Feasibility of high resolution single shot imaging at 7T.

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Introduction
Diffusion weighted imaging, and in particular diffusion tensor imaging (DTI), has the potential to reveal some of the fine structure in the brain that is not accessible by conventional MRI. To attain this, one needs to achieve a high spatial resolution, while maintaining a sufficient signal to noise ratio (SNR). In addition, motion-related artifacts need to be kept at a minimum by using single-shot imaging techniques such as EPI. While the SNR constraint can be eased by using high field strength and receive coil arrays, the resolution of single shot EPI images is limited by $T^*$ decay, which is accelerated at higher field strength ($T^*$ is the $T_2^*$ relaxation time). One way to alleviate this problem is the use of parallel imaging techniques such as SENSE [2], which allow for an increase in spatial resolution in the presence of $T^*$ decay [1]. Here we demonstrate SENSE imaging at 7 T, and the feasibility to acquire single shot images at 1.25x1.25 mm$^2$ in-plane resolution.

Methods
Experiments were performed on a GE 7 T scanner, equipped with a Nova Medical 8 channel receive-only brain array and a birdcage type volume exciter. The design of the 8-channel brain array was based on the design described earlier [3]. All volunteers involved in this study gave informed consent in accordance with a NINDS IRB protocol. Prior to imaging, higher order shimming was performed using the phase information of the coil sensitivity maps. As part of the imaging sequence, a set of coil sensitivity maps was acquired using an interleaved EPI, it is important that the coil sensitivity maps are measured with an interleaved EPI, it is important that the coil sensitivity maps are measured with an interleaved EPI, it is important that the coil sensitivity maps are measured with an interleaved EPI.

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Results & Discussion
Examples of single shot SENSE-EPI image quality at 7 T are given in Figure 1 and 2. Figure 1 shows twelve axial slices with 1.7x1.7 mm$^2$ resolution, Figure 2 shows the same slices at 1.25x1.25 mm$^2$ resolution. The images demonstrate that, in spite of the low $T^*$ at 7 T, high resolution single shot imaging is possible with high image quality and SNR. The lower slices of the high resolution data show some areas with increased intensity on the left side due to the scaling of the SENSE reference images. As there is no body coil reference possible, the reference is calculated from a combination of the eight coil images. These have hot spots close to the coil elements that can not always be corrected in this method. Note this is a scaling factor that cancels out in the calculation of a diffusion map. The SNR varies widely due to the high image contrast; in the 1.72 mm$^2$ images it was 50–350, with 70–120 for most tissue voxels, in the 1.252 mm$^2$ scan it was 20–100, with 30–40 in most tissue voxels. The stability (the ratio of the SD over time and the average per voxel) is shown in Fig. 3.

In the current implementation the coil reference is acquired as an interleaved EPI, which appears to suffer occasionally from respiratory and/or motion induced artifacts. This is demonstrated in Fig. 4, which shows the fitted phase and frequency of a navigator echo. There is a clear periodic modulation visible in both plots. Analysis of the phase of images acquired with a TR of 100ms showed there is also significant spatial non-uniformity in the phase modulation, i.e. different parts of the brain require a different correction which is not possible with a simple zero or first order navigator. It is however possible to acquire the reference data at a lower resolution in a single shot. The results indicate the feasibility of single shot diffusion imaging at 7.0 T. We are currently working on increasing the number of channels to further improve resolution through increasing SNR and SENSE performance.

References