# Probing hippocampus' functional properties with activation databases

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Our understanding of brain function with neuroimaging approaches has been fairly limited so far, mainly because current knowledge has been derived from brain-behavior studies aiming to map psychological concepts to the brain. Illustrating this issue, the pluripotency across behavioral functions of the hippocampus still remains poorly explained from a functional neurobiological view. Recent endeavors in activation data aggregation could contribute to our understanding by revealing functional patterns and properties that can only be observed when pooling observations of brain functional signal across an extended range of behavioral conditions[1]. Here, we examined a well-acknowledged functional subdivision of the hippocampus in the light of activations databases. We first applied a behavioral profiling approach to each subregion based on two different databases of activation studies, we then searched for the number of functional dimensions processed by each subregion (i.e. functional dimensionality) at the subject level within a dataset of subjects scanned across a wide range of behavioral paradigms.

We focused on a well-acknowledged tripartite (head, body and tail) model of the right hippocampus. The subregions were defined in a recent study by multimodal parcellation[2]. Behavioral profiling of each subregion was performed across two databases: BrainMap[3] and Neurosynth[4]. In BrainMap, each activation peak has been labeled according to a predefined taxonomy of behavioral domains. Behavioral profiling was performed with a reverse inference approach and a $\chi 2$ test to retain significant associations. Studies in NeuroSynth have been labeled according to terms occurrence in the paper by a text-mining approach and here terms association was defined by positive z-scores. Functional dimensionality was estimated in 10 subjects of the Individual Brain Charting (IBC) project (a high-resolution multi-task fMRI dataset)[5] with a Principal Component Analysis. The maximum log-likelihood value was used as an indicator of the optimal components' model.

Behavioral profiling across the behavioral domains of BrainMap revealed a very heterogeneous pattern of associations of the hippocampus' head and body while the tail was mainly associated with navigation. Neurosynth further corroborated the broader behavioral profile of the head and body compared to the tail. At a more qualitative level, the overview offered by both

databases suggested a gradual shift from processing of incoming information (such as perception, interoception, emotion) in the anterior part to abstract representations (independent of immediate self-centric information) in the most posterior part (Fig. 1). Examination of log-likelihood for models revealed that in most individual participants, a high-dimensionality model likely characterized the hippocampus' body (Fig. 2). Overall, the hippocampus' body appeared to process a high number of functional dimensions while other subregions could process relatively compressed representations.

Examining hippocampus' activations across an extended range of studies confirmed the pluripotency of its function in human behavior. However, using a tripartite partition model further suggests a differentiation along the anterior-posterior axis with regards to information processing properties. We here speculated a gradual shift from processing of incoming information in the anterior parts to processing of abstract representations in the most posterior parts that would support higher behavioral functions such as spatial navigation and episodic memory. Importantly here, combining these results with individual high-quality data allowed us to rule out the influence of inter-individual variability artefact in the "functional richness" of hippocampus' body. Altogether, our results suggest that the hippocampus' organization and function allow the integration of various functional dimensions towards abstract representations for higher aspects of human cognition.

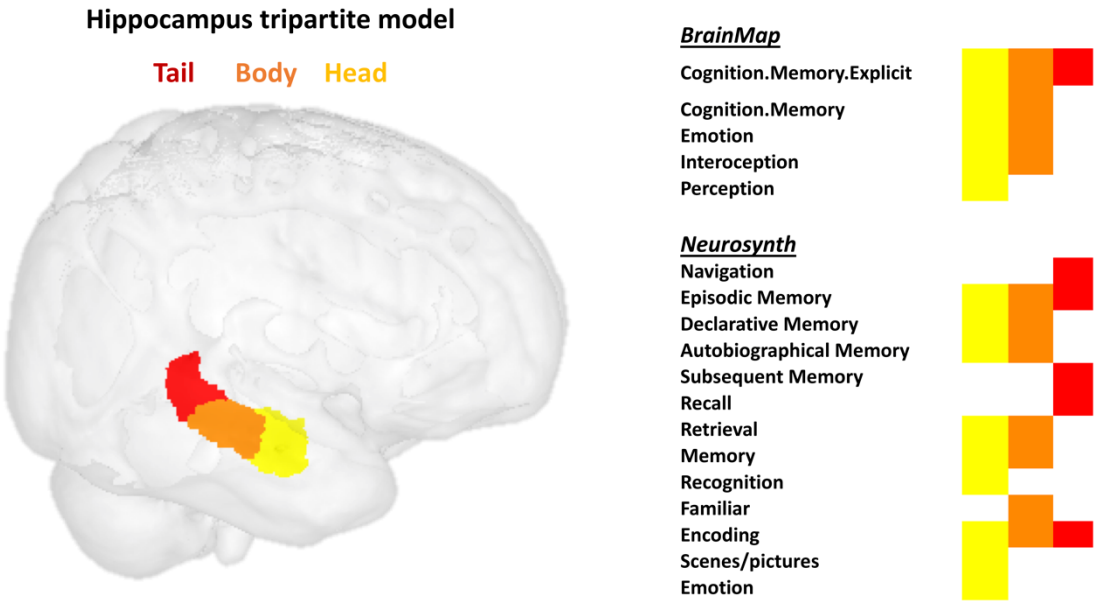


Figure 1.

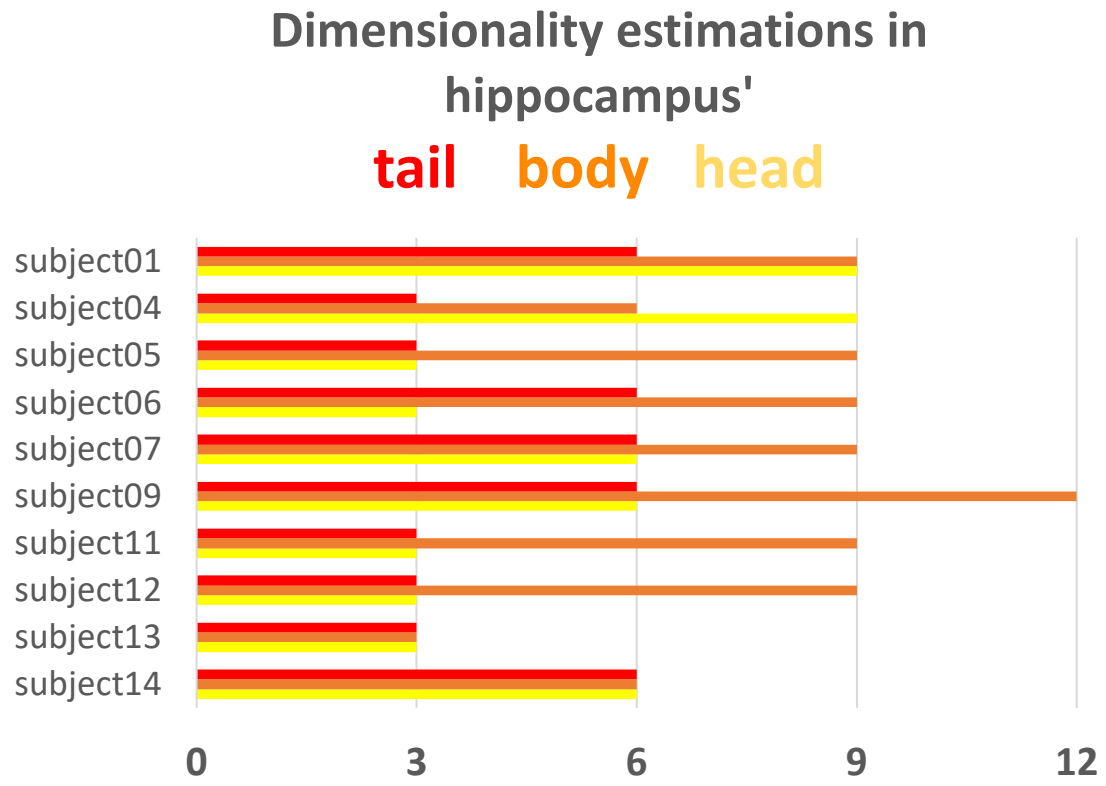


Figure 2.


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3 Laird, A. R. *et al.* The BrainMap strategy for standardization, sharing, and meta-analysis of neuroimaging data. *BMC research notes* **4**, 349, doi:10.1186/1756-0500-4-349 (2011).

4 Yarkoni, T., Poldrack, R. A., Nichols, T. E., Van Essen, D. C. & Wager, T. D. Large-scale automated synthesis of human functional neuroimaging data. *Nature methods* **8**, 665-670 (2011).

5 Pinho, A. L. *et al.* Individual Brain Charting, a high-resolution fMRI dataset for cognitive mapping. *Scientific data* **5**, 180105, doi:10.1038/sdata.2018.105 (2018).