Layer-specific myeloarchitecture of human S1 hand area in younger and older adults at 7T-MRI

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Introduction

The sense of touch is fundamental to our perception of objects. Currently, both advancing age, tactile abilities adapt.

Lately, healthy aging has been linked to cortical myelin plasticity (Callaghan 2014, Grydeland 2018), and it is little is known on how this relates to functional somatosensory cortex architecture (e.g. body topology) and tactile behavior.

It has been suggested that layer-specific variations in myelin reflects functional specializations of the local cortical architecture (Neuwenhuyss 2015). However, prior invasive studies on age-related myelochure has only described the cortex as a two-dimensional sheet.

Recent advances in magnetic resonance imaging (MRI) offer the possibility to study layer-specific myeloarchitecture in humans in-vivo (Kuehn 2017).

The present study investigated how:

- H1 myelochure of the human primary somatosensory cortex (S1) hand area varies with respect to cortical layers, finger topography and age.
- H2 variation in layer-specific S1 myelin relates to variation in resting-state connectivity.
- H3 variation in layer-specific S1 myelin relates to variation in tactile behavior.

Methods

A Cortical T1 Profiles of Left S1 Hand Area in Younger and Older Adults

B Structure-Connectivity Correlation (Kendall’s Tau)

C Structure-Behavior Correlation (Kendall’s Tau)

Discussion

H1 Layer-specific T1 mapping in younger and older adults suggests myeloarchitecture of S1 hand area is homogeneous and varies with respect to finger topography and age dependent on cortical depth.

We found increased myelin levels in inner-middle layers in older compared to younger adults. Index finger maps were more myelinated in middle layers, thumb maps in deeper layers, appearing to have a special role, most likely being preserved in older age.

H2 A significant link between resting-state connectivity and layer-specific T1 was missing. However, strongest correlations were found in superficial and deep layers known to be involved in inter-regional communication.

H3 Strongest correlations were found for spatial discrimination and deep T1 in older adults, however, a significant link was missing, including QSM as iron proxy, PH maps (Eli 2021) and behavioral marker of all five fingers may clarify the link between cortical myelin and tactile behavior.

References


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Figure 1: General procedure and extraction of cortical quantitative T1 (Q1) maps. 7T-MRI data of 36 healthy, right-handed volunteers (n=19 younger adults: mean age = 25 ± 3 years; n=17 older adults: mean age = 73 ± 4 years) were acquired at a Siemens 7 T Tim Trio scanner (ch 1: 87.8/2000, 2.5 mm isotropic; ch 2: 1.5 mm isotropic). T1-behavior was tested in 3 conditions: 1. 50% stimulation; 2. 100% stimulation; 3. 150% stimulation. Myelin maps were estimated from the region of interest using the equivalent model (Weisbrod 2014) implemented in the CIB toolbox. Extracted values were averaged across cortical depths (superficial, intermediate, inner-middle, deep) and mapped onto the inflated surfaces. Voxel-tactile stimulation applied to the fingertips of the right hand during functional scanning (blacked design). 5 seconds stimulation duration was used to isolate the hand area in the functional scans. Please note that lower T1 values indicate higher myelin levels (colored in red).

Figure 2: T1 profiles and statistical results. (A) Layer-dependent distribution with increasing myelin levels (decreasing T1 values) from superficial to deeper layers (gray scale in black color). The 3 most superficial and the 2 deepest layers (grey color) were included. Normal cortical T1 values (mildly shell) were averaged into core depths (superficial: ch. superficial-middle, inner-middle, deep), depicted in red. Activated peaks of tactor were plotted to T1 maps (second row). There was a significant main effect of cortical depth with p < 0.001 ***), a trend towards a main effect of finger mainly driven by ch. small (P < 0.05); a significant interaction between cortical depth and age group with lower T1, values of inner-middle cortical depth in older compared to younger adults with p < 0.05 (t) and b (interaction between cortical depth and age group). (B) Significant correlation coefficients across layers and 7 finger maps (superficial: ch. superficial-middle, inner-middle, deep). (C) Significant correlation coefficients across layers and between finger performance (stroke counts, detection accuracy, discrimination, precision). Correlation coefficients given as Kendall’s Tau. Negative correlations colored in shades of orange, positive correlations colored in shades of yellow.