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Optimized preoperative motor cortex mapping in brain tumors using advanced processing of transcranial magnetic stimulation data



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Steven De Vleeschouwer<sup>c</sup>, Wim Van Paesschen<sup>a,d</sup>

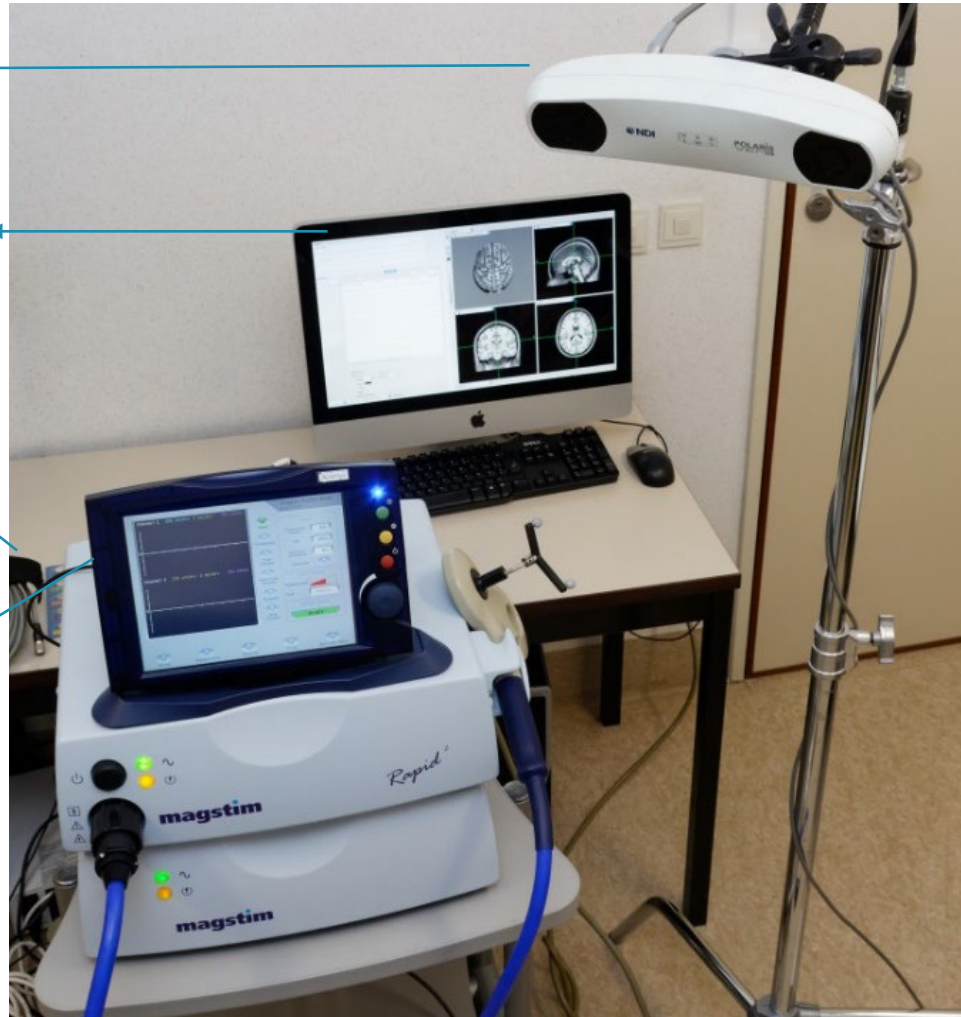
# Transcranial magnetic stimulation (TMS)

Infrared camera

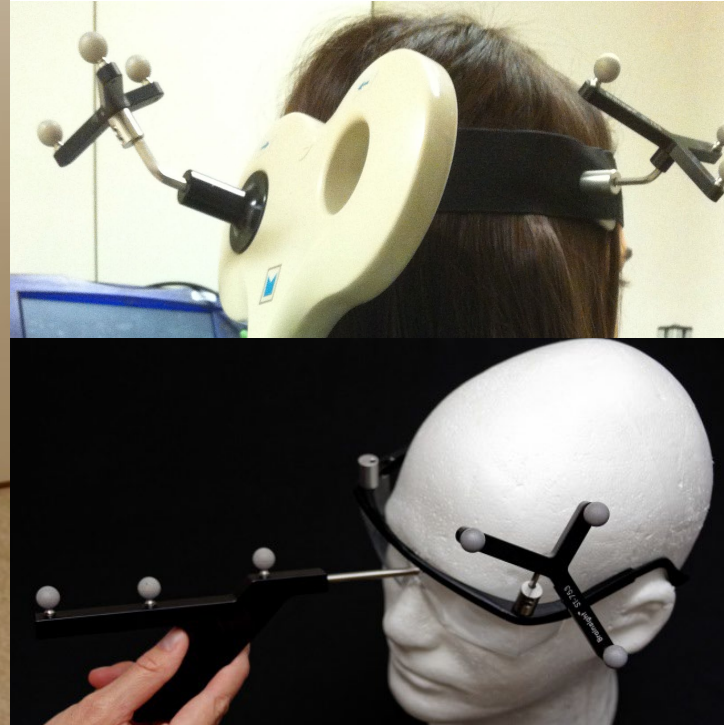
Navigation software

EMG (motor activity)

TMS-machine current generation, intensity, frequency...



Size of the head relative to size of the coil

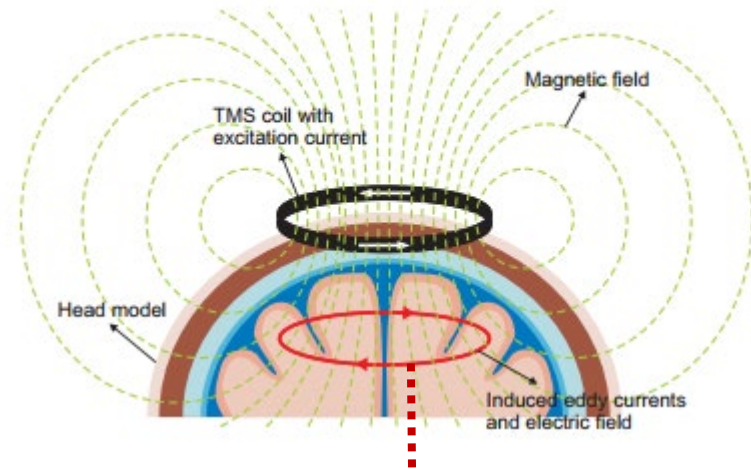


Referencing the head to the anatomical scan of the subject

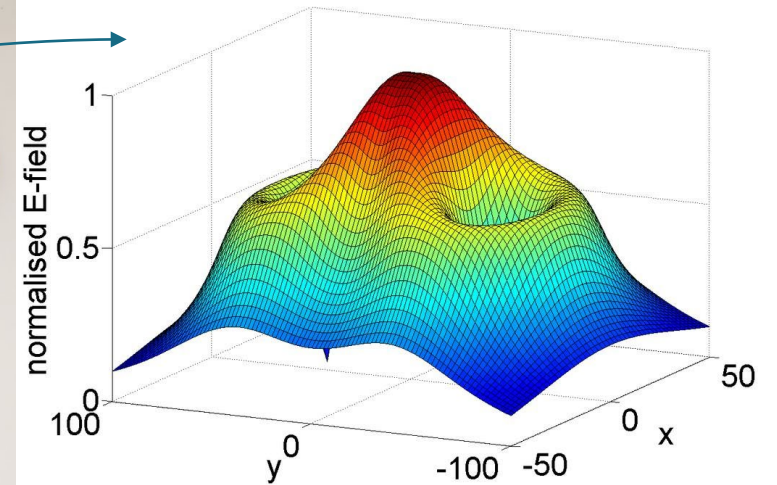
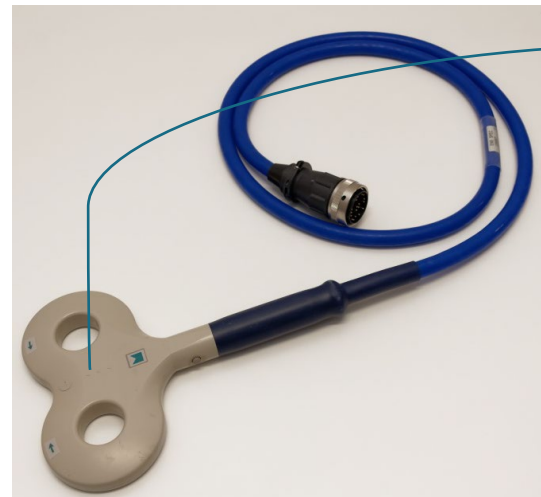
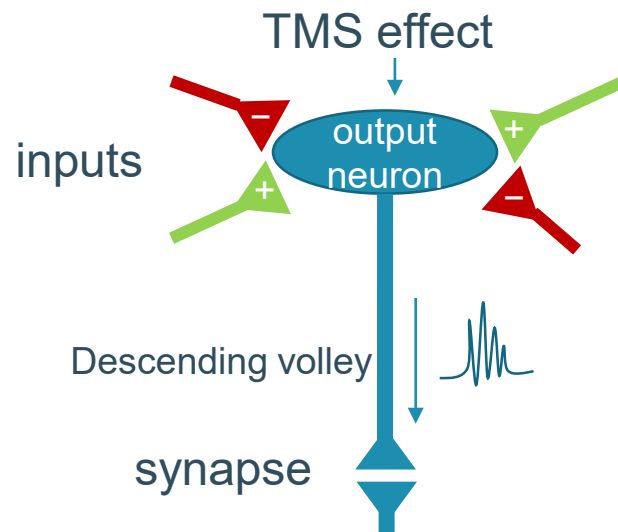


Coil calibrated for navigation

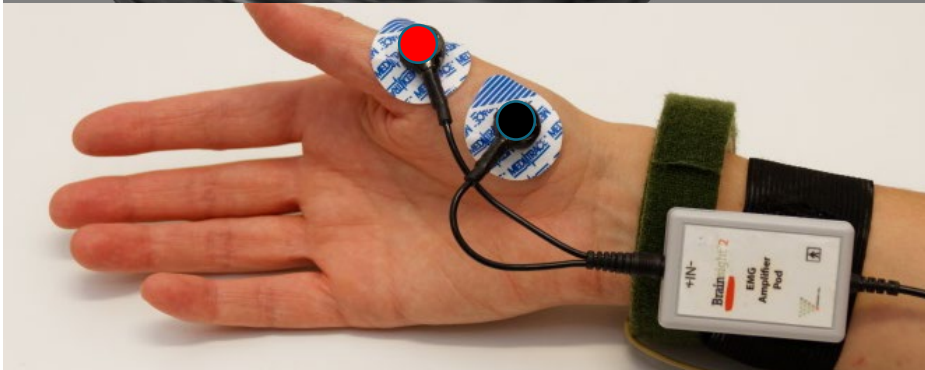
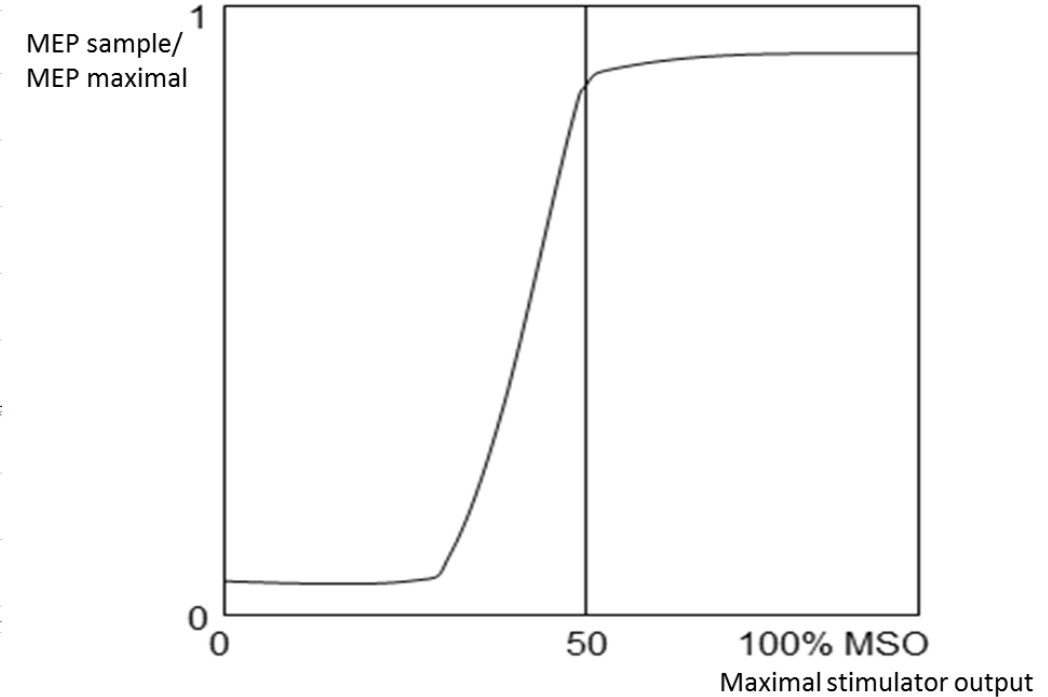
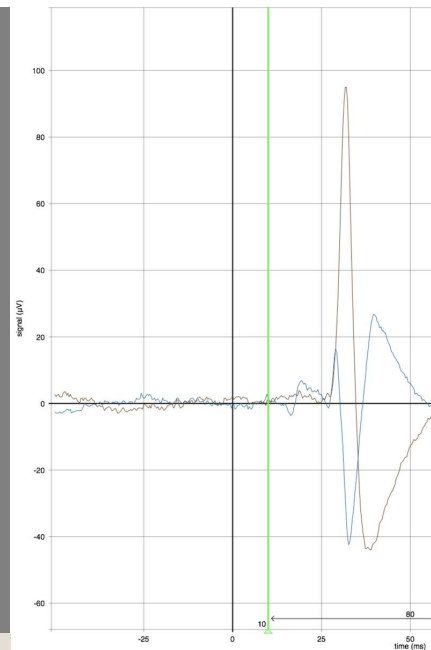
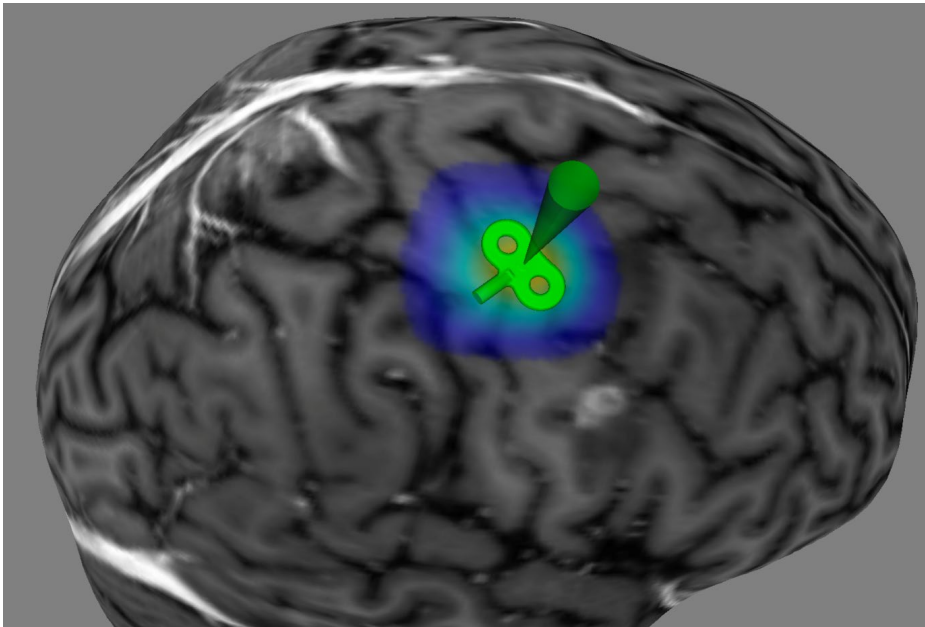
# Transcranial magnetic stimulation (TMS)



Effect of TMS-pulse on the brain:  
Activation of output neuron: action potential  
used in mapping motor cortex



# TMS to map motor function: MEPs

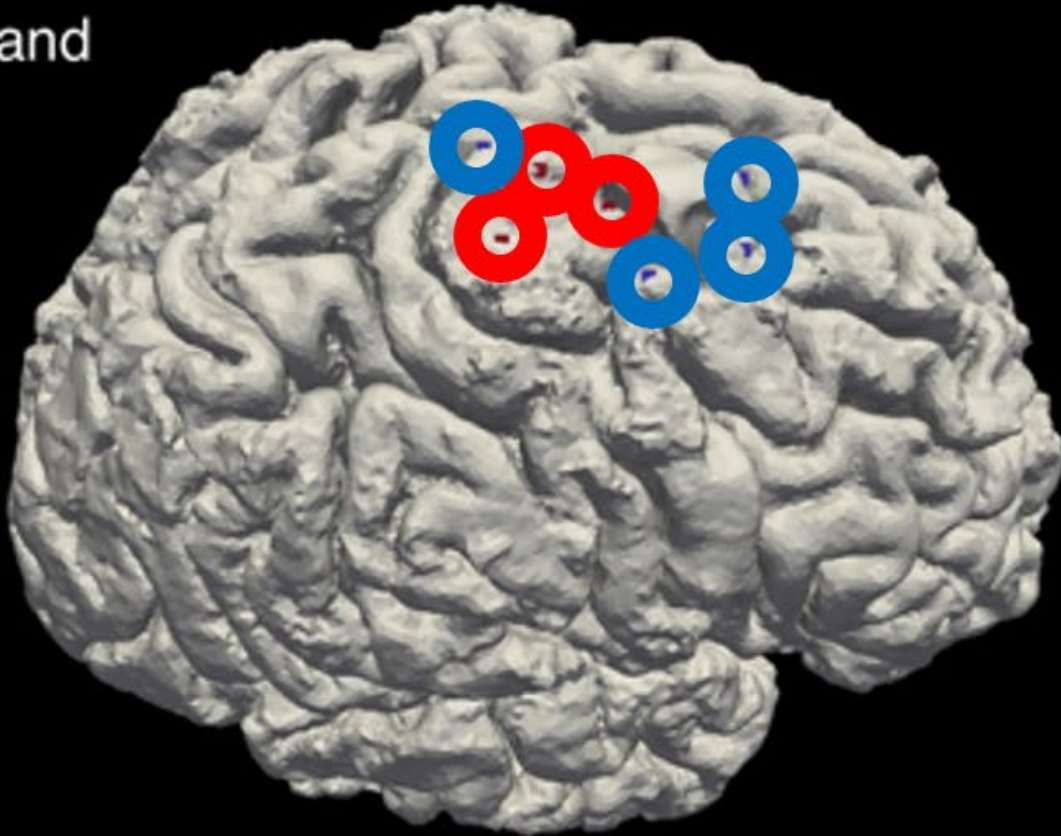


- TMS pulse over motor cortex → measurable muscle contraction = motor evoked potential (MEP)
- Amplitude of response:  
intensity of TMS-pulse (input-output curve) + location
- Intensity of TMS-pulse set as % of motor threshold (%MT)

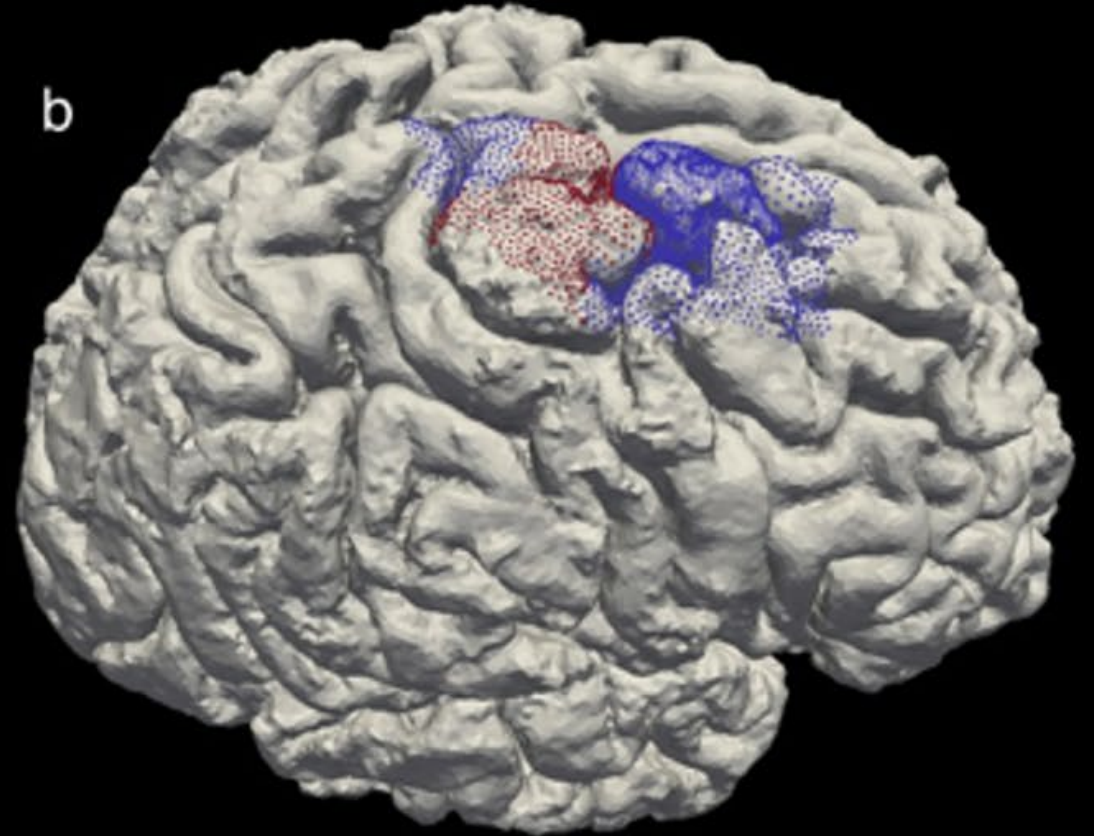
# Mapping eloquent cortex for neurosurgery

Gold standard: direct electrical cortical stimulation (DCS)

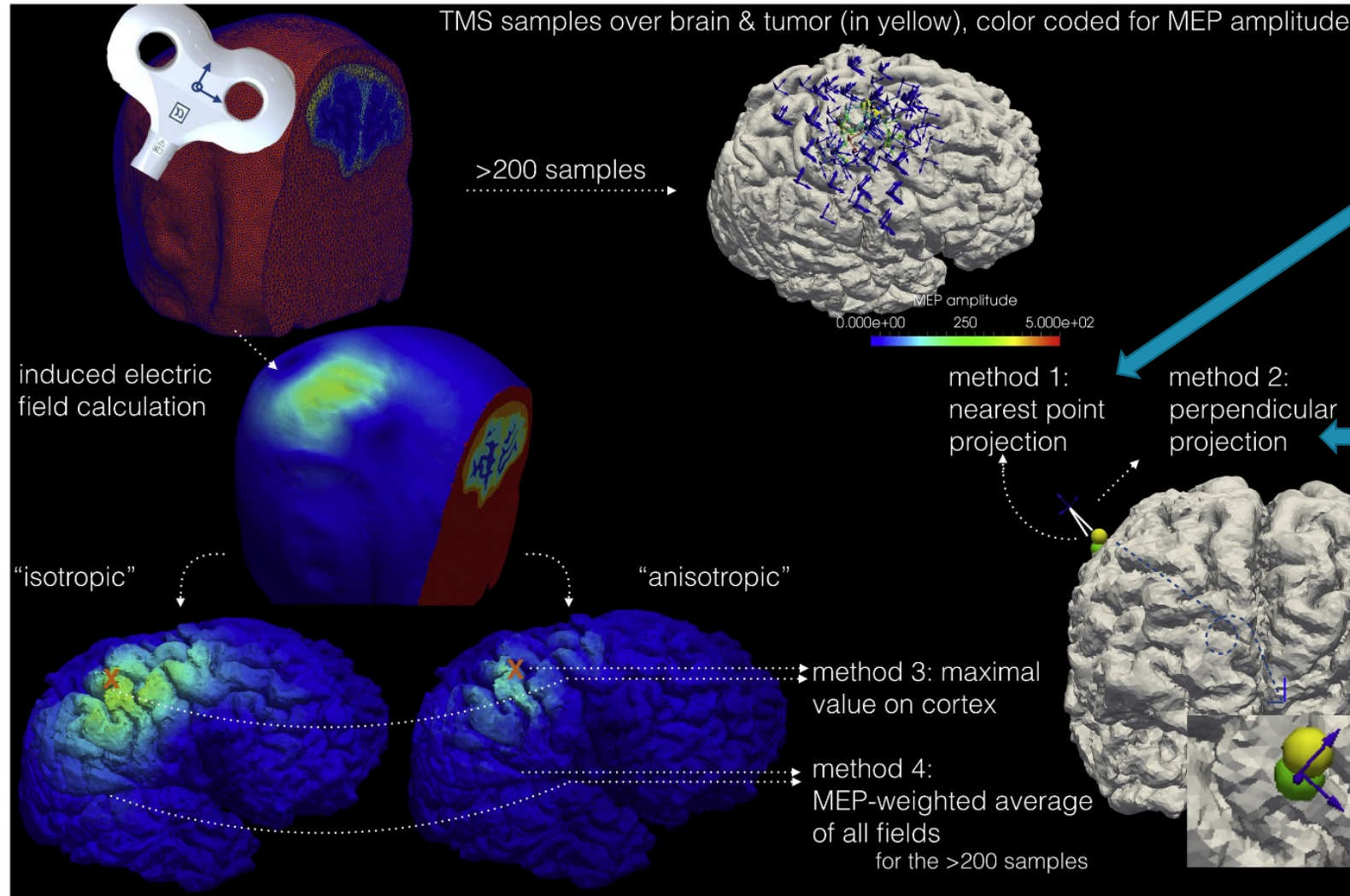
hand  
a



b



# TMS to map motor function: analysing the data



Point based methods

METHOD 1  
Nearest point projection ●

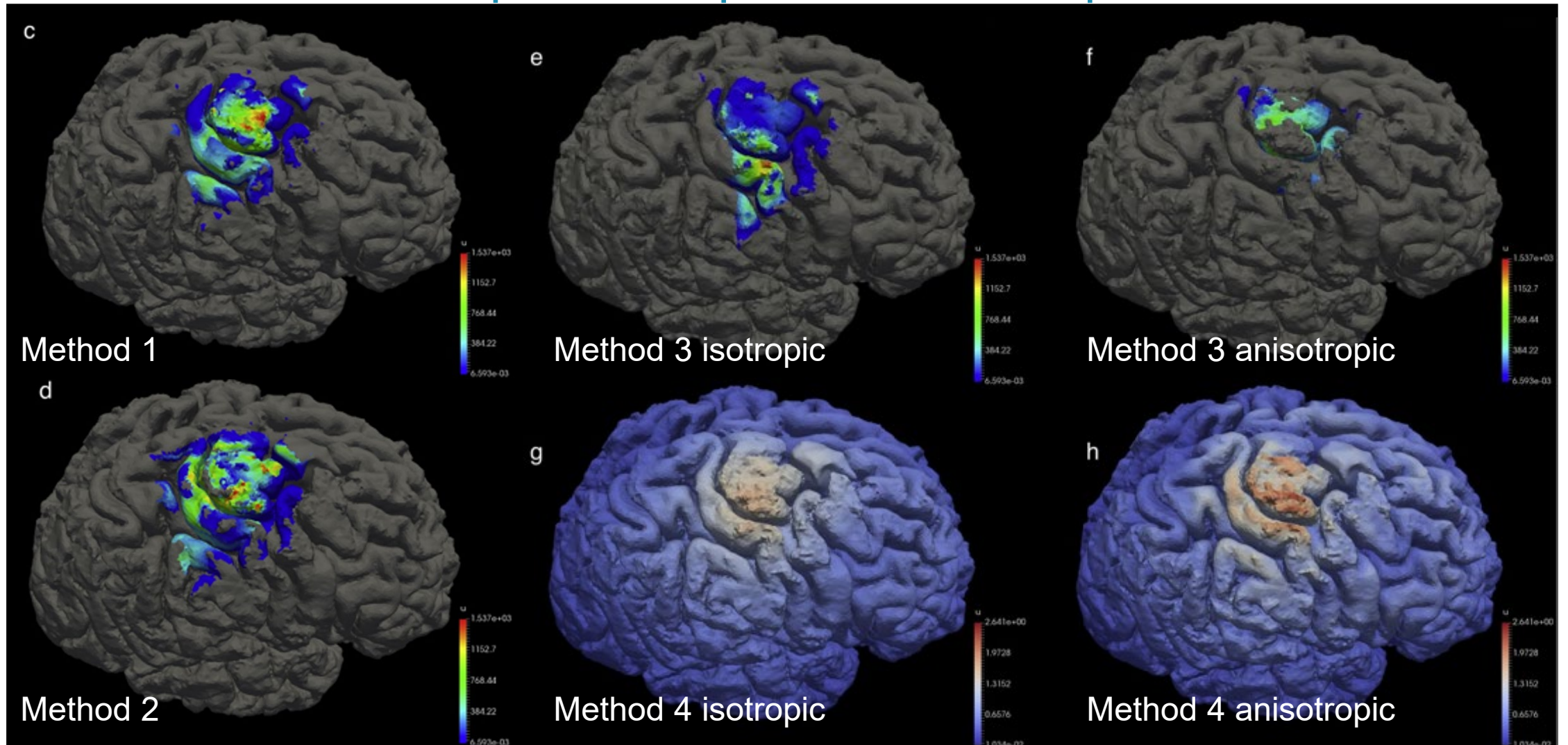
METHOD 2  
Perpendicular projection ●

Induced electric field based models

METHOD 3  
✗ Point of maximal intensity on cortex

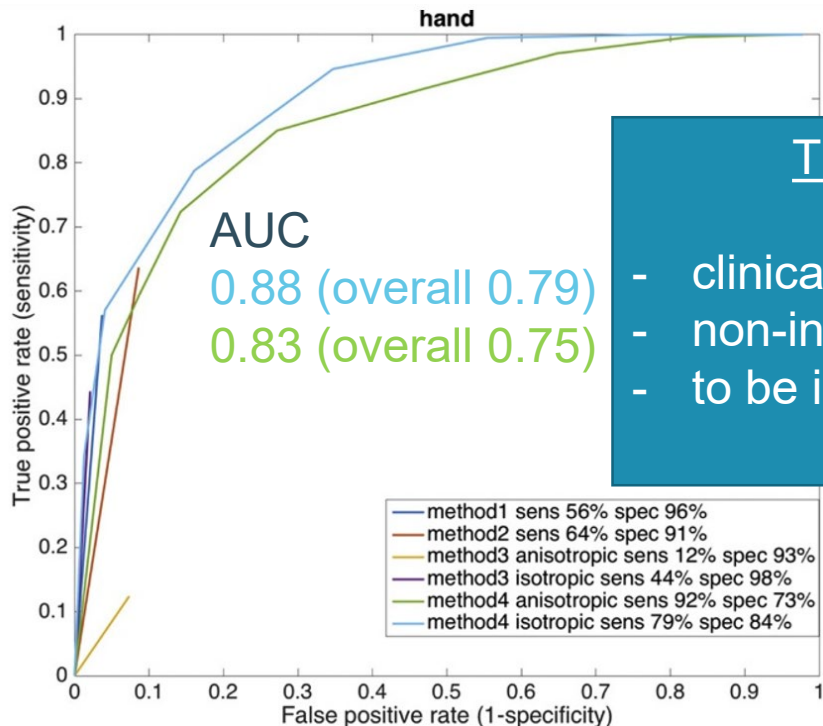
METHOD 4  
MEP-weighted average of fields (whole brain)

# Study on using TMS to map motor function: all maps of one patient as example



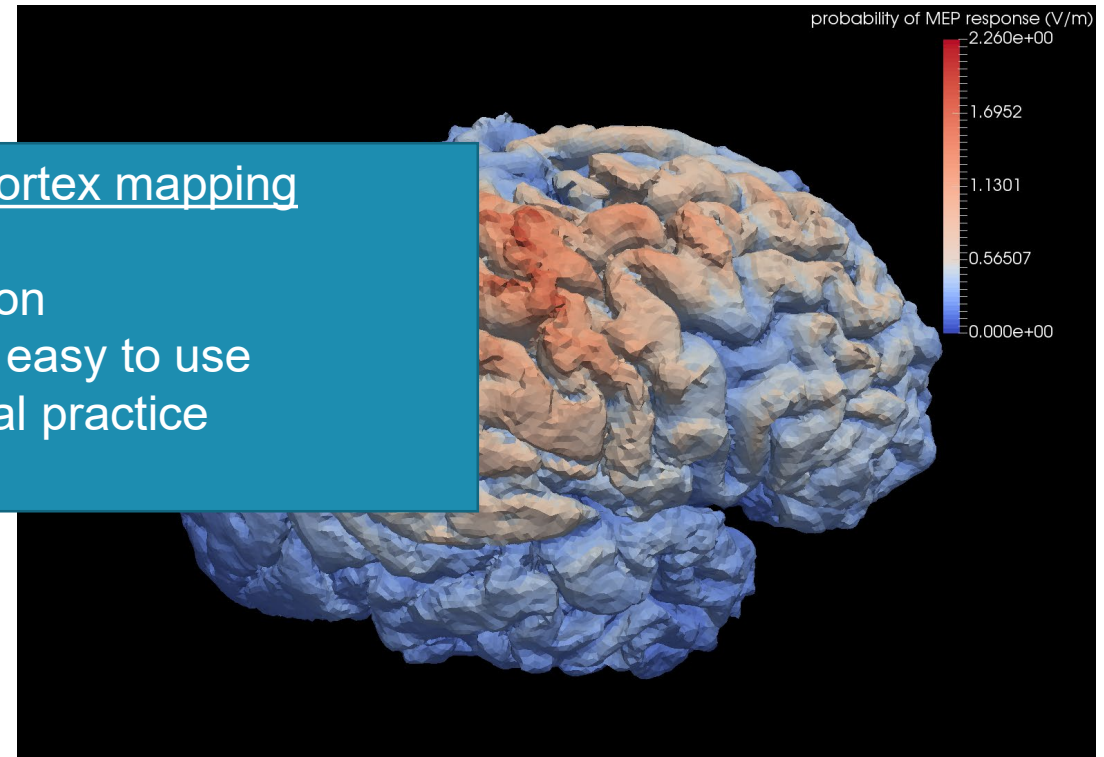
# Study on using TMS to map motor function: results

|      | method 1 |      | method 2 |      | method 3 isotropic |      | method 3 anisotropic |      | method 4 isotropic |      | method 4 anisotropic |      |
|------|----------|------|----------|------|--------------------|------|----------------------|------|--------------------|------|----------------------|------|
|      | sens     | spec | sens     | spec | sens               | spec | sens                 | spec | sens               | spec | sens                 | spec |
| mean | 46,1     | 86,1 | 55,9     | 84,8 | 38,3               | 88,7 | 40,2                 | 85,7 | 83,2               | 66,7 | 76,4                 | 70,6 |
| SD   | 27,9     | 7,3  | 24,7     | 5,1  | 23,9               | 9,4  | 33,5                 | 16,2 | 13,0               | 18,4 | 16,0                 | 15,5 |



## TMS based motor cortex mapping

- clinically useful information
- non-invasive, (relatively) easy to use
- to be introduced in clinical practice





# It would not have been possible without...

- Institute of Innovation by Science and Technology Flanders:  
project number 090850
- Belgian brain tumor support second price 2016



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Department of radiology

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