Comparison of template and individual-based gradient compensated EPI in regions affected by local susceptibility-induced signal loss

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INTRODUCTION Anatomy-related susceptibility gradients in the human head lead to artefacts in echo planar imaging (EPI), the imaging method most commonly used for fMRI. These artefacts are especially pronounced in the prefrontal cortex and cause severe signal dropouts as well as local geometric distortions. Previous studies demonstrated compensation of local signal losses using additional compensation gradients [1]. Recently it has been shown that the use of a common gradient compensation template results in improved fMRI sensitivity in areas affected by strong susceptibility gradients (e.g. the orbitofrontal cortex) [2]. This study evaluates the concept by comparing four groups: (1) no compensation; (2) common template – volunteer not member of the template; (3) common template – volunteer member of the template; and (4) individually compensated.

METHODS All experiments were performed on a 3T scanner (MAGNETOM Tim Trio, Siemens Medical Systems, Erlangen) equipped with the AutoAlign module (CorTechs) which aims to prescribe identical slice positions in different subjects (see Figure 1). Eight volunteers (5 female, 3 male) participated in the study. A modified EPI sequence with distortion correction and Prospective Acquisition Correction (PACE) (40 slices, slice thickness 3 mm, matrix size 64x64, FoV 192 mm, TE 30 ms, TR 2.5 s) was used with and without compensation gradients for signal dropout reduction. The compensation gradients were derived from field maps and were optimized for the prefrontal cortex and the amygdala areas (40 slices, slice thickness 3 mm, matrix size 64x64, FoV 192 mm, TE1 6 ms, TE2 8.46 ms, TR 0.5 s). For the common template, four field maps (2 female, 2 male) were included. The compensation gradients were applied for 15 slices (slice 5-19) in all three directions. The gradient compensation strength was slice-dependent and was designed to have a smooth transition (using a Gaussian filter) for all directions (peak values are from -143 to 114 µT/m). Echo planar images for all four groups were processed using SPM8 (Wellcome Trust Centre for Neuroimaging, London) for motion correction and normalization. Averaged signal intensity across a ROI selected in the prefrontal cortex was analyzed based on the normalized data for all four groups.

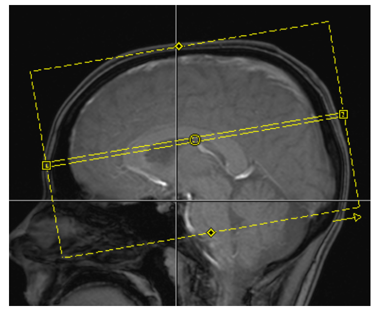

Figure 1: Acquisition volume shown (yellow box) is determined by the AutoAlign module.

RESULTS and DISCUSSION The signal intensities for all compensation cases are higher in the prefrontal cortex compared to the corresponding uncompensated case as shown in the echo planar images in Figure 2. In Figure 3 the percentage signal increase in relation to the uncompensated case is shown for all volunteers. The average signal enhancement (in the prefrontal ROI) for group 2 (common template – not member) is 39.8 ± 5.6%, for group 3 (common template – member) is 37.8 ± 7.1% and for group 4 (individual) is 34.7 ± 4.6%. As expected, signal loss of about 16 % was observed in a control region in the same compensated slices, but outside the optimized area. In general, results show that using a slice-dependent compensation method can compensate susceptibility-induced signal loss. The minor variations in the signal intensity increase between the three compensated cases are not statistically significant, with a slight trend towards template-based correction. The latter may be explained by the fact that averaging between the template members imposes some smoothing and increases the stability of corrections.

CONCLUSION The use of a slice-dependent gradient compensation method improves signal intensity in areas where the compensation is optimized (e.g. the orbitofrontal cortex) and which are otherwise affected by strong susceptibility gradients. In general the signal improvement is about 35% in these areas. Comparing the three different groups (common template – (not) member, individual) the signal increase shows no significant variations. It seems possible to use this method for functional experiments without repeating the calibration individually, thus saving adjustment and calculation time.

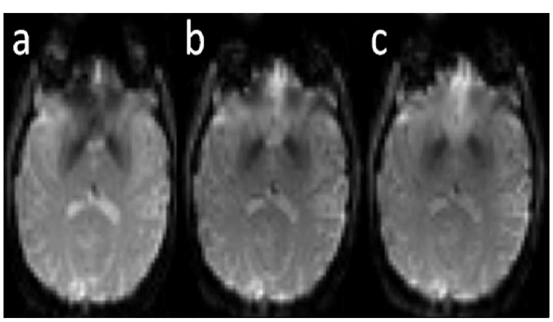

Figure 2: Echo planar images of one slice of volunteer 6 with (a) no compensation, (b) common template and (c) individual compensation.

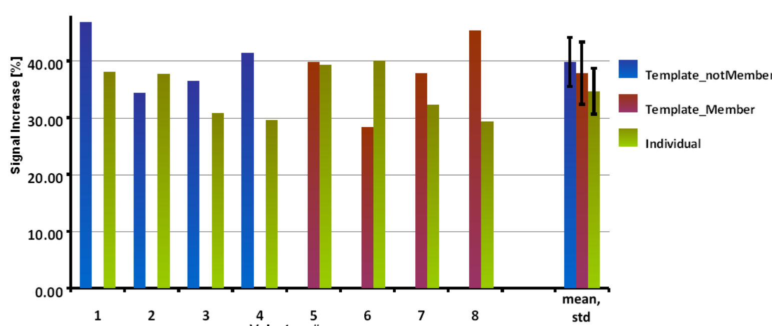

Figure 3: The mean signal increase for all volunteers in chosen ROI (prefrontal cortex) for different compensation cases.

REFERENCES

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