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# Determining Motor Hotspot/Threshold

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Intensive Course in Transcranial Magnetic Stimulation

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# Overview

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- 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

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

# Role of MT

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- 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

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- **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)

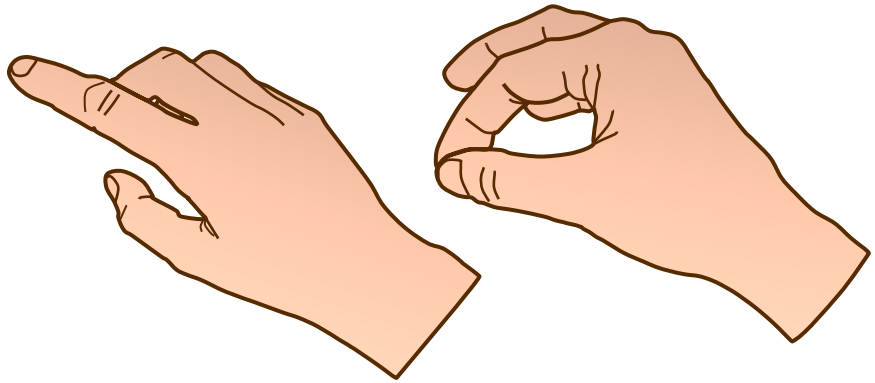
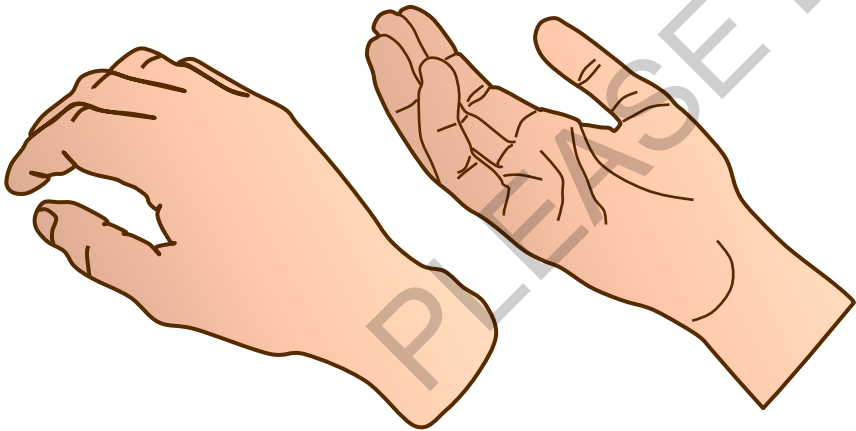
# Types of MT

Resting motor threshold (RMT)



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Active motor threshold (AMT)

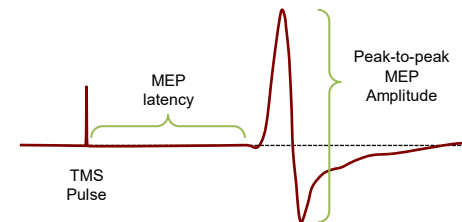
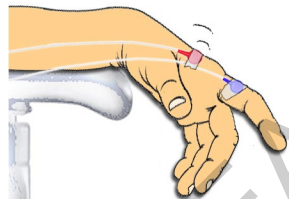
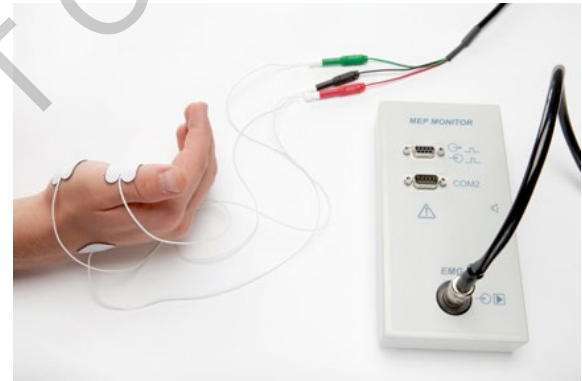


# Methods of determining MT

## Visual inspection



## Electromyography (EMG)



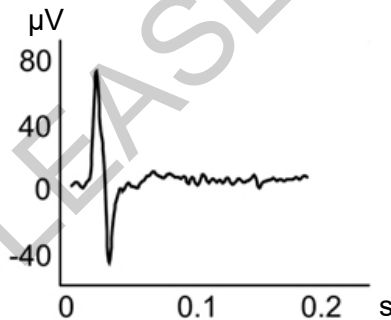


# RMT with EMG

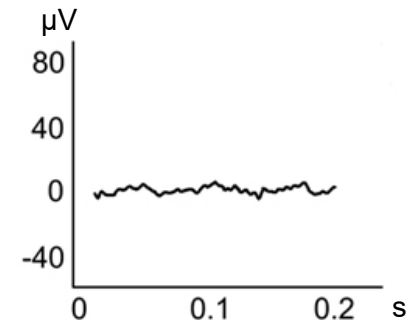
Rossini-Rothwell method:

- 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

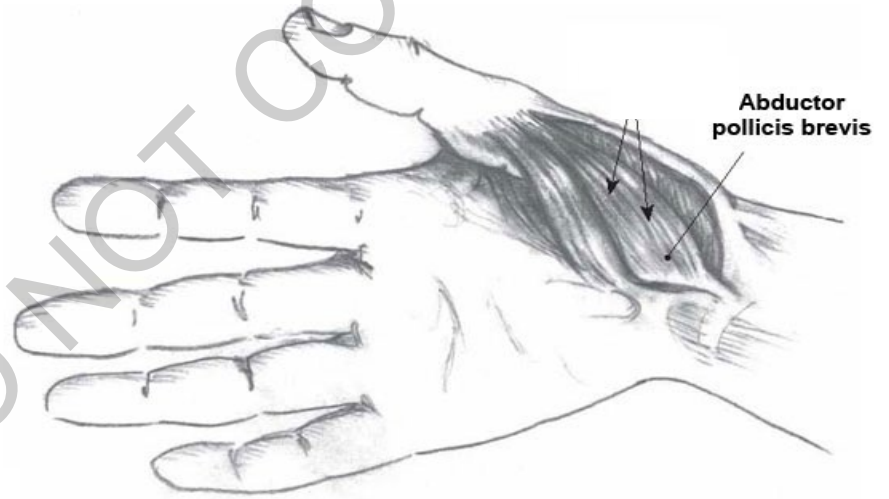
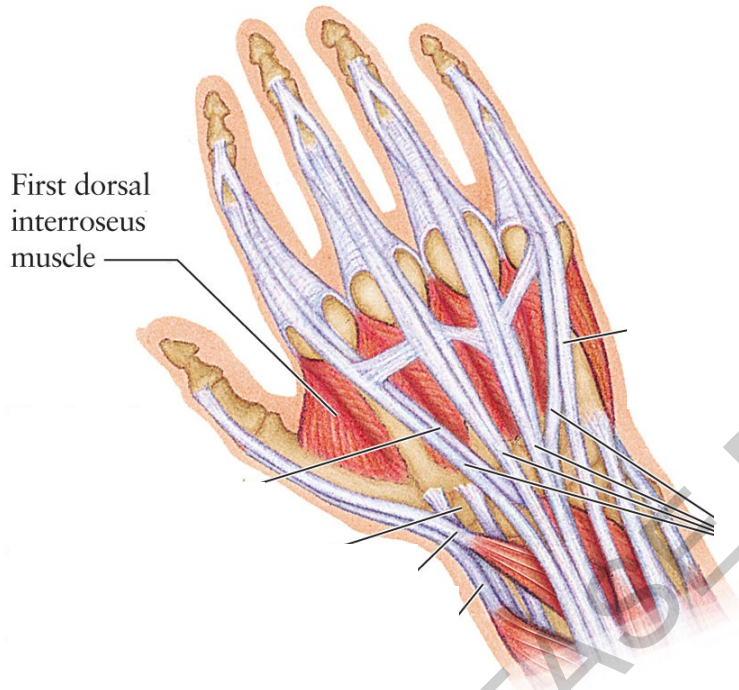


MEP not found

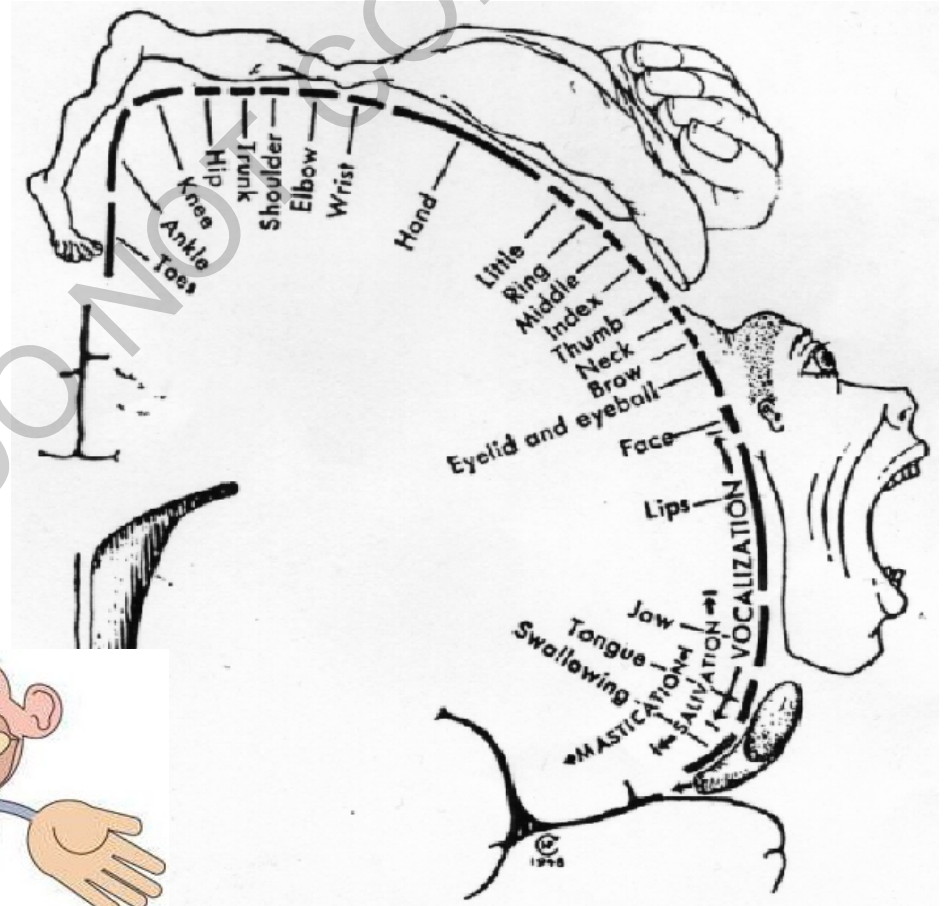
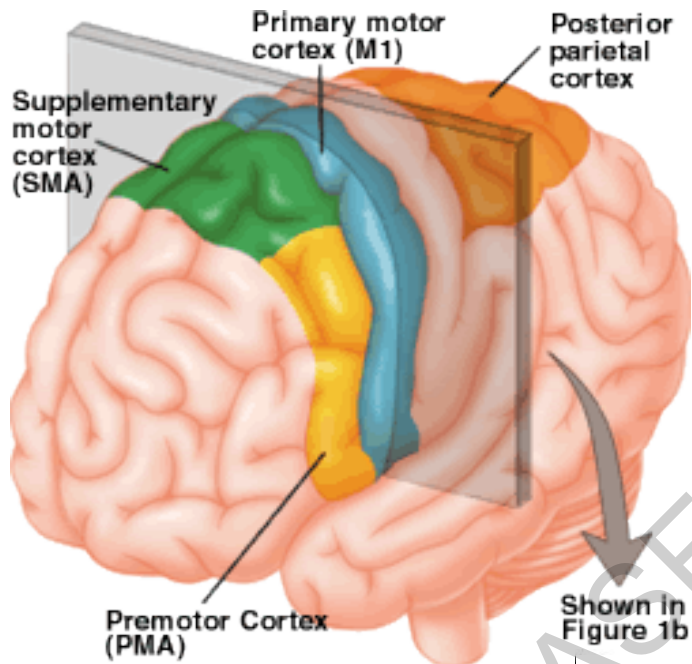


# Target muscle

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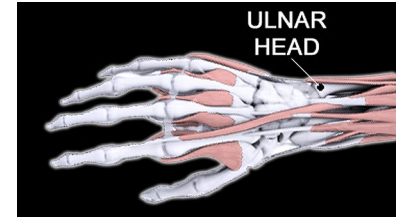
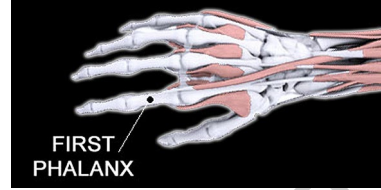
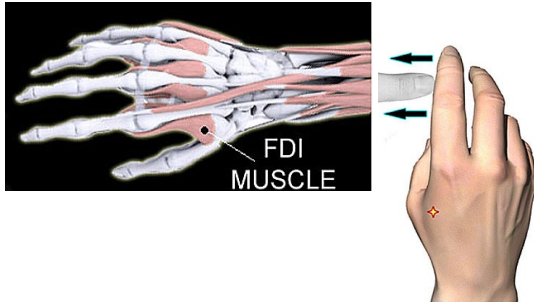


# Penfield's motor homonculus

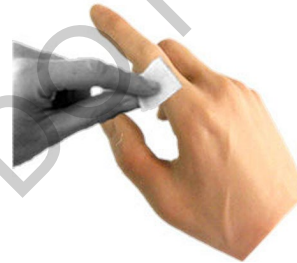


# Attaching EMG electrodes

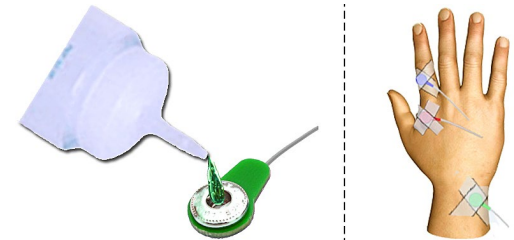
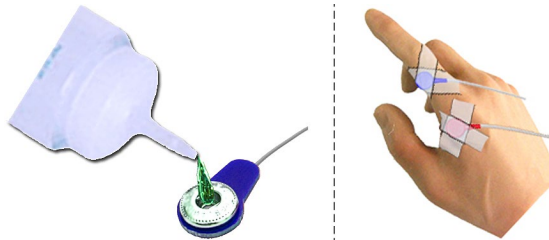
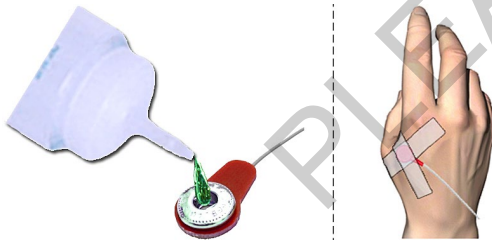
Identify



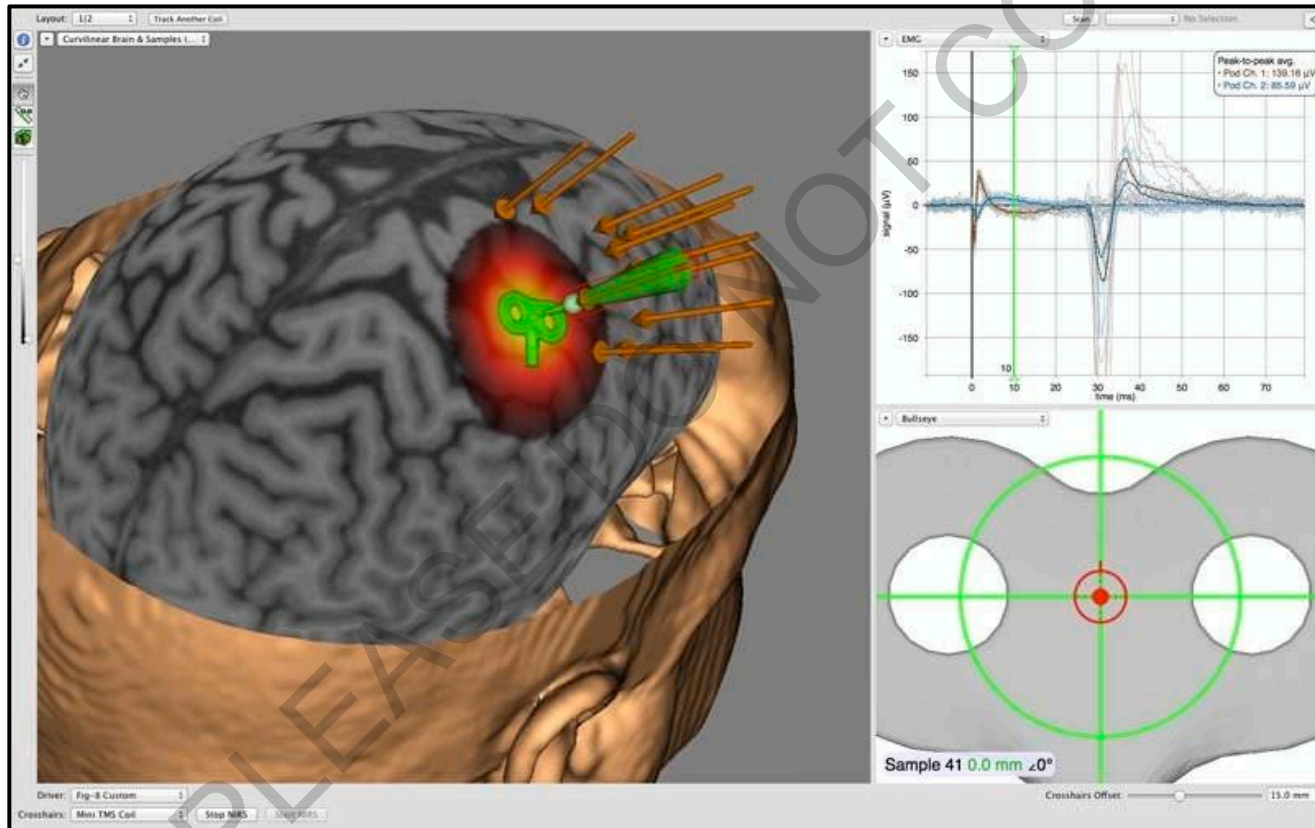
Clean



Attach



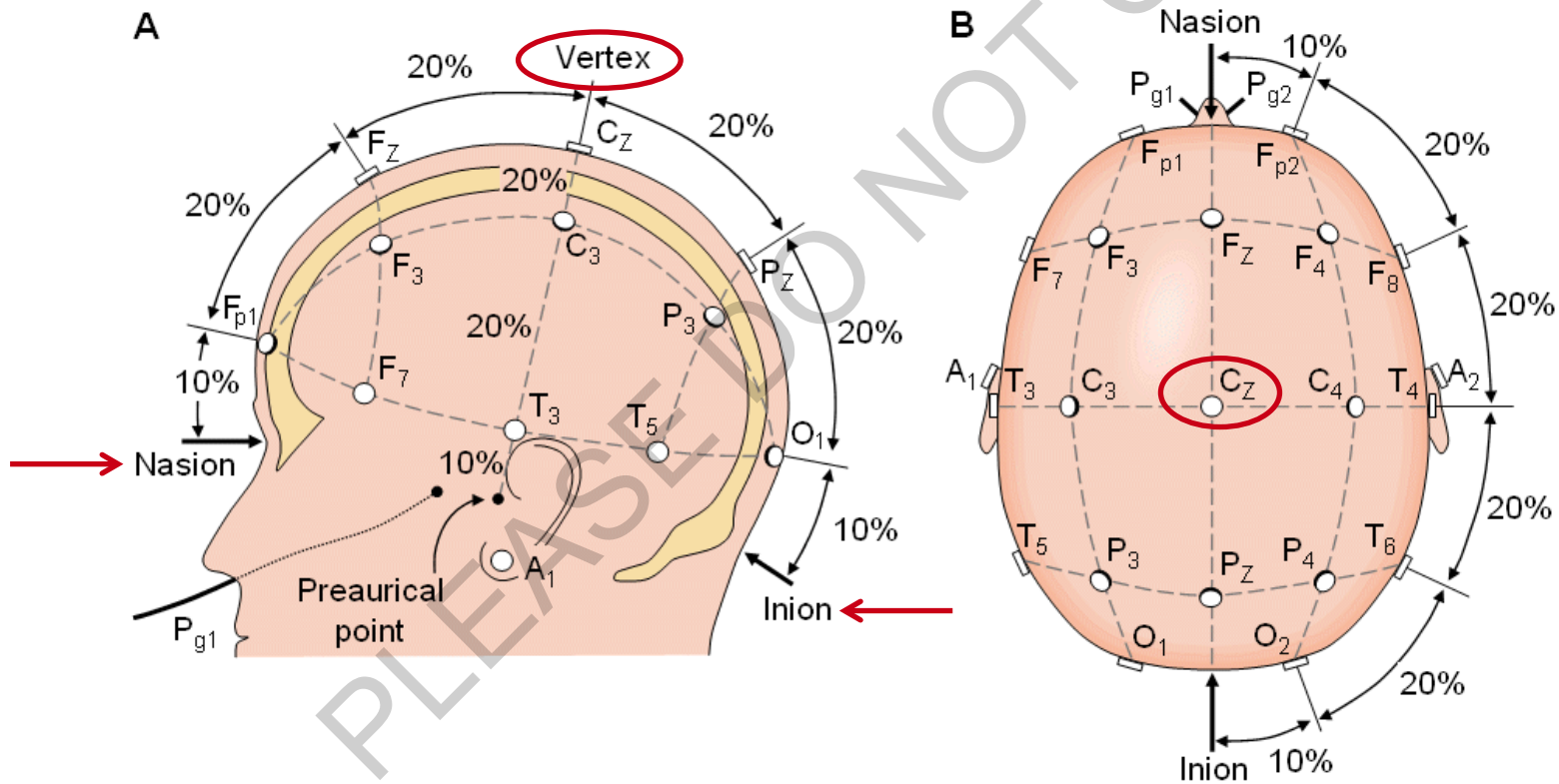
# Finding the “hot spot” with neuronavigation





# Finding the “hot spot” without neuronavigation

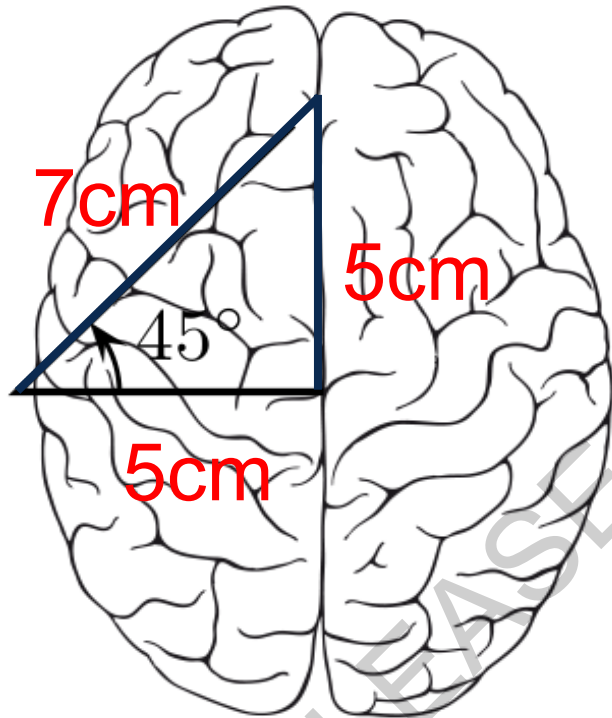
≈5 cm lateral from the vertex



(Jaspers, 1958)

# Finding a starting location

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# Finding the “hot spot”

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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

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

PLEASE DO NOT COPY

# Finding the MT

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- 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](http://clinicalresearcher.org))
- Trouble shooting:
  - No MEP detected (relaxation, AMT, silent period)
  - MEP latencies = 20-30 ms

# Phosphenes

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- 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