

Using Frontera to analyze developmental brain data

Dr. Jessica Church-Lang

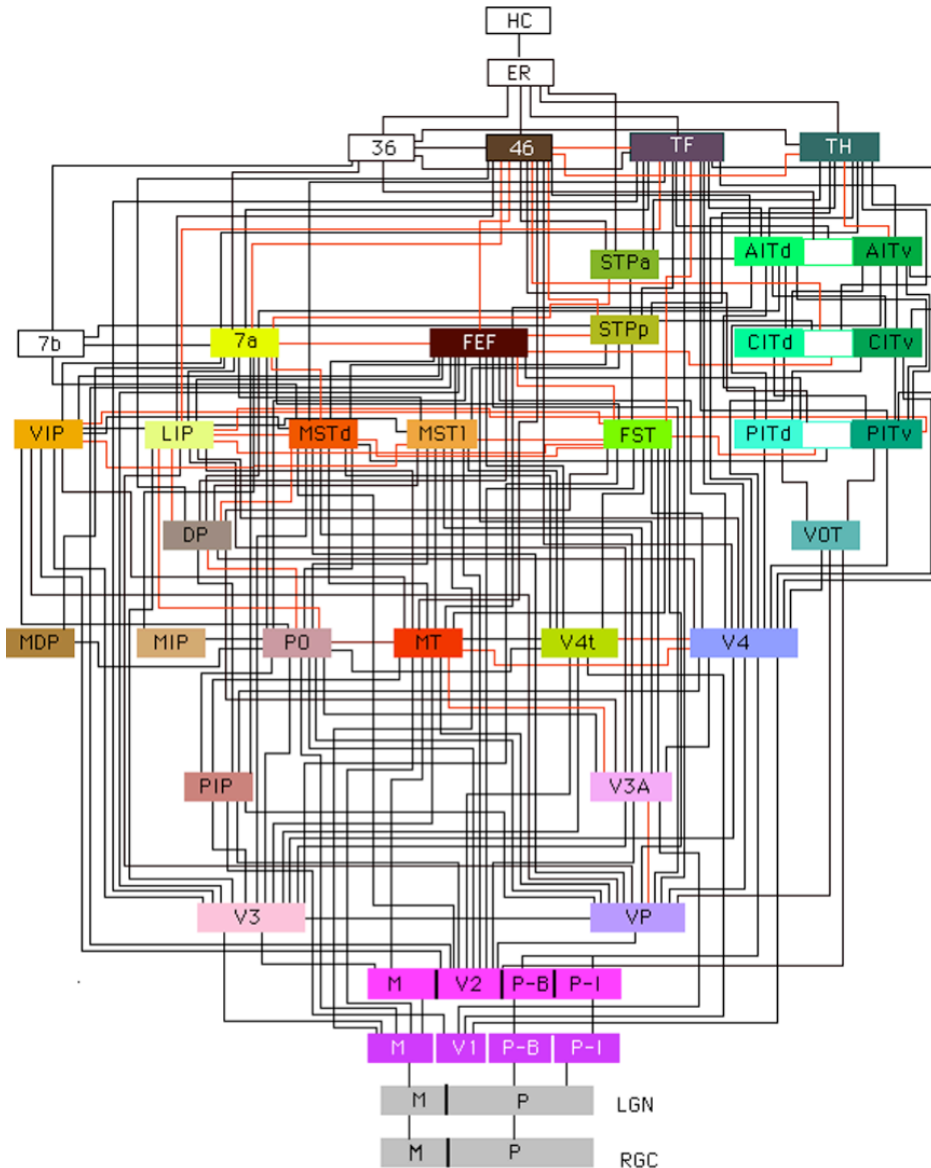
August 3, 2023



Two things to ponder:

1. People can flexibly configure the specific processes necessary to perform many different tasks
2. This is done on a massively parallel, interconnected architecture in the brain

Just the visual system

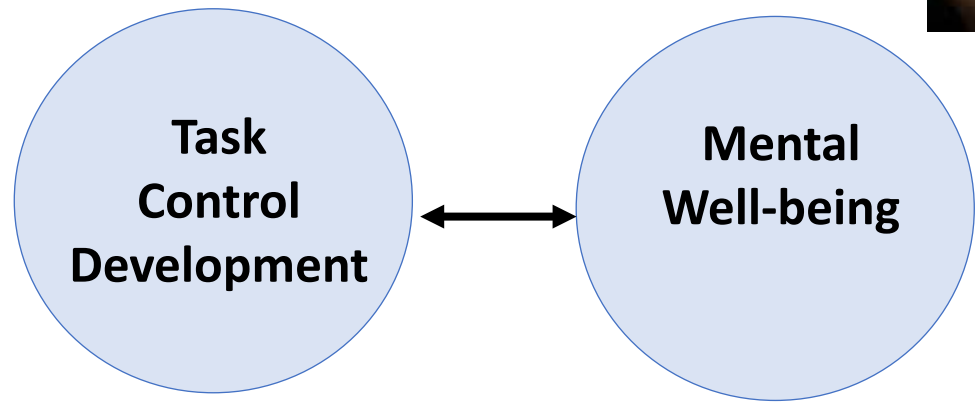




**Executive
Function
Development**

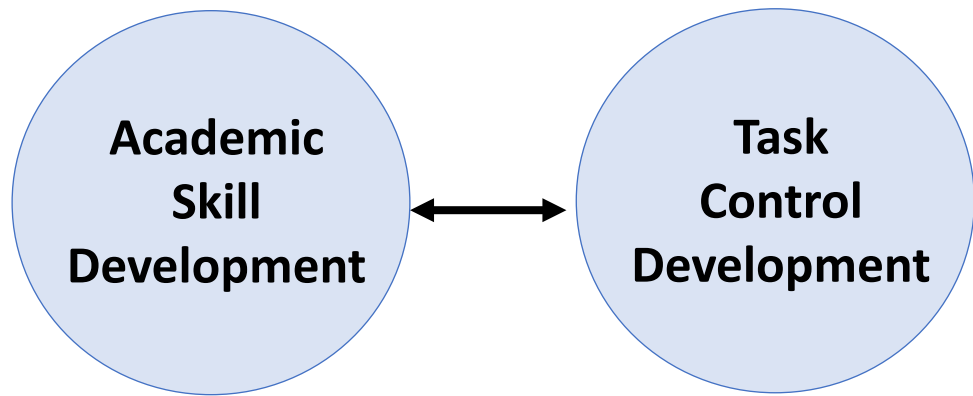


Developmental Cognitive Neuroscience Lab



HELLO
I AM...

IN CONTROL



Our primary lab tool: functional MRI

Advantages

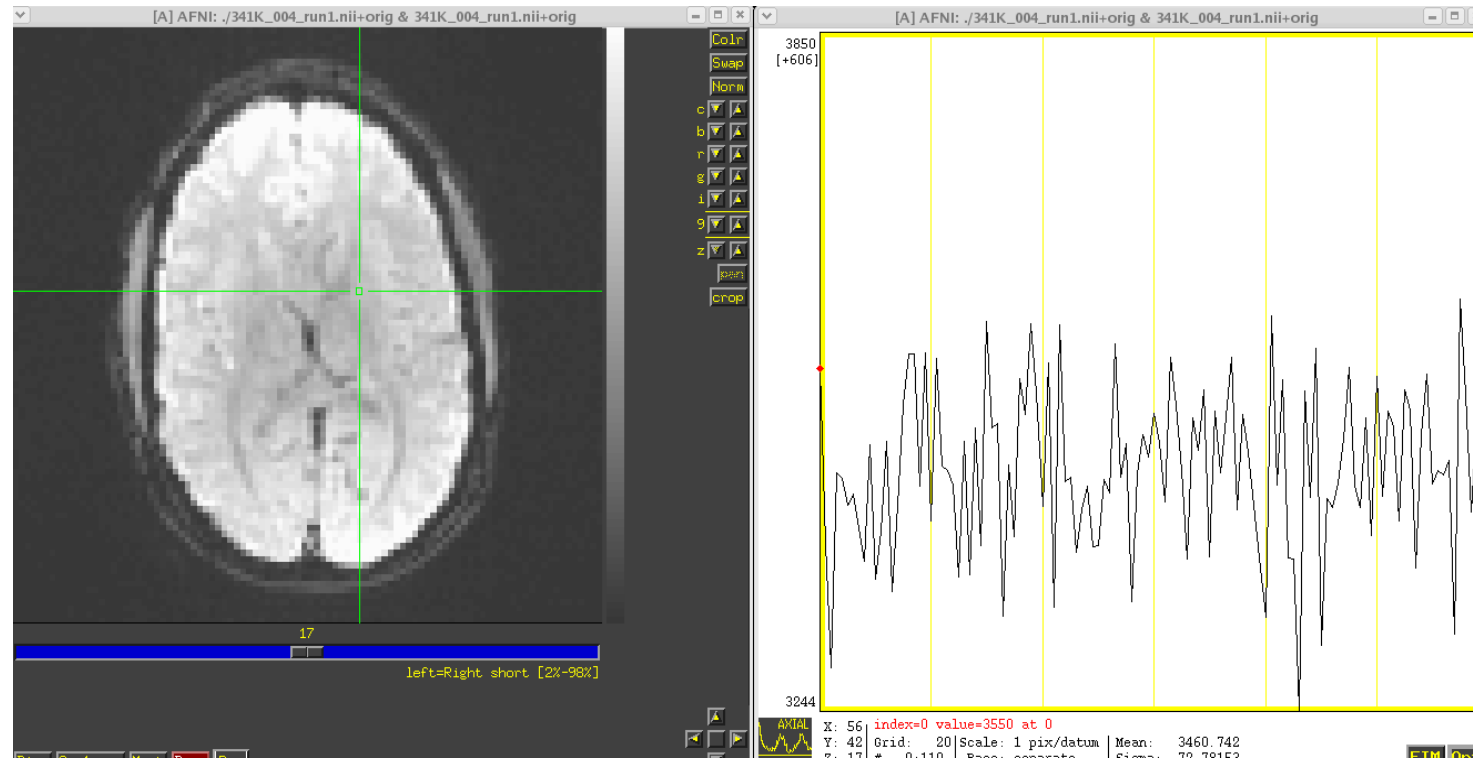
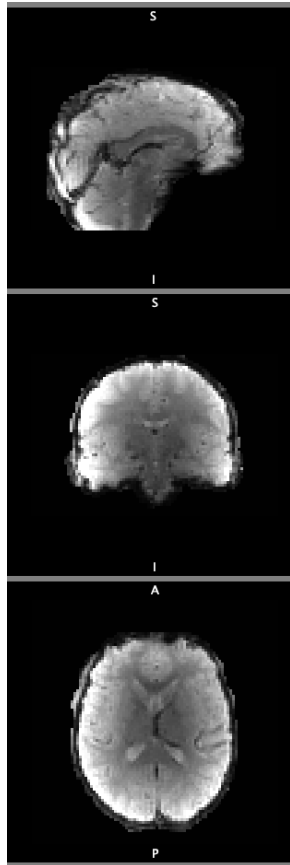
Great spatial resolution
(<3 mm!)
3-dimensional
Whole brain
No radiation

Disadvantages

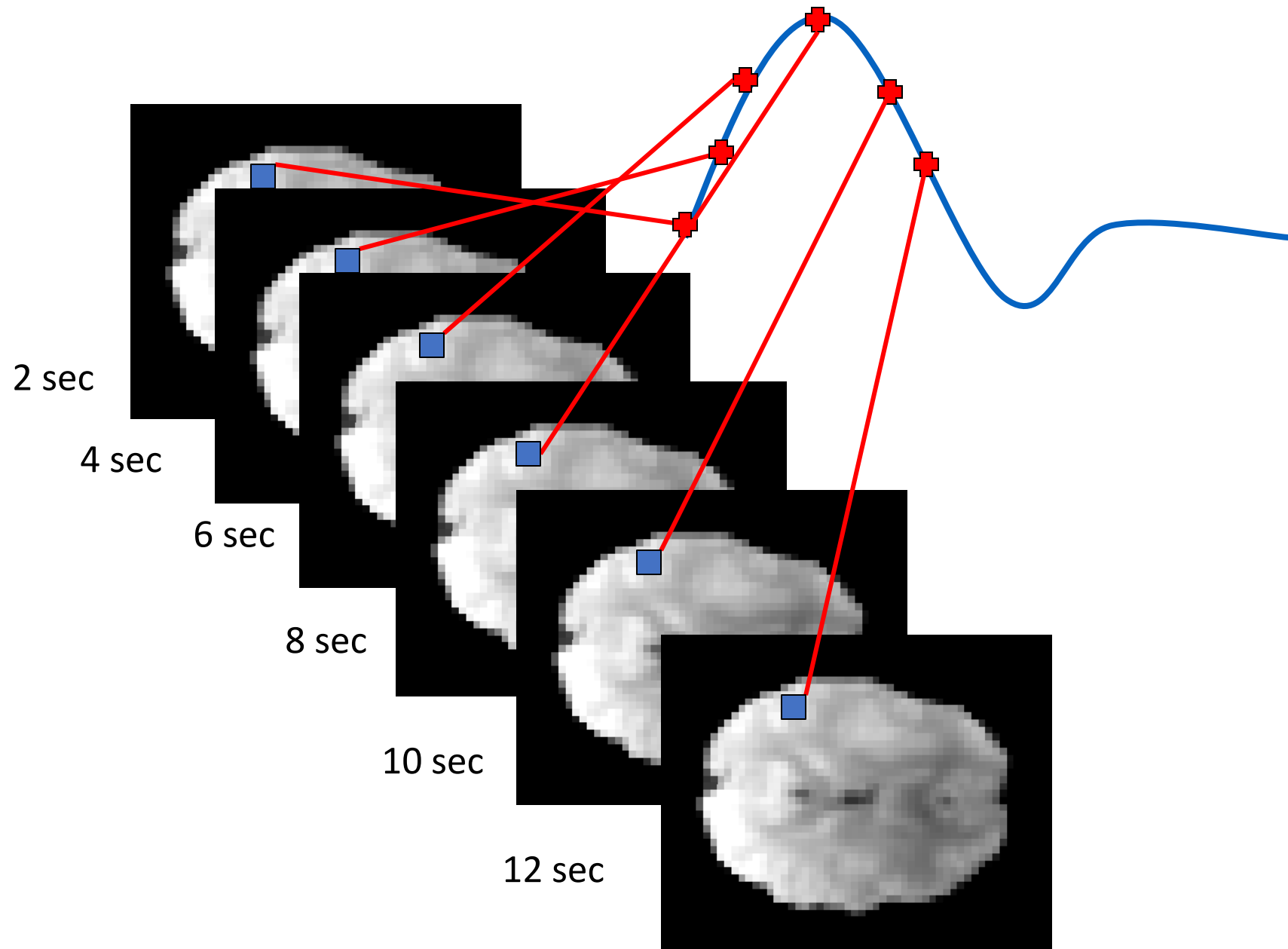
\$\$\$\$
Complicated
Slow
One person at a time
Motion sensitive



fMRI is timeseries data!



Each location (voxel – usually 2X2X2 mm) in the brain has a time series that consists of the T2 signal at each timepoint (usually every 1-2 seconds) across the recording period (5-10 minutes)







Though children are small, their brain data are mighty!

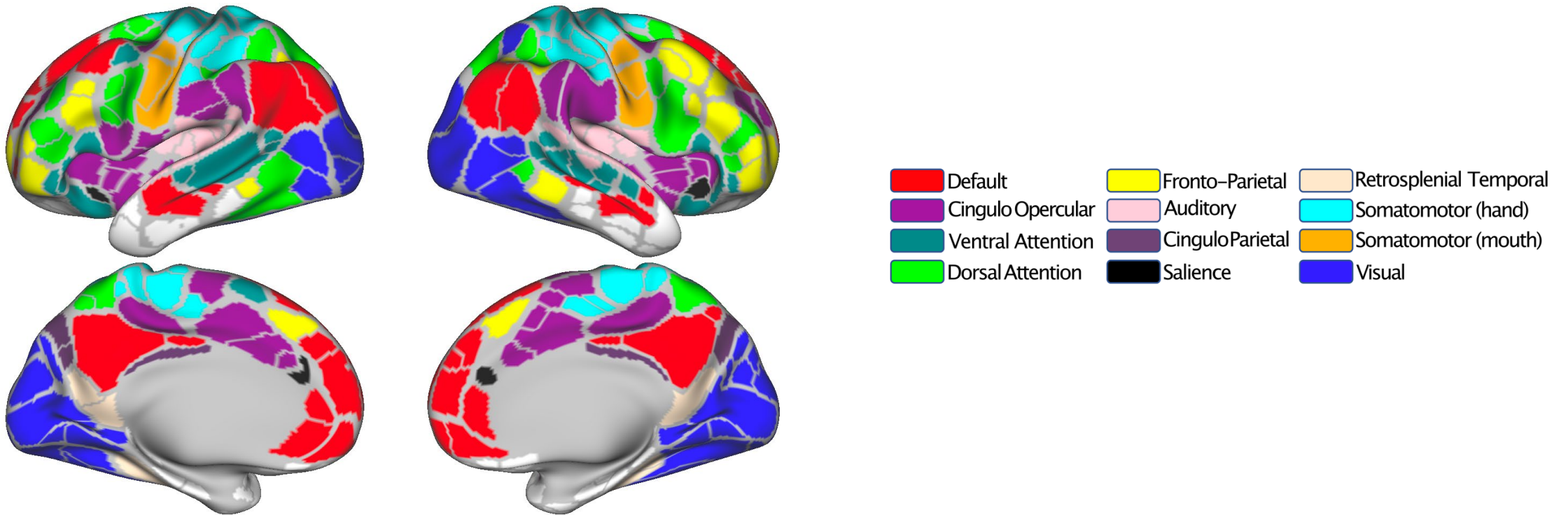


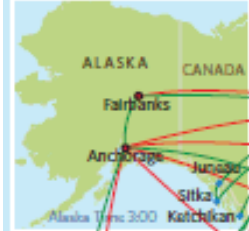
Two things to ponder:

1. People can flexibly configure the specific processes necessary to perform many different tasks
2. This is done on a massively parallel, interconnected architecture in the brain

The bigger idea of functional networks

The Brain is a series of Systems that interact/combine to accomplish our goals





Pacific Ocean



Hawaii-Alaskan Time 1:00

Mountain Time 5:00

Central Time 6:00

Eastern Time 7:00

CANADA

MEXICO

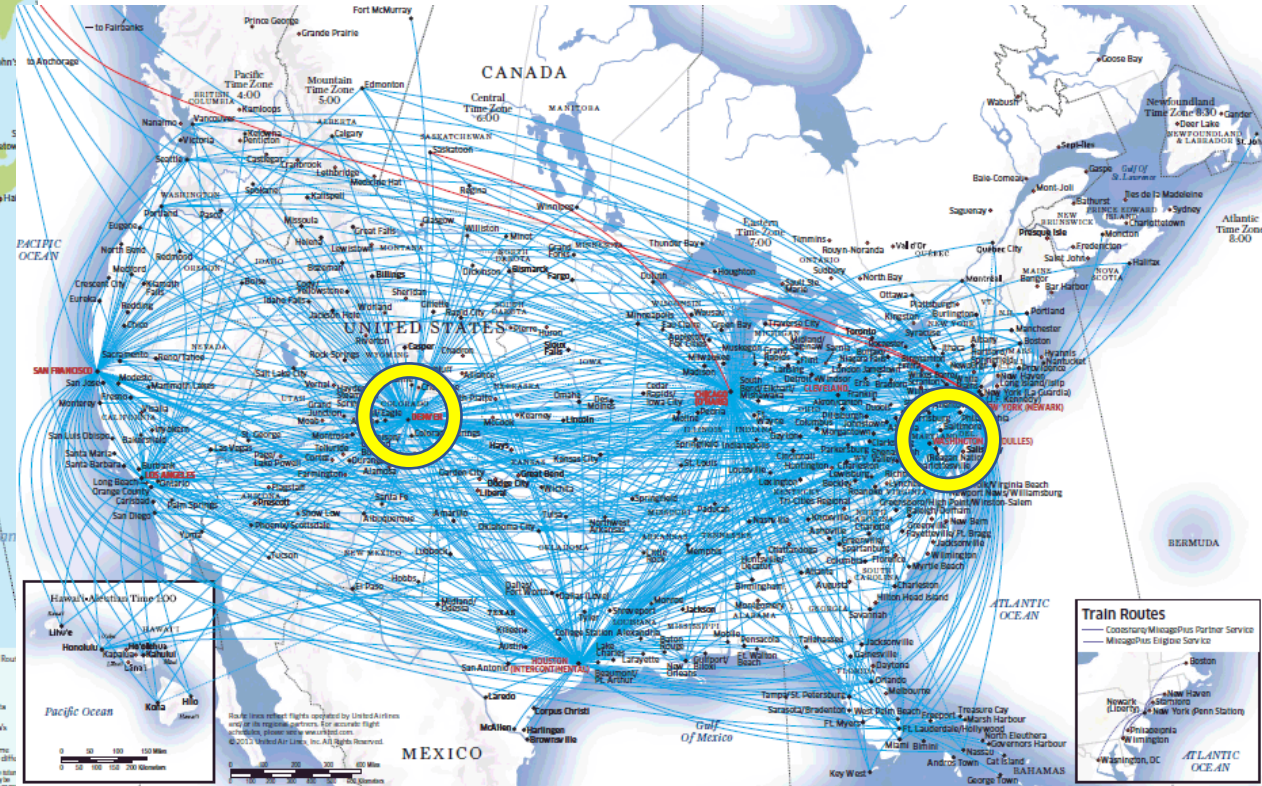
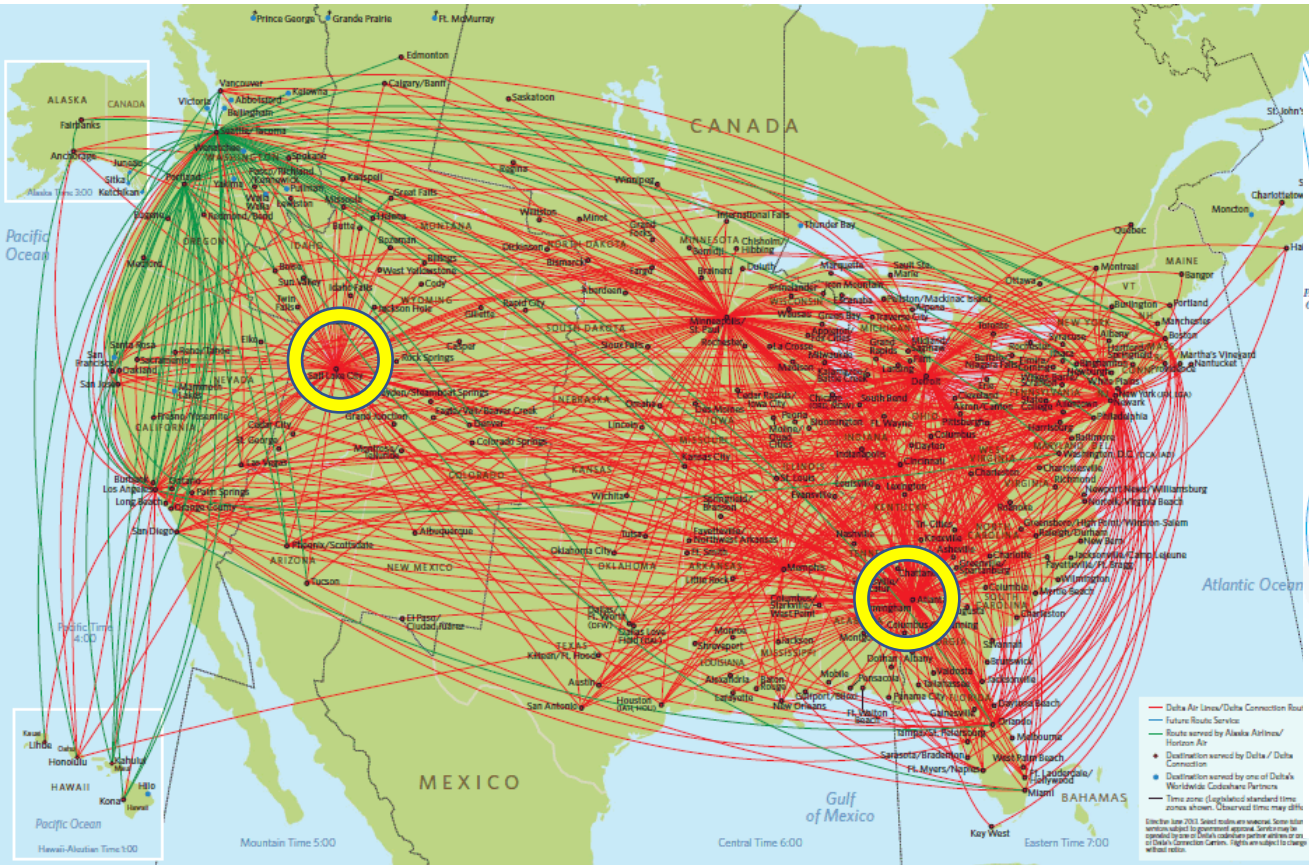
Gulf of Mexico

Atlantic Ocean

- Delta Air Lines/Delta Connection Route
- Future Route Service
- Route served by Alaska Airlines/ Horizon Air
- Destination served by Delta / Delta Connection
- Destination served by one of Delta's Worldwide Codeshare Partners
- Time zone (Leg/related standard time zones shown. Observed time may differ.)

Effective June 2013. Select cities are seasonal. Some future services subject to government approval. Service may be operated by one of Delta's codeshare partner airlines or one of Delta's Connection Carriers. Flights are subject to change without notice.

Categories of Hubs



What is a “cortical hub”?

Participation Coefficient

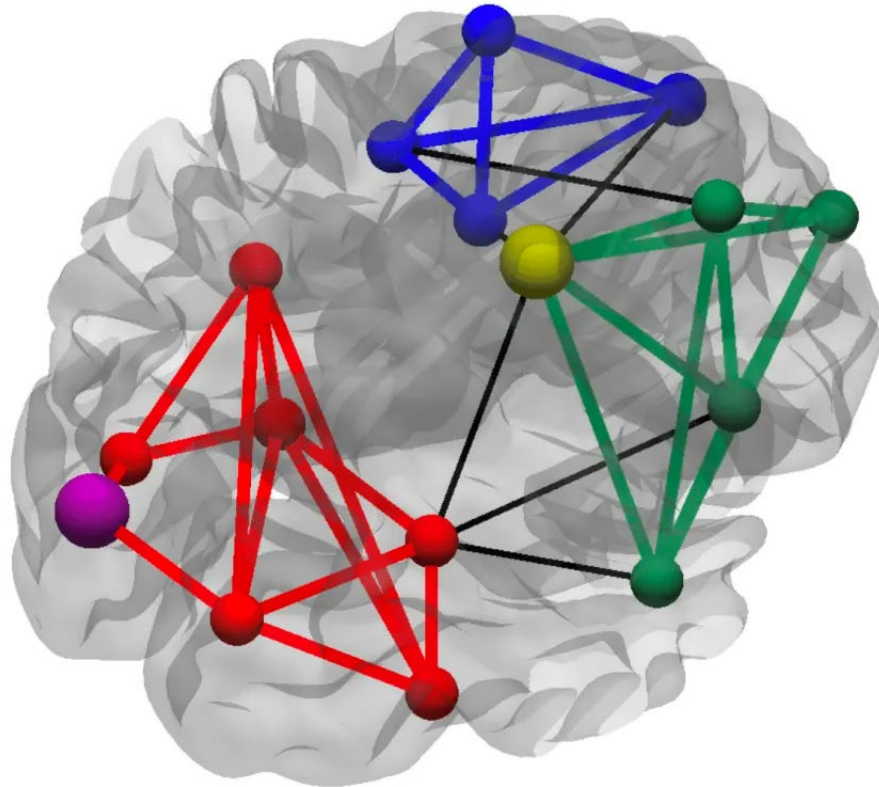


Figure from BRAPH.org

Graph of network organization of brain areas in healthy young adults

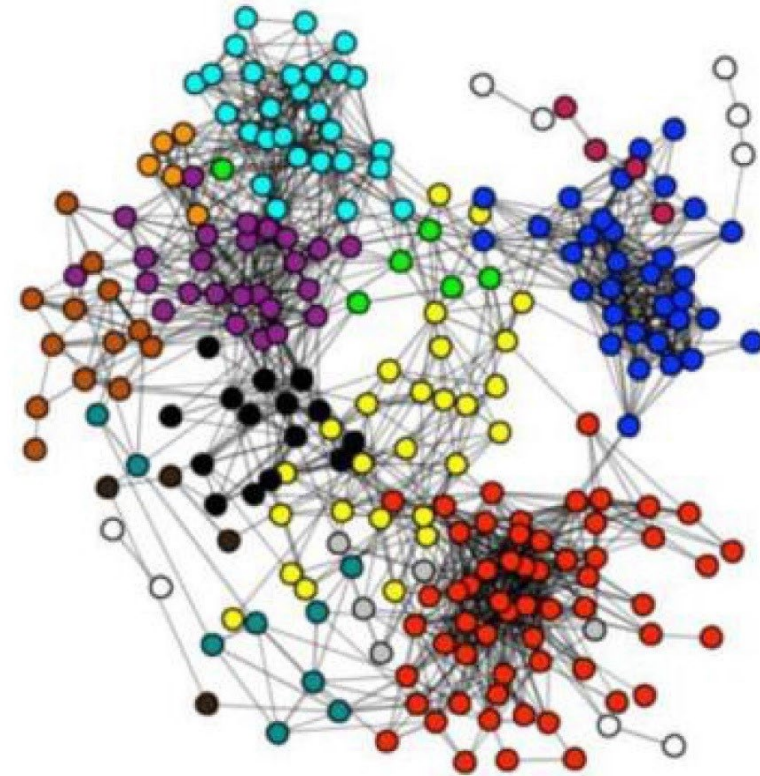


Figure: Wig, 2017



Are there clear cortical hub categories in youth and are any associated with executive function task performance?

Resting-state cortical hubs in youth organize into four categories

Demeter, D.V., Gordon, E.M., Nugiel, T., Garza, A.C., Larginho, T., Church, J.A.
2023; *Cell Reports*, 42 (5)





Participants: ABCD (n=500) and UT (n=67)

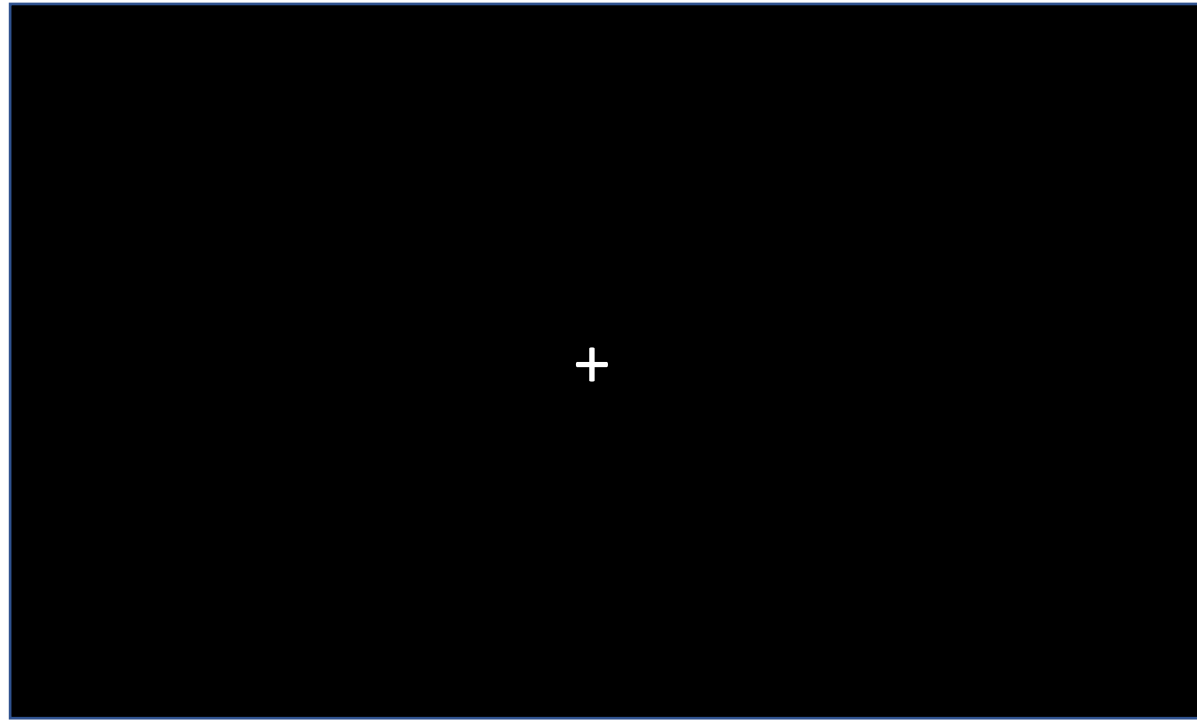
50% female

Age range 8.5-17.2 years
(mean = 10.3 years)

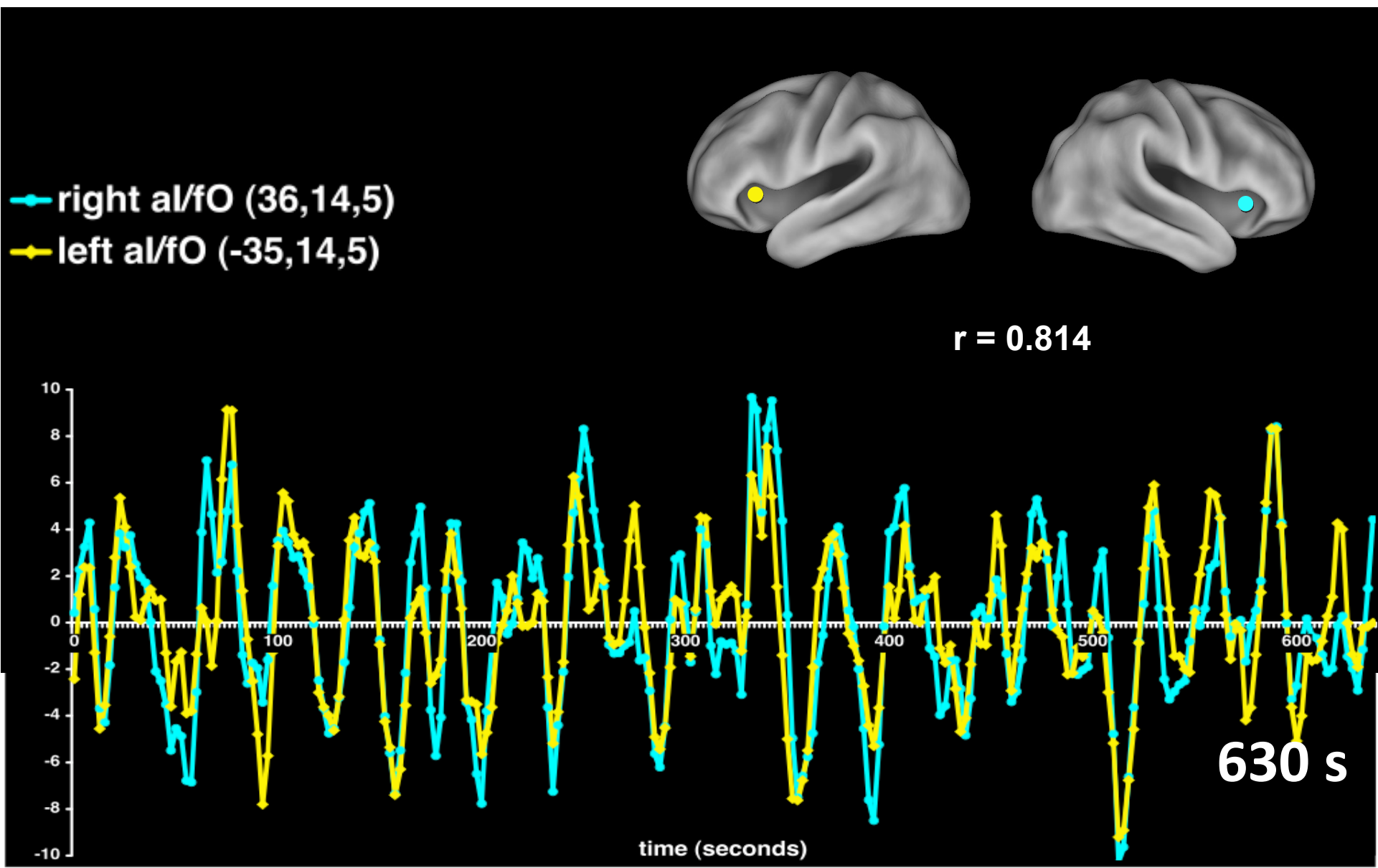
Mean “clean” scan length
(0.25mm FD) = 13:52



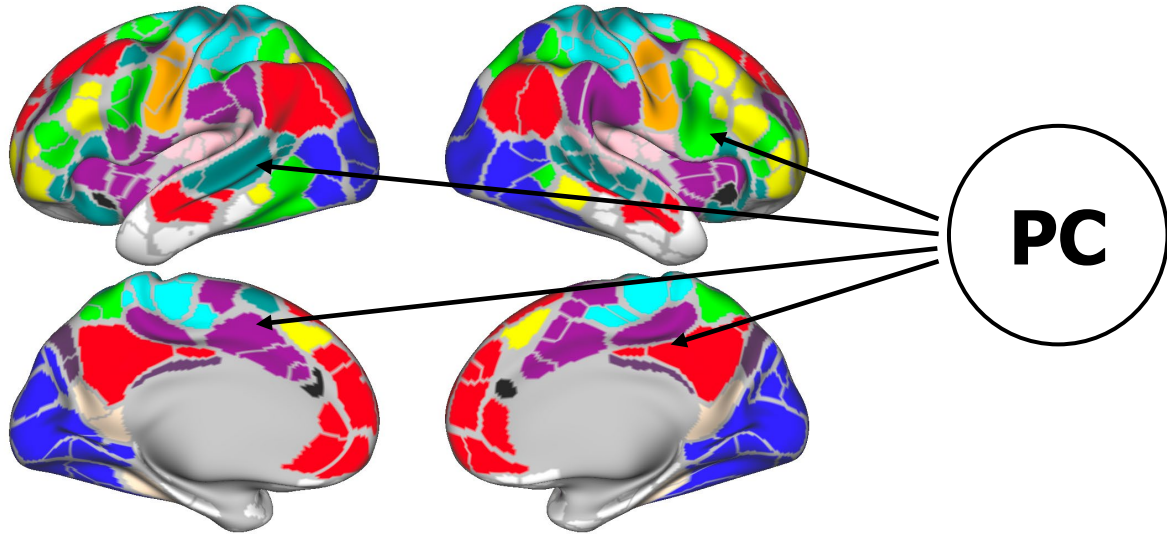
Functional correlations of the brain at rest



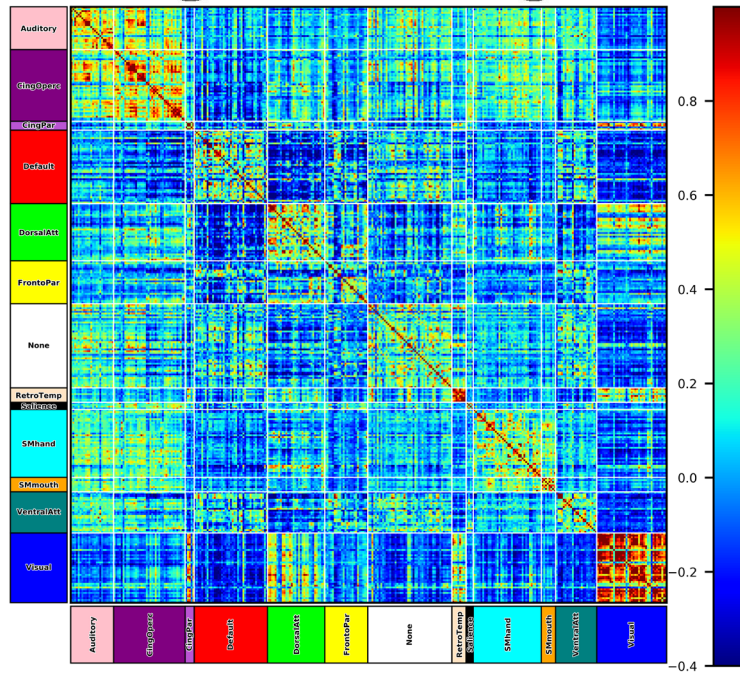
Resting state functional connectivity (rs-fcMRI)



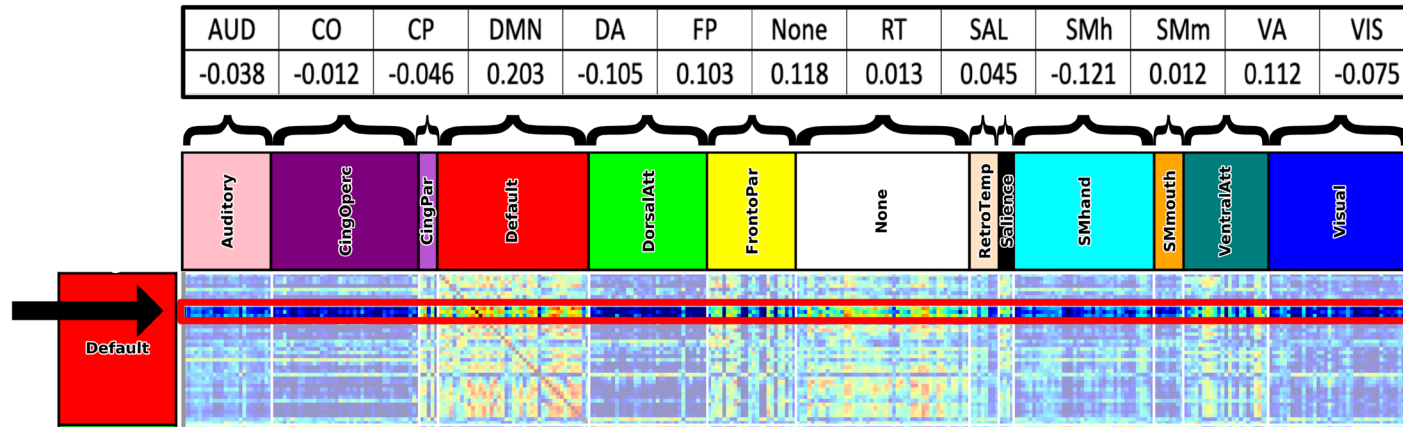
Youth Hub Identification



- Create 333x333 connectivity matrix
- Community detection per person
- Calculate participation coefficient (PC) for all parcels per person
- Hubs = PC top 20% per person
 - 67 hubs per person

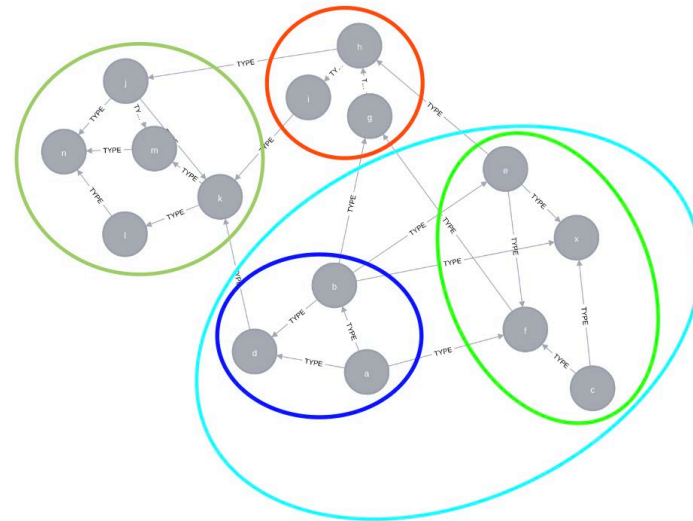


Clustering youth hub profiles

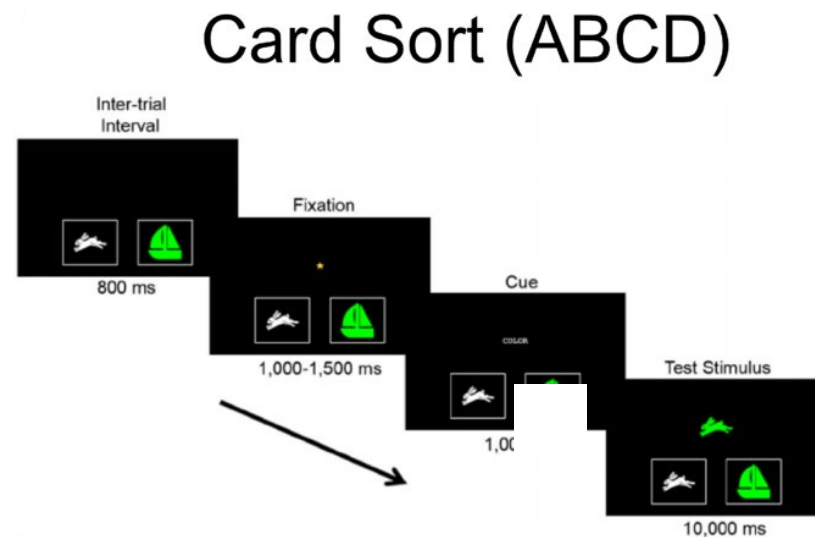
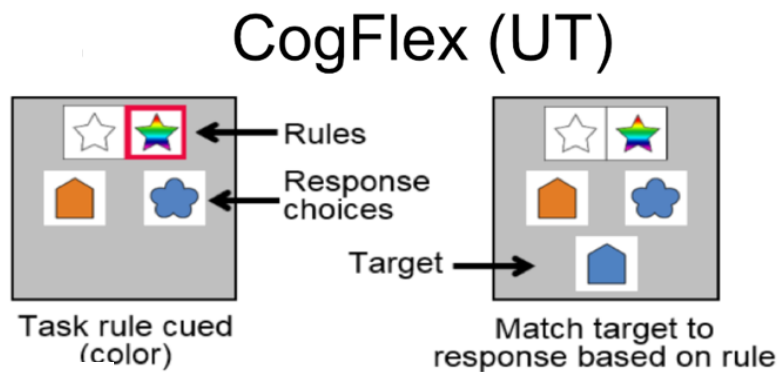


Connectivity profile for each hub

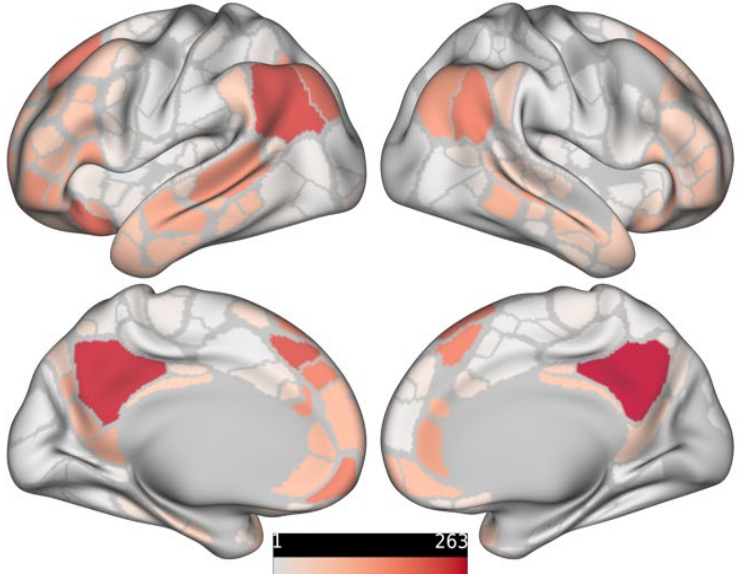
Use Louvain algorithm to identify clusters of connectivity profiles



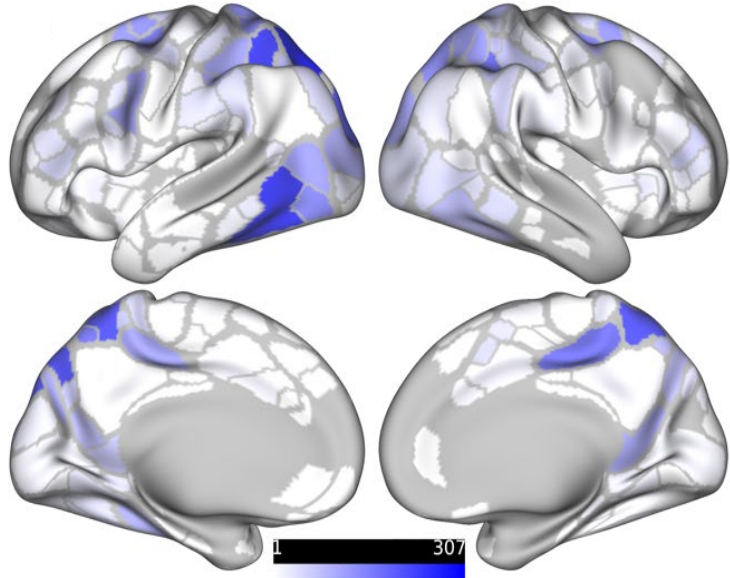
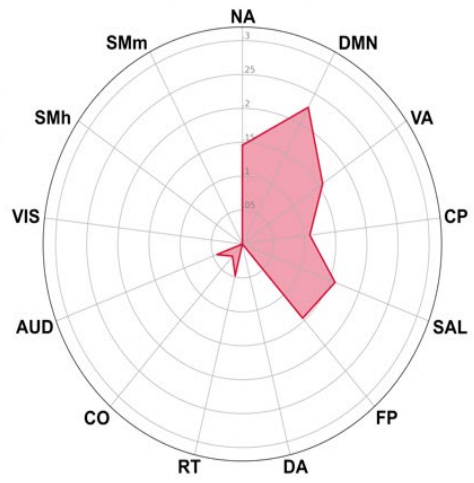
Relating any hub profiles to executive function abilities



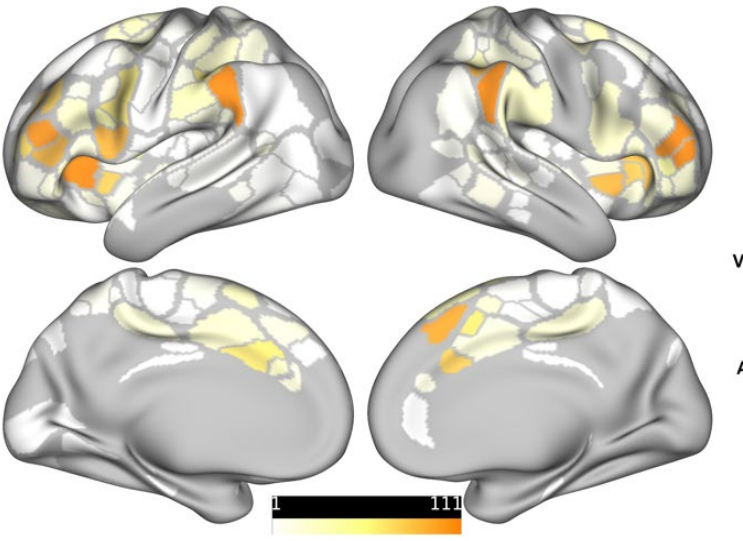
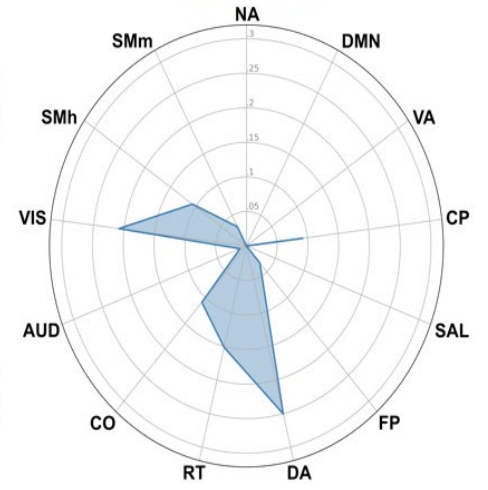
Are there hub categories in youth, and are any associated with executive function task performance?



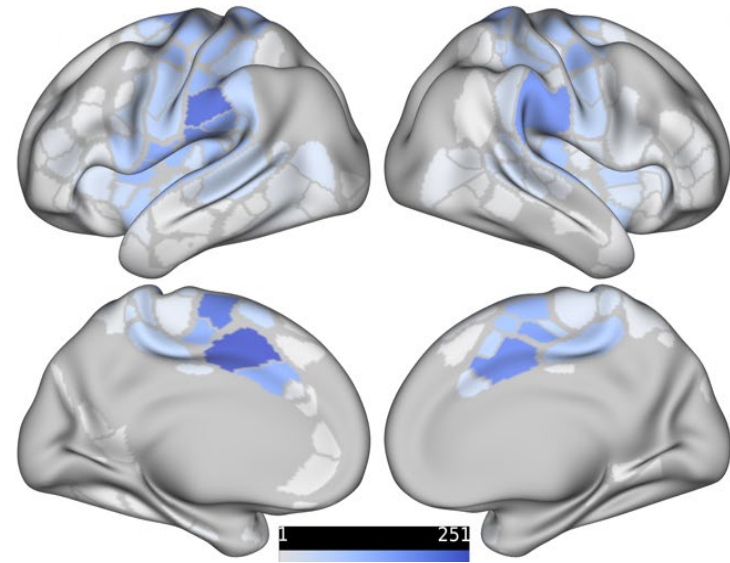
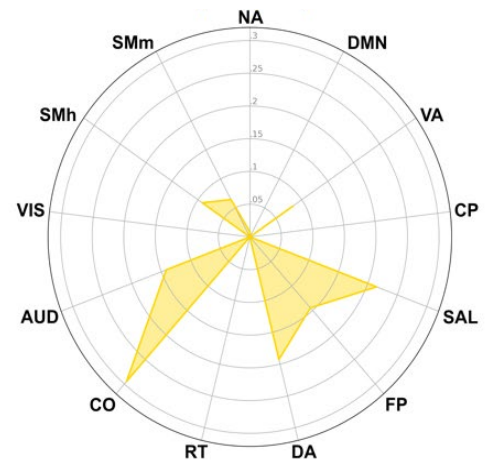
Youth Control Default



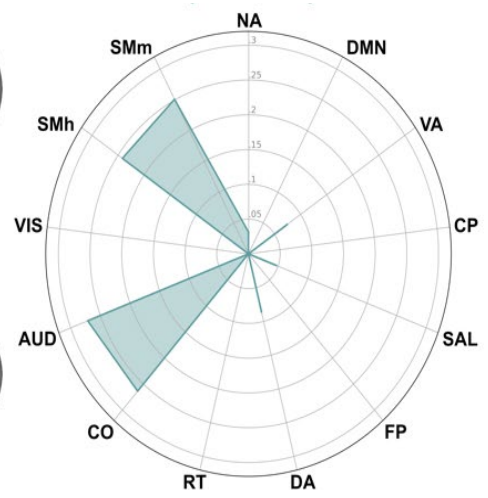
Youth Control Processing (VIS)



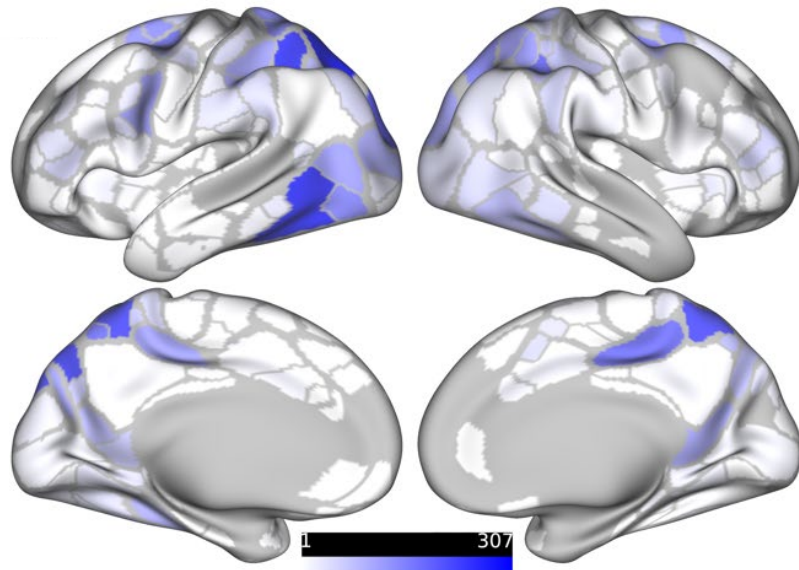
Youth Cross Control



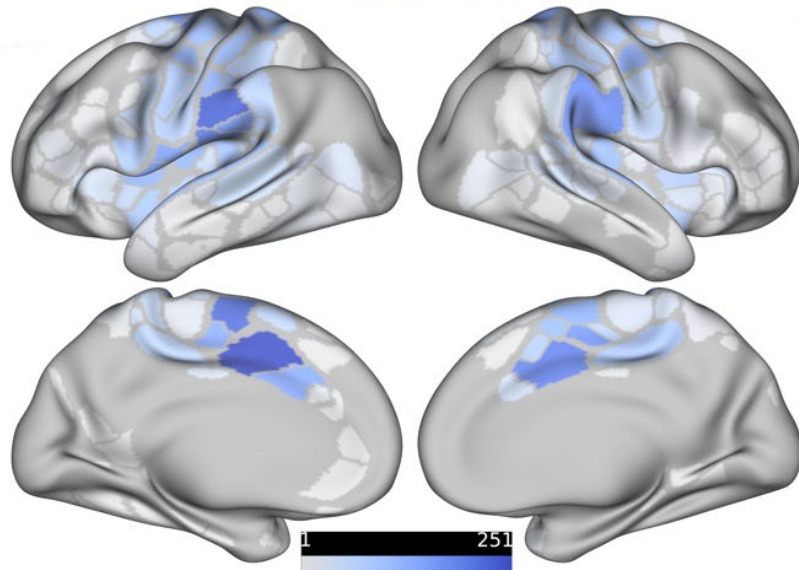
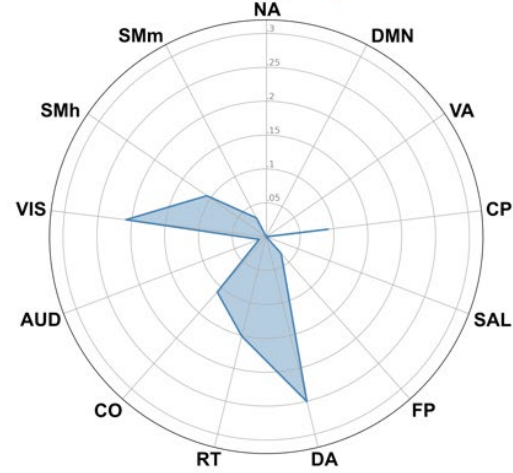
Youth Control Processing (AUD + SM)



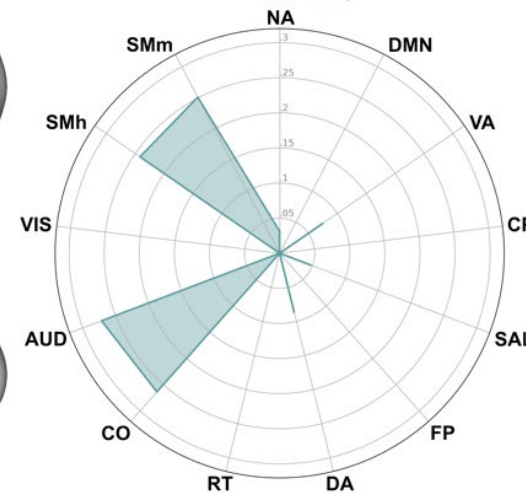
Youth control-processing hubs relate to Cognitive Flexibility



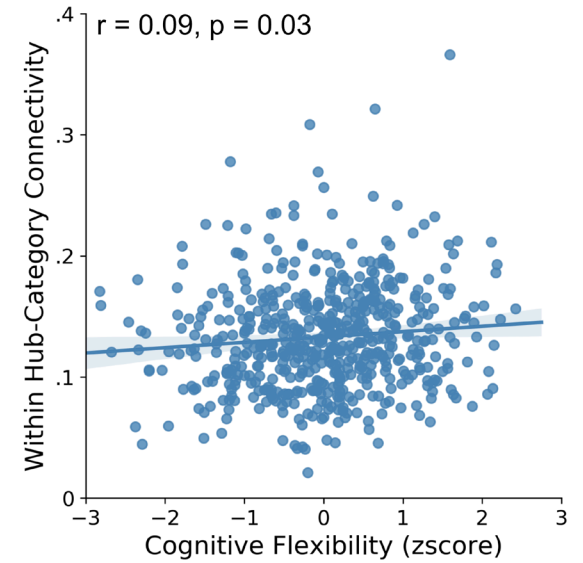
Youth Control Processing (VIS)
=10,406



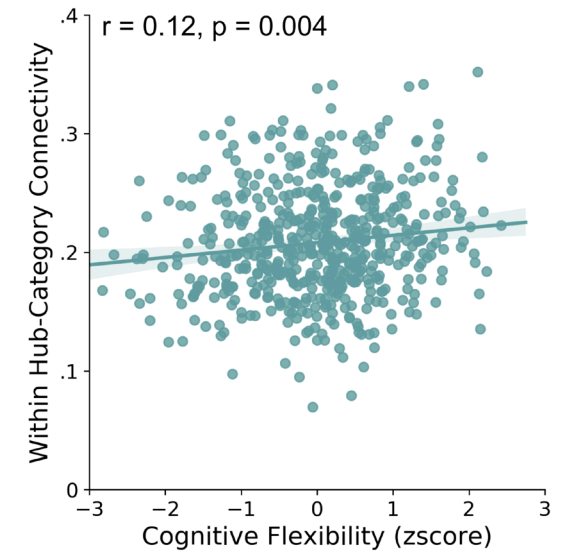
Youth Control Processing (AUD + SM)
=10,464



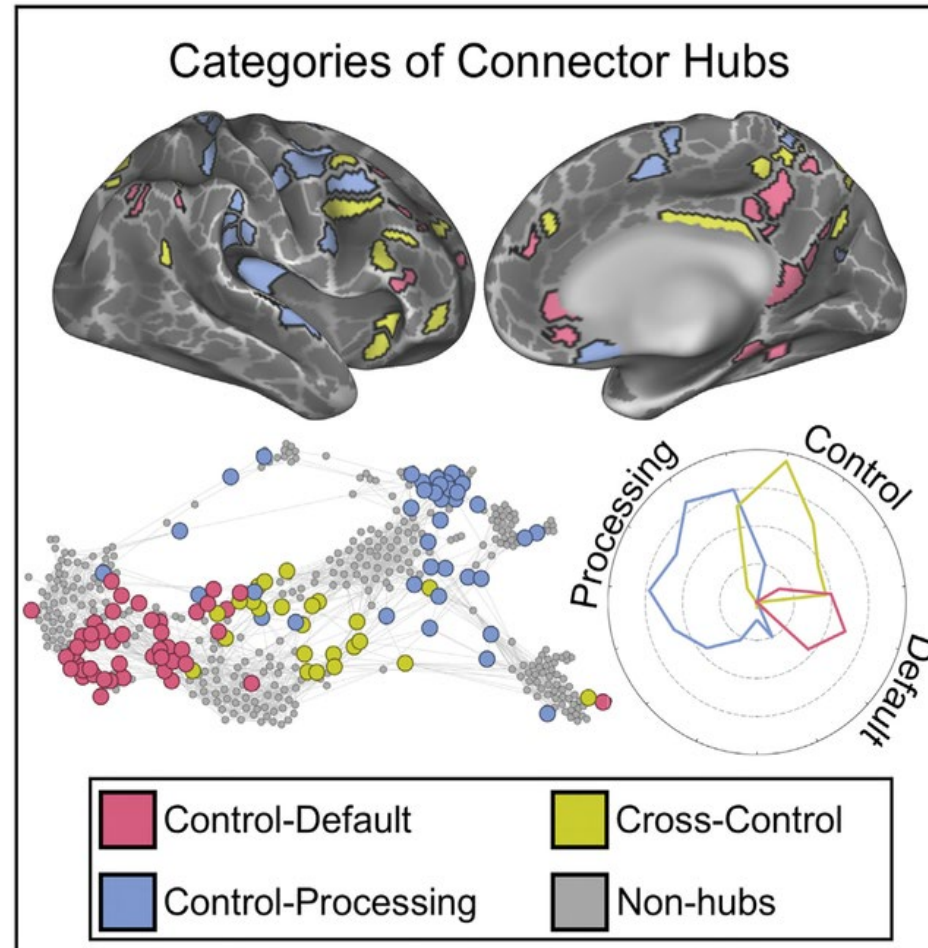
Youth Control-Processing (VIS)

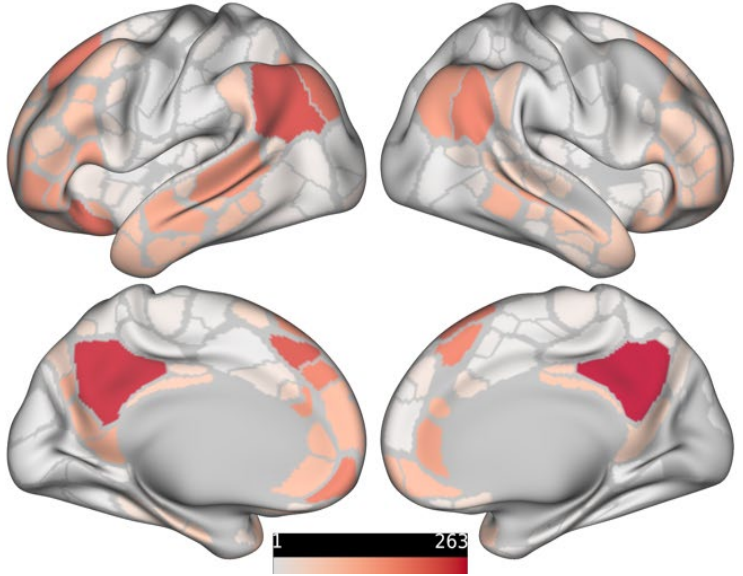


Youth Control-Processing (AUD + SM)

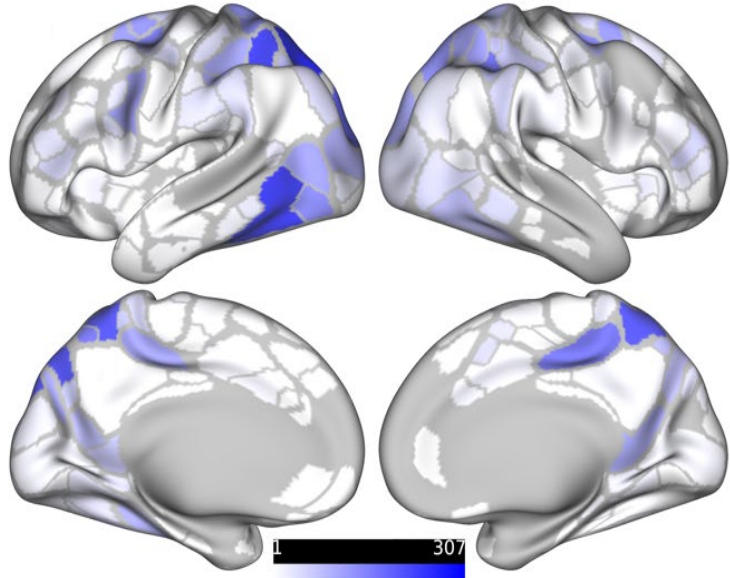
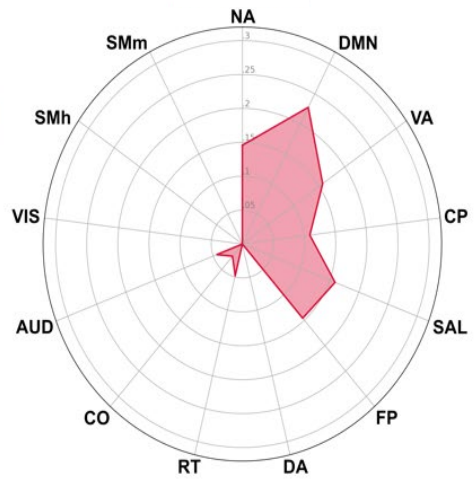


3 Different types of cortical hubs relate to task control in adults

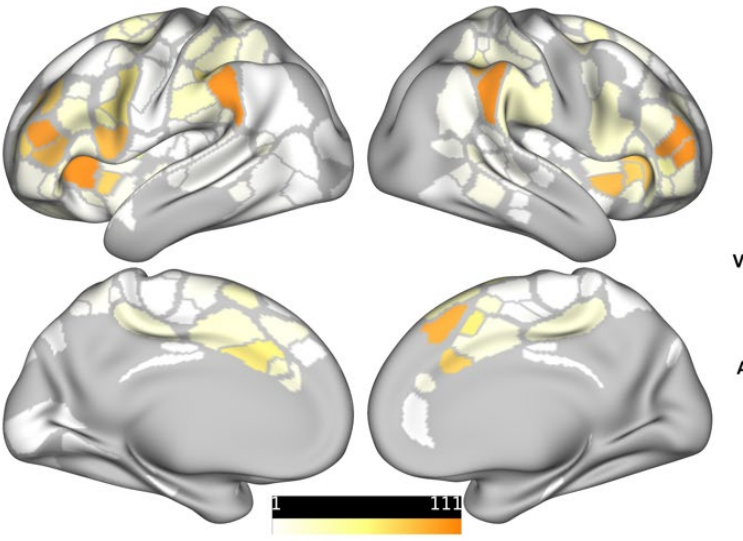
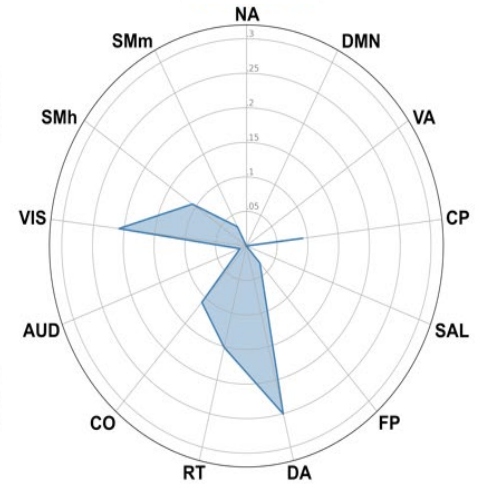




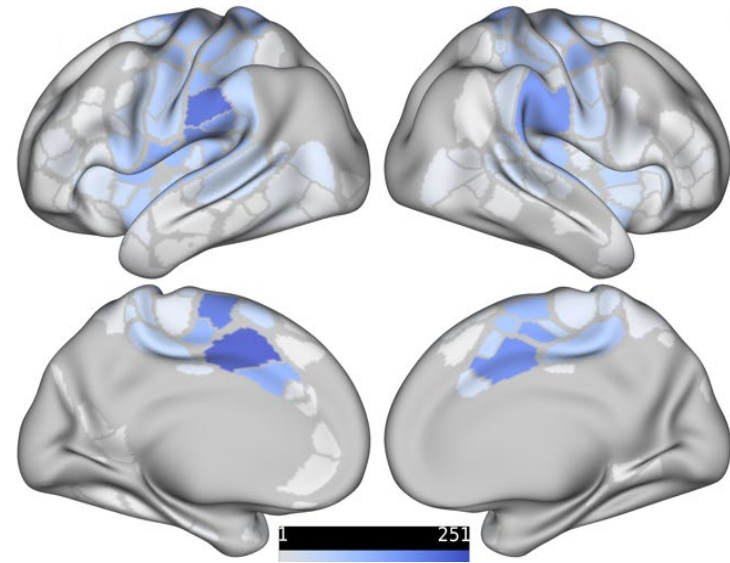
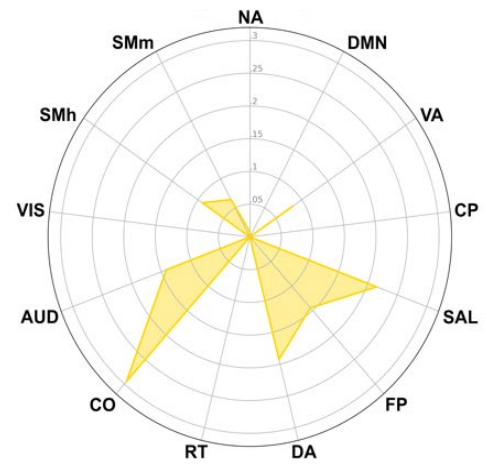
Youth Control Default



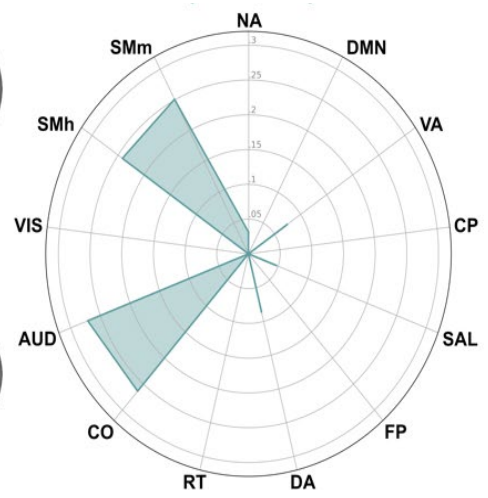
Youth Control Processing (VIS)



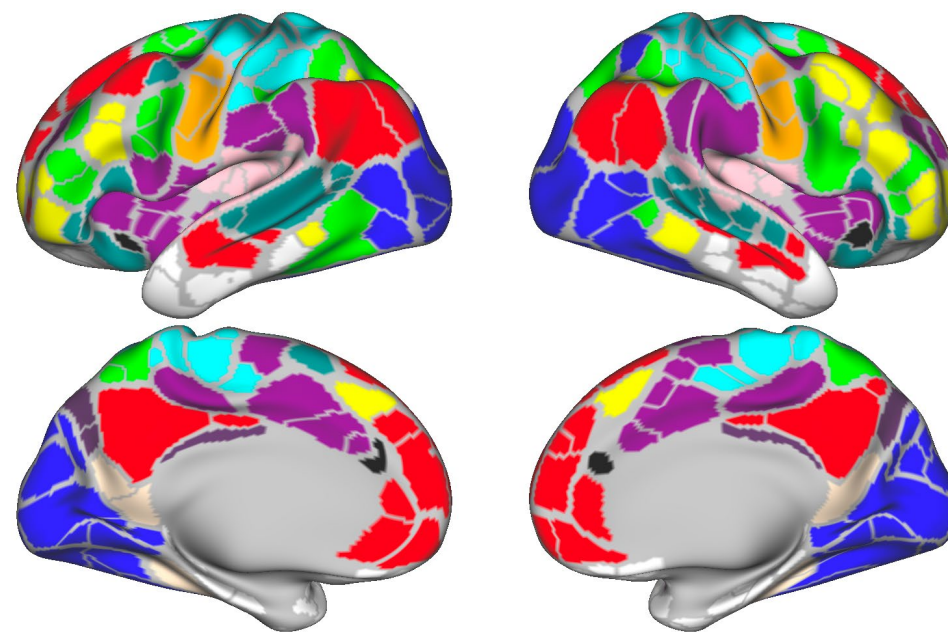
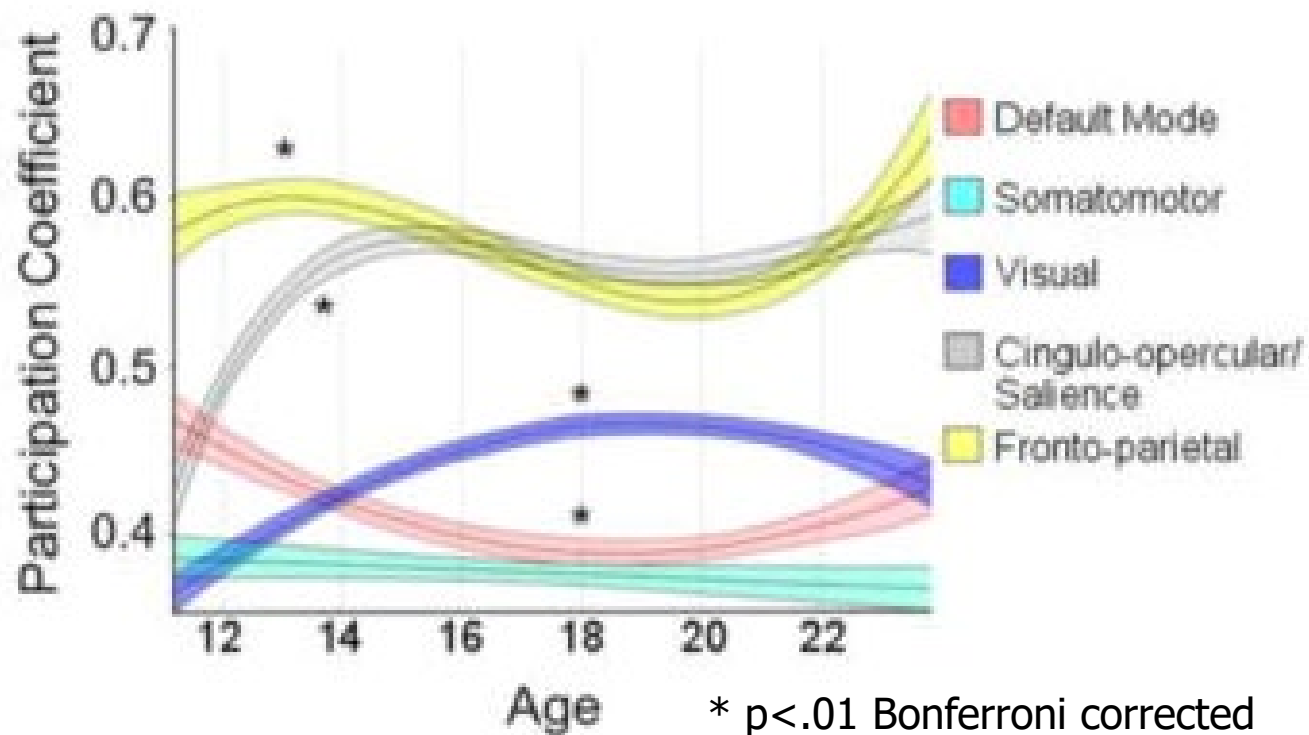
Youth Cross Control



Youth Control Processing (AUD + SM)



Developmental trajectories of cortical hubs appear non-linear





Conclusions

Cortical hub profiles in youths are similar to what have been reported in adults

But, youth control-processing hubs are split between sensory networks

These control-processing hubs relate to cognitive flexibility performance in youths

Understanding cortical hubs helps us understand brain function, communication, and vulnerabilities to injury over development

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Brittany Davis
AnnaCarolina Garza
Chuu Nyan

Victoria Cervantes
Sneha Kesavan
Klaudia Misztal
Shreya Mulukuntla
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Sonya Swami
Nihal Tangeda

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Dr. Damion Demeter
Mackenzie Mitchell
Dr. Laura Engelhardt
Dr. Annie Zheng
Dr. Joel Martinez
Many undergrad RAs!

Spring 2023

Developmental
Cognitive
Neuroscience Lab

meet the team

Thanks!

UT Psychology
UT Biomedical Imaging Center
UT Children's Research Center
TACC

Our participating families!

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Developmental Cognitive Neuroscience Lab

COLLEGE of LIBERAL ARTS



The Meadows Center
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