

# TMS suppression of V4 and V5 precludes cortical activation and function

AUSTIN KARESH, SHIVANI PALANIVEL, YESEUL HEO

## INTRODUCTION

Previous studies suggest that lesions of the **primary visual cortex (V1)** does not completely eliminate visual perception.<sup>1</sup>

Despite a lack of visual awareness, many blindsight patients are able to **recognize objects and detect motion**. Consistent with these findings, direct projections from the **lateral geniculate nucleus (LGN)** to areas **V4 and V5** in macaques have been identified.<sup>2</sup> This evidence suggests the neural mechanisms underlying **unconscious visual processing** rely on **extrastriate pathways** bypassing the primary visual cortex.

## HYPOTHESIS

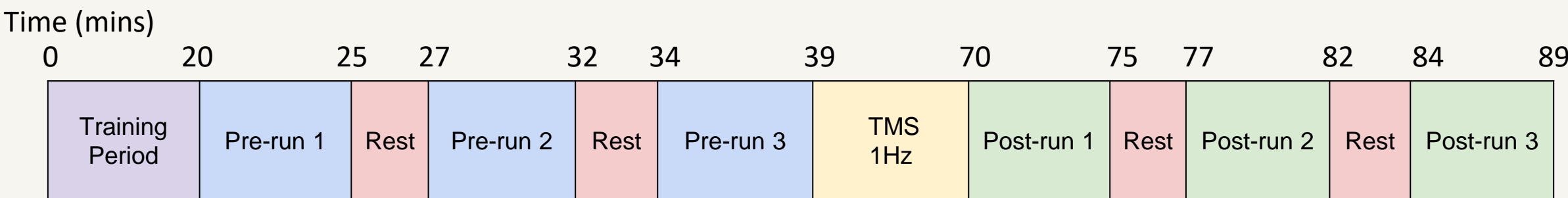
### V4 TMS Inhibition

↓ Object recognition (OR) activity - Motion detection (MD) ↑ V5

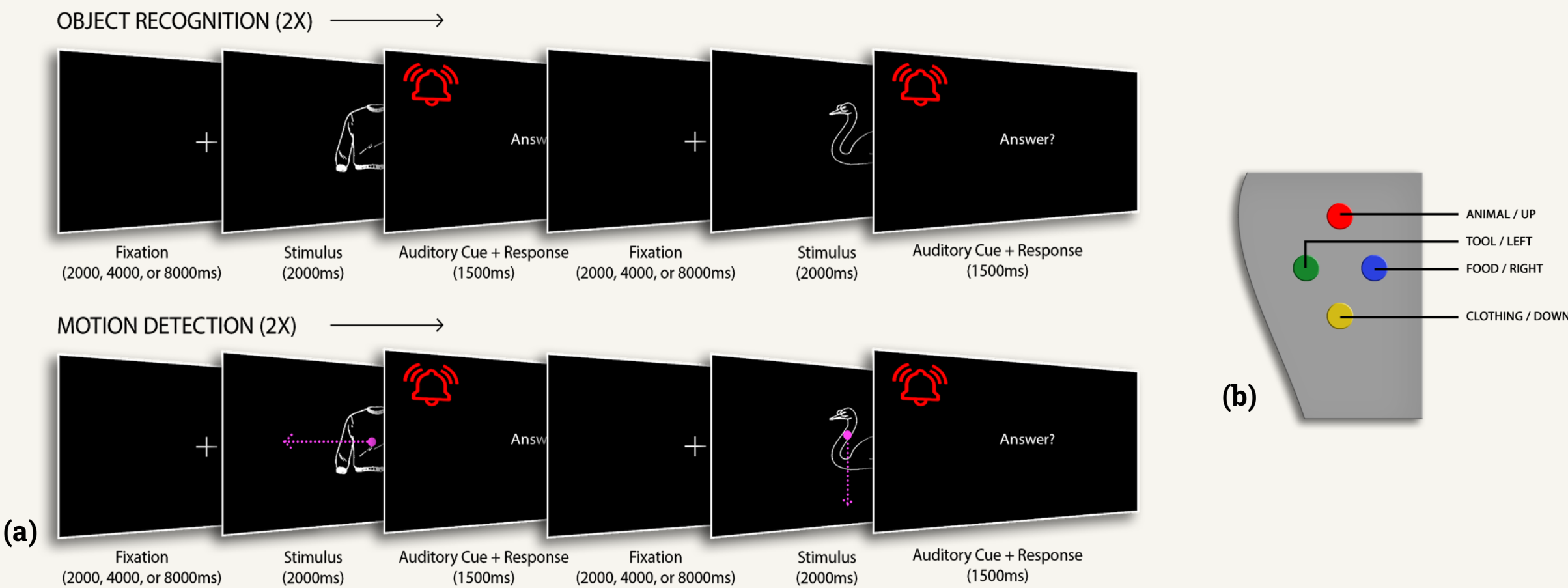
### V5 TMS Inhibition

- Object recognition (OR) activity ↓ Motion detection (MD) ↑ V4

## METHODS



**FIGURE 1. Experiment Progression.** Following a training period in a mock scanner, there were three runs in the MRI scanner prior to TMS and three runs in the scanner after TMS. Each run consisted of 20 OR tasks and 20 MD tasks. Runs were separated by two-minute rest periods. 1 Hz inhibitory TMS was applied to either V4 or V5.



**FIGURE 2. (a) Sample Task Progression.** Each run consisted of OR and MD tasks both pre- and post- TMS-induced inhibition. Red alarm signal indicates auditory cue for participants to respond with a button box as fast and accurately as possible. **(b) Button Box Layout.** Four-directional button box was used for both OR and MD tasks.

## METHODS (CONT.)

**Subjects:** 18 healthy individuals (10 F, 8 M; mean age = 23.8 yr), right-handed

**Tools:** TMS (Cadwell MES-10 stimulator & 9 cm circular coil).<sup>3</sup> fMRI (Siemens Magnetom Trio 3T scanner)

**Experiment:** After a training period (three alternating blocks of 20 OR and 20 MD) in a mock scanner, three runs (each run composed of 20 OR and 20 MD) with breaks in between were completed both before and after 1 Hz TMS inhibition (**FIGURE 1**). 9 random participants received V4 inhibition, and 9 others received V5 inhibition.

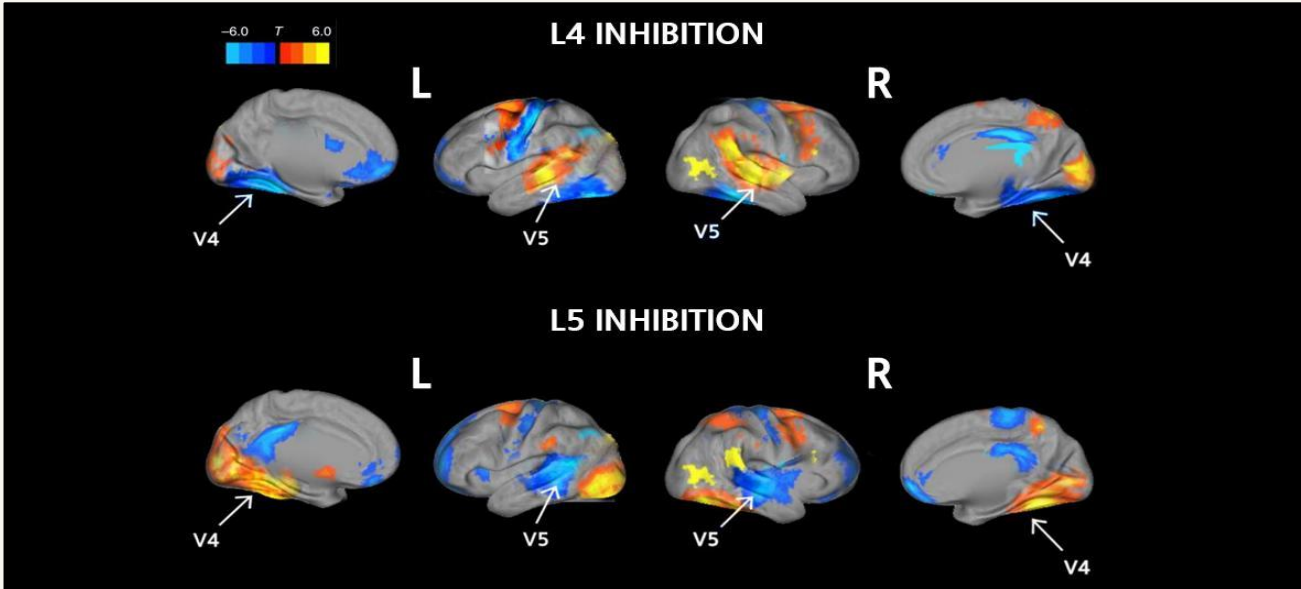
MD: Upon auditory cue, participants indicated stimuli's categories using button box (animal / tool / food / clothing)

OR: Upon auditory cue, participants indicated stimuli's directions using button box (up / left / right / down) (**FIGURE 2**)

**Analysis:** Behavioral (RT + within-subjects ANOVA using SPSS), functional (Analysis of Functional NeuroImages (AFNI))

## RESULTS

### FUNCTIONAL (fMRI)

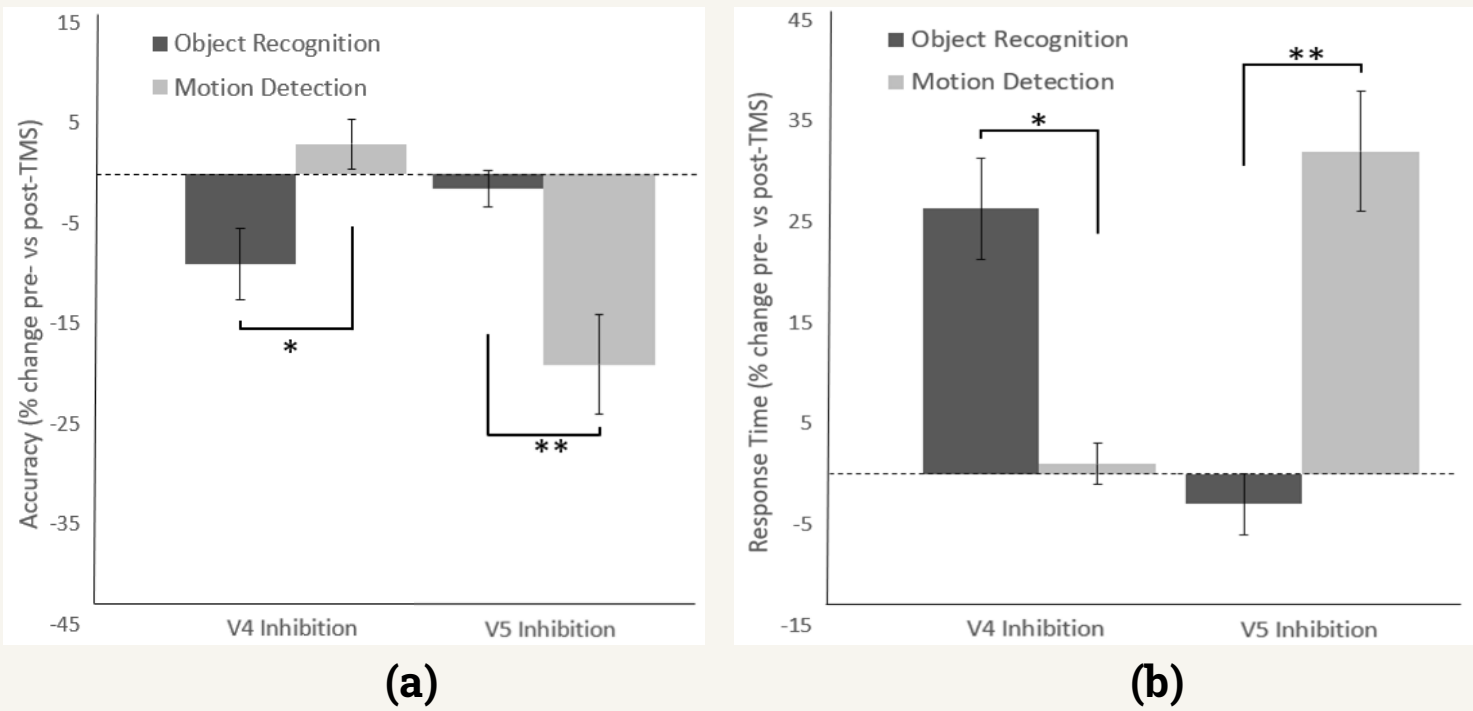


**FIGURE 3. Functional Activation Data.** TMS-induced inhibition causes decreased activation of V4 and V5, respectively, indicated by blue (inhibition) and red/yellow (excitation). Bilateral inhibition of V4 results in recruited activity from V1 and V5. Similarly, bilateral inhibition of V5 is associated with V1 and V4 excitation.

OR and MD tasks produced increase in V1 and V5 for V4-inhibited participants ( $t(17) = 2.40, p < .05$ ) and decrease in V4 ( $t(17) = 2.70, p < .05$ ).

OR and MD tasks produced increase in V1 and V4 for V5-inhibited participants ( $t(17) = 2.81, p < 0.05$ ) and decrease in V5 ( $t(17) = 2.68, p < .05$ ).

### BEHAVIORAL (Accuracy, RT)



**FIGURE 4. Behavioral Performance Data. (a) Accuracy.** V4 inhibition reduced accuracy in OR and preserved it in MD post-TMS. Contrarily, V5 inhibition reduced accuracy in MD and preserved it in OR post-TMS. **(b) Response Time.** V4 inhibition increased RT in OR and maintained it in MD post-TMS. V5 inhibition increased RT for MD and preserved it for OR.

OR accuracy before/after TMS-V4  $F(1,17) = 14.9, p < .04$

OR RT before/after TMS-V4  $F(1,17) = 7.69, p < .05$

MD accuracy before/after TMS-V5  $F(1,17) = 32.3, p < .001$

MD RT before/after TMS-V5  $F(1,17) = 122.64, p < .001$

## CONCLUSION

TMS-induced inhibition of extrastriate areas V4 & V5 associated with recruitment of V1 & opposite cortex  
V4 Inhibition = ↑ V1 & V5 Activation  
V5 Inhibition = ↑ V1 & V4 Activation (**FIGURE 3**)

Performance decreases with inhibition of V4 & V5  
V4 Inhibition = ↓ OR accuracy & ↑ OR RT  
- MD accuracy & - MD RT  
V5 Inhibition = - OR accuracy & - OR RT  
↓ MD accuracy & ↑ MD RT (**FIGURE 4**)

V4 & V5 inhibition causes functional loss of OR & MD, respectively  
Inhibition of cortex results in compensatory activation of V1 and other extrastriate cortices

Significance in identifying possible visual **neuroplasticity mechanism** following lesion  
Auxiliary mechanisms for patients to utilize surrounding brain regions to enhance vision

Suggested future research in inhibition of other visual cortices (e.g. V2, V3), animal lesion models

## ACKNOWLEDGEMENTS

This project was supported by the Georgia Tech Undergraduate Neuroscience Program.

Special thanks to Alonzo Whyte, PhD and John Johnson.

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