

# INTRINSIC FUNCTIONAL CONNECTIVITY OF THE STRIATUM IN DEVELOPING ADOLESCENTS

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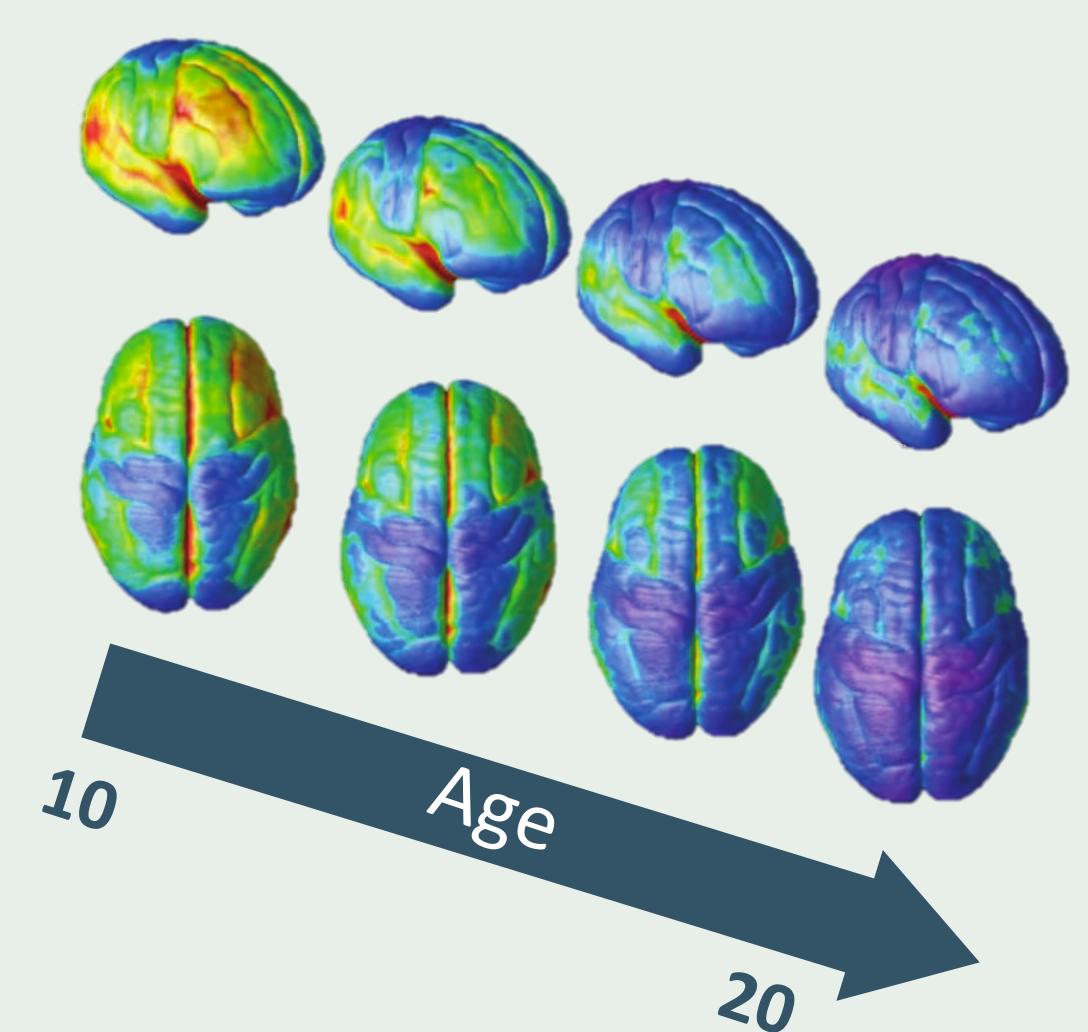
## The Elaboration of Cognitive Complexity in Adolescence

- > Theory of Mind
- > Identity Formation
- > Procedural Skills Development & Consolidation
- > Abstraction of Hierarchical Structures
- > Heightened Adaptive Behavior to Feedback

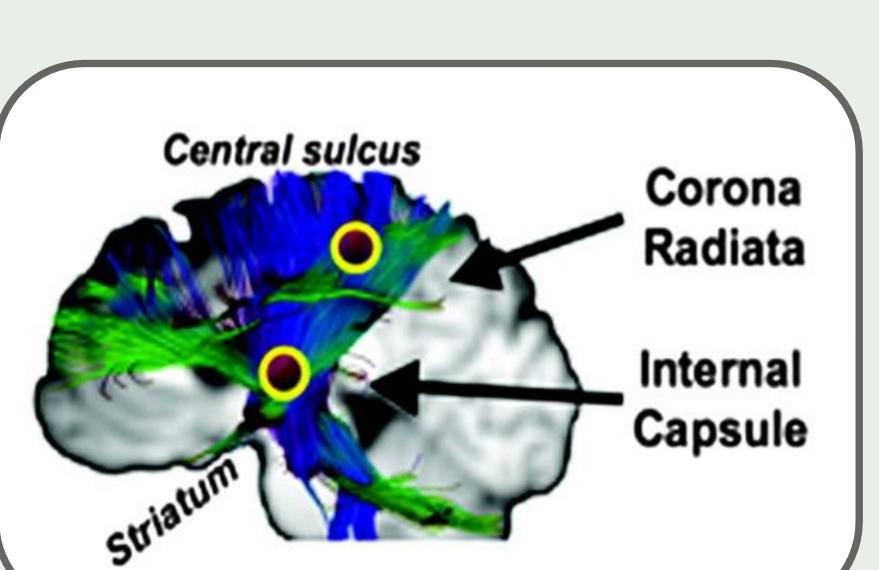
Can a neurophysiological correlate of post-pubertal cognitive maturation be identified with Magnetic Resonance Imaging?

## Peri-Pubertal Patterns of Structural & Functional Neurodevelopment

Normal aging is associated with a posterior-anterior gradient of ~0.2 mm<sup>3</sup> cortical volume loss during adolescence (Gogtay et al. 2014)

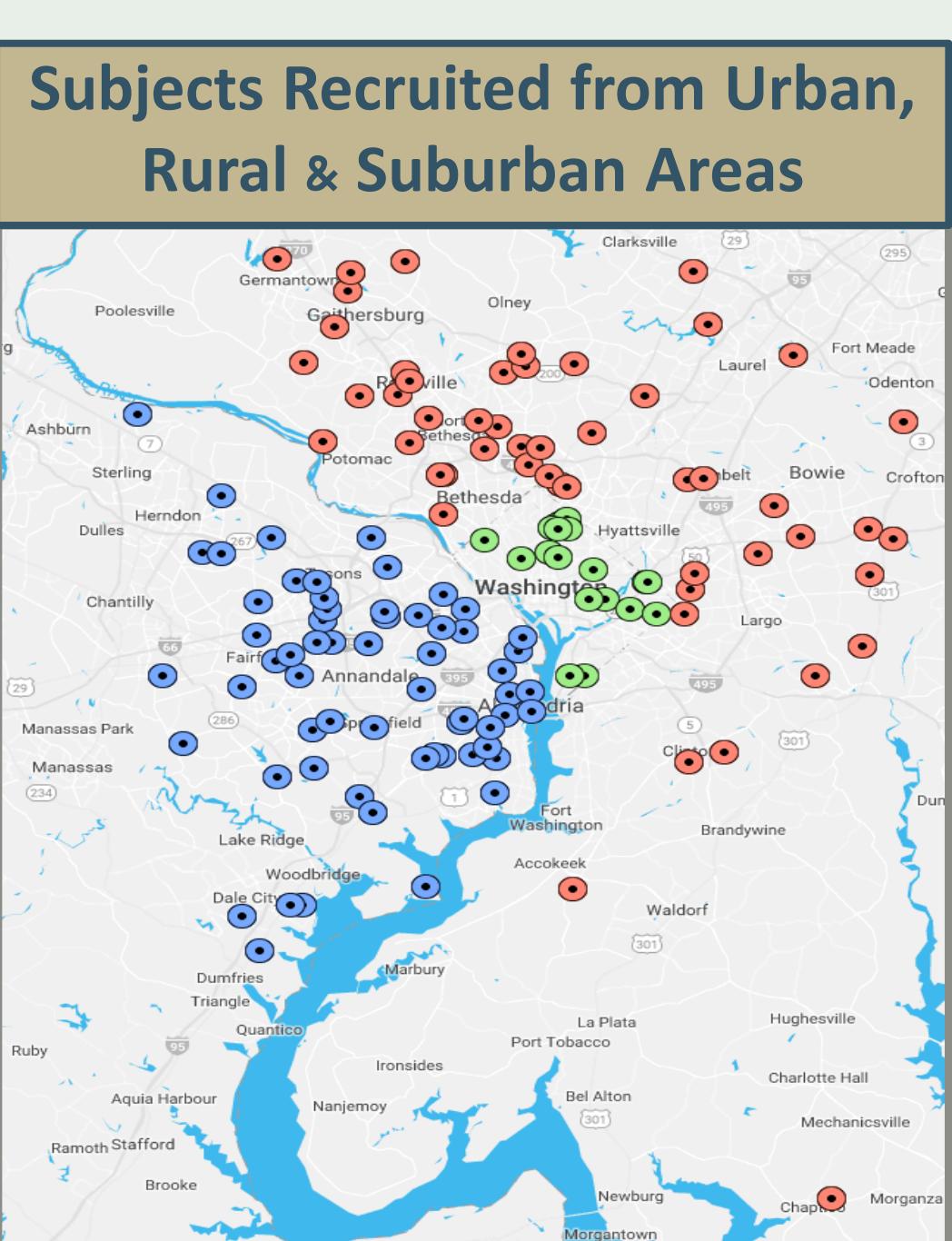


Striatal-Cortical network pruning occurs from ages 8–17 as suggested by a decrease in radial diffusivity (Asato et al. 2010) and in/out degree of correlated prefrontal-striatal BOLD time courses (Stevens et al. 2009).



## The Adolescent Development Study (ADS)

ADS is a prospective neurobehavioral longitudinal development study. All subjects were between ages 11–13 and reported drug naïvety at baseline. Subjects come in for three waves of data collection separated by ~18 months each.



### Demographics of Participant Cohort

	Total Cohort	Females	Males
N	135	73	62
Age at Baseline	12.7 (0.8)	12.6 (0.8)	12.7 (0.7)
Pubertal Status	2.2 (0.7)	2.4 (0.8)	2.0 (0.5)
Race and Ethnicity			
African American	45 (33.9%)	24 (32.9%)	21 (33.9%)
Caucasian	70 (51.9%)	35 (47.9%)	35 (56.5%)
Hispanic/Latino	9 (6.7%)	7 (9.6%)	2 (3.2%)
Other	11 (8.1%)	7 (9.6%)	4 (6.5%)
Socioeconomic Status			
Parental cumulative years education	16.2 (2.9)	15.9 (2.8)	16.6 (2.9)
Household income (n=107*)	\$50,000-\$74,999	\$50,000-\$74,999	\$50,000-\$74,999
Mean	\$100,000-\$149,000	\$75,000-\$99,999	\$100,000-\$149,999
Median	108.8 (15.3)	107.8 (13.4)	109.9 (17.3)
IQ (KBIT)			

### Pubertal Development Scale (PDS)

### Drug Use Survey Inventory - Revised

### Structural MRI Acquisition

Self-Reported Physical Changes In:

- 1. Body Hair Growth
- 2. Height Growth
- 3. Skin Changes
- 4. Facial Hair Growth
- 5. Sexual Organ Maturation

4 point scale

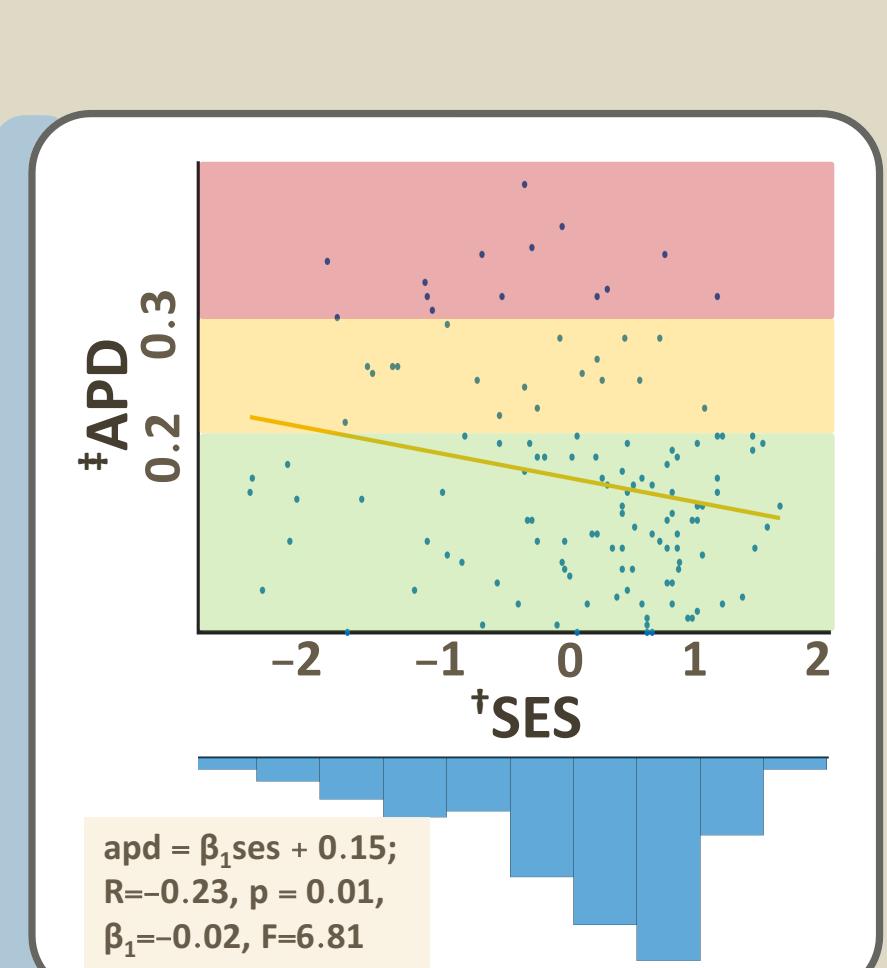
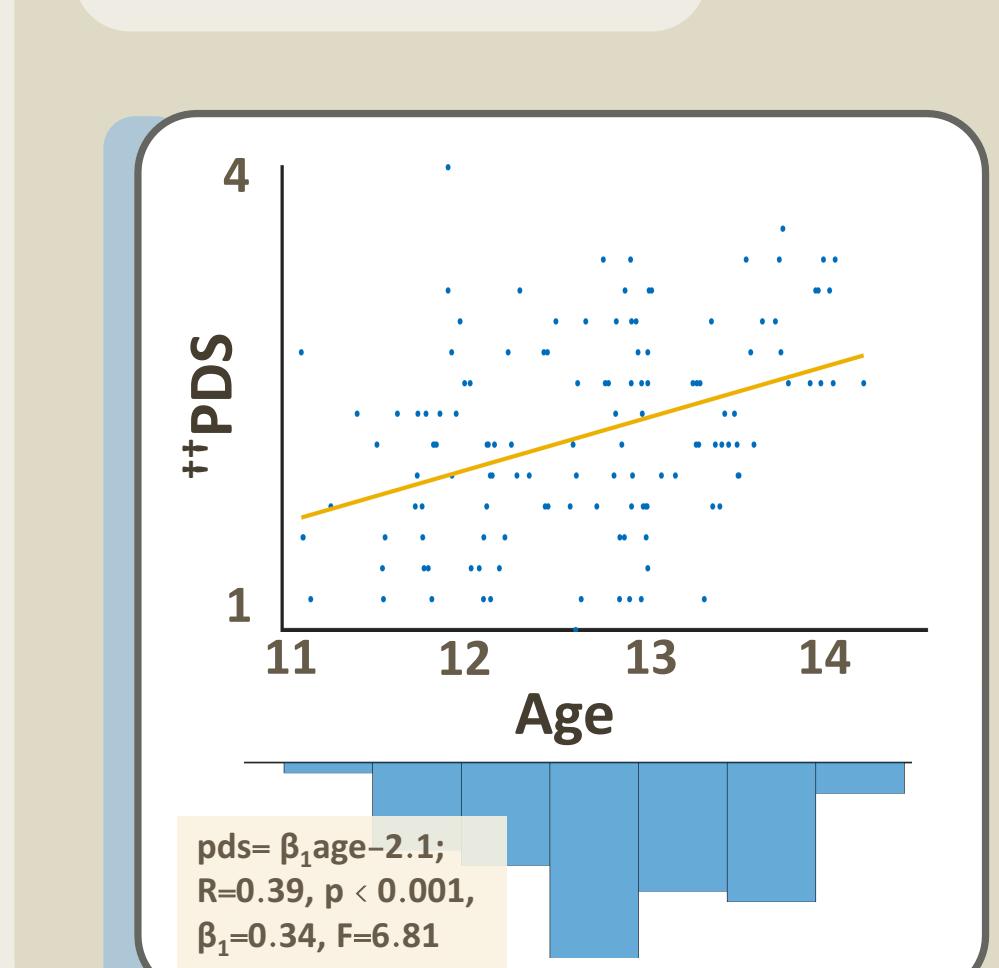
- 0 – Pre-Pubertal
- 1 – Early Pubertal
- 2 – Mid Pubertal
- 3 – Late Pubertal
- 4 – Post-Pubertal

Absolute Problem Density (APD): Probability of Developing the following at age 18:

- Behavior Problem
- Adverse Peer Relations
- Substance Use Problem
- Emotional Disorder
- Family Conflict
- Health Problem
- Work Problem
- Leisure Risk

3 T Siemens Tim Trio

- Duration: 4-18 min
- TR: 1900 ms
- TE: 2.52 ms
- Voxel size: 1 mm<sup>3</sup>



\*PDS does not covary with age or PDS ( $R=0$ ,  $p = 0.40$ ). \*SES does not covary with age ( $R=0$ ,  $p = 0.40$ ). \*\*PDS weakly related to SES,  $(R(pds,ses)) = -0.14$ ,  $p = 0.11$ .

## Analysis Pipeline SPM12 + FSL + CONN

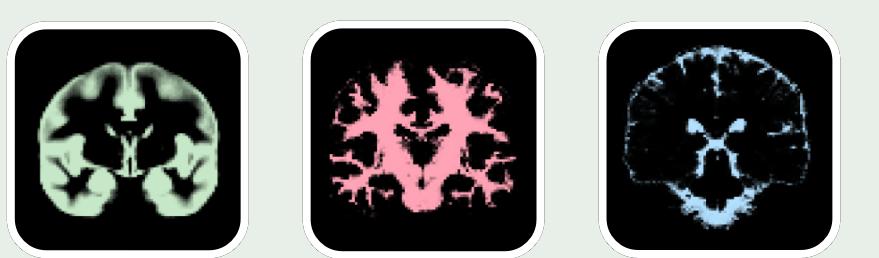
### Pre-Processing

#### Spatial Transformations of Functional & Structural Images

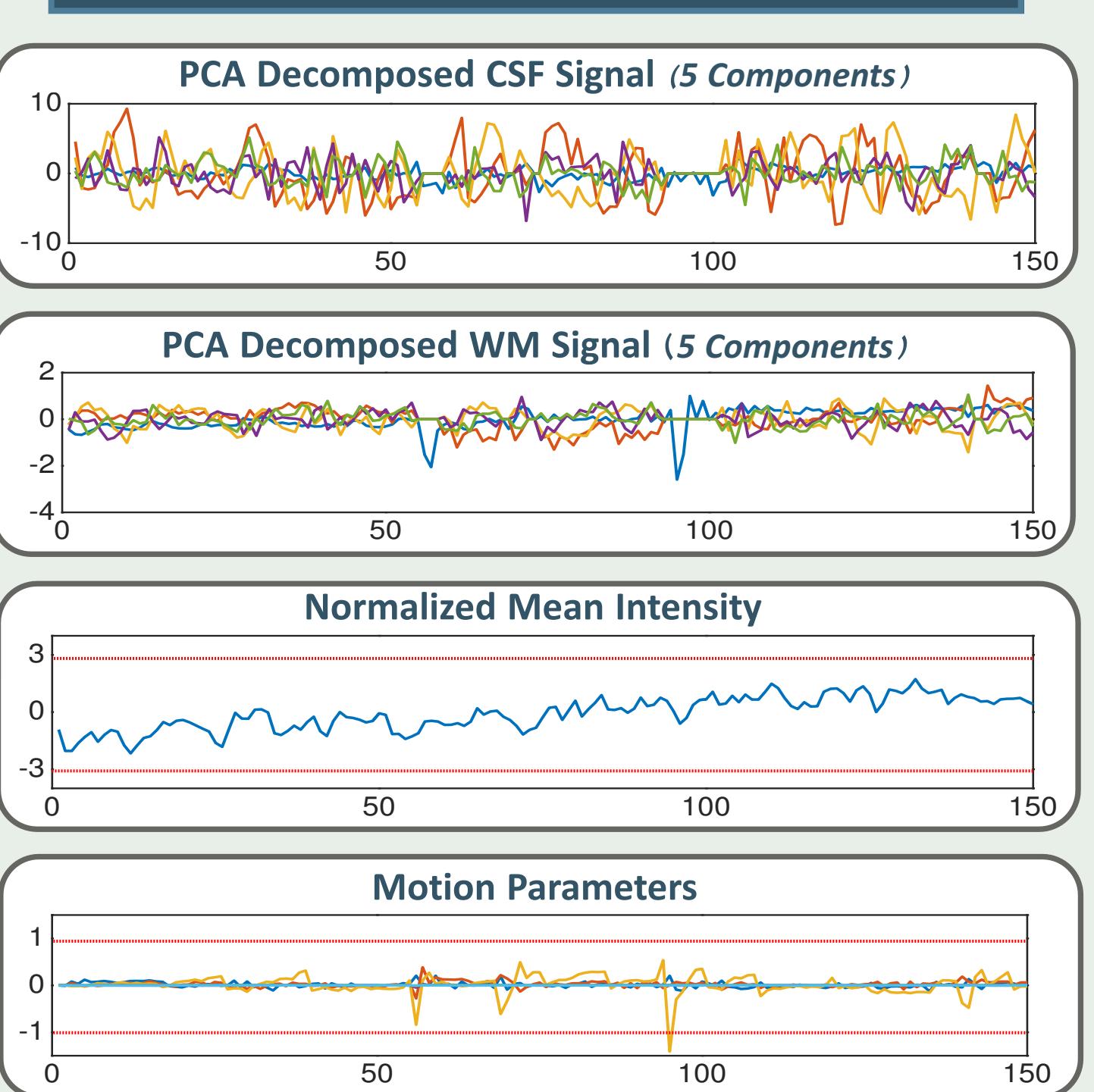
#### Slice Timing Correction

#### Normalization to MNI Space

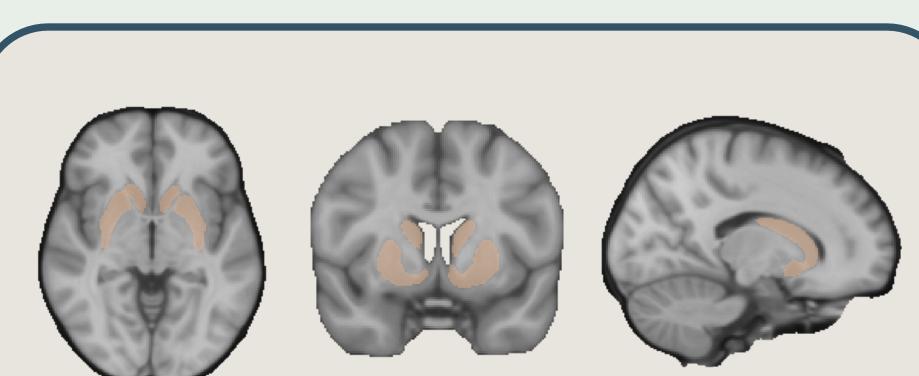
#### Gray, White & CSF Tissue Segmentation



### Filter Confound Signals



#### Striatum Masked with 7T Probabilistic Atlas, $p > 0.4$



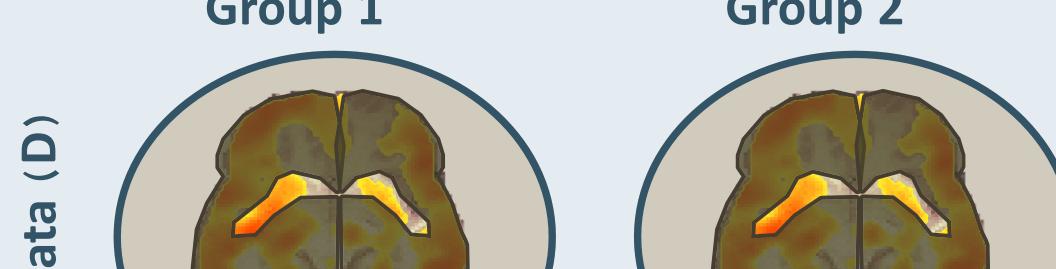
### Validation of Group ICA Model Order with Split-Half Sampling

#### Smooth with 4mm Kernel

#### Shuffle Subjects Into 2 Groups

#### Concatenate Data (D) & Estimate Group ICs for Order N=2

$$D = M^{-1} \times C$$



Estimate N Sources (C) with De-Mixing Matrix Transformation (M)



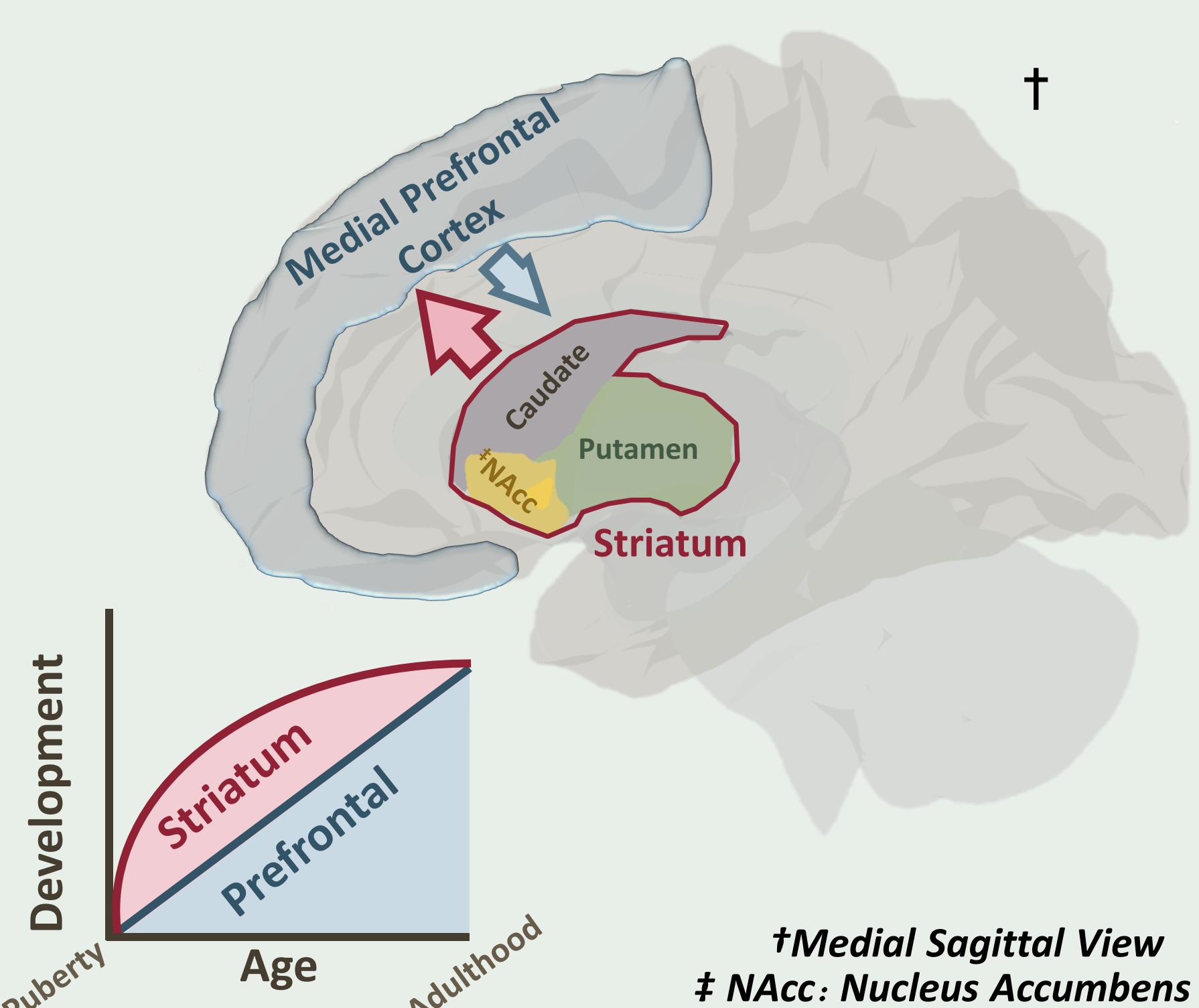
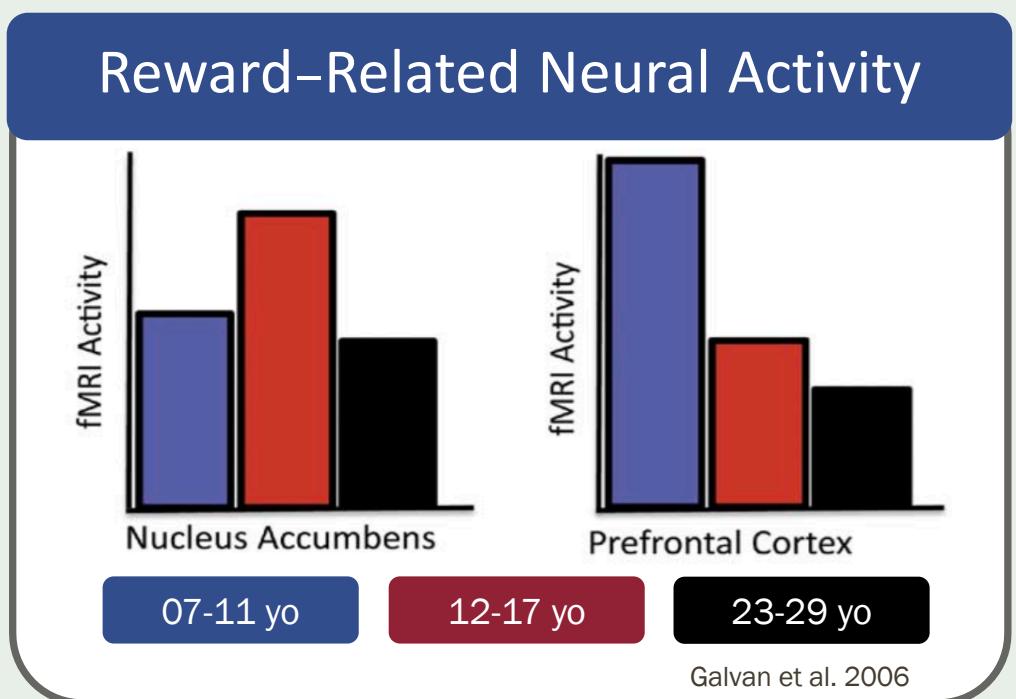
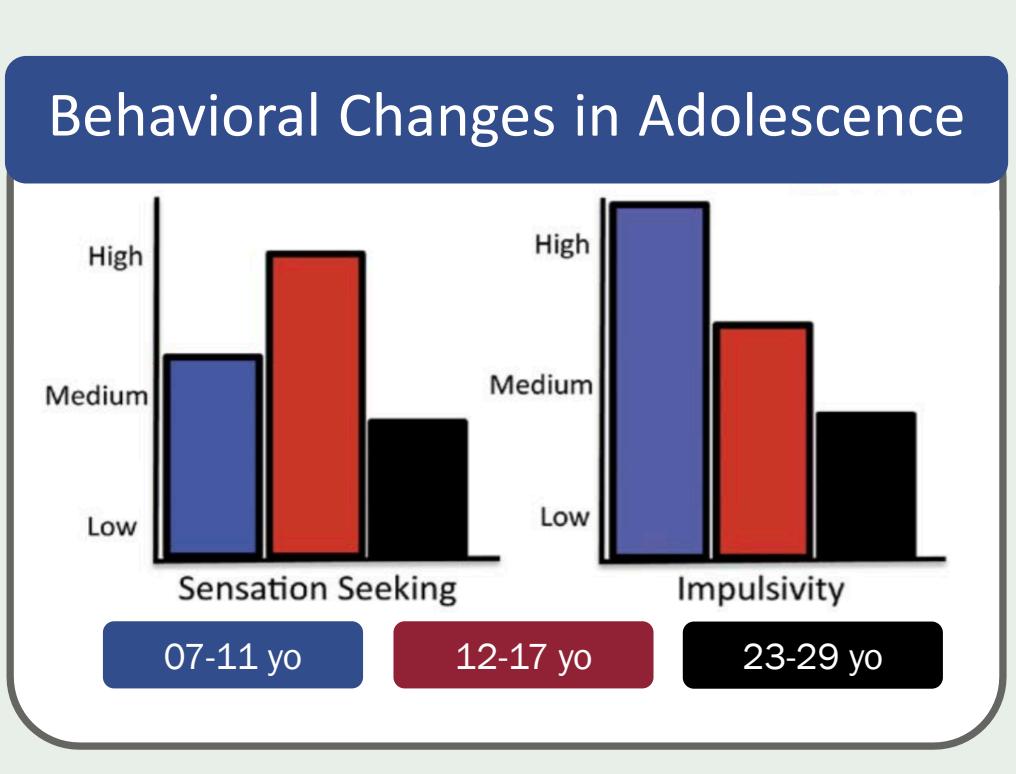
$$\text{Fidelity}_{IC\ N} = \text{Corr}(IC_N\ \text{Group 1}, IC_N\ \text{Group 2})$$

Spatial Distribution of Component Time Courses Sorted with Munkres Algorithm

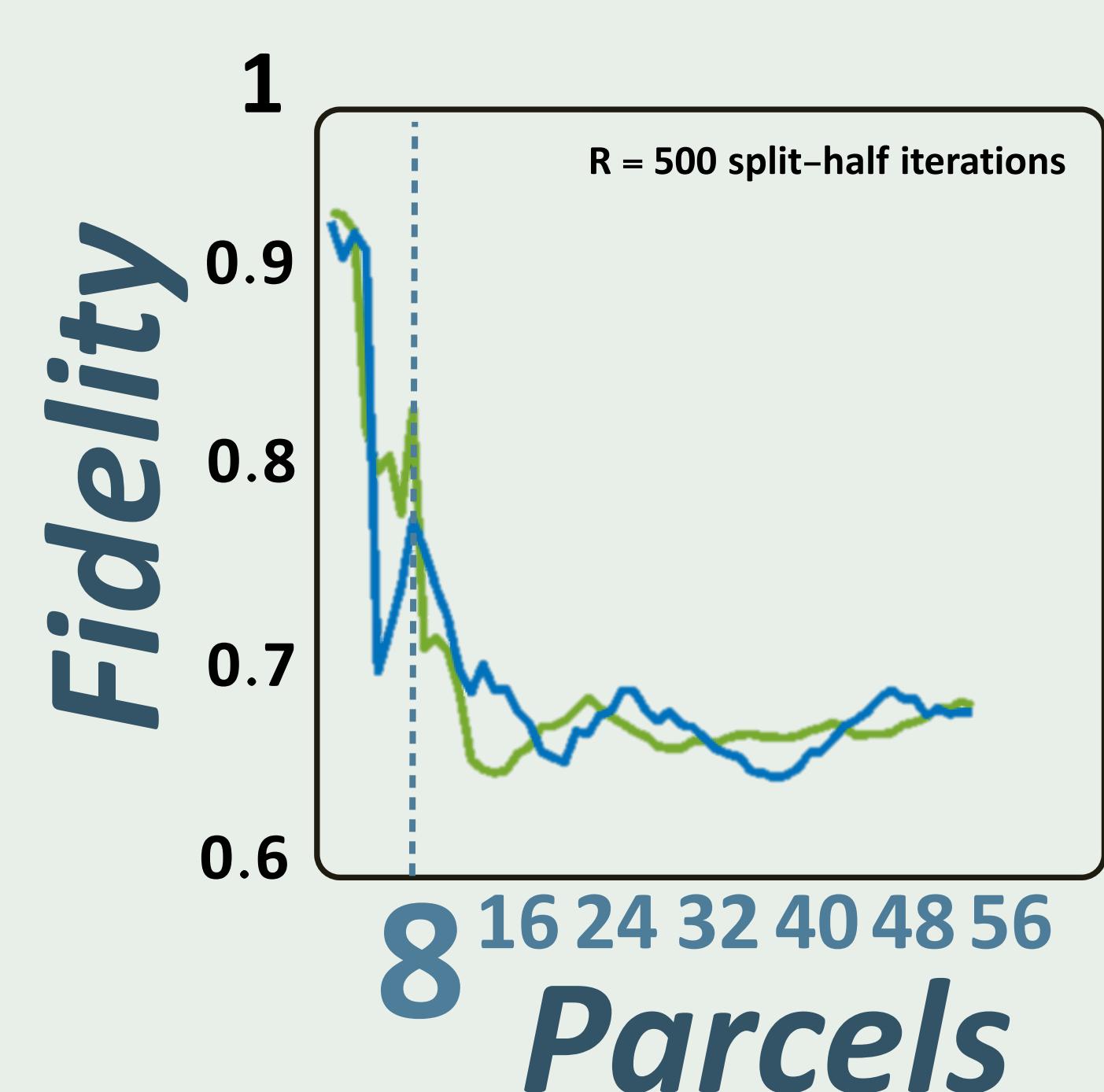
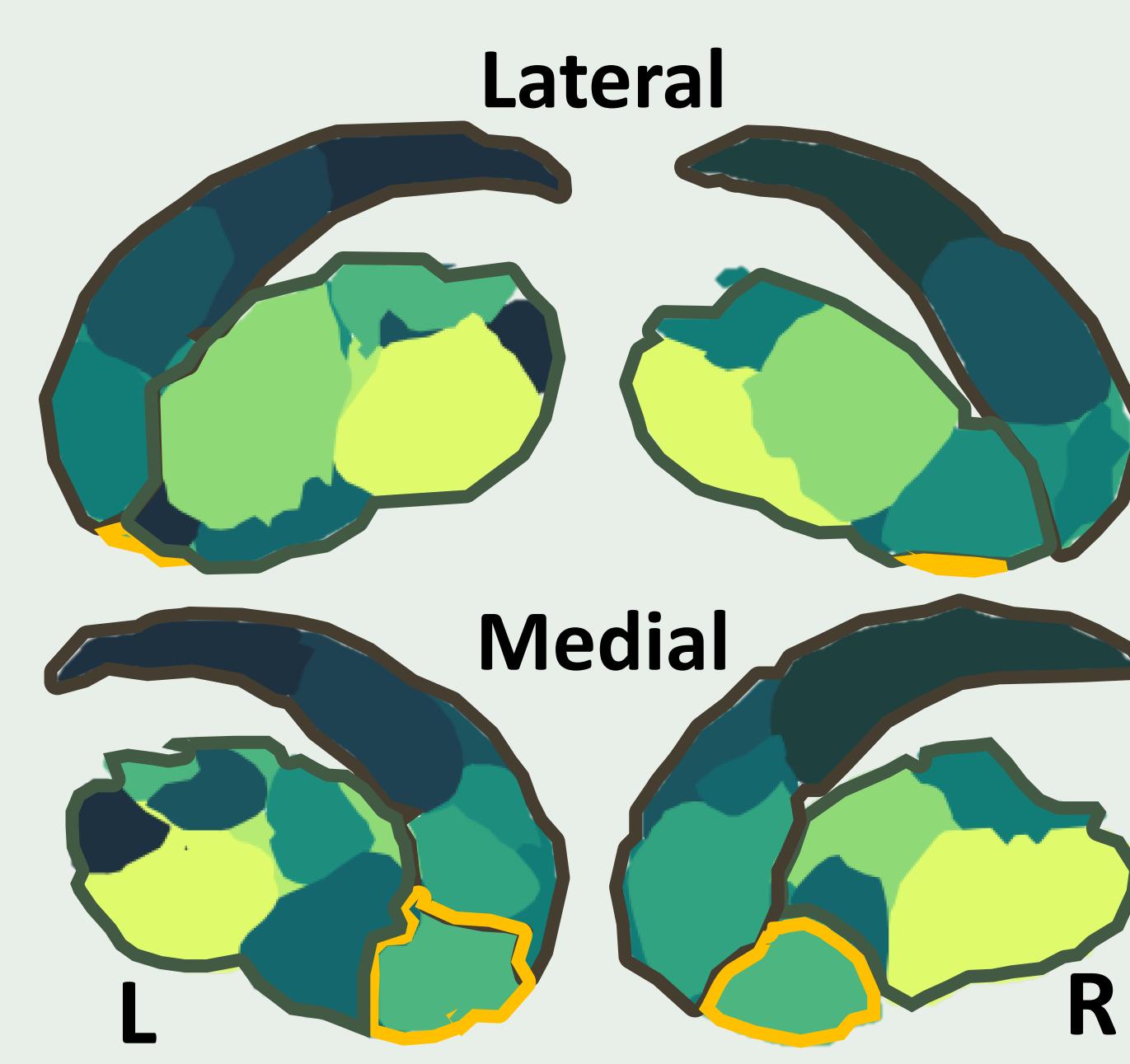
N+1:K And Repeat Subject Shuffle R Times Until Fidelity Converges

Select Ns with Highest Fidelity

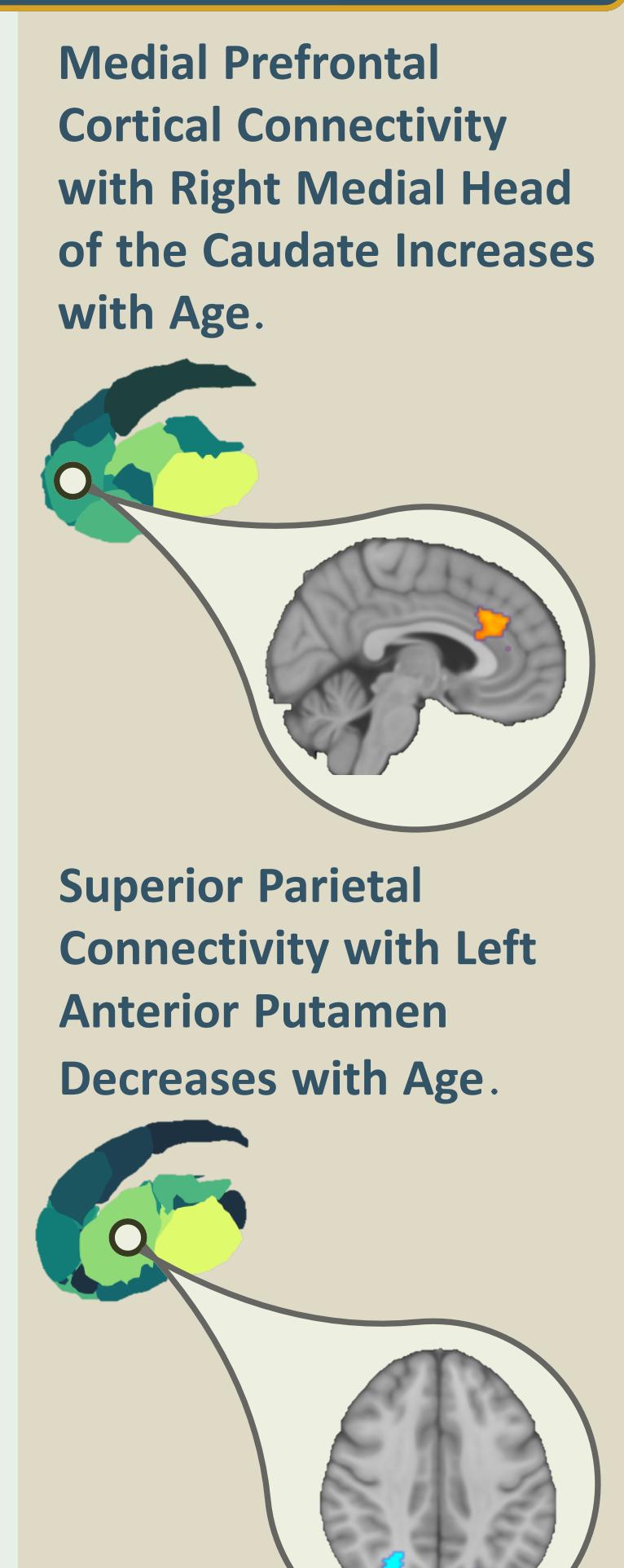
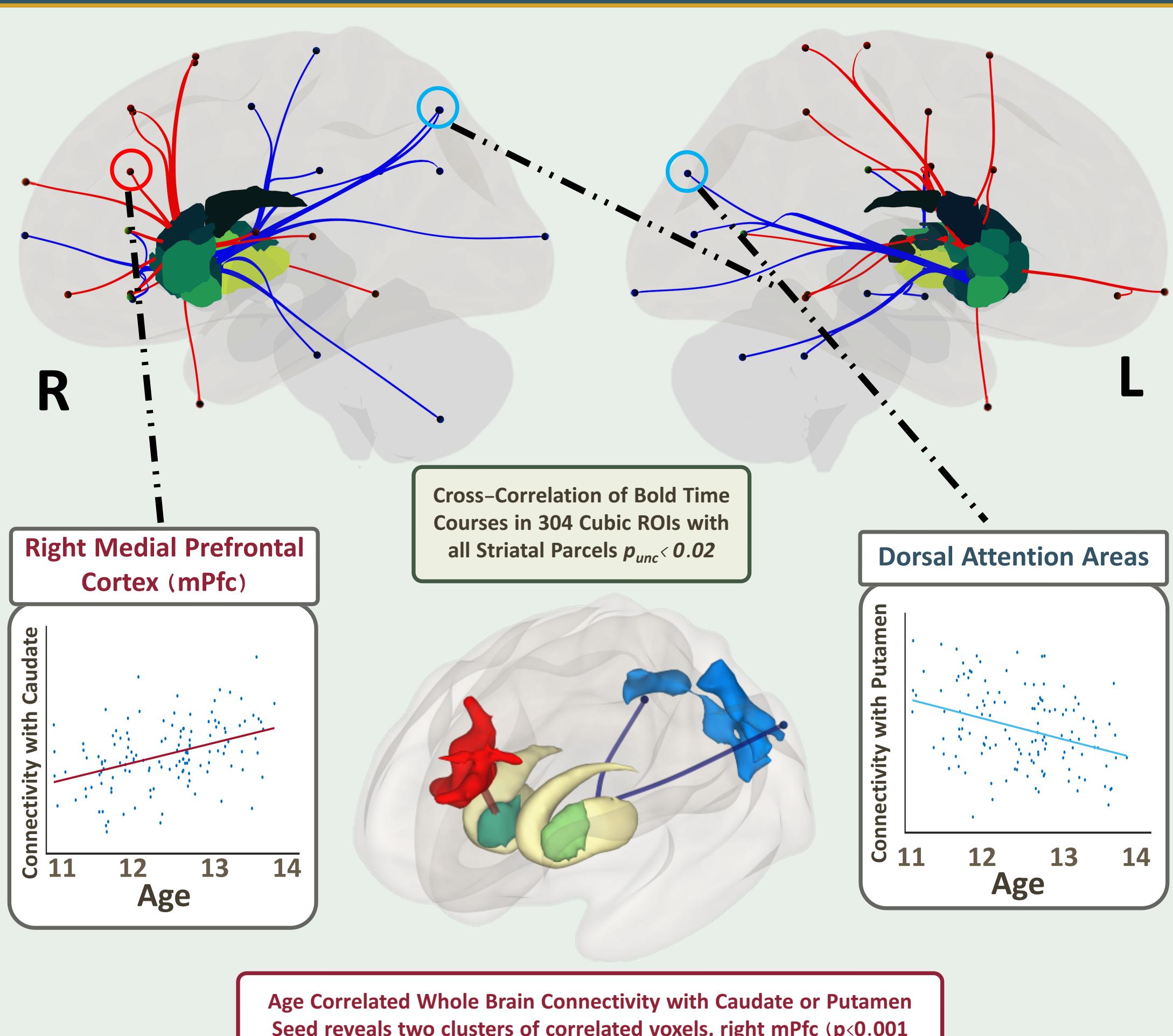
## Cognitive Maturity is Covariant with Striatal-Cortical Network Development



## ICA Functional Parcellation of Striatum & Cross-Subject Validation with Split-Half Sampling



## Cortical–Striatum Connectivity Increases Posterior-to-Anterior from Ages 11–14



## mPfc $\leftrightarrow$ medial Caudate Connectivity Correlates with Risk for Adverse Outcome at Age 18

