Hippocampal-related memory network in Multiple Sclerosis: a structural connectivity analysis

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Target audience. Neuroradiologists, radiologists, neurologists.

Background. Memory dysfunction is frequently present in patients with multiple sclerosis (MS) and it has been associated with damage of grey matter (GM) regions and of relevant white matter (WM) tracts. Diffusion tensor imaging network-based analysis enables to define and quantify structural damage in networks involved in memory performance.

Purpose. To quantify structural connectivity integrity of the hippocampal-related episodic memory network and its association with memory performance in MS patients.

Methods. Brain diffusion tensor and 3D T1-weighted sequences were obtained from 71 MS patients and 50 healthy volunteers (HV). Thirty GM regions (selected a priori as part of the hippocampal-memory network[1]) were segmented from the T1 weighted image[2] and used as seeds to perform probabilistic tractography[3] and create a connectivity network matrix for each subject. Global, nodal and edge network metrics were calculated[4]. Verbal and visuo-spatial memory were evaluated with the Paired-Associate Word Learning Test, Short Story Test, and Rey-Osterrieth Complex Figure delayed recall task. A memory cognitive impairment index (MCII) was also calculated.

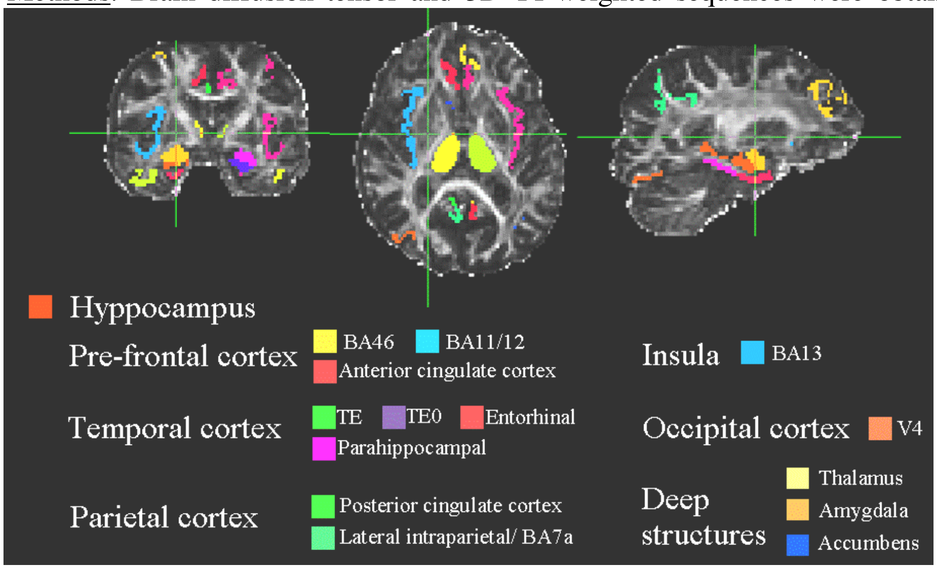

Figure 1. Hippocampal memory network: the 30 segmented regions (in colour) are overlaid on the fractional anisotropy map of a MS patient.

Results. Compared to HV, MS patients showed significantly decreased ($p<0.01$) strength, assortativity, transitivity, global efficiency and increased average path length of the whole network. Significant correlation was found between global efficiency and strength *vs* memory scores. The thalamus and parietal cortex were the nodes with highest betweenness centrality (BC) and strength of the network both in patients and HV. Several nodes showed increased BC and decreased strength in MS patients compared to HV ($p<0.01$). Thirty-nine/435 edges had decreased communicability, whereas 108/435 edges had decreased fiber count ($p<0.01$, FDR correction). The thalamus and amygdala had increased communicability with other nodes in MS patients vs HV. Performance at single cognitive tests correlated with node and edge properties.

Conclusions. The hippocampus-related memory network is globally impaired in MS patients, even if it maintains a configuration in which the thalamus and parietal lobes show the highest strength and BC. The integrity of this network seems relevant for preserving memory functions.

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References. [1] Bird CM, Burgess N. The hippocampus and memory: insights from spatial processing. Nat Rev Neurosci. 2008;9:182-194. [2] Desikan RS, Segonne F, Fischl, B, et al. An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest. Neuroimage 2006;31:968-980. [3] Behrens TEJ, Johansen-Berg H, Jbabdi S, et al. Probabilistic diffusion tractography with multiple fibre orientations. What can we gain? NeuroImage, 2007;23:144-155. [4] Rubinov M, Sporns O. Complex network measures of brain connectivity: Uses and interpretations. Neuroimage. 2010;52:1059-1069.