

Wechsler Memory Scale Revised Edition: Neural Correlates of the Visual Paired Associates Subtest Adapted for fMRI

I. Neuner^{1,2}, T. Stoecker¹, T. Kellermann², F. Schneider², N. J. Shah¹

¹Institute of Medicine, Research Centre Juelich, Juelich, Germany, ²Department of Psychiatry and Psychotherapy, RWTH Aachen University, Aachen, Germany

Introduction: The Wechsler Memory Scale in the revised version [1] is a widespread tool for the clinical neuropsychological assessment of patients suffering from various neurological or psychiatric disorders. Different subtests assess verbal memory, visual memory, attention/working memory. Most subtests contain an immediate and a delayed component. We are interested in the neural correlates underlying the visual paired associates test.

Methods: Figures and colours of the original subtest were prepared for the fMRI experiment using the Presentation software package. The subjects viewed a boxed figure (100x100 pixels) to the left of a boxed colour (100x100 pixels) in the centre of a white background. Underneath, we presented a horizontal colour panel consisting of six boxes. The colours included pink (left margin), yellow, purple, green, red and blue (right margin). Moving a cursor by clicking a button with the right or left index finger the subjects were able to highlight a certain colour.

Using a block design we presented four runs, each consisting of 3 blocks. A block consisted of the four following conditions: Fixation, encoding the combination, retrieval by marking the corresponding colour on the panel, highlighting the shown colour on the panel. Each condition consisted of six pairs which were shown for 4 seconds in every condition. Prior to each condition the subjects were instructed by an intro which was shown for 2 seconds in black letters on a white background.

We scanned 12 right-handed, healthy male volunteers aged 25–47 years (mean age: 34.8 SD 4.0) with no history of neurological or psychiatric disorder. After an instruction from a laptop outside the scanner, subjects performed the memory task. After the scans the subjects performed 3 further subtests of the WMS outside the scanner and were then scanned a second time. The delayed recall of the visual paired associates consisted of 4 runs each consisting of 3 blocks. One block consisted of the retrieval mode of condition 3 and 4 as described above.

Imaging data were acquired using a 1.5 T MRI-Scanner (Sonata, Siemens Erlangen). After anatomical images of the brain were obtained using a 3D MP-RAGE sequence (rapid acquisition gradient echo), T2* weighted echo-planar images were acquired in each session (TE 60ms, TR 3000ms, FOV 200). 30 slices per image with a thickness of 4 mm were acquired. The first scanning session acquired 116 datasets in each run, the second only 60 datasets.

Results: The data were analyzed by Statistical Parametric Mapping (SPM2, The Wellcome Department of Cognitive Neurology, Institute of Neurology, University College of London, UK). The first four datasets were discarded to avoid T₁ saturation effects. After first level analyses, we calculated a non-parametric group statistic (SnPM2b) [2] at a FWE (family wise error) corrected level of p<0.05 (pseudo-t: variance smoothed with 10 mm FWHM isotropic Gaussian kernel) for the following contrasts: Encoding-fixation, immediate recall-motor, delayed recall-motor. In the contrast encoding-fixation significant activations were detected in the left superior parietal lobe, the right inferior and superior parietal lobe, the right frontal lobe as well as in the cerebellum. During immediate recall bilateral frontal activation was detected as well as activation in the anterior cingulate gyrus, both thalami, left precuneus, left middle occipital gyrus, cerebellum and in the brainstem. During delayed recall significant activation was detected in the frontal lobe pronounced on the right side, left superior parietal gyrus, the middle and inferior occipital gyrus right and left, the precuneus left and in the cerebellum.

The performance rate of all subjects in the scanner for immediate recall was 75.4% and for delayed recall was 77.4% (WMS reference value: recall immediate 77%, delayed recall 81%). Results for immediate recall are shown in Fig. 1 and for delayed recall in Fig. 2.

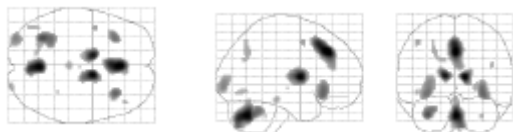


Figure 1: immediate recall

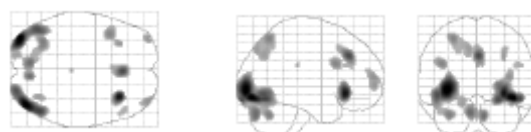


Figure 2: delayed recall

Conclusions: The adaptation of the Wechsler Memory Scale subtest for fMRI worked well in the healthy volunteers. Its application for patients needs to be proven. The underlying network of the visual paired associates test includes a frontoparietal network for encoding and a frontoparietooccipital network for recall. The cerebellum is also activated in both conditions emphasizing its role in higher cognitive functions. Noteworthy is the robust activation of both thalami during immediate recall in contrast to delayed recall. This might be in part due to the presentation of highly associative visual material which triggers "imaginal" memory [3] or it might be due to time-dependent interactions between frontal and parietal areas, the anterior cingulate gyrus and the thalami [4].

References:

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- [4] Goldman-Rakic PS et al. J Comp Neurol 1985: 242:535-560