Associations of IQ Discrepancies with Brain Activation During Conflict Resolution

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OBJECTIVE

To examine whether the functioning of frontostriatal brain circuits that support self-regulatory control and conflict resolution varies with the magnitude of the Verbal IQ-Performance IQ (VIQ-PIQ) discrepancy in healthy individuals.

BACKGROUND

- Verbal IQ-Performance IQ (VIQ-PIQ) discrepancies are common across childhood developmental disorders.
- PIQ is typically greater than VIQ (PIQ>VIQ) in Autism[1,2], Dyslexia[3], and Language Disorder[4].
- VIQ is typically greater than PIQ (VIQ>PIQ) in children with Non-Verbal Learning Disability[5].
- In healthy individuals, this discrepancy is associated with significant cortical thinning (VIQ>PIQ) or thickening (PIQ>VIQ) in frontal portions of frontostriatal circuits (inferior frontal gyrus and anterior cingulate cortex)[6].
- Herein, we assessed whether functional abnormalities in these circuits may also be associated with VIQ-PIQ discrepancies.

METHODS

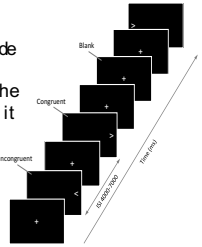
Participants

FMRI scans were acquired from 55 healthy individuals ranging in age from 7 to 22 years (Table 1).

	All (n = 55)	Female (n = 43)	Male (n = 12)
Age (years)	16.1 (3.8)	16.2 (3.6)	15.8 (4.7)
WASI FSIQ	111.7 (18.2)	111.8 (18.5)	111.3 (17.6)
WASI VIQ	113.5 (18.0)	114.4 (18.1)	110.3 (18.1)
WASI PIQ	107.3 (16.6)	106.4 (17.0)	110.3 (15.4)

Simon Task

Participants pressed a button corresponding to the side of the screen on which an arrow appeared. The task required ignoring a task-irrelevant stimulus feature (the side of the screen on which an arrow appears) when it conflicts with a more task-relevant one (the direction arrow points). Participants completed 3 runs of 55 stimuli with equal numbers of congruent/incongruent stimuli.



VIQ-PIQ Discrepancy Scores

The VIQ-PIQ discrepancy score was calculated based on each participant's VIQ and PIQ score obtained from the WASI. To create the VIQ-regressed-on-PIQ score, we regressed VIQ onto PIQ with an intercept of zero and saved the residual. These scores were normally distributed.

fMRI Image Processing

General linear models (GLM) over fMRI activations were used to extract signal differences across congruent and incongruent conditions in the Simon task. We tested whether activation of FSC circuits during correct responses on incongruent trials compared with correct responses on congruent trials varied with the size of the VIQ-PIQ discrepancy.

Statistical Analyses

A GLM was used to assess the effects of VIQ-PIQ discrepancies on frontostriatal activations during correct responses to conflict stimuli.

RESULTS

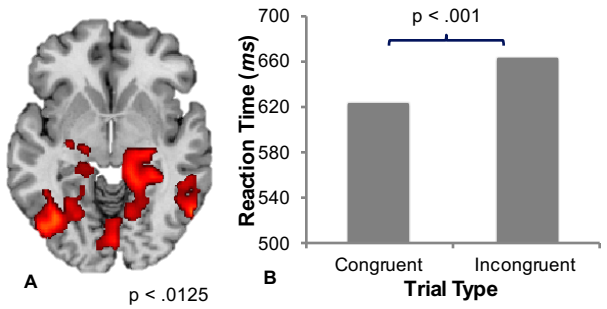


Figure 1. Mean Activation and Response Times. A. Group average brain activations in parietal regions during the engagement of cognitive control (incongruent versus congruent trials contrast) while controlling for age and sex. **B.** Reaction times plotted as a function of trial type. All participants demonstrated a conflict effect such that reaction times during congruent trials were significantly faster than reaction times during incongruent trials (p<.001).

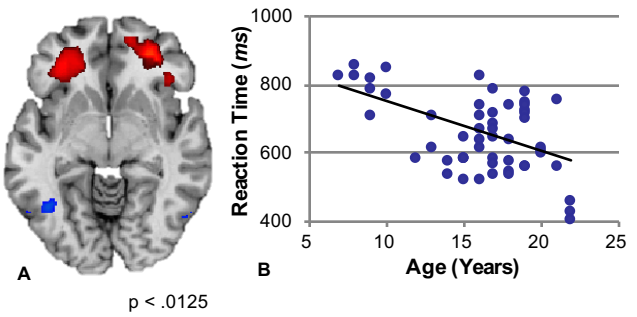


Figure 2. Age effects on performance. A. Activation of frontal regions during the engagement of cognitive control was associated with increasing age. **B.** Age was associated with improved performance on the Simon task, such that older children responded faster on incongruent trials than did younger children (p < .001).

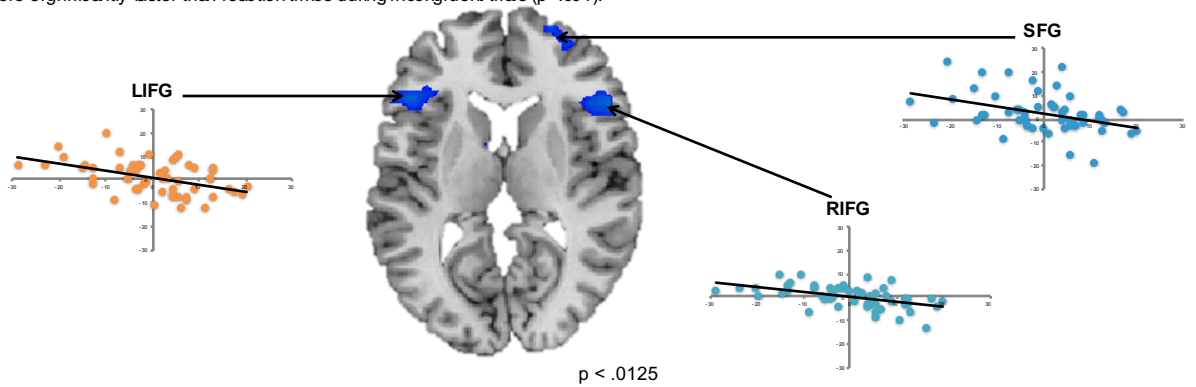


Figure 3. Association with VIQ_PIQ Discrepancy. Activation during conflict trials was inversely associated with the magnitude of the VIQ-PIQ discrepancy in frontal regions, while controlling for age and sex. Scatterplots of mean centered beta estimates from the superior frontal gyrus (SFG), left inferior frontal gyrus (LIFG), and right inferior frontal gyrus (RIFG) clusters plotted against VIQ-PIQ discrepancy.

CONCLUSIONS

- Greater conflict-related frontal activation with advancing age reflects the typical functional development of these cortices.
- Decreased activation with greater IQ discrepancies suggests that functional abnormalities in frontal cortices may contribute to discrepancies between (or deficits in) specific cognitive abilities in healthy individuals.
- We now plan to use these methods to assess associations of these discrepancies with fronto-striatal and parietal structure and function across various psychiatric disorders in which specific cognitive abilities are impaired.

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