Connectivity and replay during post-encoding rest promotes the consolidation of durable memories
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Background: Memory consolidation transforms initially fragile memories into a durable engram. This is thought to partly depend on resting-state dynamics after the encoding of new information. During post-encoding rest, the hippocampus initiates spontaneous “replay” of stimulus-specific content that was recently experienced. This is accompanied by increased cross-talk between the hippocampus and neocortex, in particular the ventromedial prefrontal cortex (VMPFC), which embeds and stabilizes the memory trace into a wider neocortical network. In addition, the thalamus is gaining attention as an important relay-station for these interactions. We hypothesized that durable memory consolidation would depend on hippocampal-thalamic-neocortical connectivity during post-encoding rest. Second, we predicted increased, stimulus-specific replay of durable memory content (compared to forgotten material) within this network.

Methods: Thirty-four subjects studied unique picture-location associations inside the MR-scanner and performed a cued-recall test immediately after study, as well as 48 hours later. Associative memories were defined as “durable” if they were preserved during both retrieval tests. Resting-state scans were performed before (baseline rest) and after study (post-encoding rest). Next, seeds were placed in bilateral hippocampus, thalamus, and the VMPFC, and whole-brain connectivity was analyzed using multiple linear regression with individual durable memory scores as a covariate. Replay was assessed with representational similarity analysis, which computed the similarity between multi-voxel patterns during study and rest. This yielded a stimulus-specific “replay index” for each picture-location association.

Results: During post-encoding rest, the hippocampus, thalamus, and the VMPFC revealed increased coupling to the posterior parietal cortex in relation to durable memory performance. This relationship was not present during the baseline rest. Furthermore, we found increased stimulus-specific replay of durable memories (compared to forgotten material) in the left hippocampus.

Conclusions: In sum, we found a positive association between durable memory performance and connectivity of the hippocampus, thalamus and the VMPFC with the posterior parietal cortex, which may be related to the coding of the specific picture-location associations. Also, we found increased stimulus-specific replay of durable memories in the hippocampus. While data analysis is currently being finalized, these results provide first evidence that the consolidation of durable memories depends on both connectivity and replay within a hippocampal-thalamic-neocortical network.