Multi echo susceptibility weighted imaging: Improving image contrast by applying the susceptibility weighted phase mask to maps of the R2* decay

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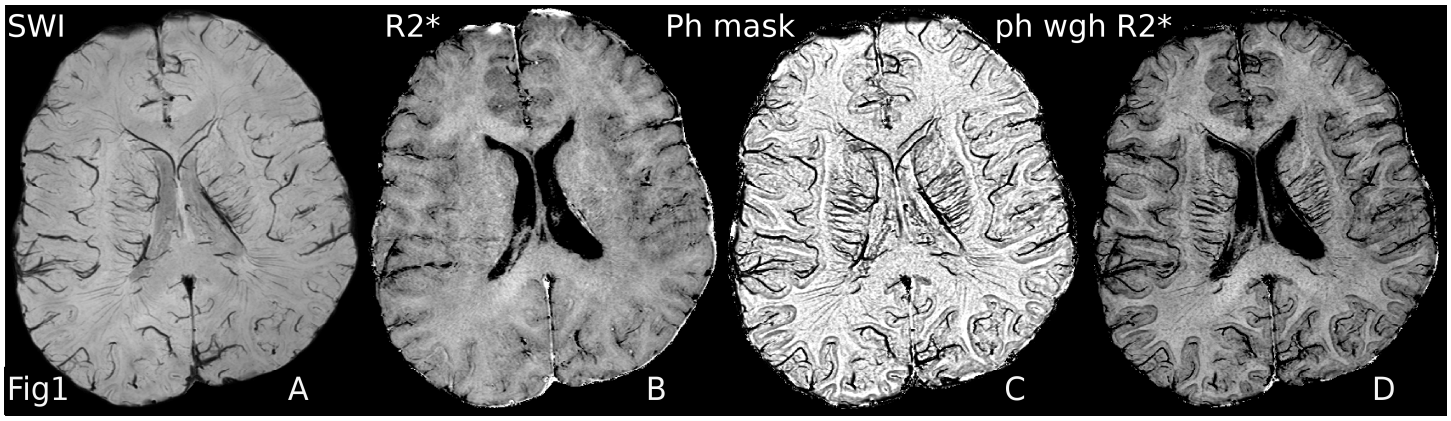
Introduction: Magnetic susceptibility weighted phase images (SWI) provide improved anatomical contrast compared to the corresponding magnitude images [1,2]. At 3 Tesla, T2* of white matter (WM) is about 50 ms and T2* of grey matter (GM) is about 65 ms; therefore, a very long TE would have to be used for good GM/WM contrast in a magnitude image. However the GM/WM contrast is present in R2* maps, even if these maps are computed from echoes shorter than the TE for optimum contrast. The purpose of this study was to perform multi echo SWI from which R2* maps and phase maps are computed and then combined into phase filtered R2* maps with improved GM/WM contrast.

Methods: 3D multi echo gradient echo data were acquired in 24 healthy volunteers on a 3T system (Philips Achieva) using an 8 channel head coil: TE=13ms–41ms; echo interval=7ms; TR/FA=45/17°; FOV=210x160x60mm^3; acquired spatial resolution=0.5x0.75x1.5 mm^3; reconstructed voxel size=0.4x0.4x0.75 mm^3; reconstruction matrix of 512x512x80 voxels; scan duration = 6.7 min. Phase images were corrected using homodyne filters in k-space with the filter behaviour adjusted to the echo time: at TE = 13 ms the filtersize was 0.2 of the k-space dimension. For the subsequent echoes the size was incremented by 0.05 k-space widths. SW images were computed for each individual echo using standard SWI processing [3] and averaged to create the final SW image. Maps of R2* relaxation rates were computed from the five magnitude images using a Levenberg-Marquardt least squares method for non-linear equations with correction for signal decay due to background field inhomogeneities [4,5]. For the phase filtered R2* maps, the 5 phase masks were averaged and multiplied several times with the corresponding R2* map. CNR was computed using ROIs in cortical GM and in WM. The standard deviation in the corpus callosum was used as a measure of noise.

Results: T2* values of 50 ms for WM and 65 ms for GM. a The contrast between GM and WM in the R2* map (Fig. 1B) is improved compared to the magnitude (Fig. 1A). Ten-fold multiplication of the phase mask (Fig. 1C) with the R2* map results in both good GM/WM contrast and good visibility of venous vessels. Small veins are most visible in the SW image. The CNR increases with the number of multiplications with the phase mask and reaches a plateau at about 10 to 12 multiplications (Fig. 2).



Discussion: Susceptibility weighted imaging with multiple echoes provides quantitative maps of R2*, field maps and images with improved GM/WM contrast in the R2* maps combined with the phase images. It should be kept in mind that veins are bright in the R2* maps but dark in the phase mask. Therefore they are visible in the SWI than in the phase weighted R2* images. The T2* values determined in the study are in good agreement with previous studies [6,7].

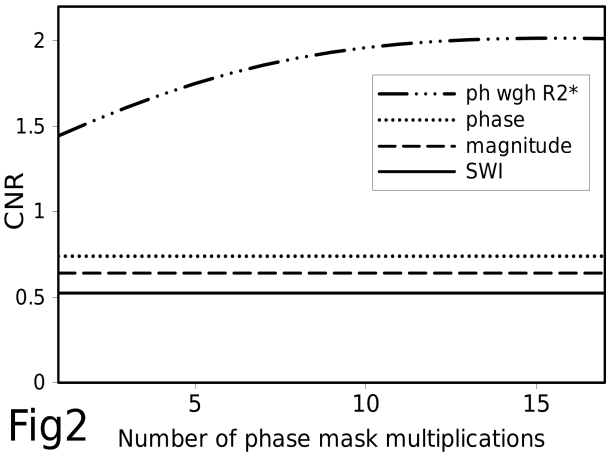


Fig2

References: [1] Duyn et al. Proc Natl Acad Sci U S A, 104(28):11796-801 **[2]** Rauscher et al. AJNR Am J Neuroradiol. 2005 Apr;26(4):736-42. **[3]** Reichenbach et al. NMR Biomed. 2001; 14(7-8):453-67. **[4]** Fernández-Seara et al Magn Reson Med 2000;44:358-366. **[5]** Dahnke et al. Magn Reson Med 2005;53:1202-1206. **[6]** Péran et al. J Magn Reson Imaging 2007;26:1413-1420. **[7]** Du et al. J Magn Reson Imaging 2009;30:449-454.