

# MAPPING THE MEMORY CIRCUIT: SEGMENTATION OF FORNIX, FIMBRIA AND ALVEUS ON HIGH-RESOLUTION 3T MRI



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## INTRODUCTION

- Projections from within the hippocampus form collections of thin white matter (alveus and fimbria) leading out of the medial temporal lobe via the fornix and project to the thalamus
- Standard DTI measures for the above regions suffer from partial volume effects and the inherent resolution constraints in acquisition limit its application to only the fornix. Volumetry of these regions may therefore serve as a better or complementary analysis metric.
- Limitations in scan resolution have led to the exclusion of the alveus and fimbria altogether

### GOALS:

- To develop a strict and anatomically detailed protocol for manual segmentation of the above mentioned WM structures using high-resolution images
- To explore whether these structures could serve as biomarkers for distinguishing Alzheimer's disease (AD) or mild cognitive impairment (MCI) from healthy controls

## METHODS

- Manual segmentation on high-resolution MRI images (T1/T2-weighted, voxel size = 0.3mm isotropic) for three healthy controls (1male, 2female, aged 29-57 yrs).
- Intrarater reliability performed on two randomly selected hemispheres and evaluated using Dice kappa overlap metric
- Manual atlases were used for automatic segmentation of 151 individuals from the ADNI 3T baseline dataset (47 normal controls, 69 MCI & 47 AD)
- MAGEt Brain segmentation (previously validated for use in medial temporal automated segmentation) was used to automatically segment WM using the three high resolution atlases created.

**Hypothesis:** Given the volumetric stepwise declines observed in the hippocampus with respect to controls vs MCI & AD, we hypothesized the same effects would be observed in the above white matter regions.

## RESULTS

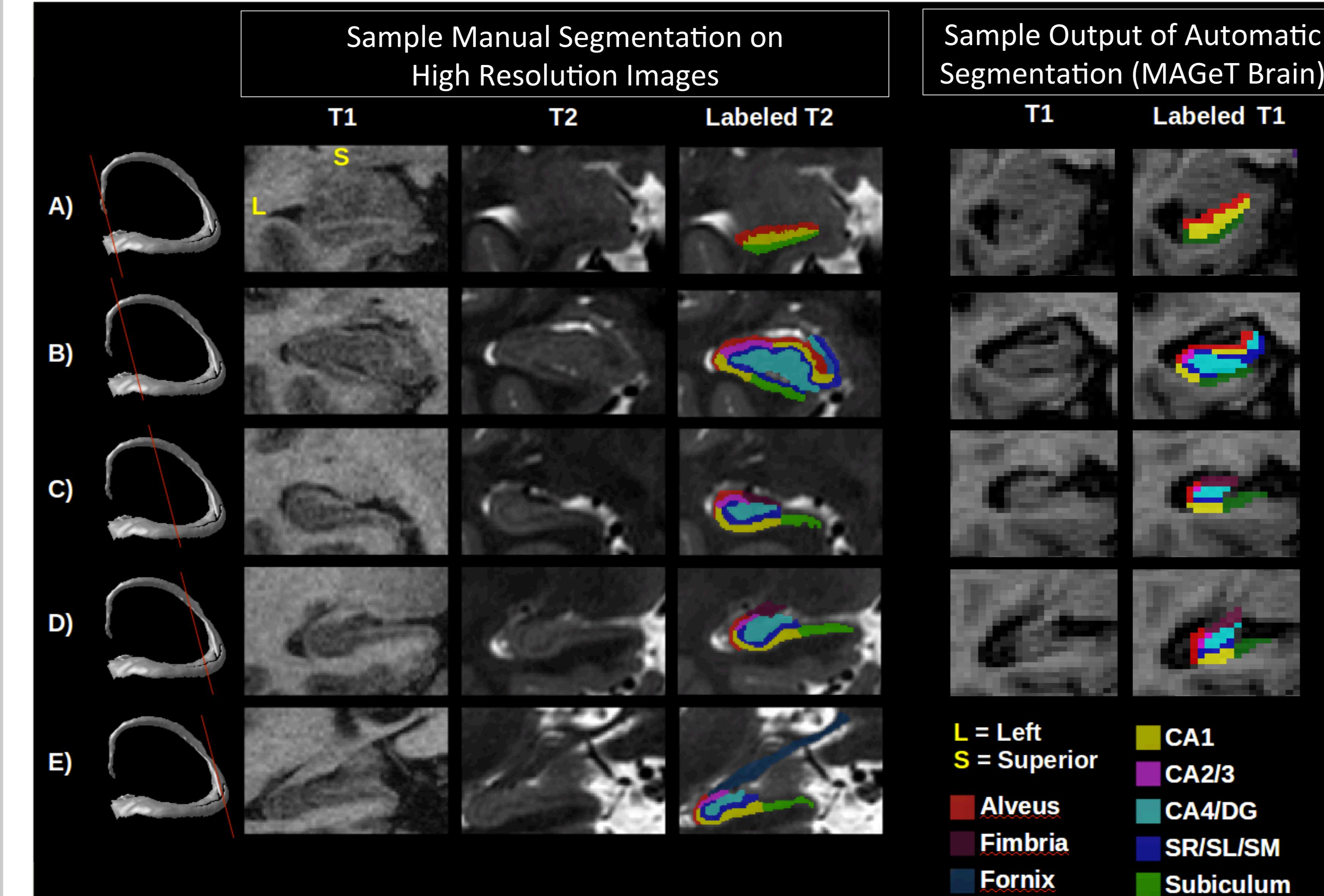


Figure 1. Example of high-resolution and automatic segmentations for the left alveus, fimbria and fornix. Columns A-E show unlabeled and labeled coronal slices for white matter surrounding the hippocampus.

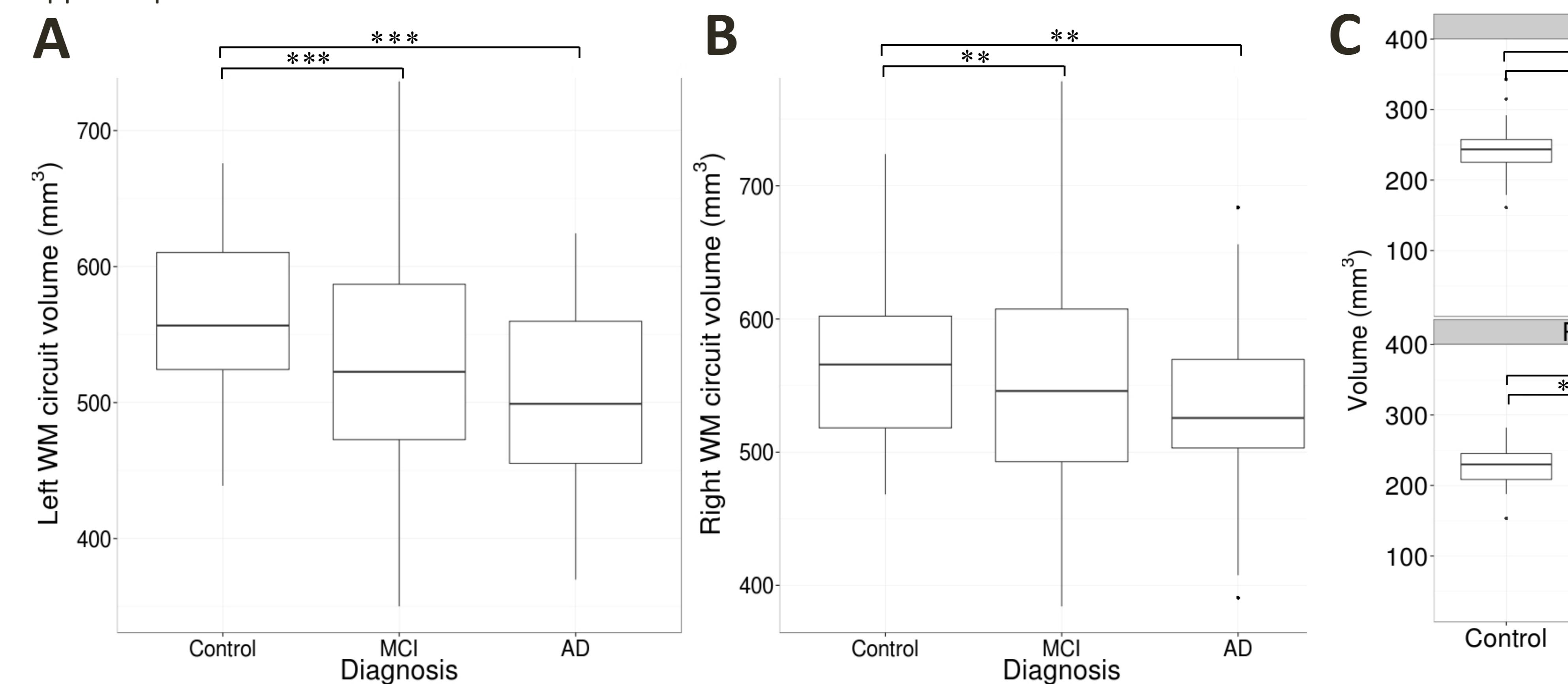


Figure 2. Summary of volumetric outputs from MAGEt brain segmentation. A general linear model controlling for age, sex and intracranial volume indicated robust significant differences between white matter structures of healthy controls compared to MCI or AD cohorts. **A:** Results of combined left white matter structures (i.e. left alveus, fimbria and fornix). **B:** Results of combined right white matter structures (i.e. right alveus, fimbria and fornix). **C:** Results of right/left alveus, fimbria and fornix volumes across all cohorts. All structures except for the right alveus were significantly different in MCI and AD cohorts when compared to controls. Save for the left fimbria, results did not reveal significant differences between MCI and AD cohorts. \*p<.05, \*\*p<0.01, \*\*\*p<0.001.

## SUMMARY

- A general linear model controlling for age, sex and intracranial volume indicated robust significant differences between white matter structures of healthy controls compared to MCI or AD cohorts.
- The MCI cohort showed decreases in the left ( $t=-4.44$ ,  $p<0.001$ ) and right ( $t=-3.19$ ,  $p<0.01$ ) WM compared to controls. Results did not reveal significant differences between MCI and AD. Similar significant differences were also observed individually for the alveus, fimbria and fornix.

To our knowledge, our group is the first to develop a reliable and anatomically complete protocol for identification of all WM structures (i.e. alveus, fimbria and fornix) involved in the hippocampal memory circuit. In addition, we have also demonstrated that use of such labels can be useful in automatic segmentation and serve as potential neuroimaging biomarkers.

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