Neurostimulation reveals prefrontal cortex plays a central role in endogenous but not exogenous attention

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BACKGROUND

Covert spatial attention [1]

- EXOgenous: involuntary, stimulus-driven, automatic, transient (~100ms)
- ENDOgenous: voluntary, goal-directed, flexible, sustained (~300ms)

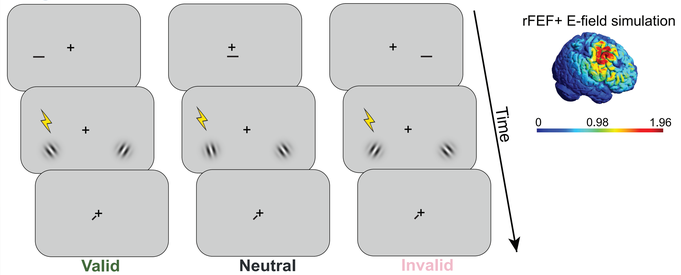
fMRI studies provide *correlational* evidence. Some report that rFEF+ is part of the cortical network for both EXO and ENDO [2]; others report it is primarily for ENDO [3,4].

Transcranial Magnetic Stimulation (TMS) briefly alters cortical activity (state-dependent), making it an ideal tool to assess whether an area is critical for a task and to infer *causality*.

	Critical/Causal Role?	
TMS	EXOgenous attention	ENDOgenous attention
Early visual areas (V1/V2)	✓ [5,6]	X [7]
right Frontal eye fields (rFEF+)	?	✓ [7]

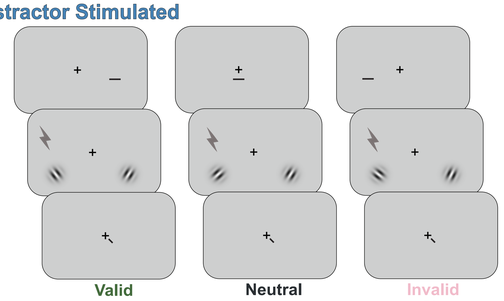
METHOD

Target Stimulated

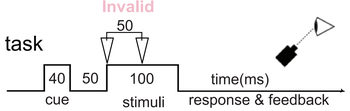


rFEF+ E-field simulation

Distractor Stimulated



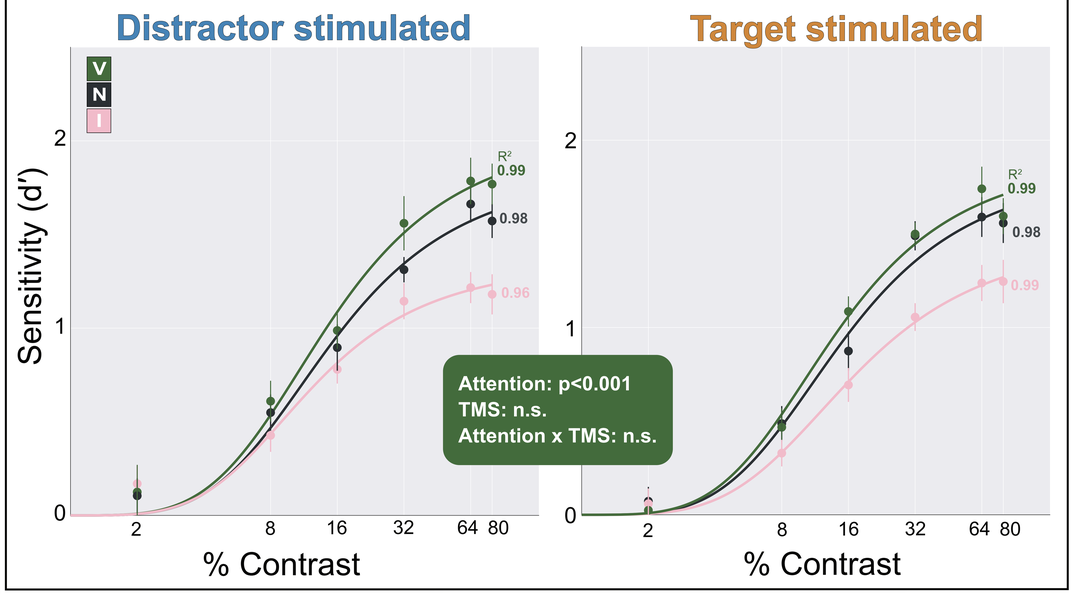
- 2 alternative forced choice (2AFC) task
- 6 stimulus contrast 2-80%
- 3 attentional cues
  Valid / Neutral / **Invalid**
- 2 TMS conditions [8]
  Target stimulated / **Distractor stimulated**



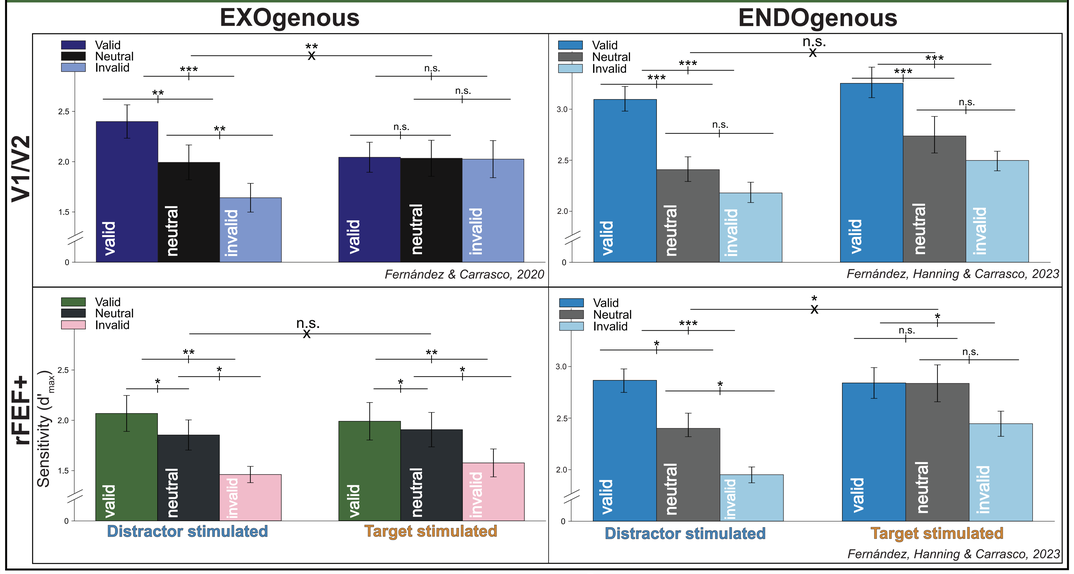
localization of rFEF+ [9]

n=12

TMS on rFEF+ yield SIMILAR EXOGENOUS EFFECTS for



DIFFERENTIAL TMS EFFECTS on V1/V2 and rFEF+



REFERENCES

[1] Carrasco M (2011). *Vis Res.*
[2] Corbetta M, Patel G & Shulman GL (2008). *Neuron*.
[3] Chica AB, Bartolomeo P & Lupiáñez J (2013). *Behav Brain Res.*
[4] Beck DM & Kastner S (2014).*Oxford Handbook of Attention.*
[5] Fernández A & Carrasco M (2020). *Curr Bio.*
[6] Lee HH, Fernández A & Carrasco M (2024). *iScience.*
[7] Fernández A, Hanning NM & Carrasco M (2023). *PNAS.*
[8] Dugué L, Roberts M & Carrasco M (2016). *Curr Bio.*
[9] Wang L, Mruczek REB, Arcaro MJ & Kastner S (2015). *Cereb Cort.*

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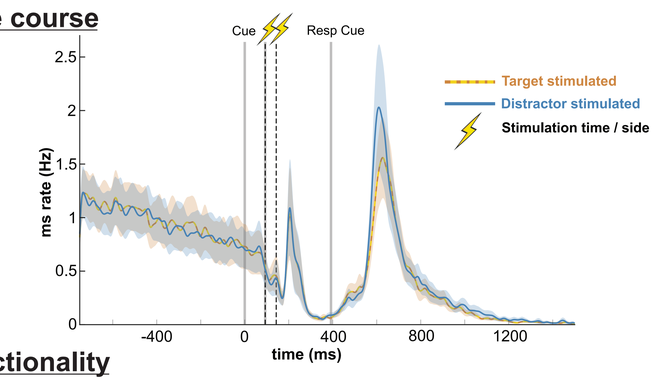
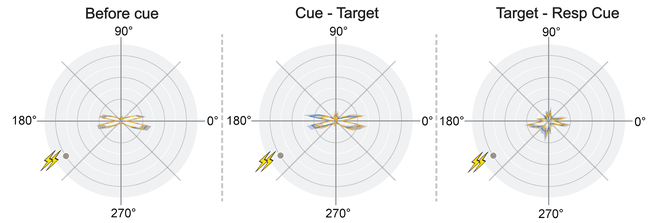
TMS on rFEF+: MICROSACCADES

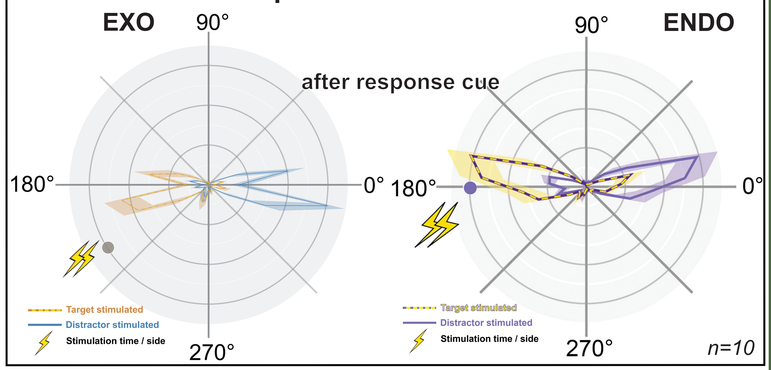
Time course



Directionality



Similar pattern after rFEF+ TMS on



CONCLUSION

- TMS applied to rFEF+: EXOgenous attention response gain remains in both target and distractor-stimulated conditions
- rFEF+ is *not* a critical node in the cortical network of EXOgenous attention

	DOUBLE DISSOCIATION	
TMS	EXOgenous attention	ENDOgenous attention
Early visual areas (V1/V2)	✓ [5,6]	X [7]
right Frontal eye fields (rFEF+)	X	✓ [7]