Decomposing the hippocampus into anatomical informative shape measures

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Target Audience: Researchers interested in structural brain imaging, in particular those who focus on the hippocampus and/or mouse MRI.

Purpose: Assessment of the anatomy of the hippocampus usually relies on the volume of the structure, the volume of its subfields, or global shape metrics. We propose to develop novel analyses of hippocampal shape that align with our knowledge of the anatomy of the hippocampus, such as the thickness of the pyramidal cell layer, oriens or radiatum layers, or the geodesic distance traversed along the perforant path.

Methods: A detailed atlas of the mouse hippocampus derived from ultra high-field MRI (1) was used to determine boundaries for computing Laplace's equation for measuring path lengths (2), analogous to how cortical thickness can be measured (2, 3). We defined separate boundary sets for the stratum radiatum, stratum oriens, and pyramidal cell layers of the hippocampus as well as the molecular and granular cell layers of the dentate gyrus.

As a test case of these techniques we applied them to a dataset examining the effects of the estrous cycle on the female mouse hippocampus (4). The boundary sets were aligned to each brain in the study through a combination of linear and non-linear registration steps as previously described (5).

Results: An example of these thickness measurements across the hippocampal layers is illustrated for the stratum radiatum in Figure 1. As can be further seen in the same figure, the pattern of changes in length of the striatum radiatum varies throughout the estrous cycle. The temporal pattern of thickness changes differs for the three CA regions (CA 1-3).

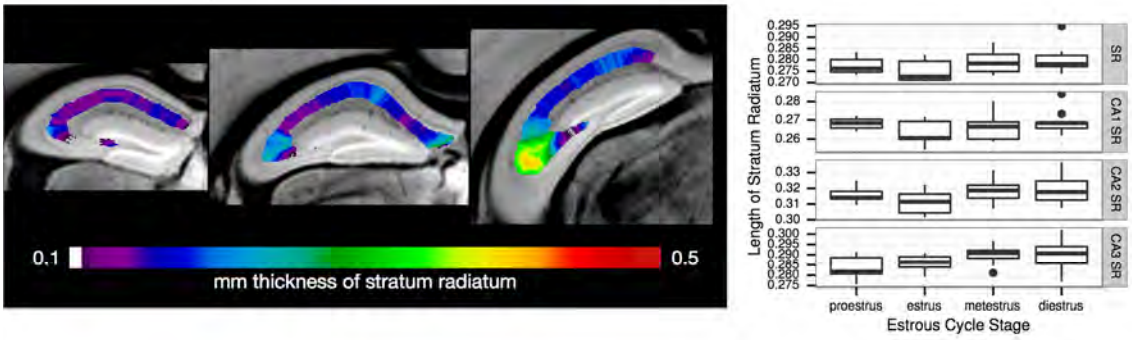

Figure 1: Three coronal slices showing length measurements of the stratum radiatum, and boxplots illustrating how the length alters across the female mouse's estrous cycle.

Discussion: The ability to examine cortical thickness separately from cortical surface area and volume has provided many important insights from the brain imaging literature. Here we provide similar anatomically informed, automated methods for studying hippocampal shape by decomposing the hippocampus into its intrinsic layers and measuring their geometric properties. Applying these methods to multiple, varied datasets will help determine the utility of this approach. These layers correspond to specific cell populations with well-defined functions. Our approach could thus be a more functionally relevant assessment of brain structure.

References:

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