Learning an Ordered Series: An fMRI Study

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Keywords: transitive inference, hippocampus, parietal cortex

Representation of ordered stimuli

Results from lesion studies in animal research and imaging studies in human research have shown the importance of hippocampus (HC) in the representation of ordered stimuli. More specifically, HC has been found to be involved in judgments about non-adjacent pairs (A-C; A-D; B-D;...) after being trained only on adjacent pairs (A-B; B-C; C-D; ...). fMRI studies in humans suggest that also intraparietal cortex is involved: Parietal cortex activation is observed during transitive inference tasks (e.g. Acuna et al., 2003; Marshuetz et al., 2000). However, parietal activation could be confounded with task difficulty.

The aim of this experiment is threefold. First, we want to integrate previous findings on hippocampus and parietal sulcus in one study. Second, we want to differentiate whether hippocampus is responsible for learning new associations or for transitive inference specifically. Third, we want to disentangle parietal activation from its possible confound with task difficulty.

Experiment

Procedure

Sixteen male, right-handed participants had to learn an ordered series of six arbitrary stimuli while being scanned. They were shown 24 blocks of triplets. Each triplet consisted of a learn, test, and control phase. In each phase two stimuli were shown simultaneously. During the learn and test phase participants were instructed to select the 'last' stimulus in the order. Only adjacent pairs where presented in the learn phase, whereas the test phase consisted only of non-adjacent pairs. Importantly, during the last four blocks, new figures were presented in the learn and test phase, meaning that the participants had to restart learning.

Scanning Parameters

Siemens 3T Trio, Echo-Planar Imaging Sequence, TR=2500ms, TE=33s, flip angle 90°, 40 axial slices with an in-plane resolution of 3x3 mm. Slice thickness=3mm.

Results

Behavioral data showed an increase in performance for the test phase until the new figures were presented. The performance in the control phase quickly reached ceiling level (Figure 1).

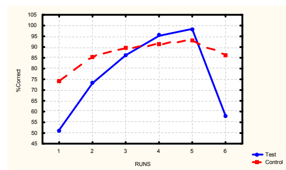

Figure 1: Performance in test and control phase

Imaging data showed hippocampal activation increasing significantly until the 20th block. When new stimuli were presented it dropped back to base level (Figure 2).

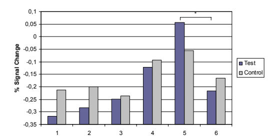

Figure 2: Percent Signal Change in Hippocampus

Parietal activation was found in both hemispheres when contrasting test with control for the blocks matched in performance. However, whereas the activation in left Angular Gyrus (AG) appears to increase as the order becomes known, the activation of right AG shows the reversed pattern and thus seems to indicate task difficulty.

Acknowledgements

The contribution of FVO and TV was funded by project G.0188.04 from the Fund of Scientific Research-Flanders. The contribution of WF was funded by Grant P5/04 from the Interuniversity Attraction Poles Programme – Belgian Science Policy.

Discussion

We replicated previous findings concerning the involvement of hippocampus and parietal cortex in ordinal judgments. However, our results indicate that parietal activation must be interpreted with caution.

References

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