

# Physiological effects of noninvasive brain stimulation: Implications for non-therapeutic use

Michael D. Fox, MD, PhD

Director, Laboratory for Brain Network Imaging and Modulation  
Associate Director, Berenson-Allen Center for Noninvasive Brain Stimulation  
Assistant Professor of Neurology, Harvard Medical School



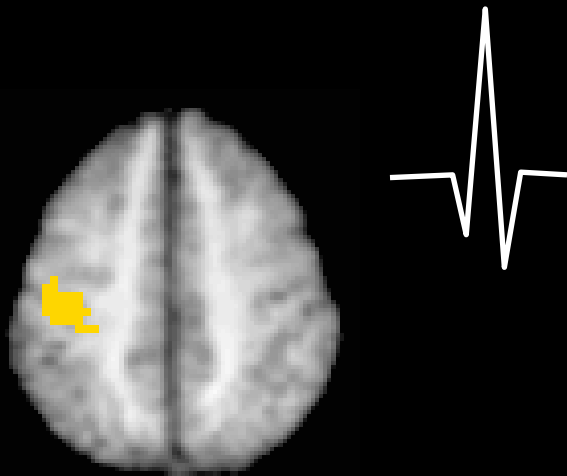
# Outline

- Where is the the effect?
- How long does it last?
- Does it come at a cost?

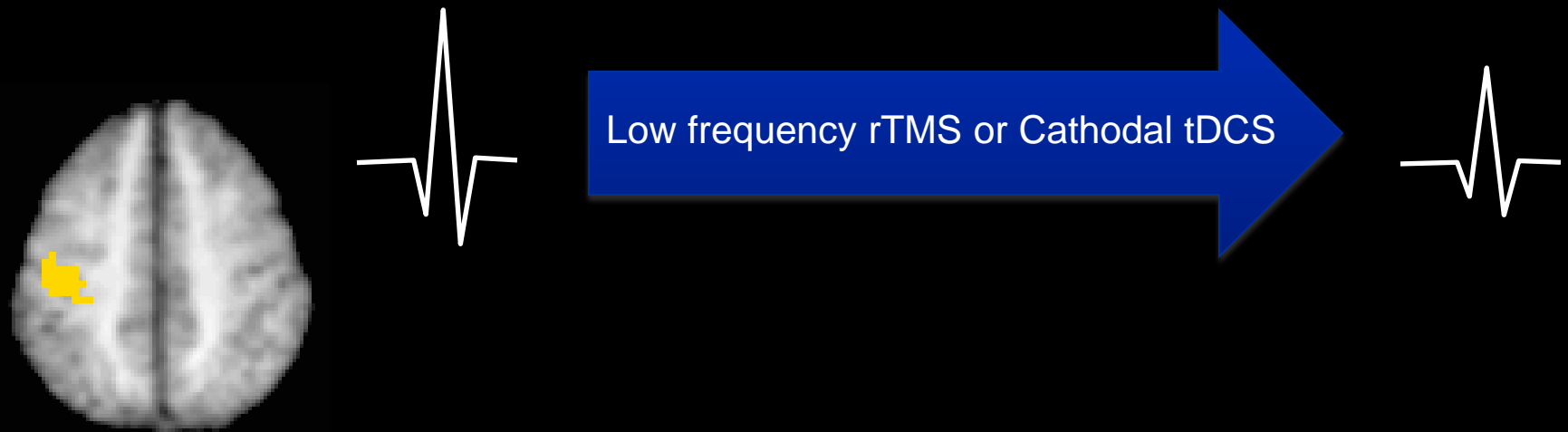
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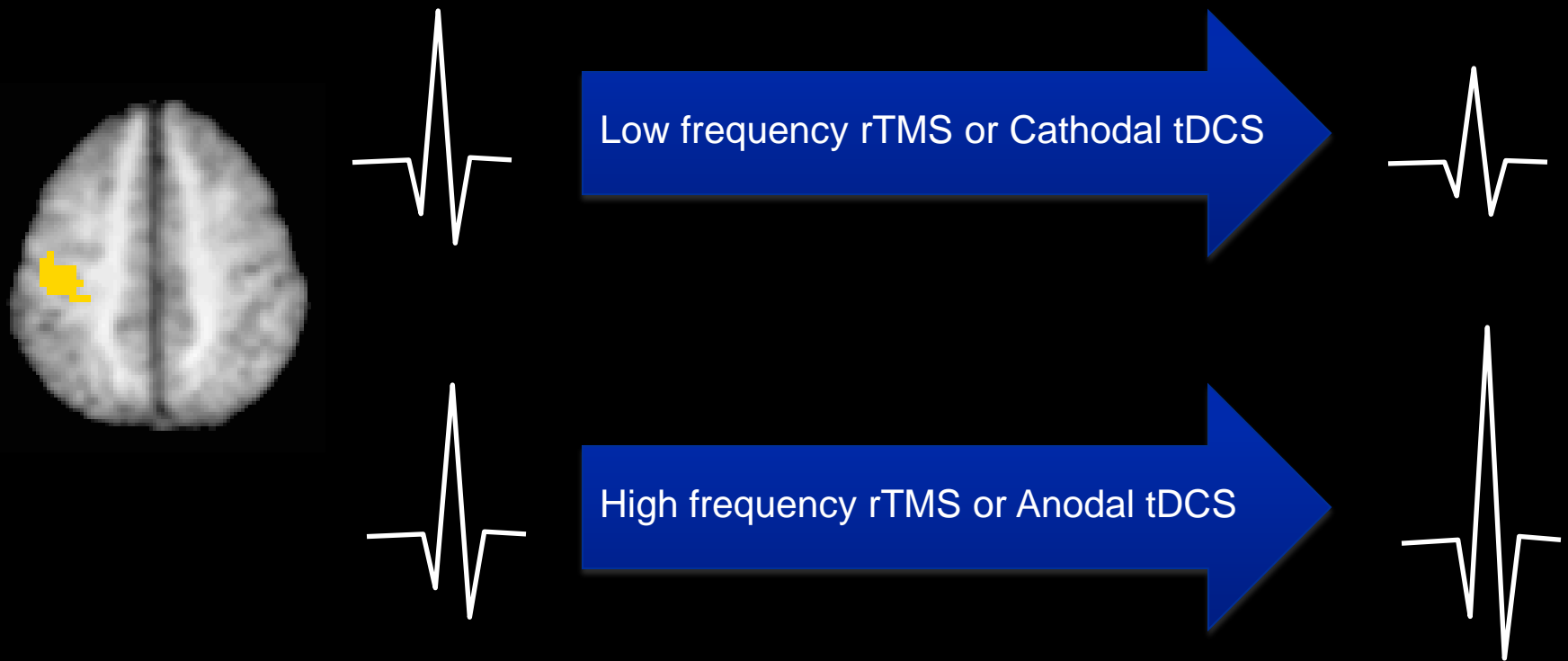
# Effects at the stimulation site



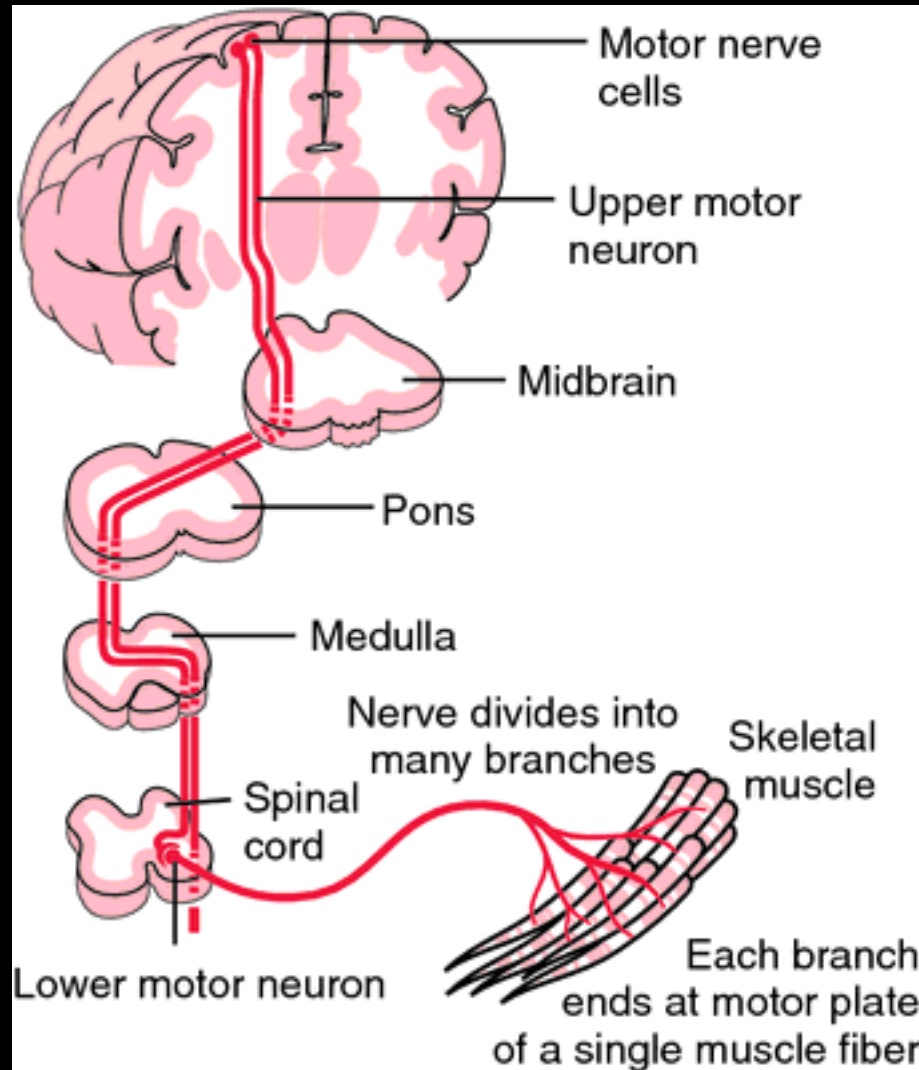
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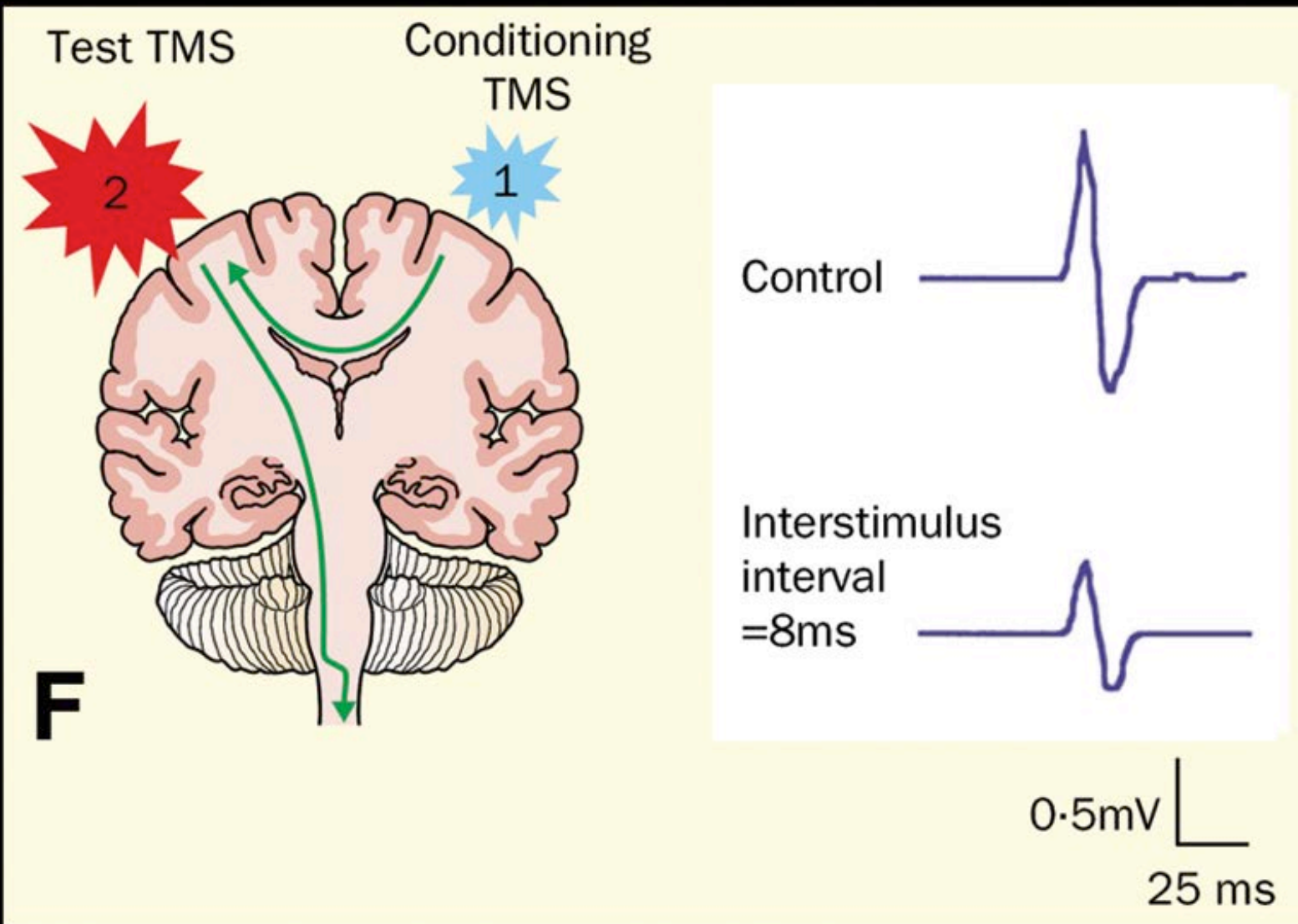
# Effects at the stimulation site



# Trans-synaptic Propagation

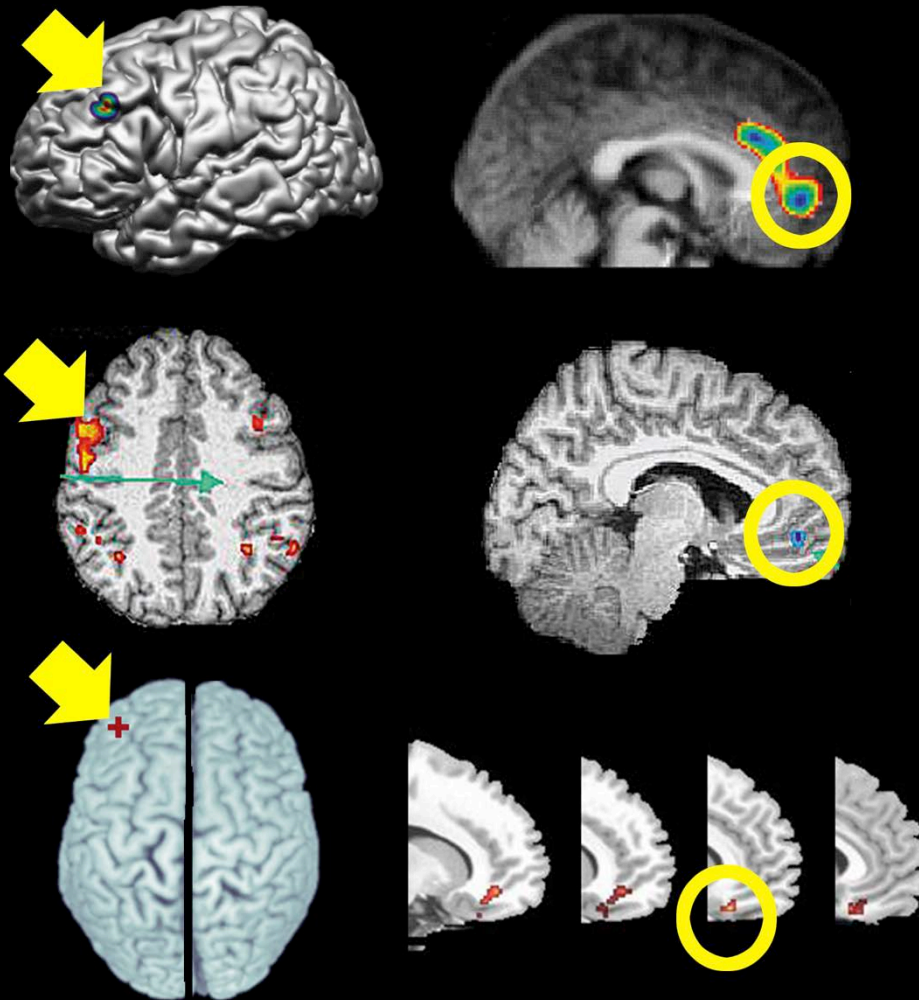


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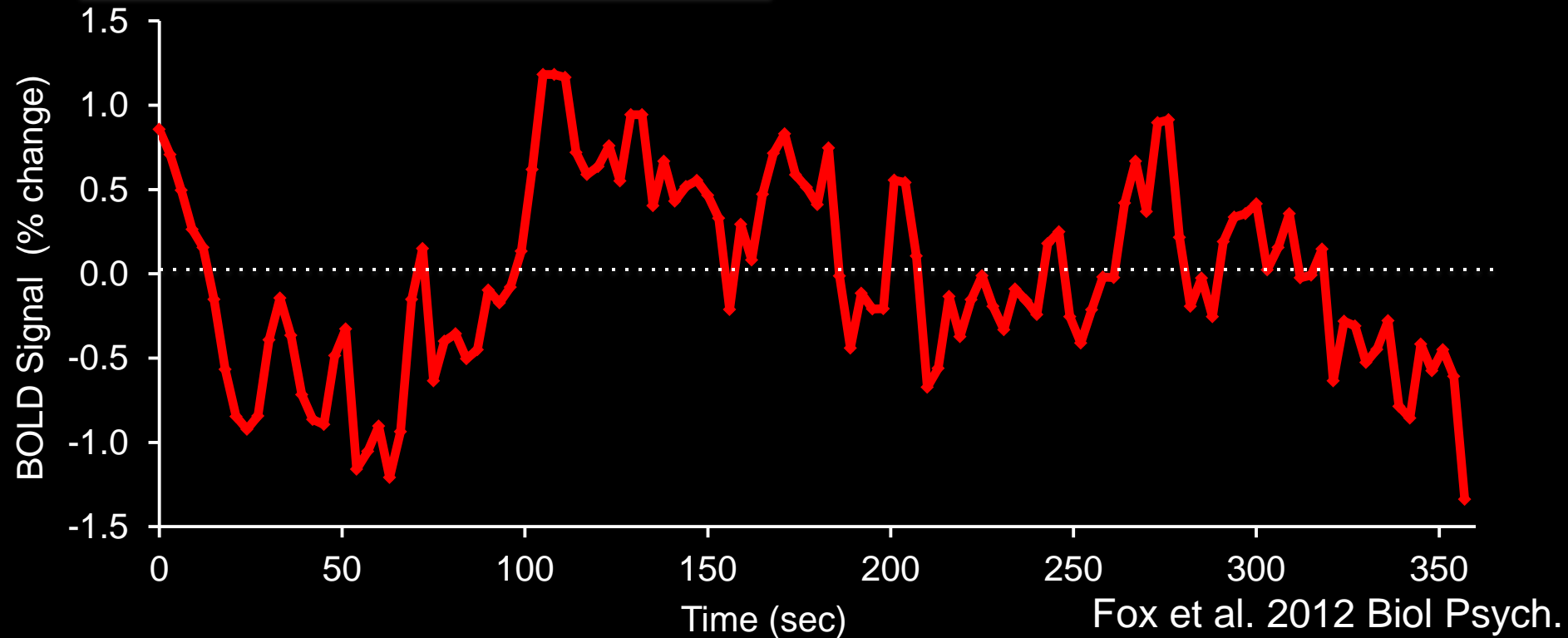
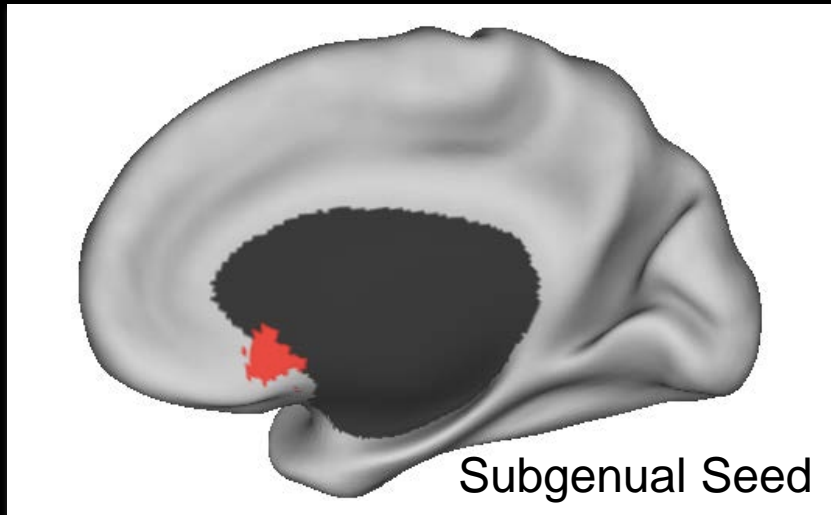




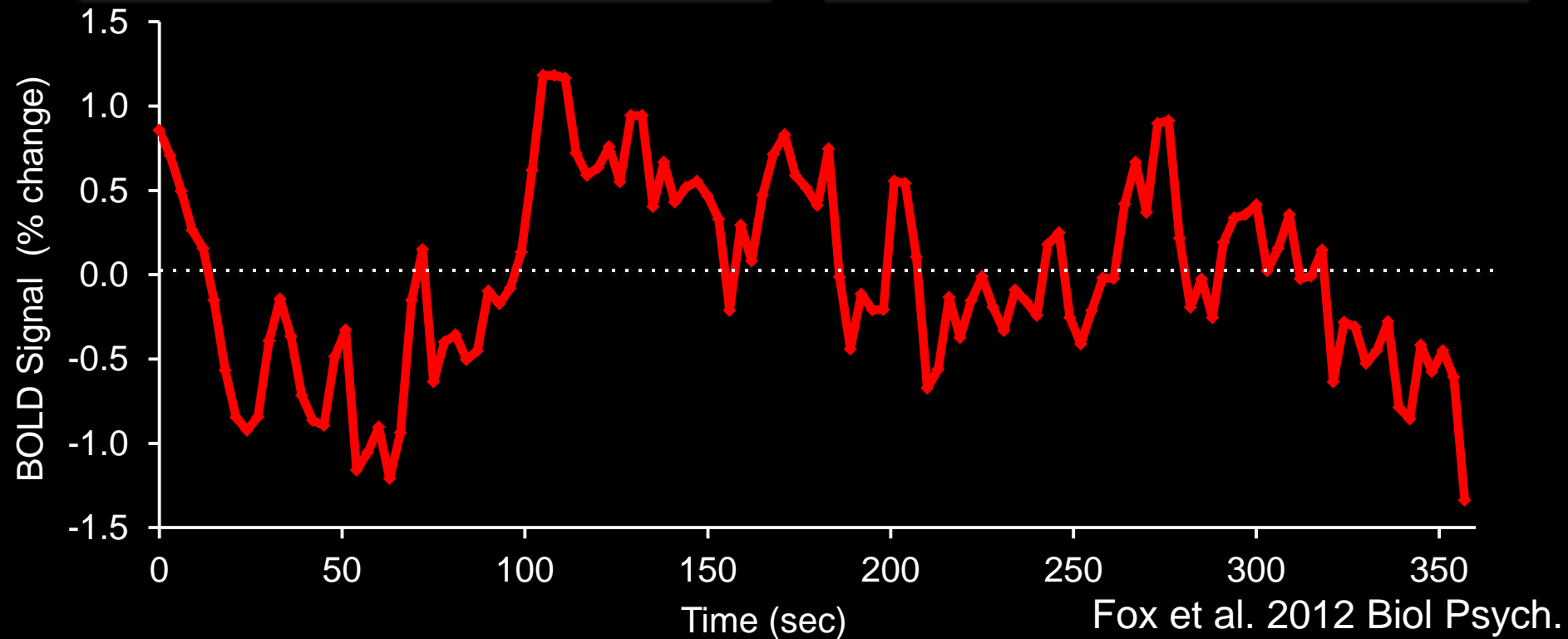
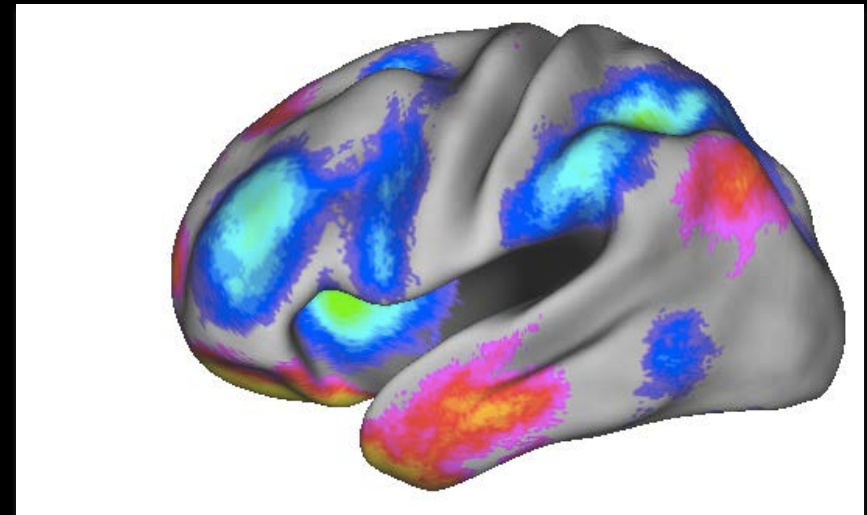
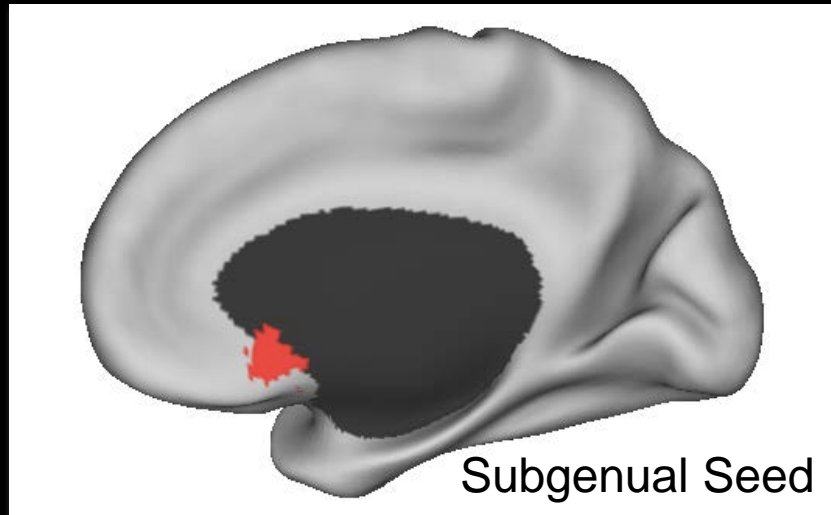
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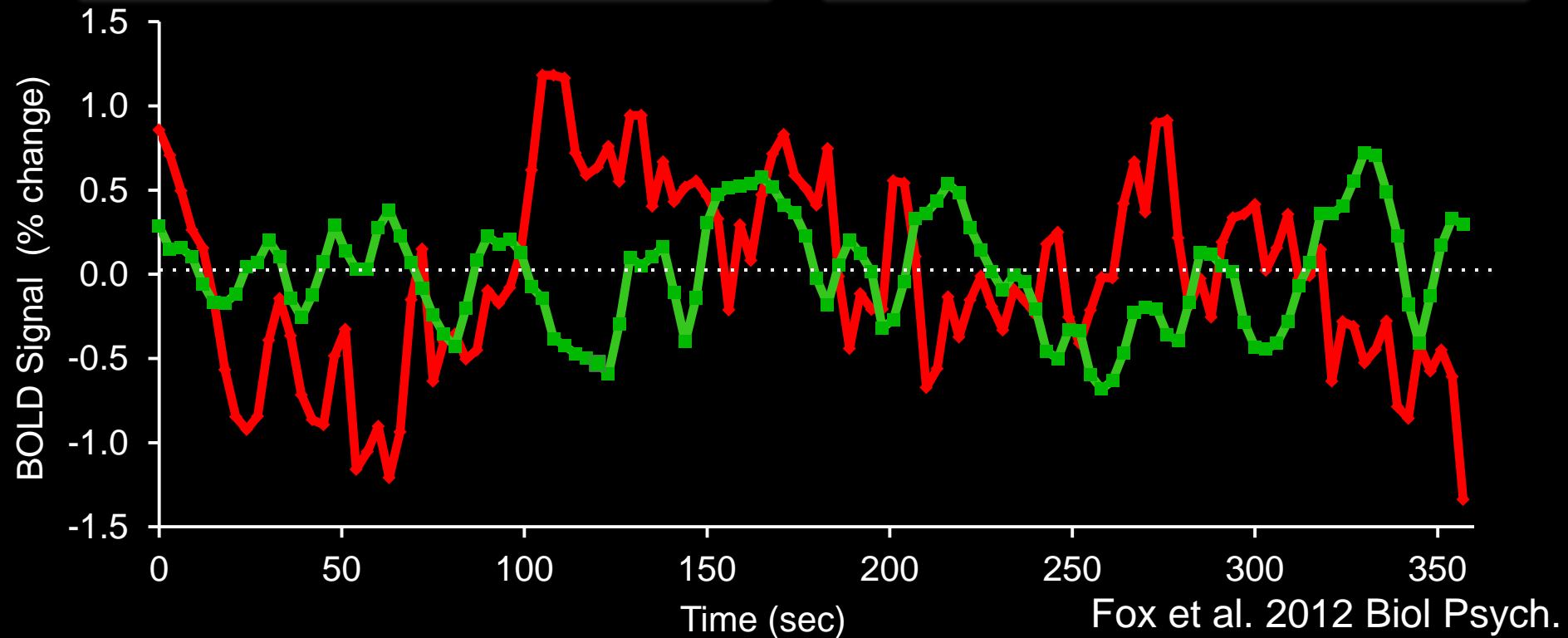
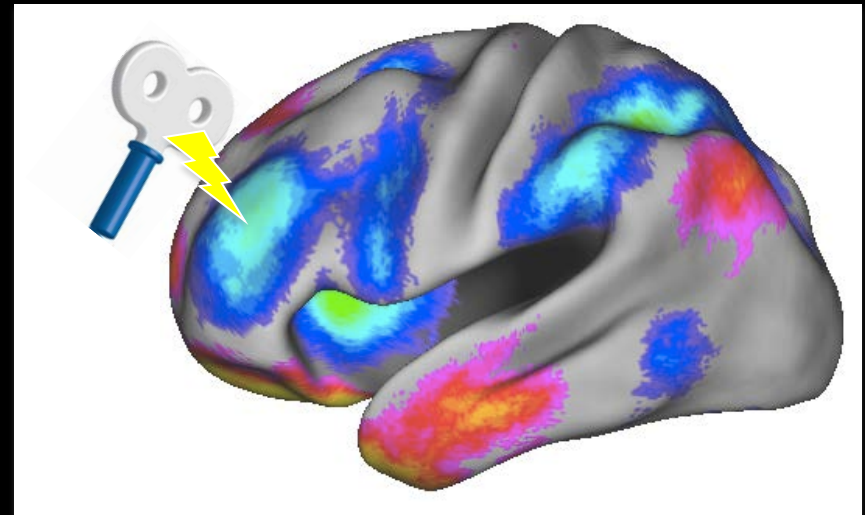
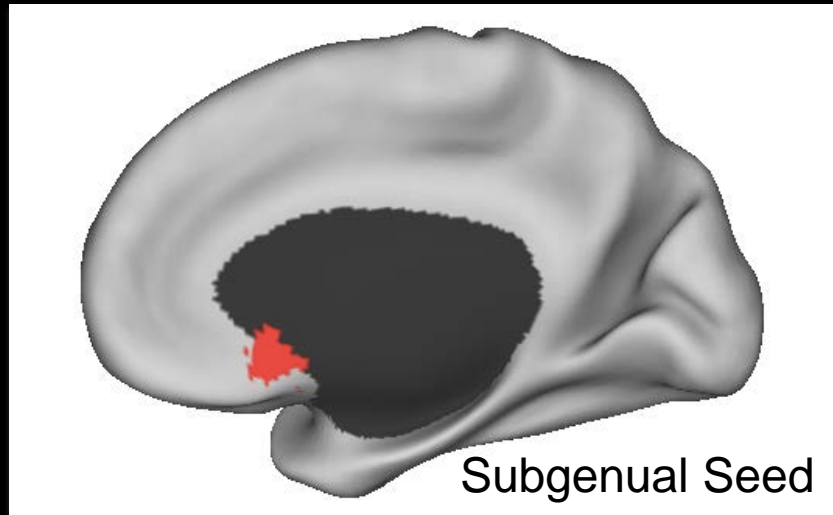
# Benefit of trans-synaptic propagation



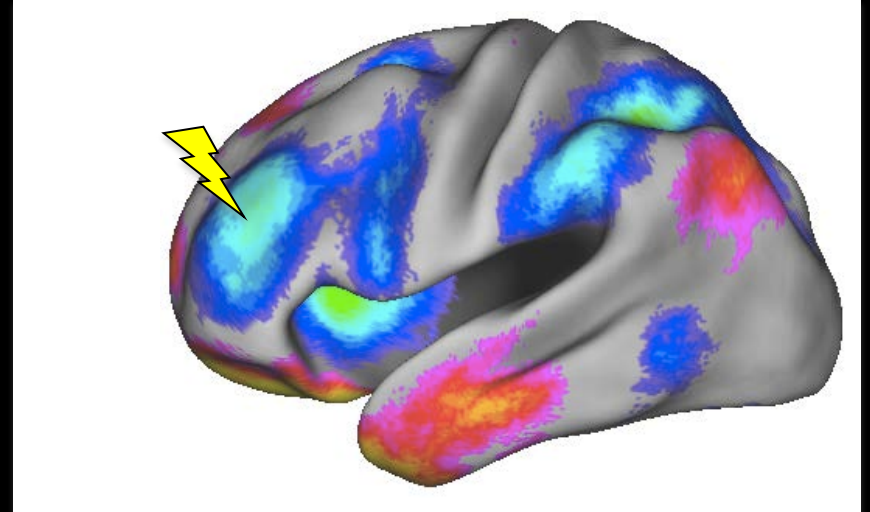
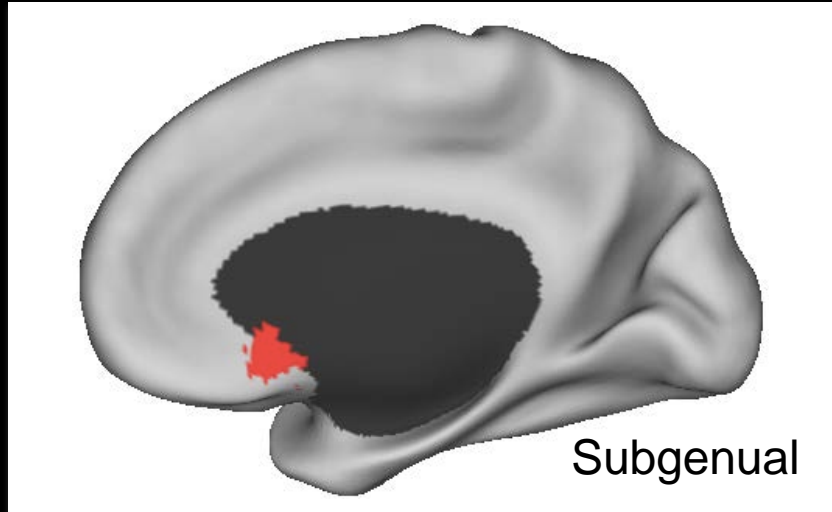
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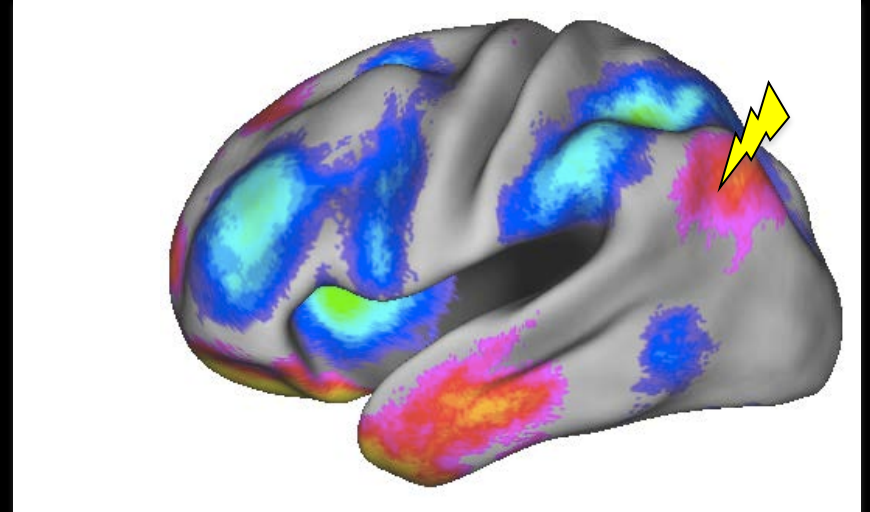
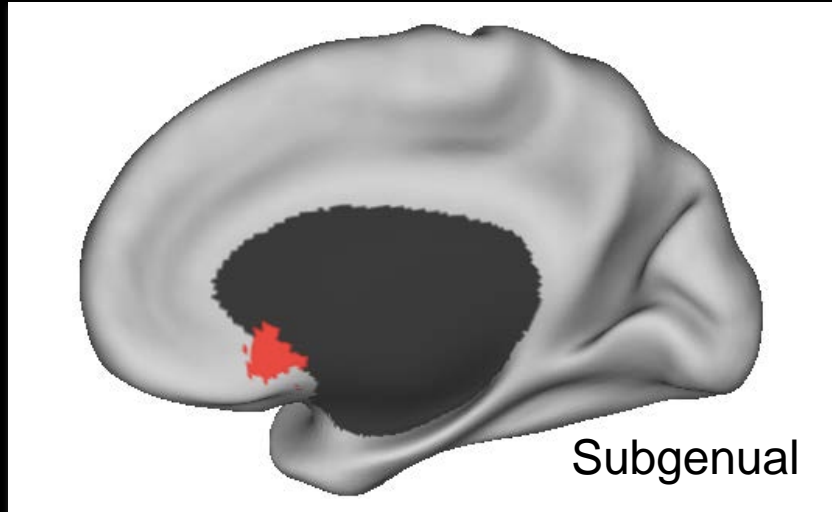
# Benefit of trans-synaptic propagation



# Risk of trans-synaptic propagation



# Risk of trans-synaptic propagation



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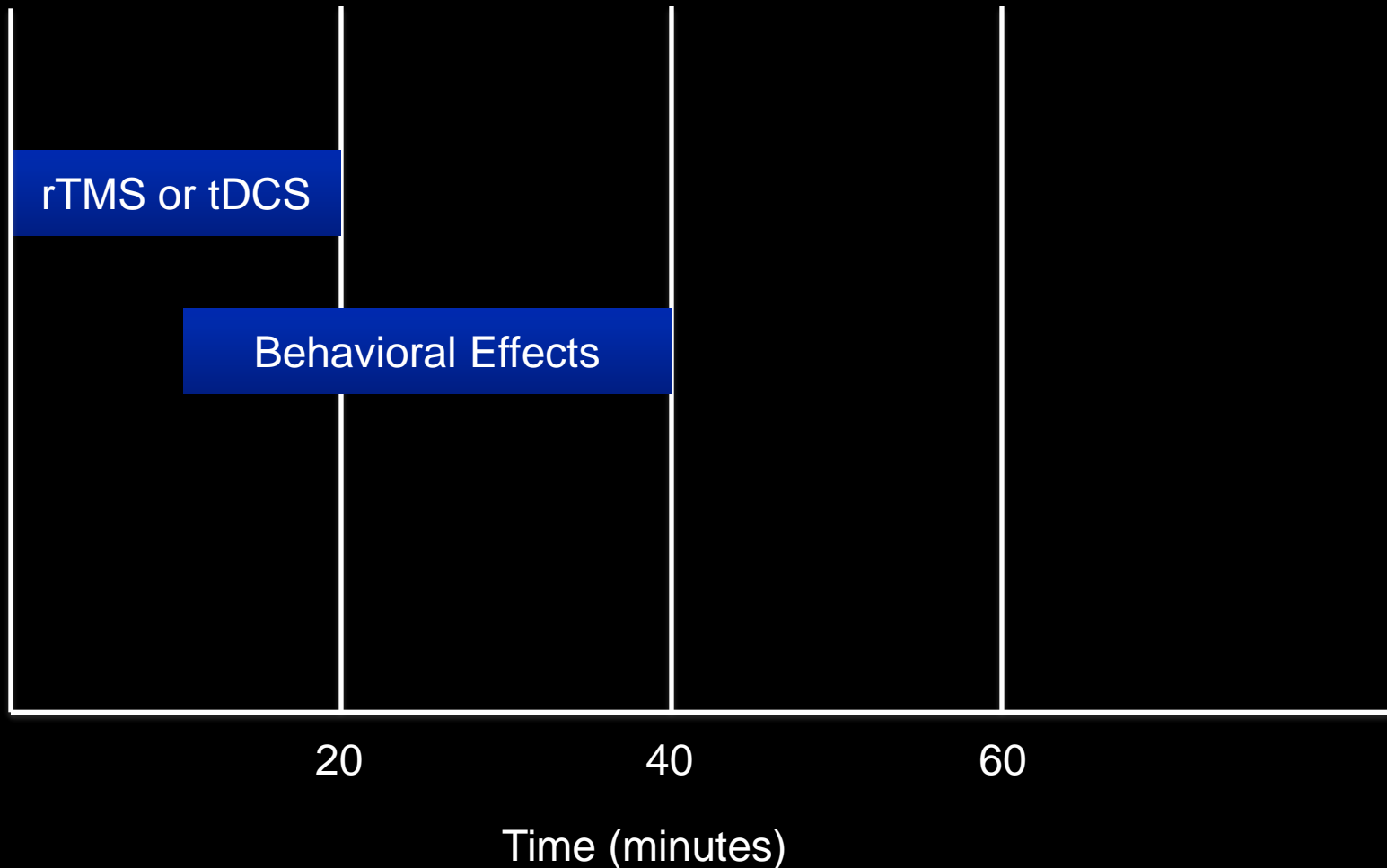
- Where is the the effect?
  - Well beyond the stimulated region
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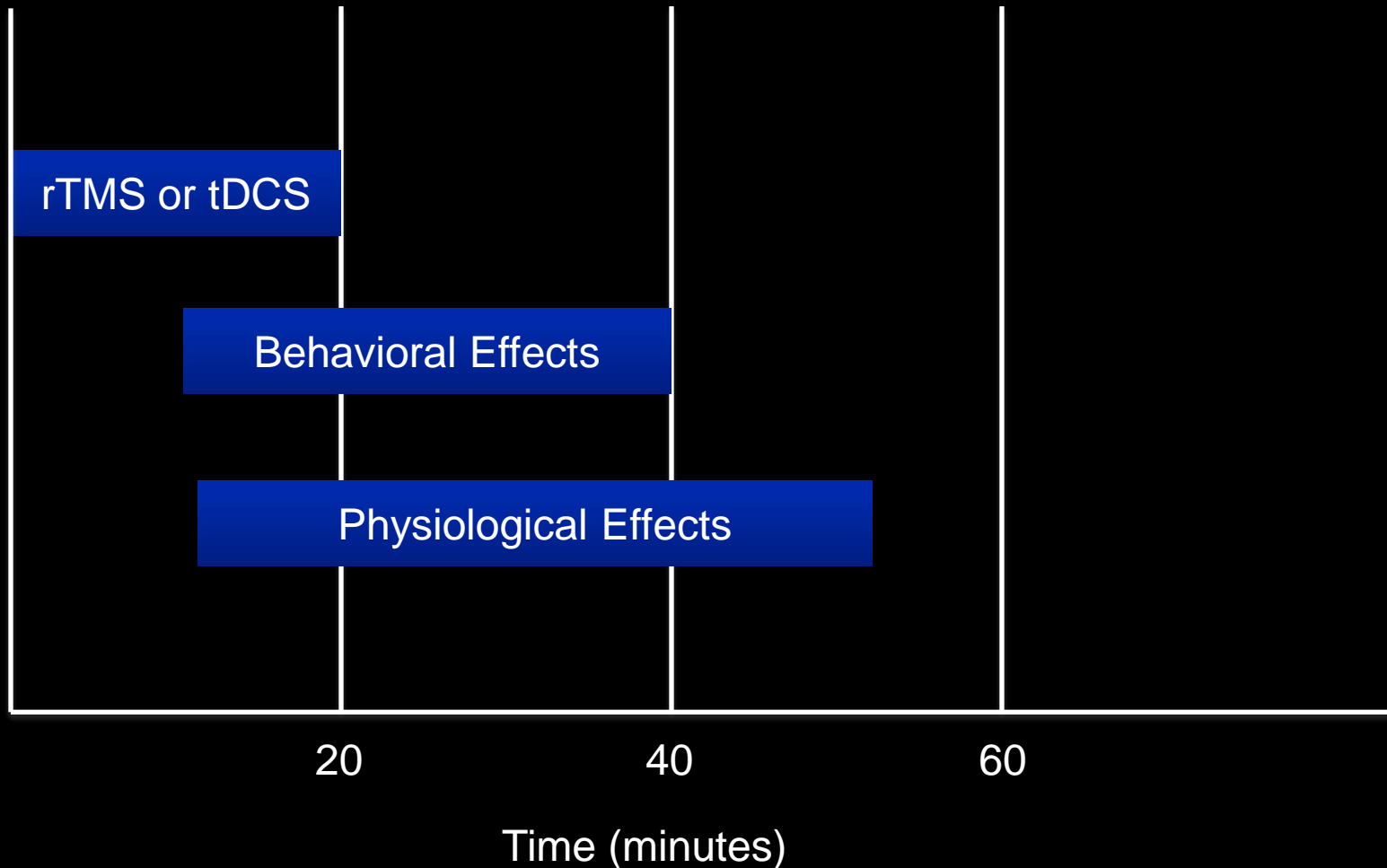
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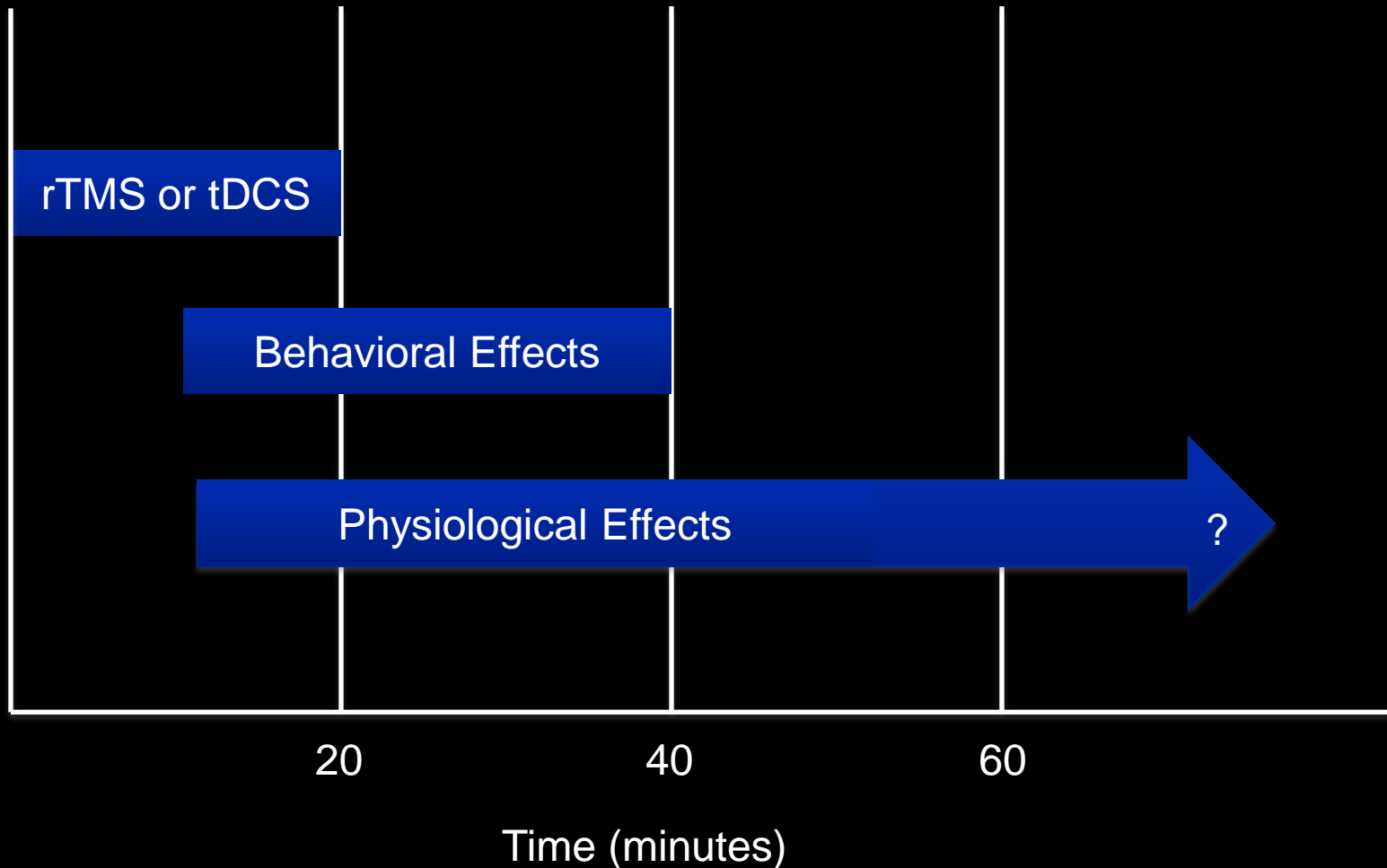
# Single Session of Noninvasive Brain Stimulation



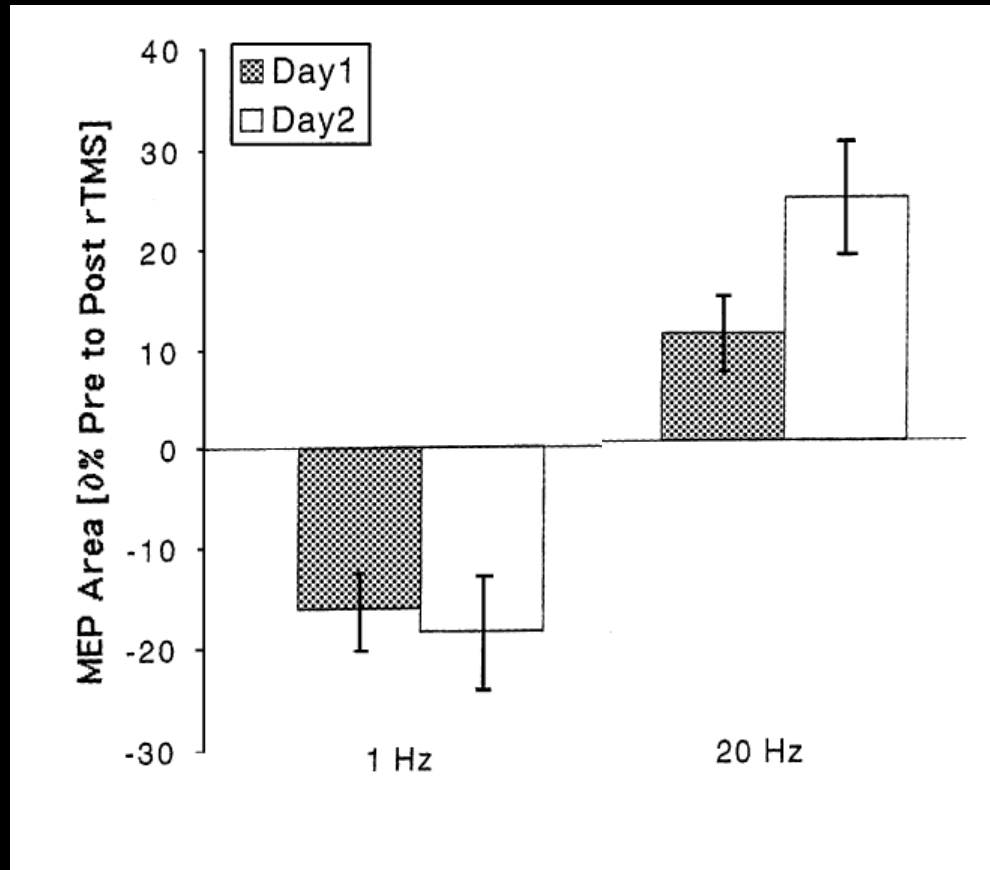
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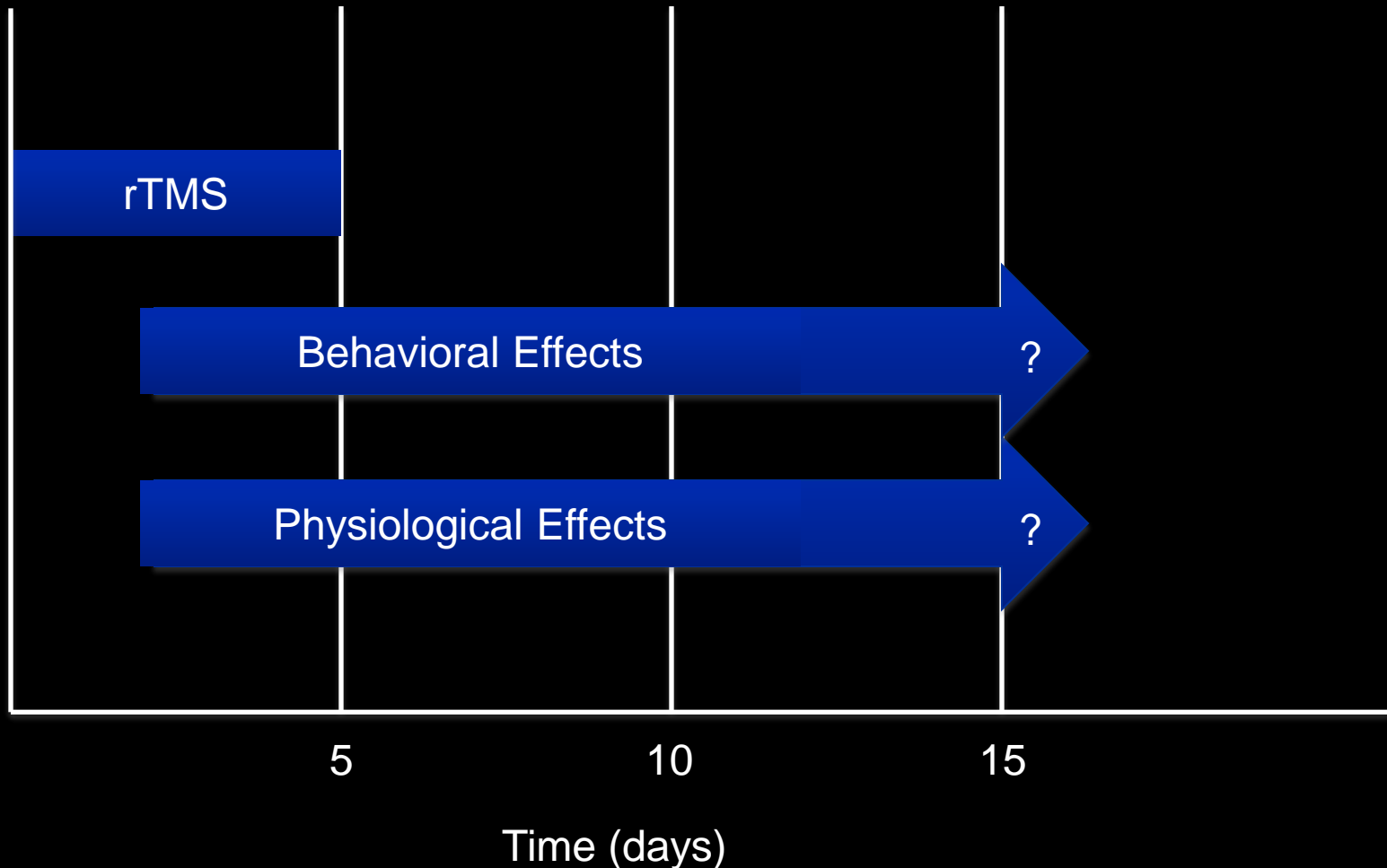
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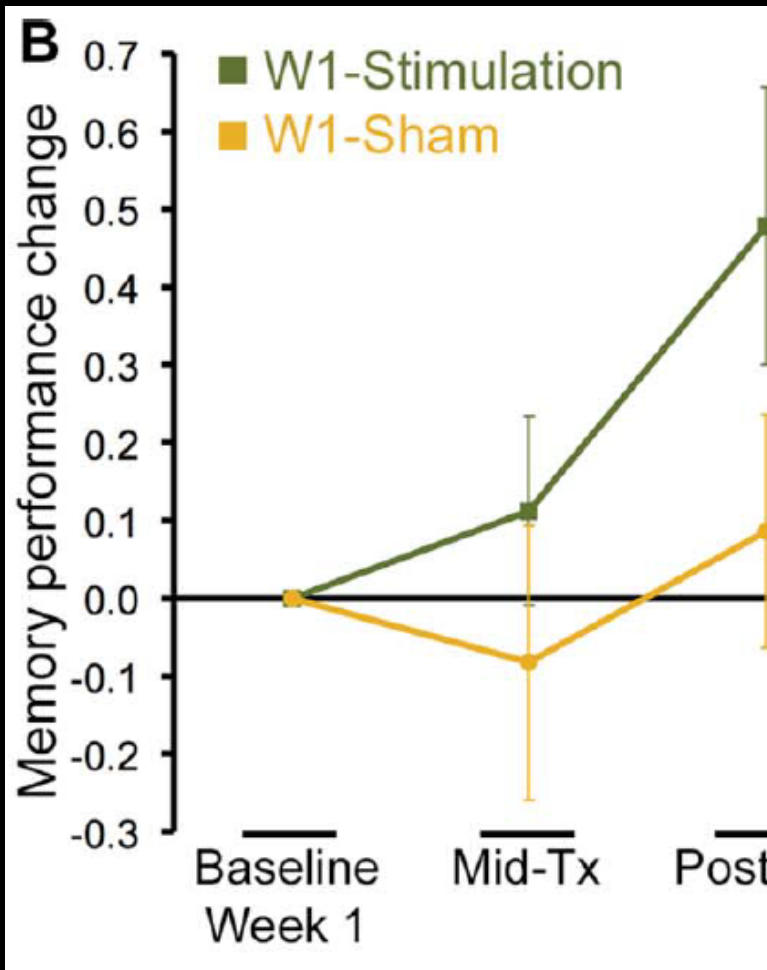
# Persistent effects of a single session?



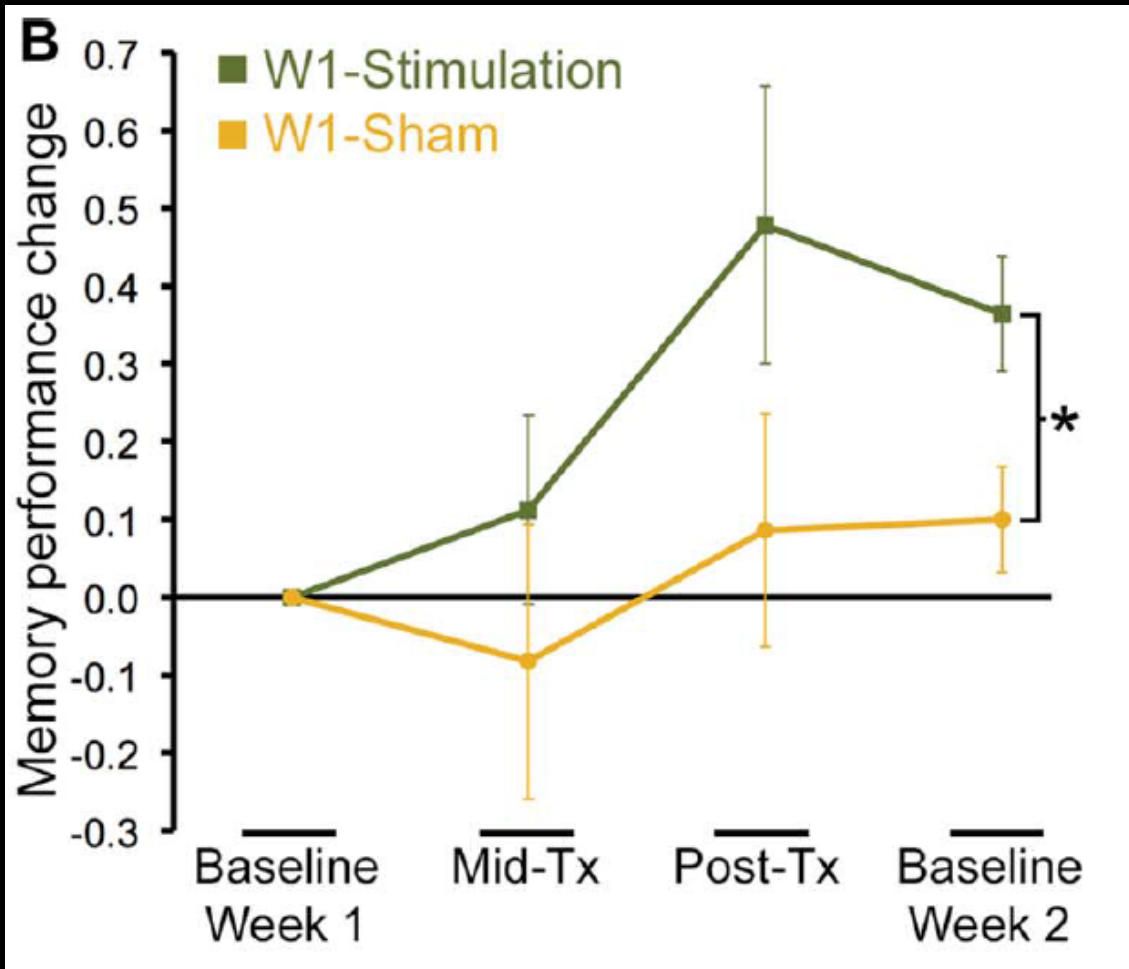
# Repeated Sessions of Noninvasive Brain Stimulation



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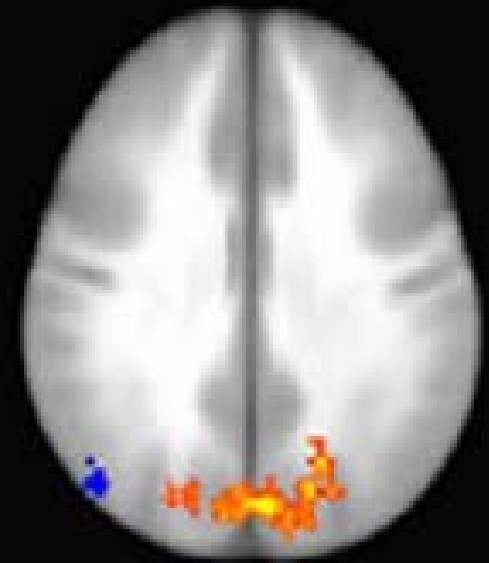
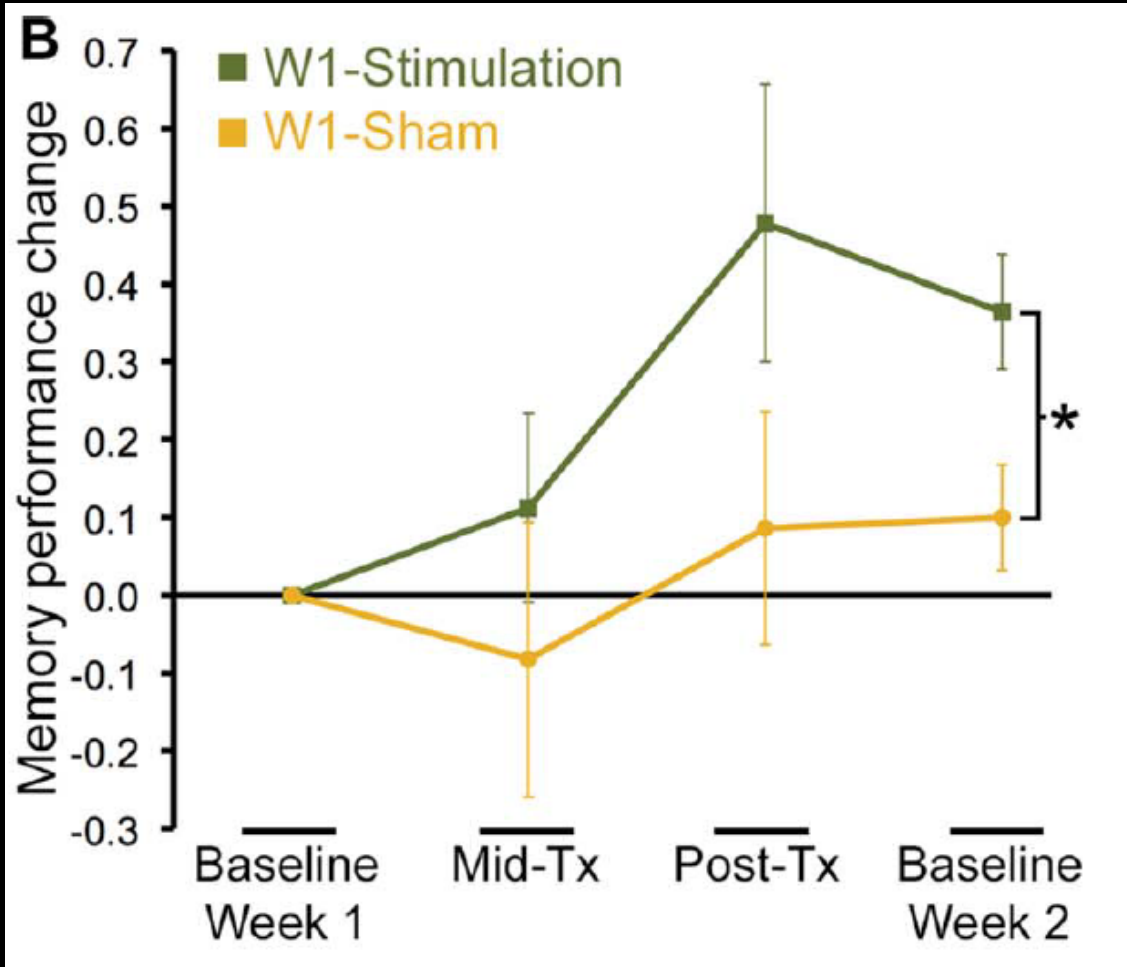


# Repeated Sessions of Noninvasive Brain Stimulation





# Repeated Sessions of Noninvasive Brain Stimulation



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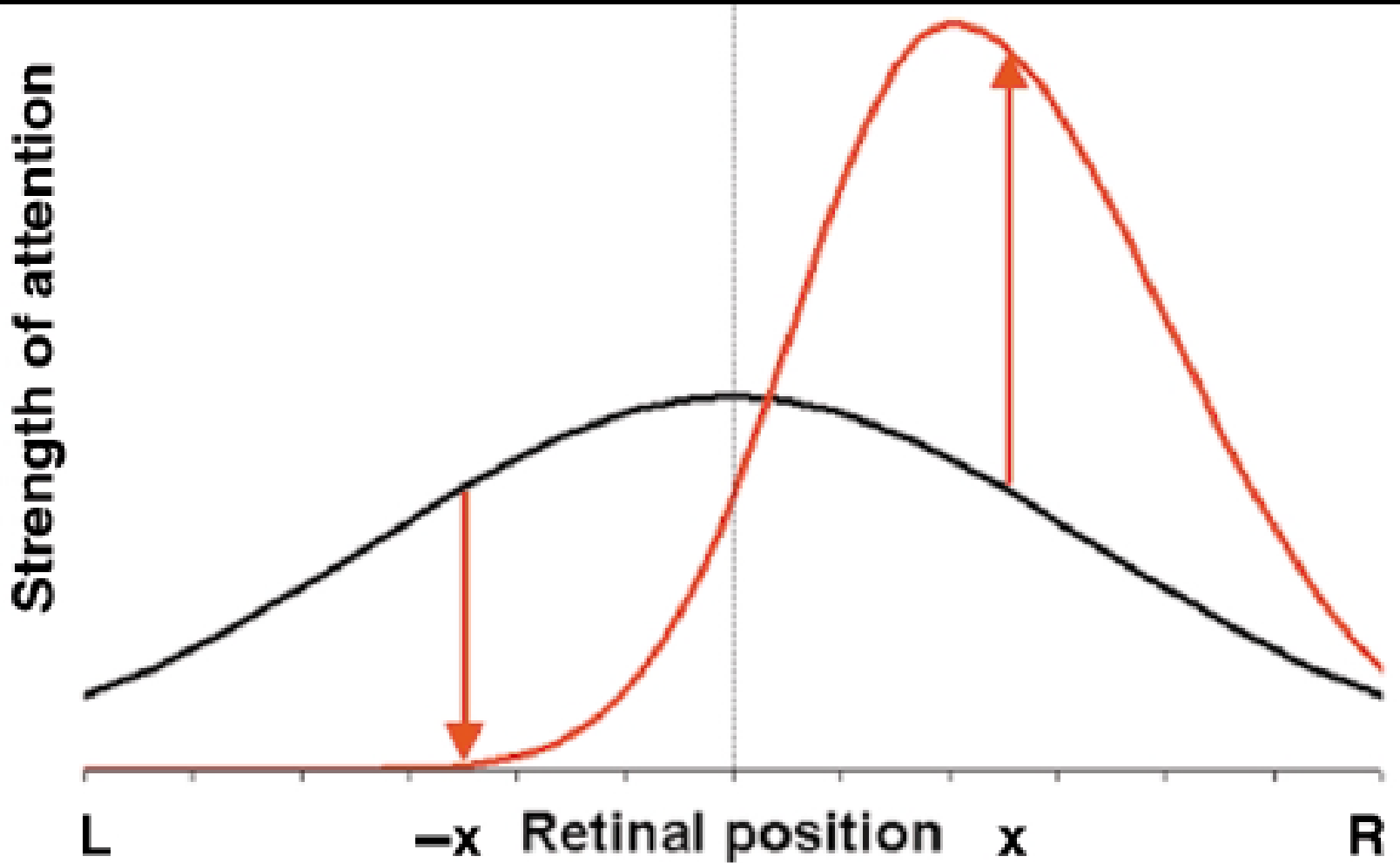
# Outline

- Where is the the effect?
  - Well beyond the stimulated region
- **How long does it last?**
  - **Well past the end of stimulation**
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# Manipulating attention



L

$-x$

Retinal position

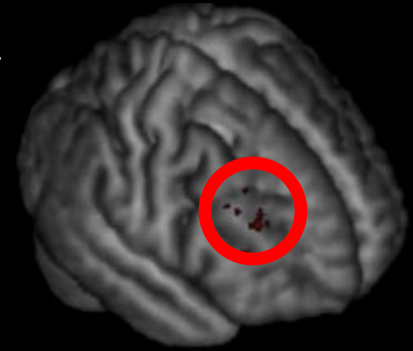
$x$

R

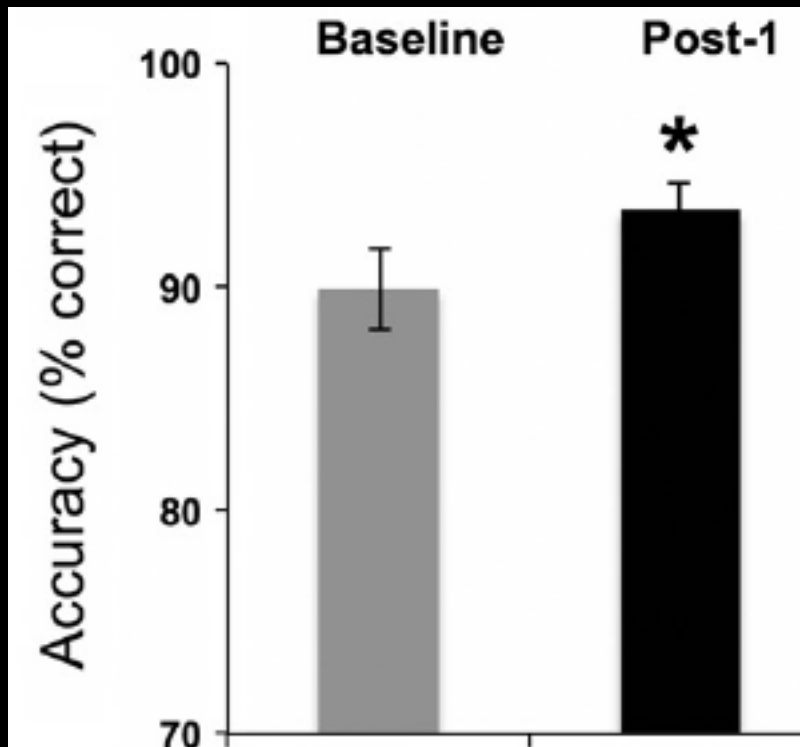
Black = Baseline

Red = Following 1Hz rTMS to R Parietal Cortex

# Improving Working Memory



Verbal

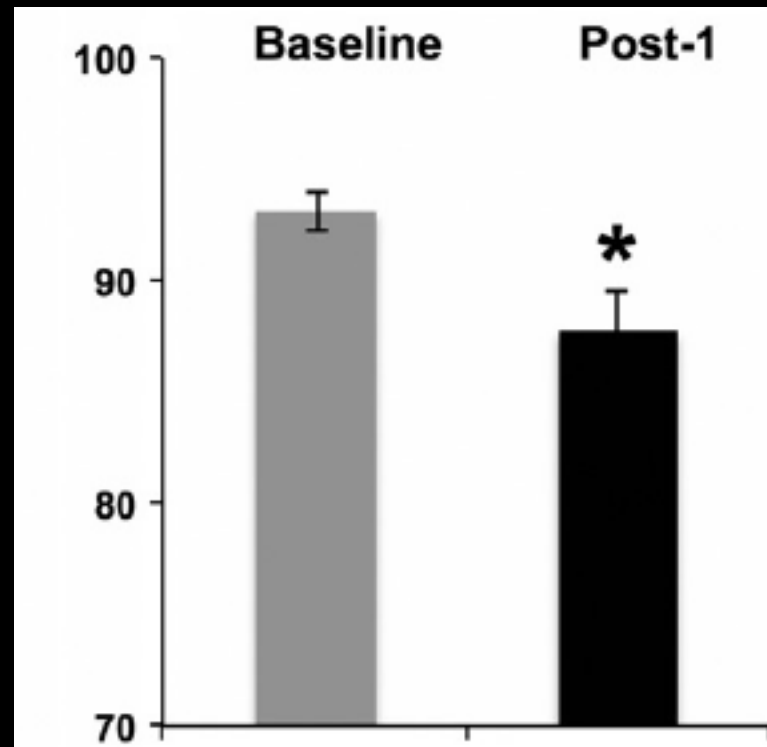
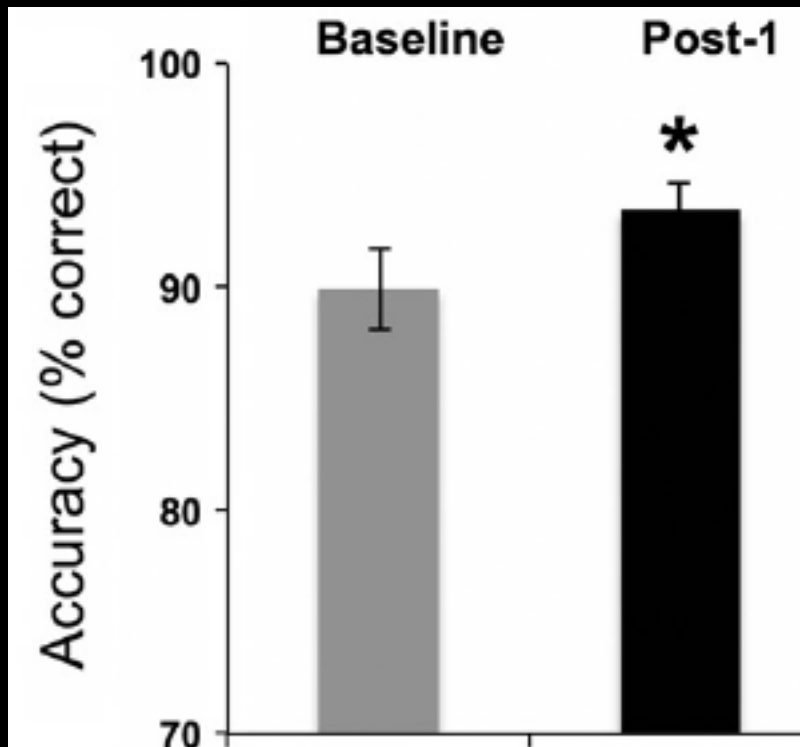


# Improving Working Memory



Verbal

Spatial



# Outline

- Where is the the effect?
  - Well beyond the stimulated region
- How long does it last?
  - Well past the end of stimulation
- **Does it come at a cost?**



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  - In some cases yes

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# Is this fundamentally different from oral compounds?



Foc.us tDCS headset

Vs.



# Caffeine



- Widespread effects on brain networks, including the autonomic nervous system
- Repeated consumption has cumulative effects (dependence)
- Beneficial effects can come at a cost (tremor, insomnia)

# Conclusions

- Noninvasive brain stimulation has effects beyond the stimulation site and beyond the stimulation session

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- While helpful for therapeutic applications, these factors may pose risks for non-therapeutic use
- Benefits may come with side effects, however this is not necessarily different from oral compounds