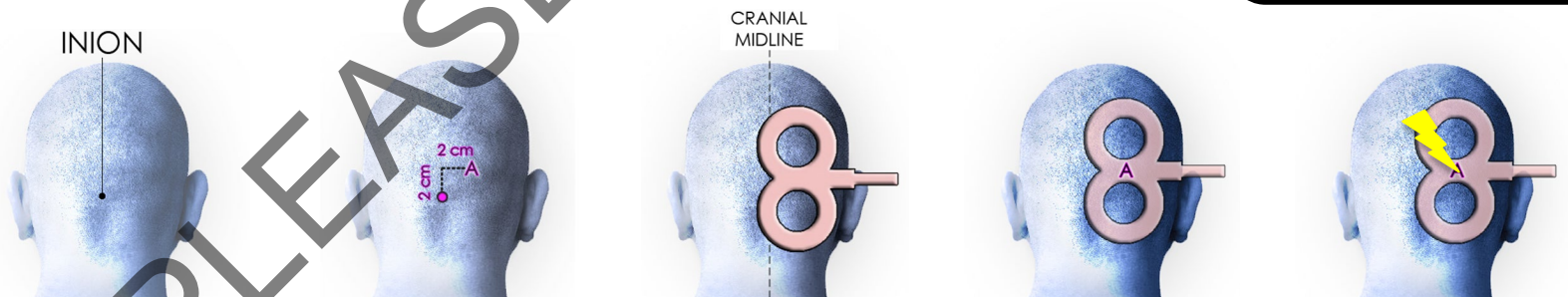


Eyes open: scotoma

- Means to probe excitability of visual cortex (like MEPs)
- Unlike MEPs, phosphenes are subjective

Phosphene hotspot/threshold

- Measure 2cm dorsal and 2cm lateral from the inion
- Center the coil with handle pointing away from midline
- Phosphenes should appear in contralateral visual field
- Increase intensity or move coil until phosphenes are reported
- Assess phosphene threshold same as motor (i.e., 5 of 10)





Safety First!!!



- Screen for contraindications and side-effects
- Earplugs must be worn by subject and operator