Age-related changes in T1 relaxation times across the surface of the cortex

David H. Salat\textsuperscript{1,2}, Anders M. Dale\textsuperscript{1}, Andre J.W. van der Kouwe\textsuperscript{1}, Richard J. Clarke\textsuperscript{2}, Florent Segonne\textsuperscript{1}, Suzanne Corkin\textsuperscript{1,2}, Bruce Fischl\textsuperscript{1}

1. MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging, Charlestown MA
2. MIT Department of Brain and Cognitive Sciences, Cambridge MA

Abstract

Introduction

The brain undergoes substantial morphological and neurochemical changes with advancing age. Although gross atrophy is typically apparent in magnetic resonance (MR) scans of older adults, conventional MR is unable to detect more subtle changes in tissue composition. Quantitative MR imaging (qMRI) techniques can be used to estimate MR tissue signal parameters, such as signal relaxation times. Prior studies have used qMRI to detect brain changes below the resolution of conventional MRI in clinical syndromes such as sickle cell disease [1]. Thus, changes in qMRI measures may be useful for detecting more subtle tissue changes, and could be useful in clinical applications, such as the diagnosis of preclinical dementia.

Past qMRI studies have measured only age-related T1 changes in a limited number of cortical regions [2]. We examined how T1 relaxation times change with normal aging using accurate reconstructions of the brain from MR scans [3, 4], allowing visualization of change across the complete cortical surface.

Methods

We obtained scans from younger (YP; n = 8; mean age = 24.3, 18-35; 5M/3F) and older participants (OP; n = 6; mean age = 73.5, 68-80; 3M/3F). YP were recruited from the MIT/ Meghan community. OP were recruited through the Harvard Cooperative on Aging. Participants were excluded if they had a history of neurological, psychiatric, or medical illness that could contribute to dementia. Multiple high-resolution FLASH scans with different flip angles were collected for the calculation of T1 relaxation times (Siemens 1.5T Sonata, resolution 1x1x1 mm, TR = 20ms, TE = 3.2ms, FA = 3\textdegree, 5\textdegree, 15\textdegree, and 30\textdegree in most participants). The optimal gray/white and pial surface placement as well as the MR tissue parameters (T1 and proton density) were then estimated using a maximum likelihood approach. First a rough estimate of the per-class tissue parameters (white matter/gray matter/CSF) was used to find the optimal surface placement, then the parameters were re-estimated, and the surfaces were re-positioned. This procedure was iterated until convergence. Maps were averaged across participants, using a spherical morph to align cortical folding [5].
Results

Preliminary results suggested that OP had significantly smaller relaxation times bilaterally that were most pronounced in inferior frontal (near Brodmann area [BA] 47) and anterior temporal cortex (near BA 21/22), and the entire cingulated gyrus (near BA 23/24). In contrast, there were mean increases in portions of primary somatosensory (near BA 1) and visual cortex (near BA 17/18; although these differences did not reach statistical significance). Differences were estimated at ~75 to 90 msec in statistically significant regions.

Discussion

Aging is accompanied by T1 relaxation changes in inferior frontal, anterior temporal, and cingulate cortices. These regional differences have only slight overlap with reported age-related morphological changes, such as cortical thinning measured with structural imaging techniques [6]. Future studies will examine the biological mechanisms of these changes and their significance with normal aging.