'Homogeneity Helmet' for correcting susceptibility artifacts in f-MRI

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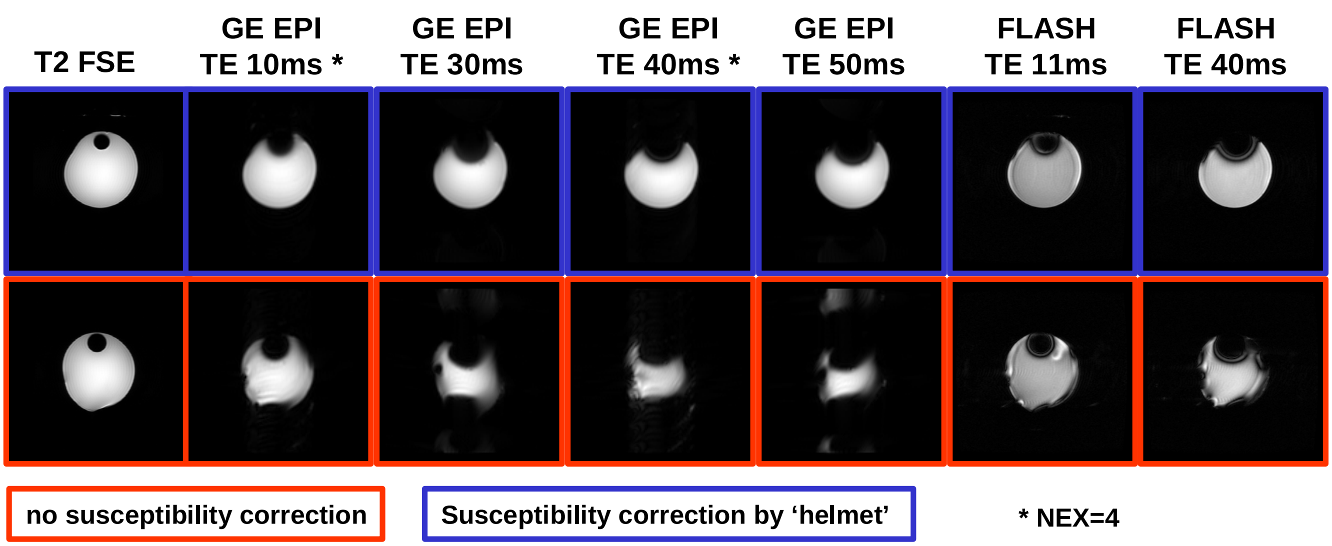
Introduction f-MRI experiments are based on fast gradient echo sequences, which are vulnerable to artifacts resulting from B_0 inhomogeneities. These artifacts are the result of susceptibility variation across the head and are most severe in regions where air-tissue transitions exist, such as near the mouth, nasal sinuses, ears and in the cortex. Susceptibility artifacts can cause geometrical distortions in the image as well as loss of signal due to T_2^* dephasing. The extent of these artifacts increases with the main field and thus compromises the SNR benefit gained for f-MRI in higher fields. B_0 homogeneity correction was suggested by means of passive oral and ear shims for the correction of susceptibility artifacts stemming from the mouth and ear cavities [1]. We aimed at correcting the inhomogeneity caused by susceptibility variations at the external boundary of the head, by surrounding the head with a proton-less liquid which susceptibility is similar to that of the head. The goal of our work is to create a helmet which exterior half is a pillow placed within the head-coil and which posterior half is placed on the head just under the rung of the head-coil. Such a device will cause minimal patient inconvenience and can thus yield a non-penalty correction for B_0 variation, especially in the cortex. We conducted preliminary experiments on several head-like samples and corrected some of the artifacts in EPI experiments caused by susceptibility inhomogeneity.

Materials and methods In order to imitate the effect of an air cavity inside the head, we used a soft, water-filled balloon, ~14cm in diameter, that contained a rigid, air-filled sphere ~4cm in diameter. This phantom was surrounded by a Fluorinert-containing balloon. Teflon arcs maintained a fluid thickness of at least 3cm around the phantom. Fluorinert is a perfluorinated hydrocarbon with similar magnetic susceptibility to that of biological tissues and can thus serve to shift the boundary effect of B_0 away from the imaged object.

Imaging was preformed on a 3T GE Signa imager and AutoShim was used. We utilized FSE imaging for assessing the geometry of the phantom. FLASH imaging was performed for observing the extent of T_2^* distortions and EPI sequences were utilized under several TE values, up to 50ms which is commonly used for f-MRI experiments.

Results and discussion The figure compares images obtained with (top) and without (bottom) susceptibility correction by the Fluorinert 'helmet'. From the FSE images one can see that minor geometry difference was introduced by adding the 'helmet'. Artifacts reduction is observed for EPI images at all TE values, but the effect is most dramatic for TE=50ms which mimics BOLD conditions. From the FLASH images one can learn that correction for T_2^* reduction is mainly in the periphery of the phantom, as could be expected due to the $1/r^3$ dependency of B_0 on susceptibility. Note that for all EPI images the effect is major in both restoring the right geometry and in increasing T_2^* which is expressed by a higher total integral of the images, thus increasing SNR.



Conclusions

We have demonstrated that a dramatic susceptibility artifacts correction can be attained by surrounding the imaged object by a 'helmet' of MRI-inert fluid. Developing such 'helmets' for human use can significantly improve the outcome of f-MRI experiments in both their geometrical accuracy and their total SNR and may lead the way to functional imaging of problematic brain regions.

References

(1) J.L. Wilson, M. Jenkinson and P. Jezzard, Optimisation of static field homogeneity in human brain using diamagnetic passive shims. *Magn. Reson. Med.* **48** (2002), pp. 906–914.