

Intuitive Physics and Intuitive Psychology: The Role of the Anterior Cingulate

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Background

- Two fundamental facets of human cognition are the ability to understand and predict the physical dynamics of our everyday environments (intuitive physics) and the ability to understand and predict others' thoughts and behaviors (intuitive psychology).
- Findings in patient populations suggest that intuitive physics and intuitive psychology are independent – one domain can be impaired while the other is intact^{1,2}. Further, brain imaging suggests the two domains may be in a push-pull relationship – intuitive physics tasks deactivate brain regions involved in intuitive psychology and vice-versa³.

What structures mediate the interaction between intuitive physics and intuitive psychology in the brain?

- The Anterior Cingulate Cortex (ACC) may be a good candidate for such a role. It has been proposed that the ACC acts as a "switch" between cognitive modes, and dorsal "cognitive" and ventral "emotional" subdivisions within the ACC have been described.

Here, we explore the functional connectivity of the dorsal and ventral ACC, asking whether they differentially connect with brain regions implicated in intuitive physics and intuitive psychology, respectively.

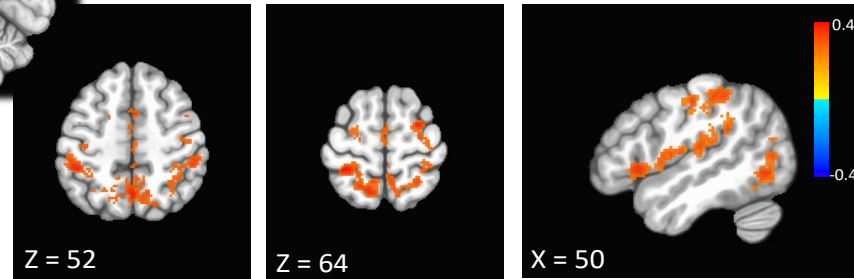
Methods

- 10 subjects so far (18 to 24 years old – 7 females).
- 5-minute resting state with eyes fixated on a cross.
- fMRI parameters : Siemens Trio 3T MRI scanner; TR = 1.37s, TE = 27ms; Voxel size:2.3x2.3x3.5mm.
- Image preprocessing was carried out with AFNI. Data were band-pass filtered ($0.009 < f < 0.08$).
- 6 motion parameters (roll, pitch, yaw, dS, dP, dL) were included as nuisance regressors.
- Correlation techniques: We computed correlations between time courses of two 6-mm-diameter seeds based on previous literature⁴ in ventral ACC ($x=5, y=-34, z=12$), dorsal ACC ($x=5, y=4, z=37$) with every other voxel in the brain.
- Correlation values were z-transformed and averaged across participants.

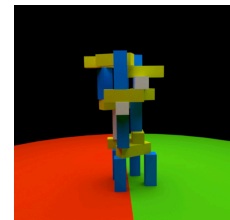
Results



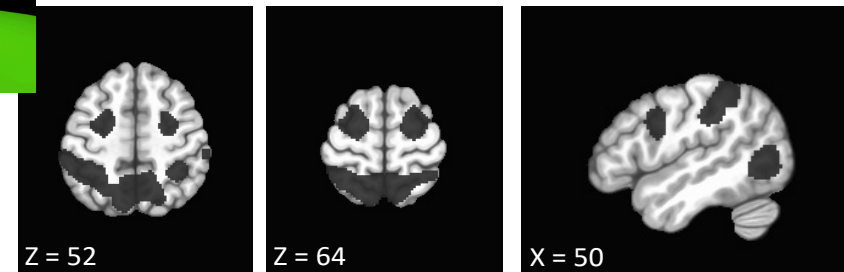
Peak resting-state connectivity of the dorsal ACC



The strongest functional connections of the dorsal ACC closely mirror the set of regions engaged by intuitive physics tasks

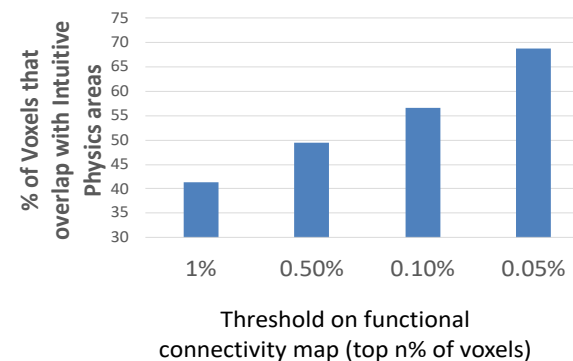


Brain regions implicated in intuitive physics

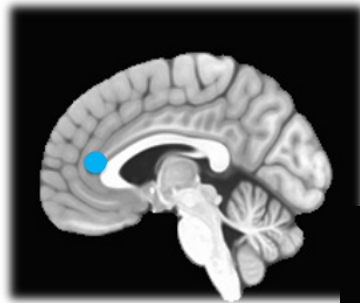


To compute the overlap with regions implicated in intuitive physics, we used the difference between dACC and vACC correlations for each voxel, isolating the connectivity unique to the dACC.

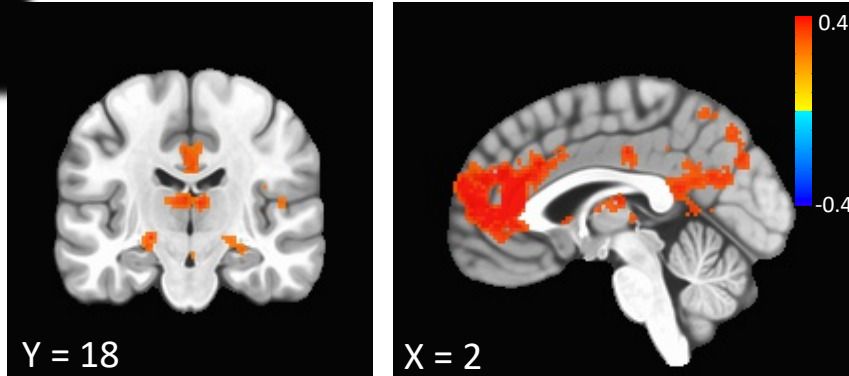
We compared dACC connectivity with regions localized using a physical judgment task from ref 5.



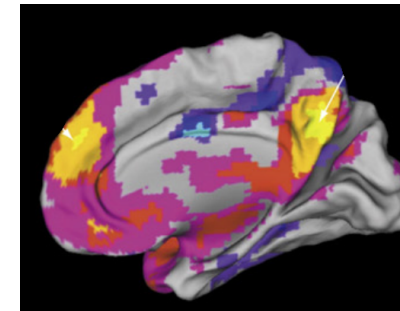
Applying an increasingly stringent threshold on dACC connectivity revealed an increasing degree of overlap with regions engaged by physical prediction



Peak resting-state connectivity of the **ventral ACC**

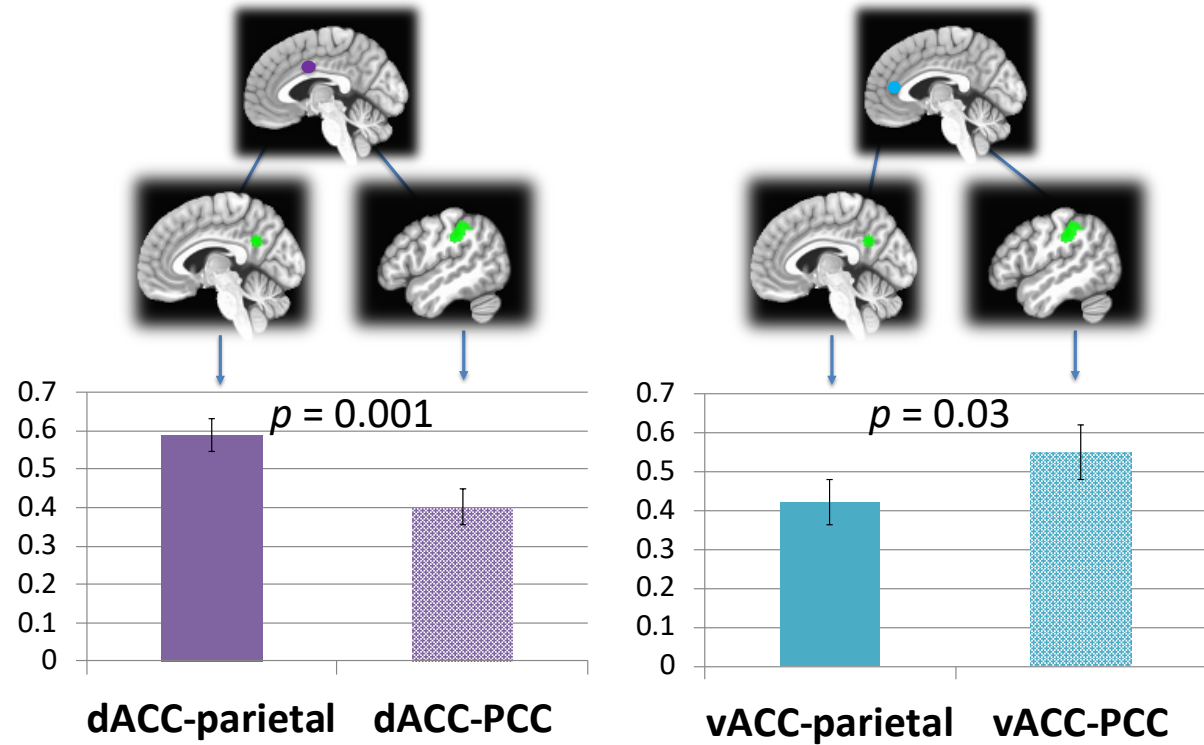


Brain regions correlated with ventral ACC show apparent overlap with those engaged in intuitive psychology³. Our planned analyses will test the degree of overlap by functionally localizing intuitive psychology regions.



from Jack et al.
(2013; ref 3)

yellow/red
regions are
those recruited
for social tasks



We ran a correlation analysis with ROIs within the intuitive psychology and intuitive physics networks. We used an ROI in PCC and another in the parietal lobule based on previous literature for intuitive psychology³ and intuitive physics⁵ respectively. The interaction between dACC and vACC was significant ($p=0.004$). The dACC is significantly more correlated with areas for intuitive physics (parietal lobule) than with areas for intuitive psychology (PCC; $p=0.001$) while the vACC shows significantly stronger correlations with the PCC than parietal lobule ($p=0.03$).

Conclusions

- Our exploratory analyses suggest that the **ventral ACC** and the **dorsal ACC** may be **differentially connected** to brain areas recruited for **intuitive psychology** and **intuitive physics**.
- These results position the ACC as a candidate for interactions between brain regions recruited for intuitive physics and intuitive psychology. A push-pull relationship between these domains may be driven by motivational factors regulated in the ACC.

References

1. Baron-Cohen et al. (2001) Are intuitive physics and intuitive psychology independent? A test with children with Asperger Syndrome. *Journal of Developmental and Learning Disorders*.
2. Kamps et al. (2017) Dissociating intuitive physics from intuitive psychology: Evidence from Williams syndrome. *Cognition*
3. Jack et al. (2013) fMRI reveals reciprocal inhibition between social and physical cognitive domains. *J.Neurosci*.
4. Margulies et al. (2007) Mapping the functional connectivity of anterior cingulate cortex. *Neuroimage*.
5. Fischer et al. (2016) Functional neuroanatomy of intuitive physical inference. *PNAS*.