MRI can detect brain shape changes in mice caused by five days of learning

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Introduction

Several studies have indicated that the shape of the brain can be influenced by experience and environment. Whether these shape changes occur rapidly and consistently in a learning paradigm and are detectable by MRI, is, however, still unknown.

Methods

In this study we used 3 cohorts of male C57Bl6/129Sv mice trained for five days each (6 trials/day) on different versions of the Morris Water Maze (MWM) along with an untrained control cohort (6 mice). One cohort of 6 mice (the non-spatial cued MWM group) was trained using a cued platform and a dark curtain surrounding the pool, obscuring all spatial cues. The second cohort of 6 mice (the spatial cued MWM group) was trained using a cued platform but with the spatial cues visible. The third cohort of 14 mice (the spatial MWM group) was trained with the submerged (non-cued) platform and all spatial cues visible. The mice were then returned to their cages for 10 days before being sacrificed and their brains fixed. High-field (7T) magnetic resonance images (MRI) of whole brains with 32µm voxel resolution were then obtained and analysed using automated image registration techniques for subtle shape differences [1]. A by group ANOVA was performed at every voxel, multiple comparisons accounted for by thesholding at a 1% False Discovery Rate.

Results

Multiple brain regions differed significantly between groups. The most significant findings include increases in size of the dentate gyrus ($p<0.001$) in the spatial MWM group as well increases in size of several white matter tracts ($p<0.0001$), cerebellar nuclei ($p<0.001$), and the striatum ($p<0.0008$) for the non-spatial cued MWM group. There was a significant inverse relationship between the size of the striatum and the dentate gyrus($r=-0.55$, $p<0.0009$).

Conclusions

Five days of training were enough to cause subtle but discernible changes in the shape of the brain detectable by MRI. These shape changes localized in a task specific fashion, with the hippocampus increasing in size in the two groups capable of using spatial information, and the cerebellum, striatum, and cortex increasing in the non-spatial cued group. Further, the inverse relationship between the size of the dentate gyrus and the striatum support the hypothesis that these two memory systems interact in a competitive fashion [2]. These data indicate that MR based shape measures can localize areas involved in skill acquisition in mice.

[1] Kovacevic N et al. (2005) Cereb Cortex. 15:5 639-45
[2] Poldrack RA, Packard MG. (2003) Neuropsychologia. 41:3 245-51

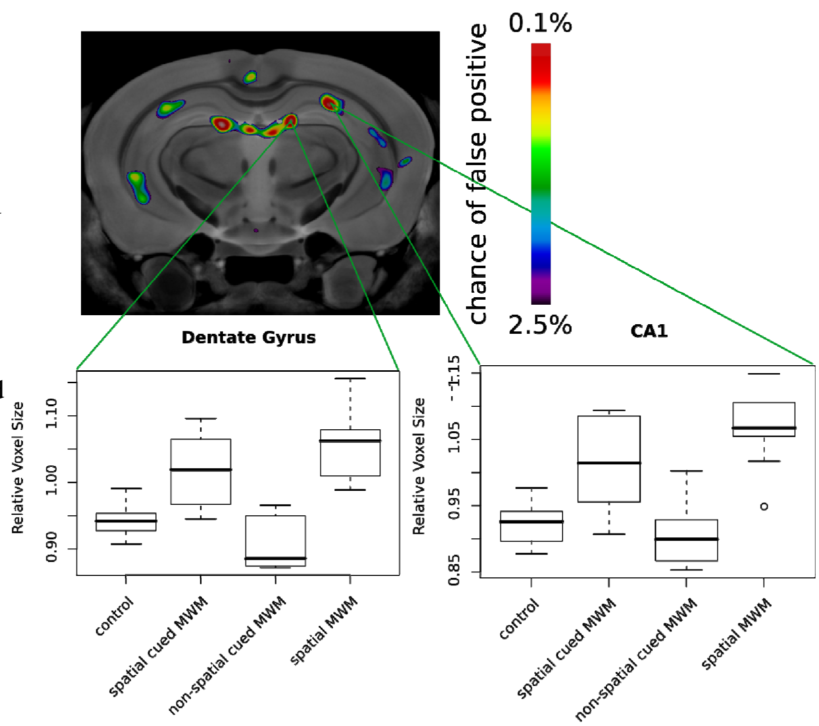

Figure 1: Learning dependent anatomical changes in the hippocampus seen by MRI.