Gray and White matter differences in young adults with ADHD

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Introduction.
Numerous neuroimaging studies suggest anatomical differences between children and adolescents diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and controls (see Bush et al., 2005 for review). These differences have been noted in a variety of regions including prefrontal, parietal & temporal cortex, as well as the basal ganglia (specifically the caudate) and the cerebellum. Although there is agreement of reduced grey matter in prefrontal regions, the basal ganglia and the cerebellum, there is much less agreement for other regions.

To our knowledge, only one study has examined brain morphology in adults with ADHD, and focused strictly on orbitofrontal cortex (Hasslinger et al., 2002). Given that changes in gray and white matter density continue into adulthood (Snow et al., 2000), we utilized optimized voxel-based morphometry (VBM) to examine anatomical differences between young adults with and without ADHD.

Hypothesis.
Based on our functional imaging studies (see posters 122 & 622), we hypothesized that adults with ADHD would show reductions in grey matter volume in prefrontal and parietal regions compared to controls.

Methods
Participants.
18 college-aged adults meeting DSM-IV criteria for ADHD (combined sub-type) as diagnosed via a structured interview assessing current and childhood symptoms as well as parent report. 18 control adults were of similar age and screened to not exhibit ADHD symptoms.

Table 1: Study Participants

<table>
<thead>
<tr>
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<th>Patients (7 females)</th>
<th>Controls (11 females)</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.94 (1.66)</td>
<td>19.00 (.84)</td>
</tr>
<tr>
<td>Hyper.</td>
<td>6.11 (2.19)</td>
<td>17 (.38)</td>
</tr>
<tr>
<td>Inatt.</td>
<td>7 (1.84)</td>
<td>28 (.46)</td>
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Image Acquisition & Analysis

Acquisition: T-1 weighted anatomical images were acquired on a 3 Tesla General Electric Magnetic Resonance scanner.

Preprocessing: Using optimized VBM (Ashburner, 2000; Good et al., 2001), which is an unbiased whole brain voxel-wise analysis, we examined grey and white matter differences between individuals with ADHD and controls.

Image Acquisition & Analysis cont’d

Step 1: Spatial Normalization.

Anatomical images were spatially normalized using a 12 parameter affine transformation in SPM2 to a custom template created from the 36 participants.

Step 2: Segmentation.

Images were segmented into partial volume estimate (PVE) maps of gray/white matter and cerebrospinal fluid (CSF) using FMRIB’s Automated Segmentation Tool (FAST) and smoothed (FWHM=12 mm)

Step 3: Modulations

Data was modulated to correct for volume changes that may occur during spatial normalization.

Results

Anatomical Differences

Reduced grey matter in ADHD individuals may interfere with the creation of an attentional set for task relevant information - a function we have hypothesized for this posterior region of DLPFC (Milham et al., 2003).

Figure 3: ADHD > Controls: Grey Matter

Peak Difference: Postcentral Gyrus: x=-24, y=-38, z=74 (BA 7)

These findings suggest that more atypical morphology of the precuneus in individuals with ADHD is associated with greater hyperactivity. The reason for this association is unclear, but the precuneus has been implicated in a variety of memory and attentional functions (see Cavanna & Trimble (2006) for review).

Reduced volume in the cerebellum is consistent with prior research on children and adolescents with ADHD as well as the motor manifestation of ADHD symptoms that are reflected in hyperactivity.