Interactions among frontal-parietal and cingulo-opercular networks supporting cognitive control

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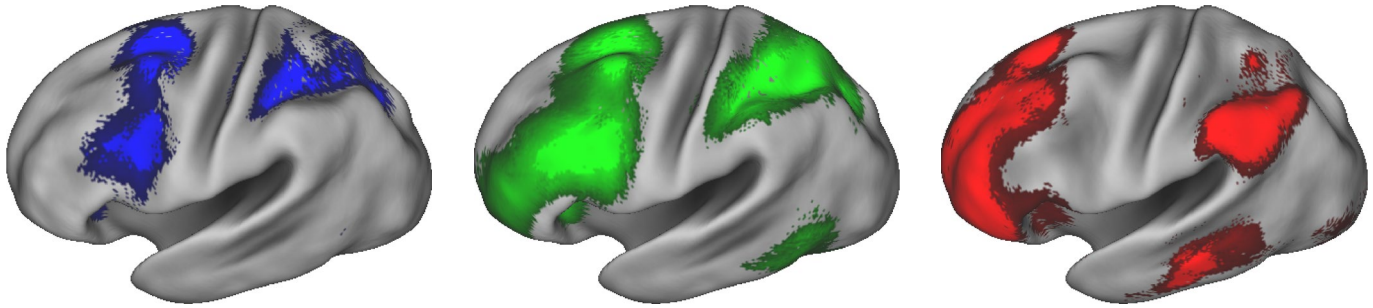
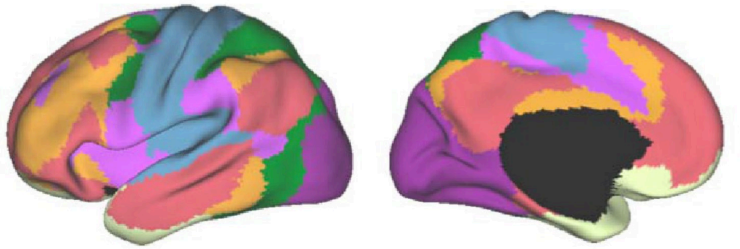
BACKGROUND

Cognitive Control involves directing one's actions based on current and future relevant demands. It can be broken down into processes of:

Sensory-Motor Control	Contextual Control	Temporal Control
Linking stimulus to action	Adapting behavior based on rules	Future-Oriented Planning



PURPOSE



Frontoparietal Control Network (FPCN)

Cinguloopercular Network (CON)

The interactions between these networks have yet to be empirically tested, and specifically, the CON's distribution and function during cognitive control is currently unclear

Question 1: What is the distribution of the CON during specific cognitive control demands?

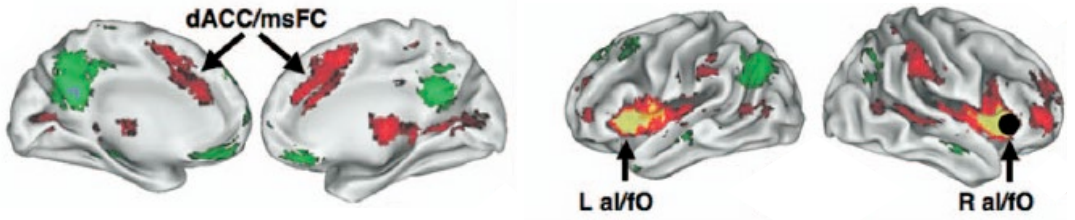
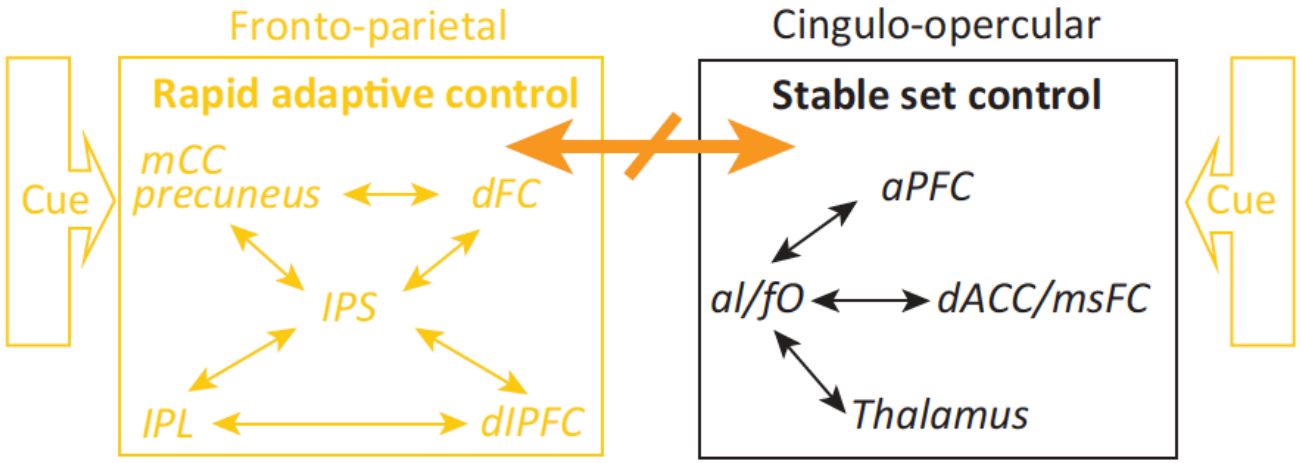


Image: Dosenbach et al., 2007, *PNAS*

Question 2: Does the CON function in a sustained or transient manner during cognitive control?



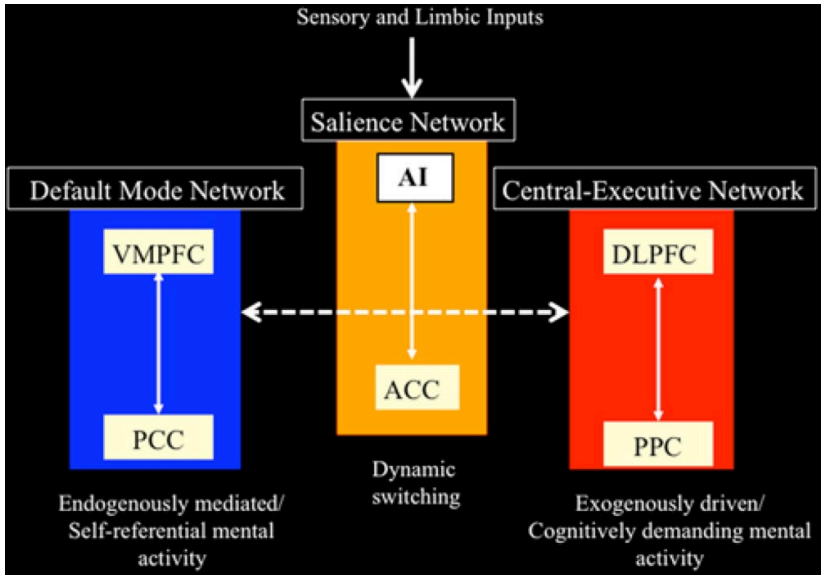


Image Left: Dosenbach et al., 2008, *TICS; Right:* Menon & Uddin, 2010, *Brain Struct Funct*

Question 3: Does the CON motivate the FPCN in the procession of activity towards behavior?

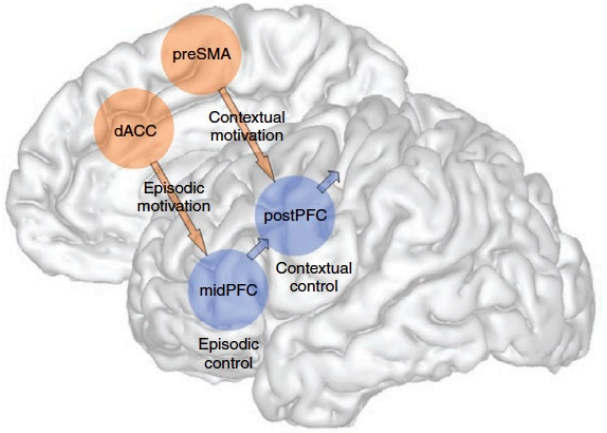
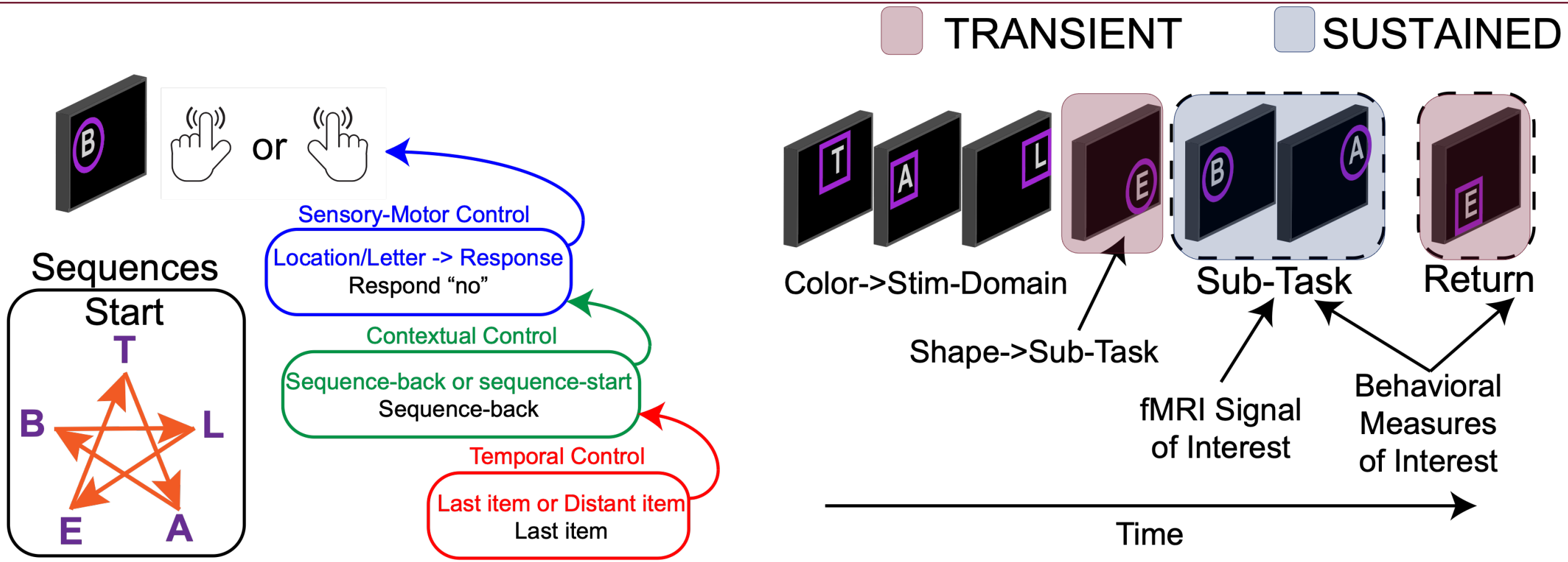


Image: Egner, 2009, *Nature Neuro*; Kouneiher et al., 2009, *Nature Neuro*

METHODS: Task, Procedure, & Analysis



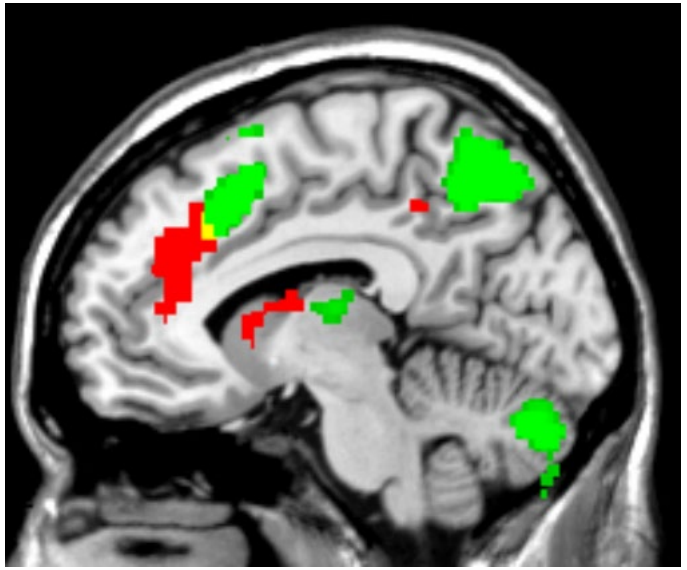
- Previously collected data-set from Nee & D'Esposito 2016 & 2017, *eLife*
- Two separate samples of young, healthy participants (n=24 and n=25) completed the task during fMRI
- fMRI contrasts compared control demand conditions
- Peak activations identified in one sample, used as ROI on remaining sample and vice versa

Question 1: CON distribution

RESULTS: CON and FPCN distributed based on control demands

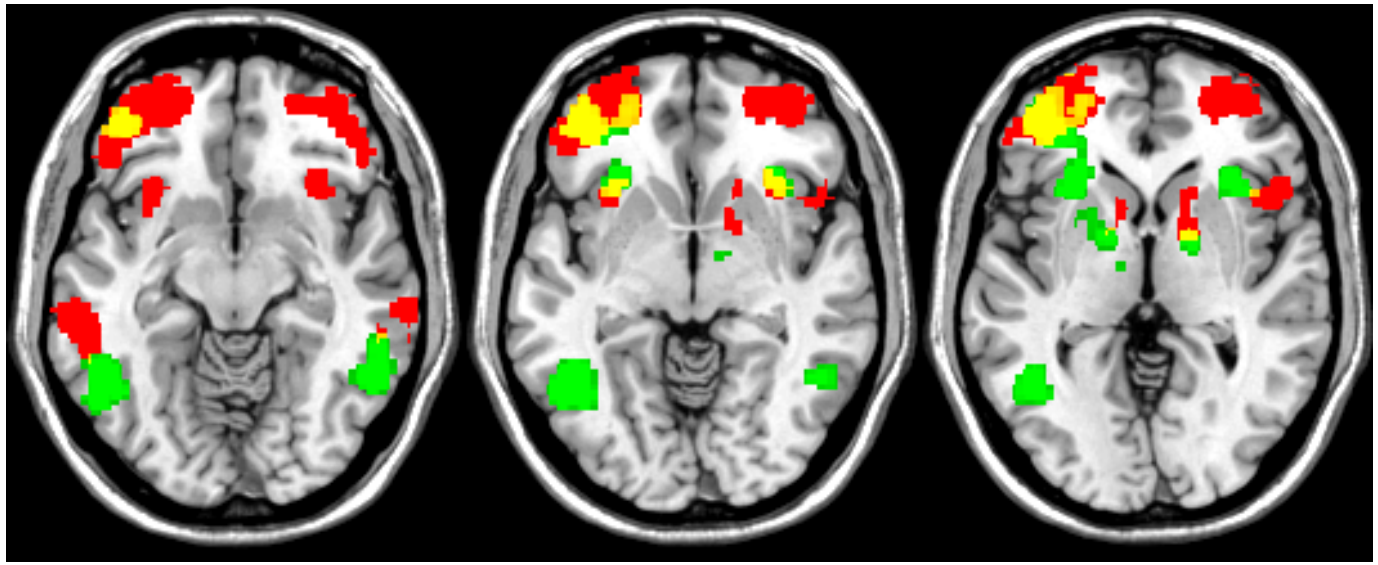
Temporal Control | Contextual Control | Overlap

dmPFC



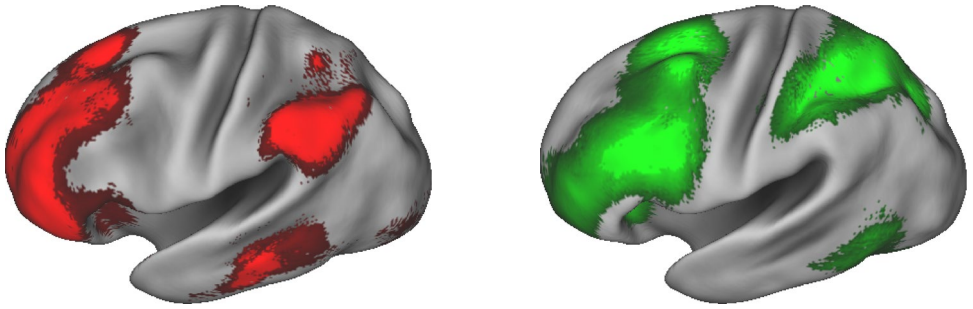
X = -8

Anterior Insula



Z = -10 -5 0

Previously reported FPCN Distribution:



Nee & D'Esposito, 2016 & 2017, *eLife*; Nee, 2021, *eLife*

Functional subnetworks observed are consistent between the FPCN and CON:

- Temporal Control Subnetwork – rostral regions of the lateral and medial PFC and ventral aI
- Contextual Control Subnetwork – mid regions of the lateral and medial PFC and dorsal aI

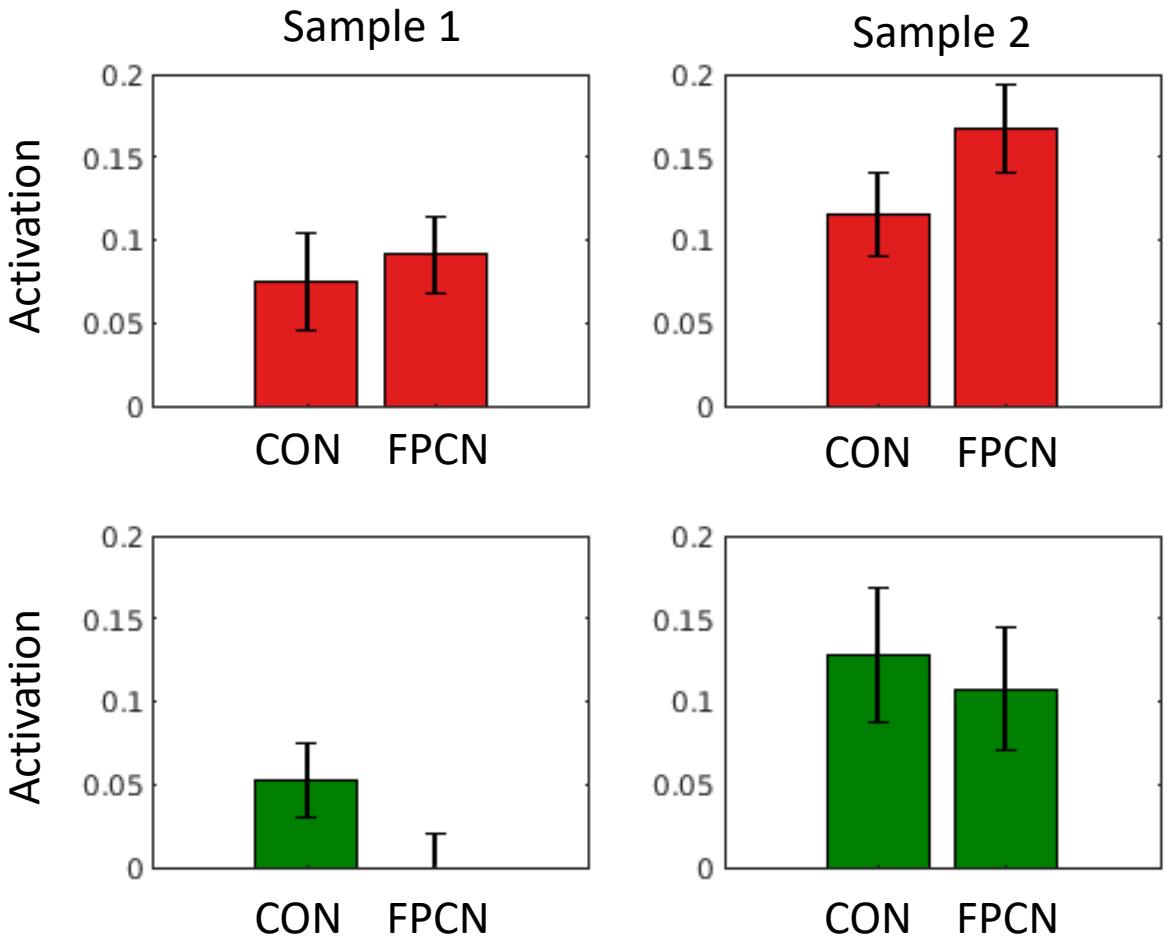
Question 2: CON sustained vs transient processing

RESULTS: CON has transient role in processing

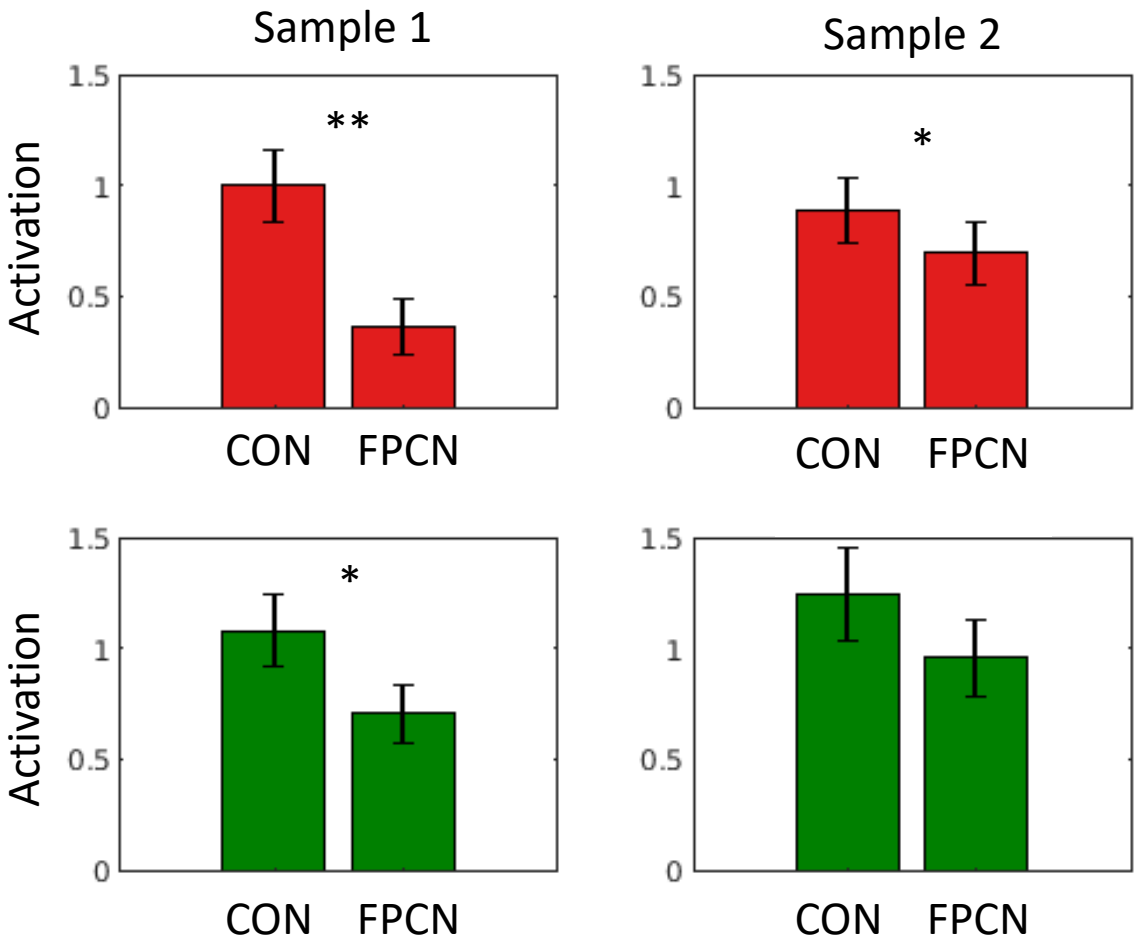
Temporal Control

Contextual Control

Sustained Phase



Transient Phase



$^{*}p < 0.05$ $^{**}p < 0.001$

Evidence for CON as playing a more transient role than the FPCN

Question 3: CON motivates the FPCN

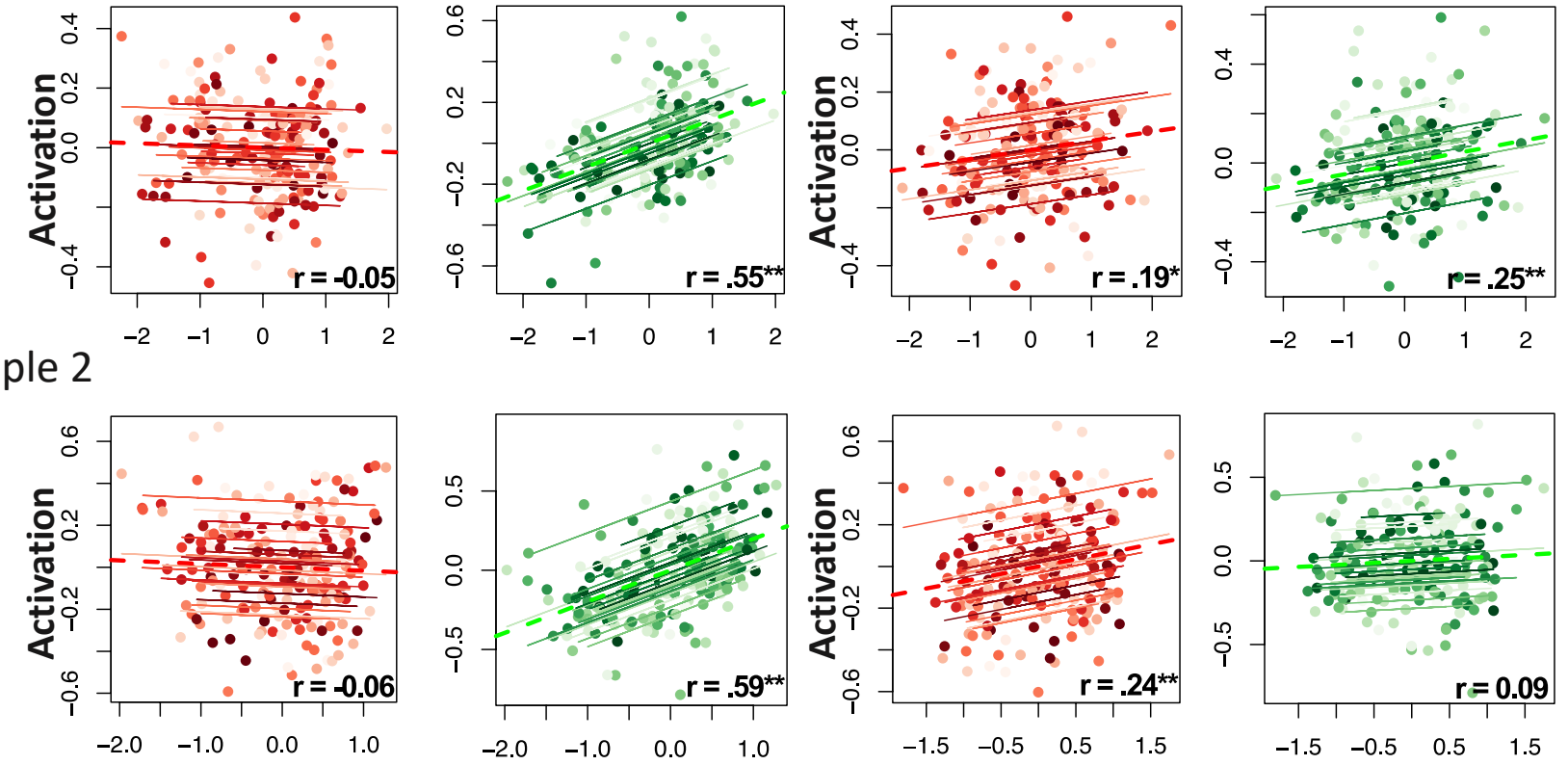
Step 1 RESULTS: CON Brain-Behavior Relationships mirror FPCN findings

Temporal Control

Contextual Control

Sample 1

Sample 2



- Contextual Control Subnetwork correlated with present behavior RT across samples
- Temporal Control Subnetwork is correlated only with future behavior RT

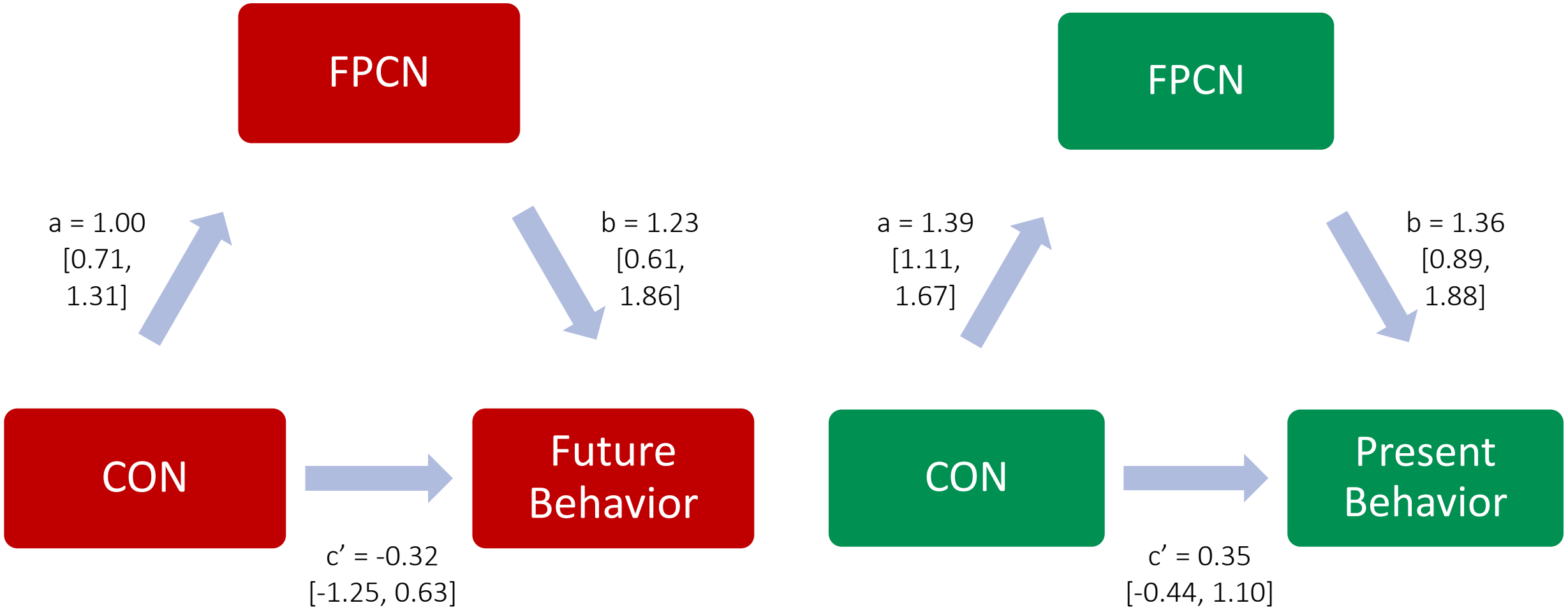
$^{*}p < 0.05$ $^{**}p < 0.001$

Question 3: CON motivates the FPCN

Step 2 RESULTS: Mediation analysis between-networks shows FPCN fully mediating the CON relationship with behavior

Temporal Control

Contextual Control



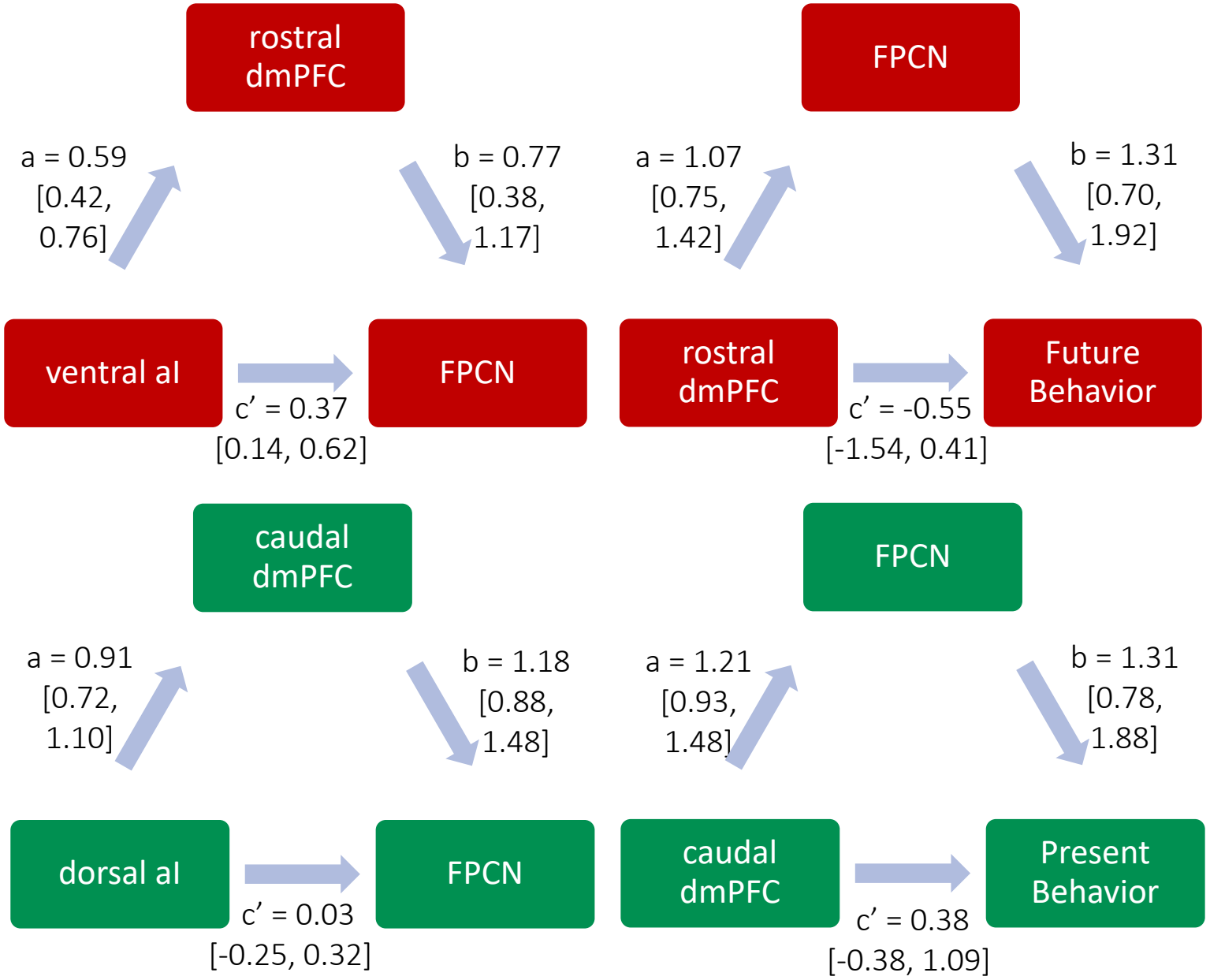
Sample 1 data shown: findings replicated in sample 2

Question 3: CON motivates the FPCN

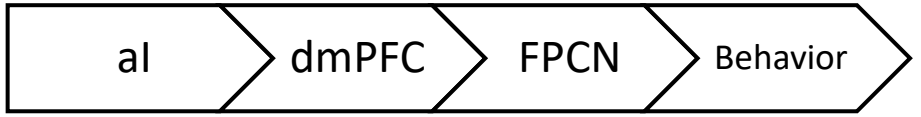
Step 3 RESULTS: Separating CON regions show mediation to behavior

Temporal Control

Contextual Control



Provides evidence for a directed relationship from the CON regions – aI to dmPFC, to the FPCN to behavior



SUMMARY

- CON and FPCN can be separated into functional subnetworks based on control demands
- CON plays a more transient role in processing
- Together there is evidence for the CON motivating the FPCN in a directional framework from the aI to dmPFC to FPCN onto behavior

Thank you!

NIMH R01 MH121509, PI: Derek Nee

NIH National Institute of Mental Health

NEUROSCIENCE 2021 50TH ANNUAL MEETING

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