

Pre-stimulus endogenous activity modulates category tuning and influences behavior

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Max G'Sell⁴, Avniel Singh Ghuman^{2,3}

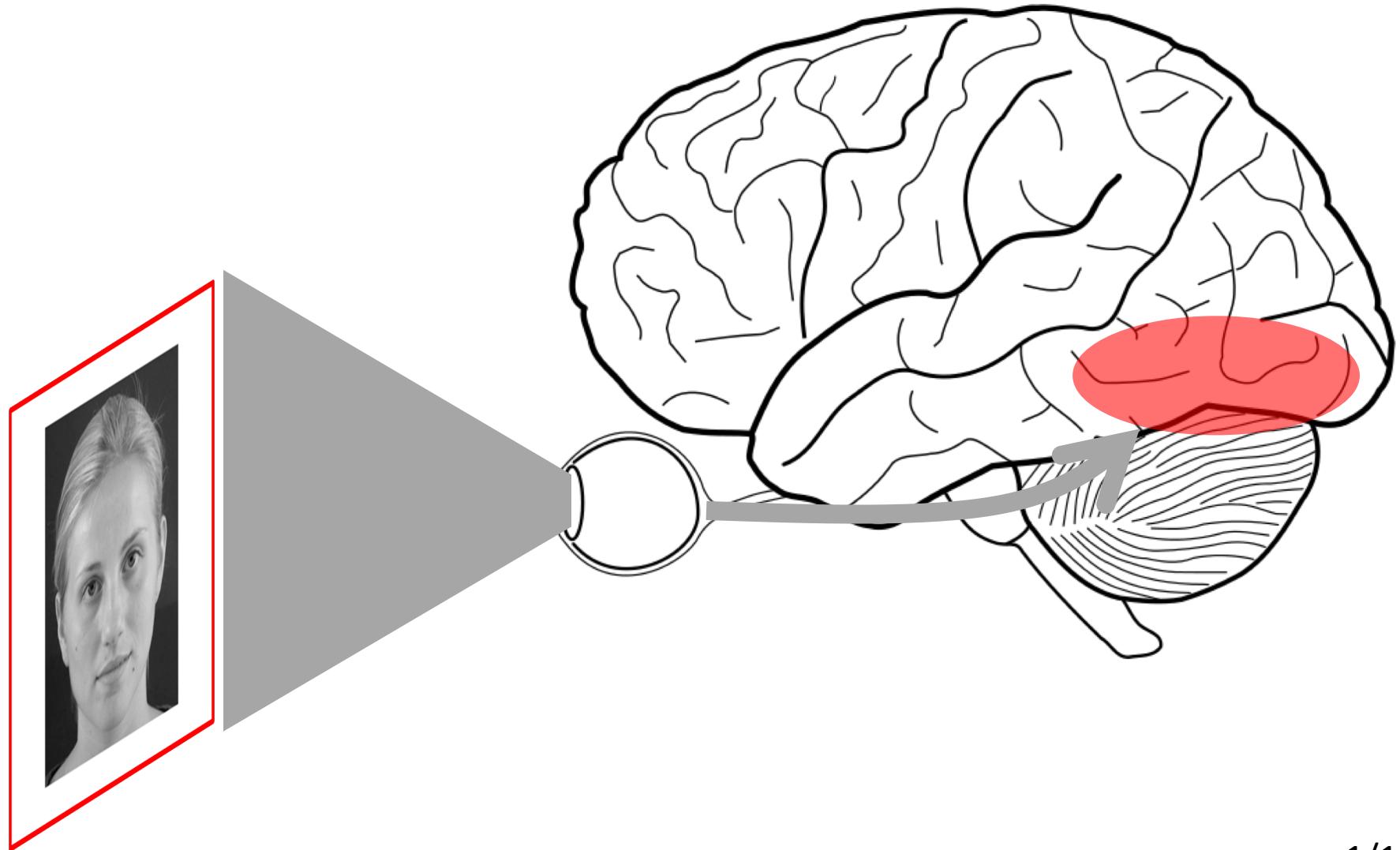
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² Center for the Neural Basis of Cognition, Carnegie Mellon University and
University of Pittsburgh

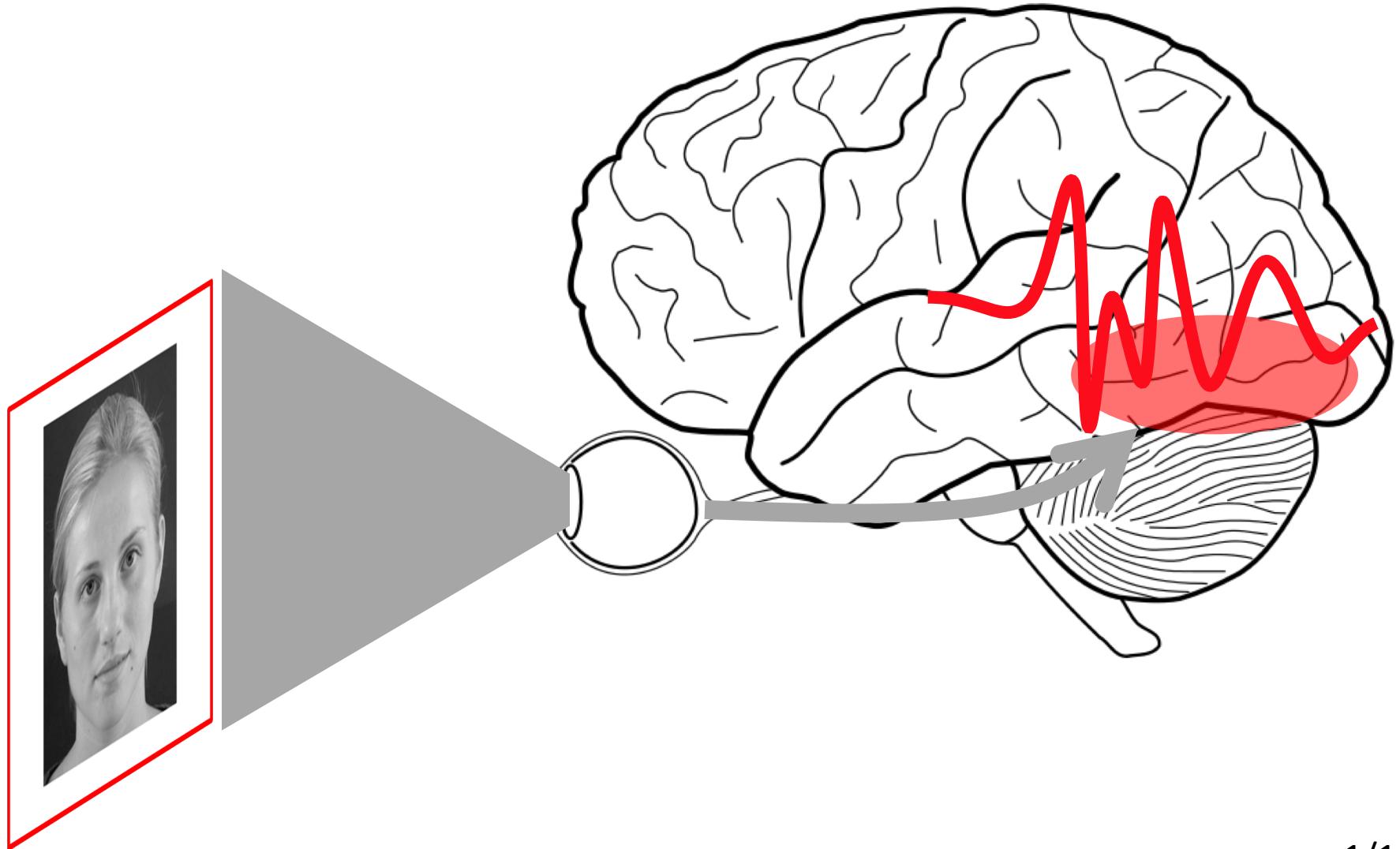
³ Dept. of Neurological Surgery, University of Pittsburgh

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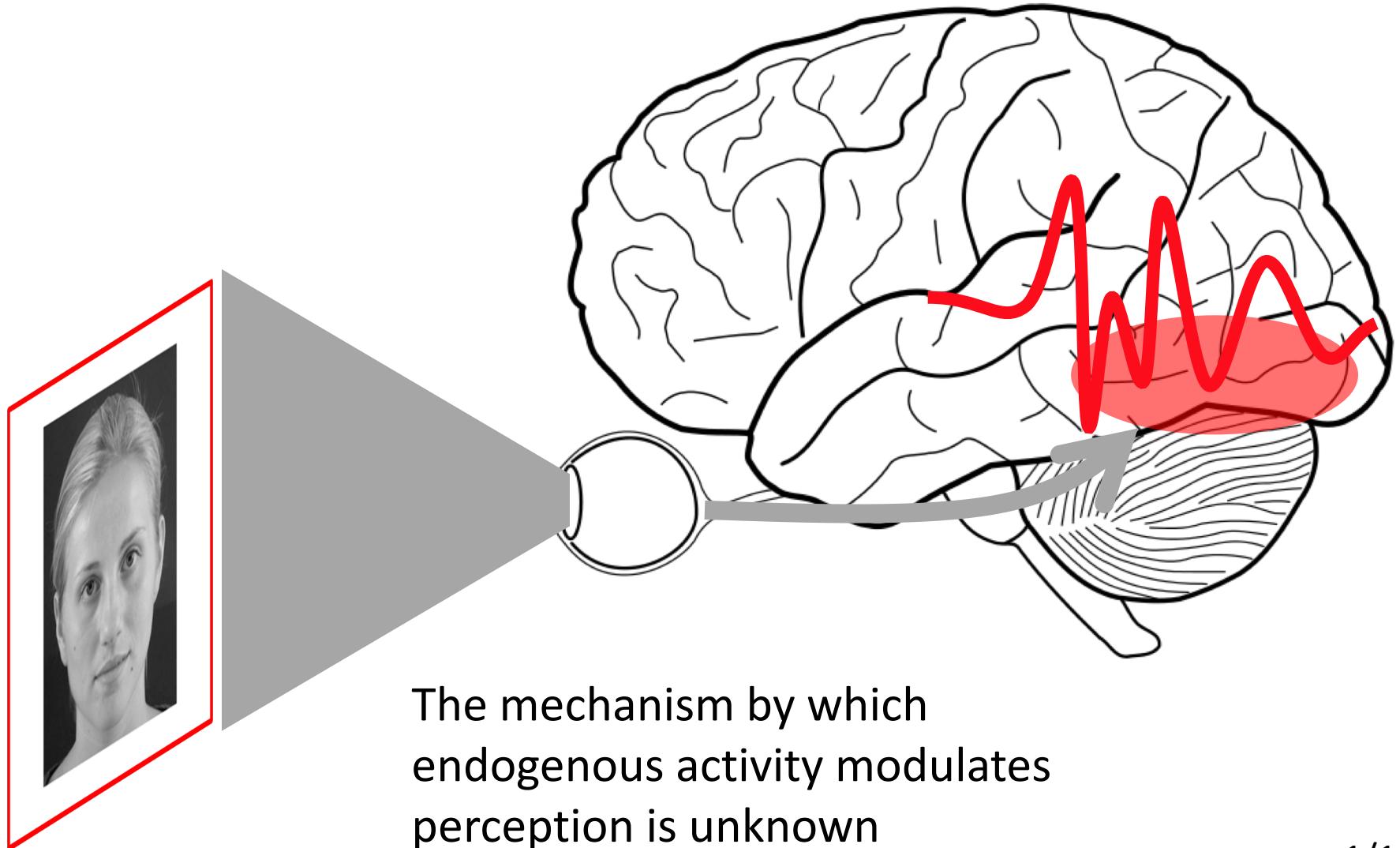
Perception depends on not only the input



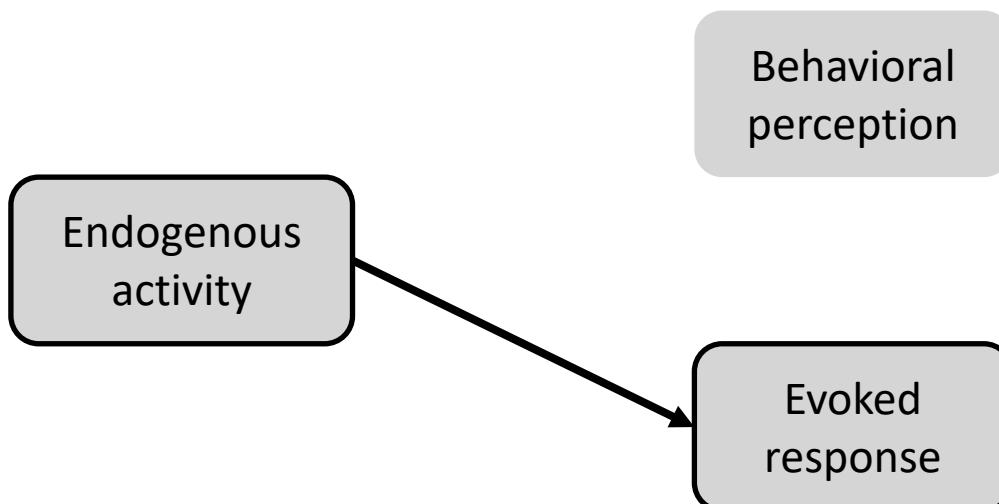
Perception depends on not only the input but also the ongoing endogenous activity in the brain



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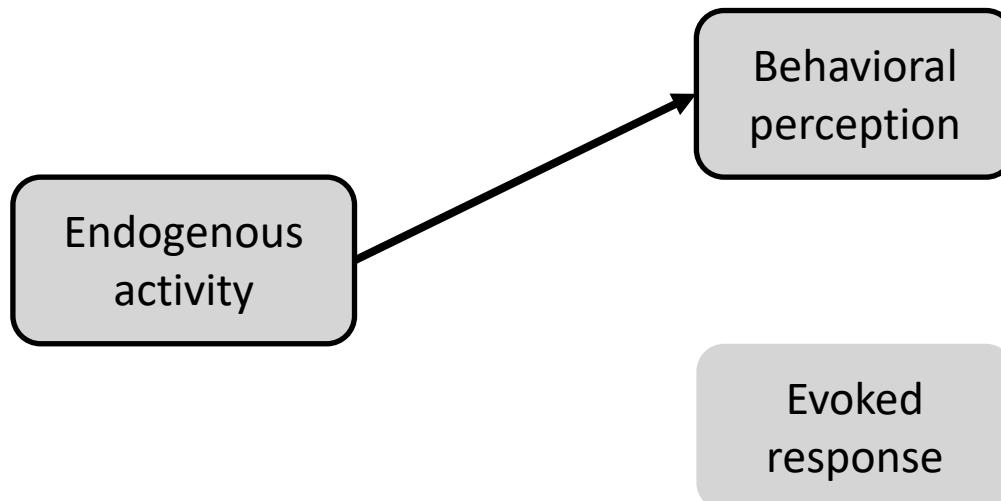


Endogenous activity correlates to post-stim activity and perceptual behavior



Arieli et al., 1996; Kisley and Gerstein, 1999;
Basar, 1980; Brandt et al., 1991;
Nikulin et al., 2007; Henriksson et al., 2015

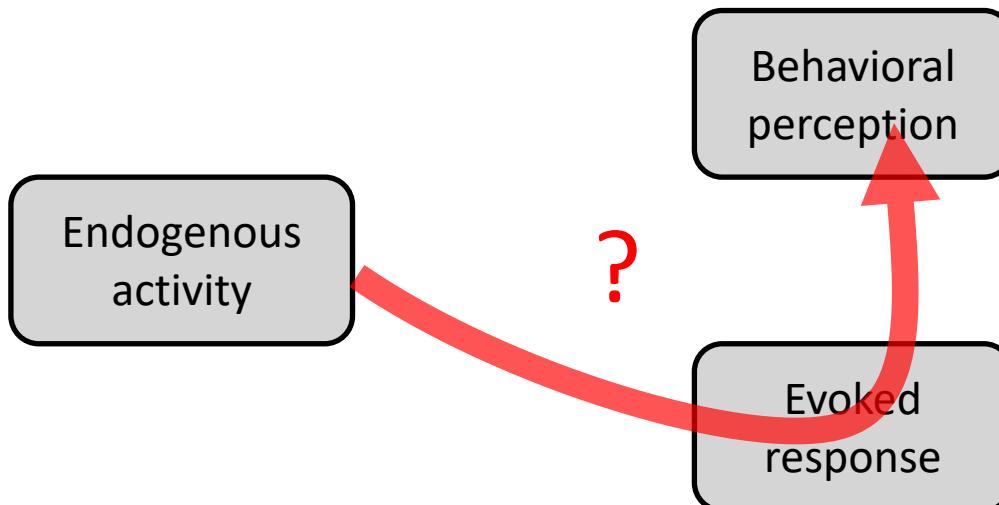
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Thut et al., 2006; Busch et al., 2009;
VanRullen et al., 2011; Ng et al., 2012;
Henry et al., 2012, 2014; Kayser et al., 2016

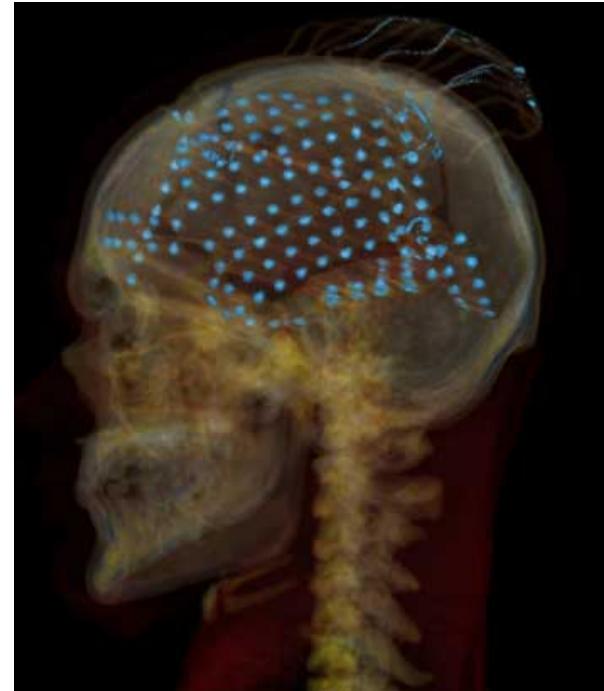
Endogenous activity correlates to post-stim activity and perceptual behavior

- It is not clear if the endogenous activity modulates neural tuning to affect perception.



Experiments

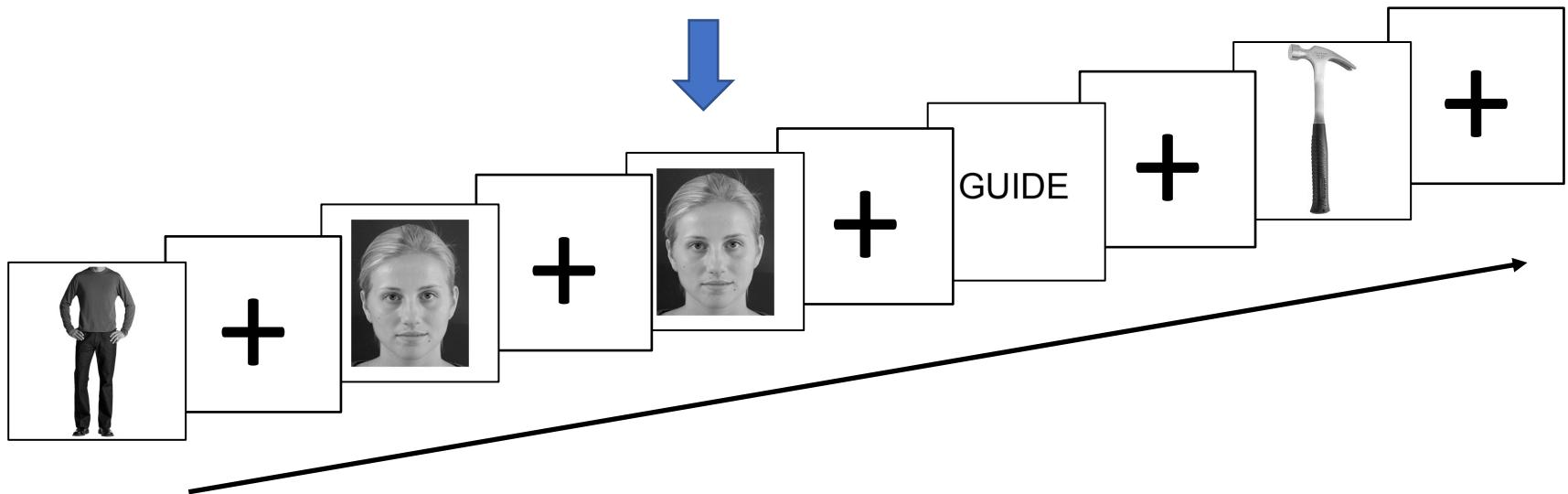
- Intracranial Electroencephalography (iEEG)
- Total number subjects: 30



(Photo Credit: Adeen Flinker)

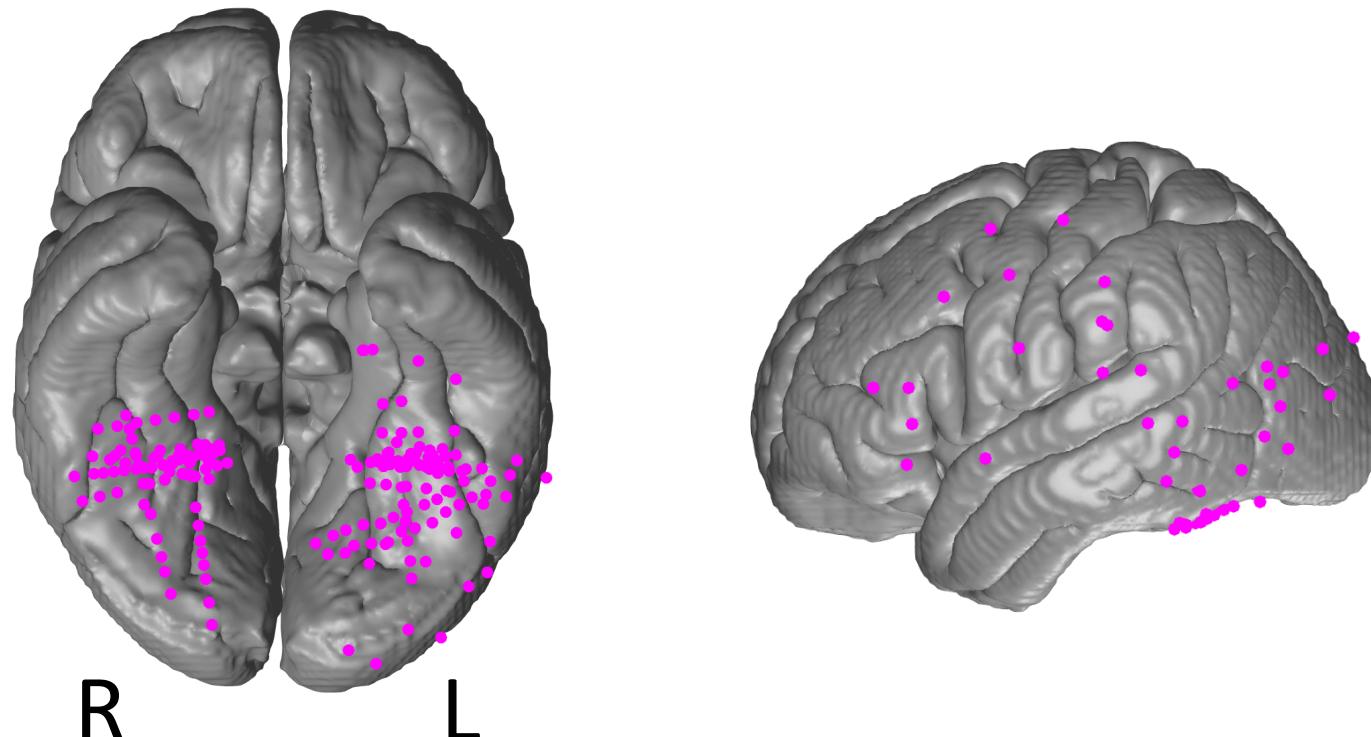
Experiments

- Task:
 - 6 categories (faces, bodies, words, houses, tools, scrambled non-objects)
 - 1-back task to detect repetitions



Experiments

- Category-selective electrodes: 246
 - faces, bodies, words, houses, tools, scrambled non-objects



Questions

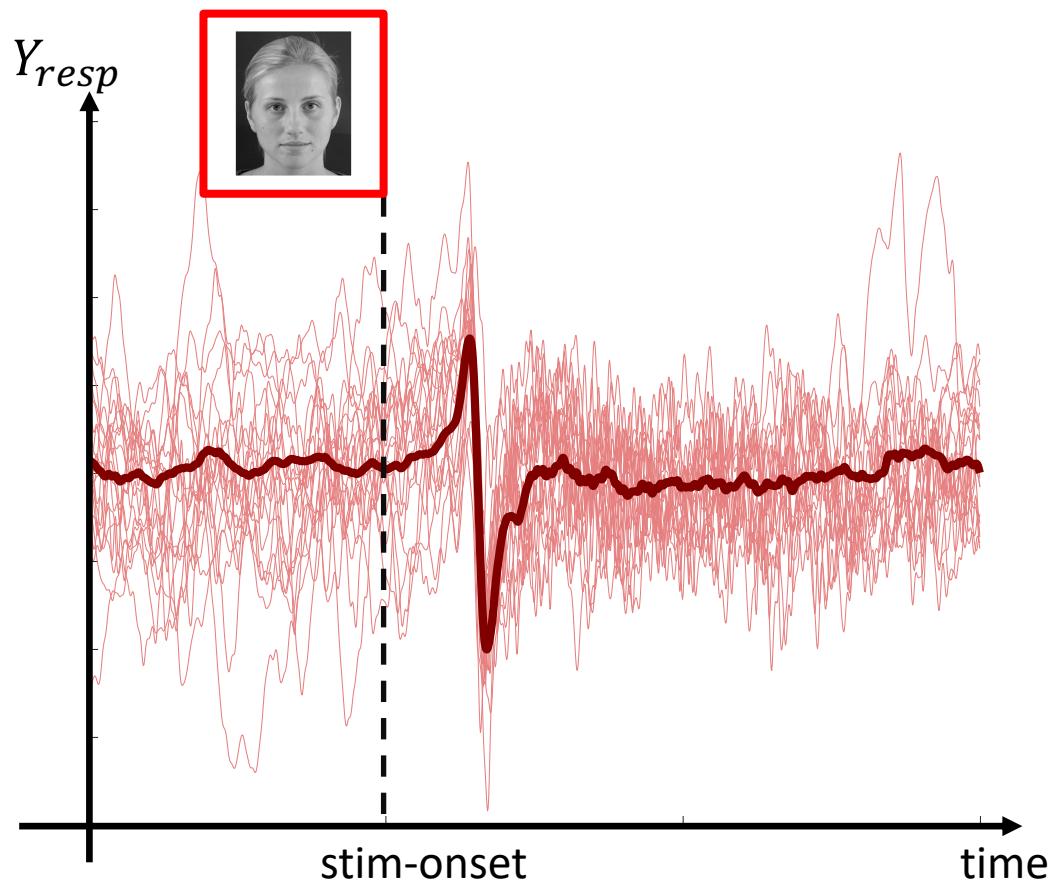
- Does pre-stimulus activity modulate the degree of category tuning in response to visual stimuli?

Questions

- Does pre-stimulus activity modulate the degree of category tuning in response to visual stimuli?
- If so, does the same aspect in pre-stimulus activity that modulates tuning also predict behavioral perception?

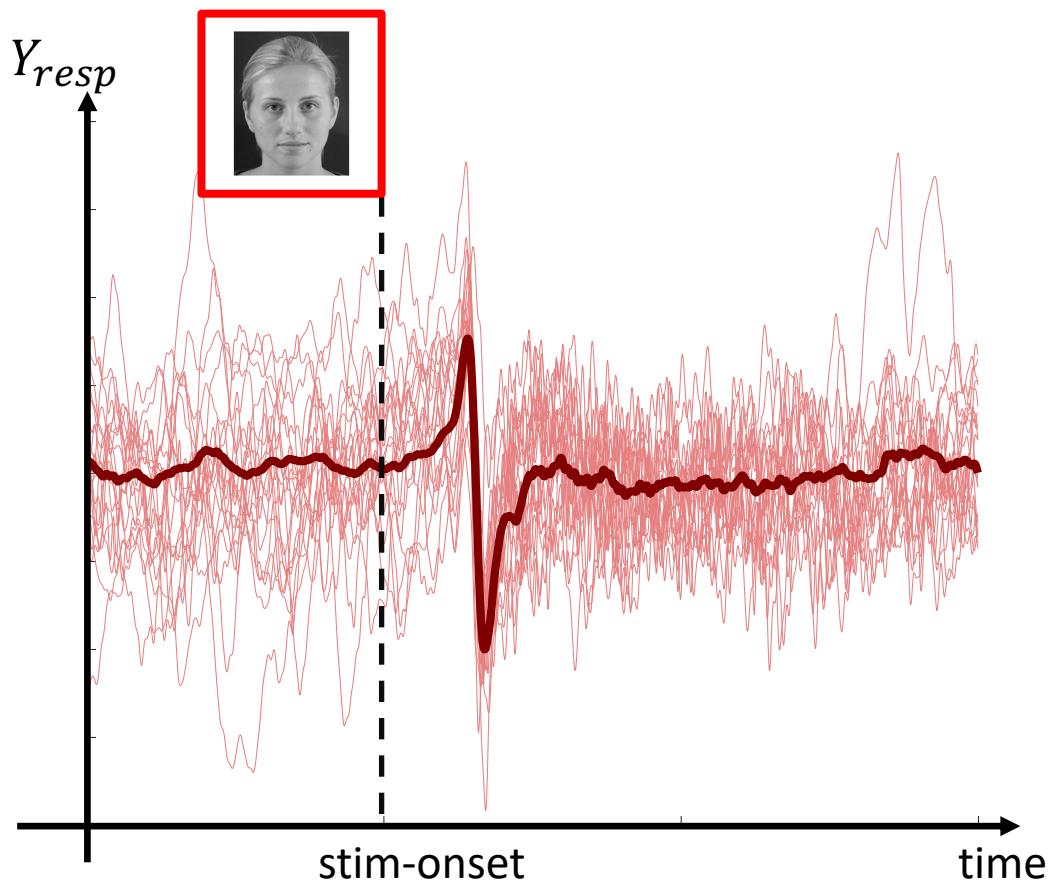
Pre-stimulus activity as proxy for ongoing endogenous activity

Y_{resp}



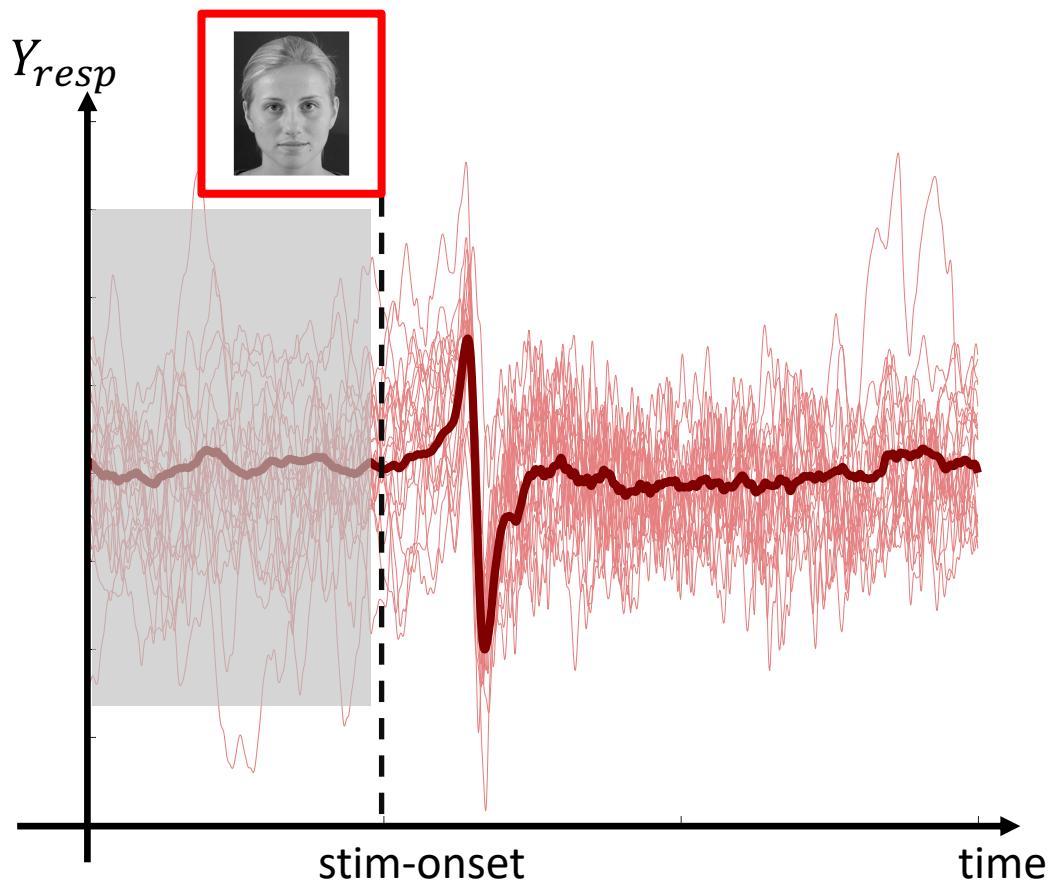
Pre-stimulus activity as proxy for ongoing endogenous activity

$$Y_{resp} = X_{evk} + E_{endo} + \epsilon'$$



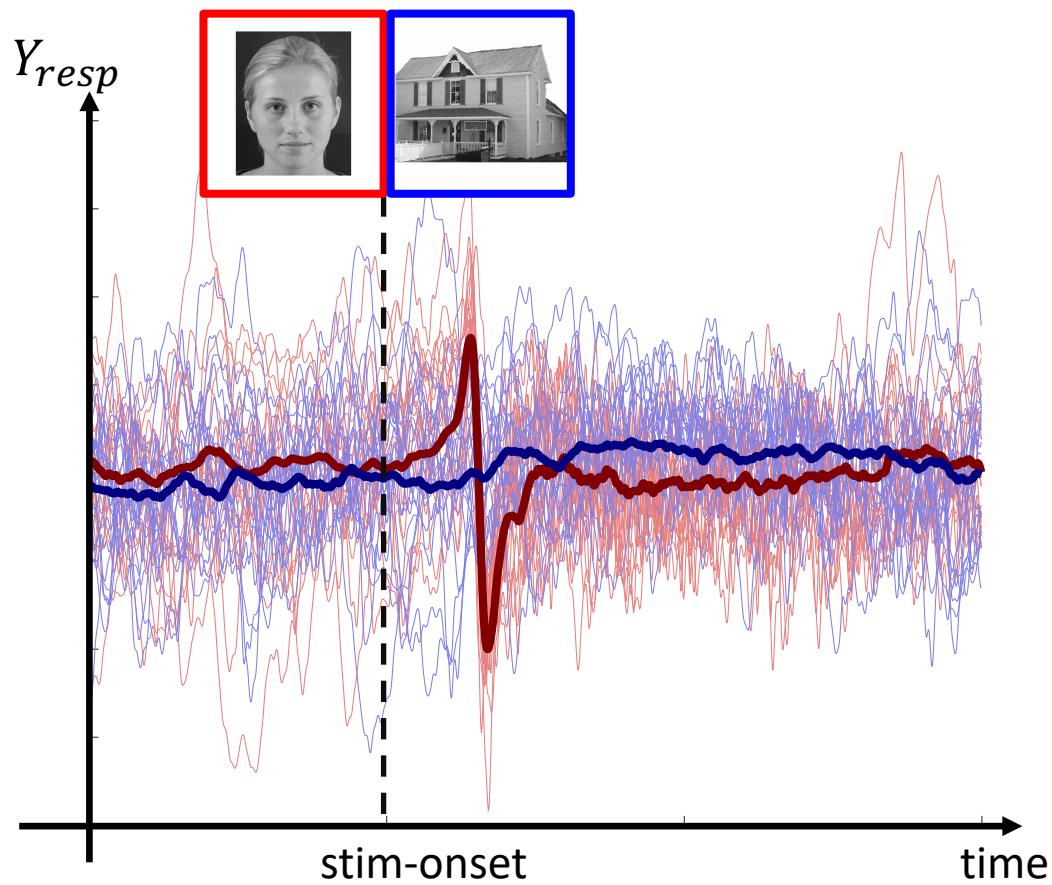
Pre-stimulus activity as proxy for ongoing endogenous activity

$$Y_{resp} = X_{evk} + \textcircled{X}_{pre} + \epsilon'$$



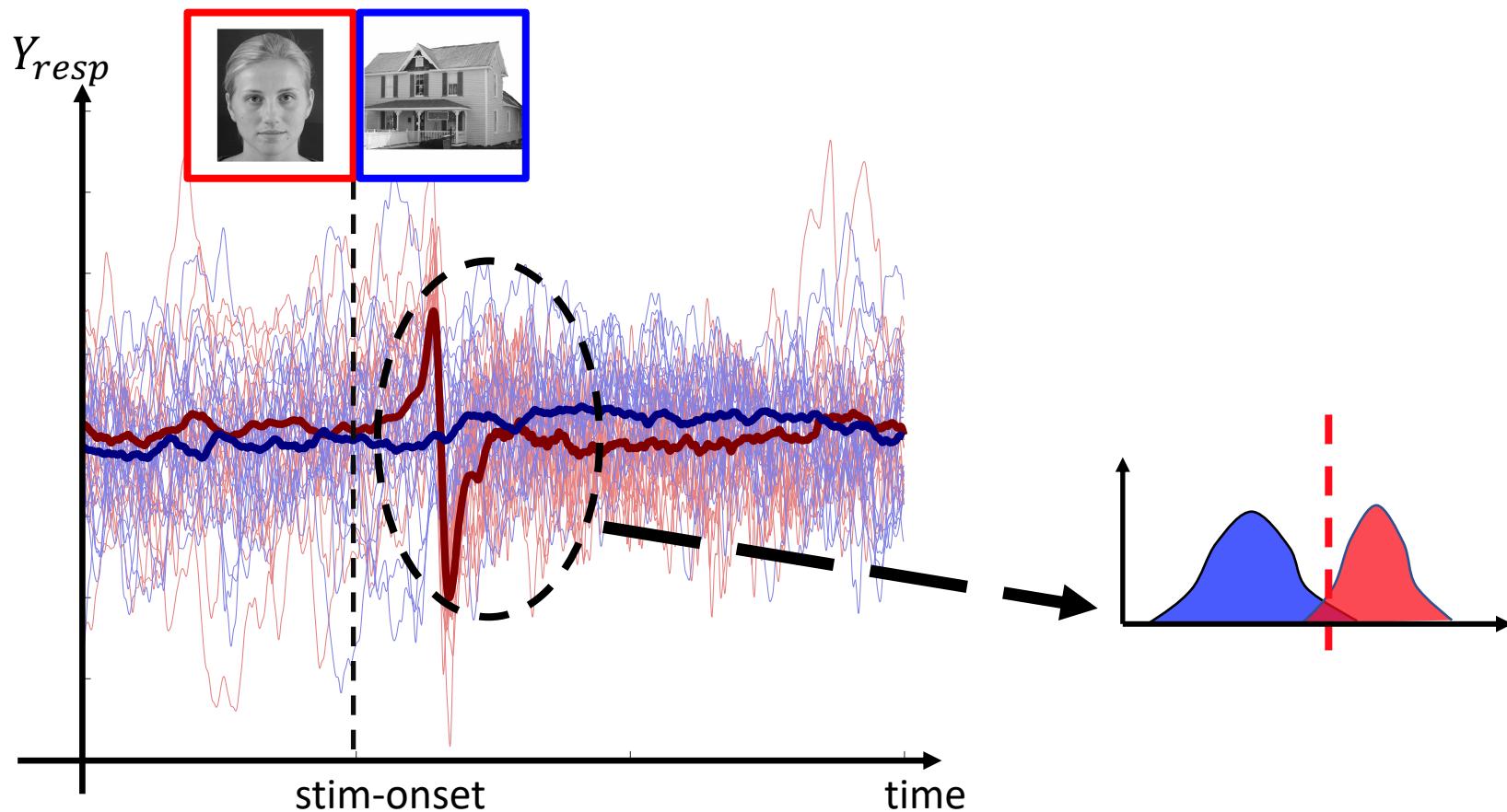
What about category tuning?

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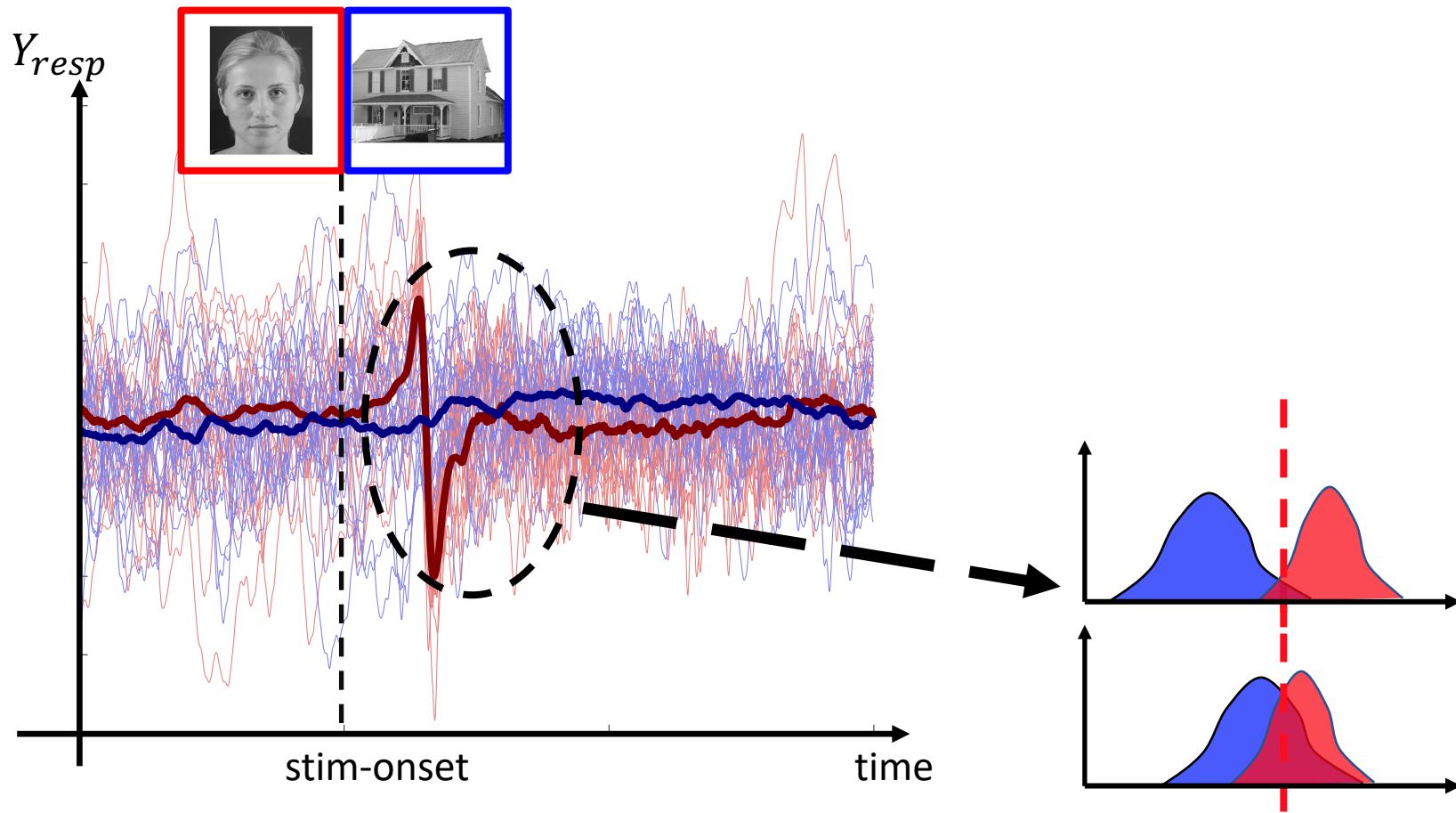
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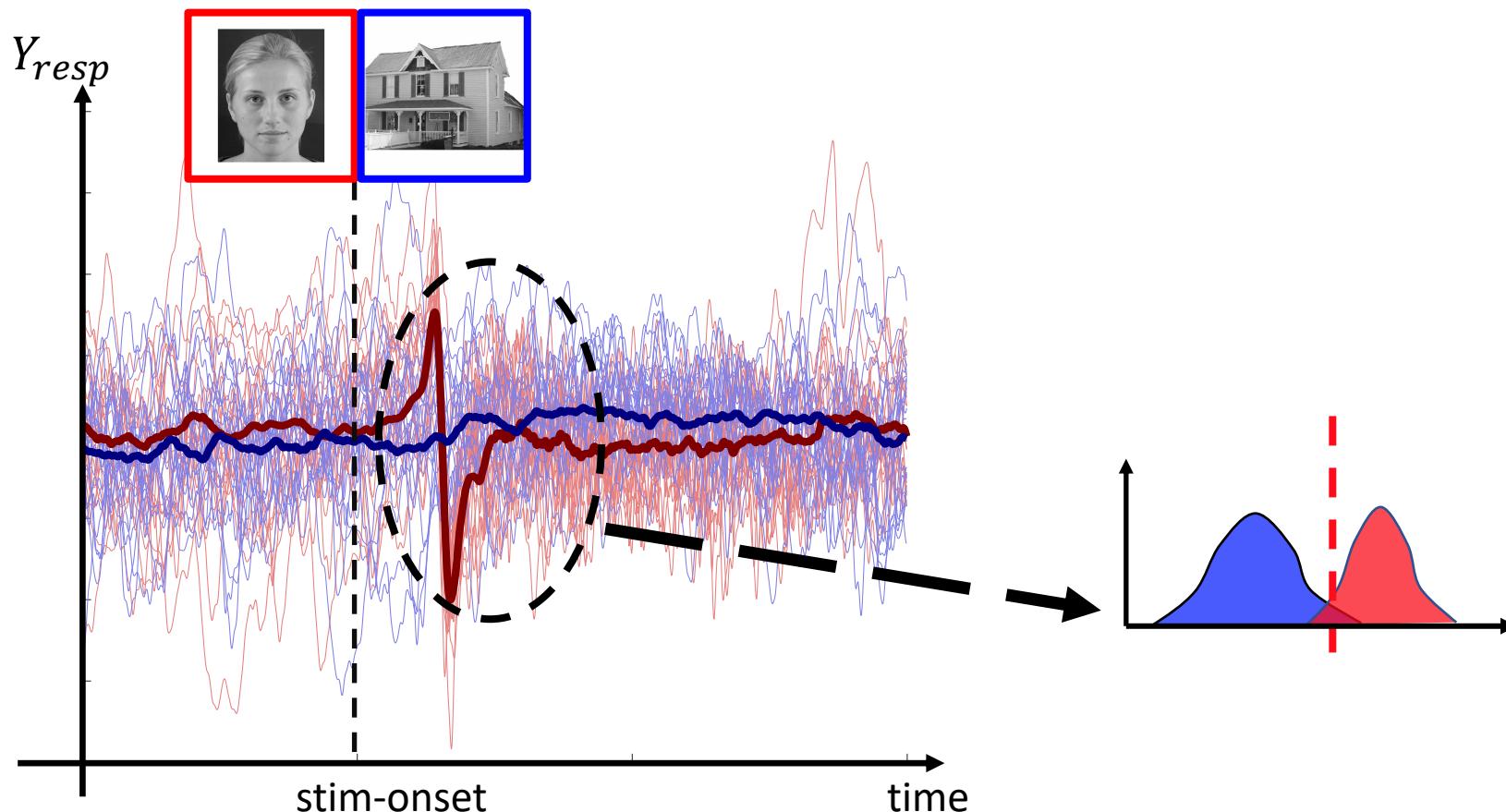
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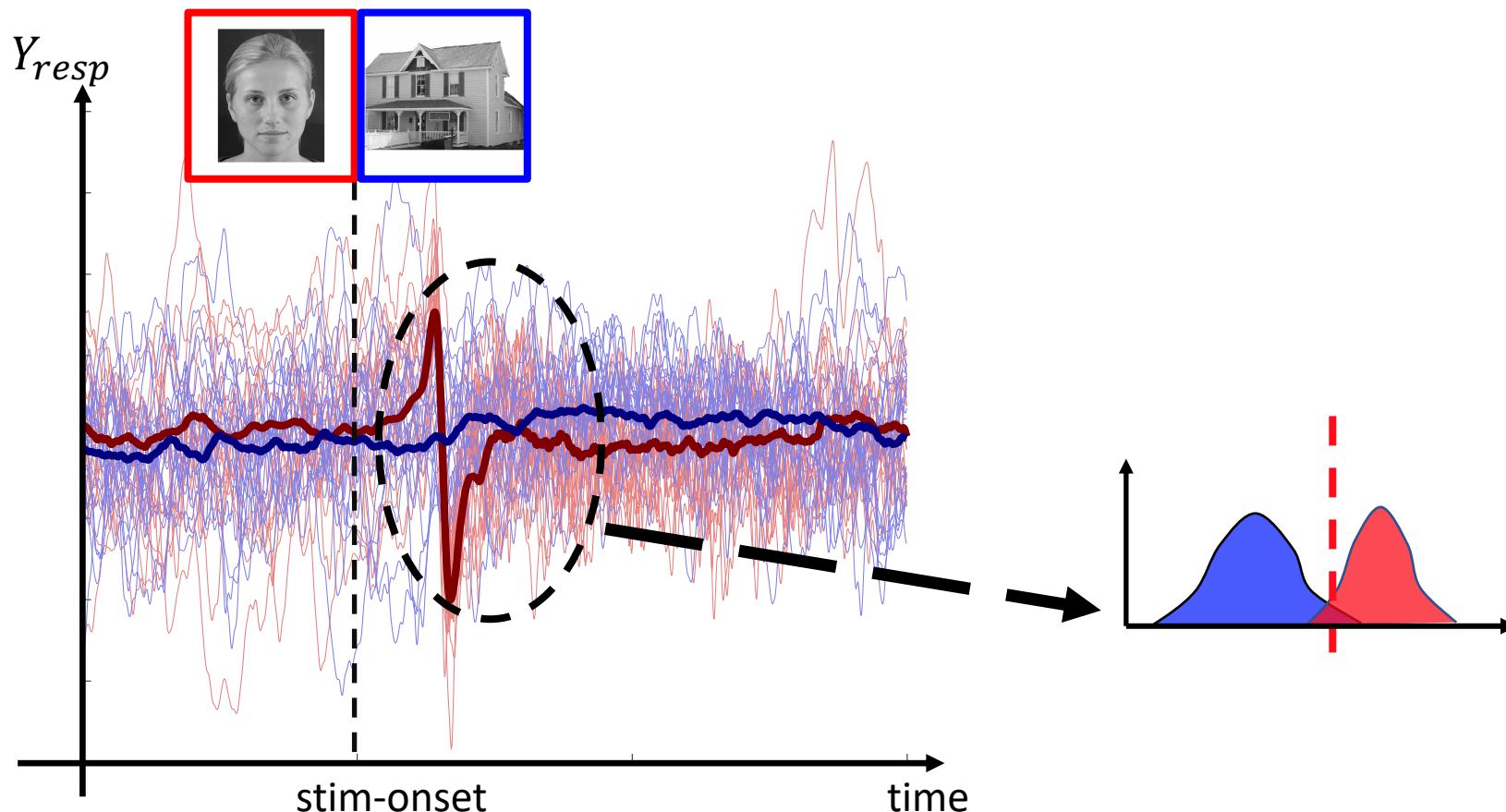
How does pre-stimulus activity modulate category tuning?

$$p(\text{category} | \underline{X_{evk}}, X_{pre}) = f(a^T \underline{X_{evk}}, b^T X_{pre})$$



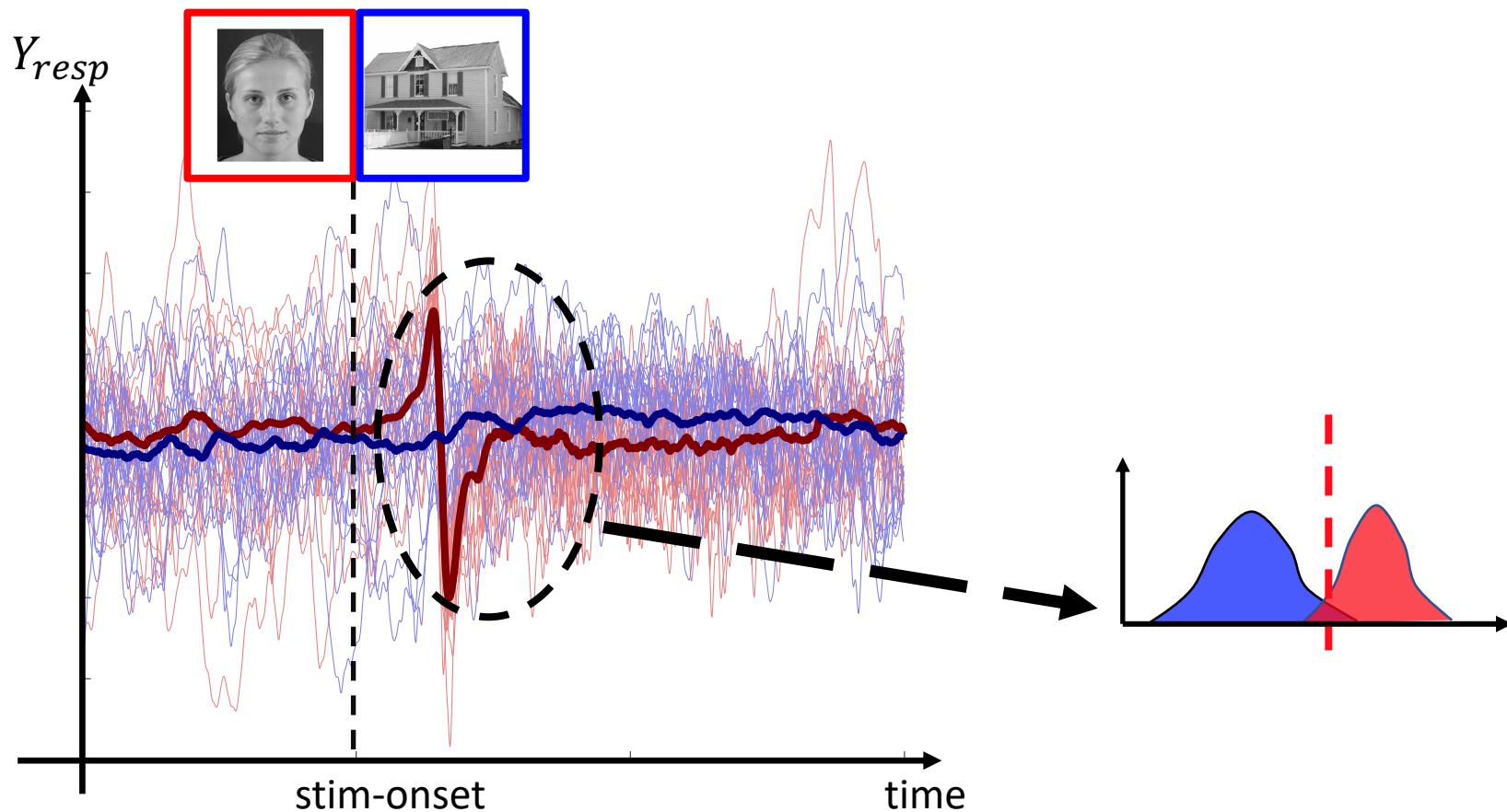
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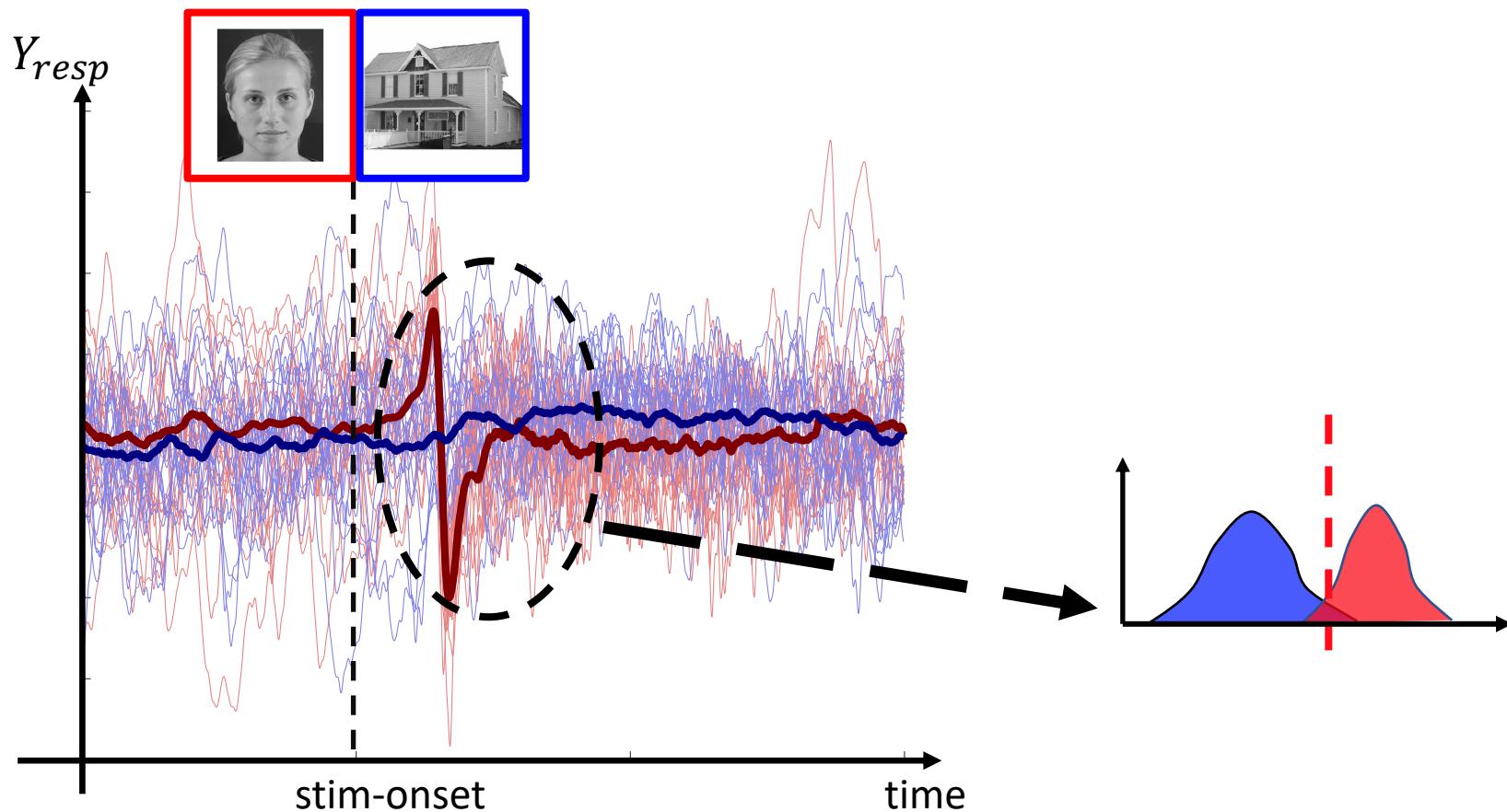
Train a classifier using only the posterior activity

$$p(\text{category} | X_{evk}) = f(a^T X_{evk})$$



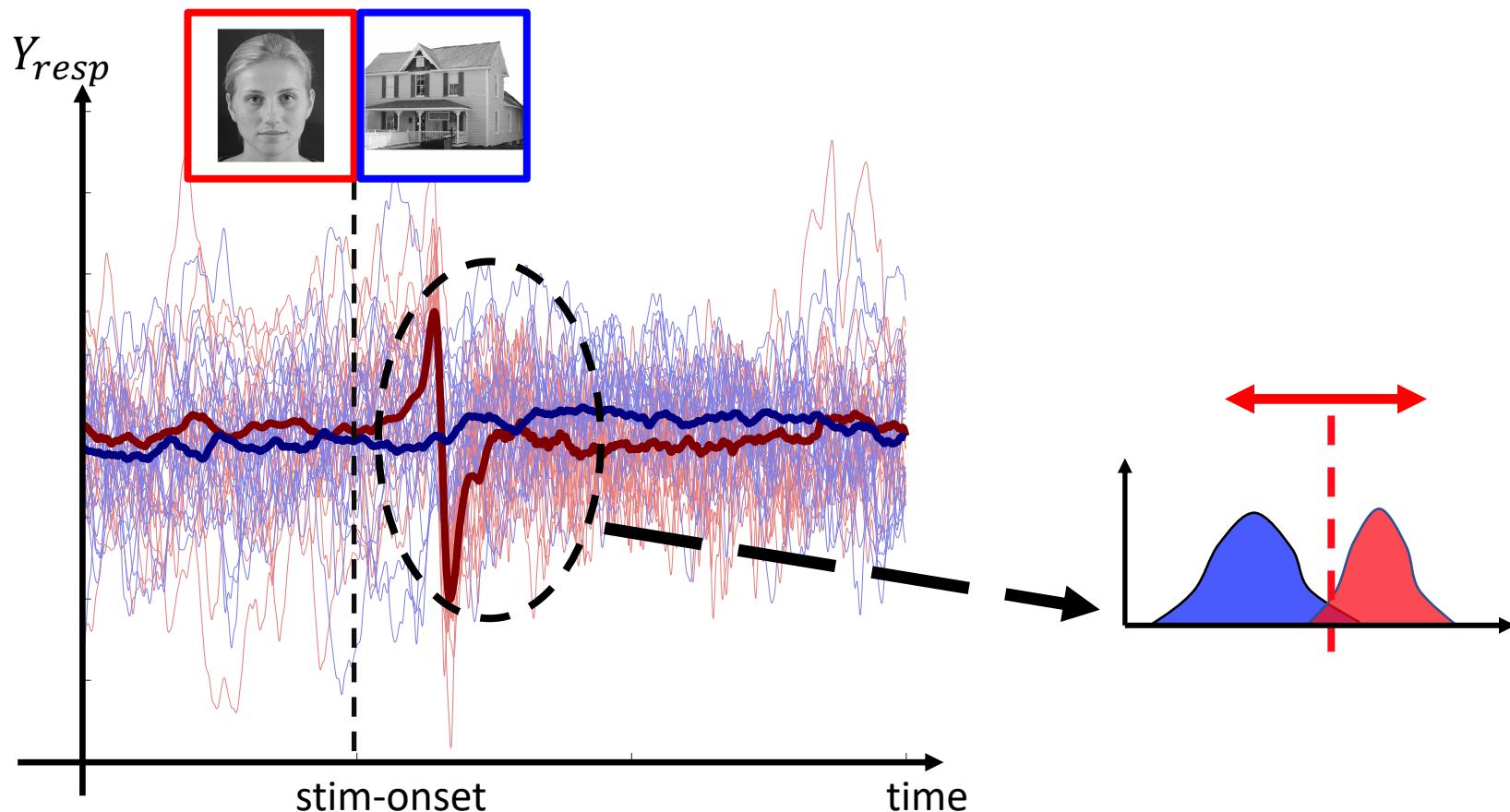
Fix the posterior discriminant component

$$p(\underline{\text{category}} | \underline{X_{evk}}, \underline{X_{pre}}) = f(a^T X_{evk} \quad \cdot)$$



Conditioning on the pre-stimulus activity

$$p(\text{category} | X_{evk}, X_{pre}) = f(a^T X_{evk}, b^T X_{pre})$$



Trial-by-trial metric of category-tuning

$$p(\text{category} | X_{evk}, X_{pre}) = f(a^T X_{evk}, b^T X_{pre})$$

- Define:
 - $a^T X_{evk}$ - (post-stimulus) category tuning

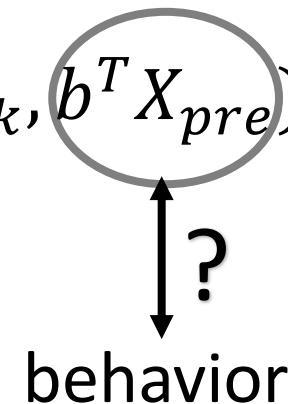
Trial-by-trial metric of pre-stimulus modulation

$$p(\text{category} | X_{evk}, X_{pre}) = f(a^T X_{evk}, b^T X_{pre})$$

- Define:
 - $a^T X_{evk}$ - (post-stimulus) category tuning
 - $b^T X_{pre}$ - (pre-stimulus) modulation index (MI)

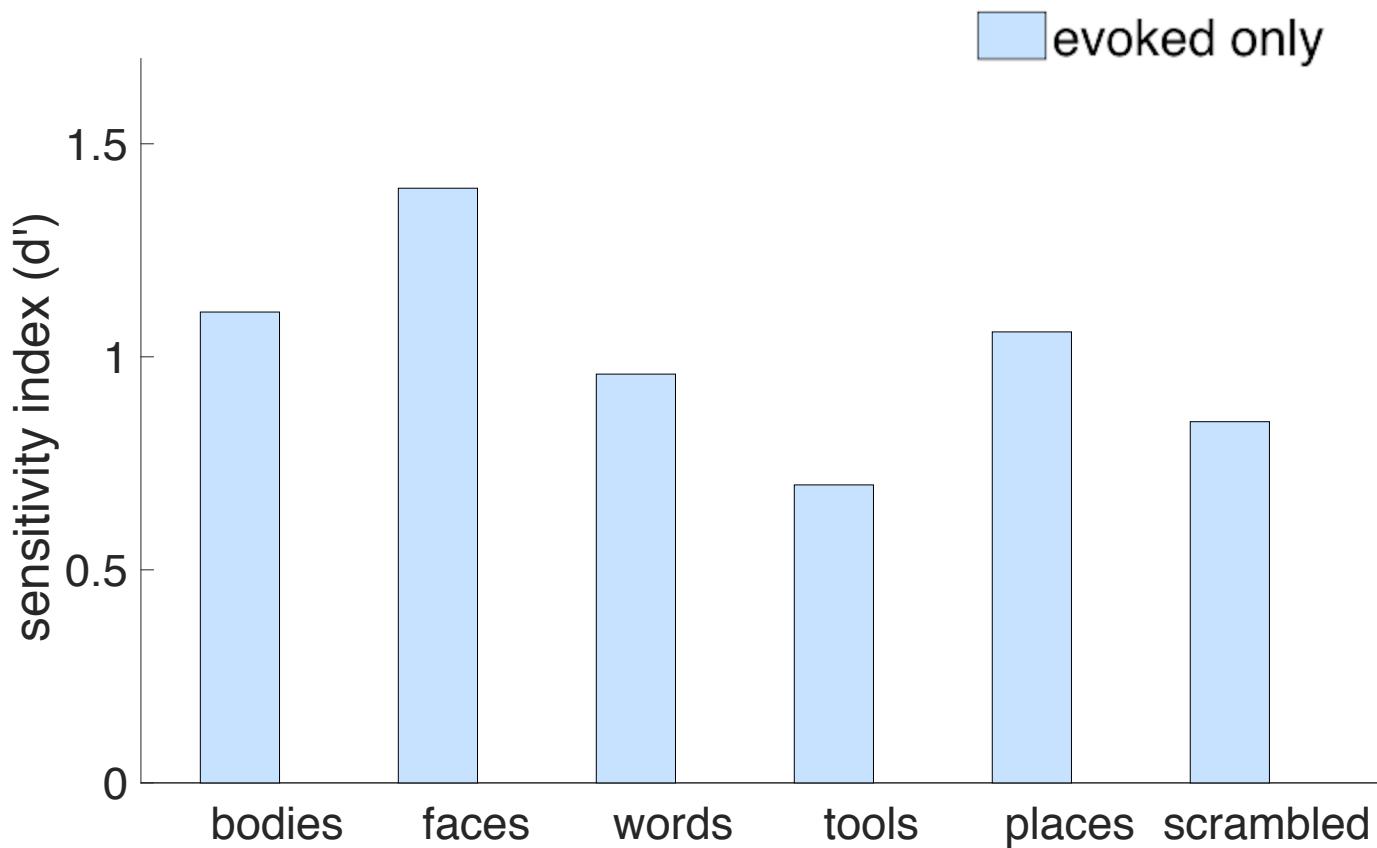
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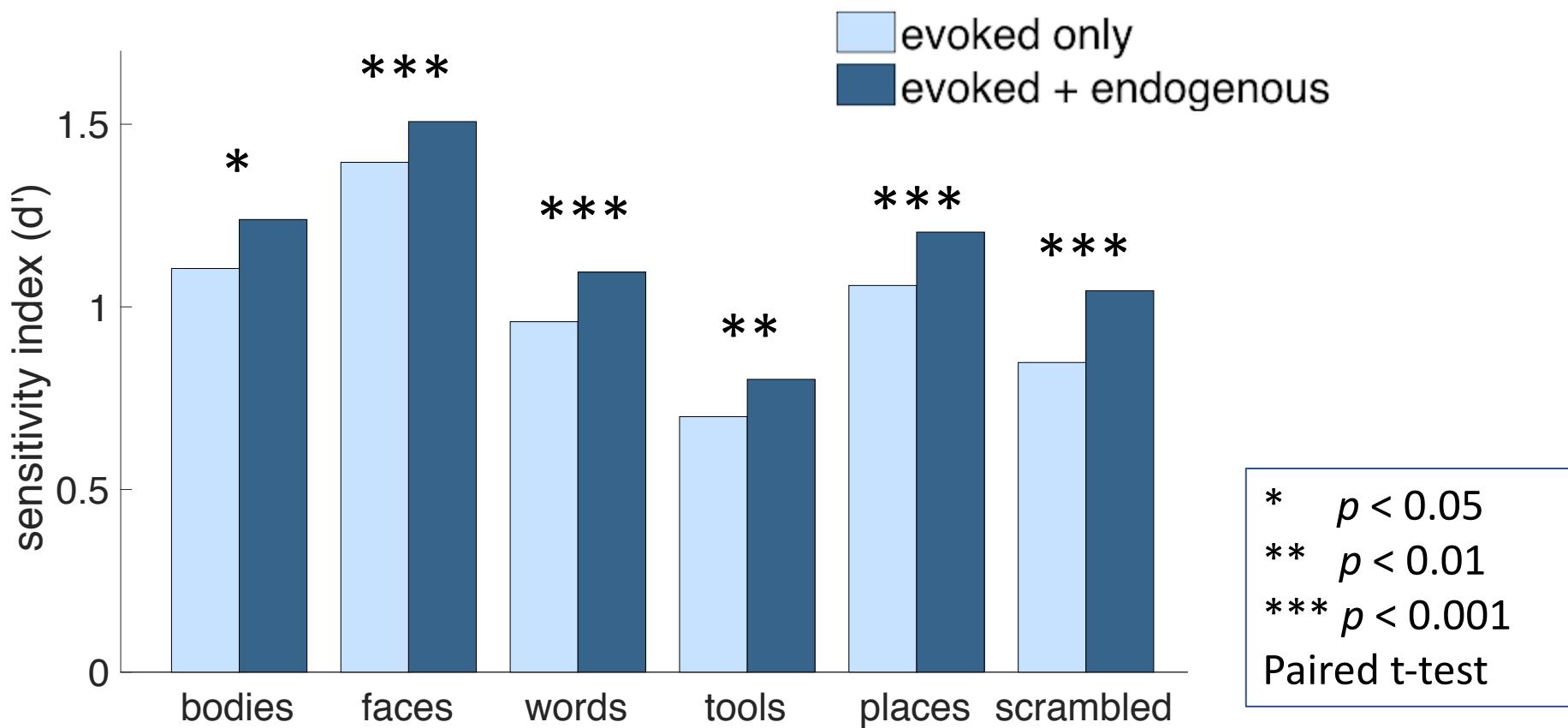


- Define:
 - $a^T X_{evk}$ - (post-stimulus) category tuning
 - $b^T X_{pre}$ - (pre-stimulus) modulation index (MI)

Does the inclusion of pre-stimulus activity improve categorical classification accuracy?

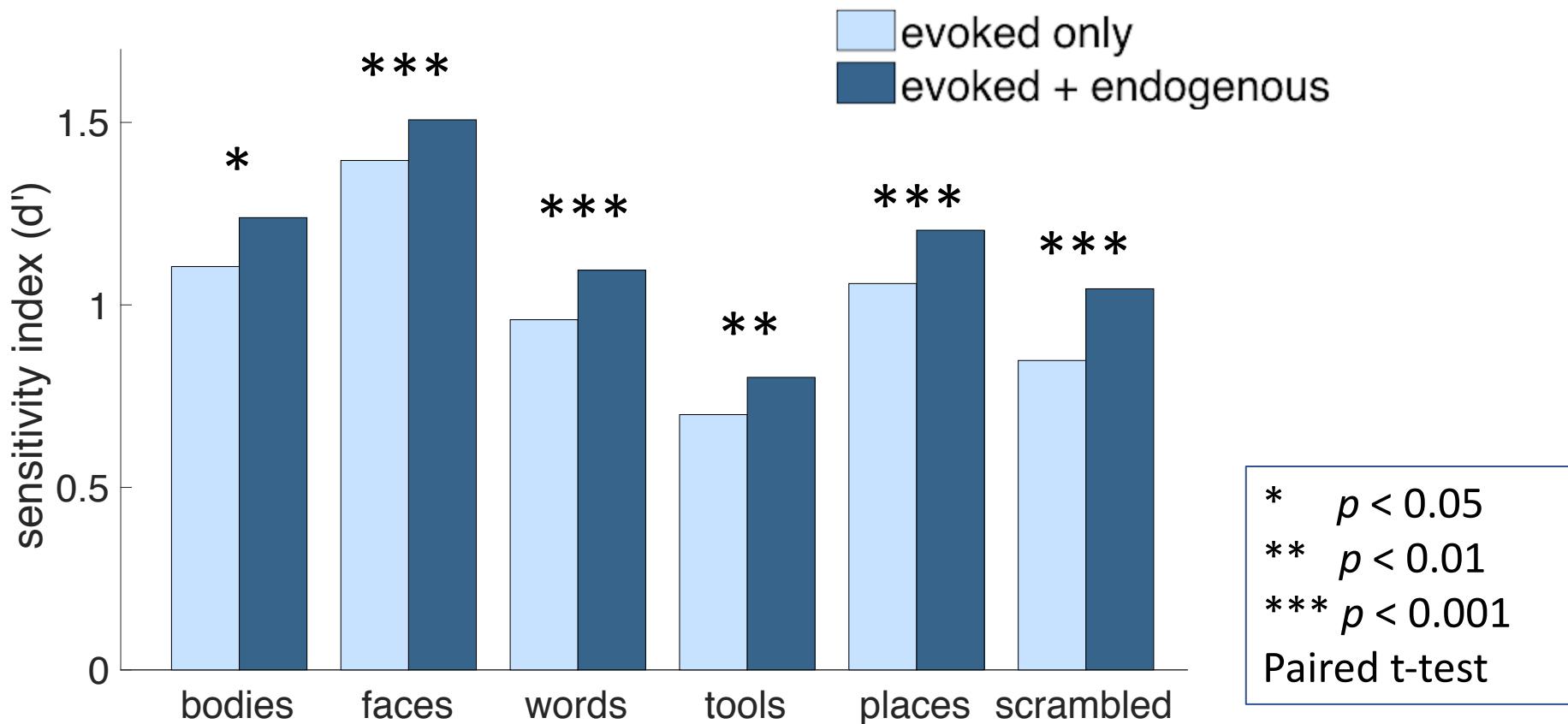


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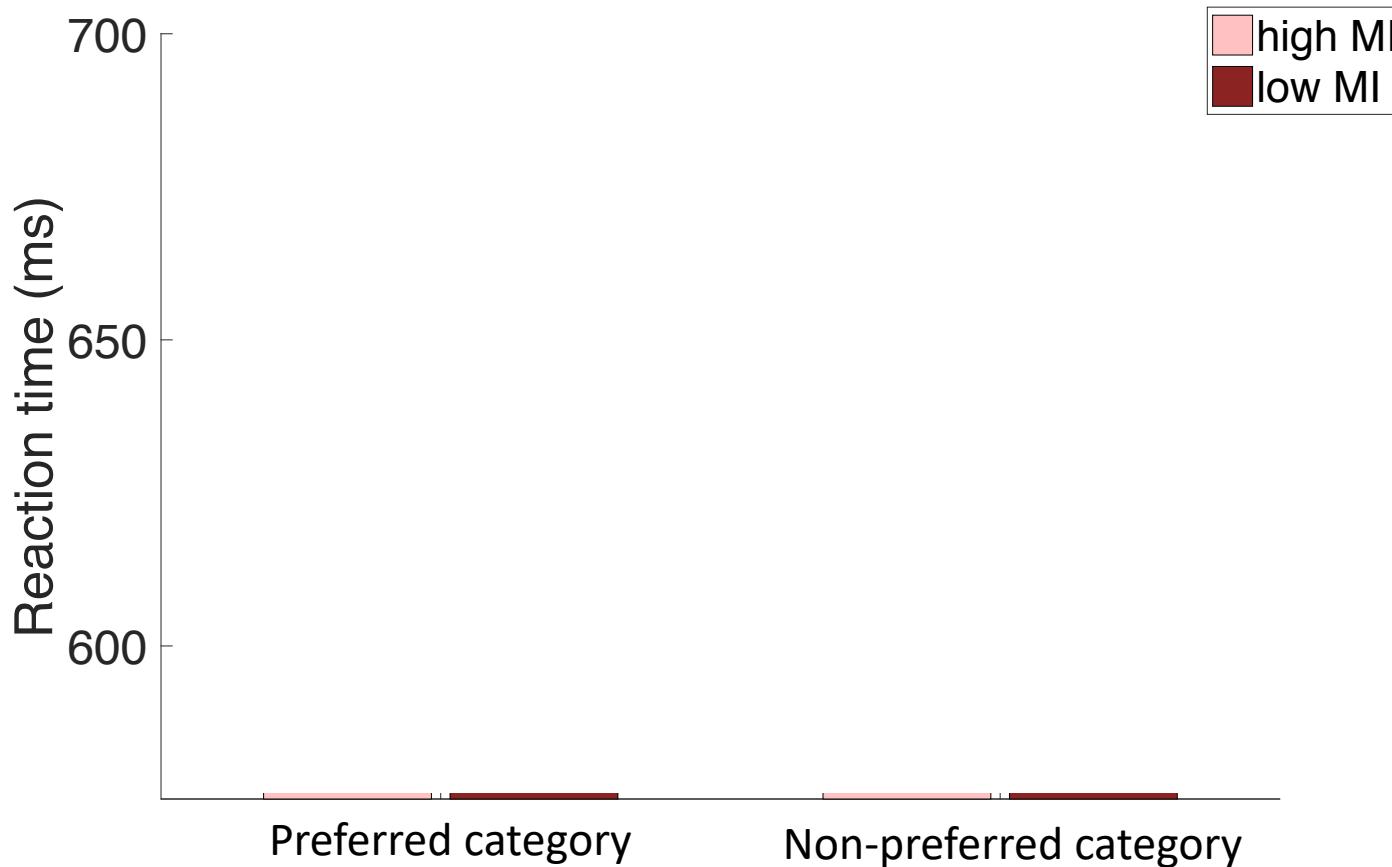


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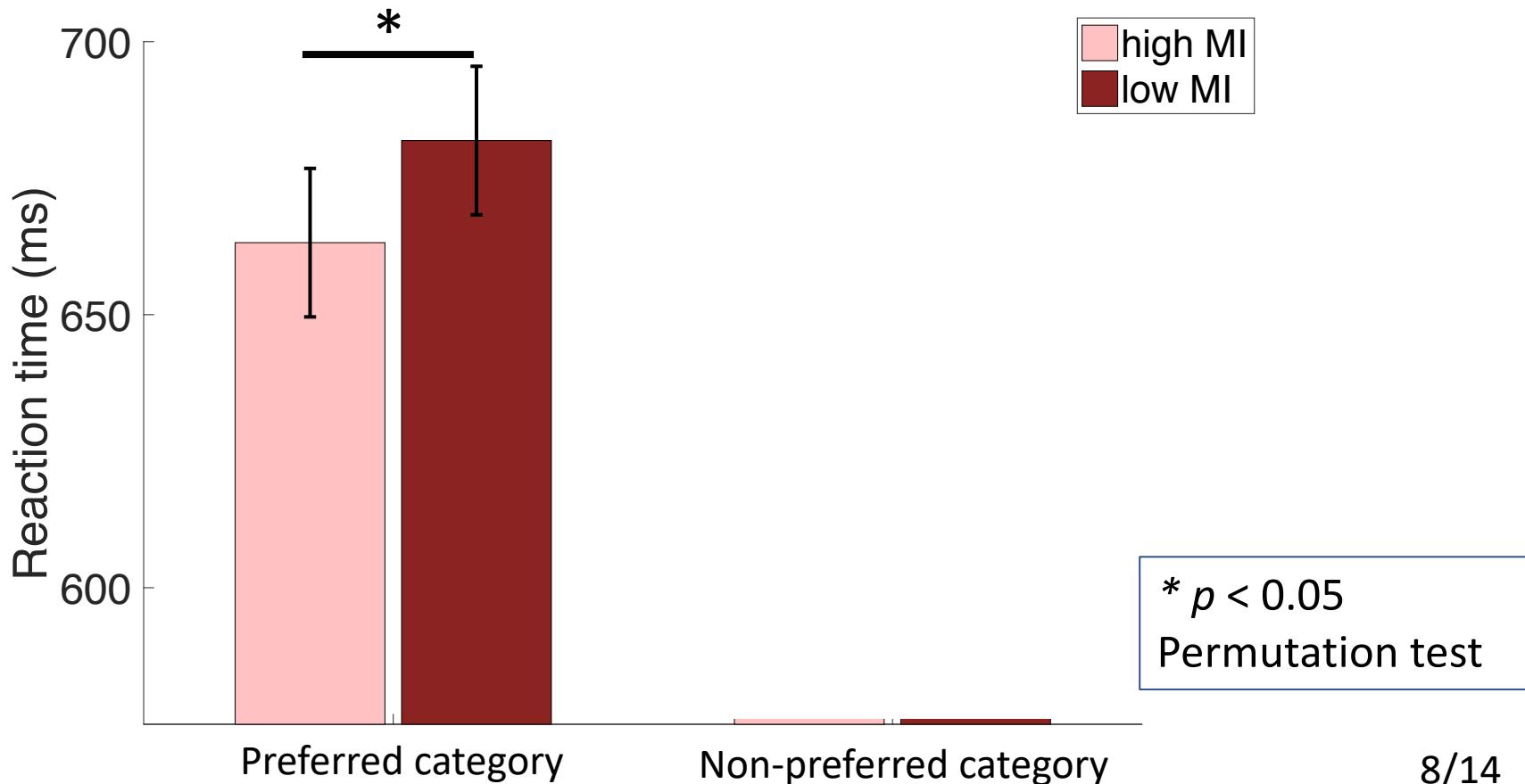
- YES. Conditioning on pre-stimulus activity functionally improves category classification.



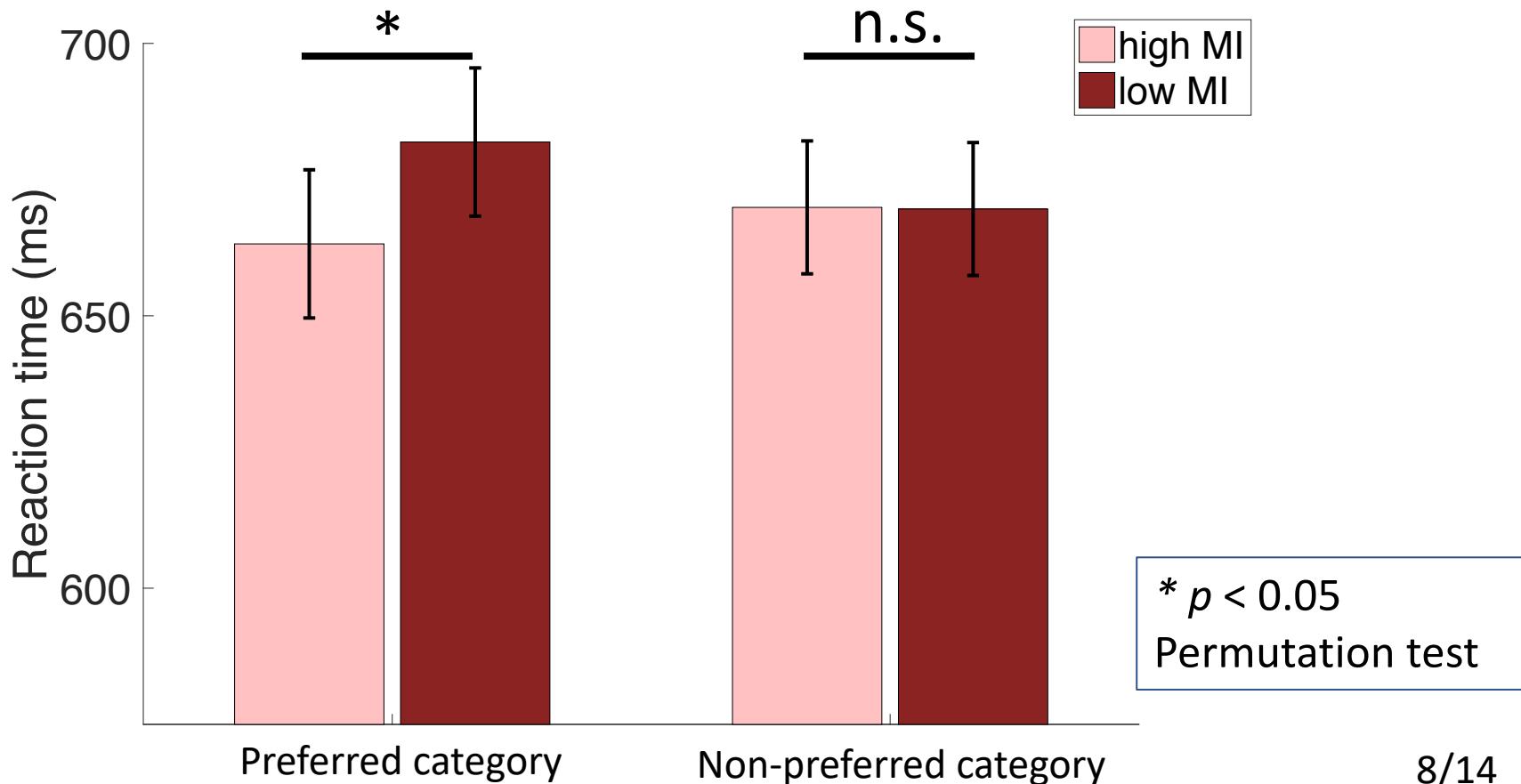
Does the same aspects of pre-stimulus activity also correlate with behavior performance?



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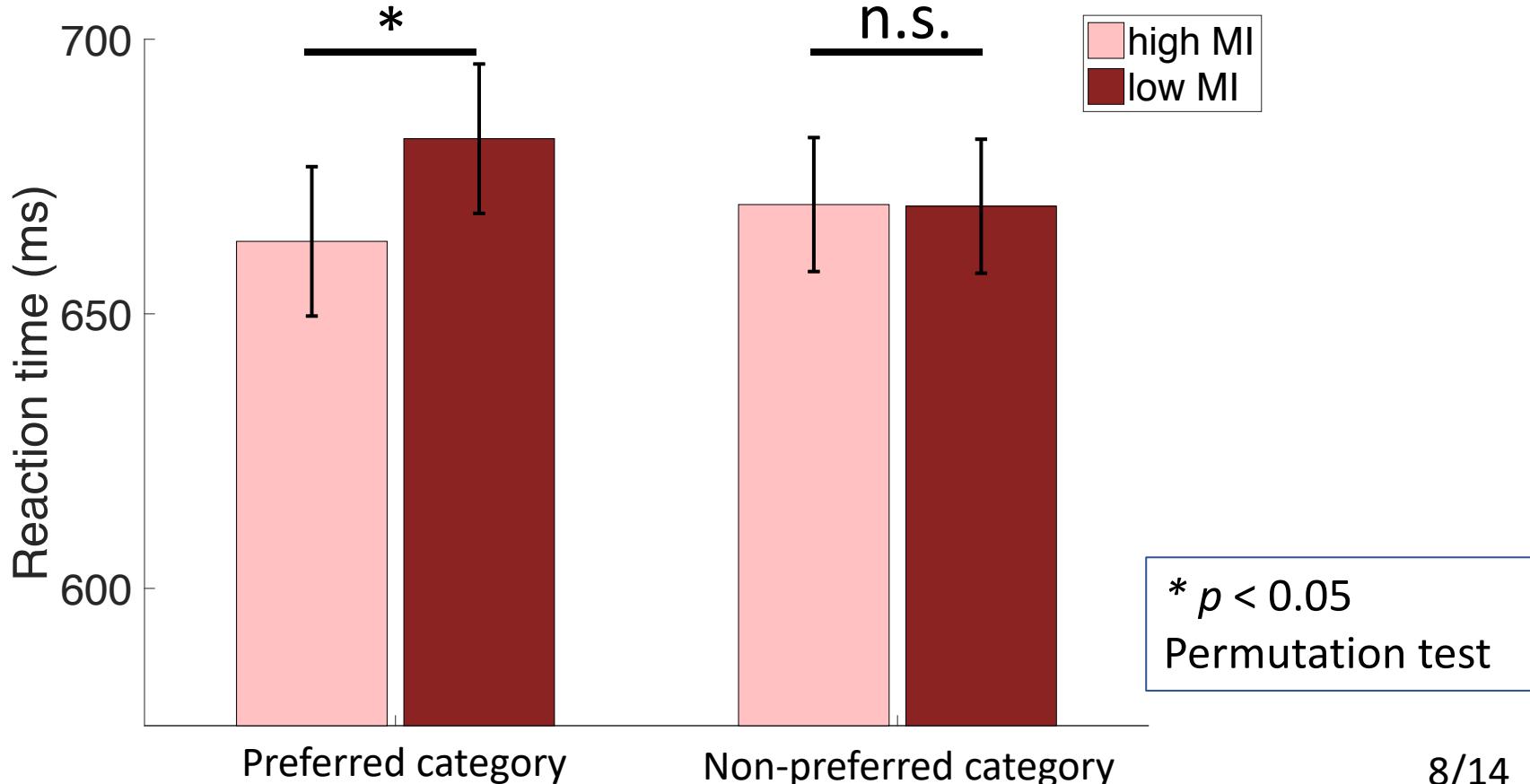


Does the same aspects of pre-stimulus activity also correlate with behavior performance?



Does the same aspects of pre-stimulus activity also correlate with behavior performance?

- YES. The same aspects in pre-stimulus activity that influences post-stimulus category tuning also predict perceptual behavior performance.



Main questions

- Does pre-stimulus activity modulate the degree of category tuning in response to visual stimuli?

YES

- If so, does the same aspect in pre-stimulus activity that modulates tuning also predict behavioral perception?

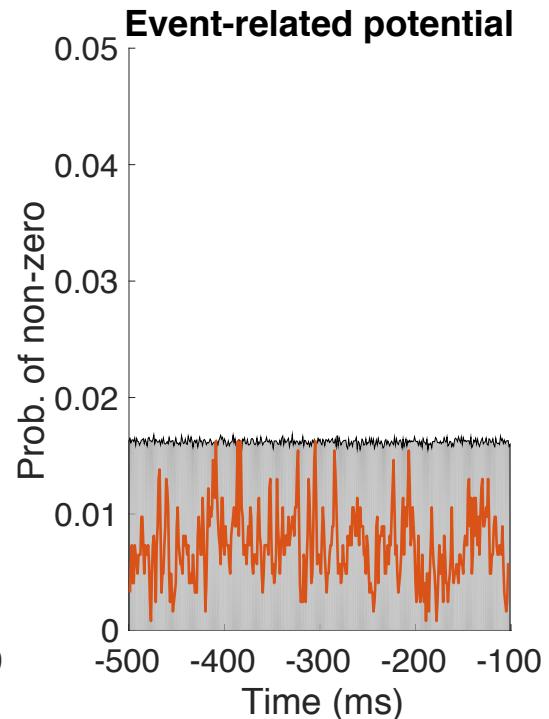
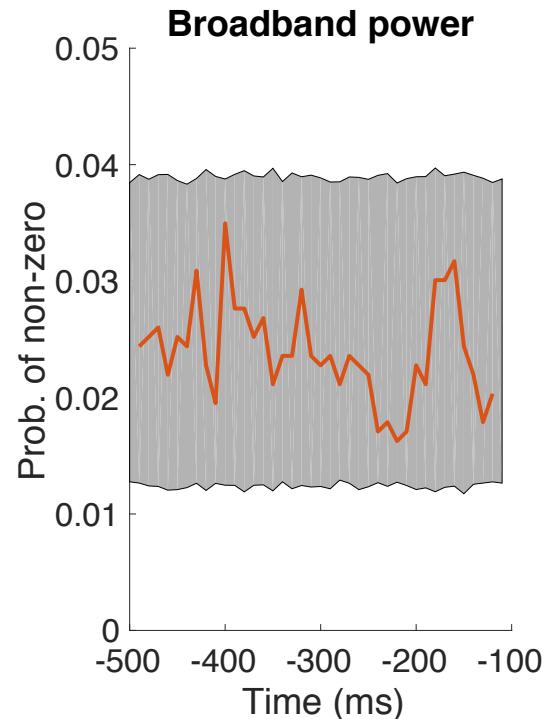
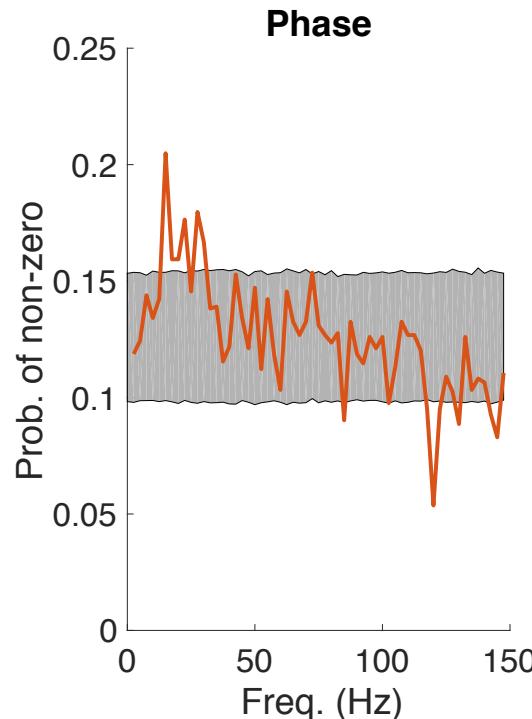
YES

What are the pre-stimulus features that contributing to the modulation?

$$p(\text{category} | X_{evk}, X_{pre}) = f(a^T X_{evk}, b^T \textcircled{X}_{pre})$$

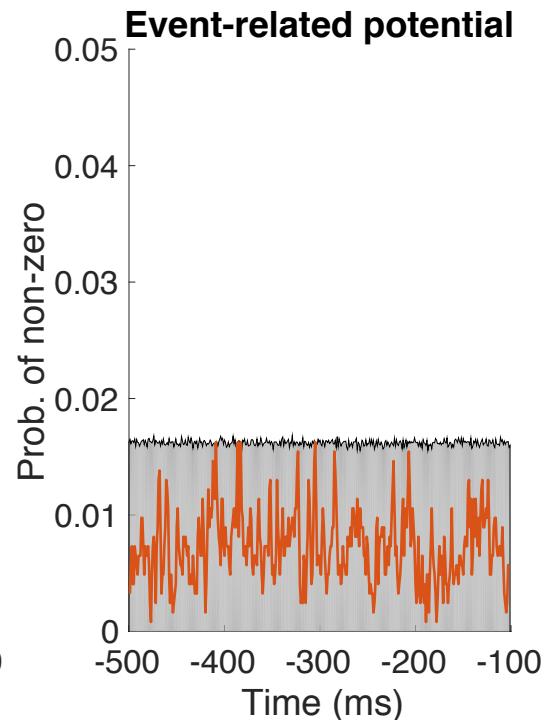
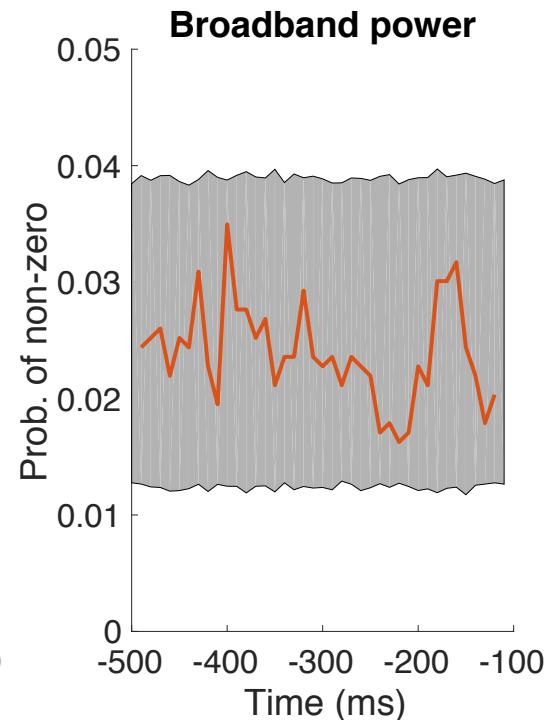
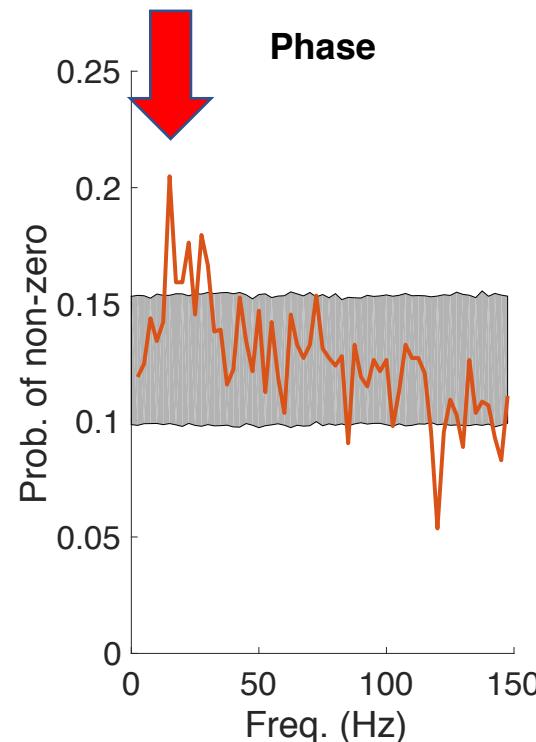
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What are the pre-stimulus features that contributing to the modulation?

- Phase around 15-30 Hz demonstrated consistent pattern.



What's the nature of the pre-stimulus modulation?

- A reflection of fluctuations in global cognitive state (e.g. arousal/attention)?

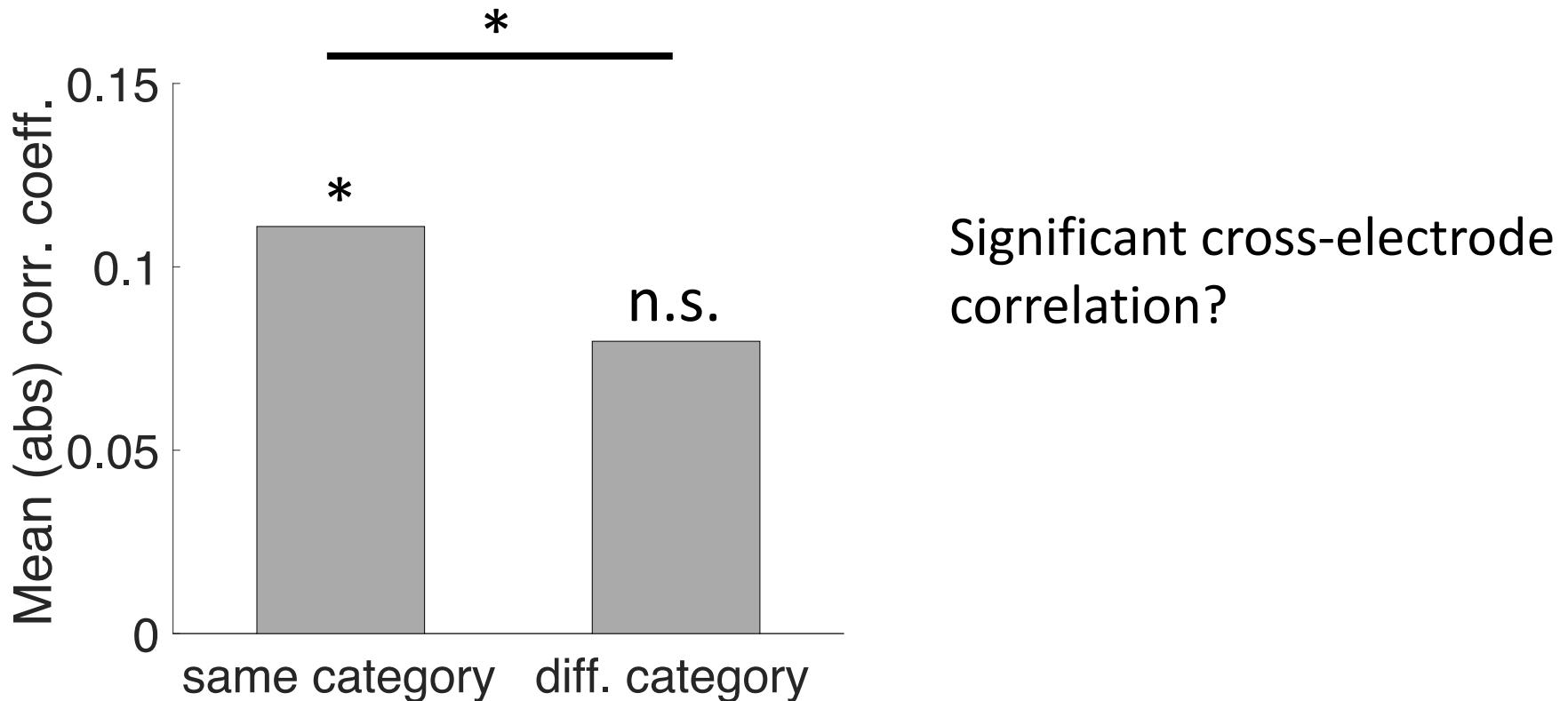
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Significant cross-electrode correlation?

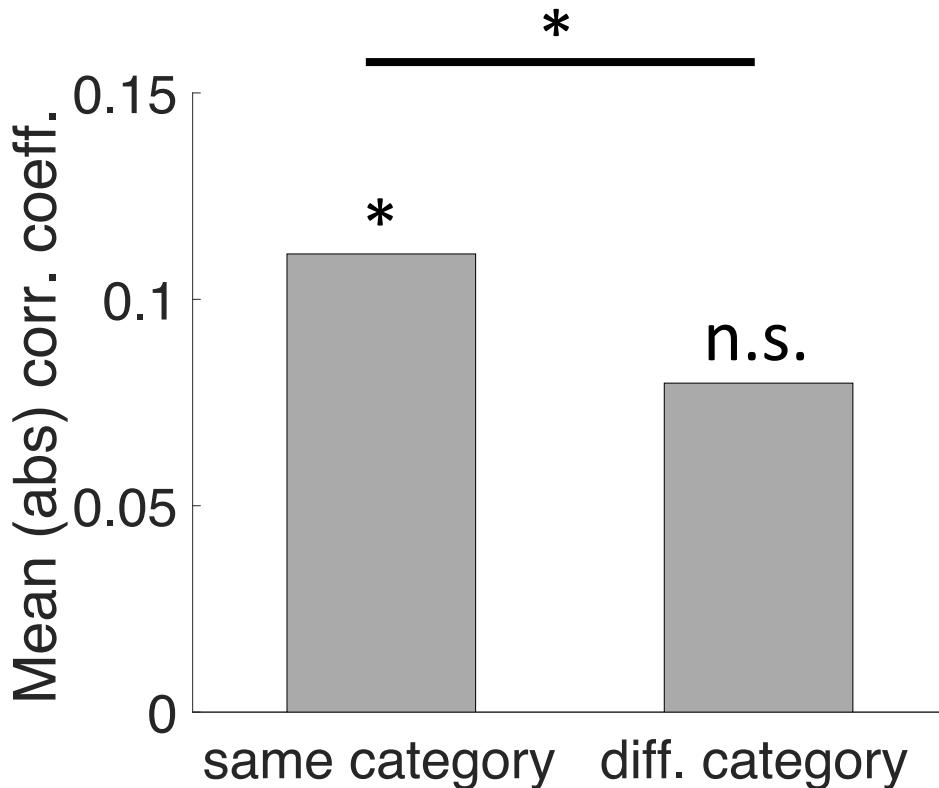
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Significant cross electrode
correlation? ~~cross~~

It is restricted to neural
circuits of the same
category-selectivity.

What's the nature of the pre-stimulus modulation?

- A reflection of fluctuations in global cognitive state (e.g. arousal/attention)?
- A reflection of infra-slow fluctuations seen in resting state?

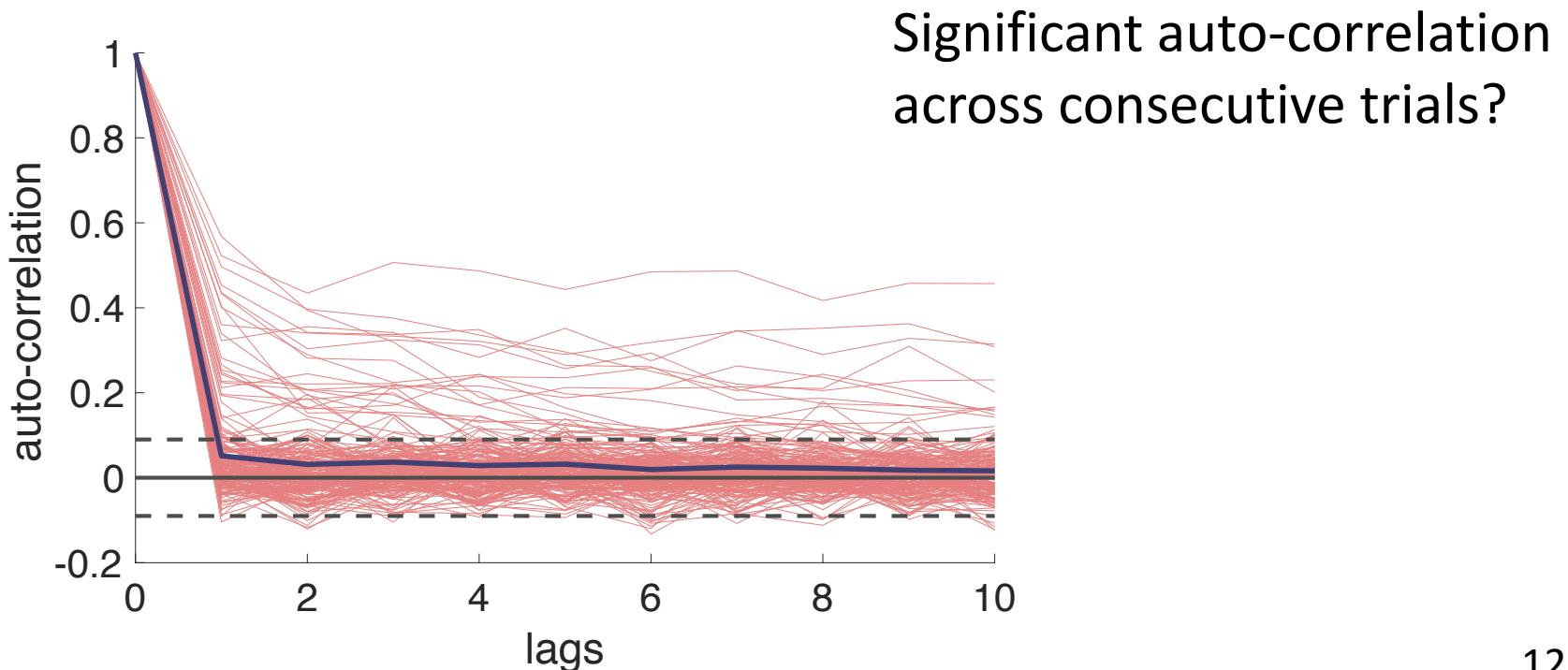
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Significant auto-correlation across consecutive trials?

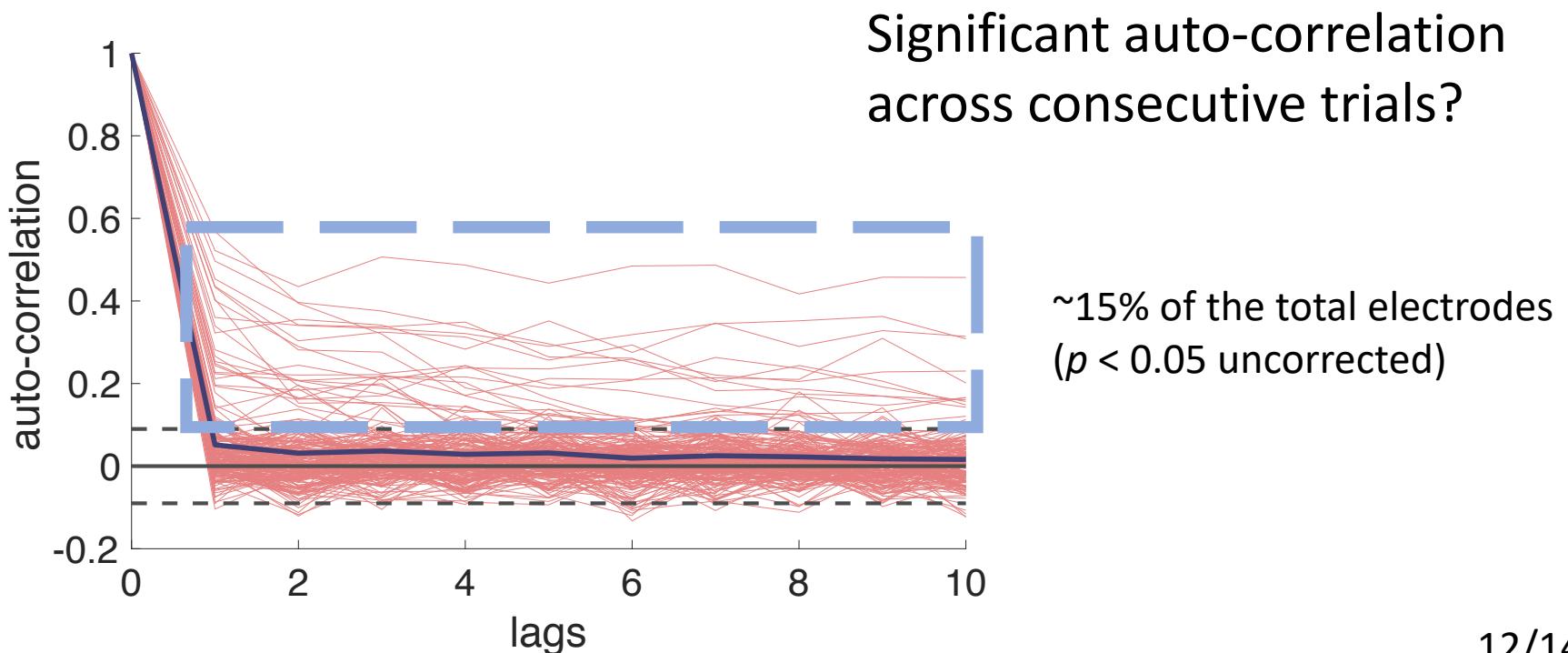
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- A reflection of fluctuations in global cognitive state (e.g. arousal/attention)?
No, the effects are only correlated within category-selective neural circuits.
- A reflection of infra-slow fluctuations seen in resting state?
Only a very small portion of the electrodes show trial-by-trial auto-correlation in endogenous modulation of tuning. The majority are transient.

Conclusion

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- The pre-stimulus modulation effect is a reflection of local processes within neural circuit.

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- The same aspects in pre-stimulus activity that influences post-stimulus category tuning also correlates with perceptual behavior performance.
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- The majority of the pre-stimulus modulation effect are transient, but ~15% of the channels show trial-by-trial auto-correlation in endogenous modulation of tuning.

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- EMU Staff and Nurses

Institutions:



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Thank you!

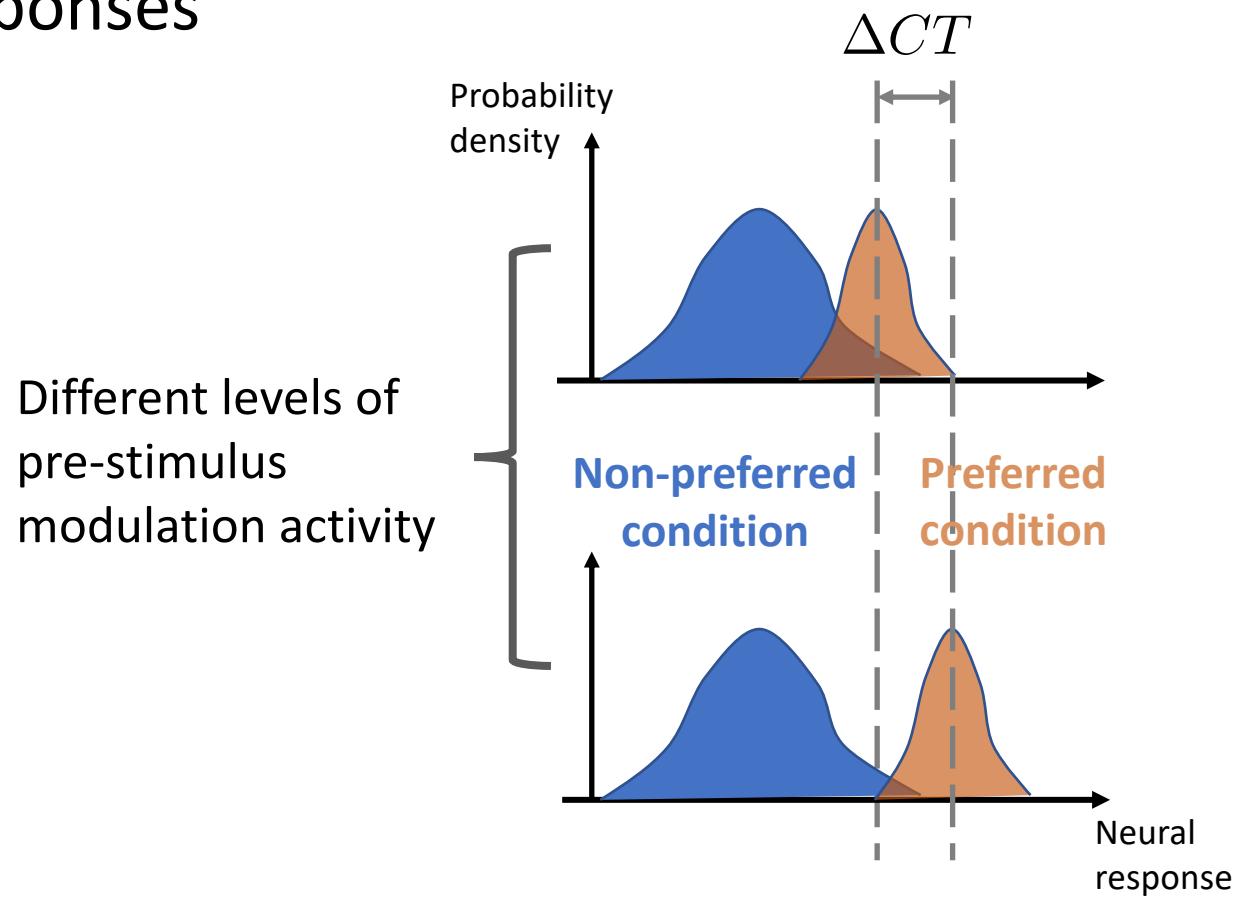


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Results: category tuning

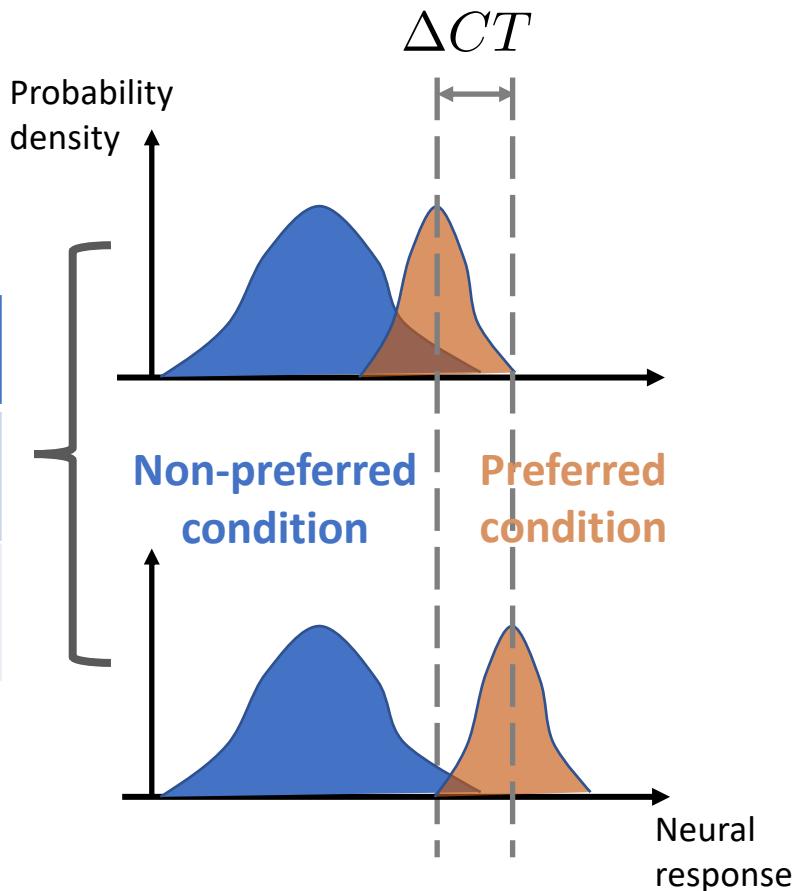
- Pre-stim activity modulated the category-tuning in the evoked-responses



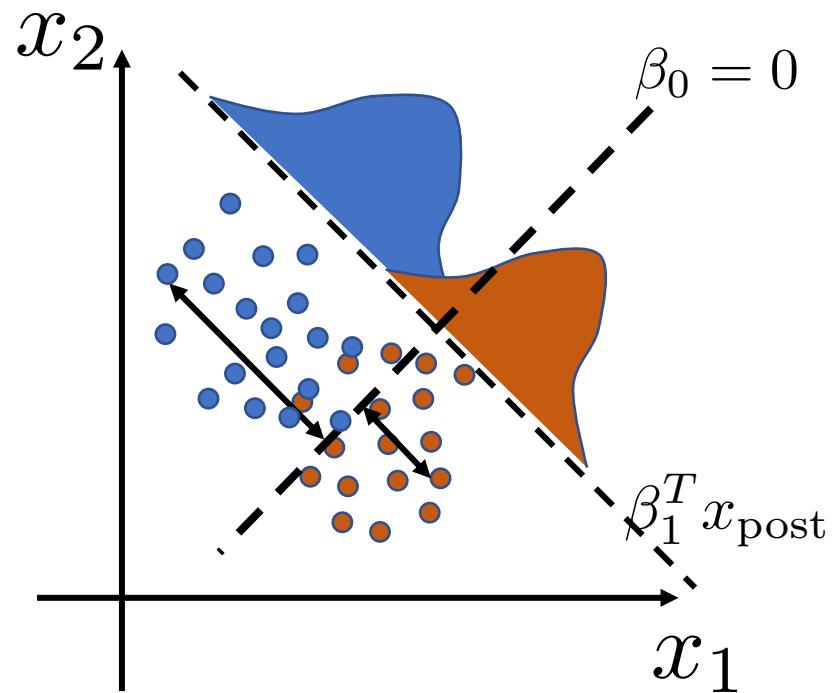
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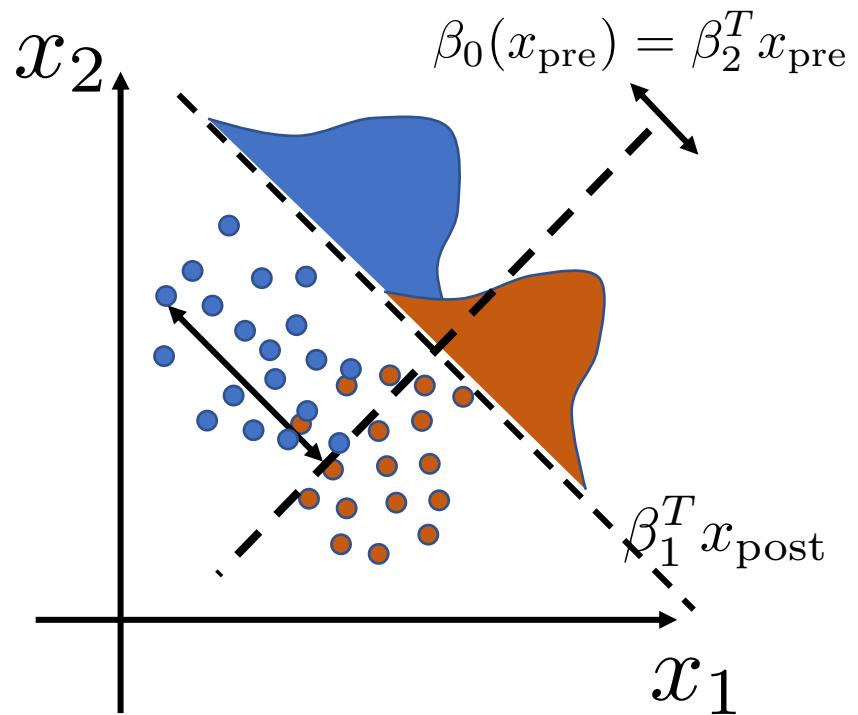
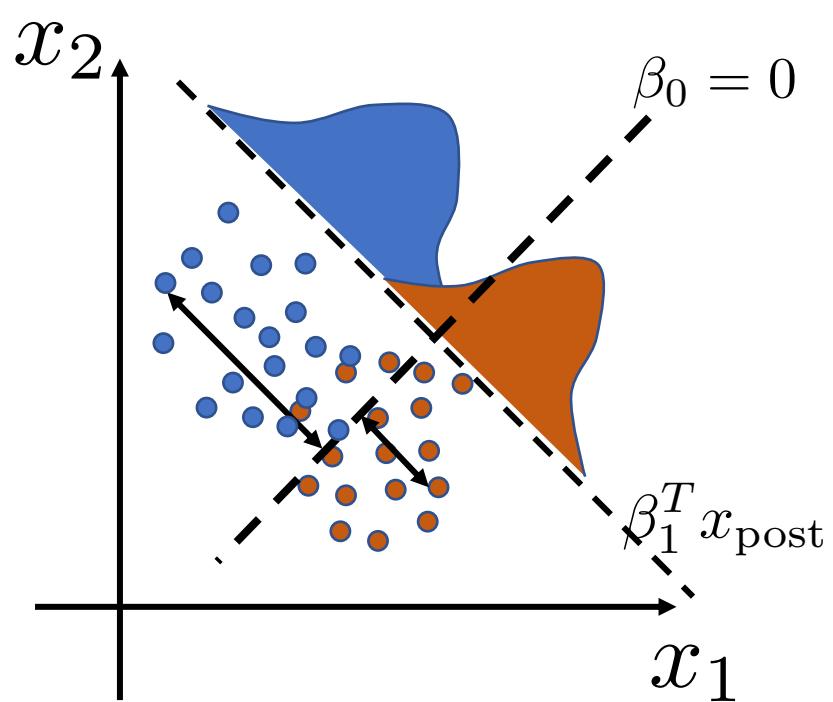
	ΔCT	p-value
Preferred condition	0.1101	< 0.001
Non-preferred condition	-0.0126	0.092



Model



Model



Model

