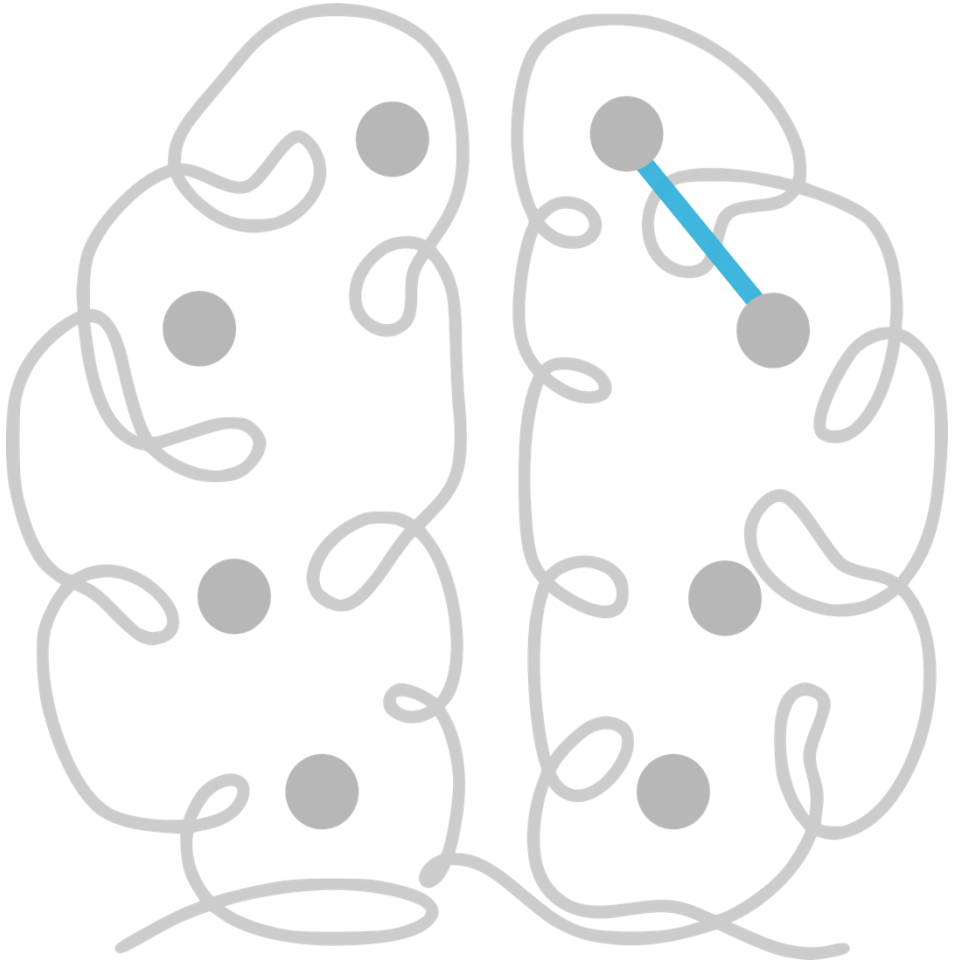
MAPPING ~~DIRECTED~~ **INFORMATION FLOW** BETWEEN **HOMOTOPIC REGIONS** OF THE HUMAN BRAIN

ANNIE G. BRYANT

BRISBANE
OHBM 2025 JUNE 24-28

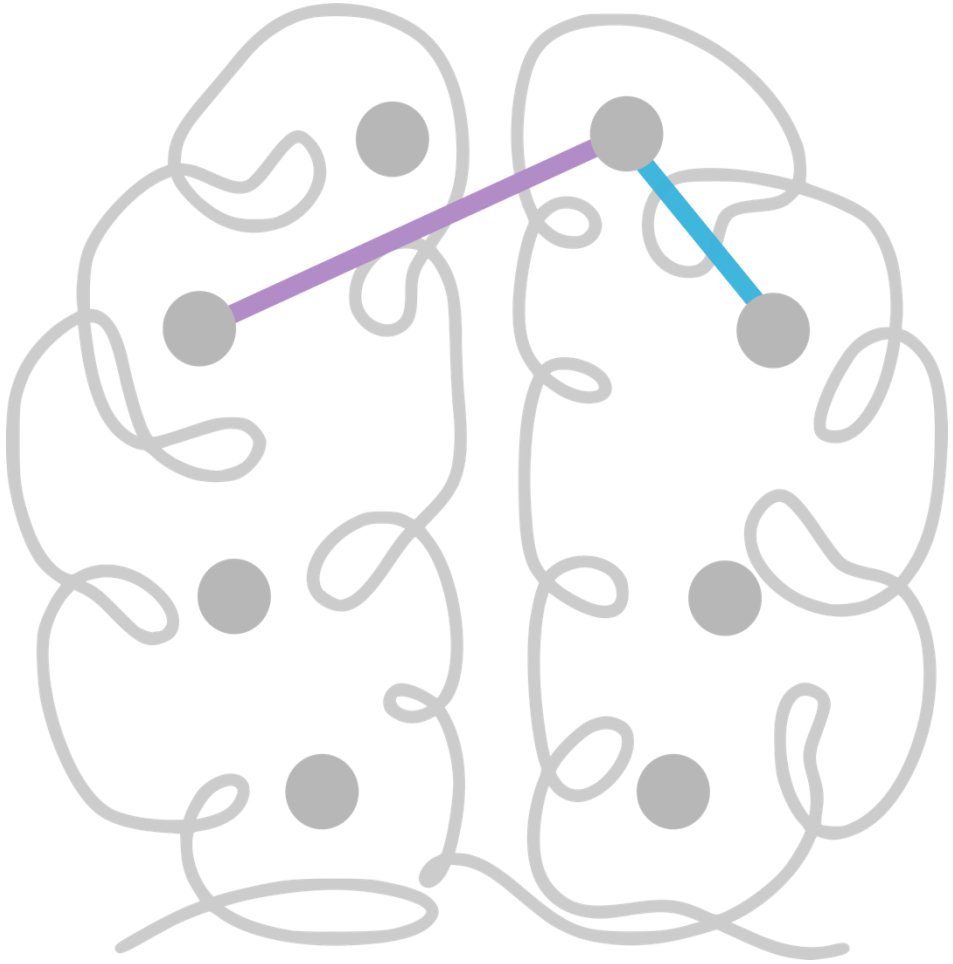
THE UNIVERSITY OF SYDNEY

Defining homotopic connectivity



Intra-hemispheric

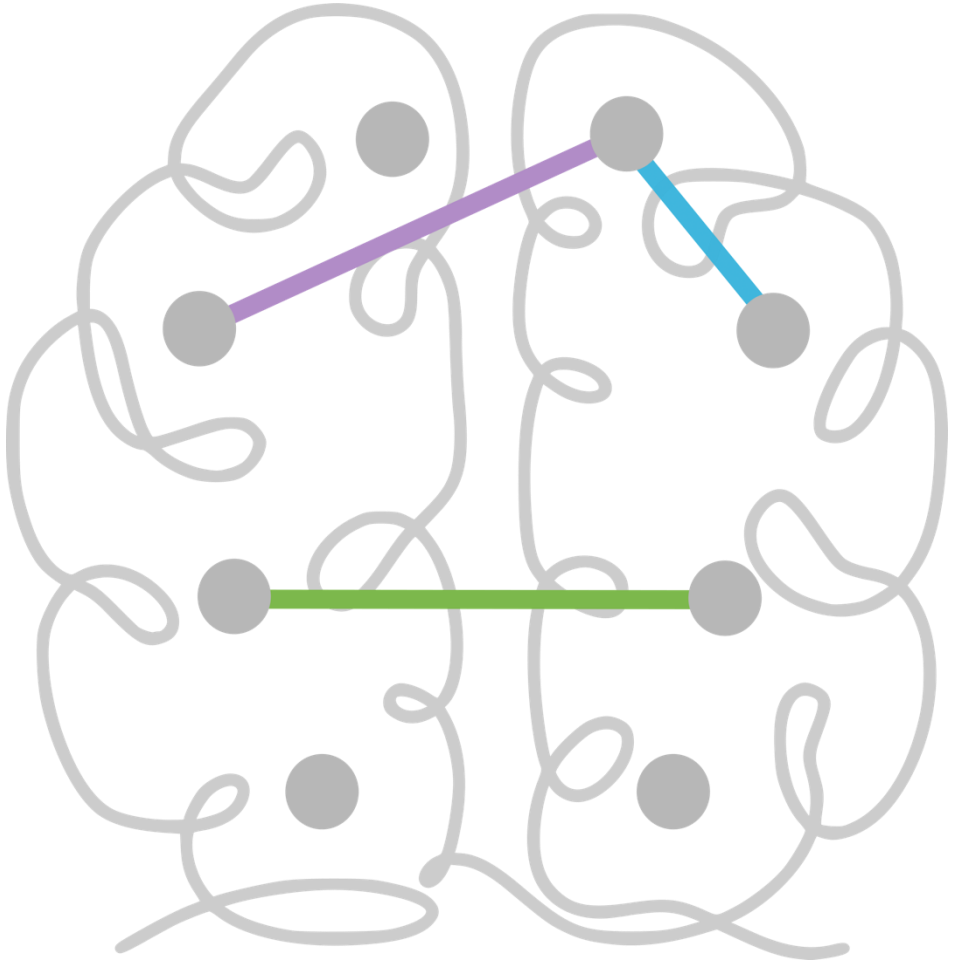
Defining homotopic connectivity



Intra-hemispheric

Inter-hemispheric

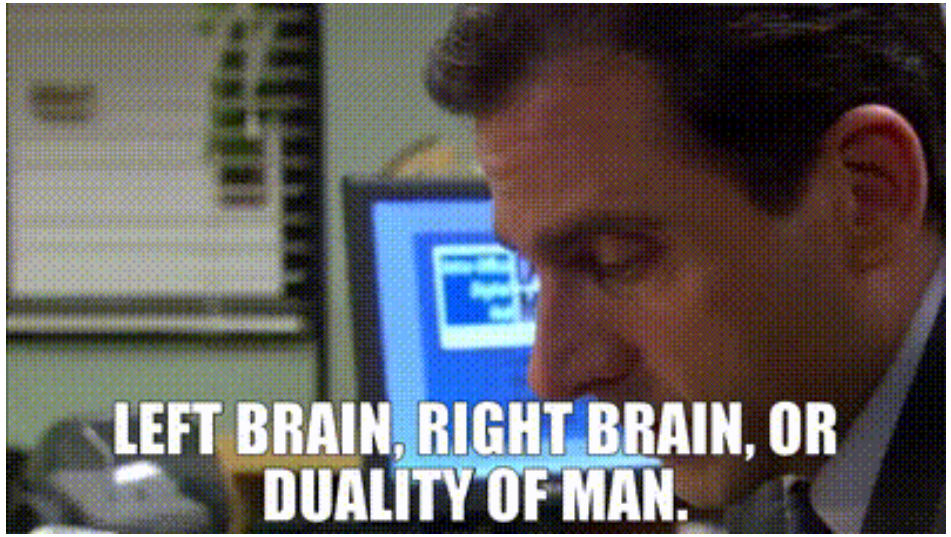
Defining homotopic connectivity



Intra-hemispheric

Inter-hemispheric

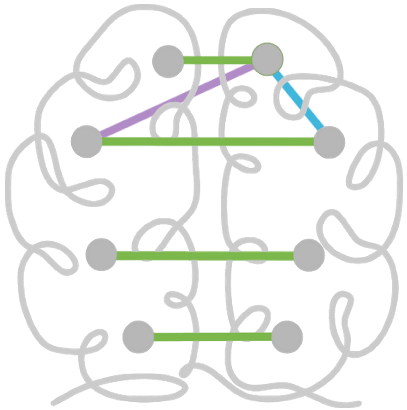
Homotopic

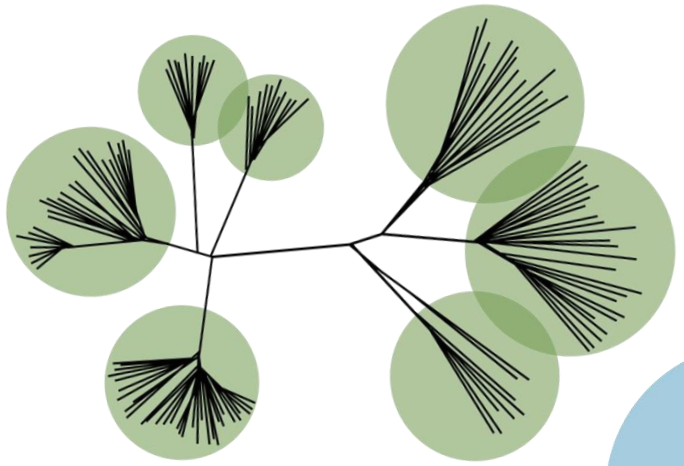


Homotopic connectivity is a cornerstone of functional architecture

Zuo et al. *J Neurosci* (2010)

- Early in embryonic development
- Maintained throughout the lifespan, with healthy aging-related changes





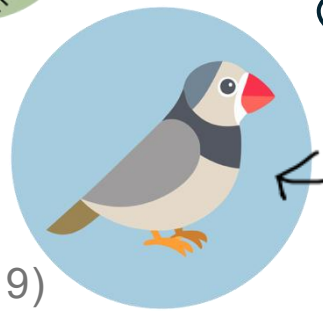
Shen et al. *PNAS* (2015)
Otte et al. *JCBFM* (2015)
Layden et al. *NeuroImage* (2019)

Observed across **numerous species**:

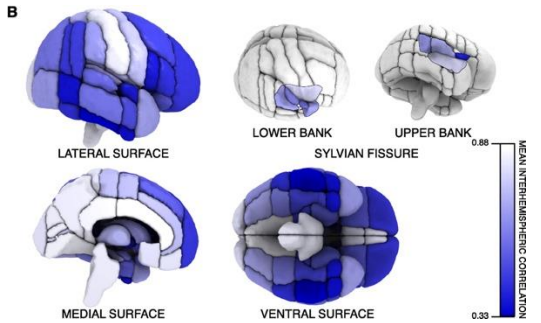
Macaque

Rodent

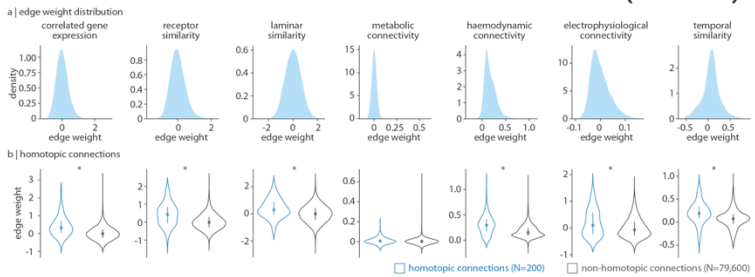
Zebra finch



Homotopic functional connectivity (HoFC) is **highest in unimodal sensory areas**, and aligns with greater **laminar**, **transcriptomic**, and **receptor density** similarity



Stark. *J Neurosci* (2008)



Hansen et al. *PLOS Comp Biol* (2023)

annie.bryant@sydney.edu.au

How does HoFC relate to **multiscale properties** of **cortical organization**?

1. How does the spatial variation in HoFC relate to macroscopic **anatomical, functional, and transcriptomic gradients** across the cortical sheet?

2. Is this evolutionarily-conserved phenomenon **robust to disease**?

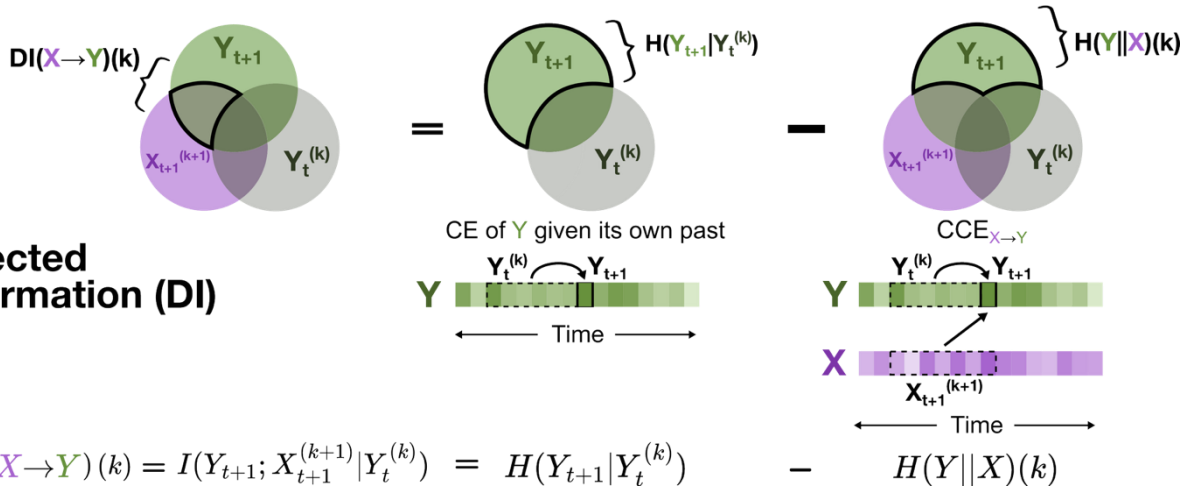
3. How does HoFC relate to broader **cortex-wide functional connectivity**?

4. What are plausible **physiological mechanisms** that may underpin HoFC?

Bryant et al. *bioRxiv* (2025)

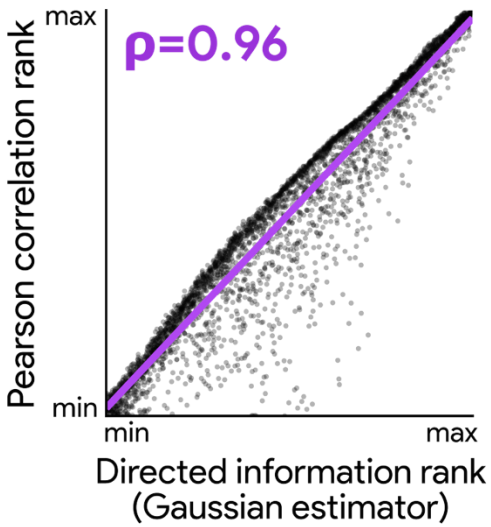
annie.bryant@sydney.edu.au

Focusing on ~~directed~~ **information flow** between hemispheres



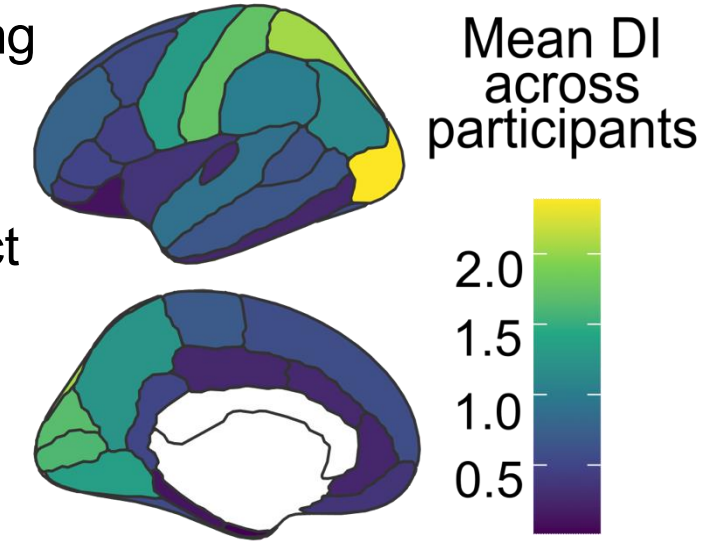
Directed information (DI)

$$DI(X \to Y)(k) = I(Y_{t+1}; X_{t+1}^{(k+1)} | Y_t^{(k)}) = H(Y_{t+1}|Y_t^{(k)}) - H(Y||X)(k)$$

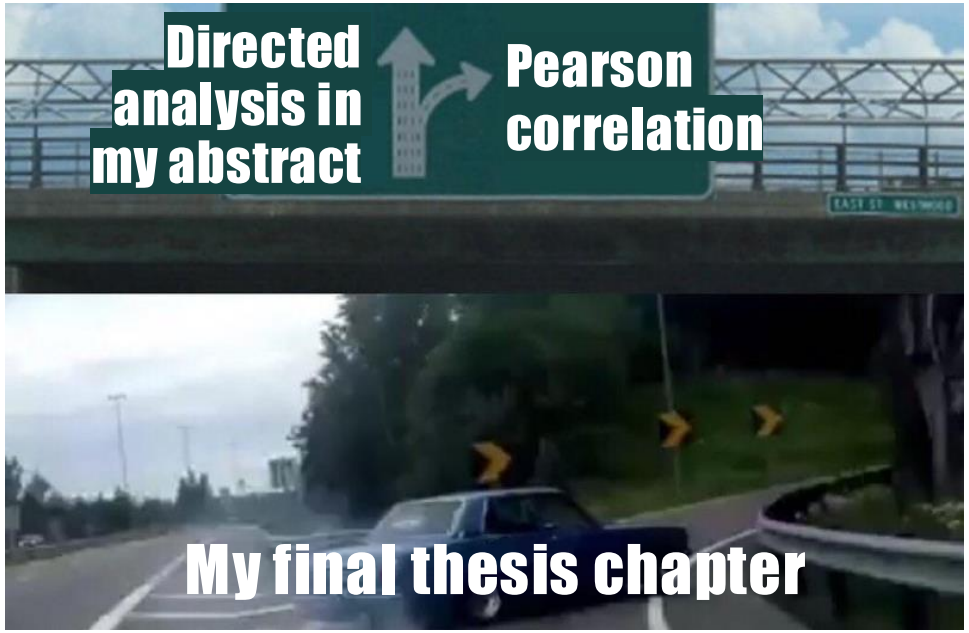


Linear, contemporaneous coupling

Directed information:
How much does knowing the *past and present* of BOLD fMRI activity in **region X** help us predict the *present activity* in **region Y**, beyond Y's own past activity?



Bryant et al. *arXiv* (2025)



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Pivoting to deeply characterize **Pearson-based HoFC**

RESEARCH ARTICLE | DISEASES AND DISORDERS

Network-based atrophy modeling in the common epilepsies: A worldwide ENIGMA study

SARA LARIVIÈRE, RAÚL RODRÍGUEZ-CRUCES, JESSICA ROYER, MARIA EUGENIA CALIGIURI, ANTONIO GAMBARDELLA, LUIS CONCHA, SIMON S. KELLER, FERNANDO CENDES, CLARISSA YASUDA, [...], AND BORIS C. BERNHARDT +52 authors Authors Info & Affiliations

SCIENCE ADVANCES · 18 Nov 2020 · Vol 6, Issue 47 · DOI: 10.1126/sciadv.abc6457

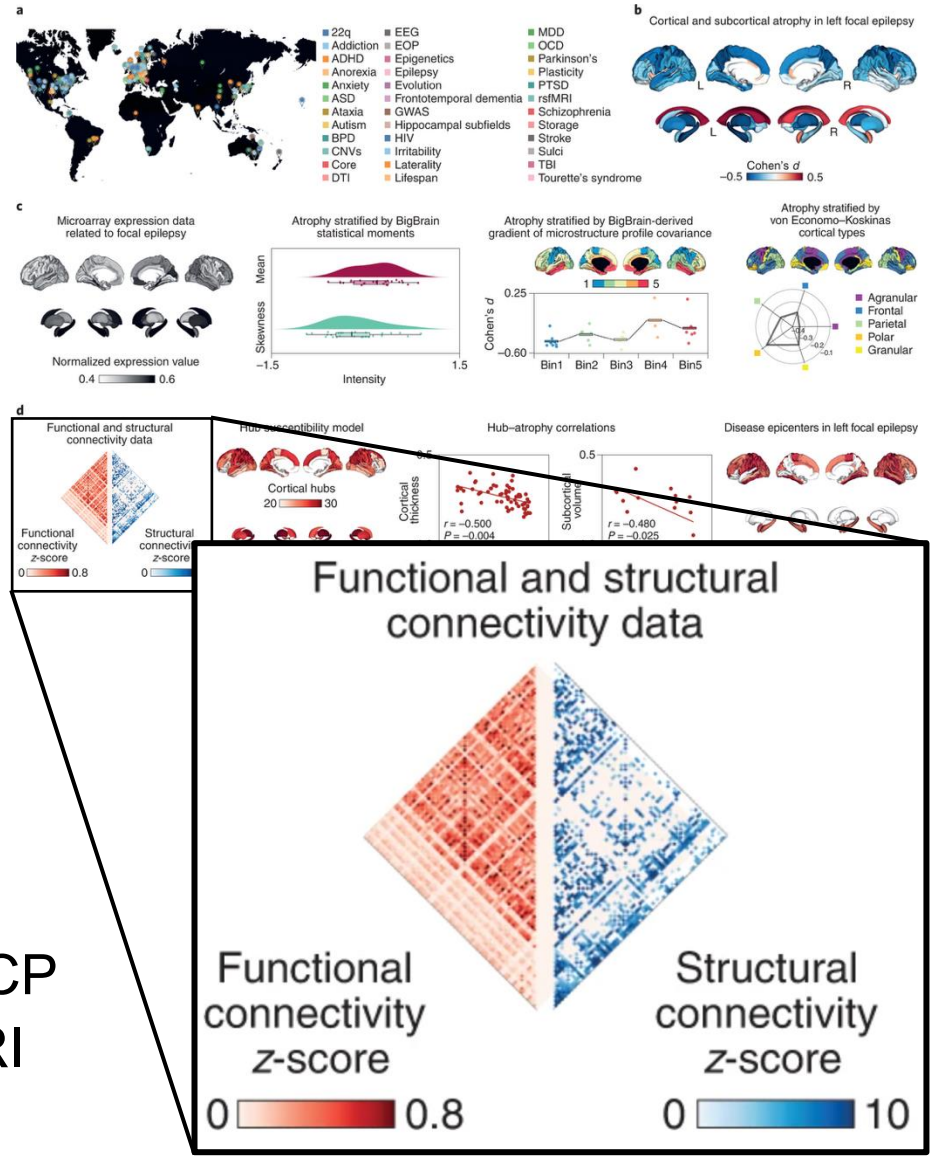
Correspondence | Published: 30 June 2021

The ENIGMA Toolbox: multiscale neural contextualization of multisite neuroimaging datasets

Sara Larivière, Casey Paquola, Bo-yong Park, Jessica Royer, Yezhou Wang, Oualid Benkarim, Reinder Vos de Wael, Sofie L. Valk, Sophia I. Thomopoulos, Matthias Kirschner, Lindsay B. Lewis, Alan C. Evans, Sanjay M. Sisodiya, Carrie R. McDonald, Paul M. Thompson & Boris C. Bernhardt

Nature Methods **18**, 698–700 (2021) | Cite this article

HUMAN Connectome PROJECT



N=207 participants from the S1200 HCP cohort with resting-state functional MRI (**FC**) and diffusion-weighted MRI (**SC**)

How does HoFC relate to **multiscale properties** of **cortical organization**?

1. How does the spatial variation in HoFC relate to macroscopic **anatomical, functional, and transcriptomic gradients** across the cortical sheet?
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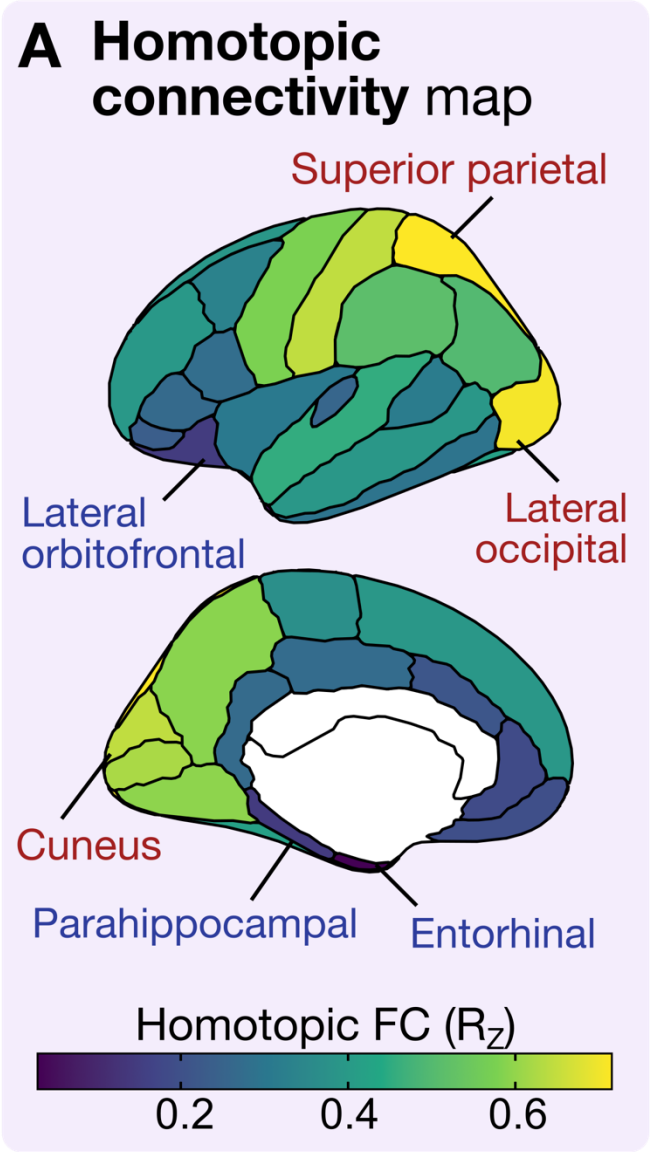
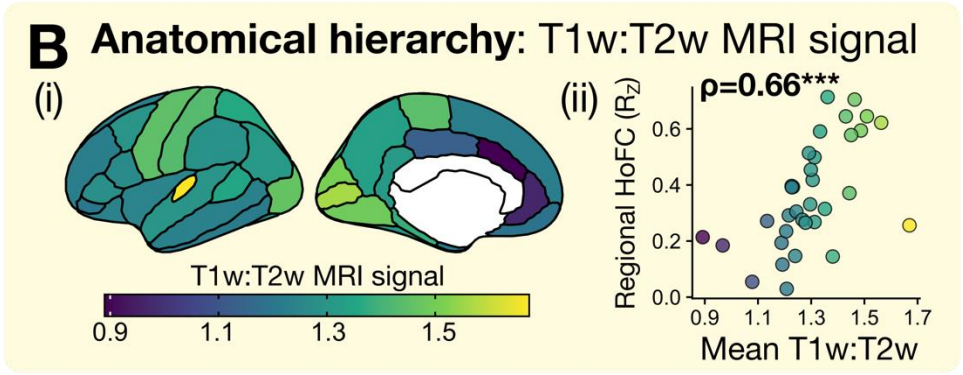
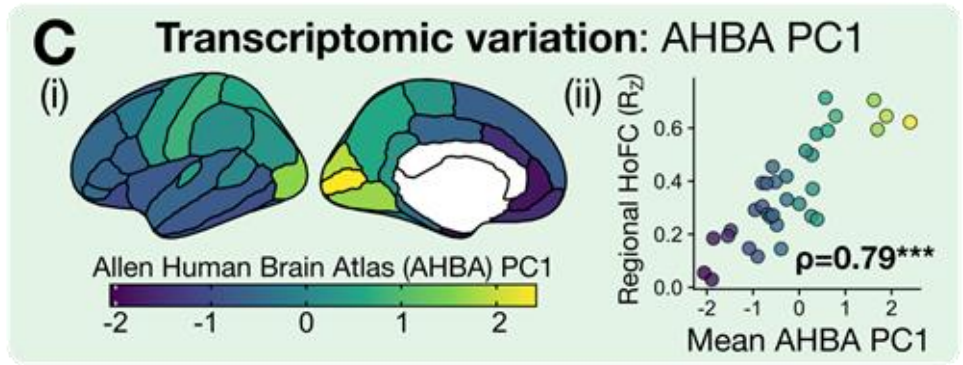
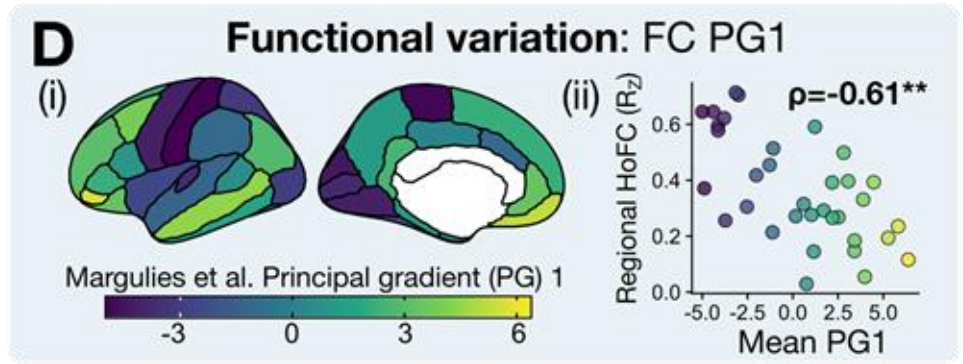
1. Cortical HoFC spatially aligns with the **anatomical hierarchy** + other maps









Burt et al. *Nat Neuro* (2018)

Hawrylycz et al. *Nature* (2012)

Margulies et al. *PNAS* (2016)

Stark & co (2008):

'**Default state**' of inter-hemispheric synchrony, which decreases in favor of **lateralized hemisphere-specific processing** as information is passed up the **putative functional hierarchy**

Bryant et al. *bioRxiv* (2025)

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🔑 How does HoFC relate to **multiscale properties** of **cortical organization**?

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2. This evolutionarily-conserved phenomenon (HoFC) is **robust to disease**

Data Descriptor | Open access | Published: 06 December 2016

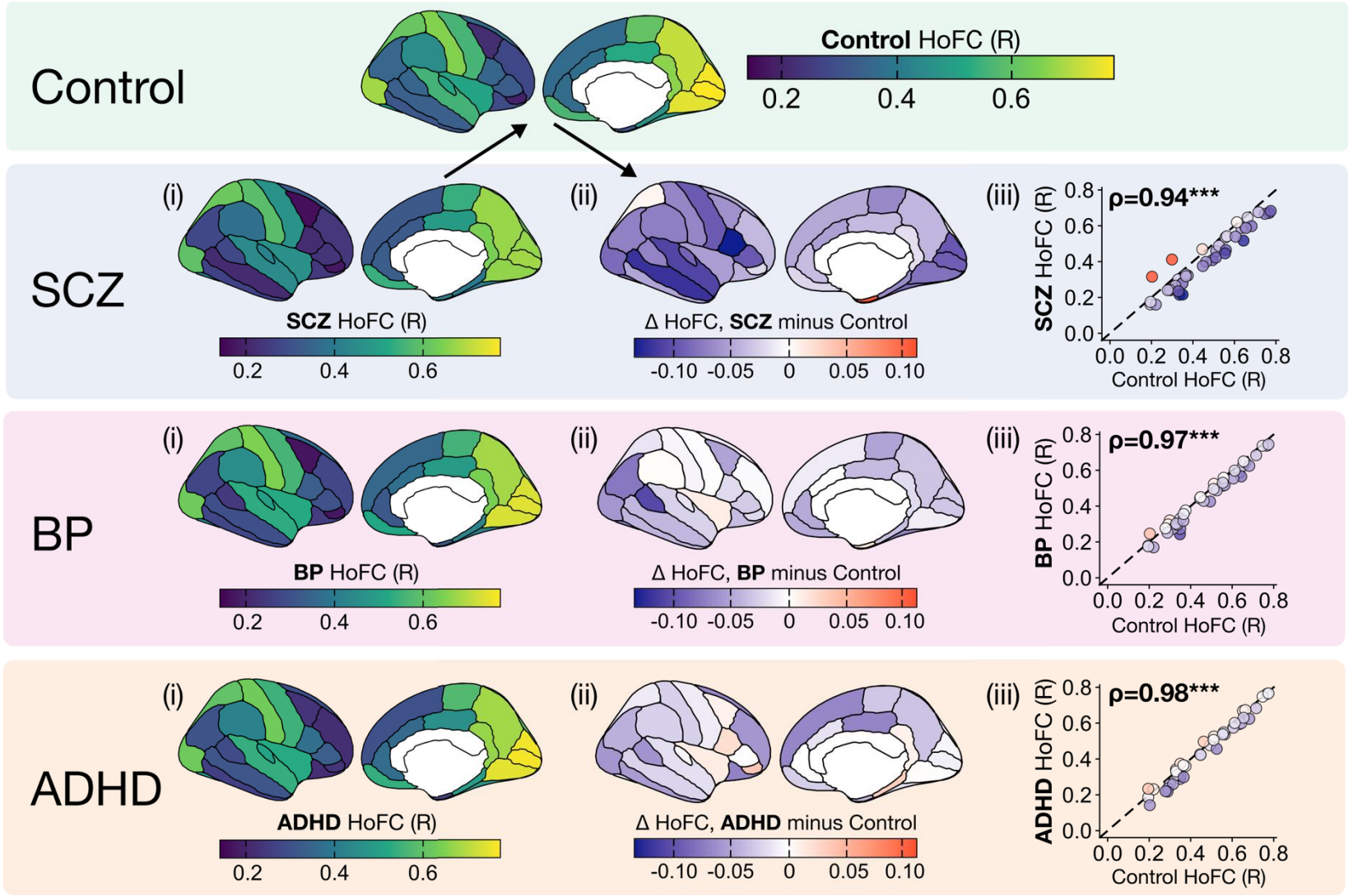
A phenome-wide examination of neural and cognitive function

R.A. Poldrack, E. Congdon, W. Triplett, K.J. Gorgolewski, K.H. Karlsgodt, J.A. Mumford, F.W. Sabb, N.B. Freimer, E.D. London, T.D. Cannon & R.M. Bilder

Scientific Data 3, Article number: 160110 (2016) | Cite this article

17k Accesses | 17 Altmetric | Metrics

N=252 participants from the UCLA Consortium for Neuropsychiatric Phenomics (CNP) cohort with resting-state functional MRI



Bryant et al. *bioRxiv* (2025)

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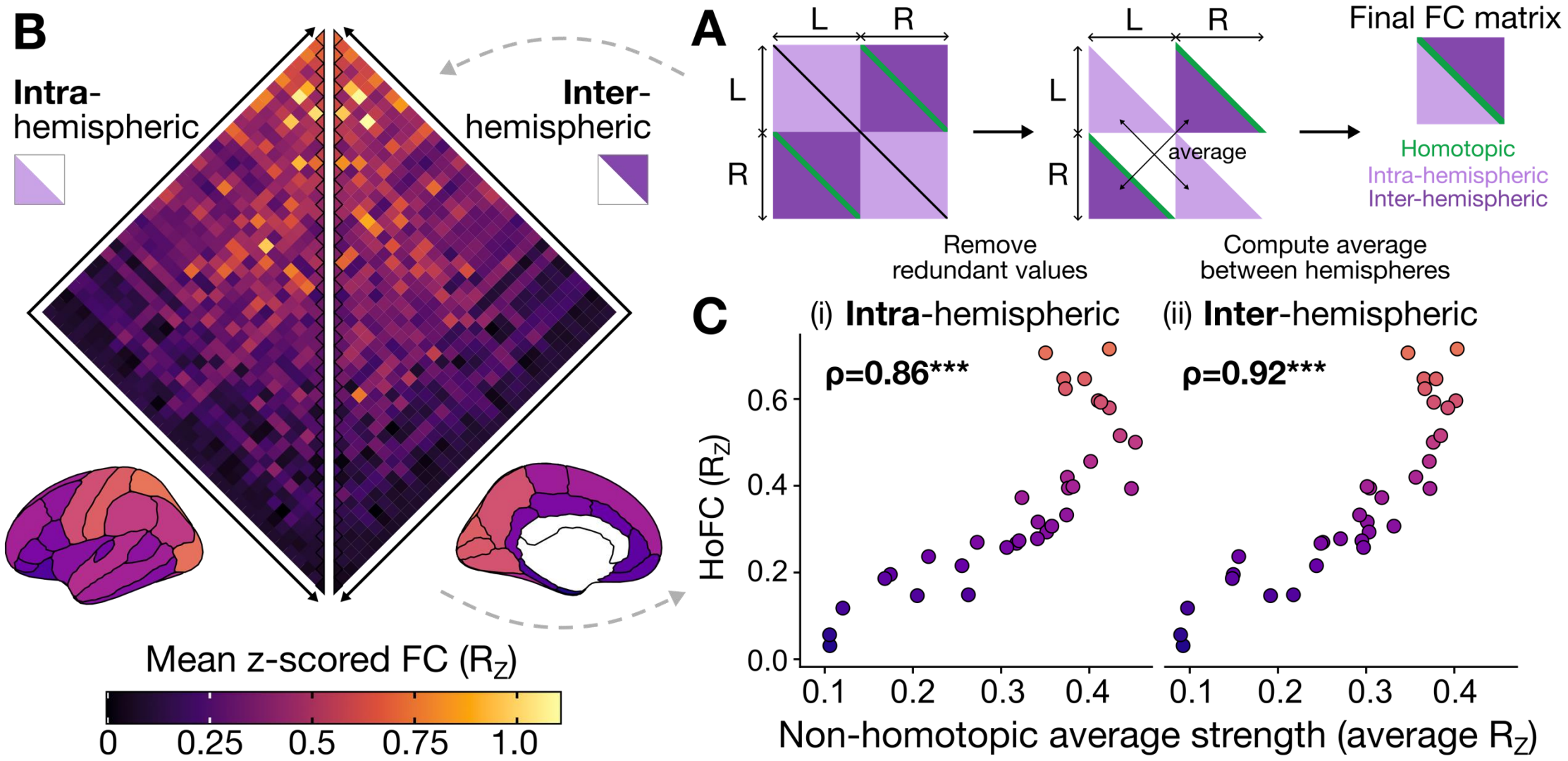
3. HoFC is **tightly coupled** to overall synchrony **within and across hemispheres**



Bryant et al. *bioRxiv* (2025)

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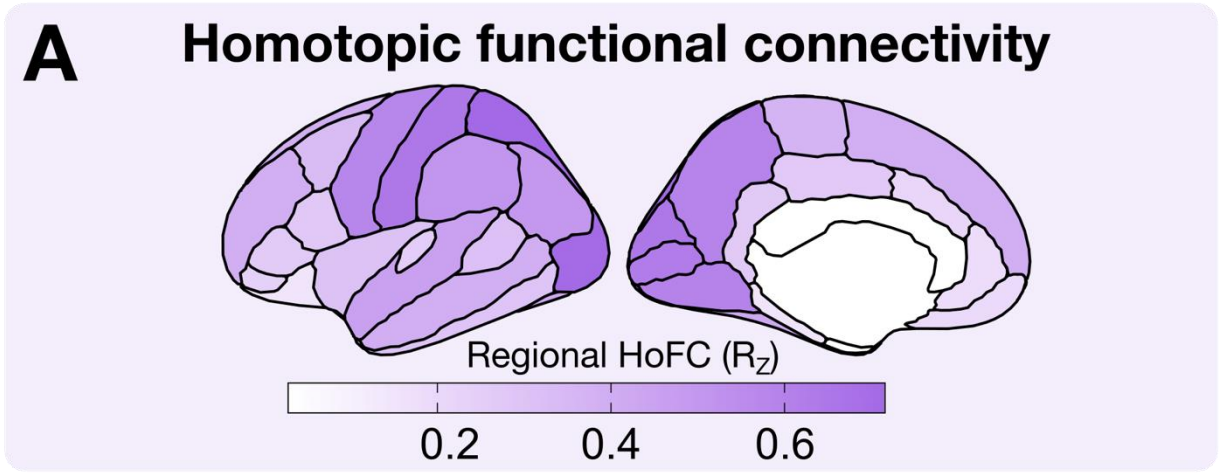
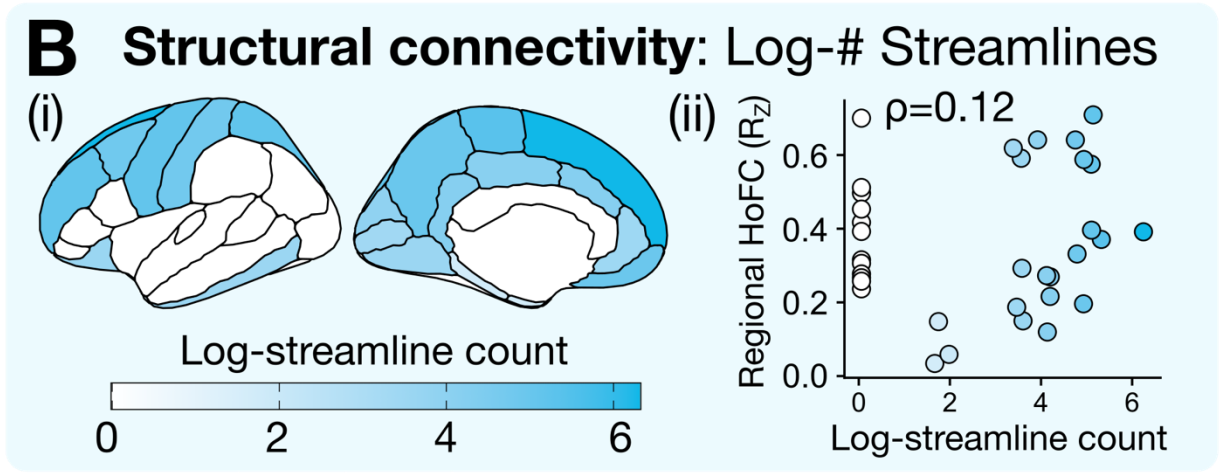
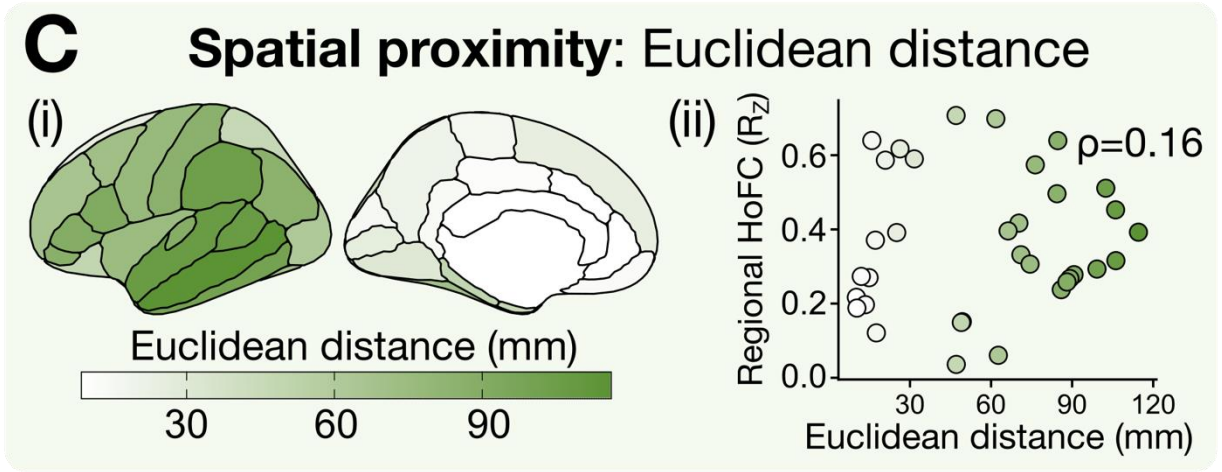
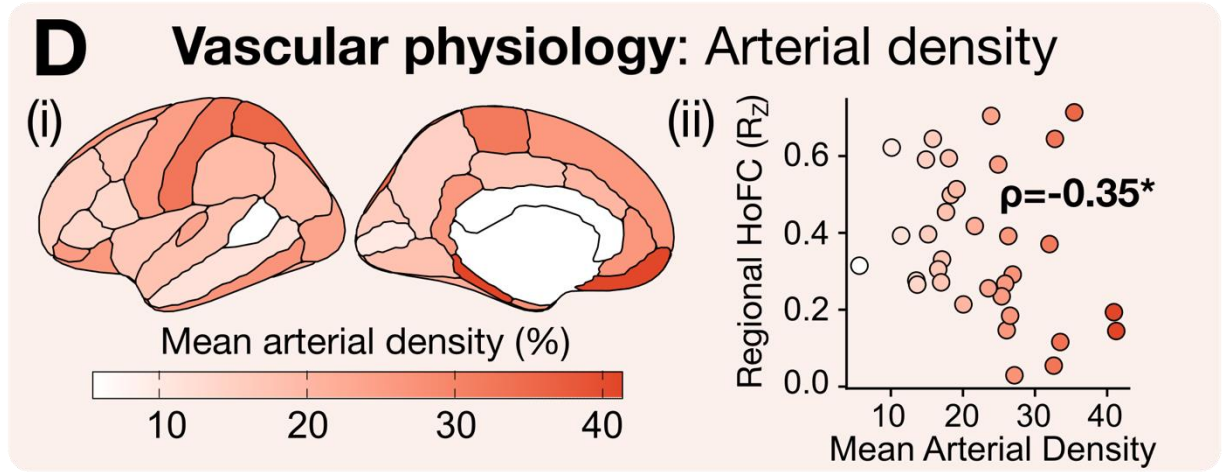
4. Structural connectivity and distance are **not associated** with HoFC strength





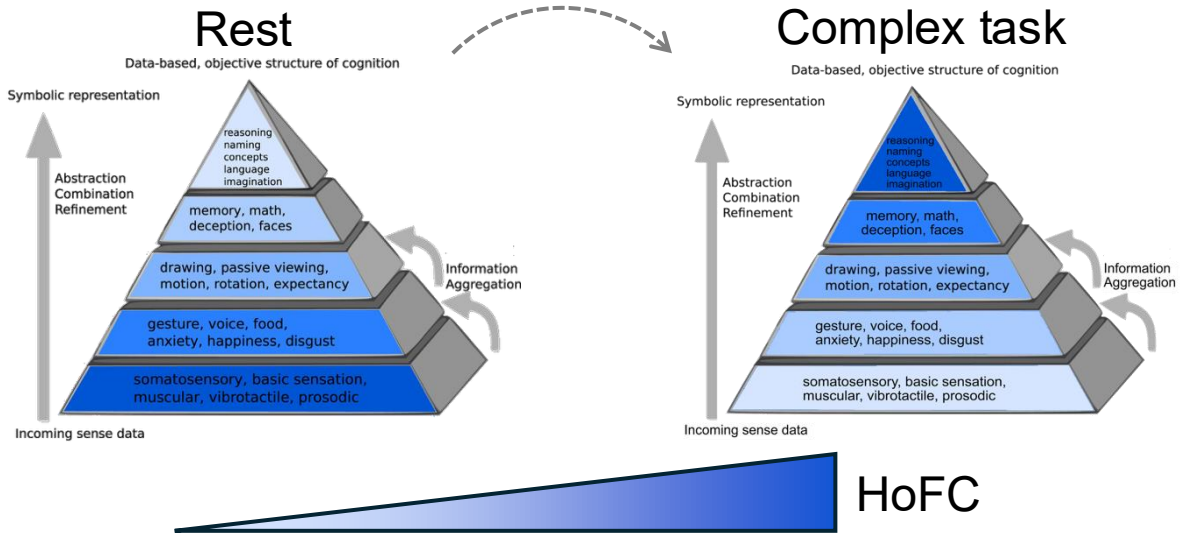




Vasculature data: Bernier et al. *Human Brain Mapping* (2018)

Bryant et al. *bioRxiv* (2025)

annie.bryant@sydney.edu.au



Is this a '**default state**' of resting inter-hemispheric synchrony in primary sensorimotor regions that decreases in favor of **hemisphere-specific processing** as information is passed up the **putative functional hierarchy**?
How does HoFC potentially reorganize across the cortical sheet with **increasing task complexity**?

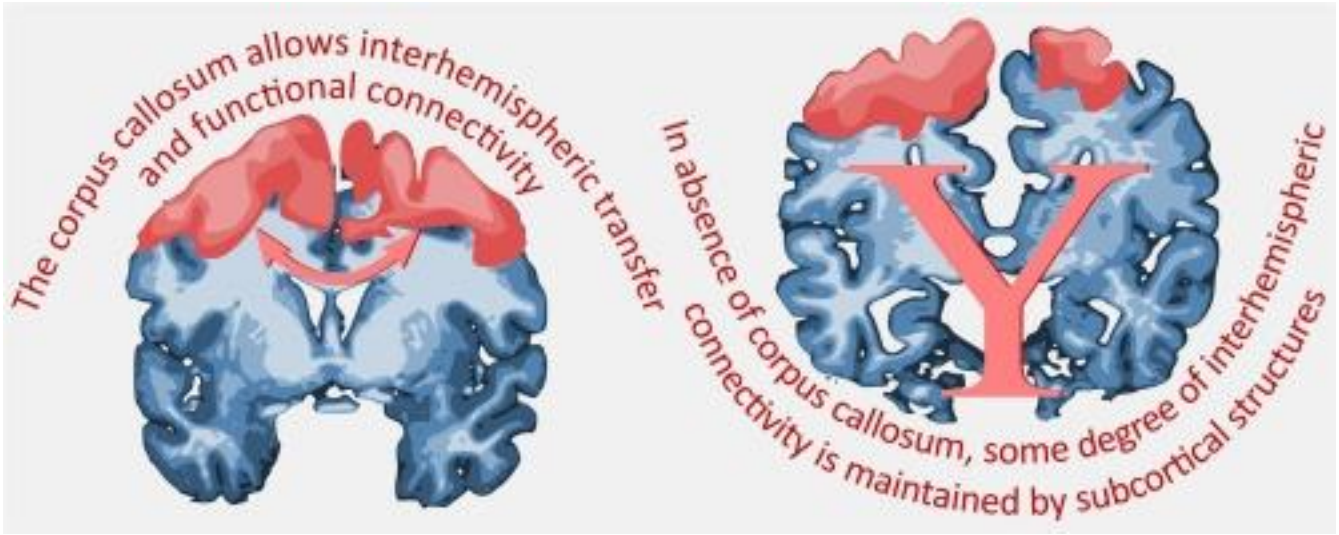
Image adapted from Taylor et al. *Sci. Rep.* (2015)

Open questions: What's next?

What **other physiological mechanisms** could support HoFC in addition to/instead of direct callosal projections?

- **Shared subcortical drive**, especially from the thalamus
- Other white matter tracts, like the **anterior commissure**

Mancuso et al. *Neurosci. Biobehav. Rev.* (2019)



Thank you for the invitation & for your time 😊

Contact me 👍

Annie G. Bryant
annie.bryant@sydney.edu.au
@anniegbryant

Find me at **Poster #1175** on **Friday and Saturday**

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Dr Kieran Owens
Dr Chetan Gohil
Trent Henderson
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Rishi Maran
Brendan Harris
Teresa Dalle Nogare
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Shine Lab

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PhD funding support from:

Australian Government
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The University of Sydney Physics Foundation

The American Australian Association Graduate Education Fund