Cortical Phase Shifts in Healthy Aging at 7 Tesla

Mathijs Buijs[1], Nhat Trung Doan[2], Sanneke van Rooden[1], Maarten Versluis[1], Julien Milles[2], Jeroen van der Grond[1], and Mark van Buchem[1]
[1]*Radiology, Leiden University Medical Center, Leiden, Netherlands,* [2]*Division of Image Processing (LKEB), Leiden University Medical Center, Leiden, Netherlands*

Target audience: Clinicians.

Introduction: Increasing attention is being given to the role of iron accumulation in the aging brain. Iron is an important element in many physiological processes, but also a major source of oxidative stress [1]. Many neurodegenerative disorders are known to be associated with increased iron accumulation [2]. In recent years susceptibility-weighted imaging (SWI), and more specifically the phase component of SWI, has become available as a method of measuring in vivo iron concentration. Scanning at ultra-high field strengths (≥7T) has increased the usability of SWI for smaller structures. The aim of this study was to investigate the appearance of phase contrast in the cerebral cortex in normal aging using SWI at 7T.

Methods: The study sample consists of three different age groups: a young group (10 subjects, mean age 23.3, sd 1.9 years), a middle age group (14 subjects, mean age 55.6, sd 4.0 years), and an old group (15 subjects, mean age 75.1, sd 3.6 years). All participants were healthy volunteers with no history of cerebrovascular or neuropsychological illness, and no neurocognitive complaints. Written informed consent was obtained from each subject. Participants were scanned using a 2D flow-compensated transverse T2*-weighted gradient-echo scan covering the frontal and parietal regions, with a total imaging duration of 10 minutes (figure 1). Imaging parameters were: TR/TE 1764/25 ms, flip angle 45°, slice thickness 1.0 mm with a 0.1 mm interslice gap, 46 slices, 240 x 180 mm field of view, 1000 x 768 matrix size; resulting in an in-plane nominal spatial resolution of 0.24 x 0.24 mm^2. Images were analyzed using an in-house developed segmentation and parcellation tool, with which the cortex was automatically segmented and registered to the AAL brain atlas. Local cortical phase profiles, with phase values at different depths were subsequently calculated per region. Differences in mean regional phase profile between groups were calculated using a permutation test and corrected for multiple comparisons using the False Discovery Rate method, with a q-value of 0.05.

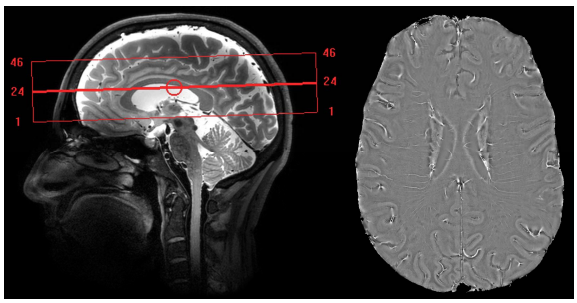

Figure 1: example of planning of T2-weighted sequence (left) and a phase image in a middle age subject (right).*

Results: Figure 2 shows mean cortical phase values in different regions and at different depths for (top row, from left to right) the young, the middle age and the old group, and the p-values of the difference in mean phase value between the young and middle age group (bottom left) and the middle age and old group (bottom right). The phase profiles measured in the different age groups show that cortical phase values increase with age in all regions, with the highest paramagnetic phase shift occurring in the cortex of the parietal lobe. The corresponding p-values show that the difference in phase shift between these two groups is highly significant for all regions excluding the superior frontal gyri, whereas between the young and the middle age group this difference is only significant in 8 of 22 measured regions.

Discussion and Conclusion: Our study shows an increase in paramagnetic phase shift with age in the cerebral cortex of healthy subjects at 7T. The most significant increase in phase shift is seen between middle and old age. This increase is likely due to a combination of increase in iron content and structural changes altering the magnetic susceptibility of the cortex. Further research will be conducted to histologically confirm these findings.

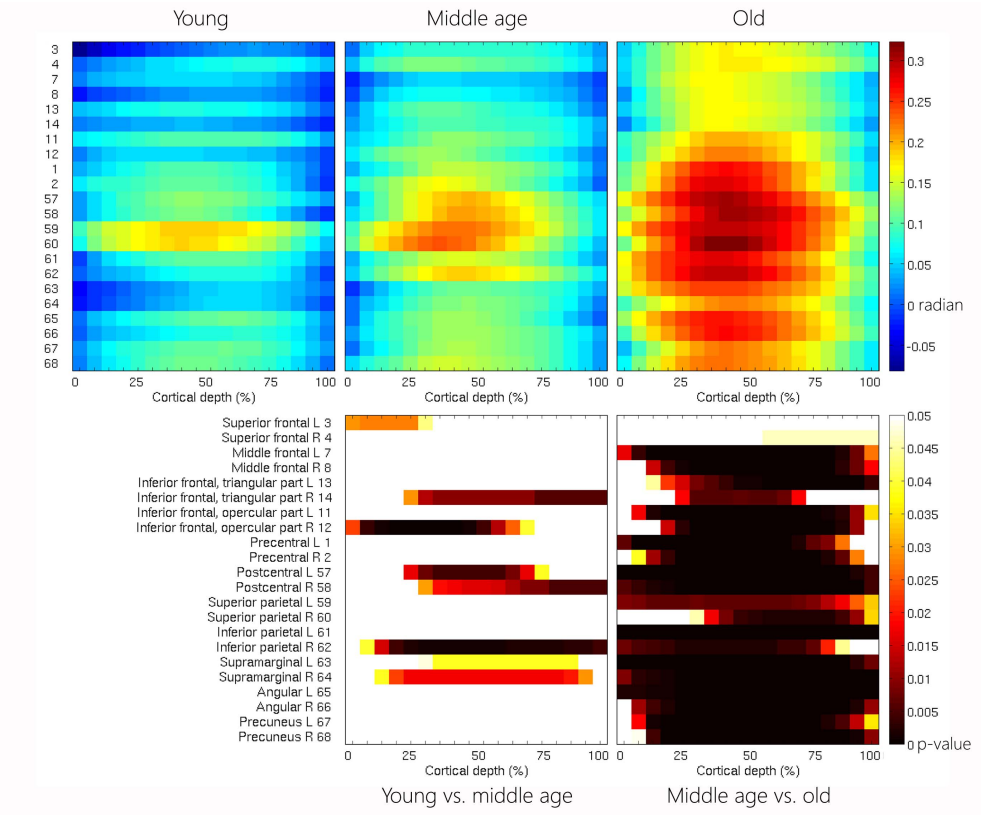

Figure 2: Top: mean phase profiles per region of the young (left), middle age (middle), and old group (right). Positive values indicate paramagnetic phase shift, negative values diamagnetic.
Bottom: p-values of difference in phase shift between young and middle age (left) and middle age and old group (right).

References: [1] Hossein Sadrzadeh SM et al. (2004) Am. J. Clin. Pathol. 121: 65-70. [2] Bartzokis G. et al. (2004) Ann. NY Acad. Sci. 1012: 224-236.