

Are representations in the hippocampus organized by the emotional content of stimuli?

A multivariate analysis of intracranial electrode recordings

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Introduction

- Traditional views of the hippocampus highlight the region's role as a rapid encoder of episodic events [1]
- Recent work suggests the hippocampus may also be capable of representing learned structure, such as categorical information [2]
- Emotional information appears to receive preferential processing in the hippocampus as evidenced by stronger memory for such stimuli [3]
- Connected structures may provide 'emotional labels' to the hippocampus for use during encoding [4]

Stimuli and Procedures

- 120 computer-generated male faces six times each (720 trials).
- Morphed to convey positive, negative, or neutral affect (40 each).
- Participants view face 1 s, then report affect of facial expression.

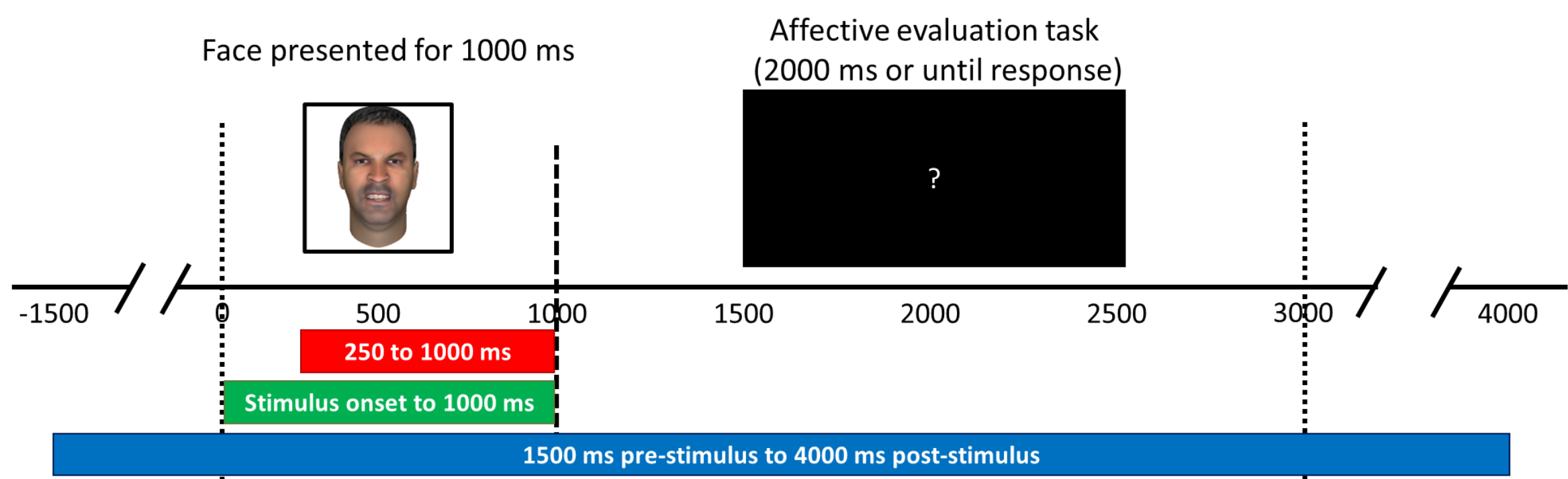


Figure 1. Trial schematic. Time points contributing to spiking analysis (red), wavelet convolution (blue), and LFP analysis (green) are shown.

Recording Protocol

- Microwires were implanted into the amygdala (AMG), hippocampus (HPC), ventromedial prefrontal cortex (vmPFC), and anterior cingulate cortex (ACC).
- HPC target was "mid-body" (~ CA3).
- 8 channels per brain region per hemisphere (64 channels total).
- One set of decoding models were fit to single- and multi-unit spiking activity
- Second set of decoding models were fit to spectral power of LFPs (obtained via Morlet wavelet).

Number of Experimental Sessions	Amygdala		Hippocampus	
	L	R	L	R
26				
2				
1				
1				

Figure 2. Presence (green) or absence (red) of electrodes in key brain regions.

Research Questions

- Is affective information represented in the hippocampus?
- If so, is this information represented in the spiking activity of individual neurons or in the local field potentials produced by much broader neuronal populations?

Theoretical Viewpoints

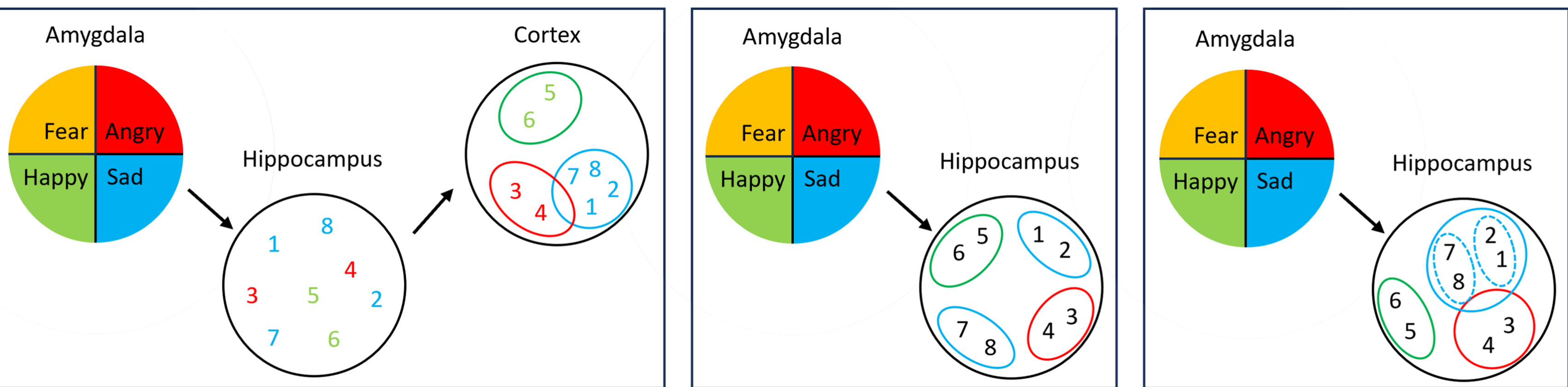


Figure 3. Different theoretical viewpoints on the role of the hippocampus in emotional memory. Left – emotional events are sparsely encoded in the hippocampus. Events similar in emotional content are represented similarly in the cortex. Middle – emotional information is used to group events that frequently co-occur together. Distinct temporal groupings are kept separate from one another. Right - Events similar in emotional content are represented using similar neural activity.

Accuracy of Cross-Validated Models

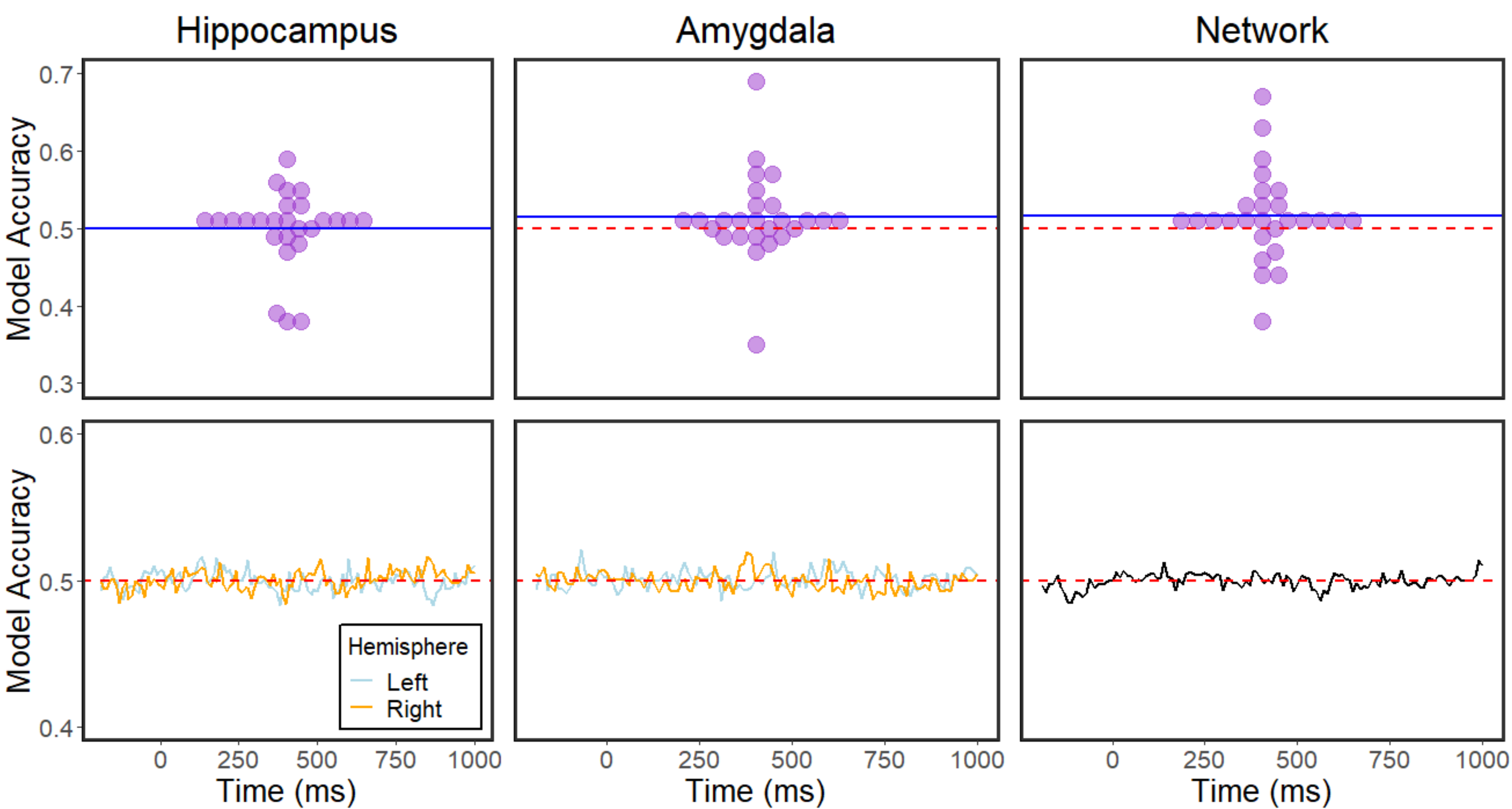


Figure 4. Cross-validated accuracies of models built using spike counts (top row) or spectral power from LFPs (bottom row). Red line indicates chance level performance.

Participants

- 30 experimental sessions from 14 pharmaco-resistant epilepsy patients (8 female; 20 – 56 years; mean age = 40 years; 1 left handed).
- Monitored for possible resection of an epileptogenic focus.
- 11 had seizure foci in hippocampus (5 L), 8 in amygdala (4 L, 1 B).

Conclusions and Discussion

- Unable to discriminate between positive and negative affect by modeling spike rates or time-varying LFP spectral power.
- Most consistent with sparse episodic encoding of individual faces.
- But results may be influenced by HPC implantation target ~ CA3.
- Cannot reject hypothesis that HPC represents categorical information while learning, before cortical consolidation.

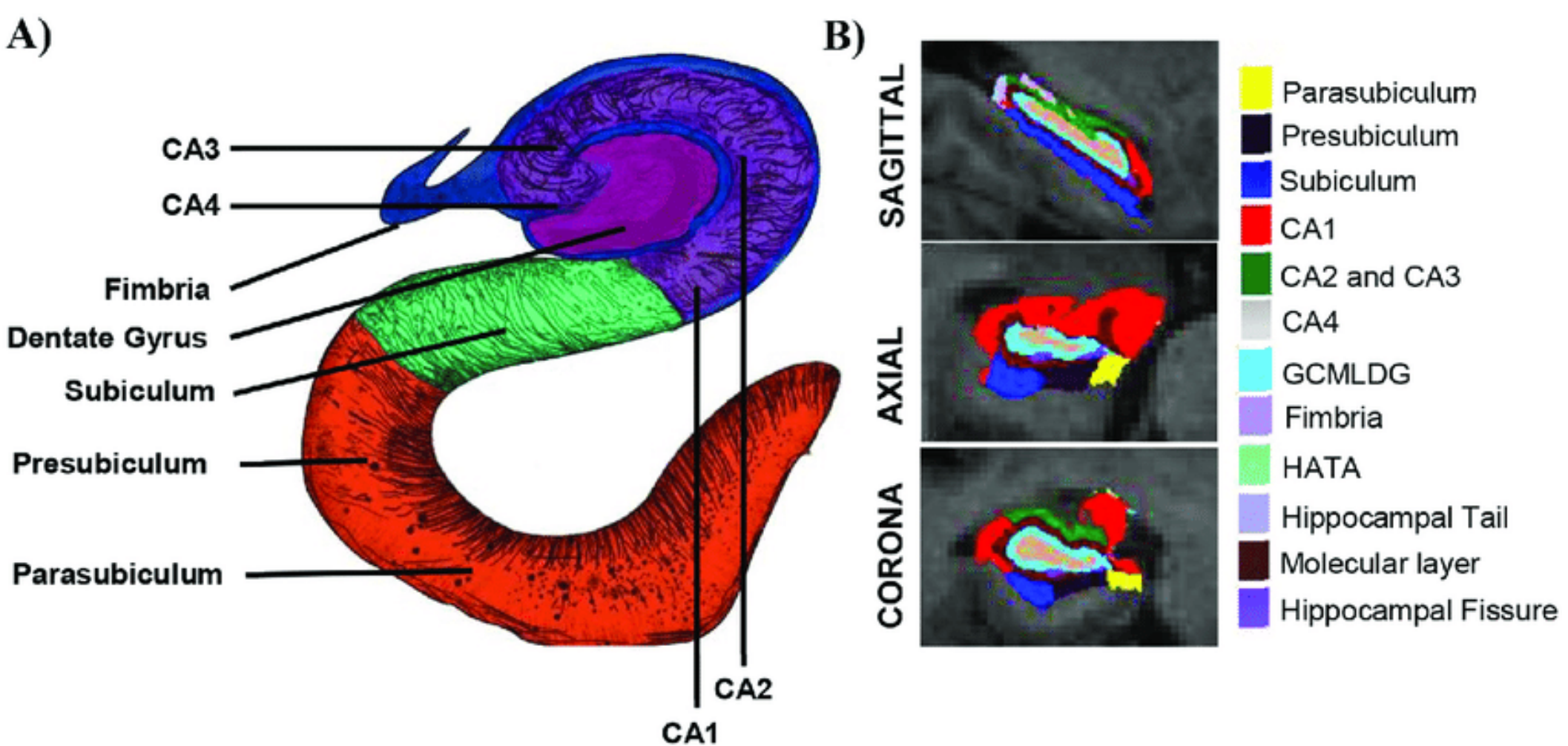


Figure 5. Segmentation of human hippocampus into subfields. Figure from Kannappan et al., 2022. [5] Published in the Public Library of Science under a CC Attribution License.

Acknowledgments

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