Puberty-Related Maturation of Adolescent Fronto-Striatal Resting-State Functional Connectivity is Implicated in the Development of Inhibitory Control

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Background & Motivation

Adolescent Biobehavioral Development

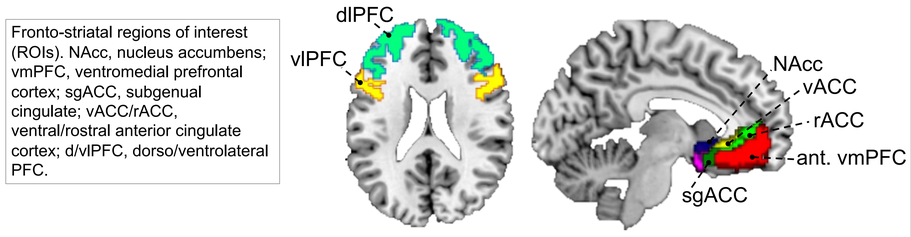
- Puberty defines adolescence, the transition to adulthood characterized by widespread biological, cognitive, and behavioral maturation.
- By the end of adolescence, individuals are better able to reliably engage brain circuitry supporting goal-directed cognitive processes[1].
- Central to these cognitive processes is specialization of fronto-striatal systems[2].
- However, the extent to which puberty contributes to maturation of this circuitry beyond age-related effects is unclear[3-6].

Hypothesis

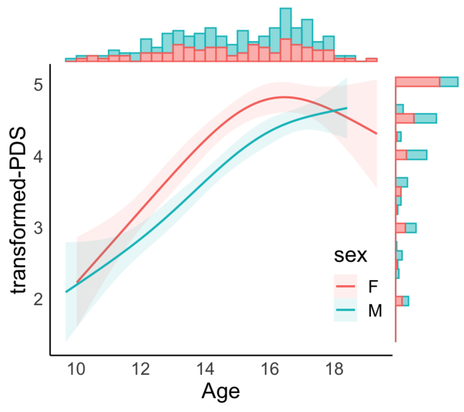
Based on the literature, we expect that puberty will be associated with NAcc medial prefrontal cortex (PFC) resting-state functional connectivity (rsFC). It is unclear how puberty will be associated with lateral PFC.

Study Design & Analyses

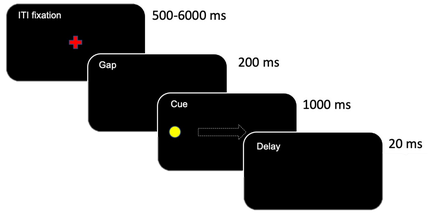
- We harmonized two datasets of 110 adolescents (52 females, 266 total scans, ages 10-18, 1-3 visits) imaged on 3T MRI scanners who had started puberty.
- Puberty was assessed using the Petersen Puberty Development Scale (PDS)[7], a self-report puberty measure; PDS scores were transformed to a 5-point Tanner scale and participants were only included in analyses if scores were ≥ 2.
- Response inhibition was assessed using mean latencies and accuracy rates from correct antisaccade task trials.
- AIC values were used to determine the best functional form of puberty (along with linear, inverse, and quadratic models) to test fronto-striatal rsFCs associated with puberty beyond age effects separately in males and females.
- We applied Bonferroni corrections (p<.0083) and covaried for age across models.



Fronto-striatal regions of interest (ROIs). NAcc, nucleus accumbens; vmPFC, ventromedial prefrontal cortex; sgACC, subgenual cingulate; vACC/rACC, ventral/rostral anterior cingulate cortex; d/vlPFC, dorso/ventrolateral PFC.



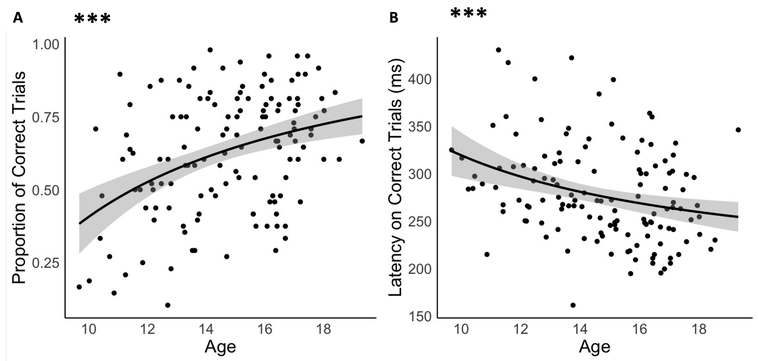
Participant age and puberty distribution by sex.



Antisaccade task. Participants are instructed to suppress looking at the yellow cue and instead look to the mirror location.

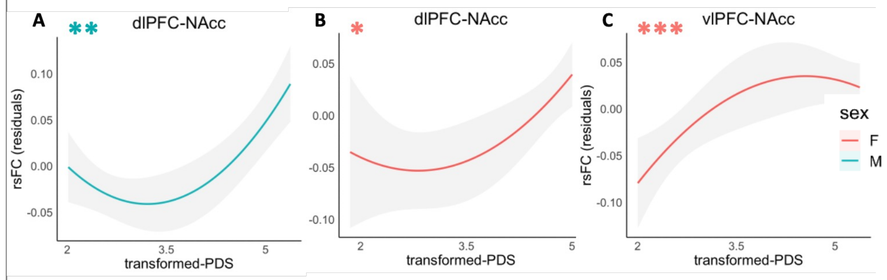
Results

Puberty and Inhibitory Control



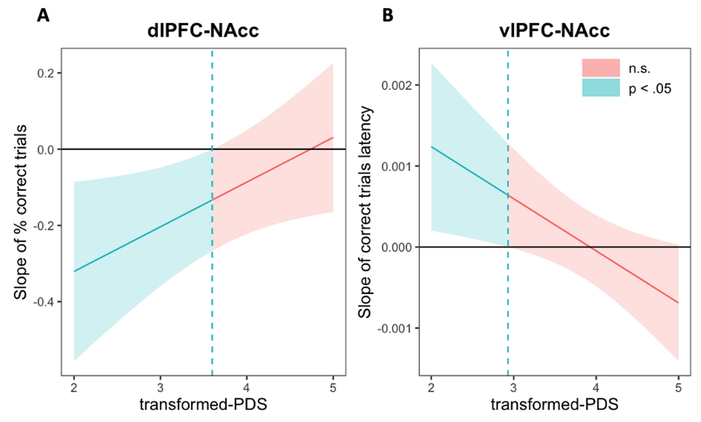
- Inhibitory responses improved with age (accuracy: β=.43, t=5.20, p<.001; latency: β=-.38, t=-4.12, p<.001) but not with puberty when controlling for age (p>.05).

Puberty and PFC-NAcc rsFC



- Puberty was associated with greater in dlPFC-NAcc rsFC in males (β=.18, t=3.46, p_{Bonf}=.007) and females (β=1.55, t=3.26, p_{Bonf}=.015); in females, puberty was also associated with vlPFC-NAcc rsFC (β=.30, t=4.99, p_{Bonf}<.001).

Puberty and PFC-NAcc rsFC and Inhibitory Control



- Puberty and antisaccade accuracy interacted to predict dlPFC-NAcc rsFC (β=.10, t=2.04, p=.041), such that stronger rsFC was associated with *worse* performance before mid-puberty.
- Puberty and correct AS trial latency interacted to predict vlPFC-NAcc rsFC (β=-.14, t=-2.51, p=.012), such that in early puberty, greater connectivity was associated with longer/slower latency.

Discussion

- Puberty was uniquely associated with increases in dlPFC-NAcc rsFC but not with medial PFC subregions.
- Females showed an additional association between puberty and vlPFC-NAcc rsFC, which may reflect their earlier pubertal maturation or changes in unique sex hormones.
- Maturation of these two fronto-striatal connections were related to antisaccade accuracy and correct trial latency, respectively.
- Taken together, these results show that beyond chronological age, pubertal maturation may play a significant role in strengthening critical fronto-striatal connectivity shown to support the maturation of cognitive control through adolescence and into adulthood.

Future Directions

- Analyzing hormonal assays can test possible mechanisms underlying the puberty-related neurobiological changes in functional development of fronto-striatal systems.
- Including younger ages (in females) and older ages (in males) will help to better characterize the effects of pubertal maturation on neurocognitive development.
- Assessing pubertal *tempo*—one's pubertal maturation relative to same-age, same-sex peers—alongside pubertal timing may yield additional important inter-individual differences in relative rates of development.
- Characterizing the effects of puberty on additional mesocorticolimbic ROIs (e.g., amygdala nuclei) supporting goal-directed (motivated) behaviors can inform neurobiological markers associated with risk of adolescent psychopathologies[8-11].

References

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