Phosphenes

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Intensive Course in Transcranial Magnetic Stimulation, 10/25/2016
What are the learning objectives of this session?

1. What are phosphenes?
2. What characterizes TMS-induced phosphenes?
3. When should you consider determining phosphene threshold?
4. What are the key steps for determining phosphene threshold?
What are phosphenes?

- From Greek *phōs* ‘light’ + *phainein* ‘to show’
- Brief visually perceived flashes of light triggered by activation of neurons within V1
- **Not** caused by phototransduction but interpreted as visual stimuli

Modified from Bear, Connors, & Paradiso, 1996
How can phosphenes be elicited?

- **Mechanical stimulation**
  - Rubbing your eyes
  - “Seeing stars” from a blow to the head
  - Pituitary tumor encroaching on optic chiasm

- **Electrical stimulation**
  - Transcranial alternating current stimulation (tACS)
  - Transcranial magnetic stimulation (TMS)
What characterizes TMS-induced phosphene?

- Subjective experience
- Retinotopically organized
- Simple geometric shapes
- Appear as light (in darkness or eyes closed)
- Appear as blurring or scotoma (eyes open)
- Vary depending on level of visual cortex stimulated

When should you consider determining phosphene threshold?

- To map the functional organization of the visual cortex
- To determine state-dependent stimulation effects
- To explore cortico-cortical interactions underlying visual attention and awareness
- To assess the relative excitability of the visual cortex to determine procedural stimulation intensity
- To record a secondary index of cortical excitability in non-motor regions
Relationship between motor and phosphene threshold

From Gerwig et al., 2003. *J Neurol Sci*

\[ r_{28} = 0.29, p > 0.1 \]

From Fried et al., 2011. *PLoS One*

\[ r_{16} = 0.27, p > 0.2 \]
Neural basis of phosphene awareness

From Taylor et al., 2010. *Hum Brain Mapp*
What are the key steps for determining phosphene threshold?

1. Choosing a stimulation target (typically V1)
2. Setting up and ensuring safety
3. Locating the phosphene hotspot (adjusting location)
4. Assessing the phosphene threshold (adjusting intensity)
Setting up and ensuring safety

Phosphenes
Locating the phosphene hotspot

1. Find the inion
2. Mark point 2 cm superior and 2 cm lateral
3. Orient coil with handle pointing laterally:
   Optimal current direction is lateral to medial in the brain
4. Phosphene should be reported in the contralateral visual field
Locating the phosphene hotspot

1. Set intensity to 30% MOS and deliver 3 pulses (6-10 s apart)
2. Go up in steps of 10% until phosphene is reported
3. Deliver several pulses to ensure a consistent response (phosphene) is evident (suprathreshold)
4. Construct and test a 5 x 5 cm grid around marked spot
   - Deliver 3 pulses at each location
   - Record phosphene incidence and vividness

5. The location that elicits the most consistent, vivid, and unambiguous phosphene is the phosphene hotspot
Assessing phosphene threshold

1. Set intensity to 30% MOS and deliver 3 pulses (6-10 s apart)
2. Go up in steps of 10% until phosphene is reported
3. Deliver several pulses to ensure a consistent response (phosphene) is evident (suprathreshold)
4. Record responses to 6 pulses
5. Progressively lower intensity (1-2%) until occurrence <50%
6. The lowest intensity that elicits a consistent, vivid, and unambiguous phosphene in $\geq 3/6$ pulses is your phosphene threshold
Further considerations

- Count only unambiguous responses (“yes” or “no”), redo “maybe”
- Can be easier if subject is blindfolded (+ waiting time)
- Have subject focus on center of visual field: Directing attention to a part of the visual field will decrease threshold to relative to rest of visual field.
Thank you for your active participation and good luck for the rest of the week!

For further questions, contact me at any time:
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