Cortical architecture of the human hippocampus

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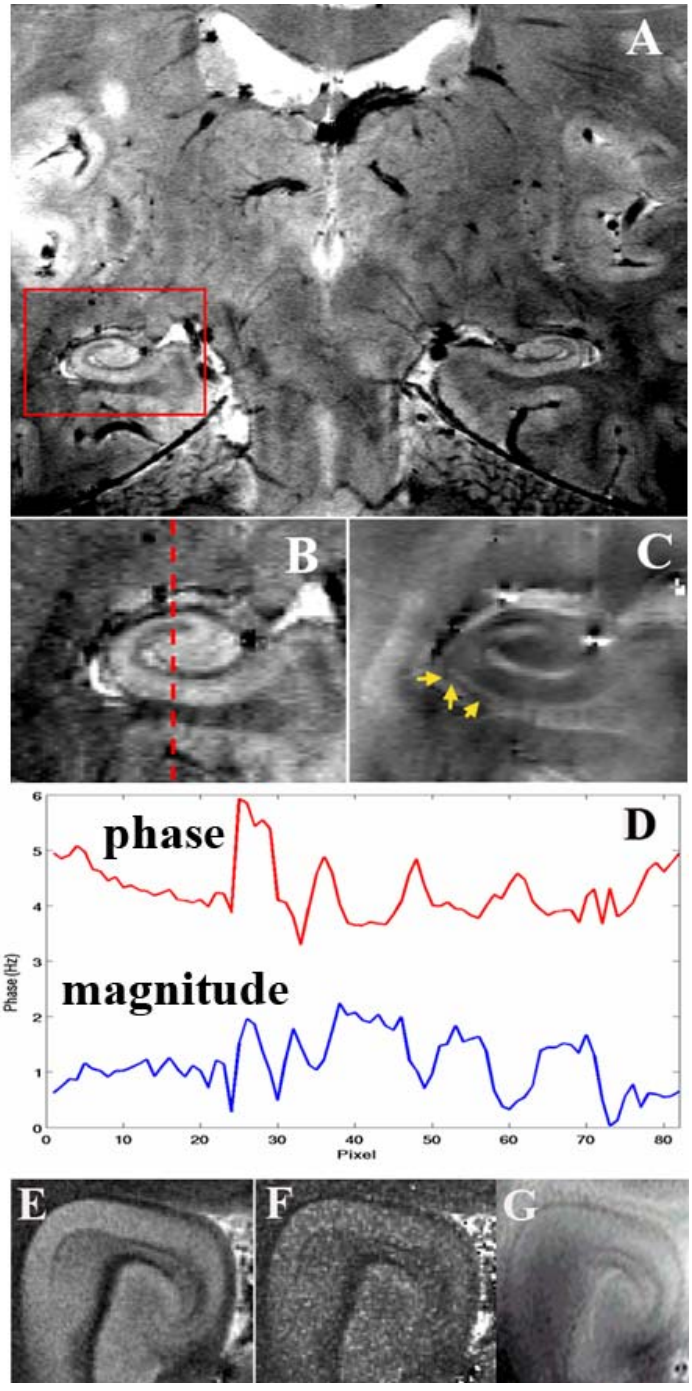
Introduction: There is growing interest in imaging the hippocampal region of the human brain, because it is one of the earliest areas affected n in Alzheimer's disease (AD). Being able to detect changes in the cortical architectural is critical for the early diagnosis of neurological disorders such as AD[1]. In this study, susceptibility-weighted high resolution MRI was used for detecting cortical laminar structure *in vivo* of the human hippocampus. Recent MRI studies[2,3] at 7T have demonstrated that susceptibility-weighted MRI contrast at ultra high magnetic field are very useful for direct visualization of the anatomical details of the brain cortical architecture, since at high field the local variations in magnetic field are enhanced in and around the brain structures with altered susceptibility, reflected as changes in T2* relaxation and local resonance frequency.

Material and Methods: The MRI scans were performed on a 7 T GE whole-body MRI scanner using a close-fitting multi-channel phased array coil (Nova Medical) for signal reception. Six normal volunteers participated in the study. In order to acquire high quality T2*-weighted images at different TEs, a 2D gradient-recalled echo sequence was employed. The main acquisition parameters for the in vivo measurements are the following: TE=20-42ms, TR=800ms, flip angle=30°, spatial resolution of 0.2×0.2×1mm^3, 11 oblique coronal slices through the medial temporal lobe. To confirm the findings from the *in vivo* measurements, we conducted also high-resolution MRI scanning of formalin-fixed brain tissue specimens. The sections of the human hippocampus were obtained from deceased patients (n=2) with no known neurological defects. The scans were performed on the 7T, using a dedicated 4- element receiver coil (OD=38mm). Similar acquisition parameters were used (TE=15-42 ms) except for a higher spatial resolution of 50x50x500 µm^3.The improved SNR with the use of the smaller detector afforded high-resolution acquisition within limited time (30 min). Data processing included the calculation of magnitude images, T_2* and phase. For the phase images, a least-square fitting of 2D polynomial up to order 5 was applied after phase unwrapping to remove the macroscopic background field variations.



Results and Discussion: Figure 1A shows a portion of a T2*-weighted magnitude image acquired from a living human brain. The left hippocampus region and the corresponding phase map are depicted in B and C, respectively. The fine structures in the hippocampus and the surrounding cortical areas are delineable both from the magnetite and phase images. An analysis of the profile (D) across the marked region (dashed red line in C) shows two interesting features: 1) the phase and magnitude can have opposite contrast depending on the location in the cortical architecture; 2) the phase offers superior contrast-to-noise ratio and the entorhinal layer II can be readily detected in the phase images (e.g. the arrows in C). There are multiple sources that can give rise to opposing contrast between the magnitude and phase images as extracted from the susceptibility-weighted acquisitions. One of the confounding factors is that the phase images are dependent on the relative orientation of the cortical structures relative to B_0, so curvature in the cortical layer structure can produce contrast changes in the phase. Furthermore, maijor sources of susceptibility contrast, such as iron and myelin, may have opposite effects on the local resonance frequency, but similar influence on T2* relaxation. Therefore, high-resolution T2*-weighted MRI at high magnetic field with quantitative analysis of T_2*, phase, and susceptibility can provide further insight into the anatomical and chemical details of the cortical architecture. As shown in Figs. 1E-G, the *ex vivo* MRI results of the tissue specimens was largely consistent with the *in vivo* observations. Confirming previous results in the neocortex[2], the phase image (G) in the hippocampus appears to have a superior contrast to noise compared to the magnitude data (E) and the calculated T2* (F) has the lowest SNR.

Références: 1. Augustimack JC et al. Ann Neurol. 57:489, 2005; 2. Duyn JH et al.PNAS 104:11796, 2007; Li TQ et al. Neuroimage 32:1032,2006.