TMS & visual cortex

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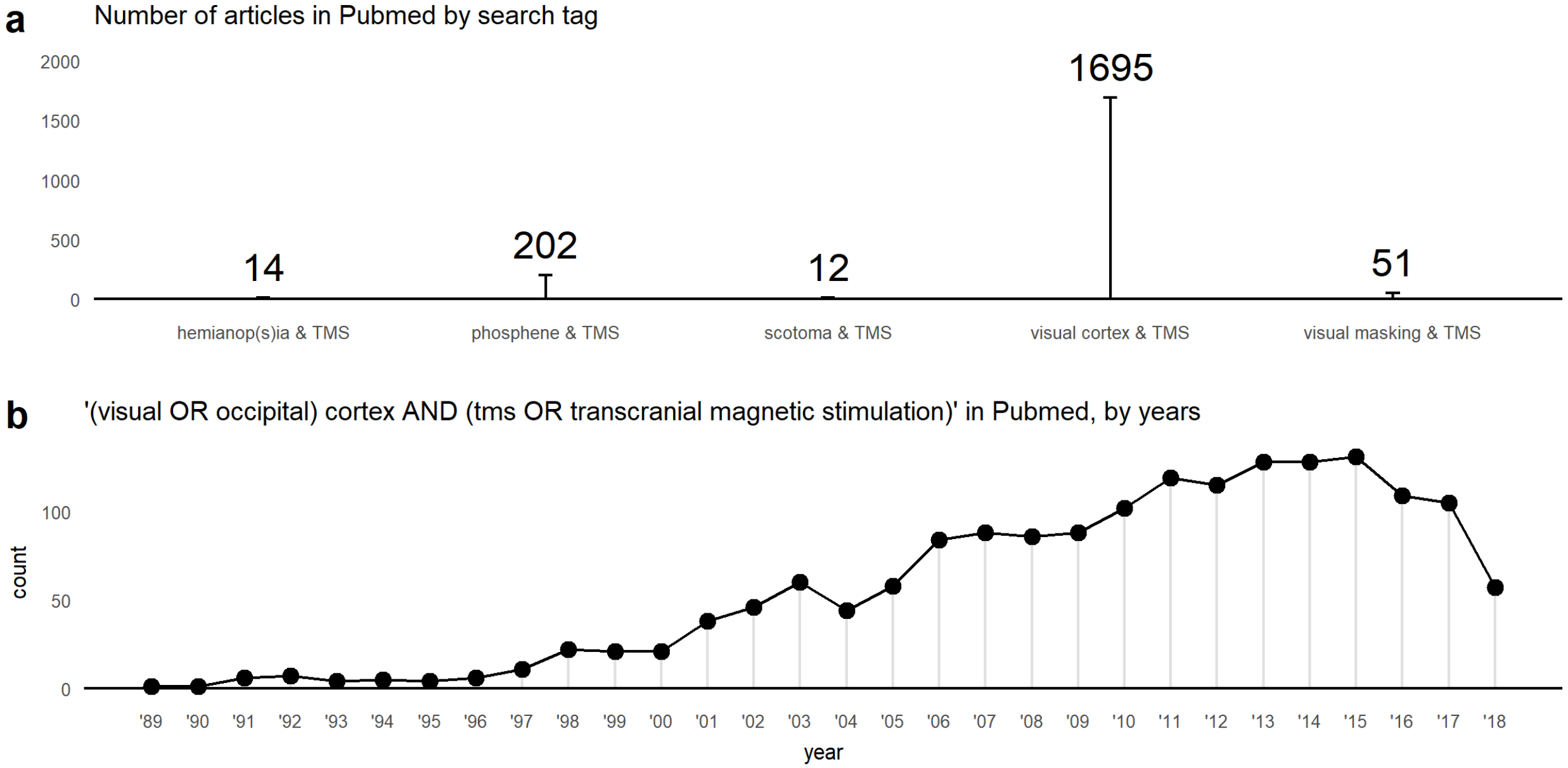
Some definitions (from Wikipedia)

- **Hemianop(s)ia** - less vision or blindness (anopsia) in half the visual field, usually on one side of the vertical midline. The most common causes of this damage are stroke, brain tumor, and trauma
- **Phosphene** - A phosphene is a phenomenon characterized by the experience of seeing light without light actually entering the eye.
- **Scotoma** (from Greek: darkness) - s an area of partial alteration in the field of vision consisting of a partially diminished or entirely degenerated visual acuity that is surrounded by a field of normal – or relatively well-preserved – vision.
- …but

Scotoma in TMS studies

- “although this term described different perceptual phenomena: a sensation of darkness in the visual field (Murd et al. 2010), a transient visual field defect (Kastner et al. 1998), a missing region from a visual pattern (Kamitani and Shimojo 1999), and suppression of visual perception (Kammer et al. 2005; Kammer 1999).” (Knight et al., 2015, p. 3215)
- “The use of the term “scotoma” in the field of TMS studies derives from its use in neuropsychological studies, and it mainly refers to a negative phenomenon in which something is missing or defective.” (Knight et al., 2015, p. 3215)


a
Number of articles in Pubmed by search tag
2000
1500
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hemianop(s)ia & TMS
phosphene & TMS
scotoma & TMS
visual cortex & TMS
visual masking & TMS
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'(visual OR occipital) cortex AND (tms OR transcranial magnetic stimulation)' in Pubmed, by years
count
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Mechanisms of phosphenes

- No consensus on the mechanisms:
  - **Stimulation of V1**: no phenomena in patients without V1 after intact extrastriate cortex is stimulated (Cowey and Walsh, 2000)
  - **Stimulation of V2/V3**: modelling TMS-induced electric field [E-field] (Thielscher et al. 2010) & MRI together with optical tracking system (Potts et al., 1998)
  - **Cortico-cortical tracts from V2/V3 to V1 (**Kammer et al. 2001)
  - **Subcortical areas**: optical radiation - Marg and Rudiak, 1994
  - **Several visual areas involvement**: central scotomas (within 1 – 3 degrees) are caused by V1 and V2/V3 stimulation, more peripheral scotomas (within 4 – 9 degrees) caused by V2/V3 stimulation (Kastner et al., 1998). Also, Kammer et al,. (2005) suggested that subcortical areas, V1 and extrastriate cortex contribute.

Inconsistency of the “hotspot” method finding

- 1-3 cm above inion
- “hunting” method – whatever induces phosphenes (usually considered as V1)
- fMRI-based (combined with E-field modelling or not)

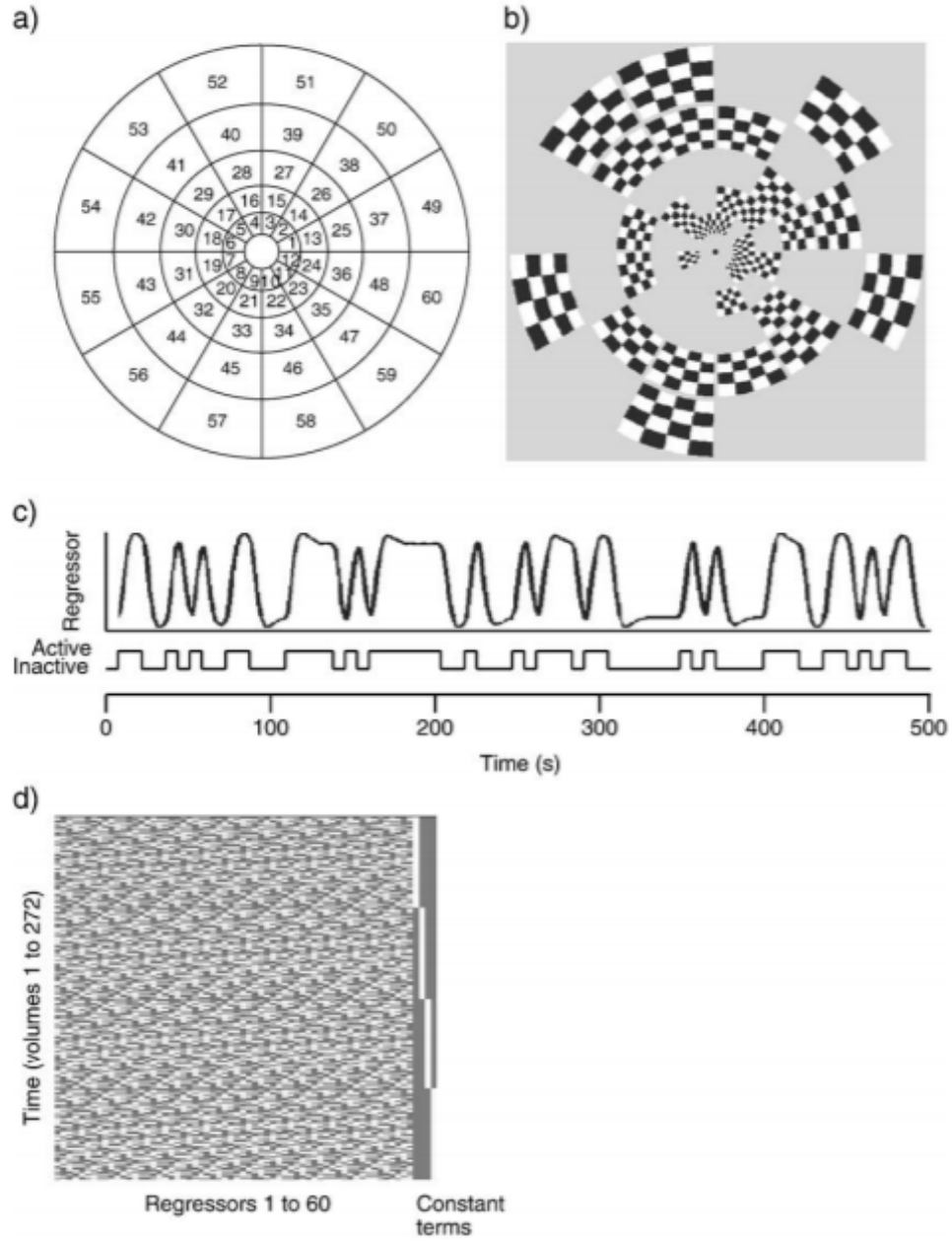


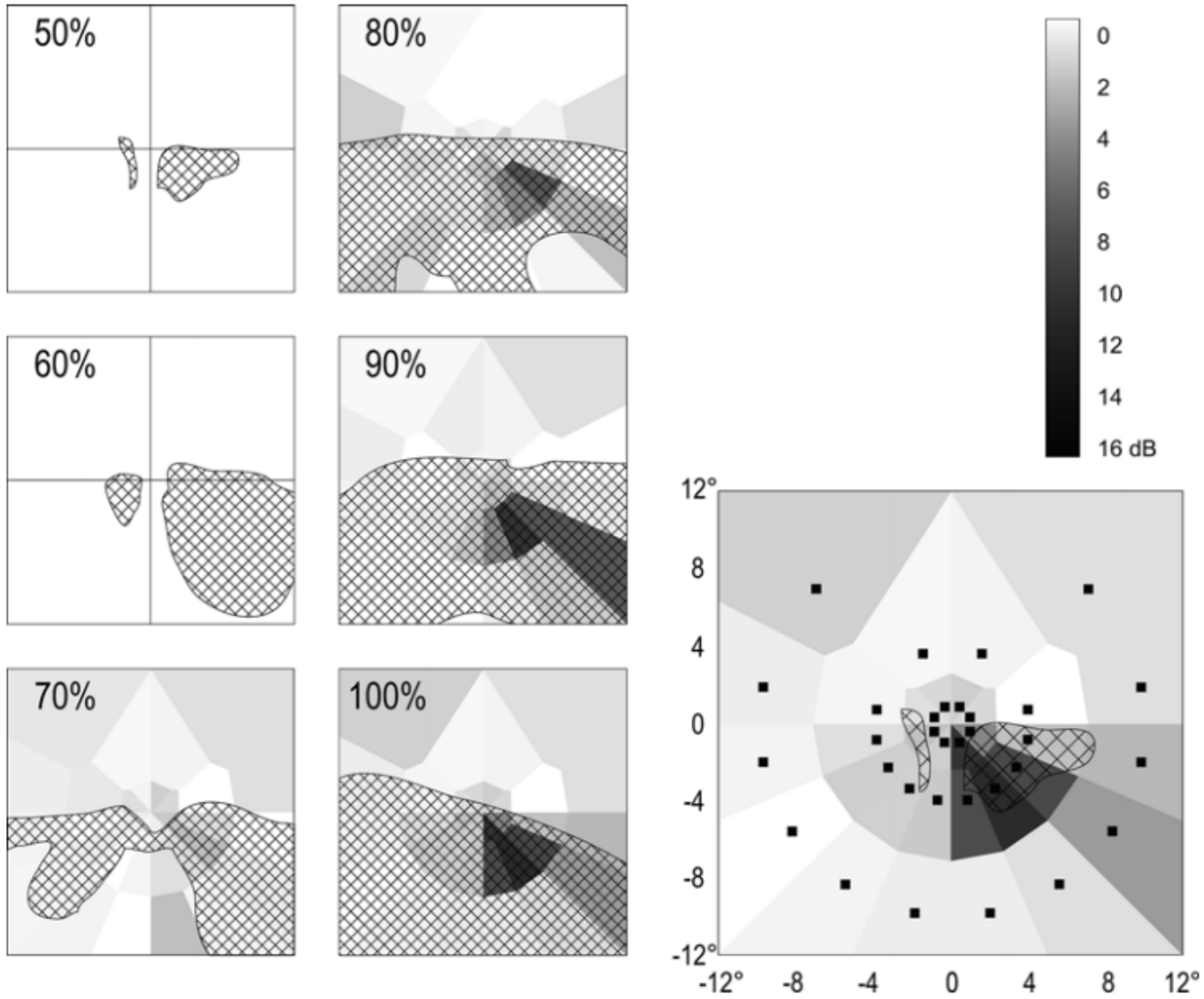
Fig. 1. Multifocal stimulation. (a) The region numbers indicate the positions in the visual field corresponding to column indices in the design matrix. Each visual field region was stimulated with the same but shifted temporal pattern. (b) The first frame in the sequence, reversing contrast at 8.3 Hz for the first 7.3 s. (c) Model regressor convolved with hemodynamic response function, and corresponding contrast reversing intervals as a function of time for region 1. (d) The design matrix, including the regressors for the mean values on the right.

Success rate (phosphenes)

- **Almost 0%**: Amassian et al. 1989; Corthout et al. 2000; Kamitani and Shimojo 1999
- **13%** (Beckers and Hömberg 1991)
- **27%** (Aurora et al. 1998)
- **58%** (Bohotin et al. 2002)
- **67%** (Meyer et al. 1991)
- **79%** (Marg and Rudiak 1994)
- **80%** (Sparing et al. 2002)
- **82%** (Kastner et al. 1998)
- **89%** (Afra et al. 1998)
- **up to 100%** in smaller samples (Cowey and Walsh 2000; Kammer 1999; Kammer and Nusseck 1998; Stewart et al. 2001).

Phenomenology of phoshenes

- Always white or grey (sometimes, grey phosphenes is called scotoma)
- Very short in time
- Different in size and form
- Higher intensity – higher size
- Almost always localized in the bottom part (due to anatomical properties of visual cortex)
- Phosphene threshold (PT) is higher than motor threshold but not much (Boroojerdi et al., 2002: 56.7% over 50.8%)


50%
80%
60%
90%
70%
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14
16 dB
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0
-4
-8
-12°
-12°
-8
-4
0
4
8
12°

Phosphene threshold (PT)

- 1 Hz rTMS can decrease PT (Boroojerdi et al. 2000)
- tACS can decrease PT - beta in light condition, alpha in dark (Kanai et al. 2008)
- Visual imagery can decrease PT (Sparing et al. 2002)