SPATIAL WORKING MEMORY IN ATTENTION DEFICIT HYPERACTIVITY DISORDER

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Target audience: Researchers interested in working memory and attention deficit hyperactivity disorder.

Purpose: Attention deficit hyperactivity disorder (ADHD) is a developmental psychiatric disorder affecting approximately 5% of the population.[1] Although working memory (WM) deficits due to ADHD are particularly prominent in spatial WM tasks, previous imaging work has focused on verbal WM tasks. We therefore developed a spatial working memory task to examine differences in brain activity between adults and children with ADHD and controls.

Methods: We studied 19 children with ADHD (9 females, age 10.6 (SD = 1.1)), 19 control children (8 females, age 10.7 (SD = 1.7)), 21 adults with ADHD (13 females, age 37.6 (SD = 10.2)) and 21 control adults (12 females, age 33.5 (SD = 10)) using functional MRI (fMRI). The spatial working memory task consisted of eleven circles positioned on a circular grid. Positions of two (low load) or four (high load) filled circles had to be memorized. MRI data were acquired on a GE 3.0 T whole-body scanner. For fMRI, 35 axial slices covering the whole brain were acquired with a multi-slice echo planar imaging (EPI) sequence (TR = 1.925 s; voxel size = 3.75x3.75x3.3 mm^3). We used SPM 8 and standard preprocessing. The retention and the probe phase were modeled separately. Temporal, dispersion derivatives, and motion regressors were added to the model.

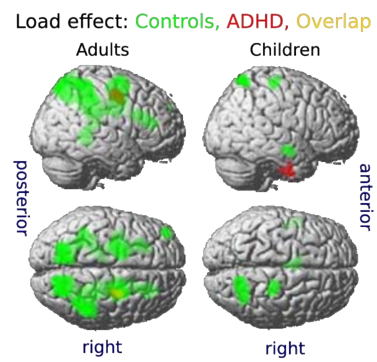

Figure 1: *Load effects in adults (left) and children (right). Controls are indicated in green, ADHD subjects in red, regions active in both groups yellow (p < 0.05, cluster extent corrected). There is no clear load effect in subjects with ADHD.*

Results: The healthy adult subjects performed with an accuracy of 94% (ADHD 95%) for the low load level (two circles) and 82% (ADHD 76%) for the high load level (four circles). The healthy children reached 85% (ADHD 82%) accuracy in the low load level and 66% (ADHD 64%) in the high load level. A repeated measures ANOVA with load low/high as within subject factor and ADHD/control and adults/children as between subject factors showed a significant difference in accuracy between the two load levels ($p < 0.001$), and a significant difference in accuracy between adults and children ($p < 0.001$). There were no significant differences in accuracy between ADHD and controls and no significant interactions (all $p > 0.1$). Typical working memory regions were activated both in controls and in subjects with ADHD. Contrasting the retention phase of the high load and the low load we found load effects in children and adult control subjects in the parietal frontal network ($p < 0.05$, cluster extent corrected), but no clear load effects in children and adult subjects with ADHD ($p < 0.05$, cluster extent corr.) (Figure 1). Contrasting the load effect during the retention phase between groups we found reduced parietal and anterior load effects in ADHD subjects ($p < 0.05$, cluster extent corr.) (Figure 2).

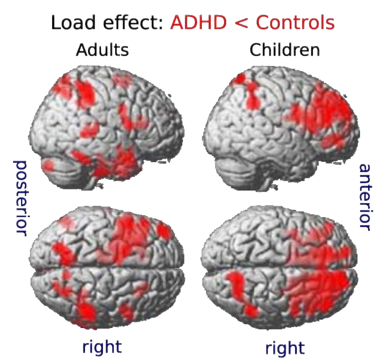

Figure 2: *Reduced load effects in adults (left) and children (right) with ADHD (p < 0.05, cluster extent corrected). ADHD subjects fail to recruit additional regions in fronto parietal regions with increasing task difficulty.*

Discussion: Although we did not find behavioral differences in task performance, our imaging results suggest that patients with ADHD do not show a significant load effect in parietal and frontal regions, resulting in a load-specific reduction compared to healthy controls. These results are in line with recent findings in the behavioral and imaging literature suggesting impaired spatial working memory in ADHD.[2,3] Children showed a smaller load effect compared to adults indicating a not yet fully developed spatial working memory network.

Conclusion: Our results suggest that ADHD subjects are not capable of recruiting a larger population of neurons to handle the increased load demand in the high load trials. This may be linked to altered spatial working memory processing in subjects with ADHD, which could either indicate impairment or higher efficiency of these regions due to compensational effects. As a next step we are planning to integrate baseline perfusion measurements and resting state fMRI analyses to clarify the interaction between task-based differences and baseline cerebral haemodynamics and connectivity in more detail.

References: [1]Polanczyk et al., Epidemiology of attention-deficit/hyperactivity disorder across the lifespan. Current Opinion in Psychiatry. 2007;20(4):386–392. [2]Bayerl et al. Disturbed brain activation during a working memory task in drug-naive adult patients with ADHD. NeuroReport. 2010;21(6):442–446. [3]Fassbender et al. Working Memory in Attention Deficit/Hyperactivity Disorder is Characterized by a Lack of Specialization of Brain Function. PLoS One. 2011;6(11).