

Pre-stimulus endogenous activity modulates category tuning in ventral temporal cortex

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

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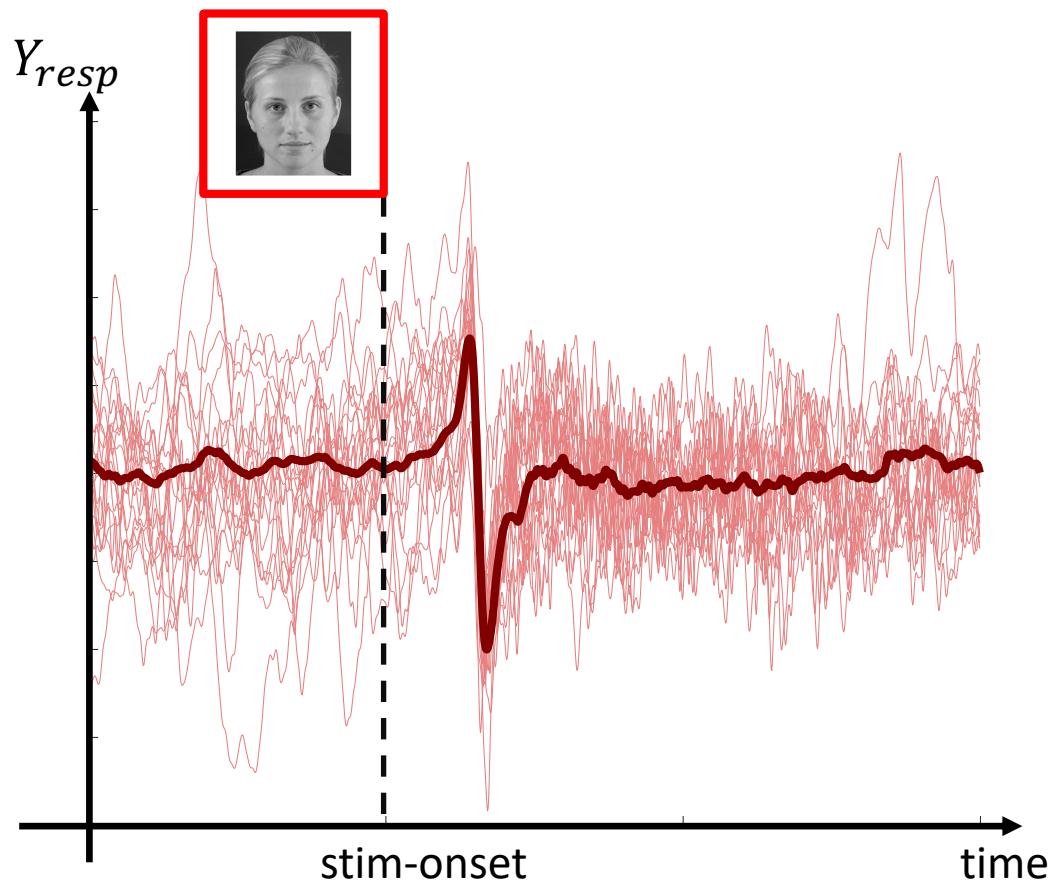
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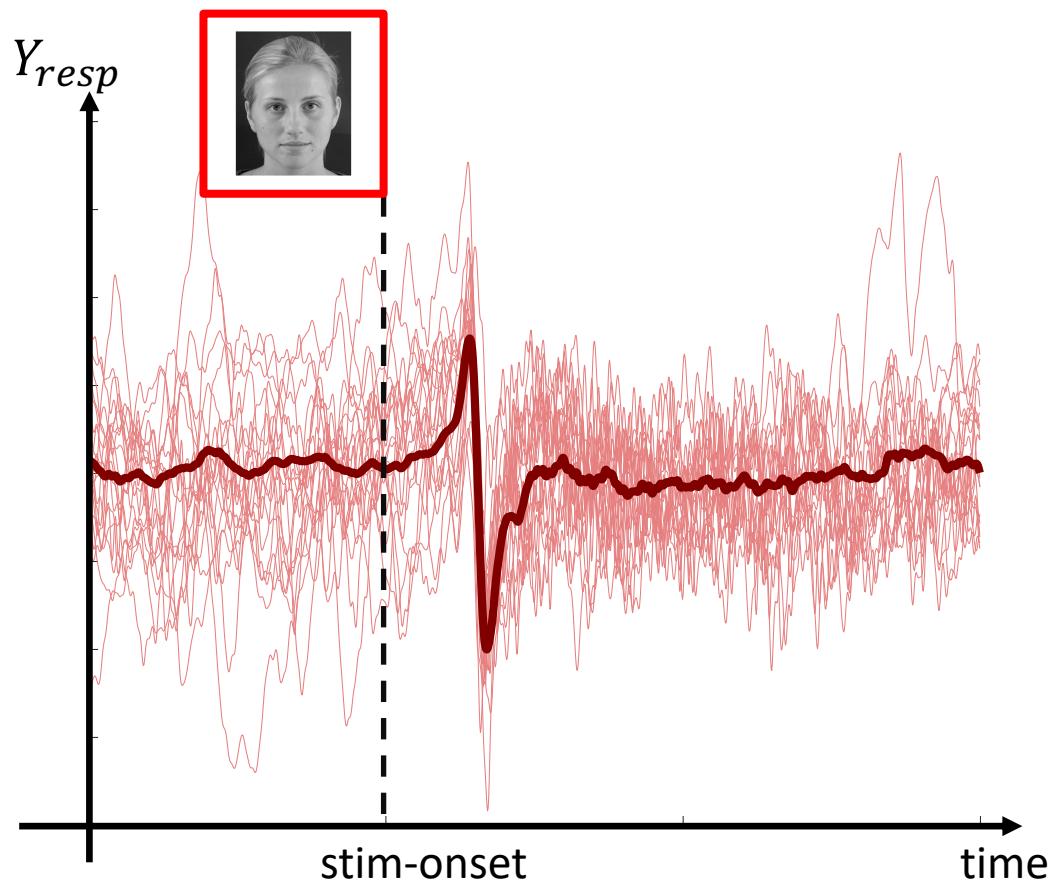
Classic view of event-related responses

$$Y_{resp} = X_{evk} + \epsilon$$



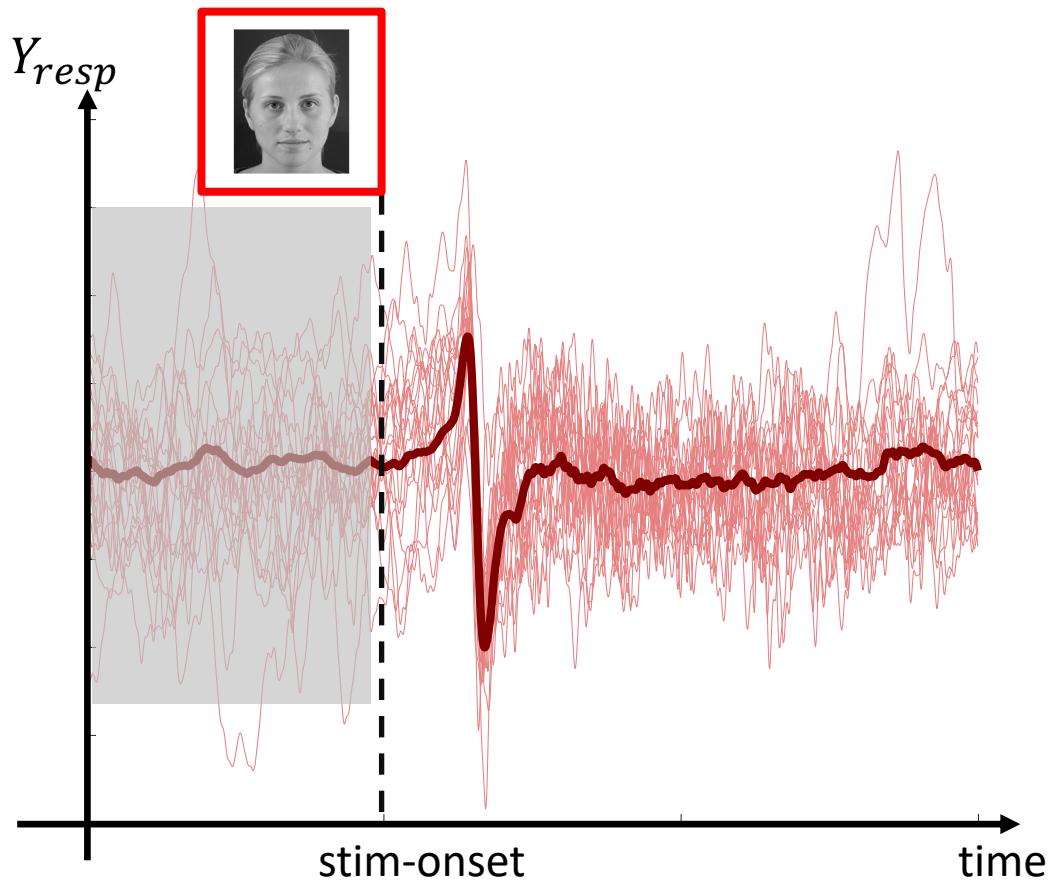
Endogenous activity

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



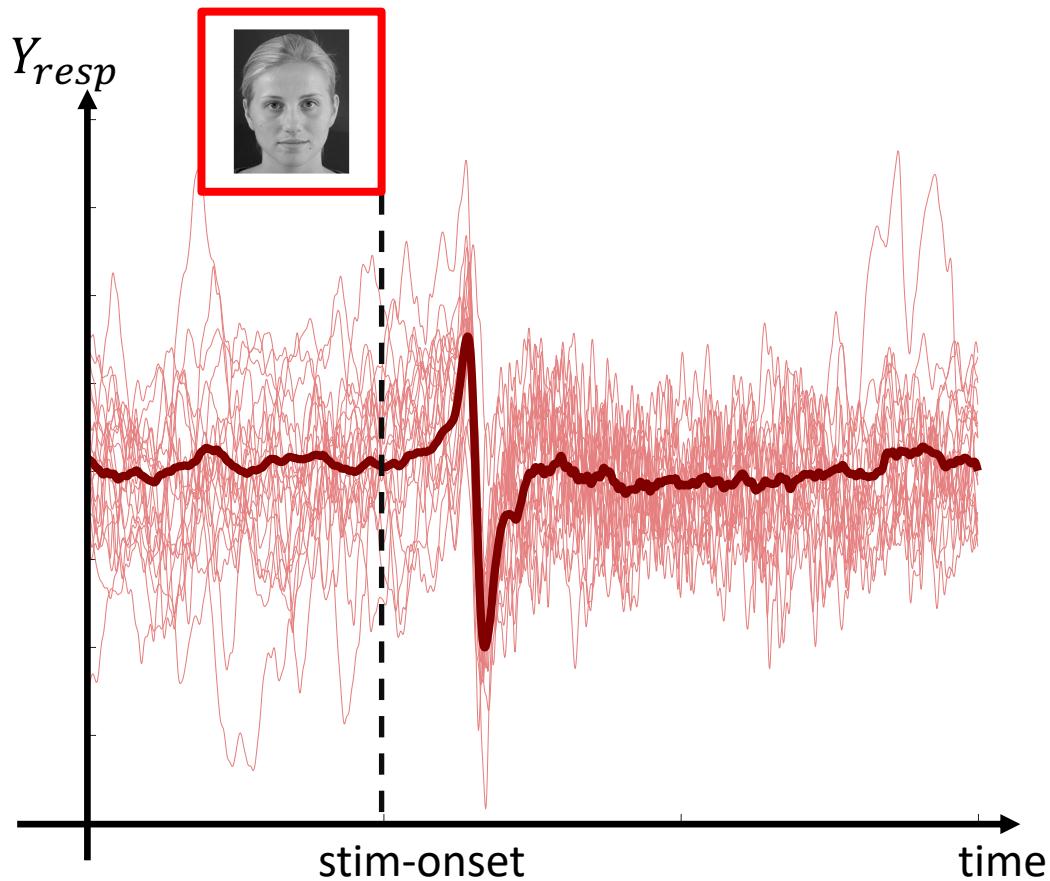
Endogenous activity

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



Endogenous activity correlates to post-stim neural response

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

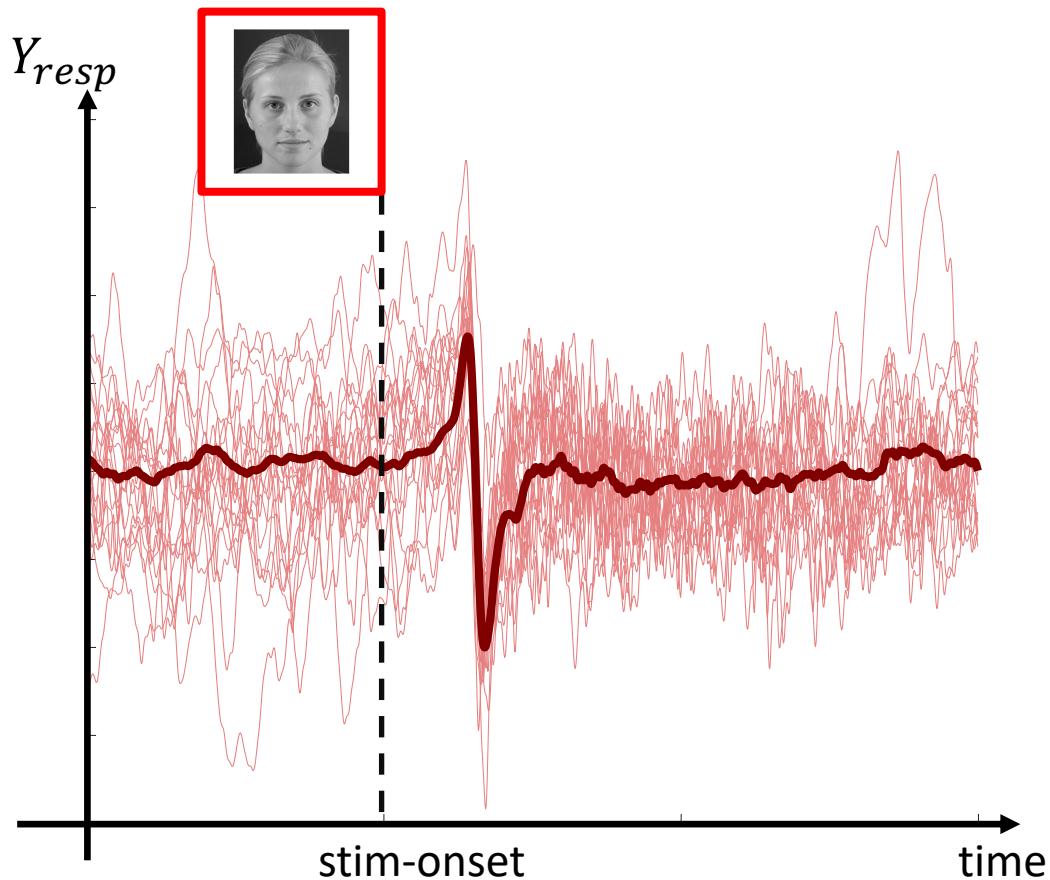


$$X_{pre} \longleftrightarrow Y_{resp}$$

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

Endogenous activity correlates to behavioral perception

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

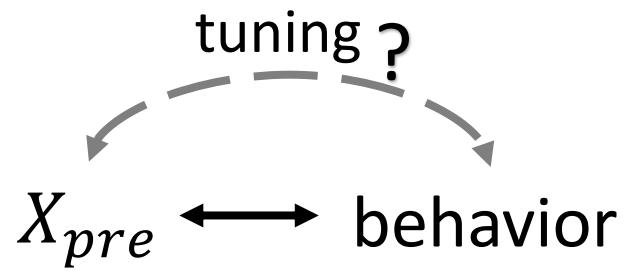
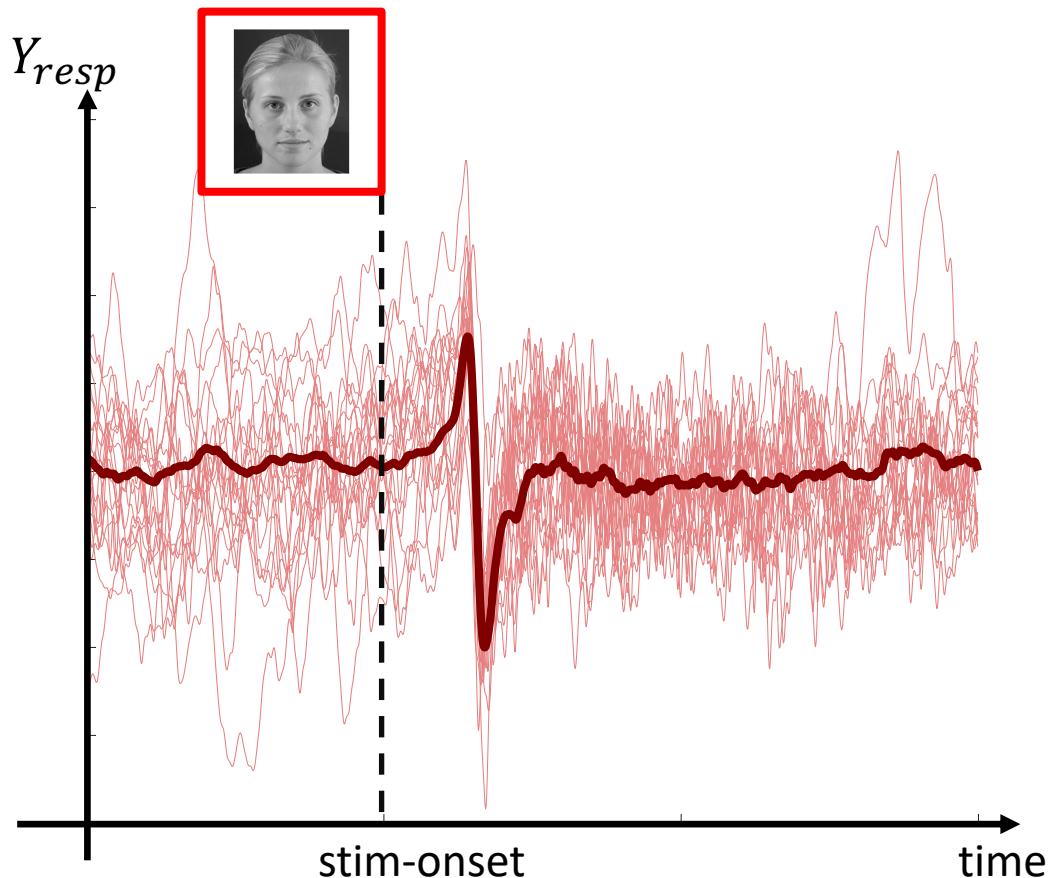


X_{pre} \longleftrightarrow behavior

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 behavioral perception

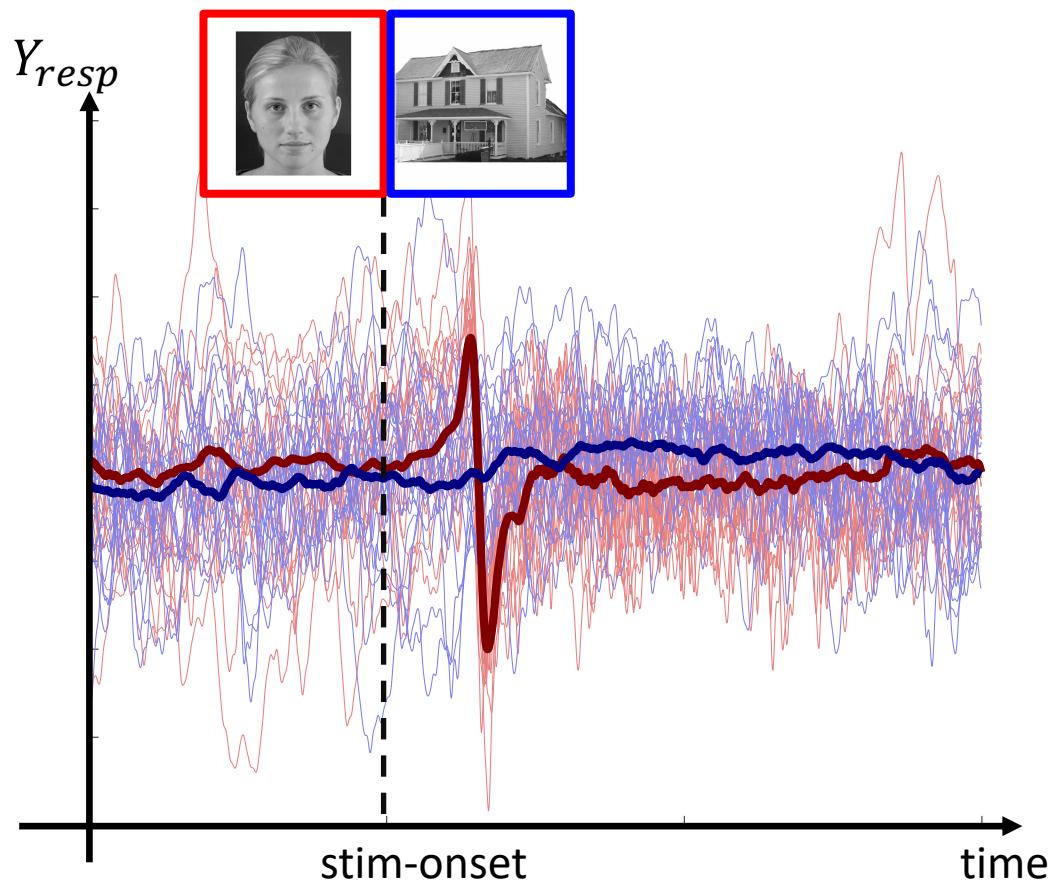
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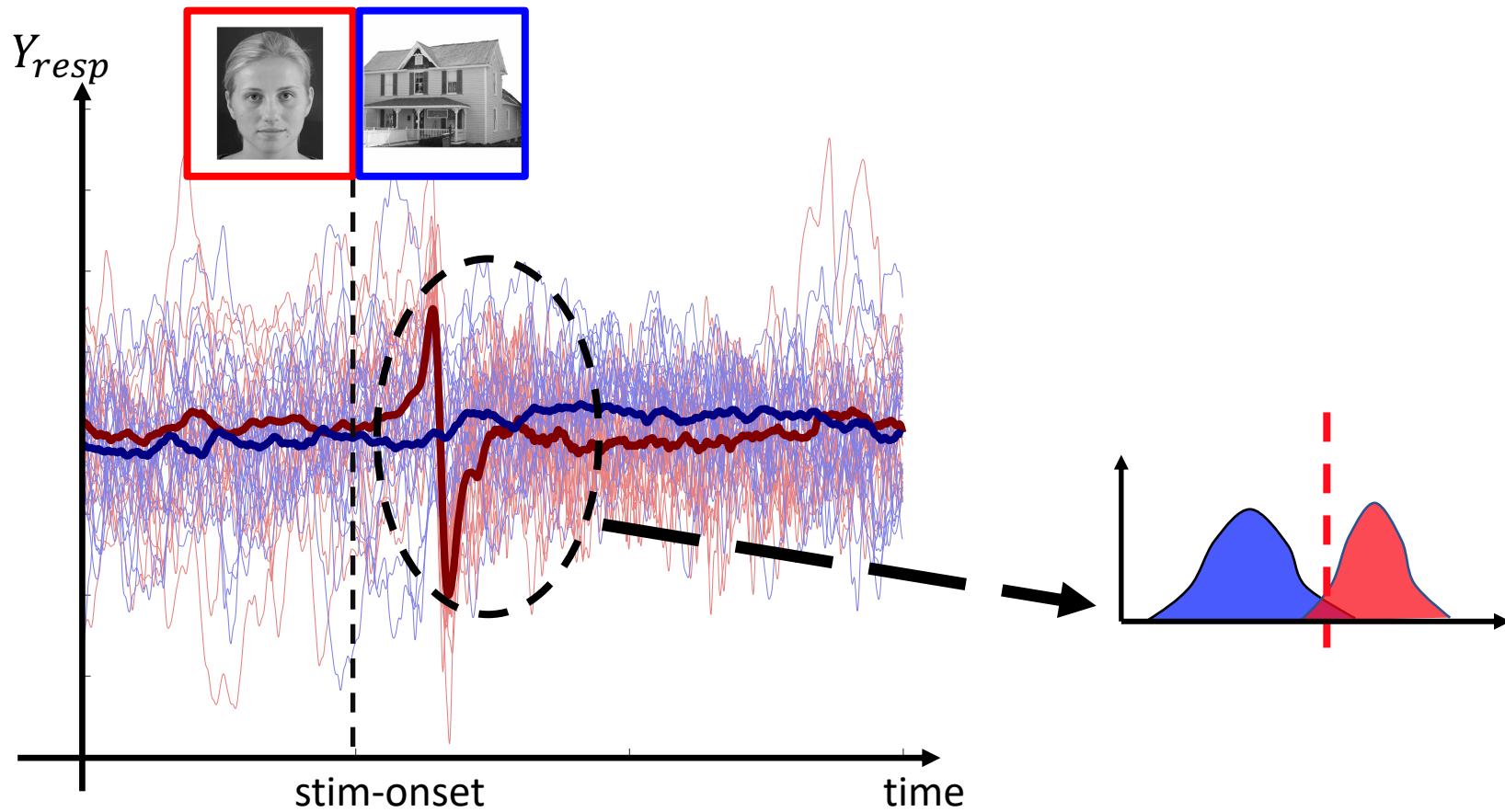
What about category tuning?

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



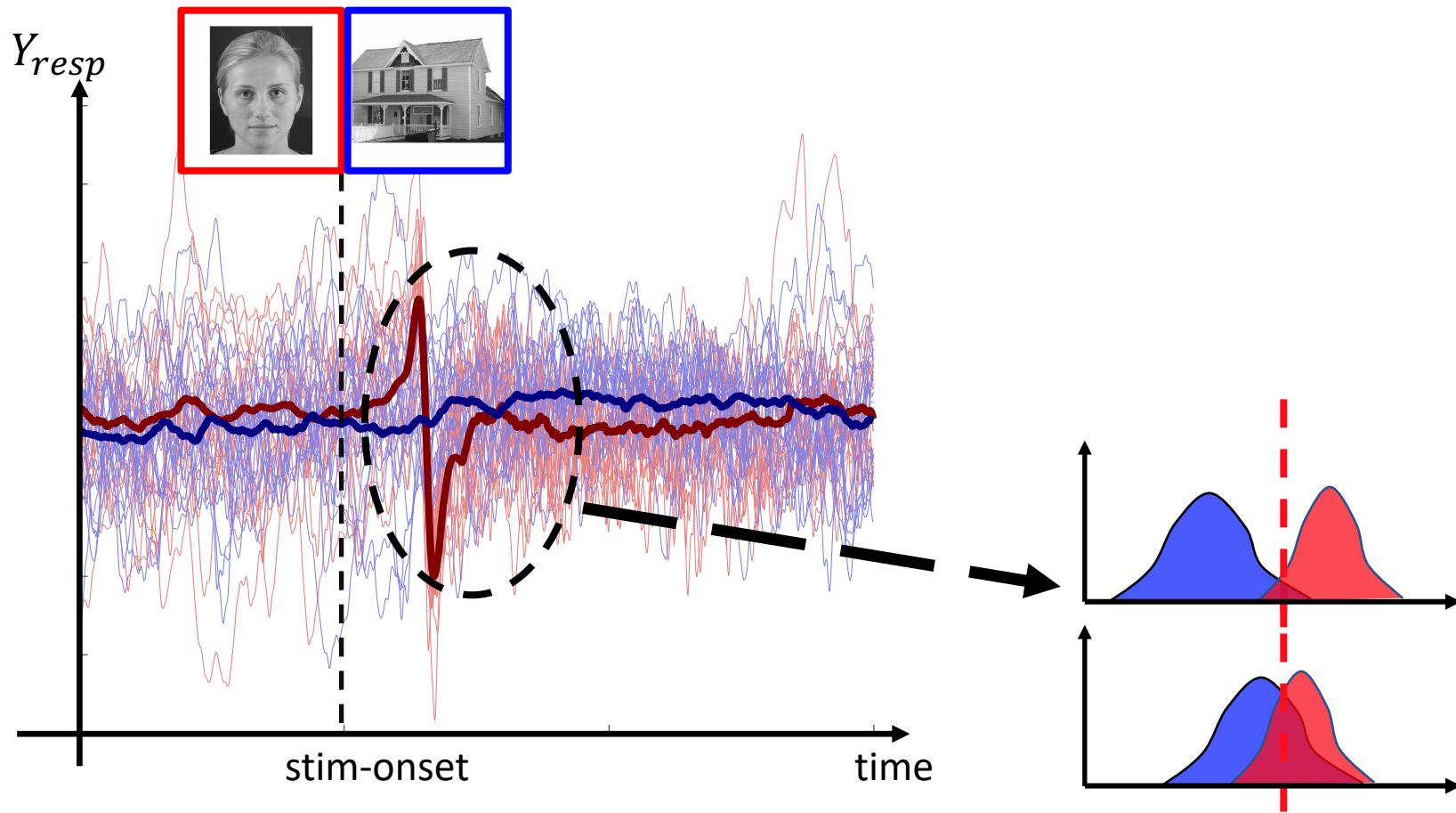
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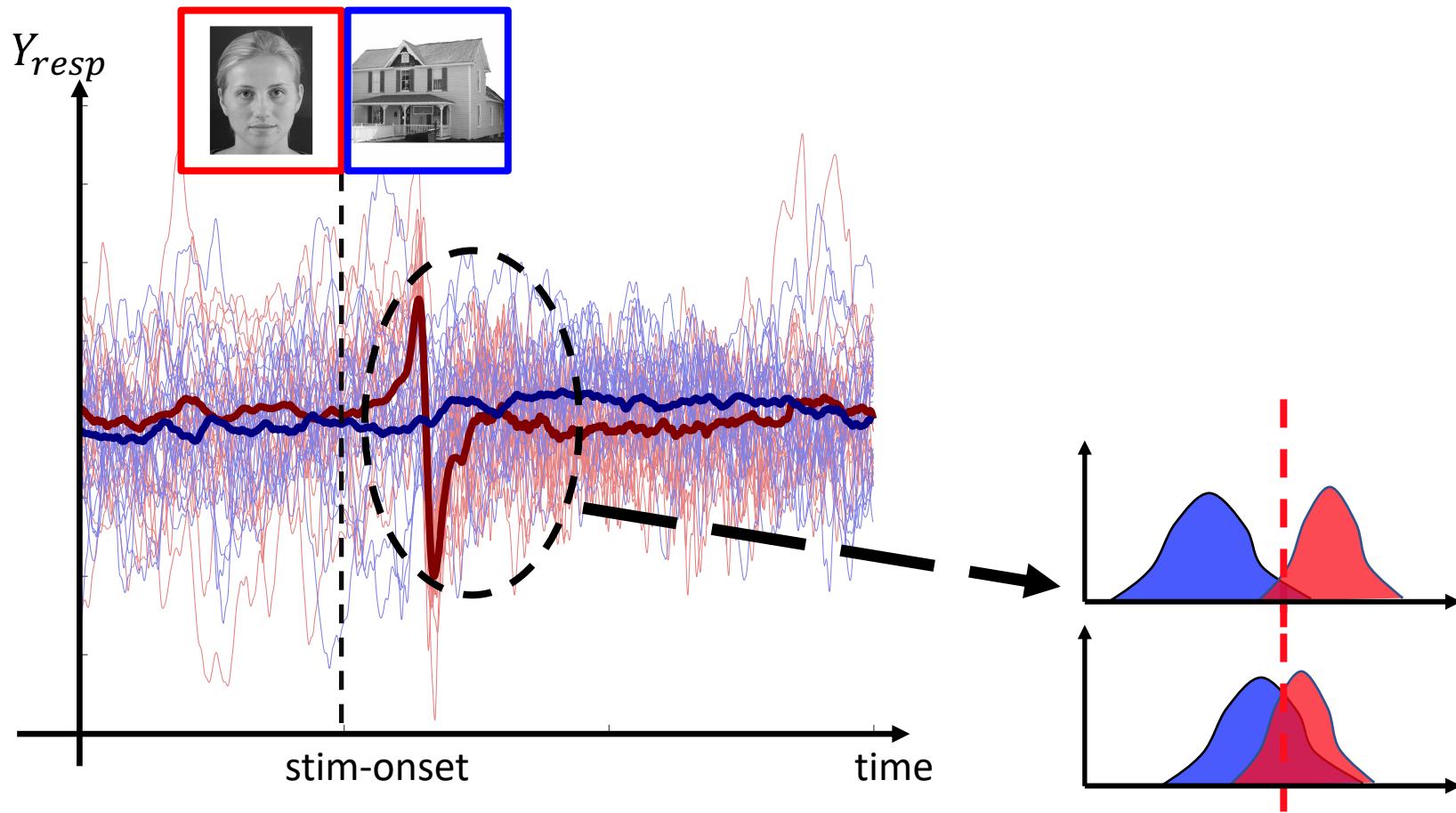
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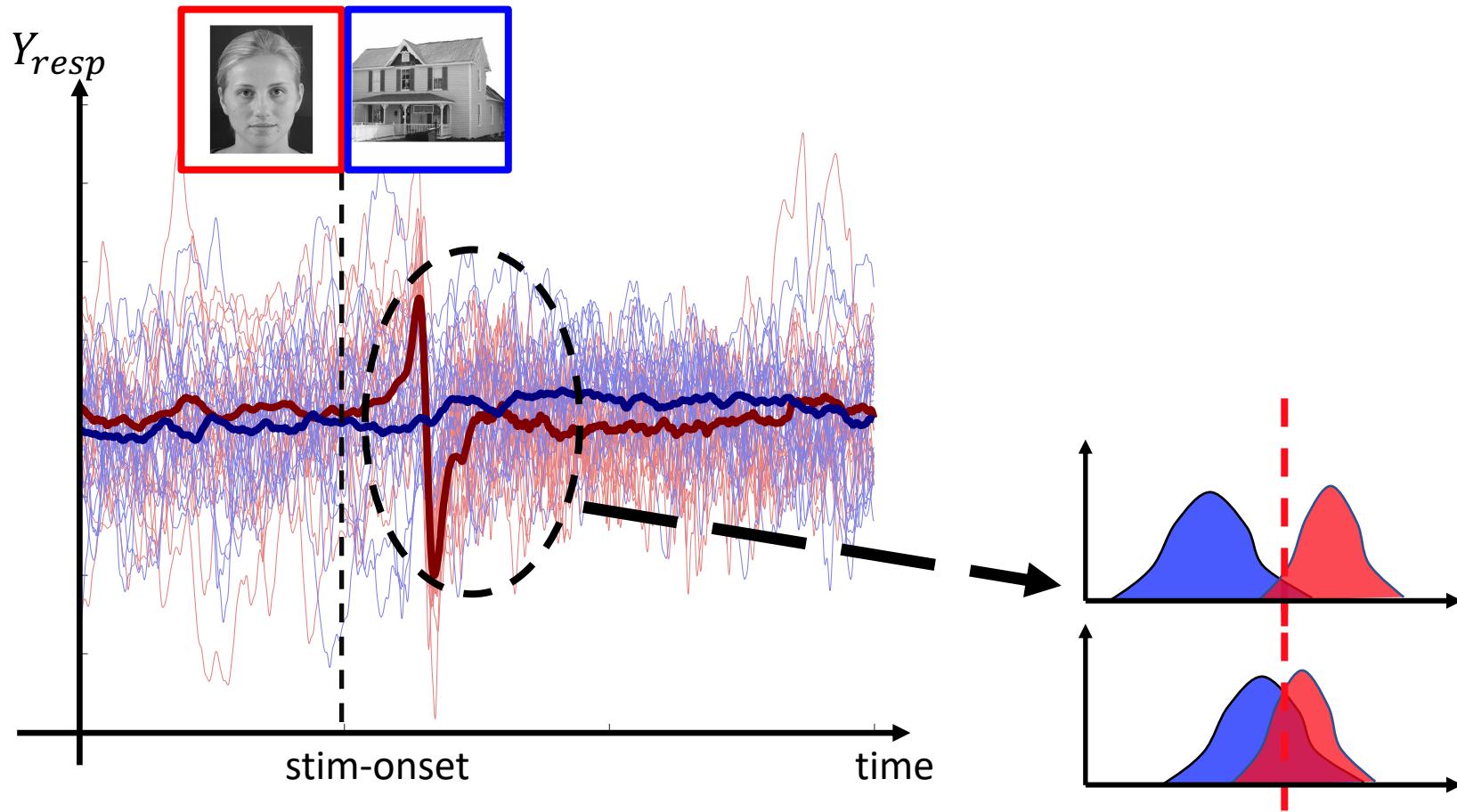
Does endogenous activity influence category tuning?

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



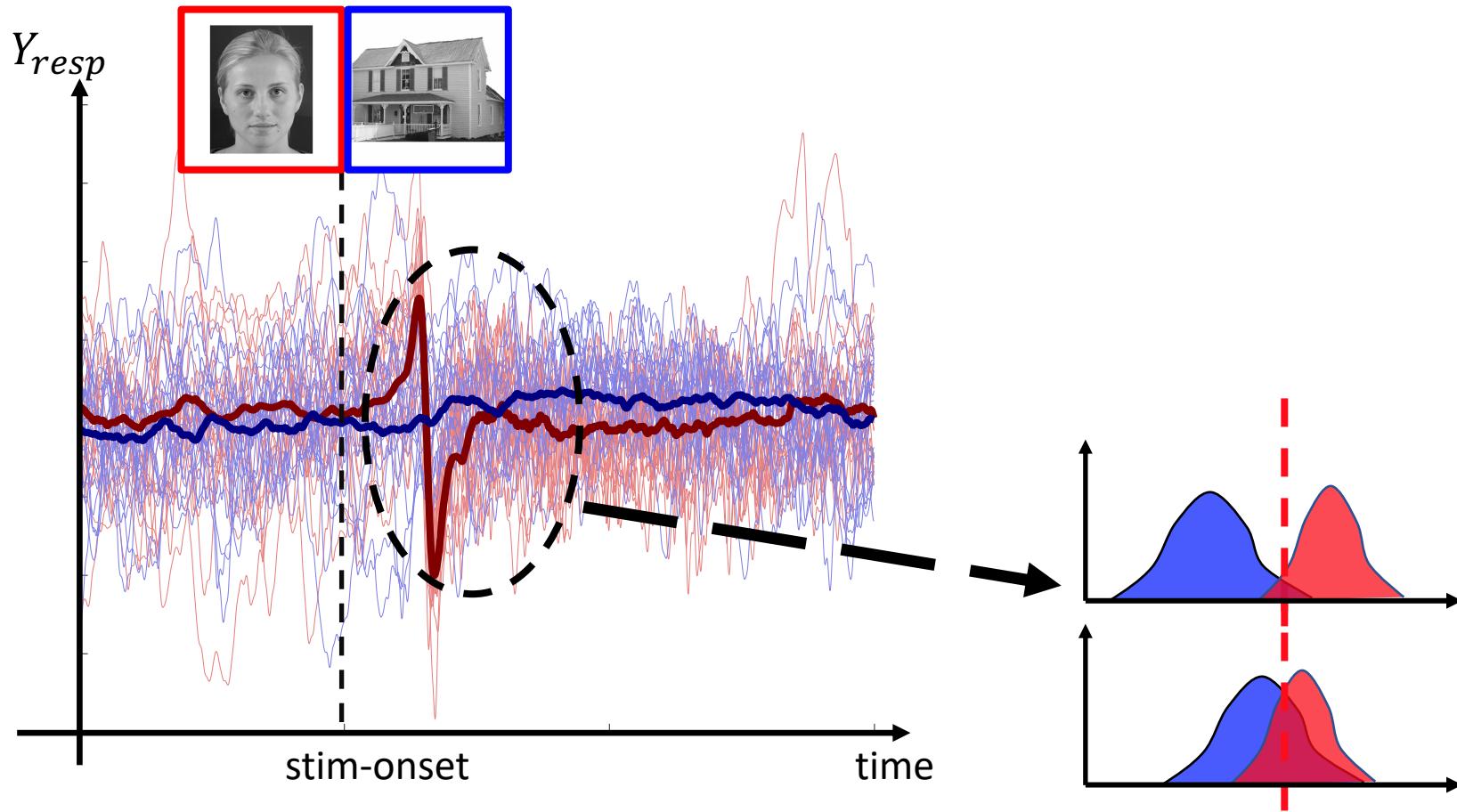
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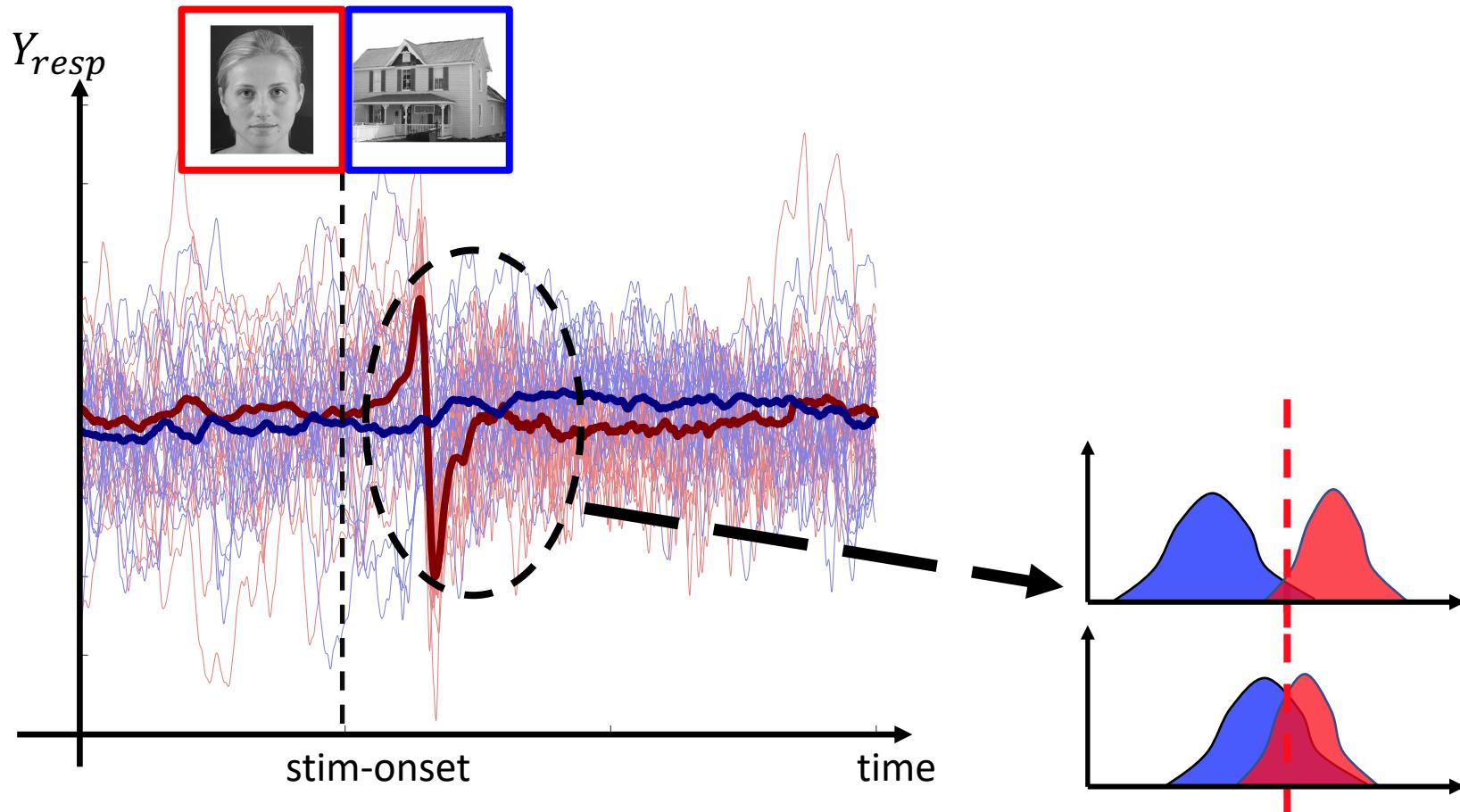
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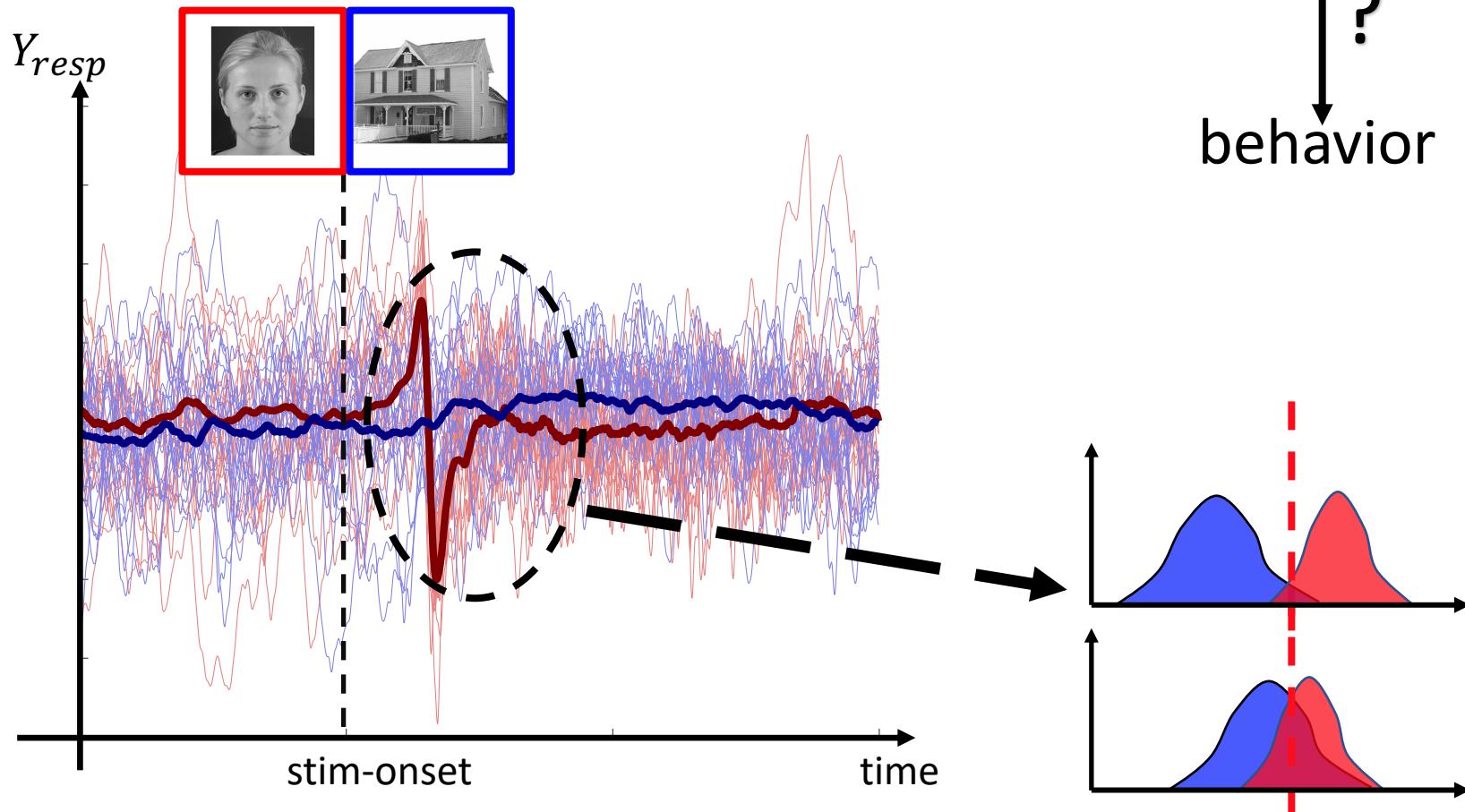
Does endogenous activity influence category tuning?

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



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Hypotheses

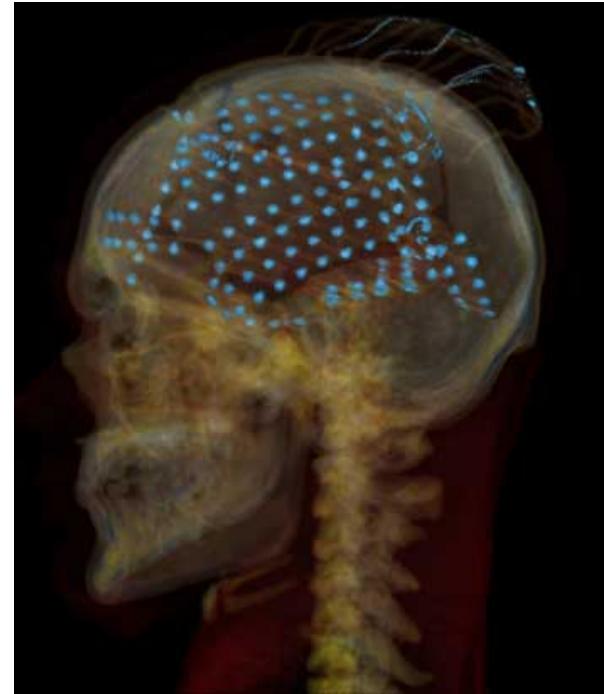
- Pre-stimulus activity modulates the degree of category tuning in response to visual stimuli.

Hypotheses

- Pre-stimulus activity modulates the degree of category tuning in response to visual stimuli.
- The same aspect in pre-stimulus activity that modulates tuning also correlates with behavioral perception.

Experiments

- Intracranial Electroencephalography (iEEG)
- Total number subjects: 32

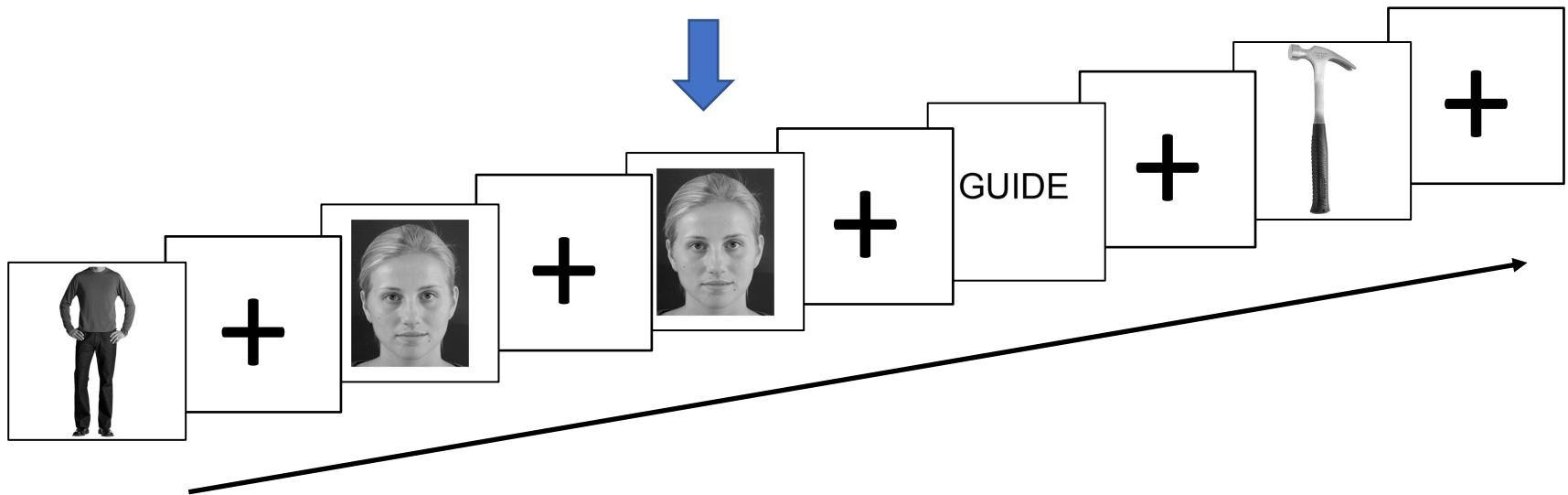


(Photo Credit: Adeen Flinker)

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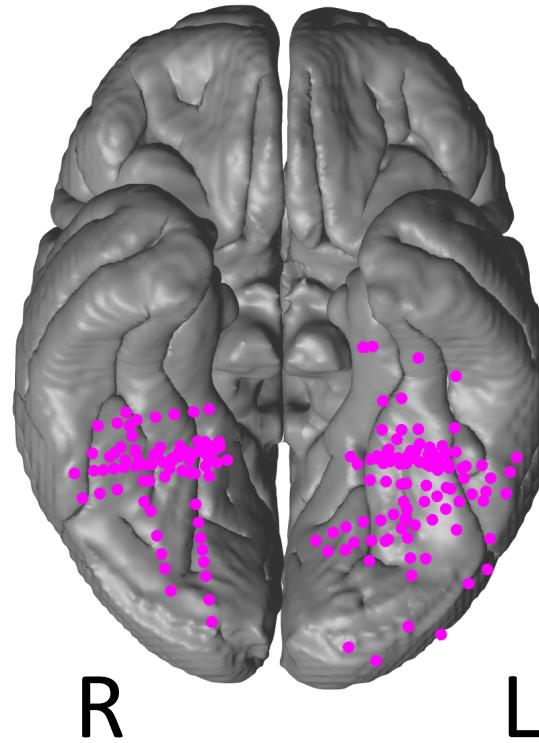
Experiments

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



Experiments

- Category-selective channels: 230
 - faces, bodies, words, houses, tools, scrambled non-objects



Methods

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

Methods

- Fit the discriminant model for category classification using only post-stimulus activity

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

Methods

- Fix the post-stimulus discriminant component and optimize the previous model conditioning on pre-stimulus activity

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

Methods

- Fix the post-stimulus discriminant component and optimize the previous model conditioning on pre-stimulus activity

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

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

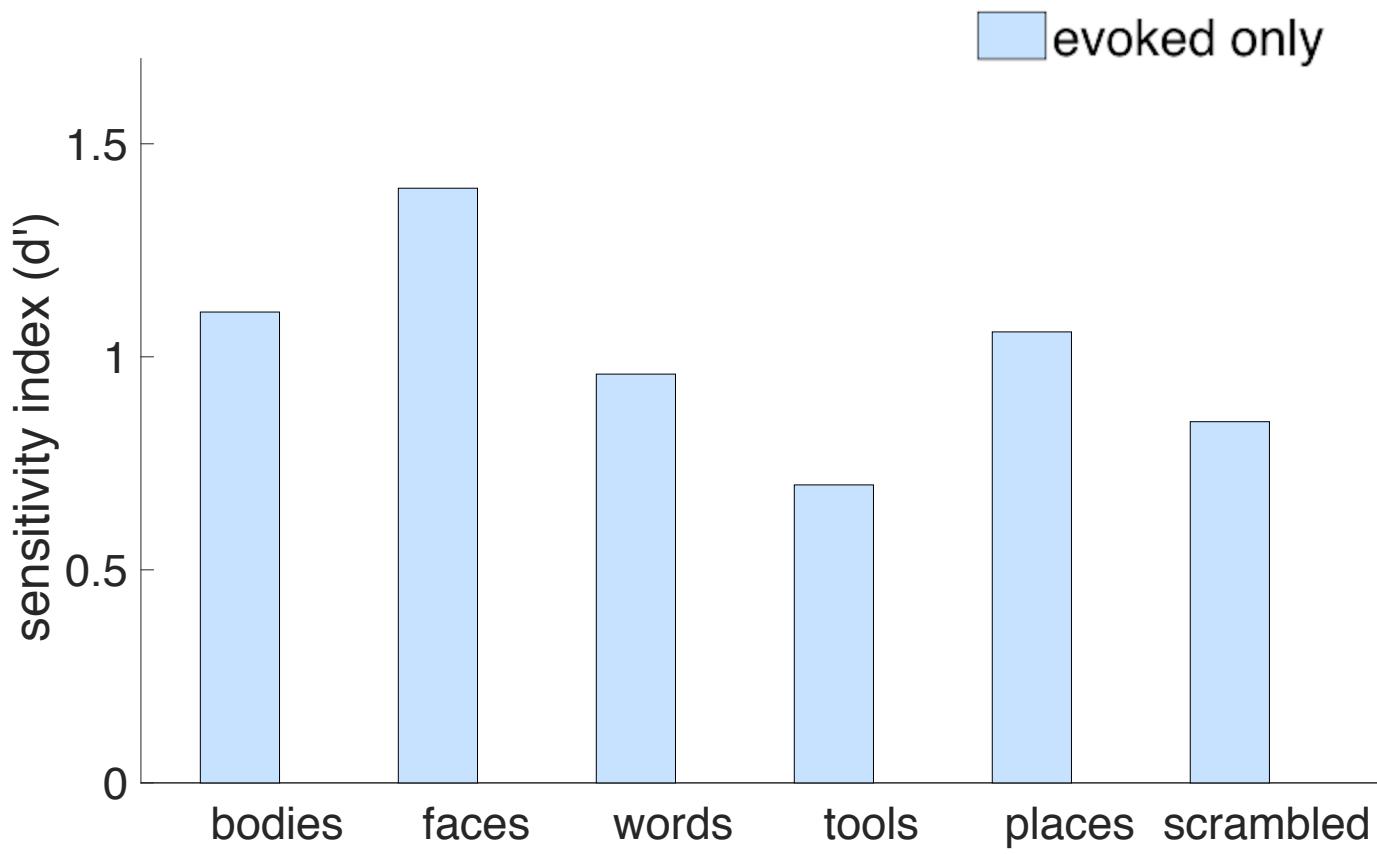
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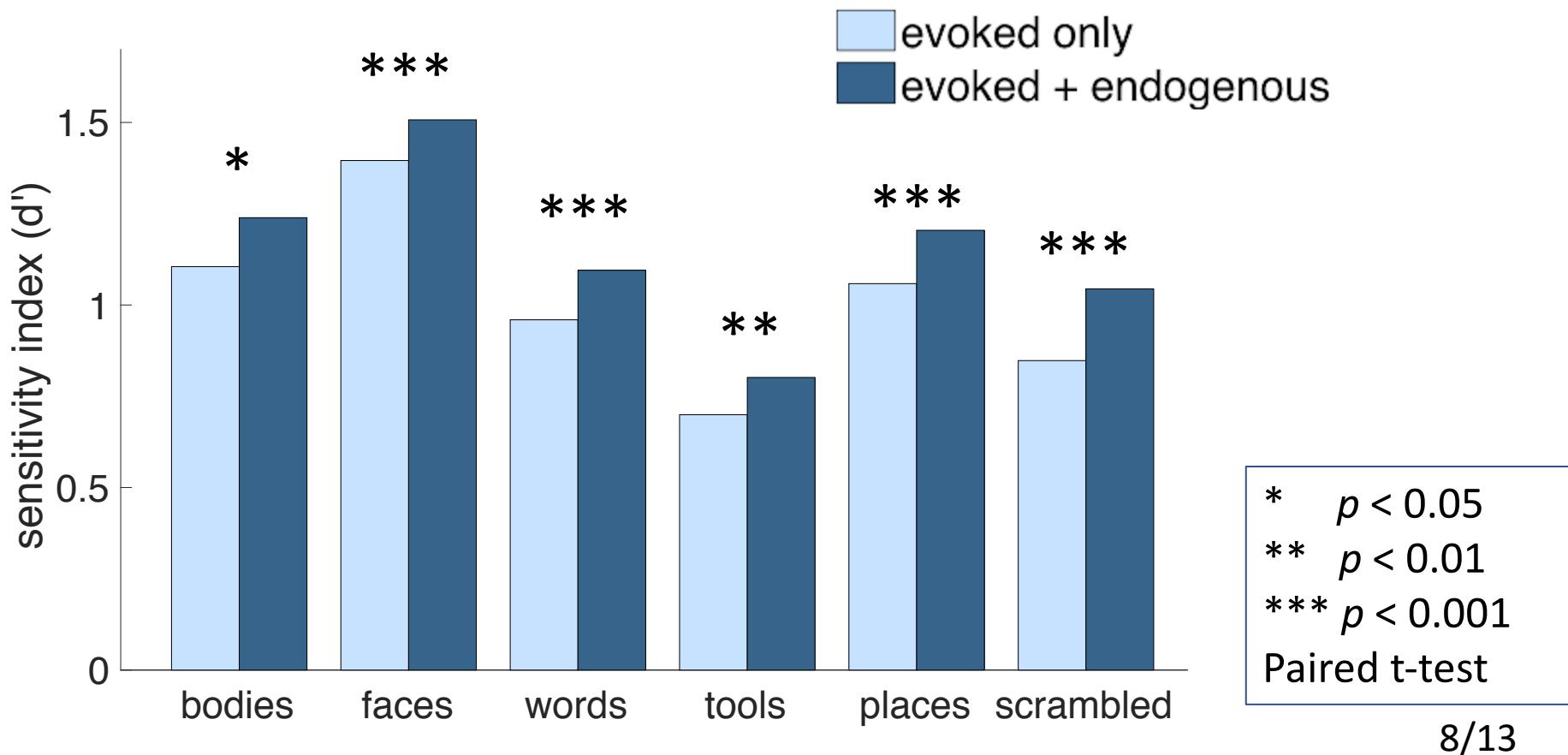
$$p(\text{category} | X_{evk}, X_{pre}) = f(a^T X_{evk}, b^T X_{pre})$$

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

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

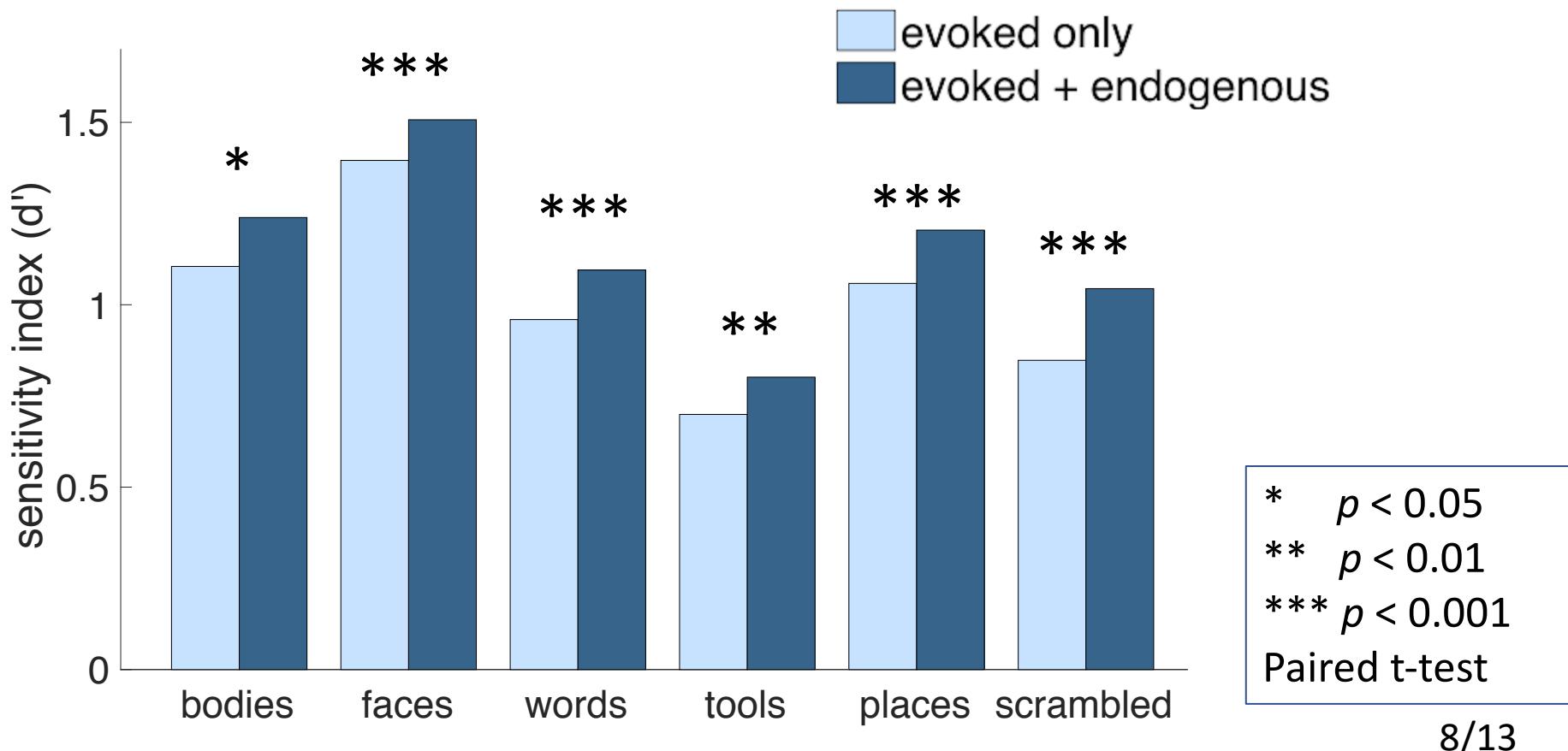


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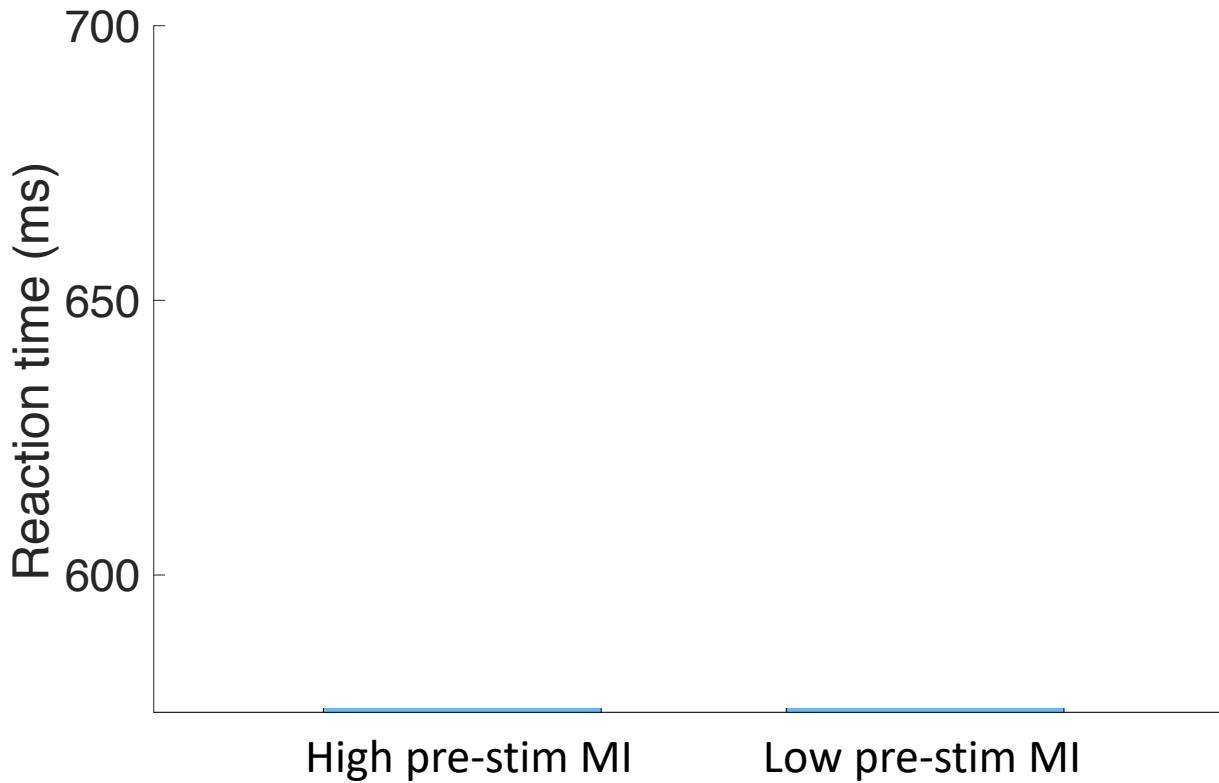


Does the inclusion of pre-stimulus activity improve categorical classification accuracy?

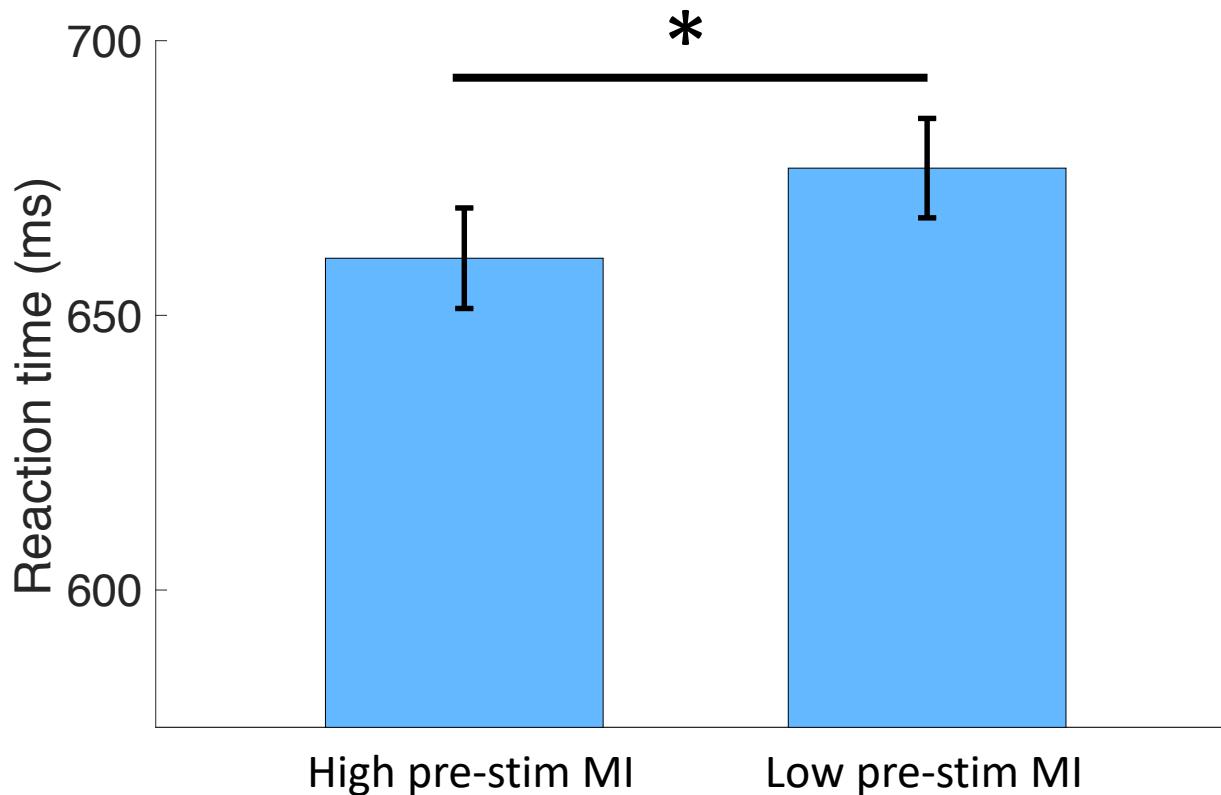
- YES. Conditioning on pre-stimulus activity functionally improves category tuning.



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



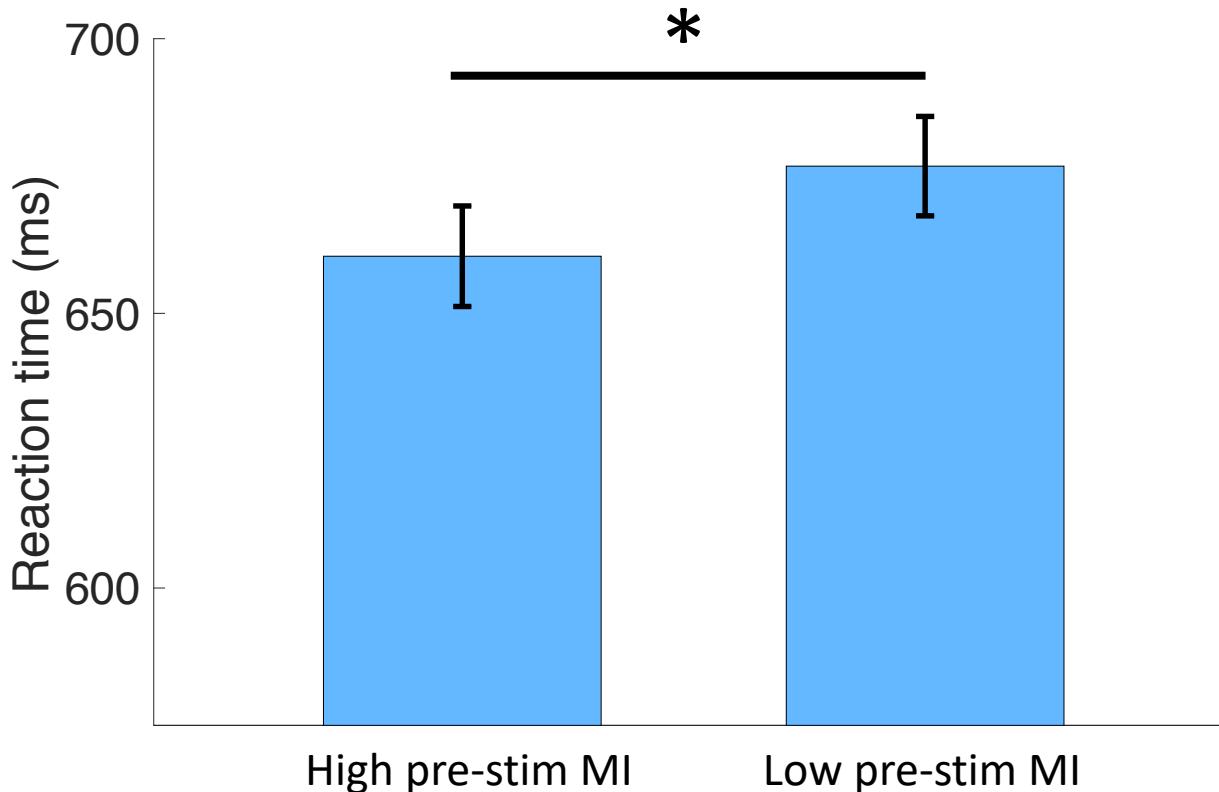
Does the same aspects of pre-stimulus activity also correlate with behavior performance?



* $p < 0.05$
Permutation test

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 correlates with perceptual behavior performance.



* $p < 0.05$
Permutation test

Main hypothesis

- ✓ • Pre-stimulus activity modulates the degree of category tuning in response to visual stimuli.
- ✓ • The same aspect in pre-stimulus activity that modulates tuning also correlates with behavioral perception.

Next questions

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

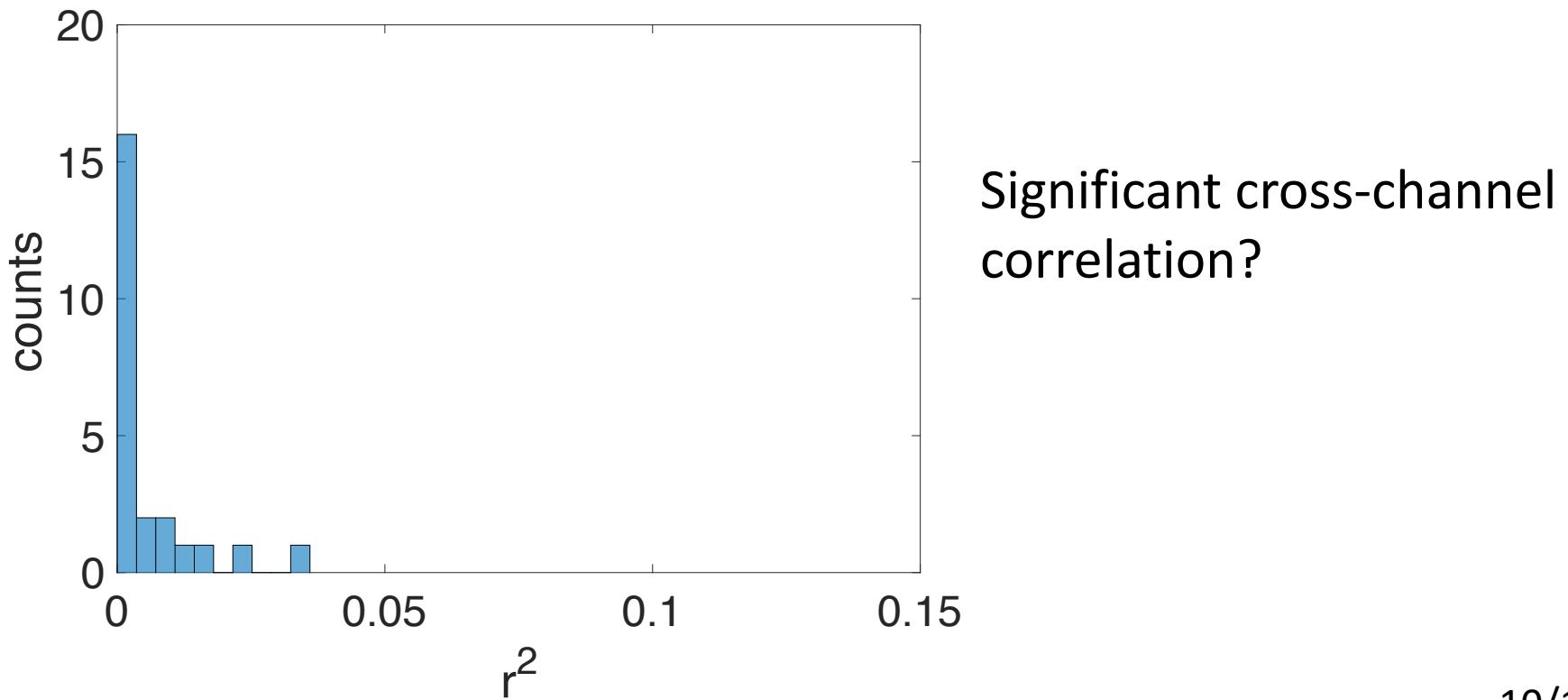
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Significant cross-channel correlation?

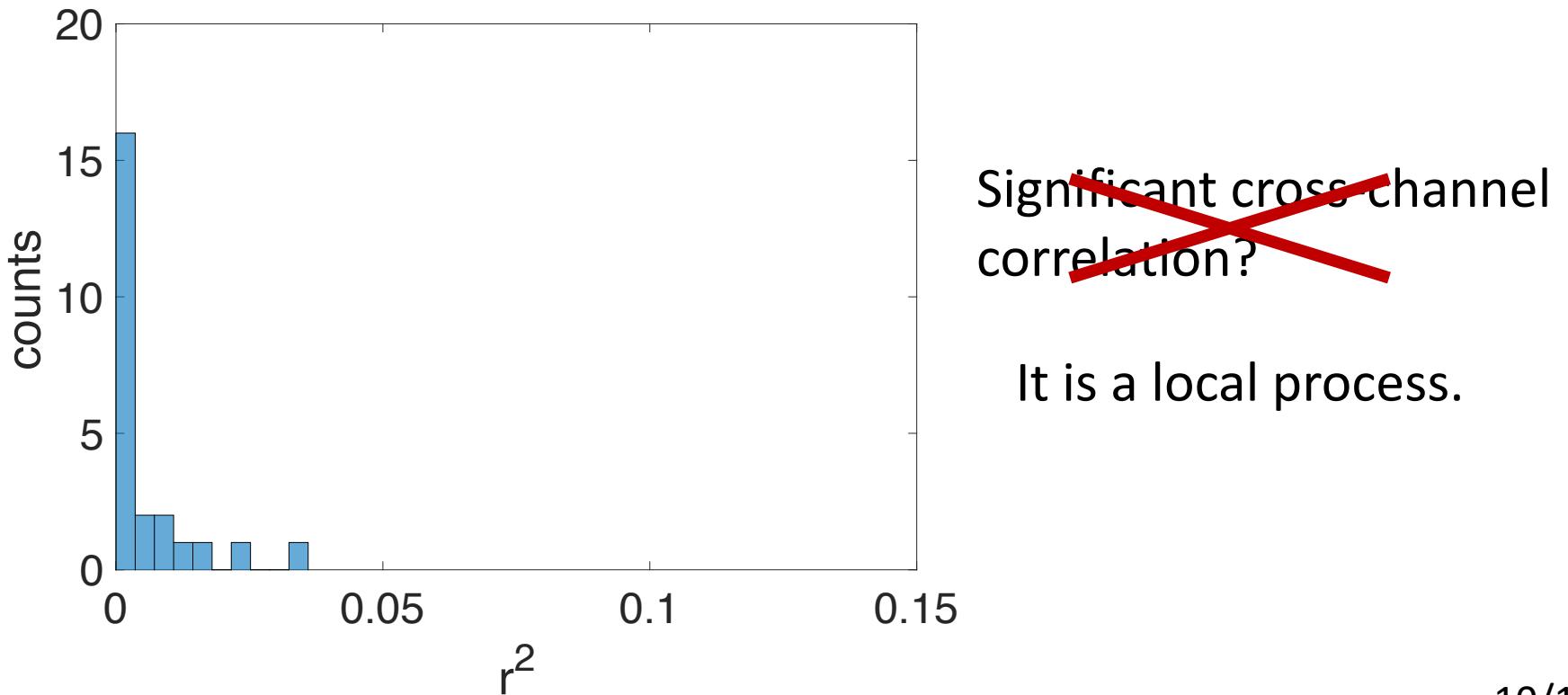
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- A reflection of infra-slow fluctuations seen in resting state?

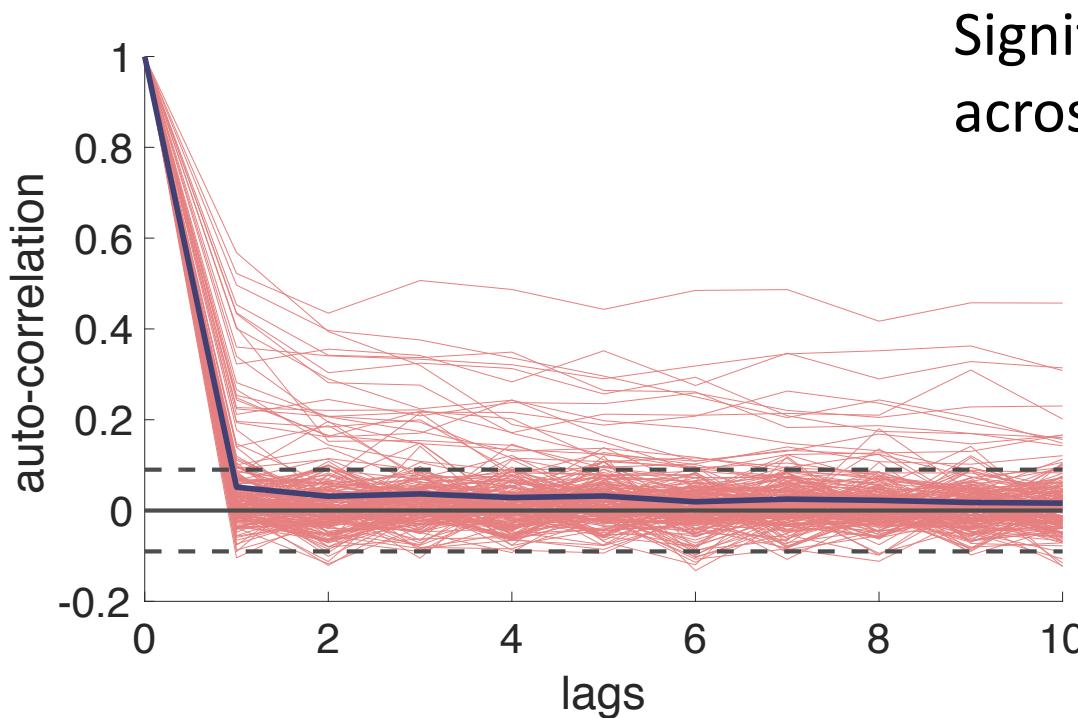
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Significant auto-correlation
across consecutive trials?

Next questions

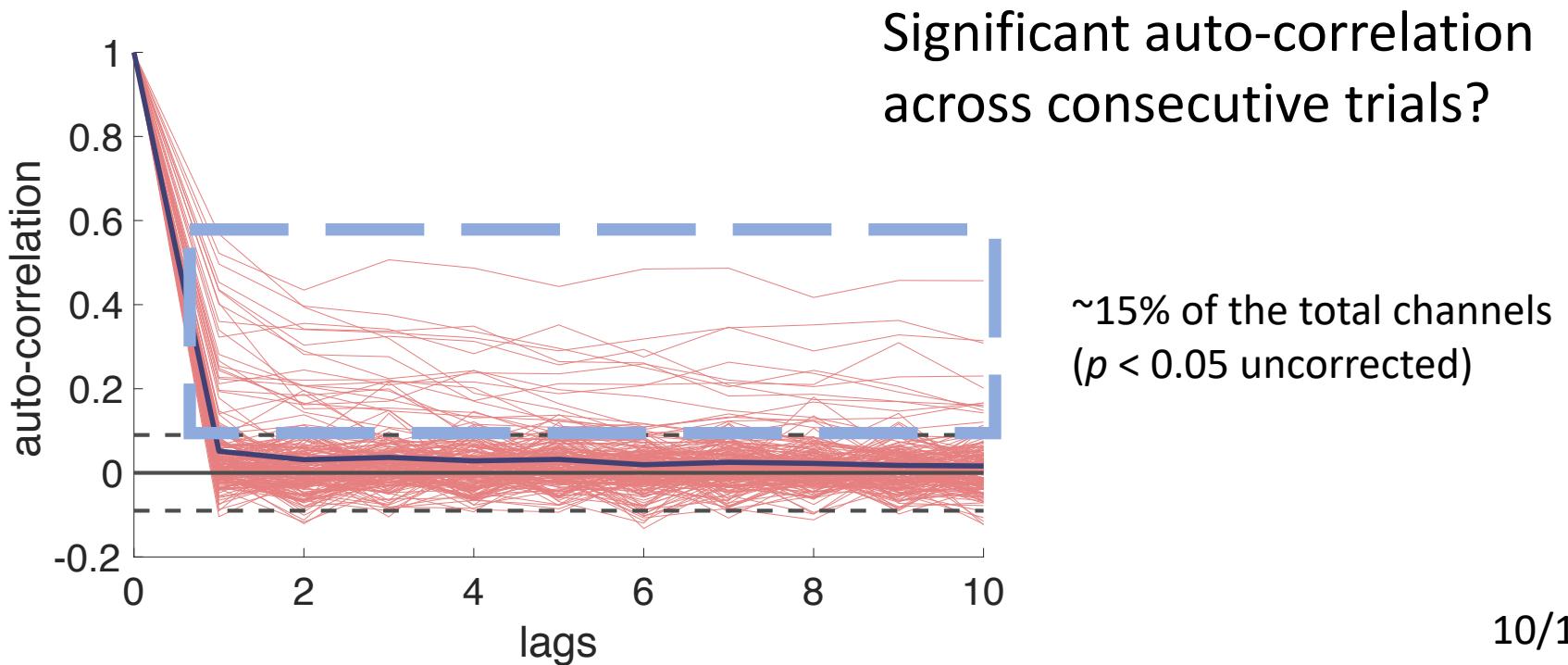
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Next questions

- A reflection of fluctuations in global cognitive state (e.g. arousal/attention)?
No, the effects are spatially uncorrelated.
- A reflection of infra-slow fluctuations seen in resting state?
Only a very small portion of the channels show trial-by-trial auto-correlation in endogenous modulation of tuning. The majority are transient.

Conclusion

- Pre-stimulus activity influences the degree of category tuning in response to visual stimuli.

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- **The pre-stimulus modulation effect is a reflection of local processes.**

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- The same aspects in pre-stimulus activity that influences post-stimulus category tuning also correlates with perceptual behavior performance.
- The pre-stimulus modulation effect is a reflection of local processes.
- 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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- The same aspects in pre-stimulus activity that influences post-stimulus category tuning also correlates with perceptual behavior performance.
- The pre-stimulus modulation effect is a reflection of local processes.
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Thank you!

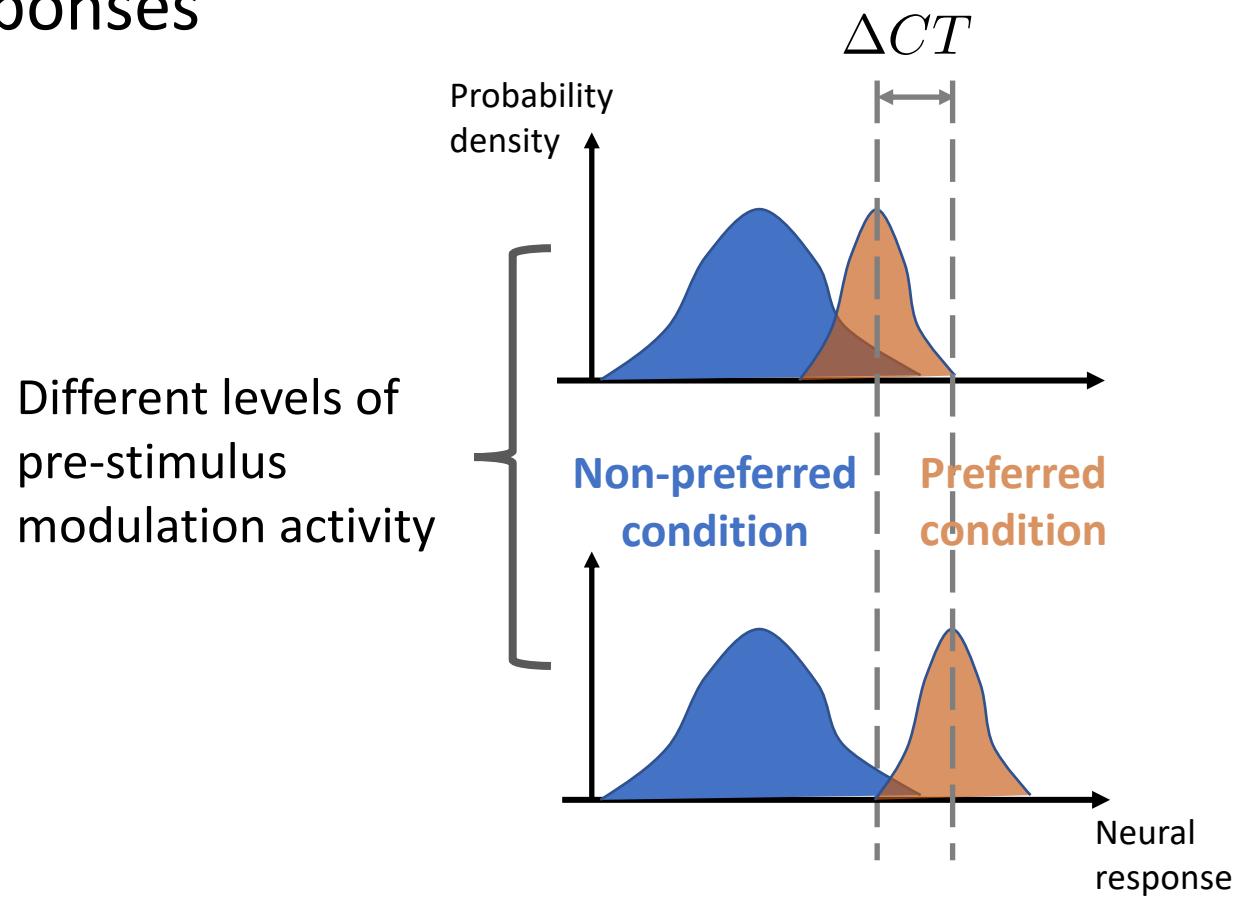


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Results: category tuning

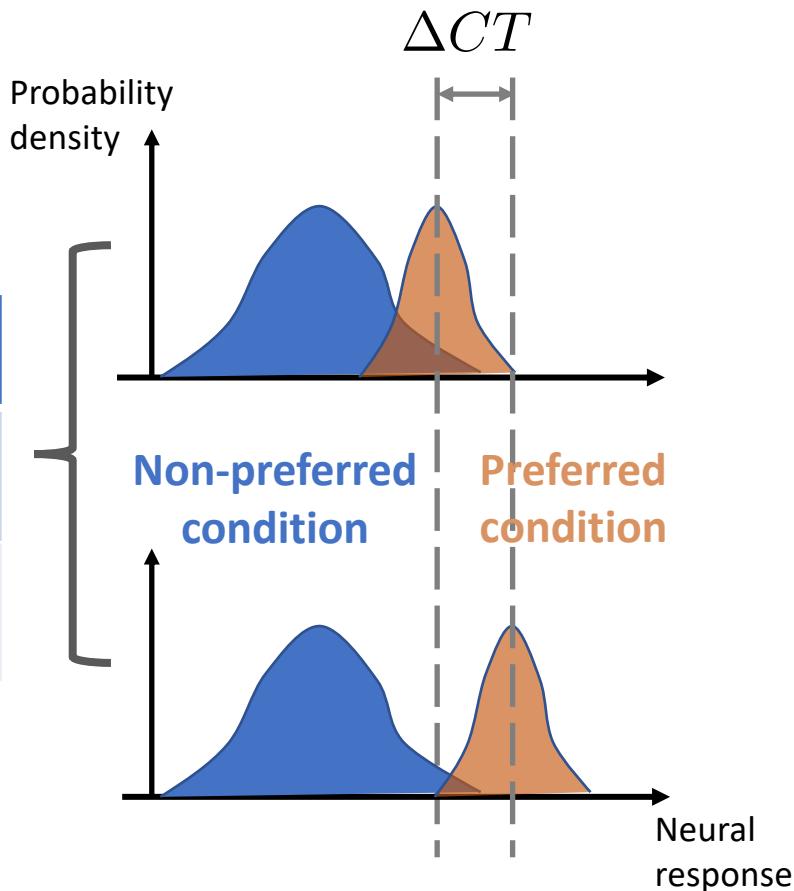
- Pre-stim activity modulated the category-tuning in the evoked-responses



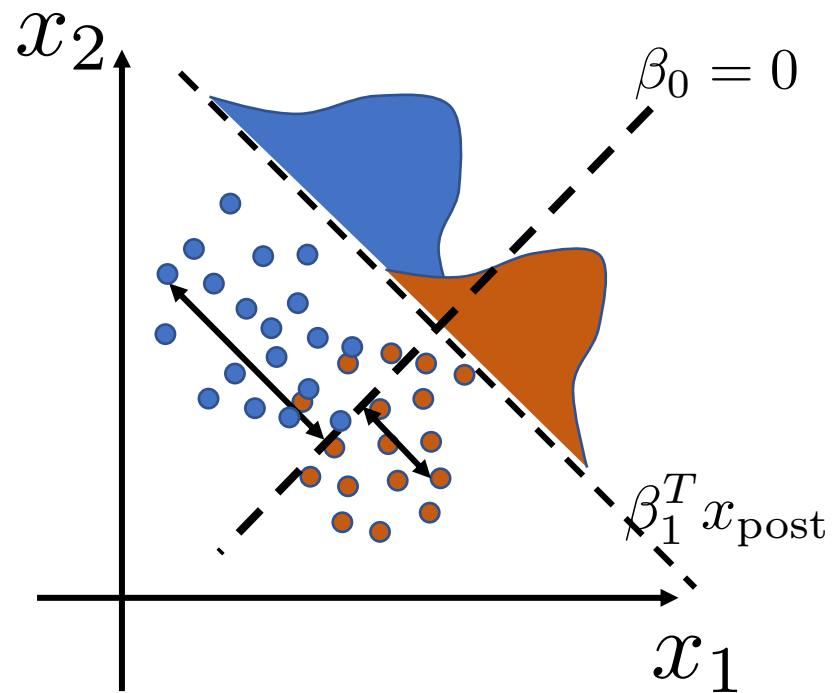
Results: category tuning

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

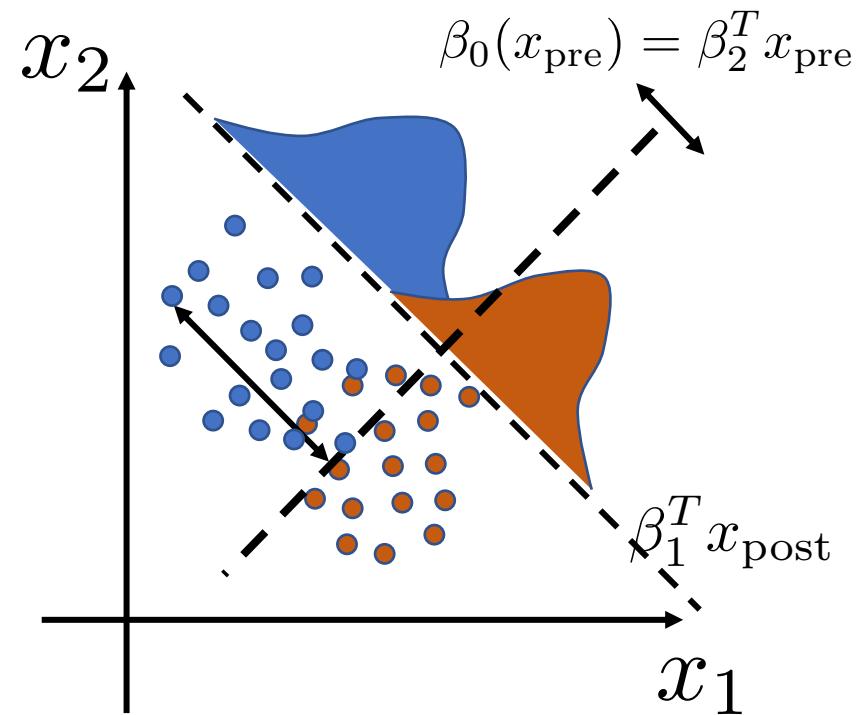
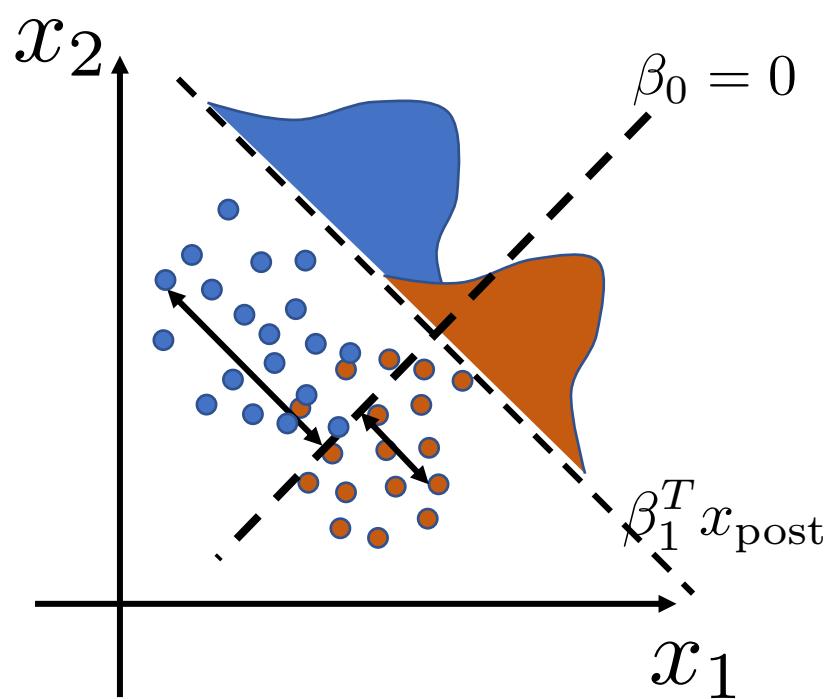
	ΔCT	p-value
Preferred condition	0.1101	< 0.001
Non-preferred condition	-0.0126	0.092



Model



Model



Model

