# Identification of Electrode Locations Within Hippocampal Substructures Using Ultra-High Field Magnetic Resonance Imaging

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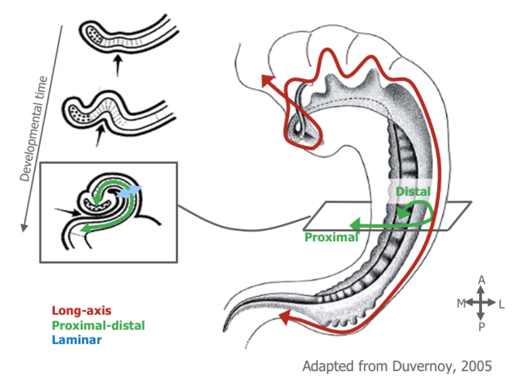
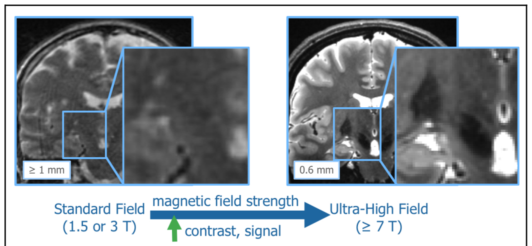
## Introduction

The hippocampus is commonly implicated in drug-resistant epilepsy with characteristic involvement of specific sectors of the cornu ammonis (CA) [1]. It can be divided longitudinally into the head, body, and tail; and unfolded along the medial-to-lateral axis into specific subfields: the subiculum, CA sectors, and dentate gyrus (DG).

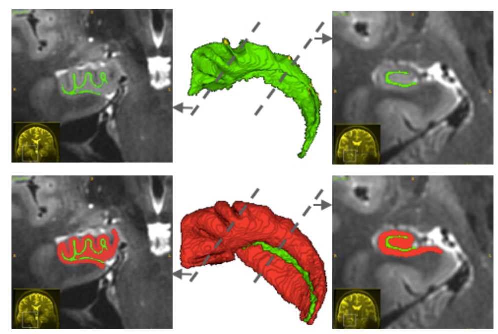



The Human Hippocampus [2].

The increased signal at ultra-high magnetic field strengths (= 7 Tesla; 7T) allows these substructures to be visualized in continuity at submillimeter resolution. We propose to use 7T magnetic resonance imaging (MRI) to identify electrode locations within the hippocampus by applying computational unfolding methods along the above described gradients [3].



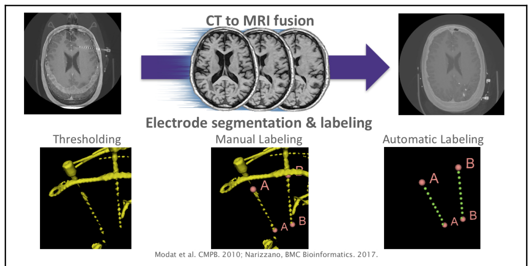

Ultra-high field MRI.



Red: hippocampal grey matter; Green: hippocampal sulcus+SRLM

## Methods: Electrode visualization

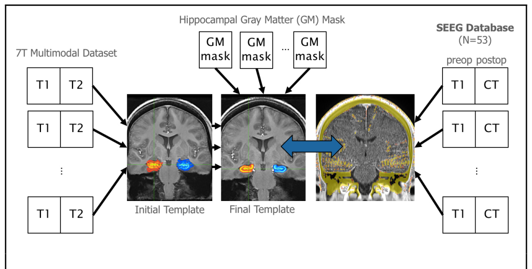
53 patients with drug-resistant epilepsy were identified. Post-operative computed tomography scans were registered with the pre-operative MRI. Electrode contacts within the hippocampus were semi-automatically labeled [4].




Electrode visualization workflow.

## Methods: Template registration

Template creation is a fundamental technique enabling the representation of brain structures in a common reference space. Each patient MRI scan was aligned with a recently developed 7T template space (0.6 mm isotropic voxel size) [5]. Transformation of electrode locations into our recently developed "unfolded" coordinate space [3] permitted hippocampal substructure labelling.

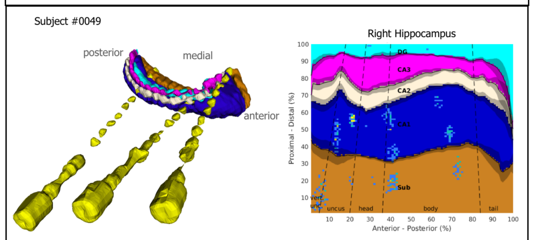



Hippocampal template creation.

## Results

Quality of the 7T template improved with the inclusion of hippocampal gray matter segmentations compared with T1w and T2w images alone. Bilateral electrode contacts were superimposed onto the unfolded coordinate space. The location of the 178 implanted hippocampal electrodes is summarized in the table below.

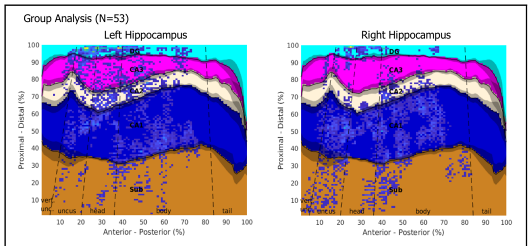
| | | # of electrodes (%) |
|---|---|---|
| Overall | Total | 178 (100%) |
| | Left | 88 (49.4%) |
| | Right | 90 (50.6%) |
| Subfield | Subiculum | 25 (14.0%) |
| | CA1 | 85 (47.8%) |
| | CA2 | 23 (12.9%) |
| | CA3/4 | 18 (10.1%) |
| | DG | 27 (15.2%) |
| AP | Head | 86 (48.3%) |
| | Body | 92 (51.7%) |
| | Tail | 0 (0.0%) |




Single subject: 3D model (left) and subfield projection (right).

## Conclusions

Here, we demonstrate the use of 7T MRI to assist with identifying the location of electrode implantations within hippocampal substructures. While limitations with existing electrode technology may prevent our ability to observe electrographic differences based on location, our findings suggest that specific targeting of hippocampal substructures is feasible using 7T MRI.




Group analysis (N=53).

## Acknowledgements

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## References

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