

Towards a Mechanistic Account of Perceptual Curiosity

Michael Cohanpour, Mariam Aly*, Jacqueline Gottlieb*

(*denotes co-PIs)

Columbia University

Perceptual Curiosity

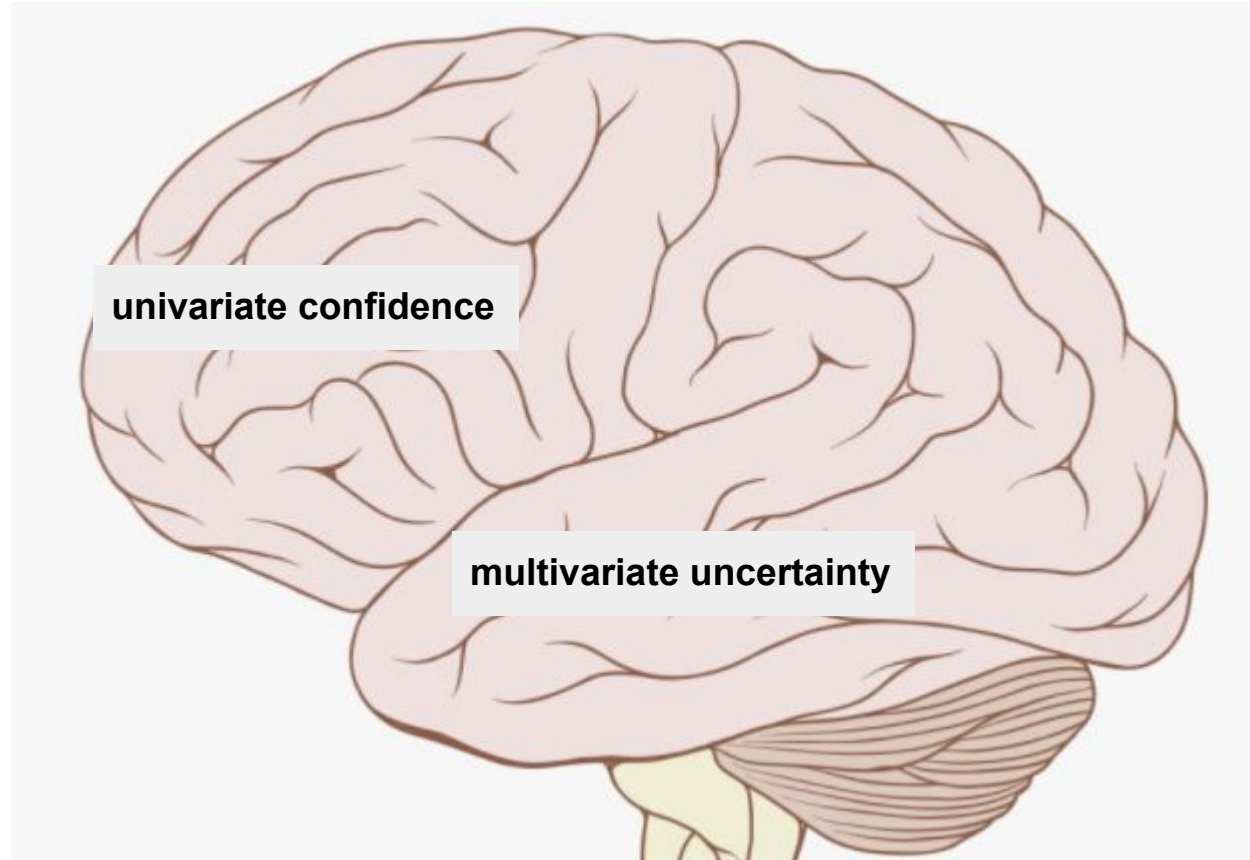
Intrinsic desire to reduce **sensory** uncertainty

Berlyne 1966; Nicki 1970; Jepma et al. 2013



Distinct neural representations of sensory uncertainty

ma et al. (2008); meynial et al. (2015); walker et al. (2020);



Questions

- How does confidence in your answer relate to perceptual curiosity?
- How do neural representations of sensory uncertainty give rise to perceptual curiosity?

Manipulating uncertainty by using texforms!



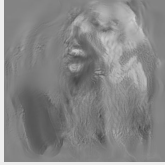
original image

Deza, Chen, Long, & Konkle (CCN 2019)
Fast Texform Algorithm.



texform

Main Task



how confident are you in
your best guess?

0 ————— 100

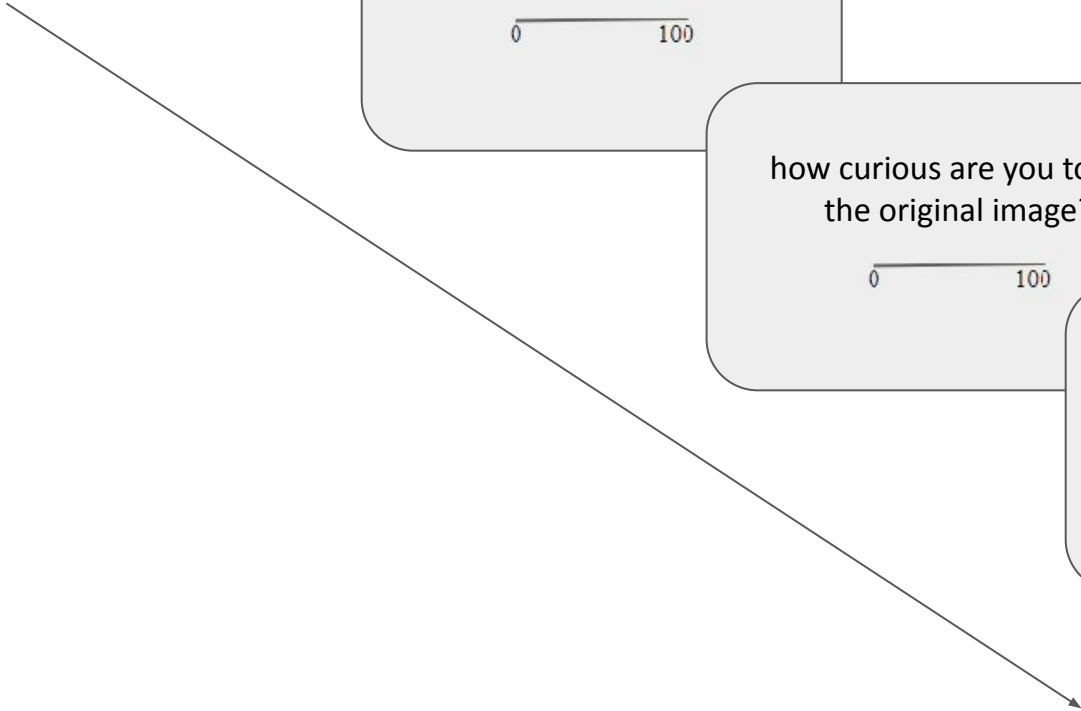
how curious are you to see
the original image?

0 ————— 100

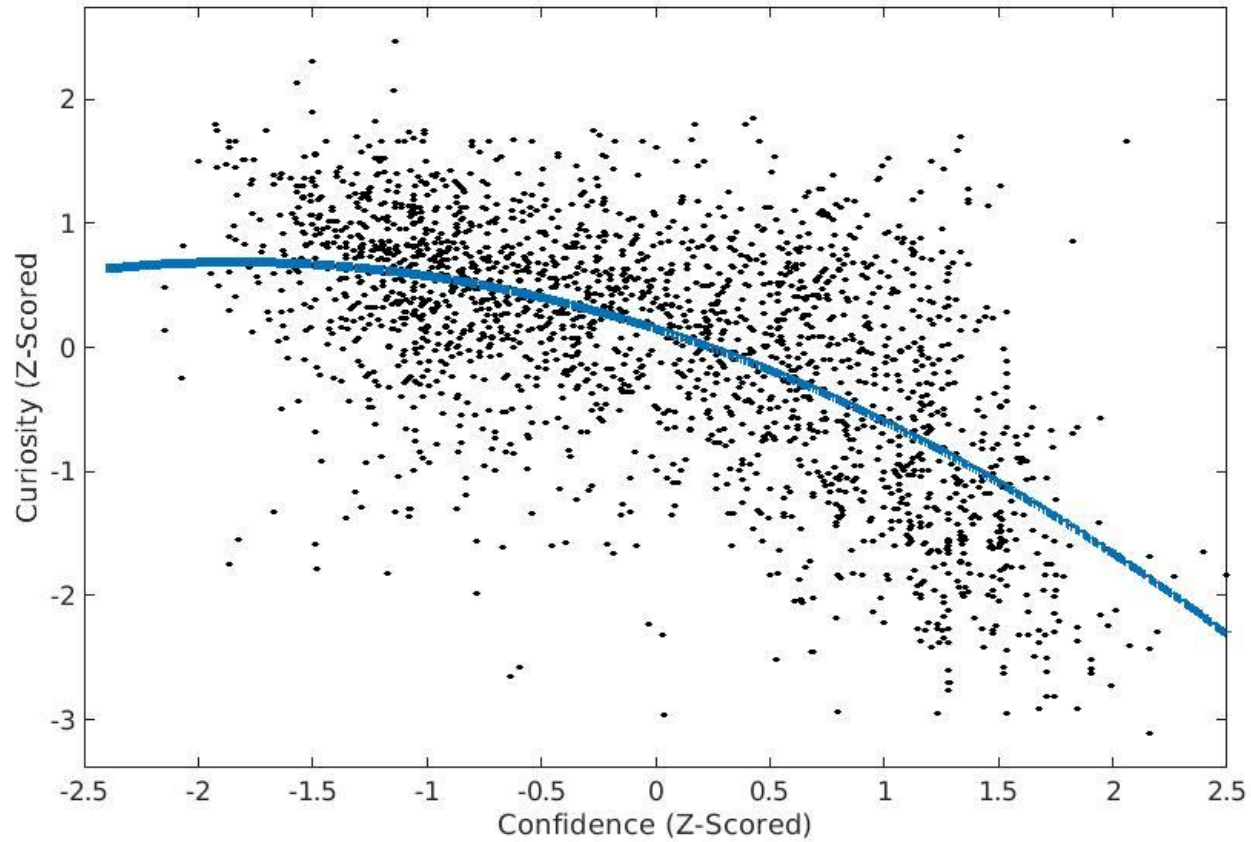


how surprised are you?

0 ————— 100

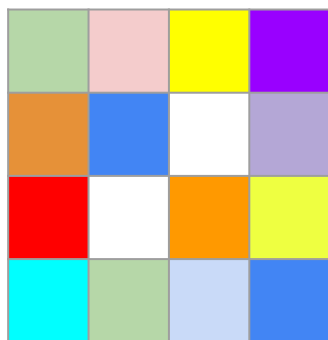


Curiosity peaks at low confidence ratings

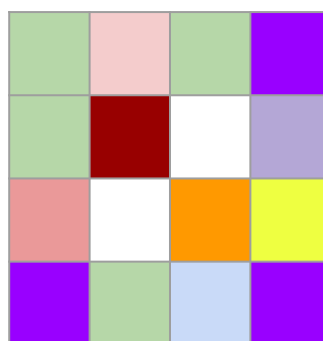
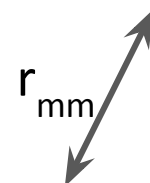
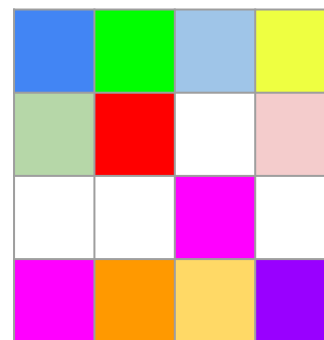


Decoding multivariate uncertainty from OTC patterns of activity

animal template



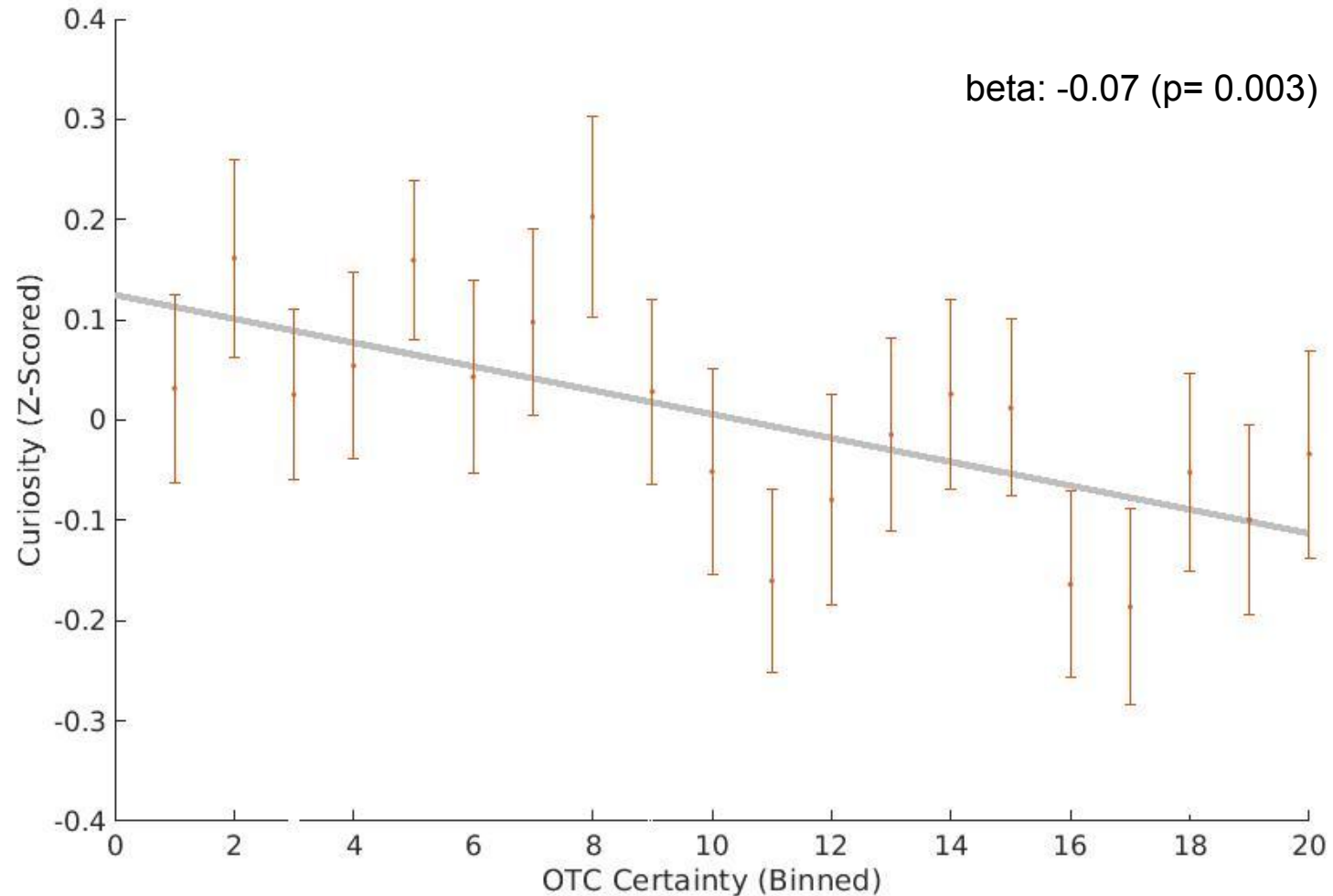
man-made template



texform pattern

$$\text{certainty} = |r_a - r_{mm}|$$

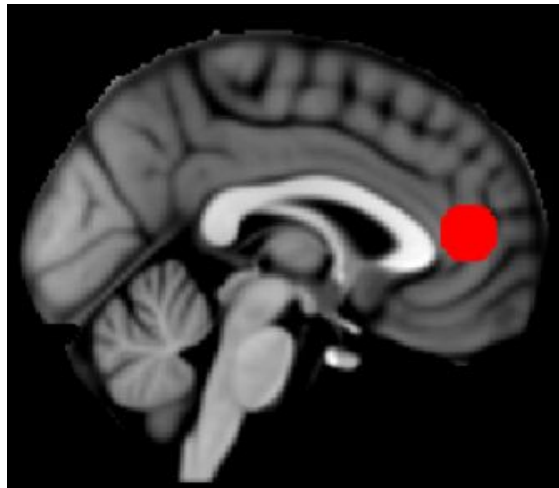
OTC certainty negatively correlates with curiosity



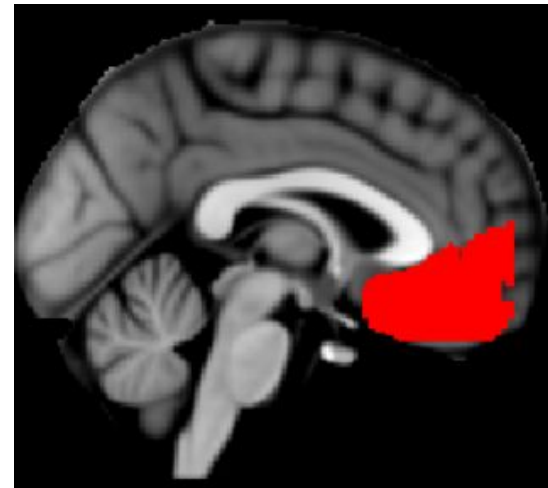
significance validated with mixed effects models

Two regions in PFC track confidence ratings

– activity in perigenual ACC (pgACC) and ventromedial PFC (vmPFC) significantly correlated with confidence ratings during texform presentation (cluster-level FWER-corrected $p = 0.05$, permutation test)



pgACC

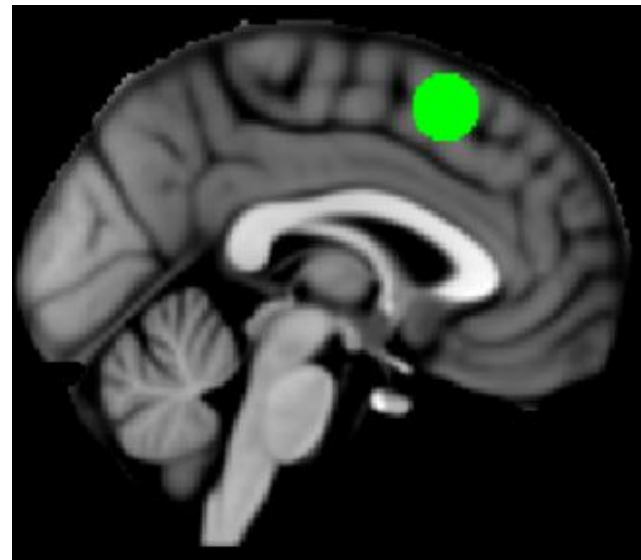


vmPFC

“confidence ROIs”

Left superior frontal gyrus tracks curiosity

– activity in left superior frontal gyrus (left SFG) significantly correlated with curiosity ratings during texform presentation (cluster-level FWER-corrected $p = 0.05$, permutation test)

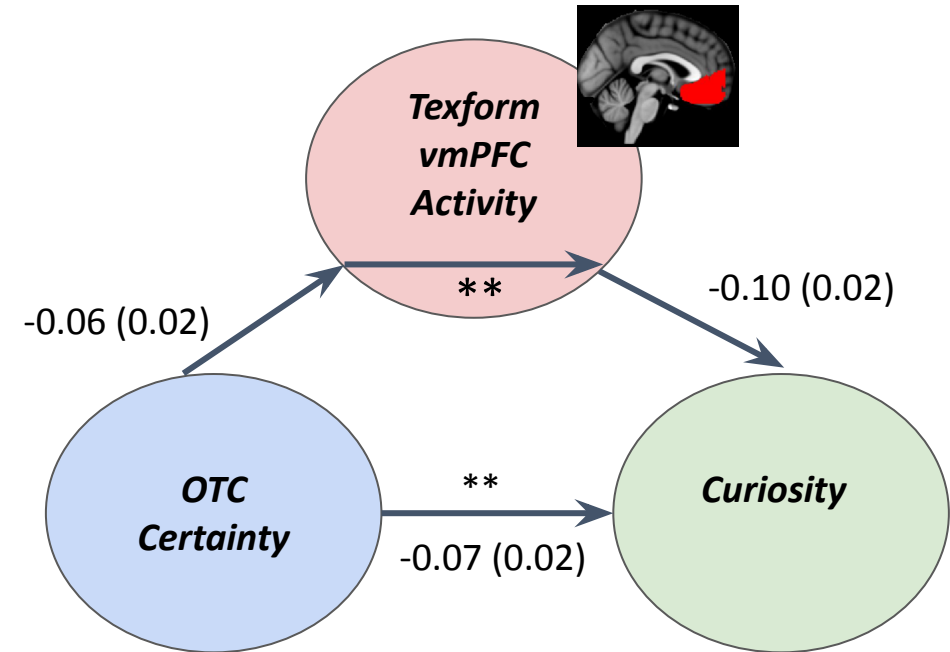
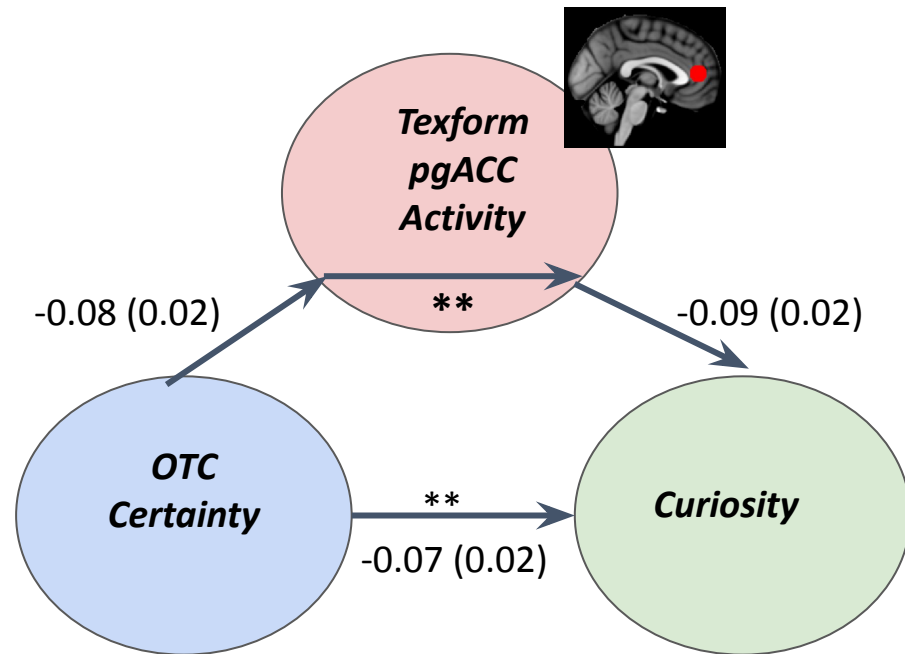


left SFG

“curiosity ROI”

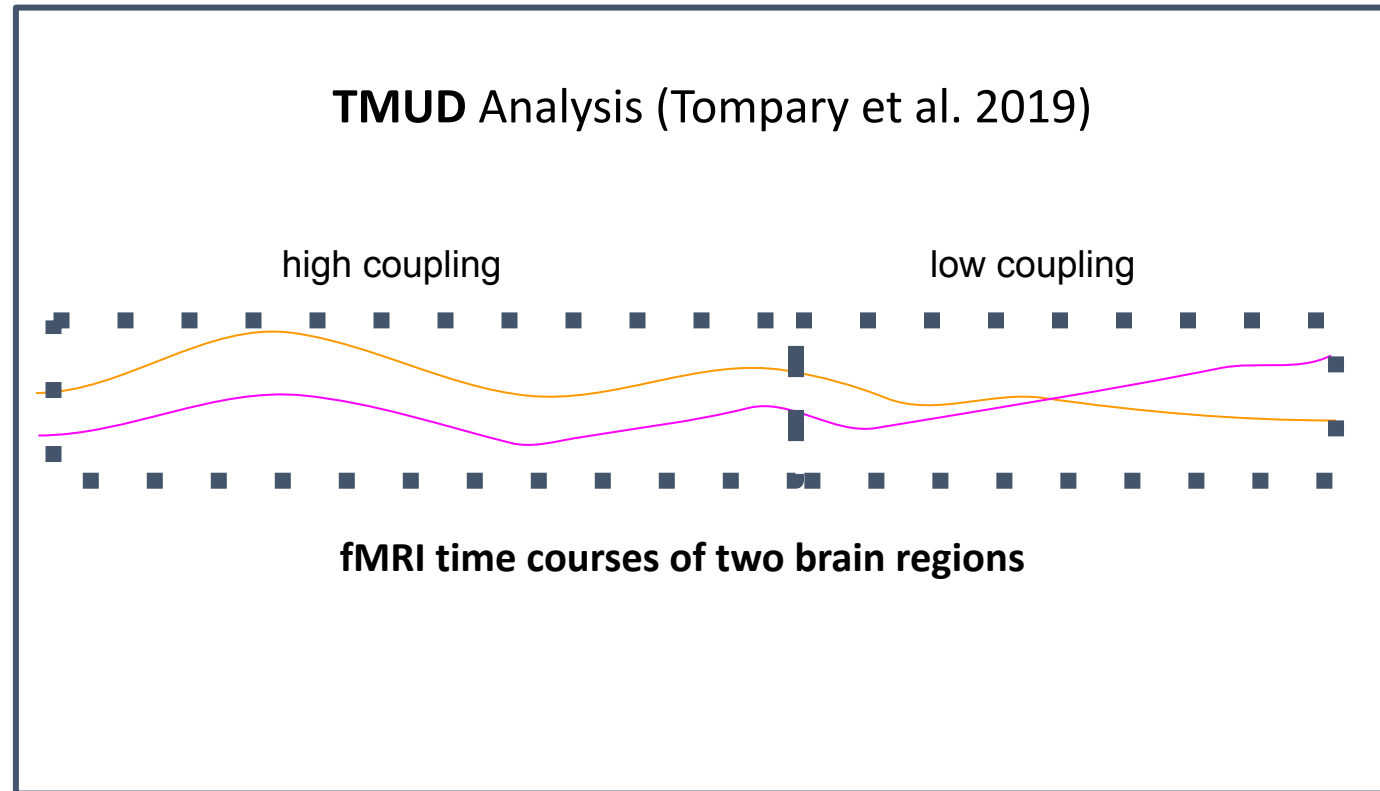
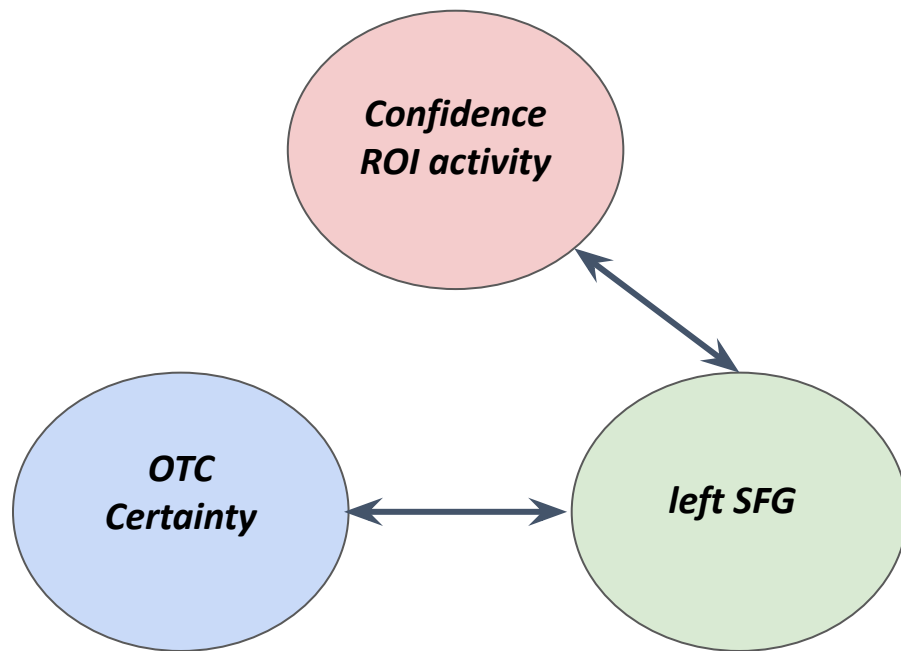
Univariate confidence as a mediator

- activity in our confidence ROIs mediate the link between OTC certainty and curiosity



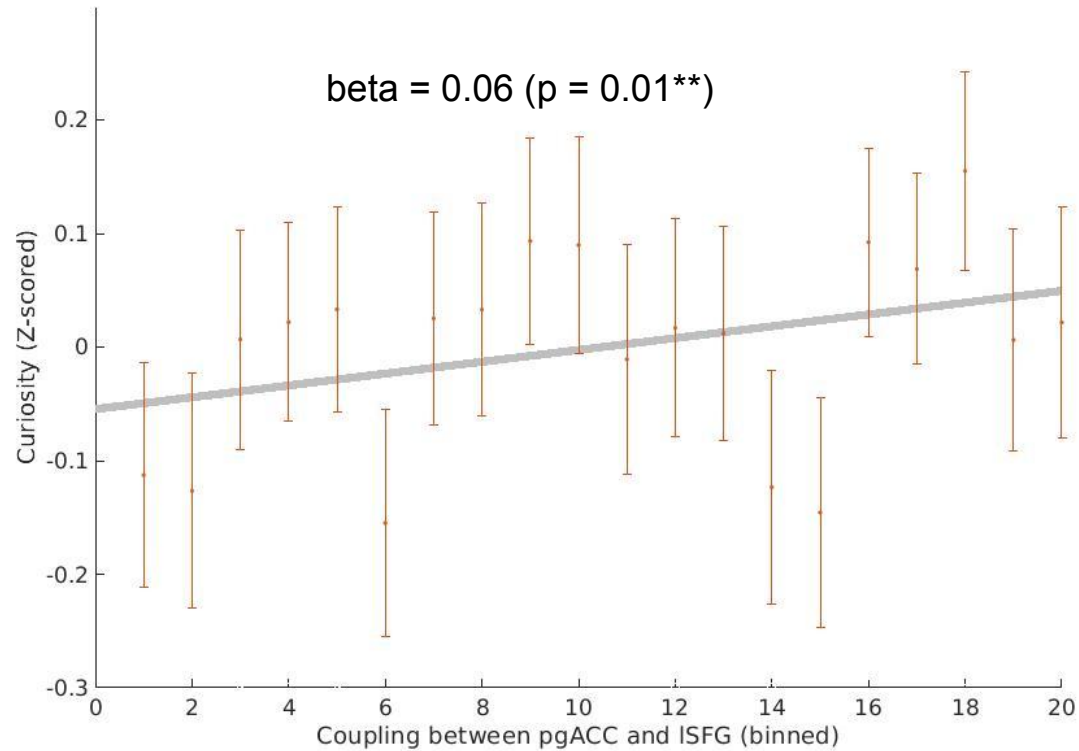
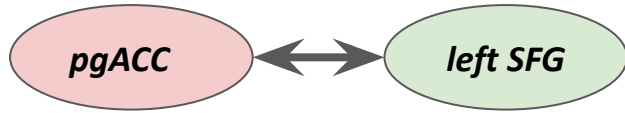
significance of indirect path validated using mixed effects modeling and bootstrapping

Trial by trial coupling with ISFG

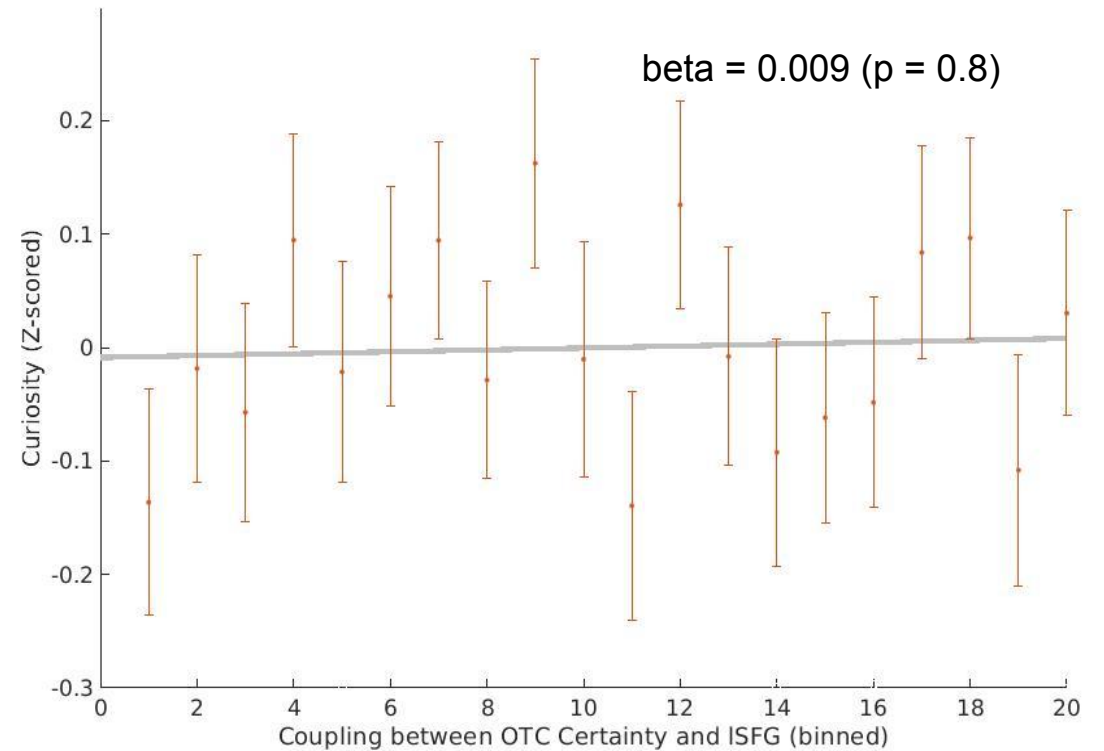
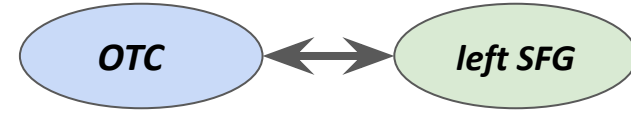


notes: used TMUD analysis to dissect an overall correlation between two brain regions into trials with high coupling versus low coupling
TMUD gives us an index of trial by trial coupling; we looked at coupling between (1) left SFG and OTC certainty and (2) left SFG and our confidence ROIs

Coupling between pgACC and left SFG correlates with curiosity



trending effect for vmPFC/ISFG coupling! ($\beta = 0.05$ $p = 0.09$)



significance validated with multiple regression

Conclusion

- there is a negative quadratic relation b/w confidence and curiosity
- brain regions that represent confidence mediate the link between OTC certainty and curiosity
- coupling between pgACC & ISFG predict curiosity, but coupling between OTC certainty & ISFG does not

Possible Mechanism: brain transforms uncertainty from a multivariate to univariate form to facilitate curiosity because univariate confidence may be more easily read out by downstream structures like ISFG

Future work

- dissociate functional roles of vmPFC and pgACC on curiosity
- understand how interactions between our ROIs facilitate memory for ambiguous visual images
- replicate results with other metrics of uncertainty
 - currently using TAFKAP (van Bergen & Jehee, 2020) to decode uncertainty from OTC

Thanks so much!

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Dr. Mariam Aly

Dr. Jacqueline Gottlieb

members of Aly Lab

members of Gottlieb Lab

members of Dynamic Perception & Memory Lab

Reminder! Come to my discussion section (P492-Perception Studies)
on November 9th from 9:45 AM-10:45 AM EST