

## Gender differences in correlations of regional white matter integrity with intelligence factor scores

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### Abstract

Studies have shown a correlation between white matter and intelligence. Previous work has shown a gender effect on these correlations. In this study we looked at correlations between regional white matter integrity as measured using MR Diffusion Tensor Imaging and intelligence factor scores in 40 normal control subjects.

### Method

#### Subjects:

The subjects were screened for medical and psychiatric illnesses including a history of head injury and substance abuse. Included were 21 males and 19 females, aged 18-35 years (mean age = 26.6, SD = 4.9; mean age for male is 26 and for female is 27). The subjects completed eight tests of the Johnson O'Connor Research Foundation: Inductive Speed (IS), Analytical Reasoning (AR), Number Series (NS), Number Facility (NF), Wiggly Block (WB), Paper Folding (PF), Verbal-Associative Memory (VAM), and Number Memory (NM). Previous research<sup>(1)</sup> showed that these tests load on four factors – Speed of Reasoning (IS and AR), Numerical (NS and NF), Spatial (WB and PF), and Memory (VAM and NM) in addition to a *g-factor*. These tests have been used in research on various aspects of cognition and intelligence<sup>(2)</sup>. For the present study, test scores were separated for sex and age in order to eliminate nuisance variance.

#### Imaging:

Imaging was performed using a Siemens 3T Allegra MRI. DTI data were acquired using a pulsed-gradient spin-echo sequence with EPI-acquisition (TR=4100ms, TE=80ms, FOV=21cm, matrix =128x128, 28 slices, thickness=3mm skip 1mm, b-factor=1250 s/mm<sup>2</sup>, 12 gradient directions, 5 averages). Fractional anisotropy (FA) and directional color maps were computed using in-house software written in *Matlab* v7. Region of Interests (ROIs) were defined on color-coded tract directional maps by two independent raters and then averaged. Portions of the following white matter tracts were surveyed using ROIs: Cingulum Bundle, Internal Capsule, Corpus Callosum, Forceps Minor, Forceps Major, Inferior- and Superior Longitudinal Fasciculus and cortical spinal tract (Fig 1). The ROI voxel locations were used to extract the FA values, then transferred to *Statistica* V7.1 and merged with intelligence factor scores for correlation analysis.

### Results

Significant correlations were found between several of the white matter tracts with the cognitive performance scores.

#### Males:

Cingulum bundle showed significant positive correlations with Reasoning-factor scores: Anterior Cingulum bundle (left:  $r=0.465$ ,  $p<0.034$ ), (right:  $r=0.496$ ,  $p<0.022$ ). Dorsal cingulum bundle (left:  $r=0.706$ ,  $p<0.000$ ), (right:  $r=0.510$ ,  $p<0.018$ ).

Corpus Callosum showed significant negative correlations with different factor scores:

Genu: negative correlations with Spatial factor scores ( $r=-0.507$ ,  $p<0.019$ )

Splenium: negative correlations with Numerical factors scores ( $r=-0.457$ ,  $p<0.037$ )

Forceps Major: negative correlations with *g-Factor*: (left:  $r=-0.533$ ,  $p<0.013$ ), (right:  $r=-0.4483$ ,  $p<0.042$ ).

#### Females:

Genu of corpus callosum was positively correlated with Memory factor scores ( $r=0.561$ ,  $p<0.012$ ). Left Forceps Major was positively correlated with *g-Factor*.

### Conclusions

Several significant positive as well as negative correlations were detected. The locations of these correlations were also consistent with the functional architecture and the factor scores with which they were correlated. The cingulum bundle, a white matter tract inside the cingulate gyrus was positively correlated with the reasoning factor scores. The cingulate gyrus is an area in the brain that is involved with early learning and problem solving, anticipation of tasks, motivation, and modulation of emotional responses<sup>(3)</sup>. The general notion of lateralization of certain functions, such as visual-spatial ability is predominantly a right brain function whereas analytical skills reside mostly in the left brain, can also be explained by the correlations in the interhemispheric connections. Significant negative correlations with spatial and numerical factor scores were found in various areas of the corpus callosum. This supports the efficiency model<sup>(4)</sup>: pruning of inefficient connections is essential to brain development. One interpretation of these negative correlations is that they represent interference from the contralateral side of the brain.

The only significant correlation detected in females were in the corpus callosum area. These correlations were positive.

These findings are also consistent with a recent report on DTI/IQ correlations on a cohort of subjects aged 5-18 where correlations were mainly negative in males and positive in females as they got older<sup>(5)</sup>. Our results confirm these findings into adulthood.

### Reference

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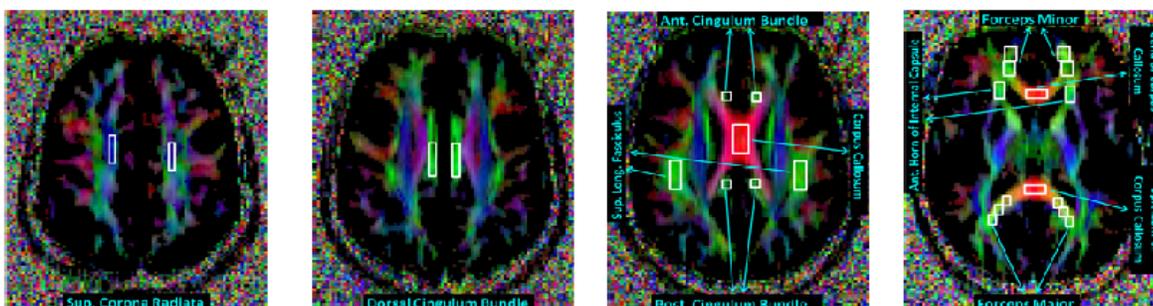


Figure 1: ROI positions superimposed on directional color-coded anisotropy maps.