Phosphenes

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Intensive Course in Transcranial Magnetic Stimulation, 10/23/2018
Questions this session will answer

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
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 phosphenes?

- Subjective experience
- Retinotopically organized
- Simple geometric shapes
- Appear as light (in darkness or eyes closed)
- Appear as blurring or scotoma (eyes open)

Figure 1. Artistic impressions of phosphenes reported by subjects. Left column: peripheral phosphenes (>5°); right column: central phosphenes (<5°). (a) Structured phosphenes: stripes, grids, or wavy lines; (b) sector-shaped light flashes, usually near the horizontal meridian, showing well defined edges; and (c) light flashes with indefinite edges (“blobs”): arcs, ovals, rectangles.

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*

$\rho_{28} = 0.29, p > 0.1$

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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 “hot spot” (adjusting location)
4. Assessing the phosphene threshold (adjusting intensity)
Setting up and ensuring safety
Locating the phosphene “hot spot”

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 “hot spot”

1. Set intensity to 30% 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 “hot spot”
Finding phosphene threshold

1. Record responses to 6 pulses
2. Progressively lower intensity (1-2%) until occurrence <50%
3. The lowest intensity that elicits a consistent, vivid, and unambiguous phosphene in ≥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!

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