Oscillatory Brain States and Variability in Visual Short-Term Memory

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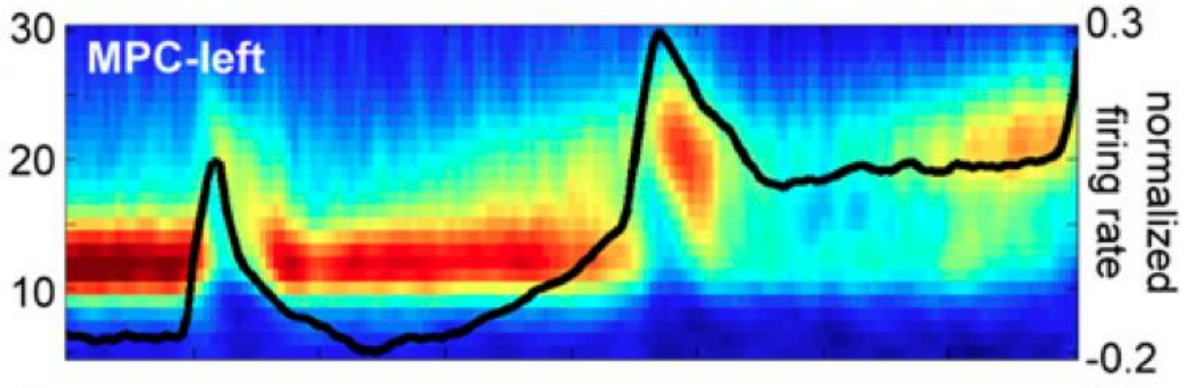
Department of Experimental Psychology
University of Oxford

Part I: Opening the Gate into Working Memory

Why Is the Prestimulus Alpha State a Good Predictor of Neural Gain?

alpha synchronization in sensory cortex predicts firing rate

Haegens et al., 2011, Bollimunta et al., 2008, 2011

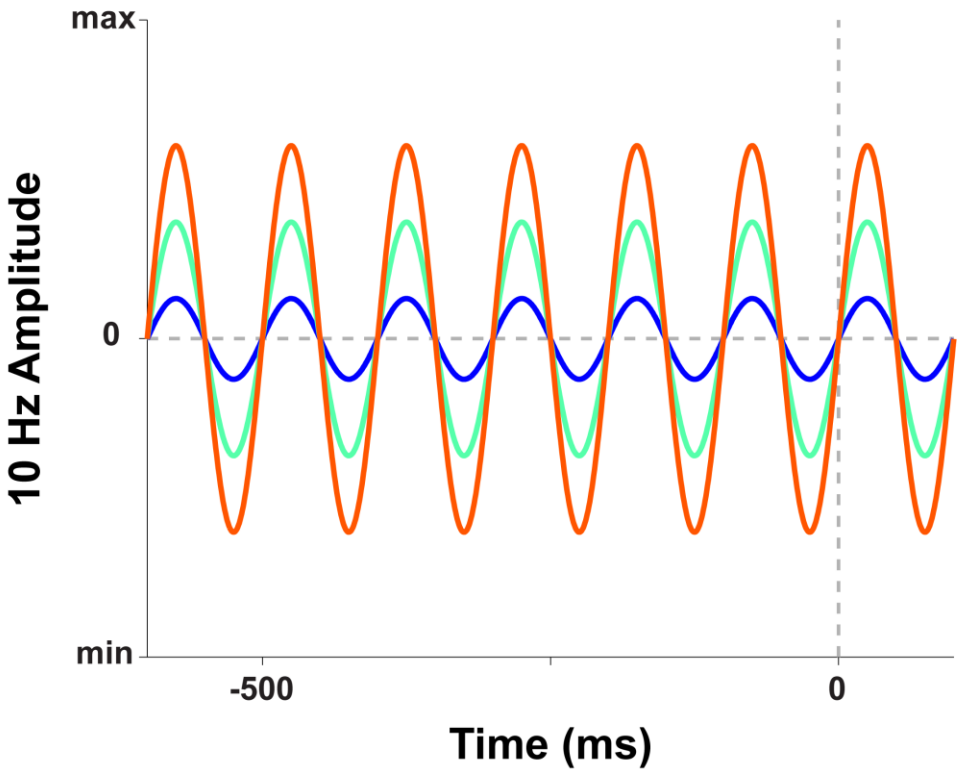


Neural Excitability as a Basis for Variability

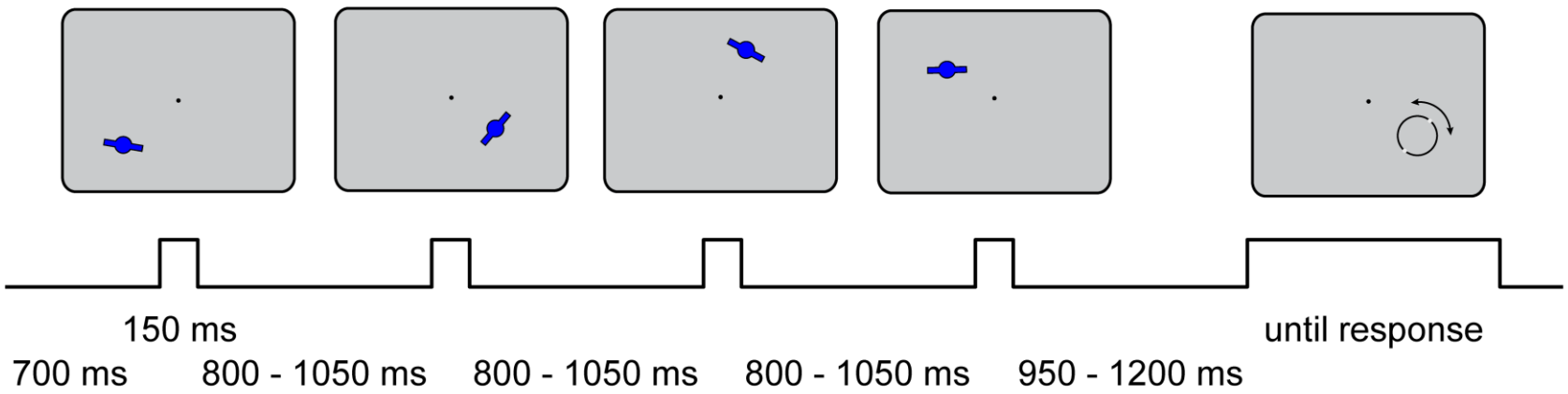
how can we tell whether the brain is in high or low precision mode?

Hypothesis

Spontaneous synchronization in the alpha-band (~10 Hz) inhibits the neural precision of the visual system by reducing neural excitability



Sequential WM Updating Task



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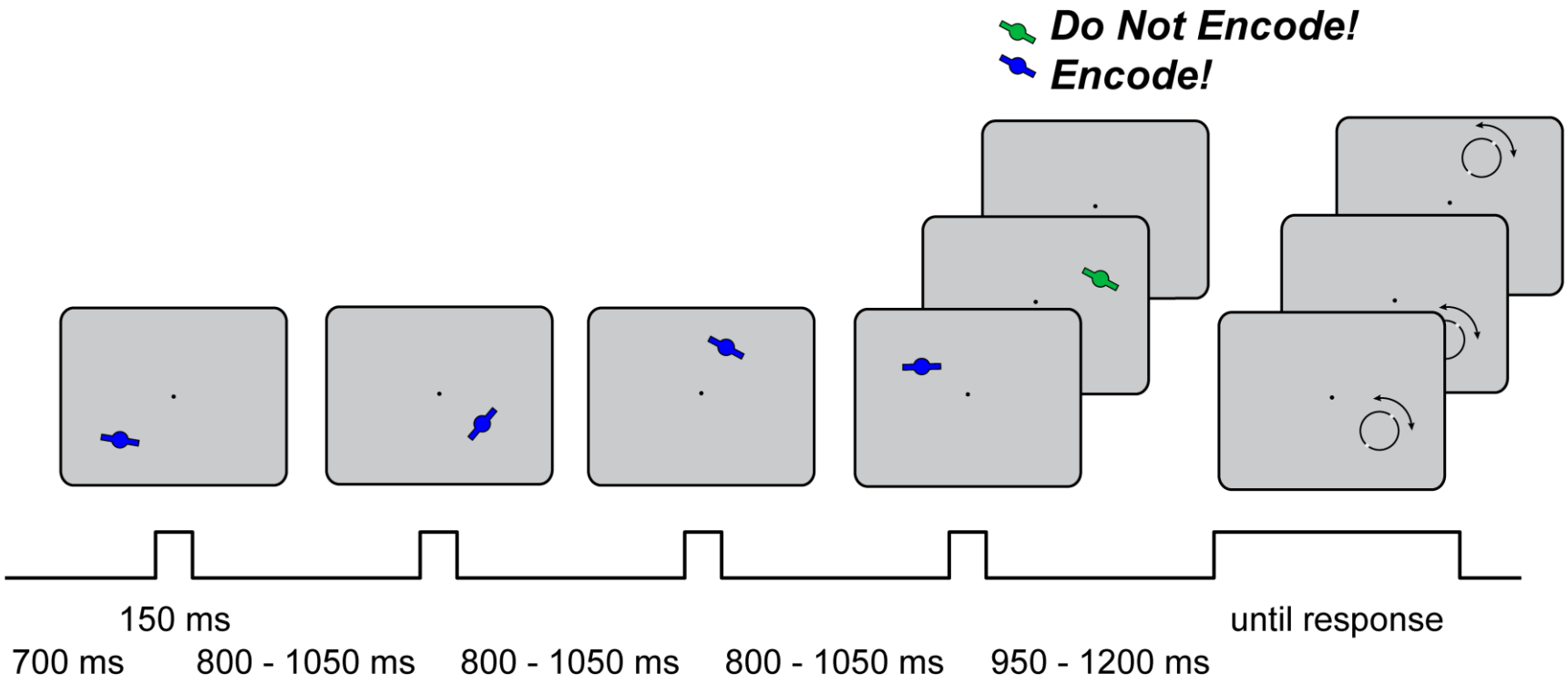

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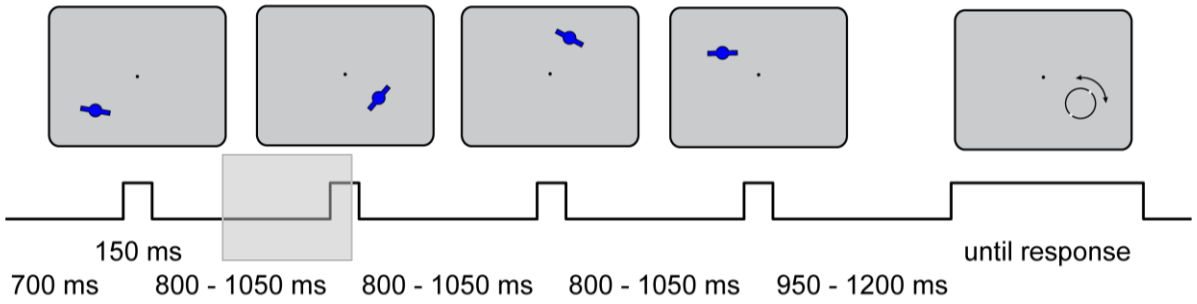
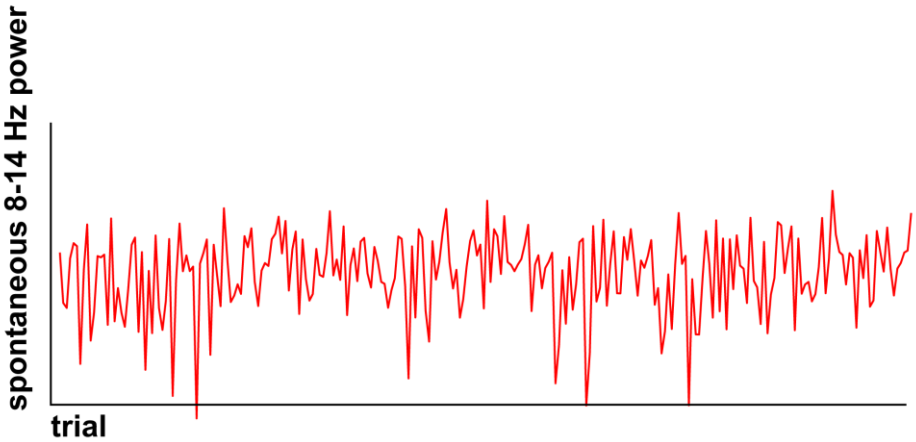
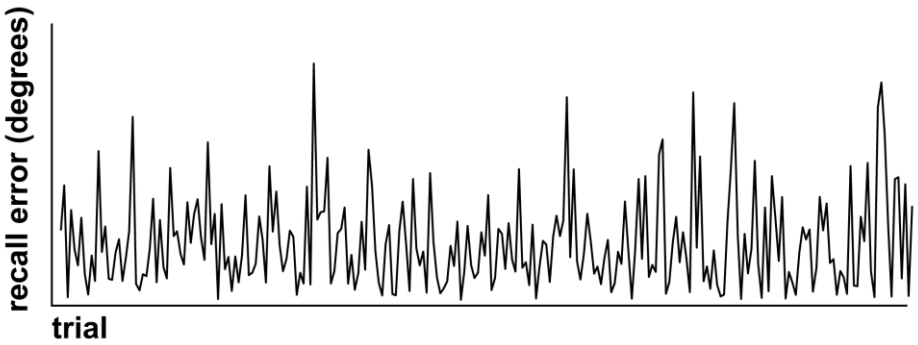


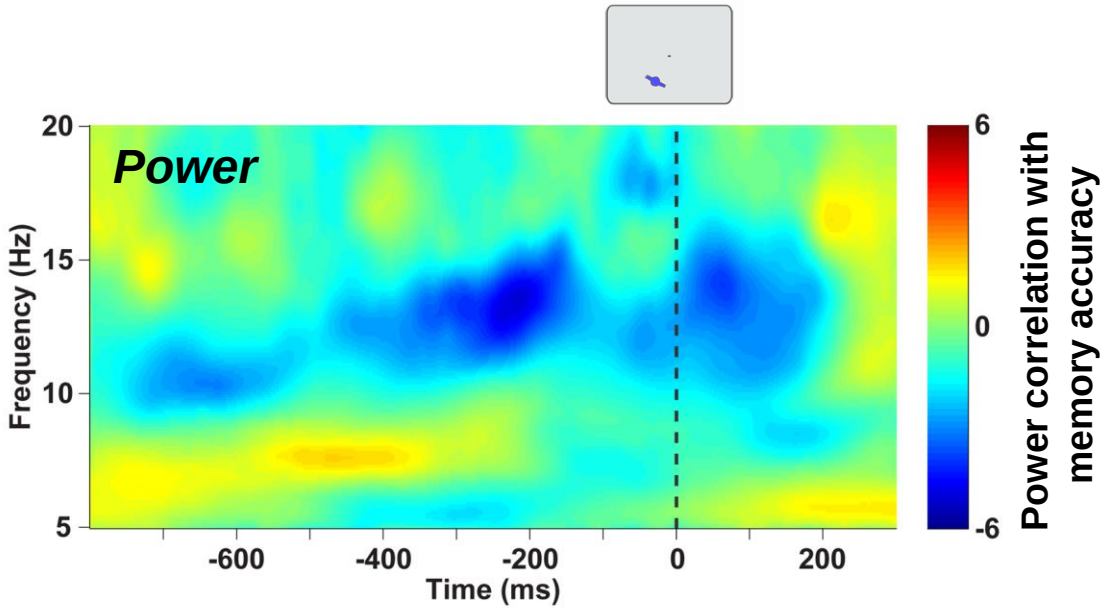


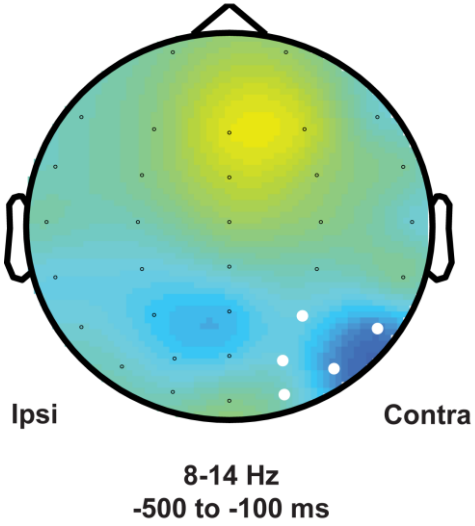


Analysis Approach

Do alpha synchronization and recall error (or precision) correlate across trials?

Prestimulus Alpha Band Power and Phase Predict WM Accuracy





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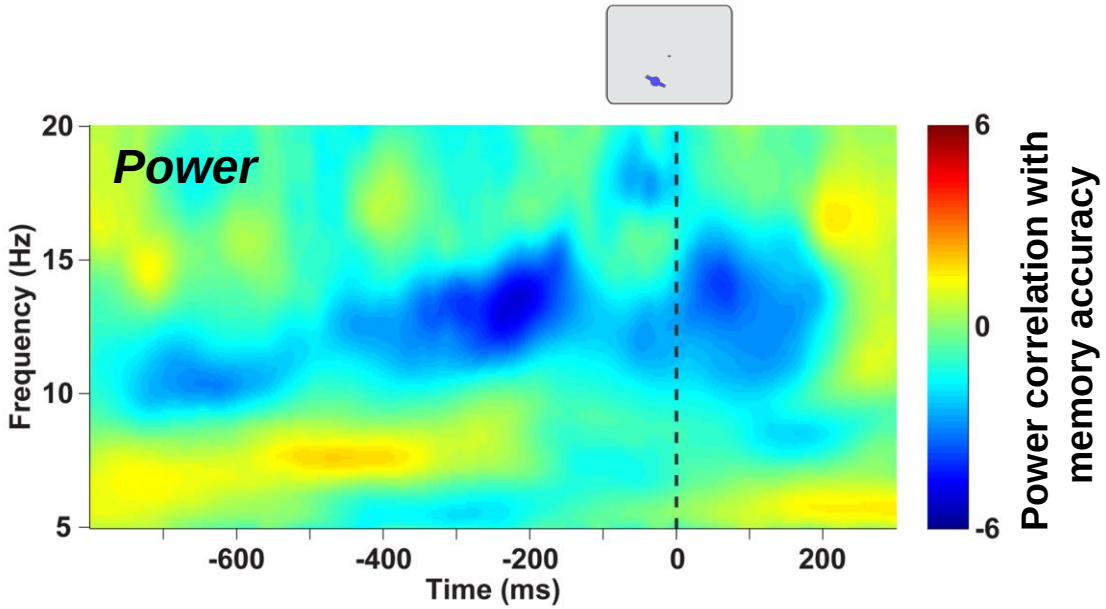
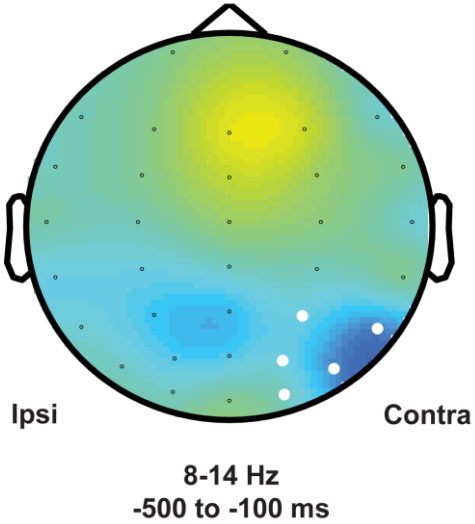
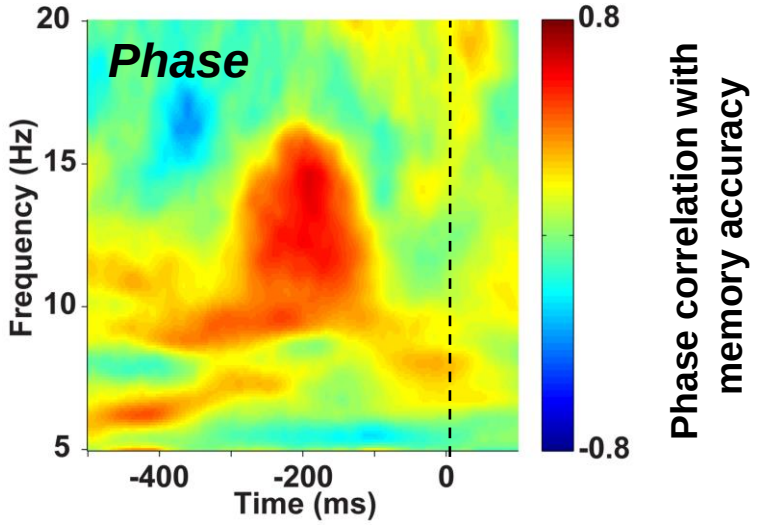
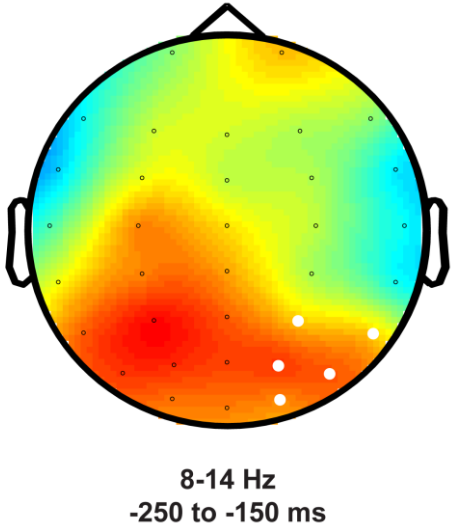
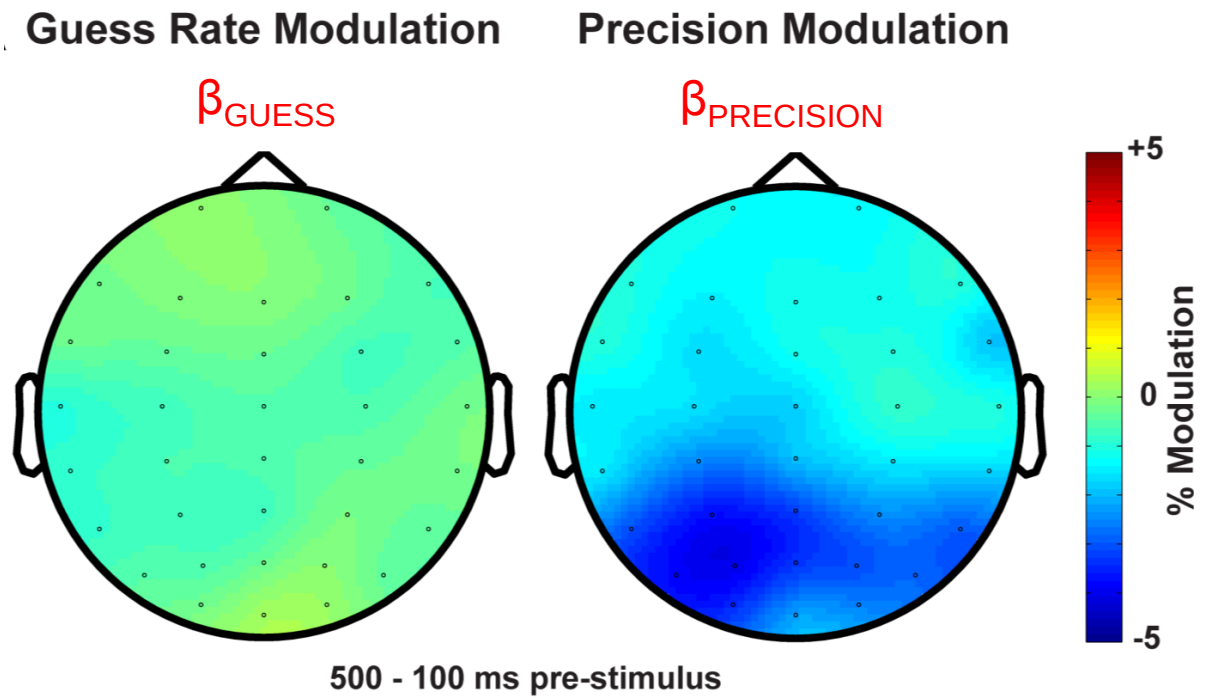








Alpha Power Modulates Memory Fidelity



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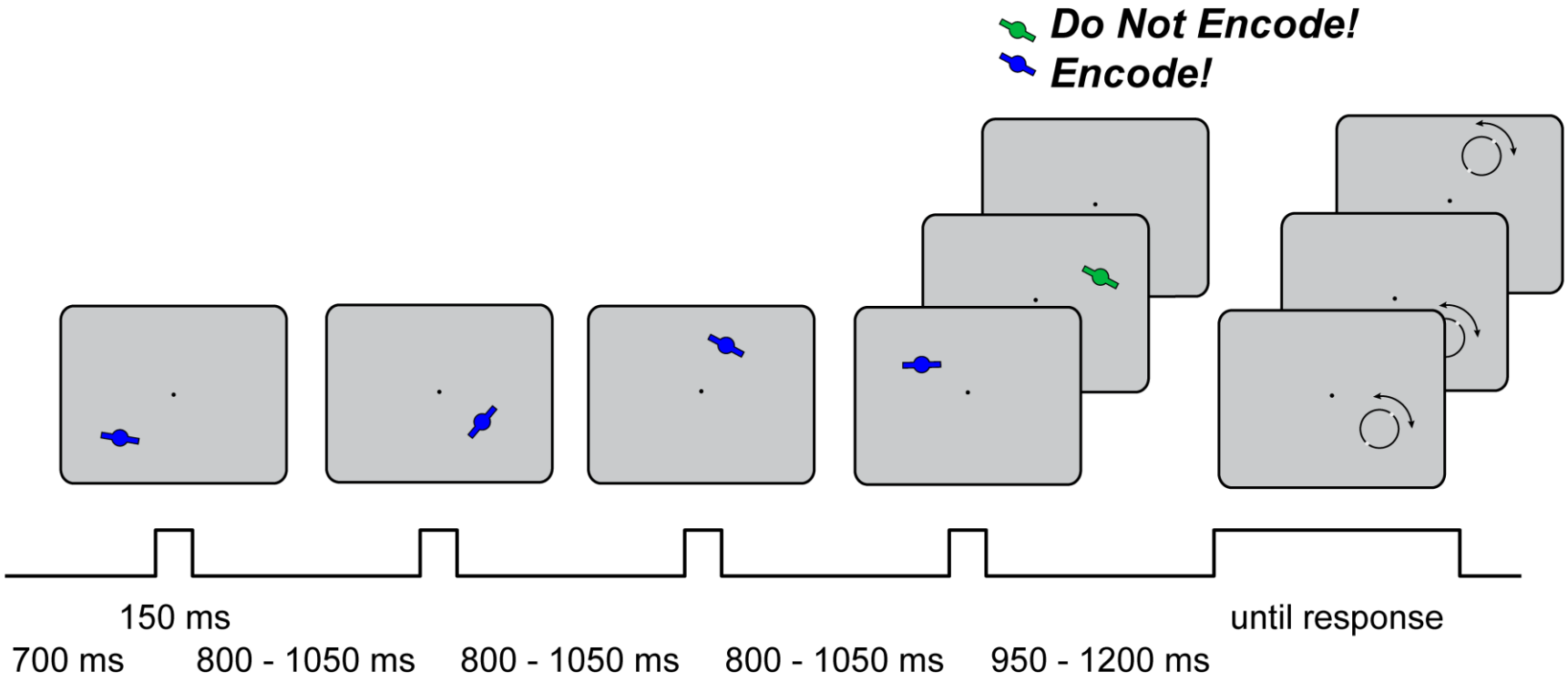
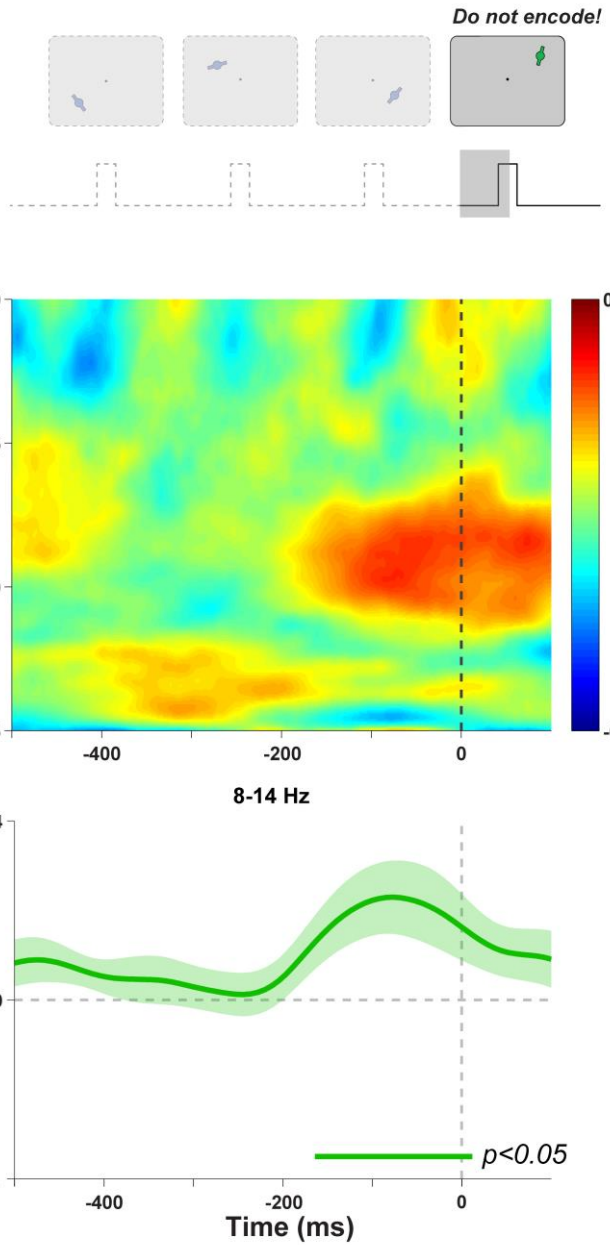


Alpha State before Distractors



Conclusions I

1. spontaneous fluctuations in posterior alpha power and phase influence working memory performance

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2. spontaneous power increases before a *distractor* also correlate with improved memory for protected items

Part II: Opening the Gate *out of* Working Memory

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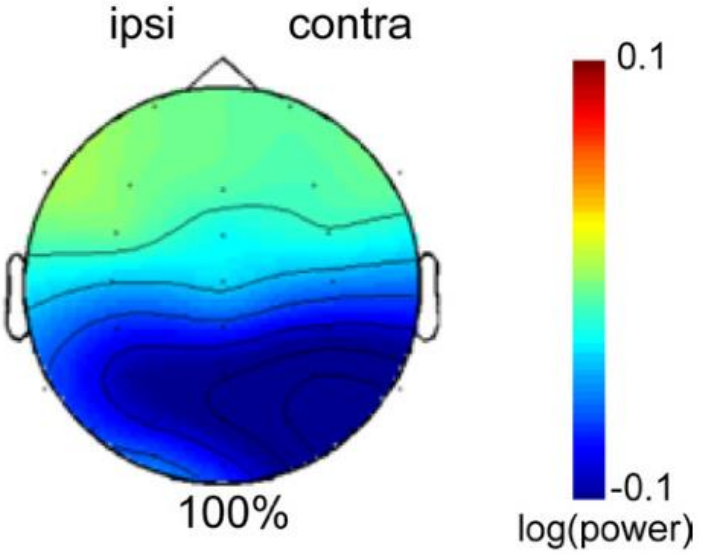
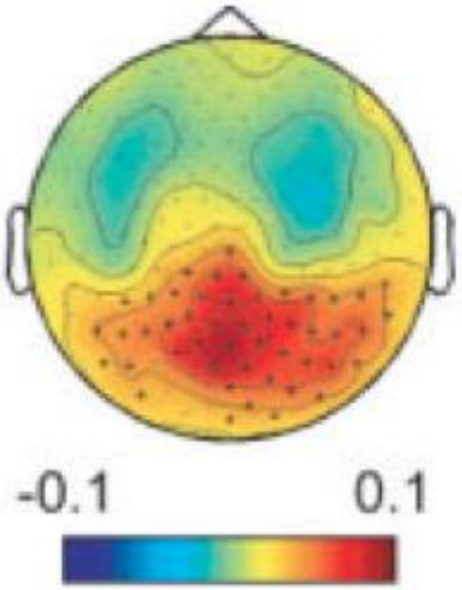
do alpha oscillations act differently after memories are already encoded?

anticipatory alpha decrease



Gould et al., 2011

alpha increase in WM delay



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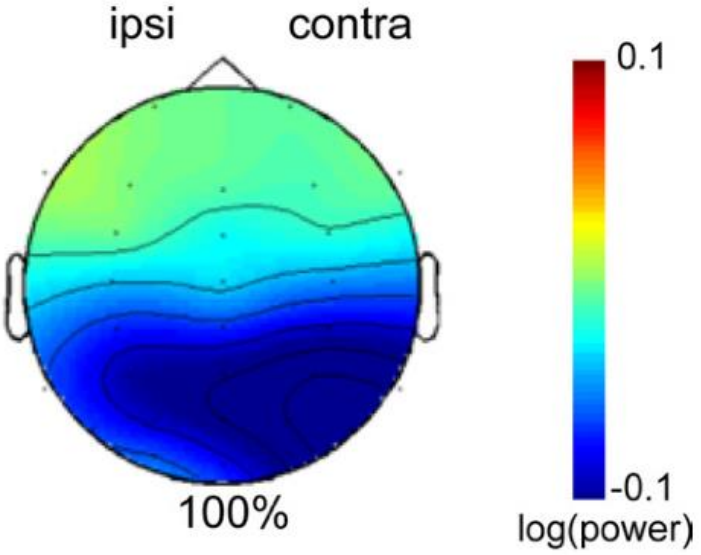

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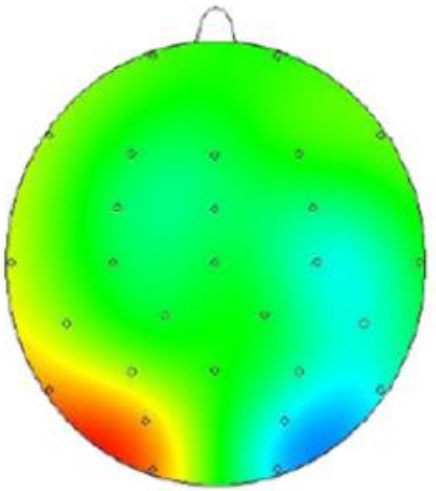
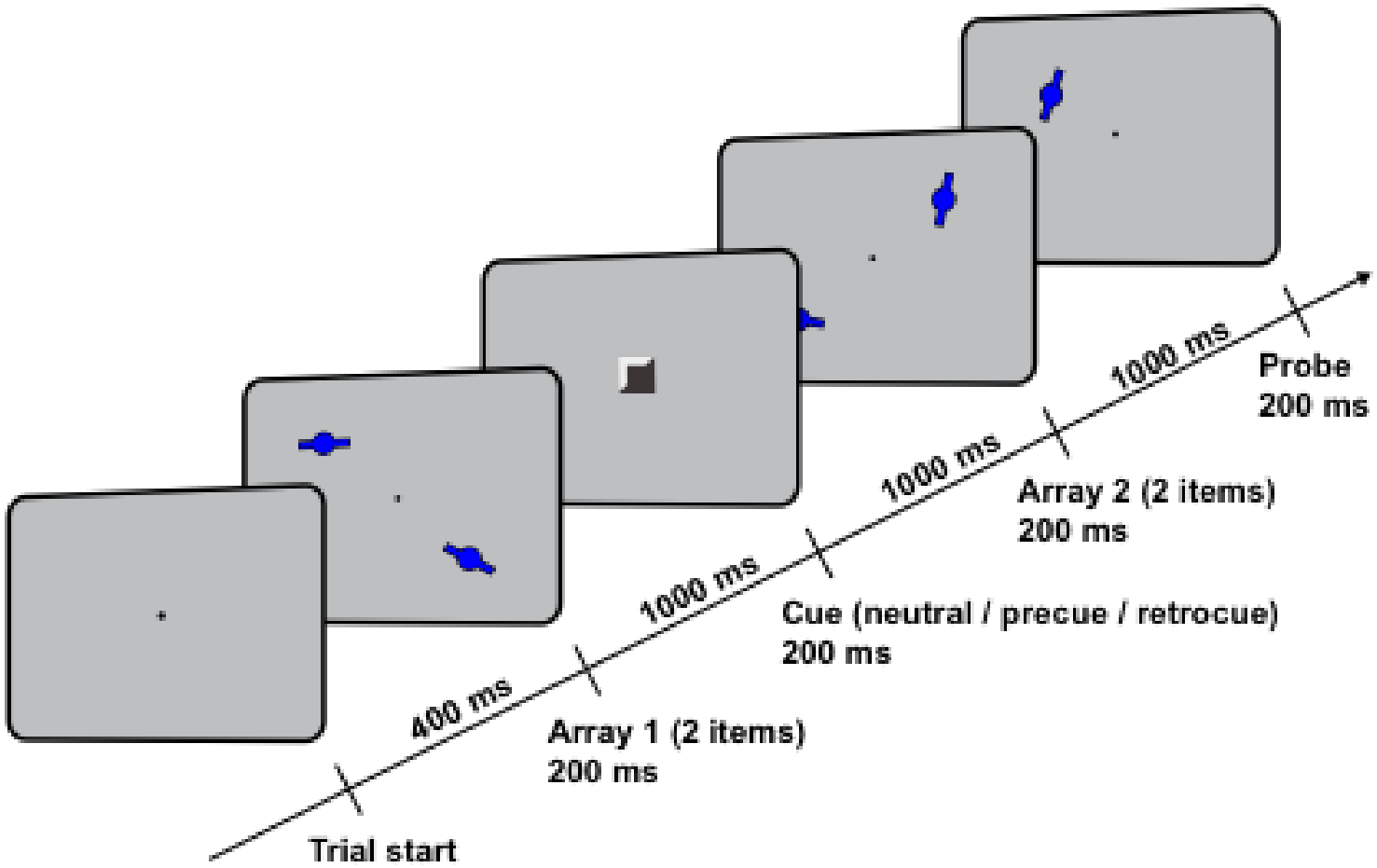
alpha lateralization in WM delay



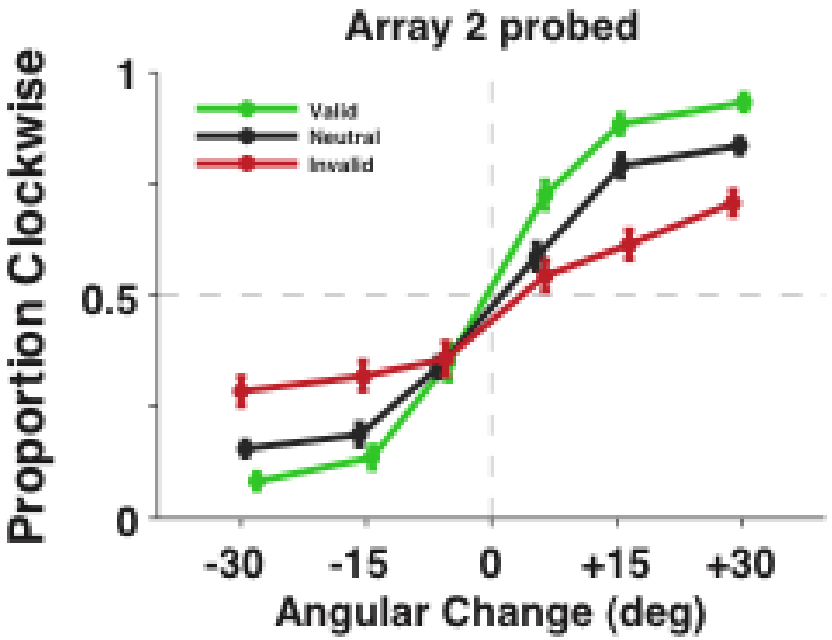
Sauseng et al., 2009

Internal vs External Updating of WM

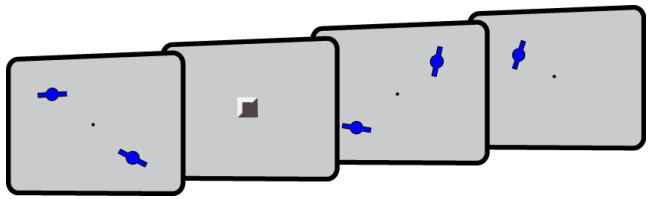


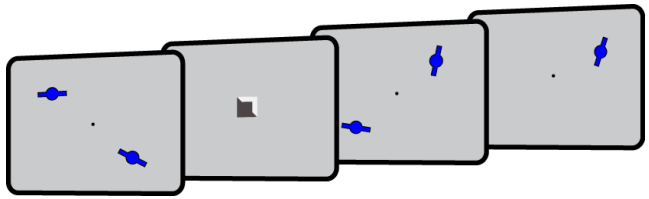
Myers, Walther, et al., under review

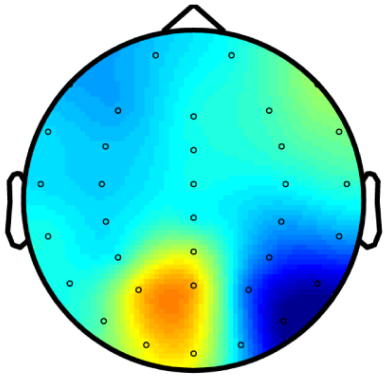
Both pre- and retro-cues improve memory

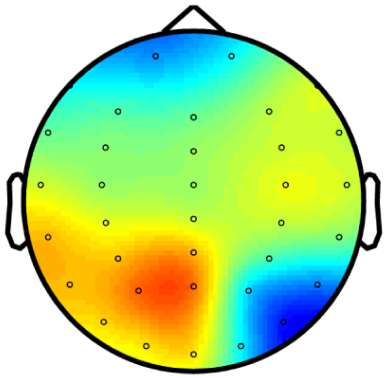


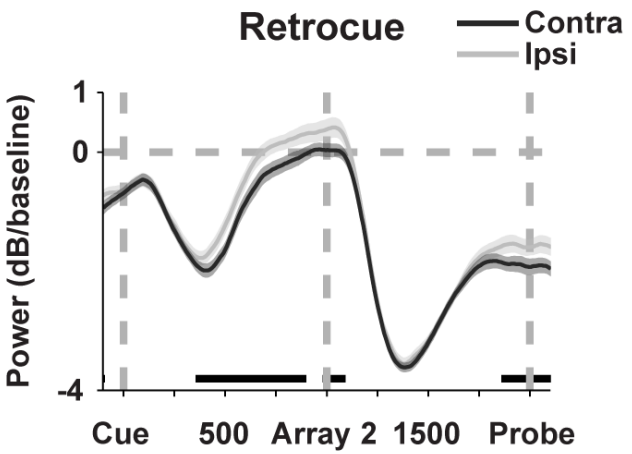
Pre- and retrocues lead to similar shifts in alpha lateralization

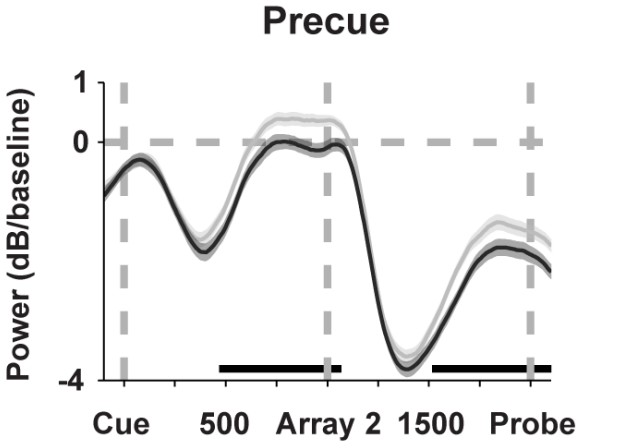




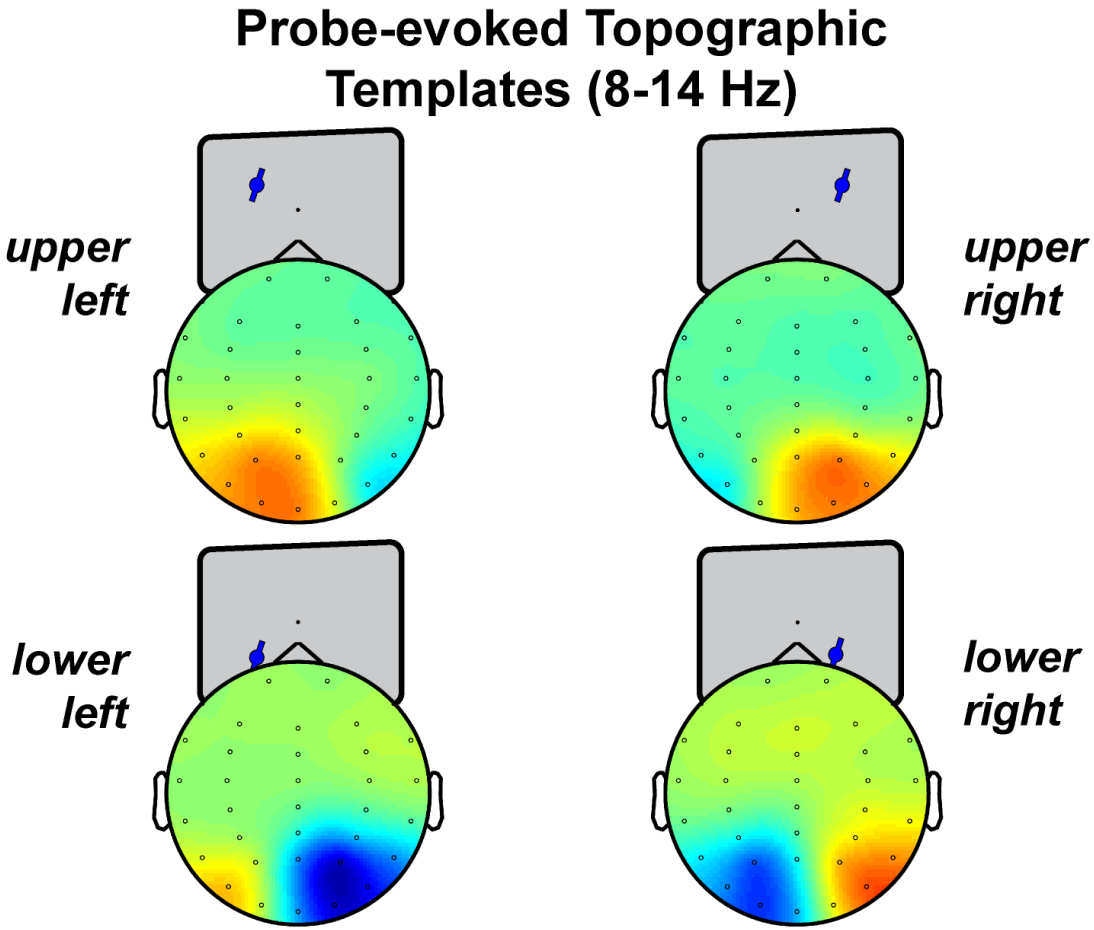








Spatially specific patterns are decodable from the alpha topography



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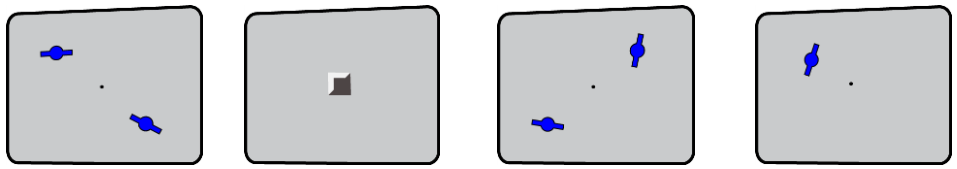
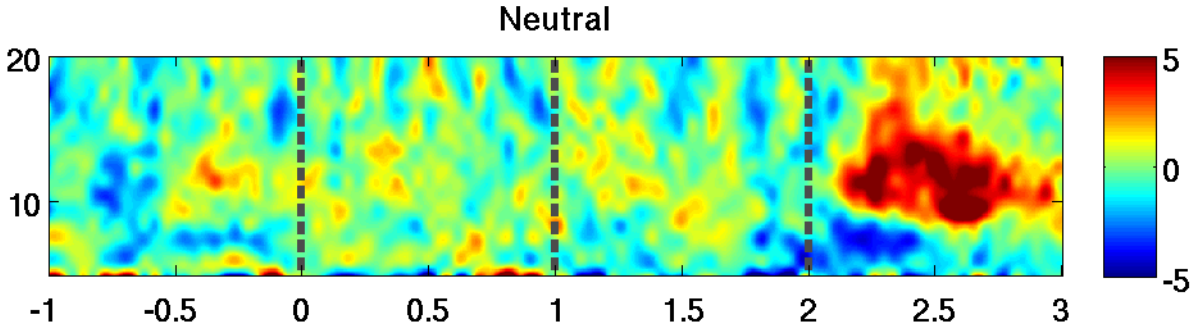
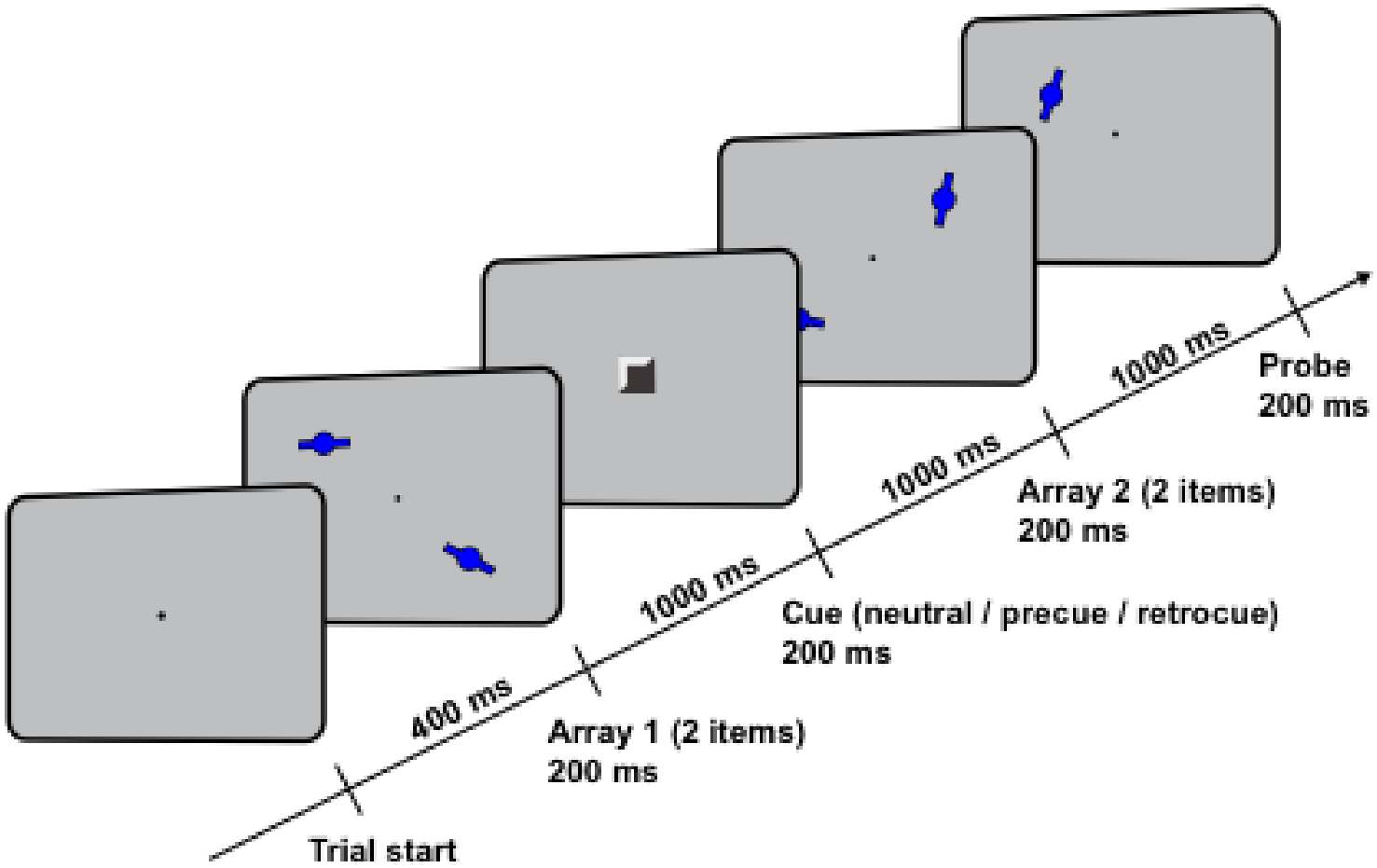
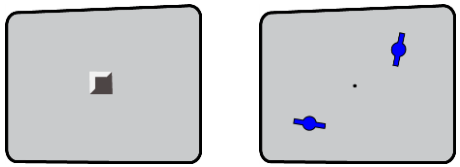


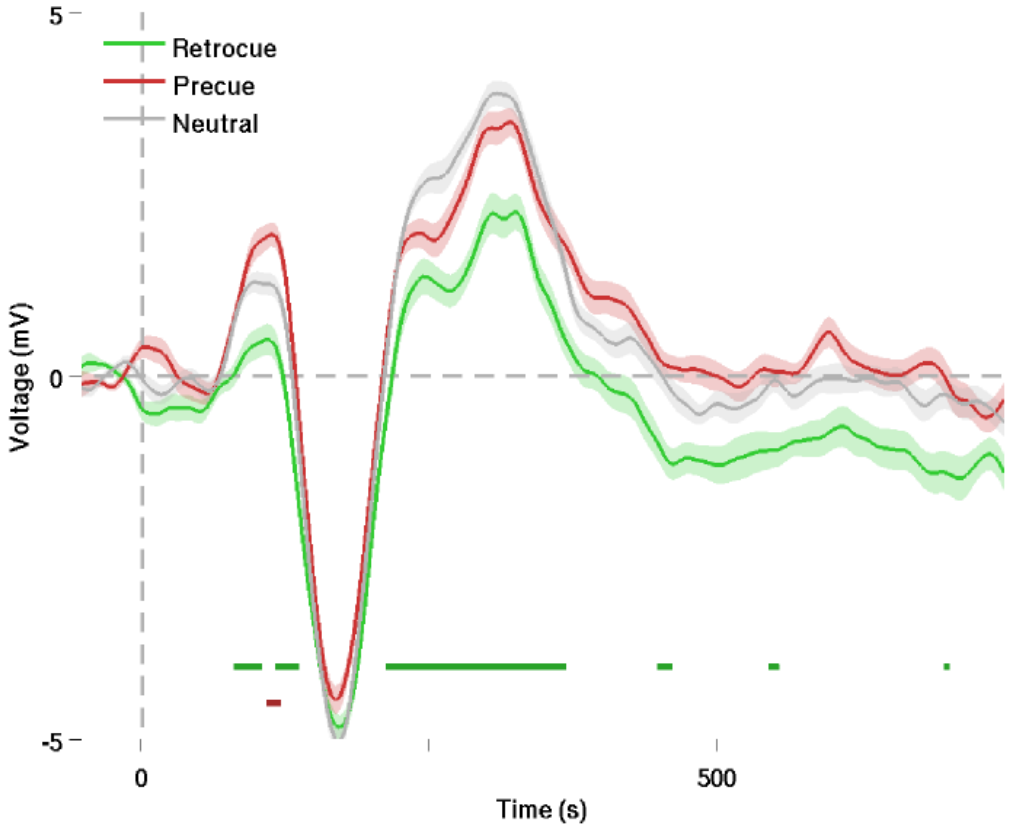


How Does the Alpha State Affect Processing of Array 2?



Cues Alter Visual Responses Within 100 ms





Conclusions II

1. anticipatory attention and retrospective attention to WM representations lead to similar shifts in alpha synchronization

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Conclusions II

1. anticipatory attention and retrospective attention to WM representations lead to similar shifts in alpha synchronization
2. alpha shifts after pre- and retrocues are followed by opposing responses to upcoming stimuli
3. alpha lateralization appears to index access to retinotopically stored WM contents

Thanks!

OHBA

Kia Nobre

Mark Stokes

Mark Woolrich

Robert Mok

George Wallis

Lena Walther *(Humboldt Uni, Berlin)*

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Wellcome Trust
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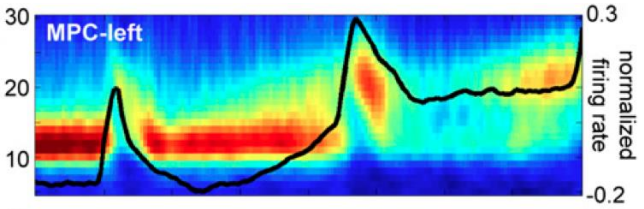
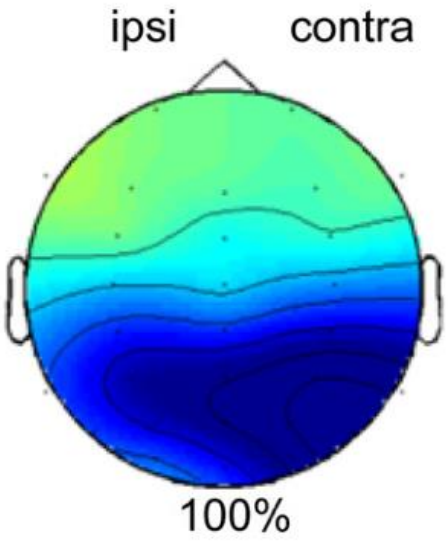
Why Is the Prestimulus Alpha State a Good Predictor of Neural Gain?

1. alpha synchronization in sensory cortex predicts firing rate
   Haegens et al., 2011, Bollimunta et al., 2008, 2011
2. top-down alpha desynchronization reflects attentional gain
   Gould et al., 2011, Gazzaley, 2011, etc.



Haegens et al., 2011



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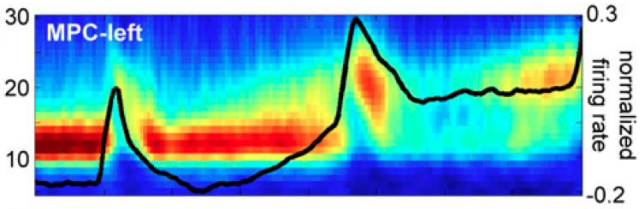

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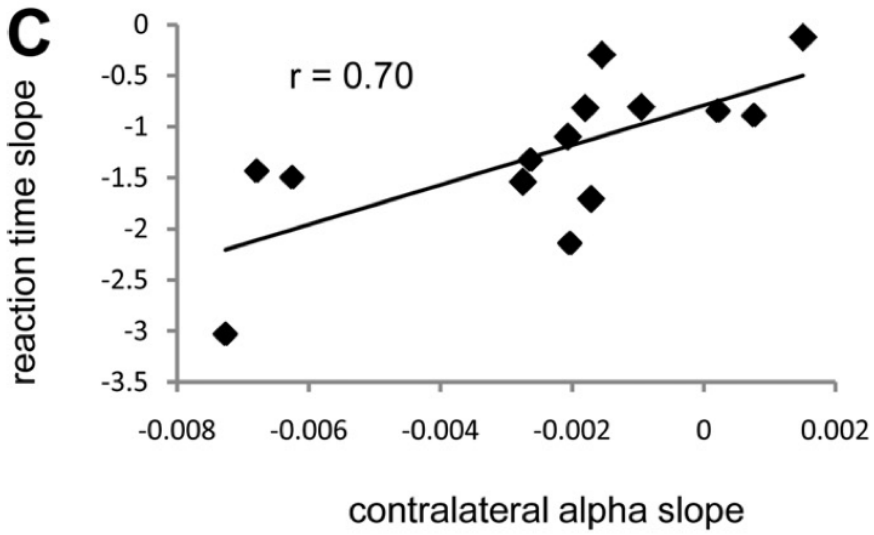

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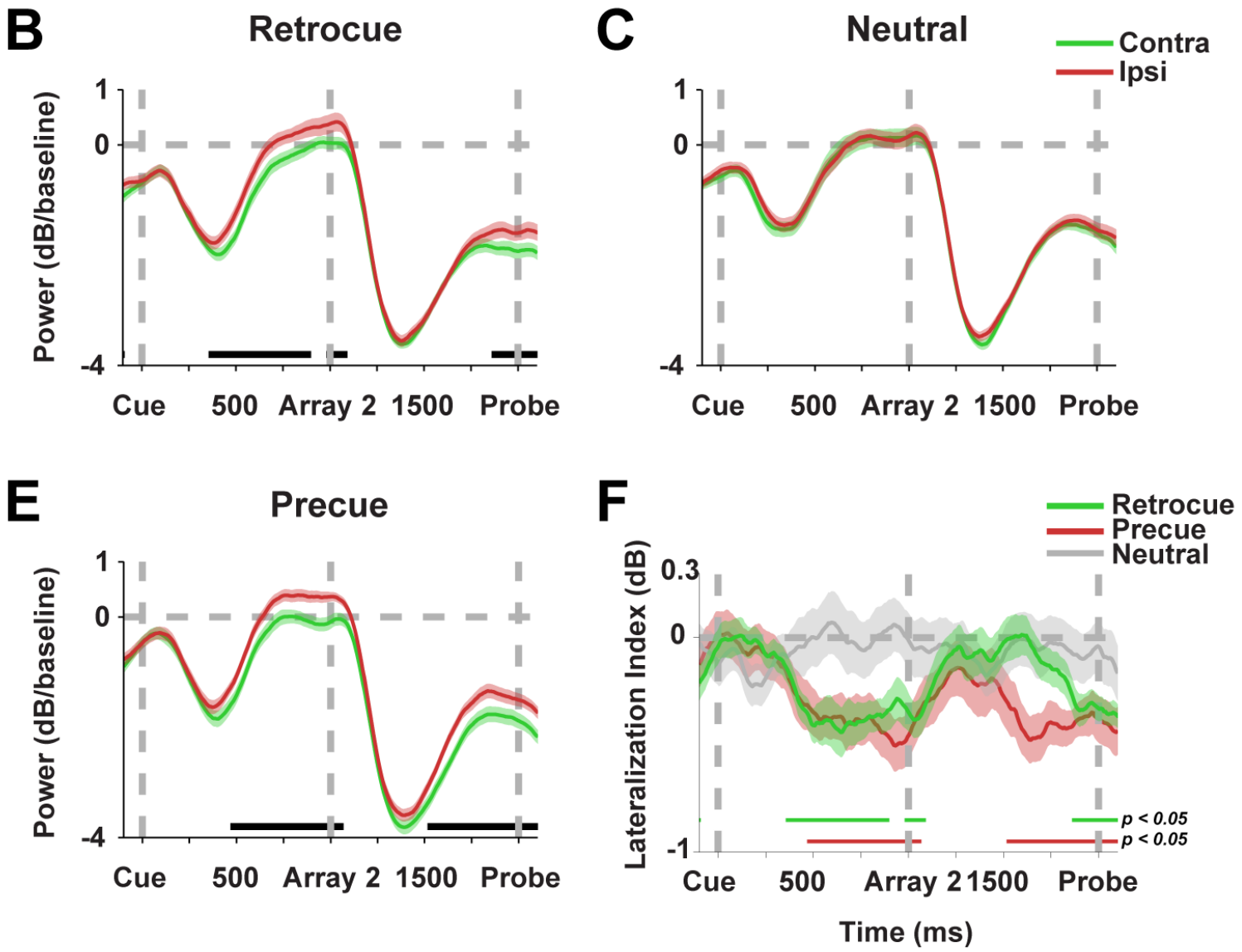
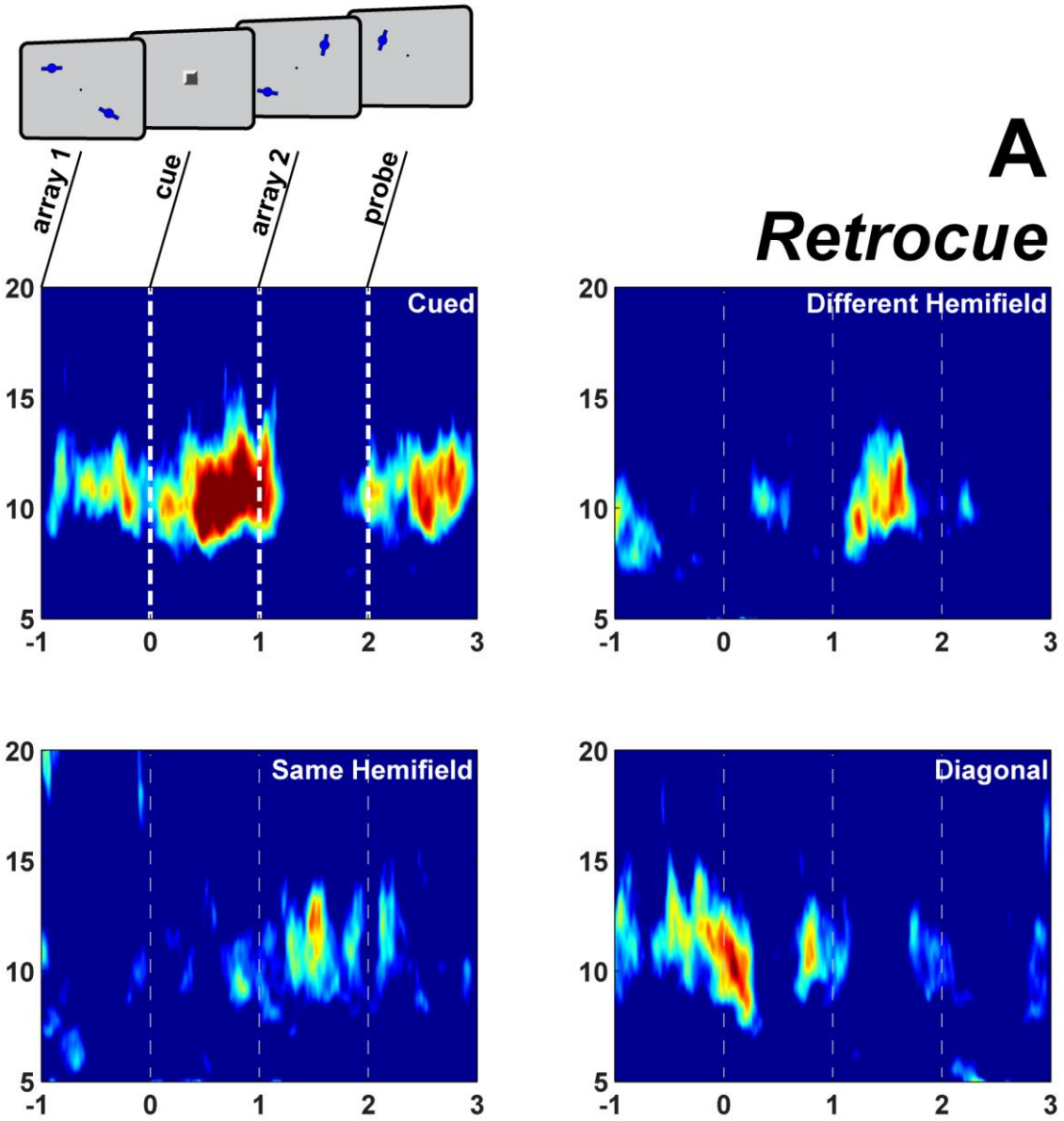


Only the Cued Quadrant Reflects Shifts in Alpha



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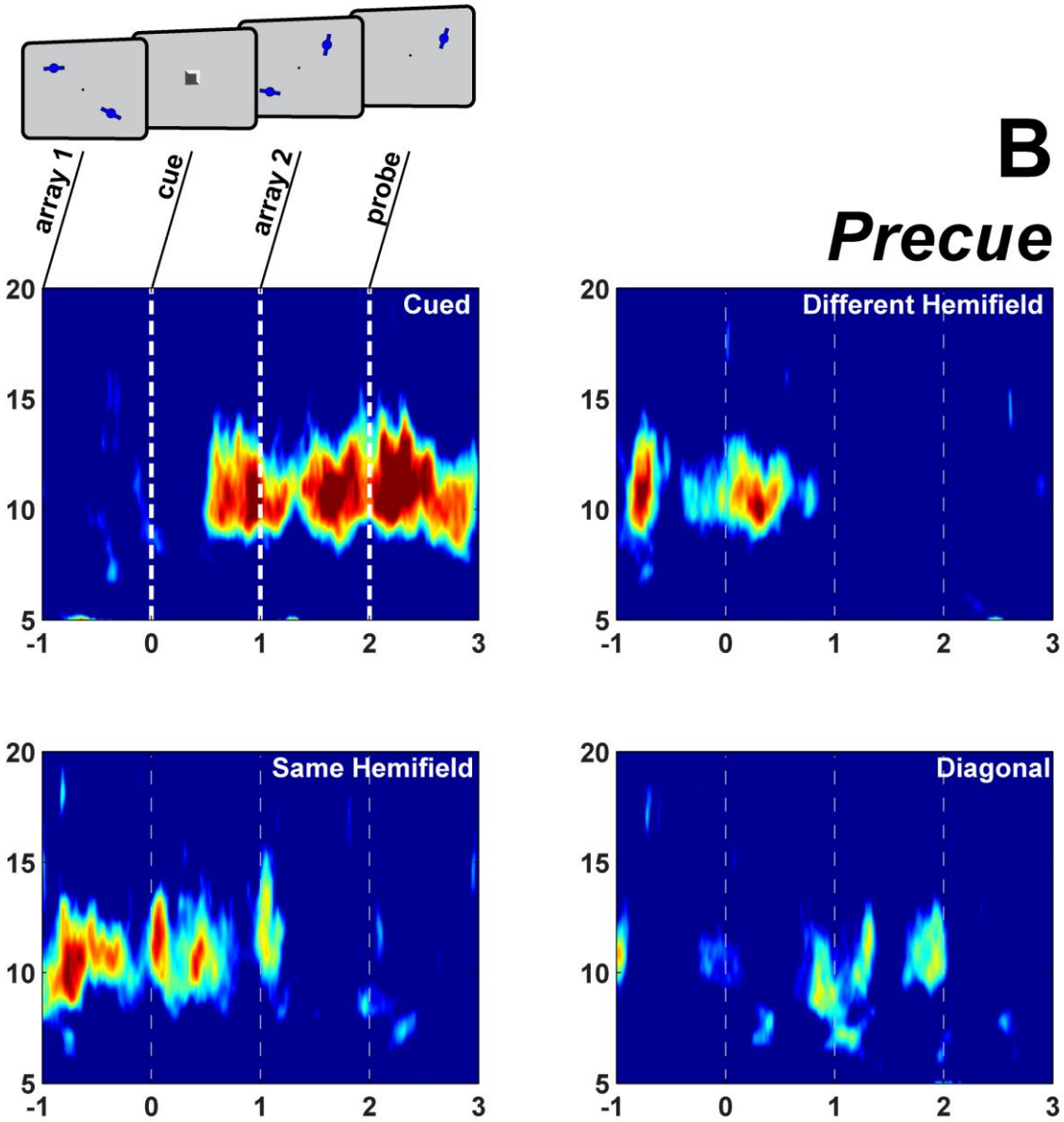
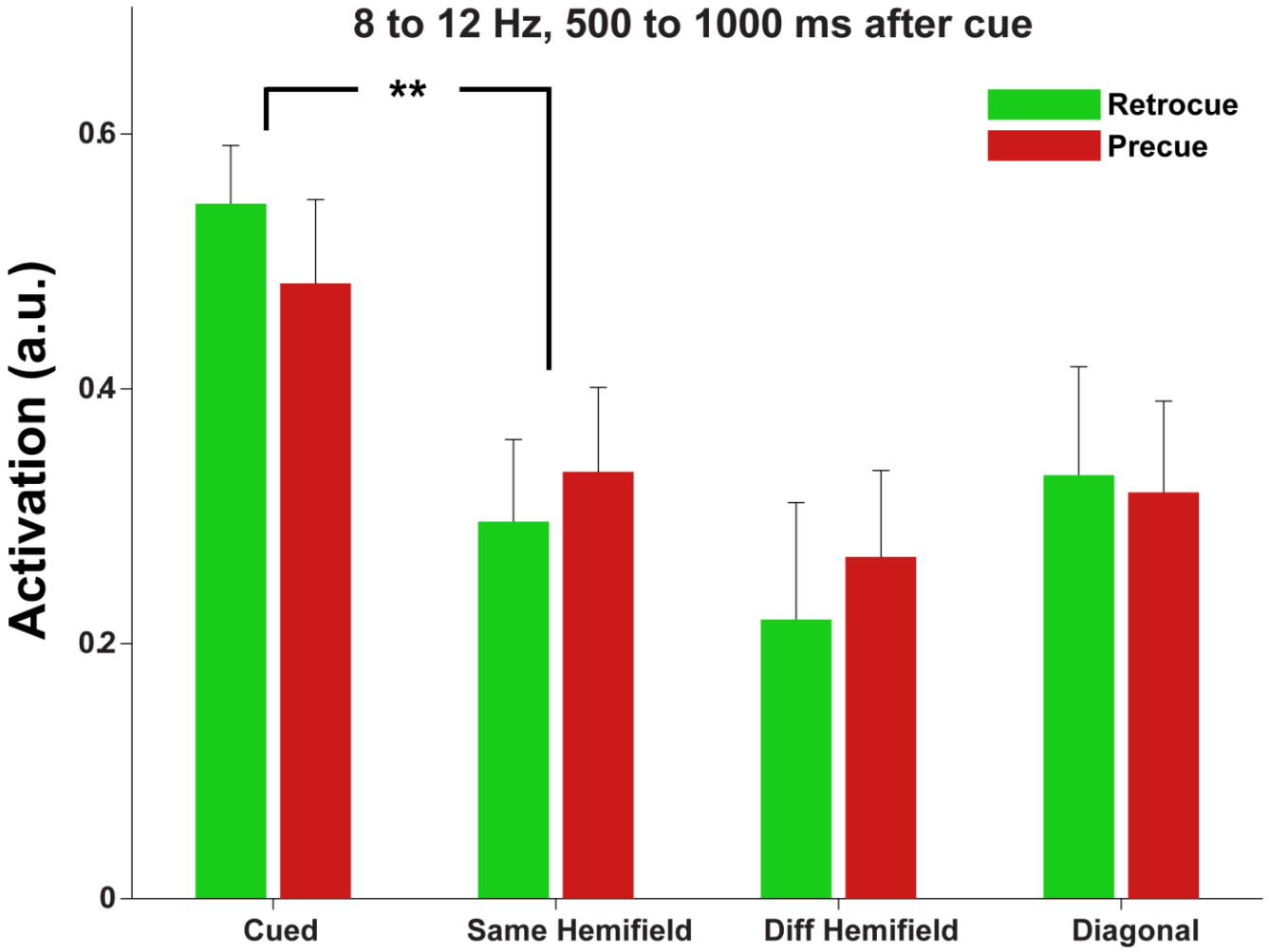
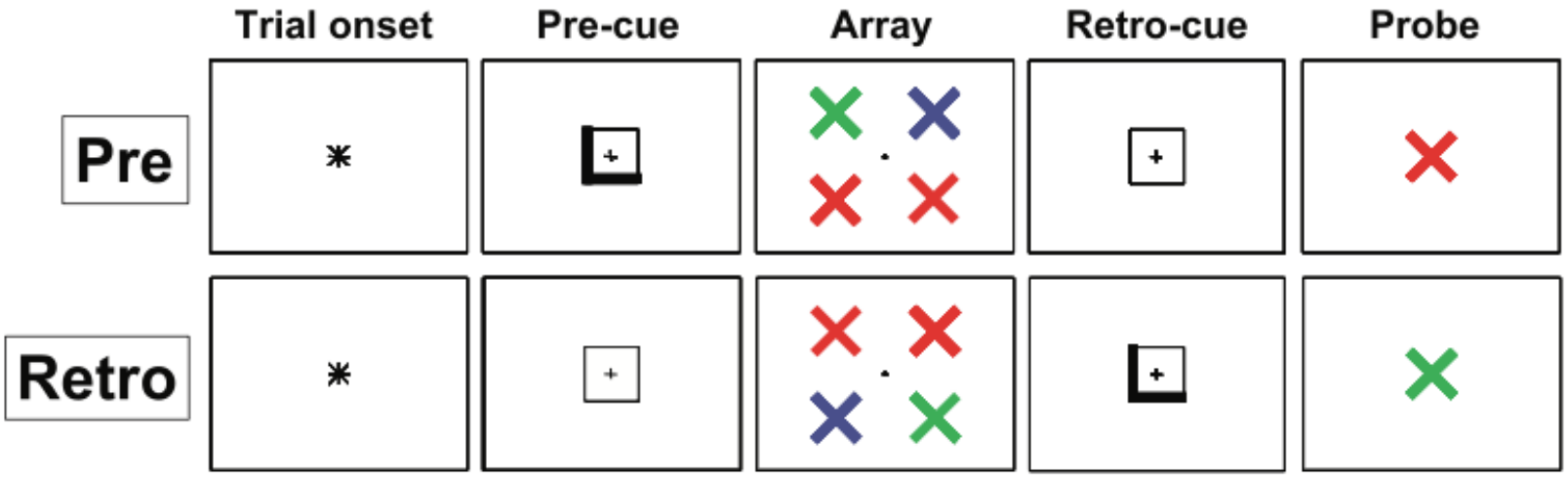


Quadrant Activation Does Not Differ for Pre- and Retrocues

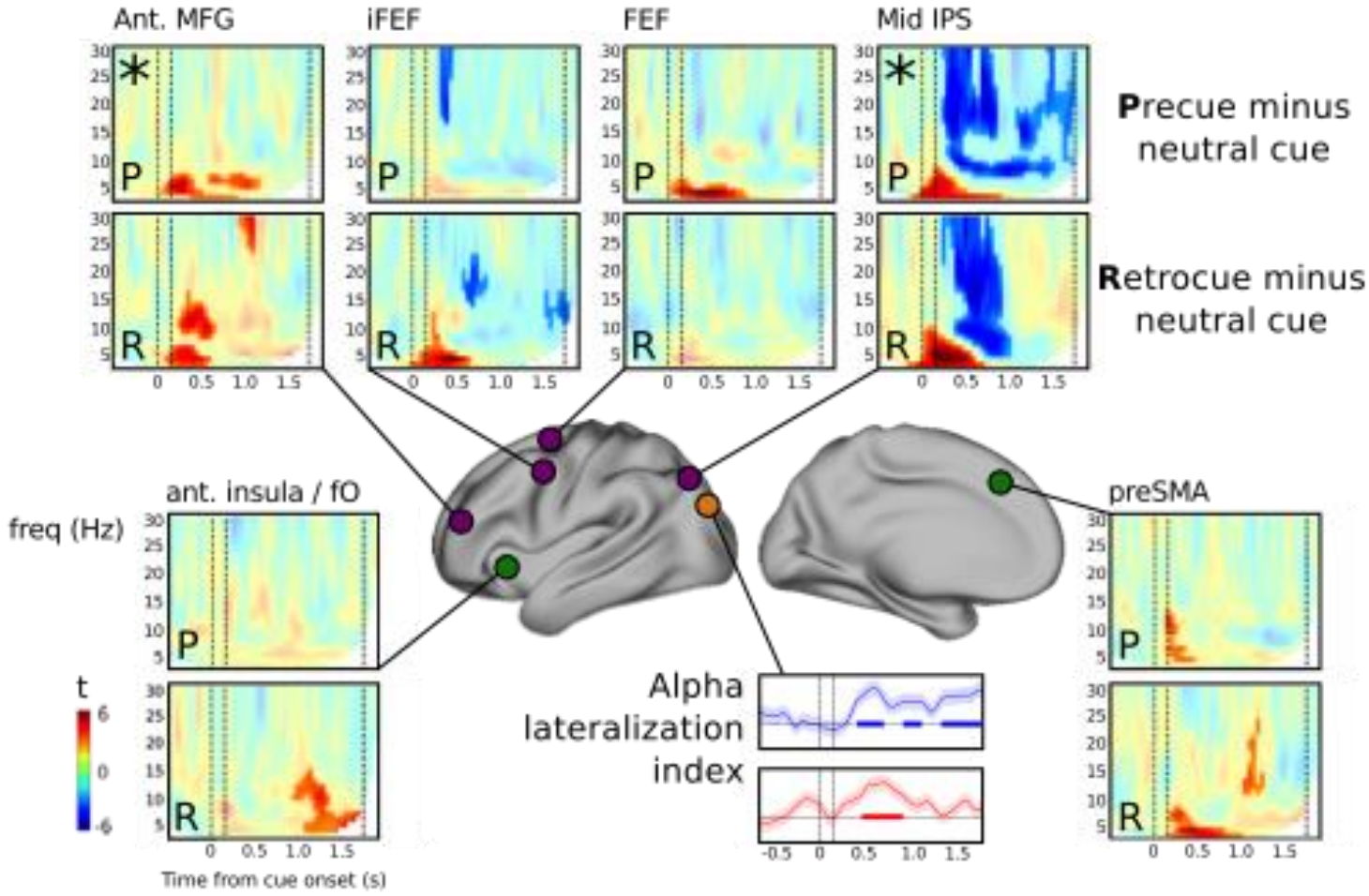


but how does spatial attention act in working memory?



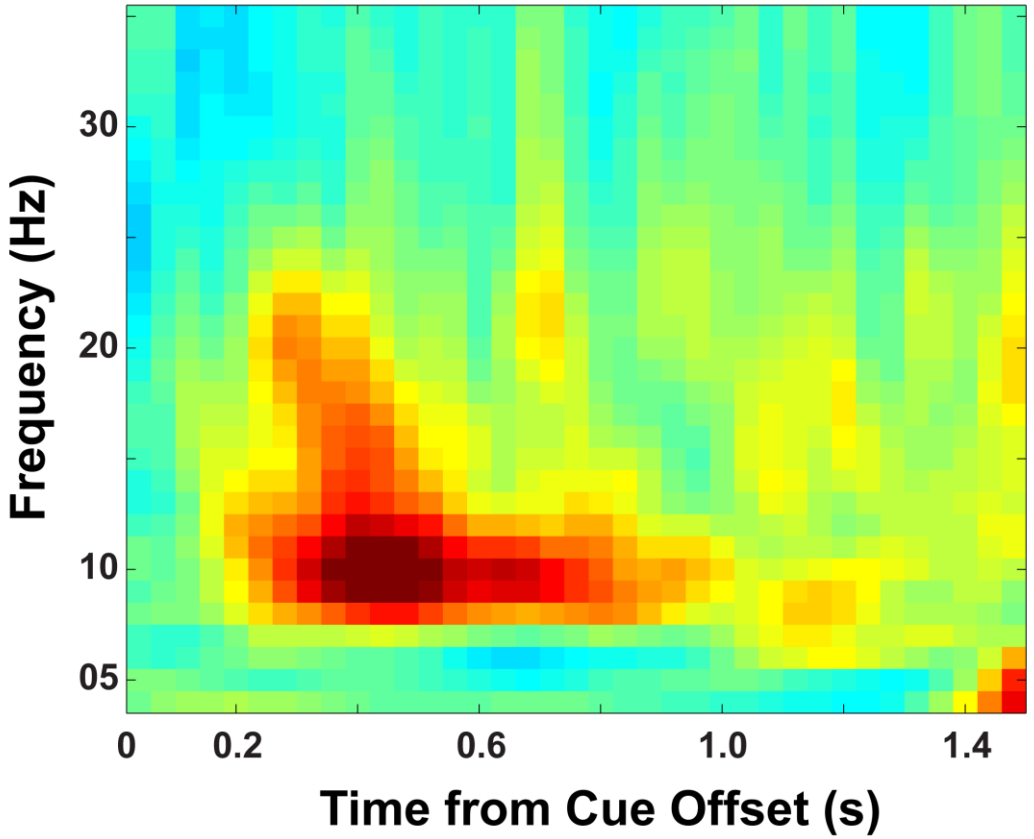
Nobre et al., 2004

Spatiotopic selection is driven by a frontal-parietal control network



Wallis et al., under review

60-80 year olds show similar selection effects



Mok et al., in preparation

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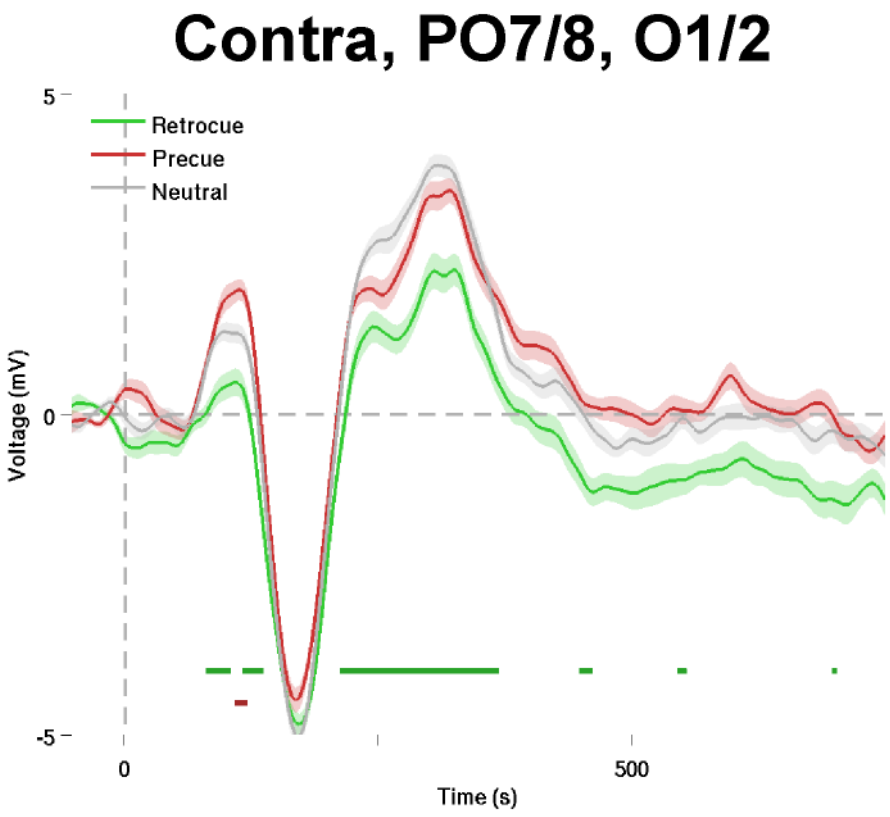
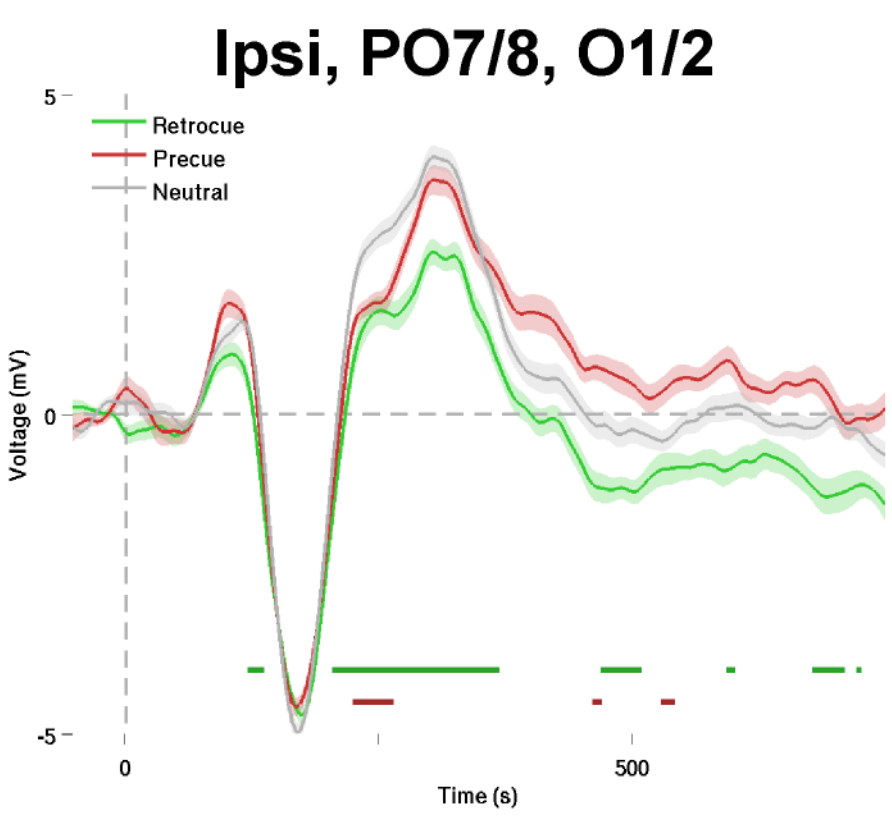
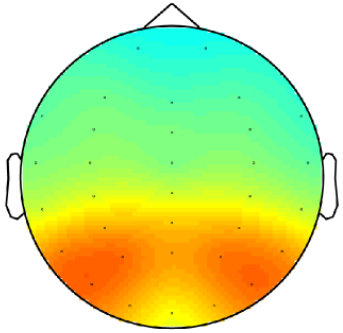
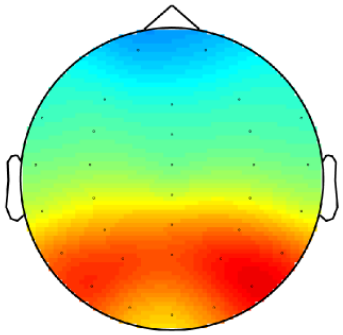




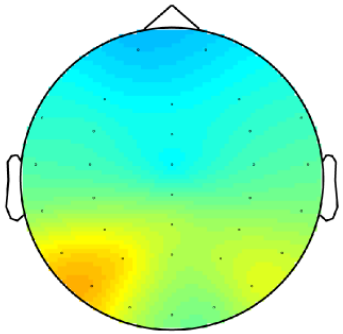
Neutral

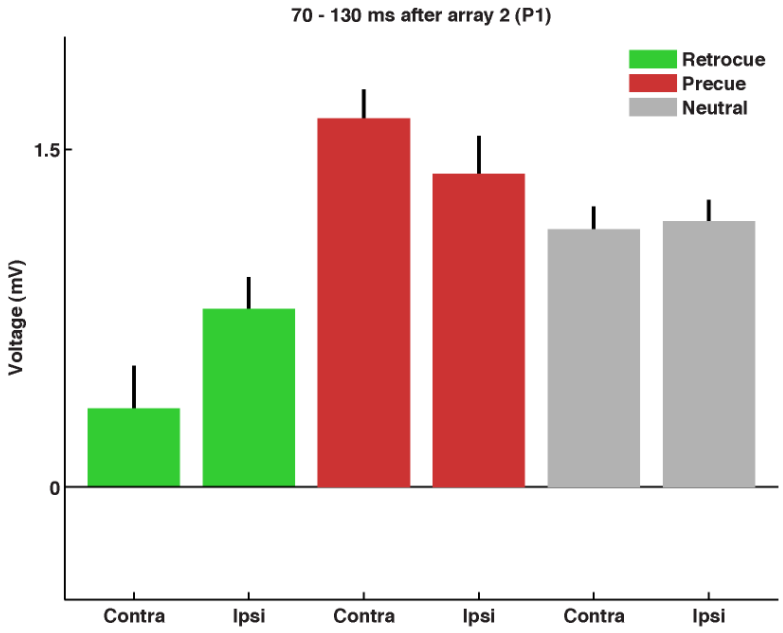


Precue

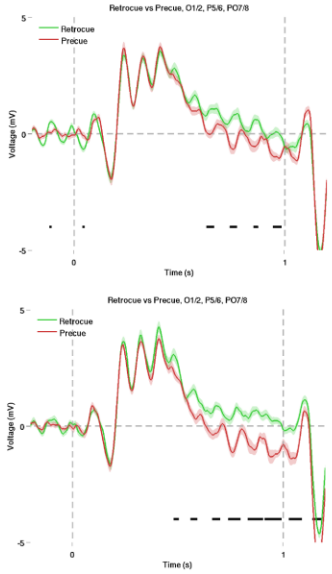


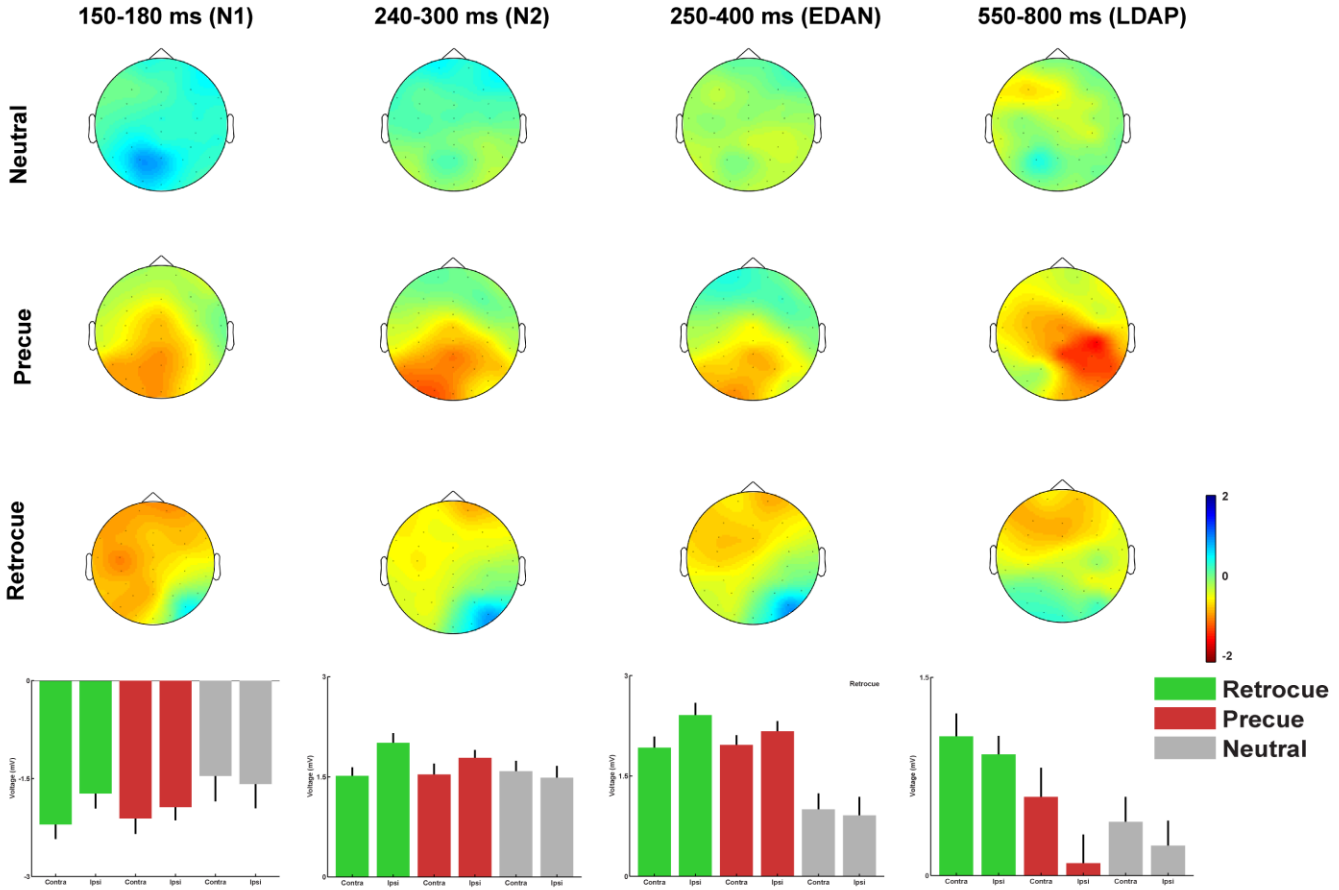
Retrocue

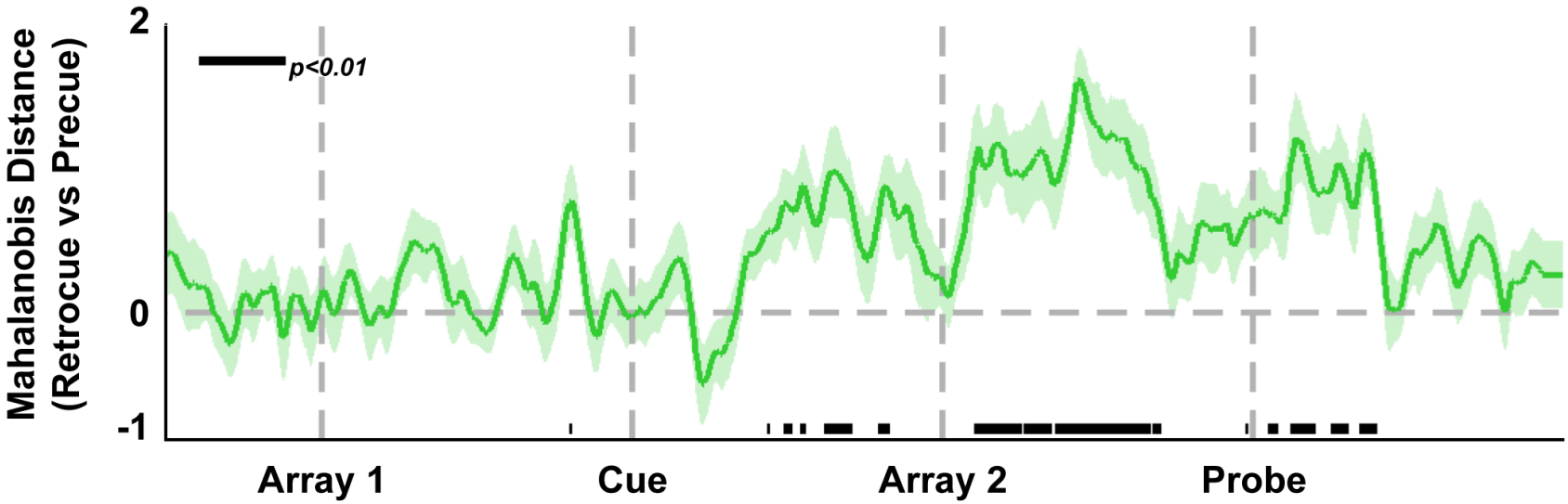




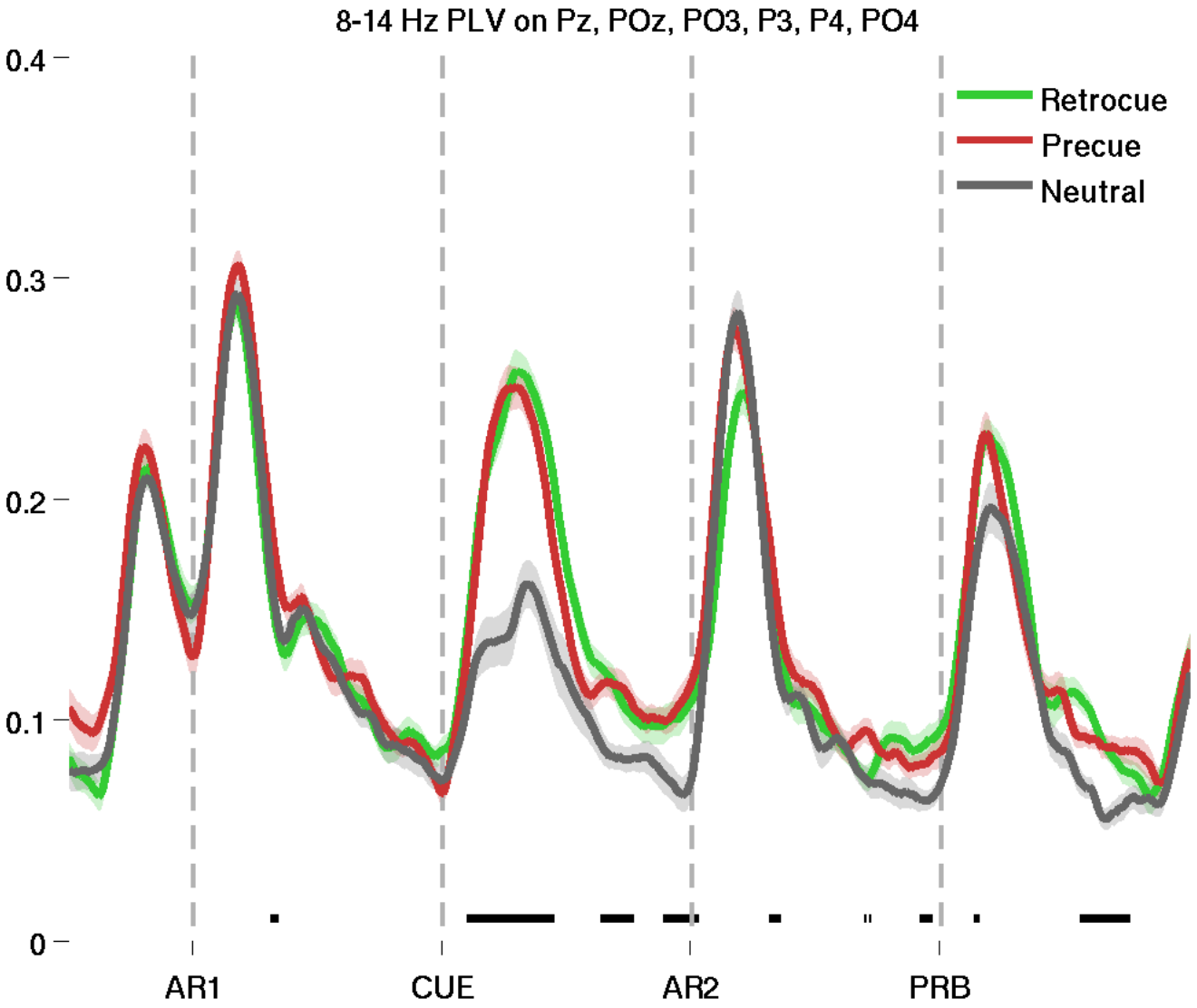
Cues Affect Broadband Lateralization



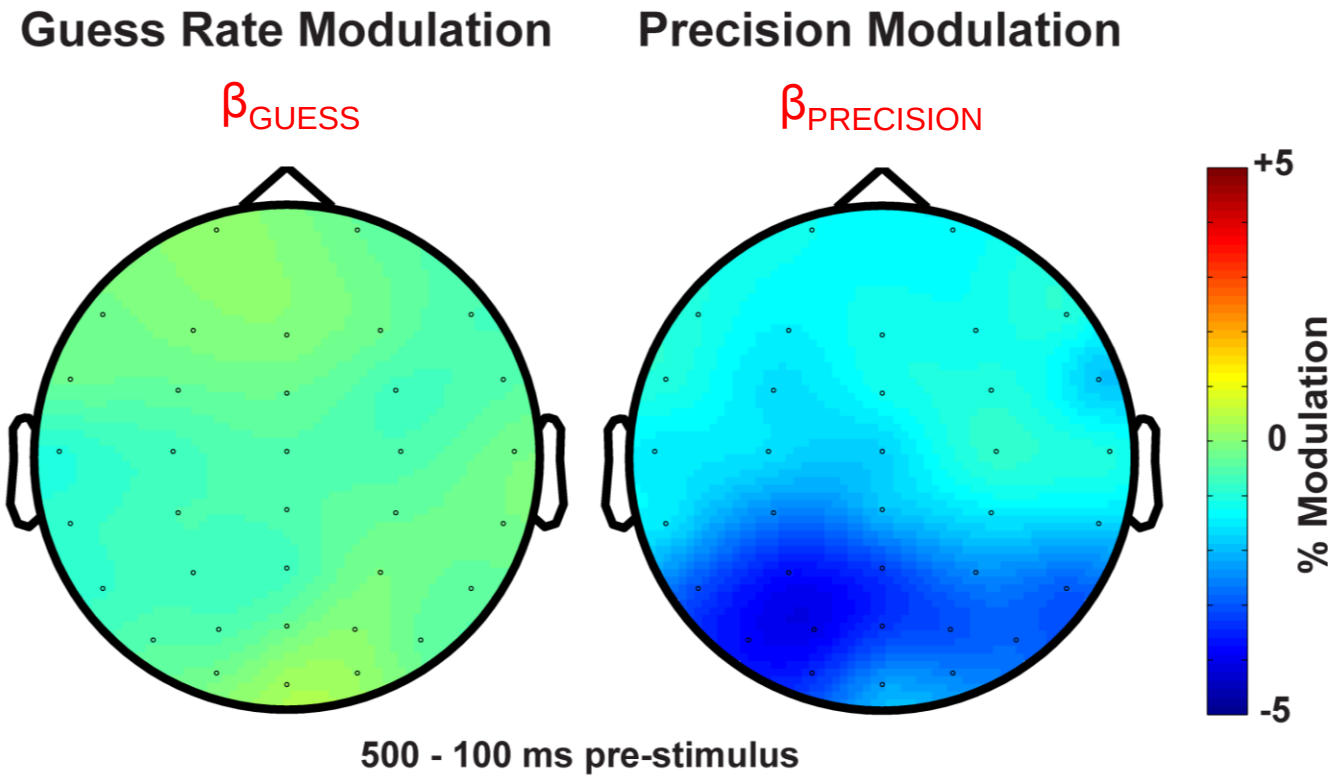



Mahalanobis Distance
(Retrocue vs Precue)
2
0
-1
p<0.01
Array 1
Cue
Array 2
Probe

Sustained Alpha Entrainment After a Cue



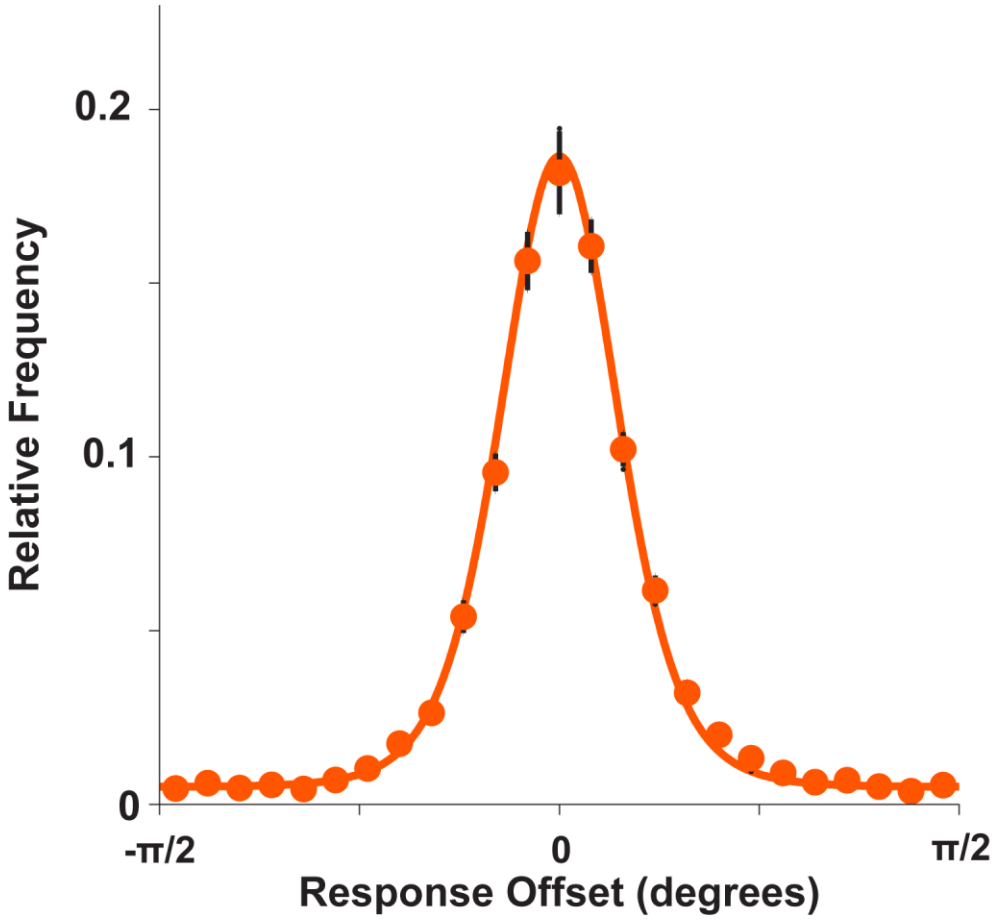
Model-based Analysis



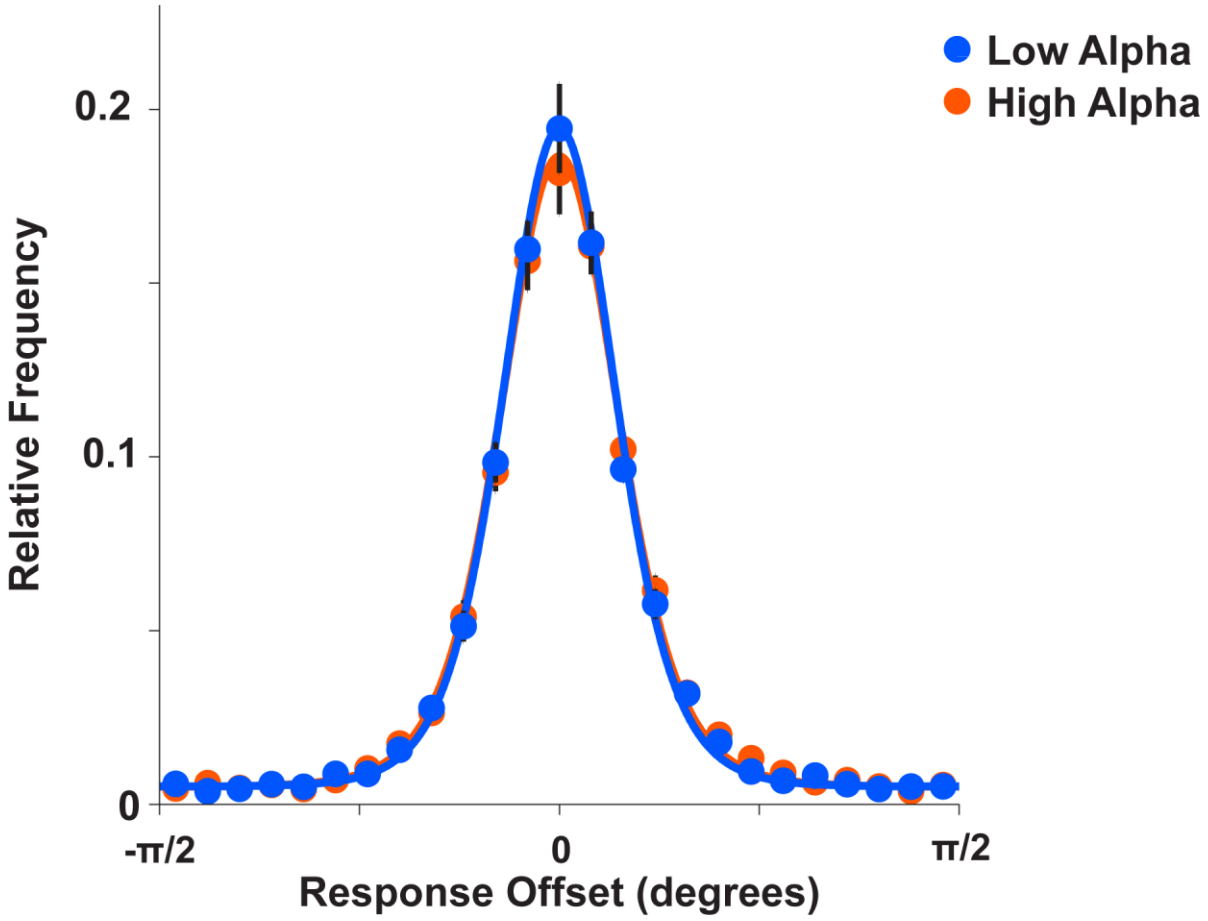
$$p(\theta,\beta_{GUESS}) = (1 - P_{GUESS}*\beta*\alpha_{POWER})*vonMises(\theta,\kappa) + P_{GUESS}*\beta*\alpha_{POWER}/2\pi$$

$$p(\theta,\beta_{PRECISION}) = (1 - P_{GUESS})*vonMises(\theta,\kappa*\beta*\alpha_{POWER}) + P_{GUESS}/2\pi$$

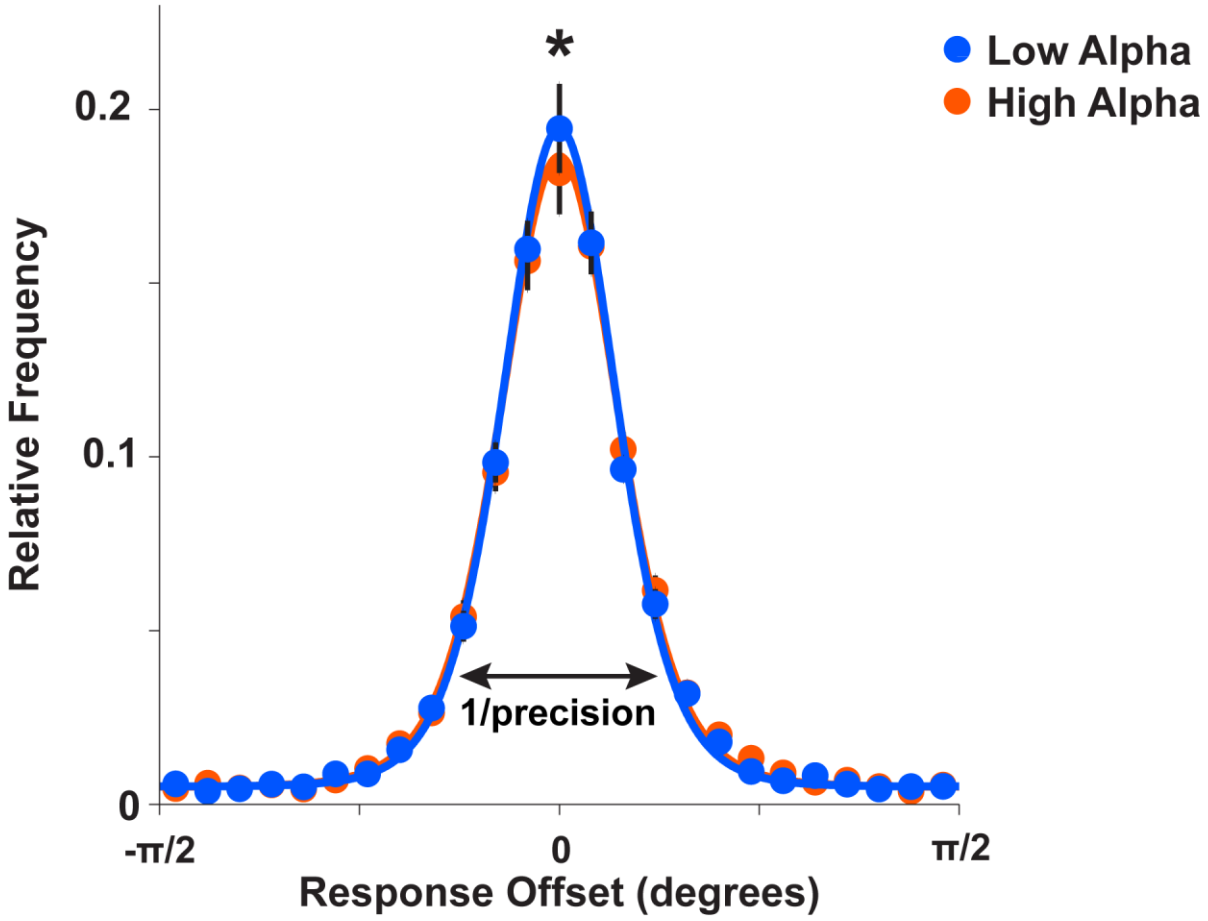
But Does Alpha State Reflect Neural Precision?



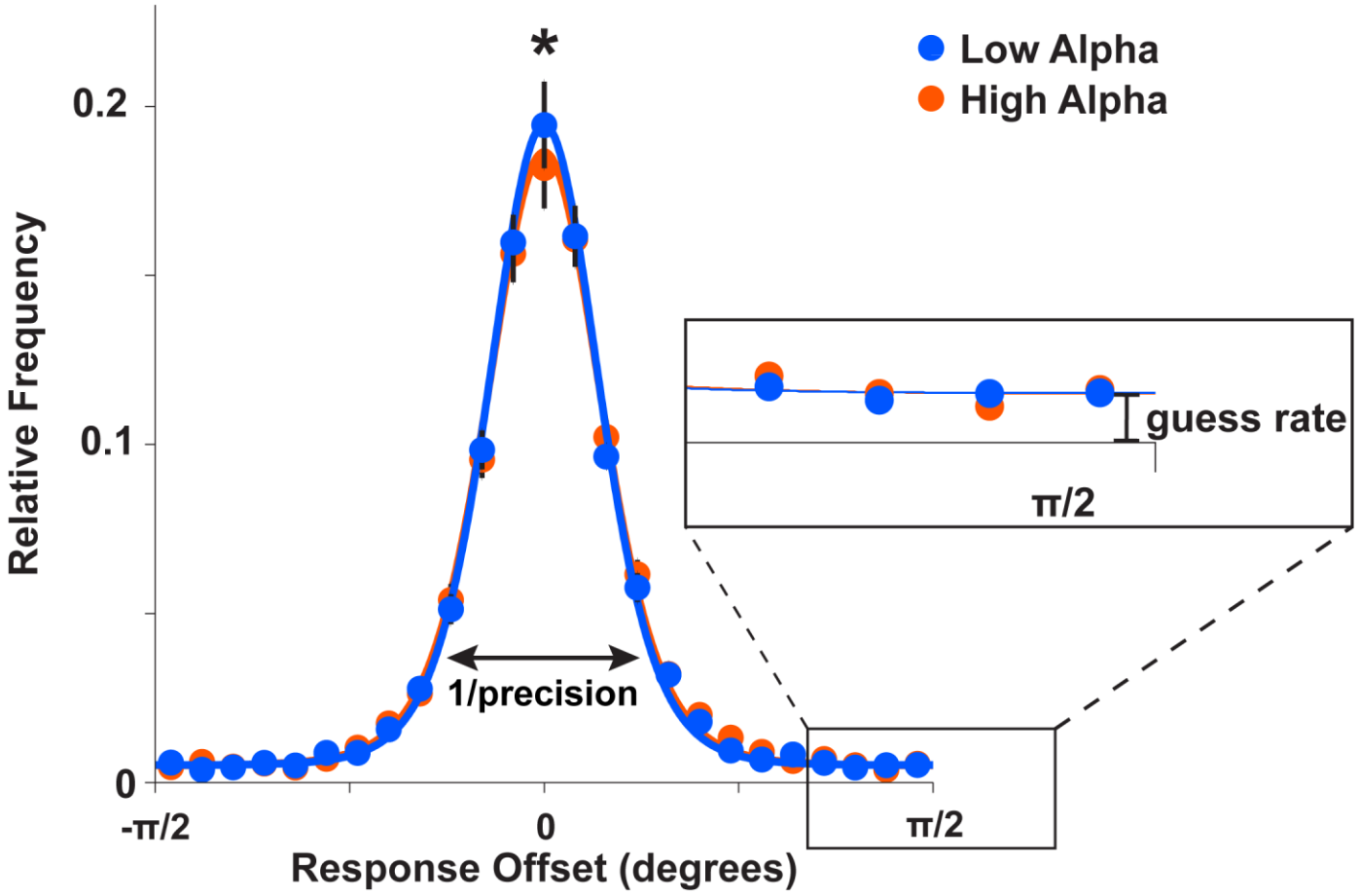
Median Split Analysis



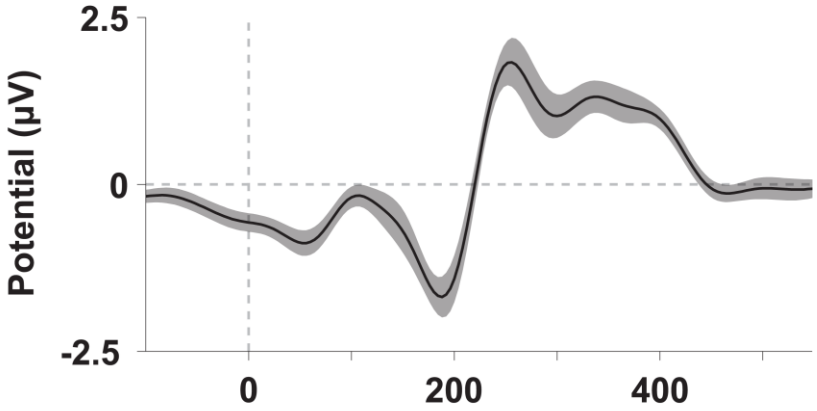
Median Split Analysis

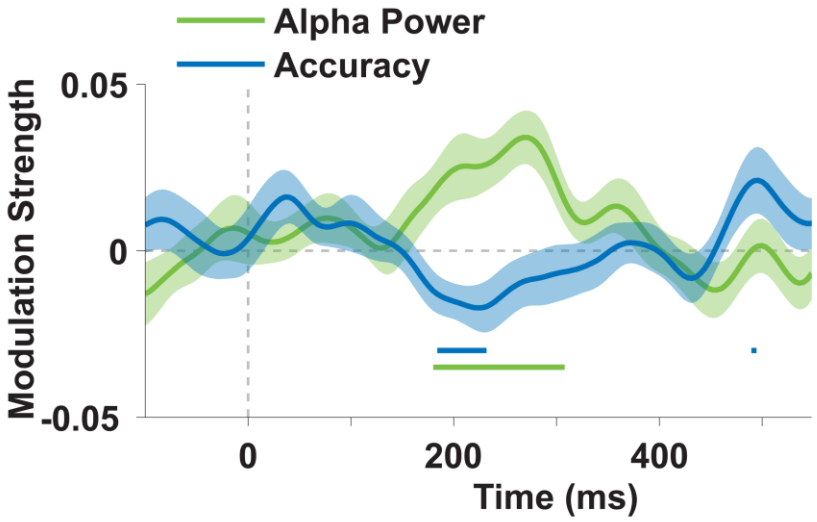


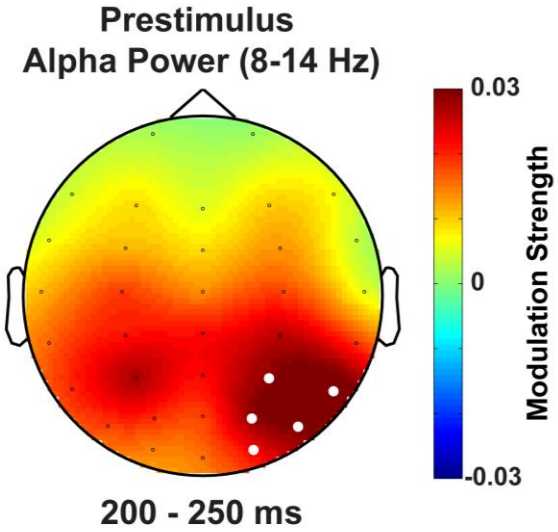
Median Split Analysis

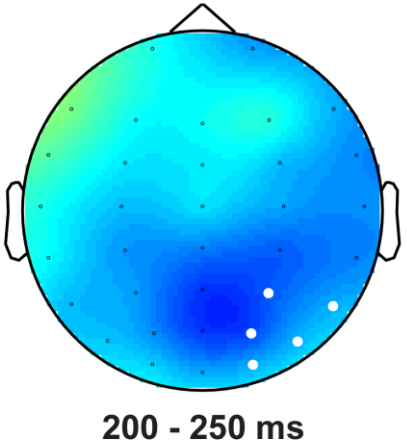


ERP Magnitude Mediates the Influence of the Alpha State on WM Accuracy





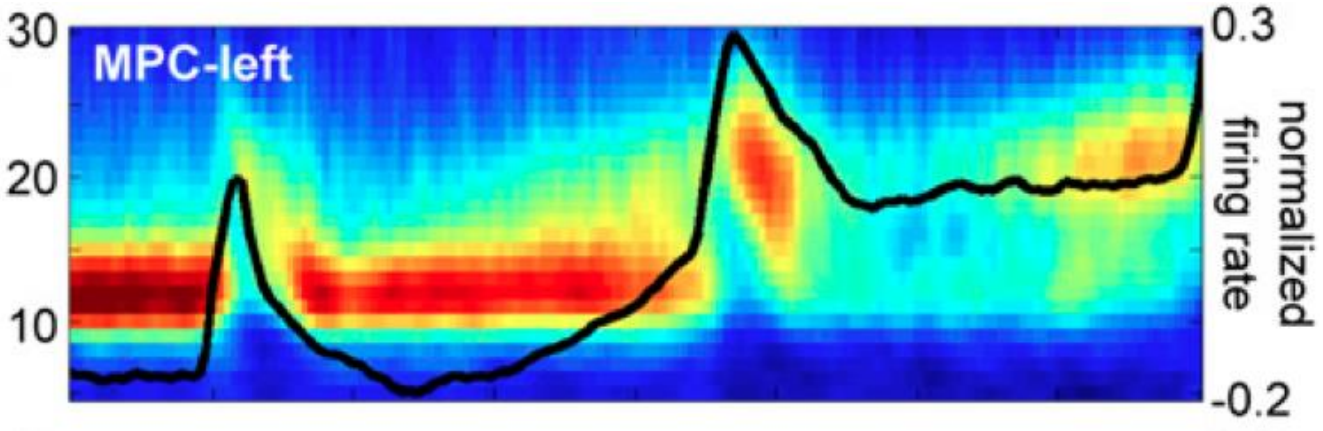




Why Are Alpha Oscillations a Good Predictor of Neural Gain?

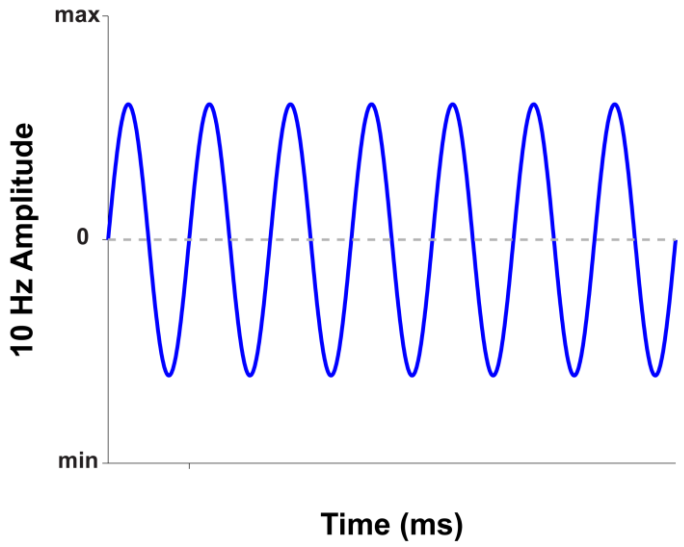
alpha synchronization in cortex predicts firing rate

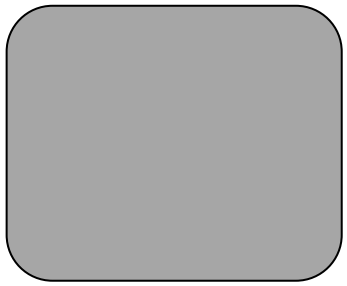
Haegens et al., 2011, Bollimunta et al., 2008, 2011

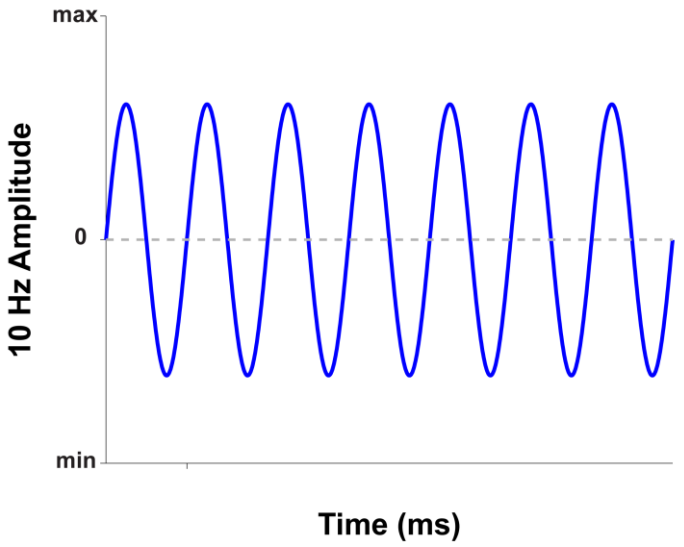


Why Are Alpha Oscillations a Good Predictor of Neural Gain?

spatial attention shifts lead to lateralized amplitude reductions of 10 Hz oscillations







Gould et al., 2011

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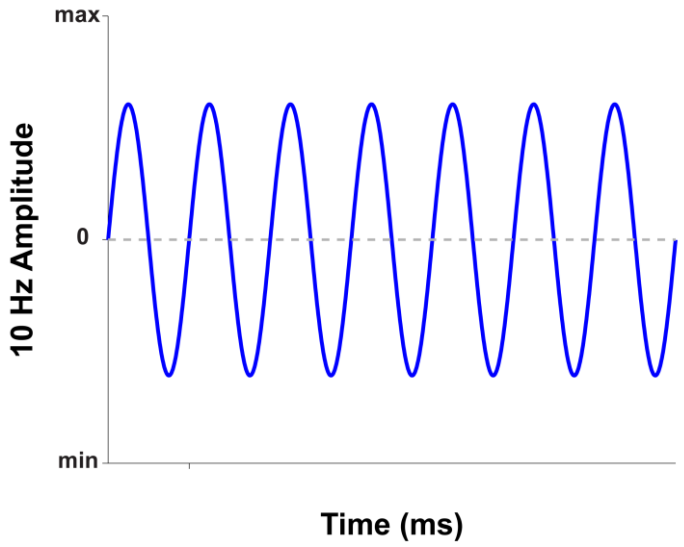

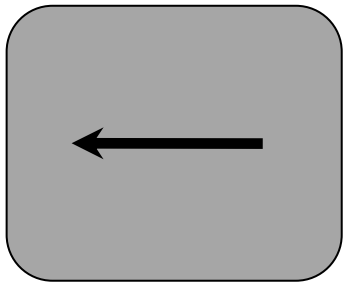

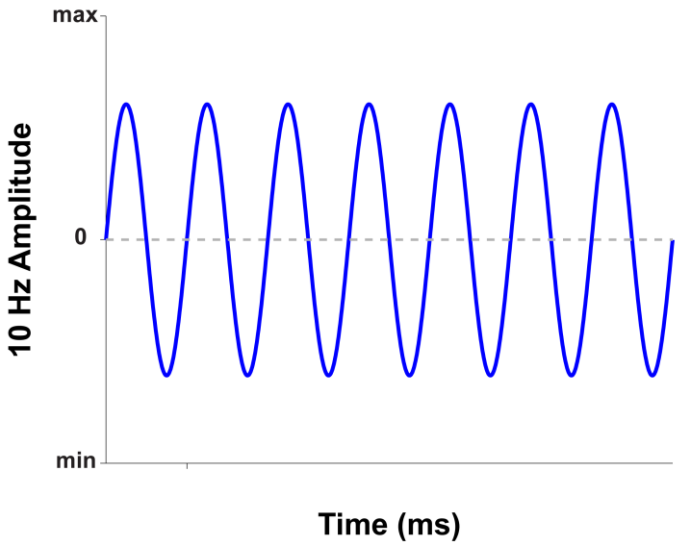

Gould et al., 2011

Thanks!

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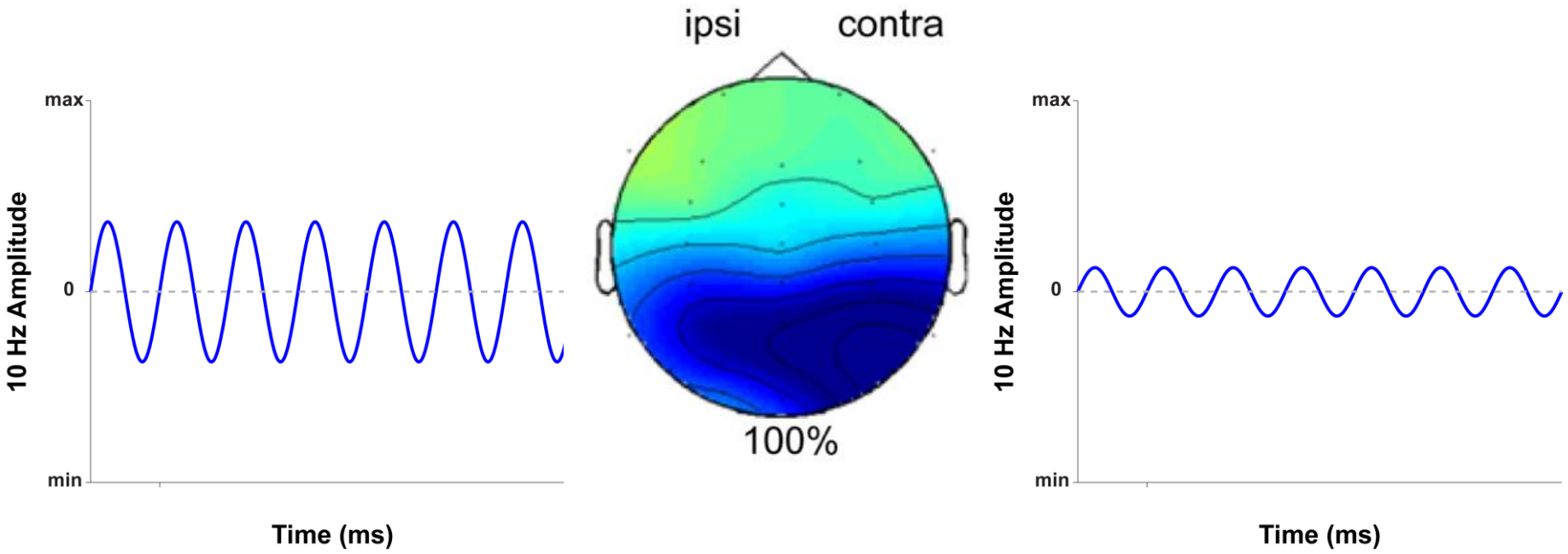

Gould et al., 2011