# The influence of SENSE on the PSF and SNR in high-resolution single-shot echo-planar DTI at 3 T

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## INTRODUCTION

Diffusion Tensor Imaging (1) has become an established tool for the non-invasive mapping of axonal structures in the living human brain. However, detailed studies of neuronal fiber tracts are seriously hampered by the current limits of the technique. Commonly relying on spin-echo EPI (SE-EPI) sequences, DTI's ability to resolve small details is strongly restricted by $T_2$* decay, causing blurring, and distortions related to $B_0$ inhomogeneities. Another serious resolution limit stems from the strong link between voxel size and signal-to-noise ratio (SNR), the latter being inherently low due to extensive $T_2$ decay and diffusion weighting. In view of these challenges, parallel DWI and DTI (2-4) is currently receiving increasing attention.

In the present work, we explore the influence of the parallel SENSE technique on the point spread function PSF and the SNR for pushing DTI resolution beyond previous limits. We discuss the seemingly paradoxical observation that parallel acquisition does not reduce but rather enhance the SNR efficiency in single-shot SE-EPI (sshSE-EPI). For the CNR a similar observation was previously made by Heidemann et al. (5).

## METHODS:

The PSFs in Figure 1 were calculated using the inverse Fourier transform of simulated signal attenuation curves. $T_2$ and $T_2^*$ were fixed to 70 ms and 44 ms according to Ref. 6.

The relative SNR yield (Fig. 2) was approximated as $\mathrm{SNR}_{\mathrm{relative}} = \exp(\Delta TE\ /\ T2) * \sqrt{f}\ /\ (g\ \sqrt{R})$ with respect to a full EPI train. Here, $\Delta TE$ denotes the echo time reduction achieved with SENSE and partial Fourier acquisition. $g$ denotes the geometry factor. For SNR estimation, actual $g$ values were calculated from one volunteer data set.

Imaging was performed on a 3 T whole body system (Philips Medical Systems, Best, the Netherlands) equipped with an eight element head coil array (MRI Devices Corporation, Waukesha, USA). For maximum spatial resolution, $R$ = 2.4 -fold SENSE reduction was combined with $f$ = 60 % partial Fourier acquisition (matrix = 256 x 256, FOV = 200 mm, 5 slices, thickness = 4 mm, $TE$ = 93 ms, $TR$ = 1927 ms).

## RESULTS:

Figure 1 illustrates different PSFs in phase encode direction for SENSE reduction factors in the range between 1 and 6. Figure 2 depicts estimates of relative SNR. SNR optima occur at $R$ values between 1.9 and 3.7.

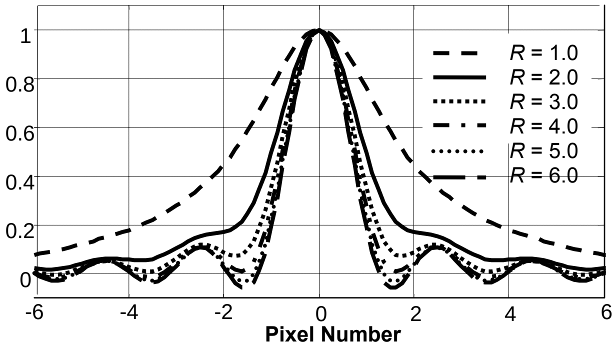

**Figure 1:** PSFs in phase encode direction for six different reduction factors.

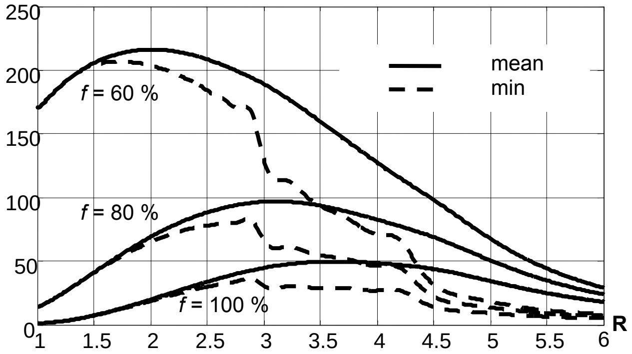

**Figure 2:** Relative SNR in sensitivity-encoded diffusion weighted images using $256^2$ acquisition matrices and partial Fourier factors of $f$ = 60 %, 80 % and 100 % as a function of R.

## DISCUSSION:

The PSF becomes narrower with increasing *k*-space velocity in the phase encode direction (which is proportional to *R*). In this regard the largest possible value for *R* would be the most favorable. Large *R*-factors are suboptimal, however, in terms of SNR. The added SNR required for reducing voxel size is partly afforded by the transition to 3 Tesla. Another significant contribution seems to stem from reducing the echo time by SENSE and partial Fourier acquisition, as suggested by the estimation of the SNR behavior. This is noteworthy because in principle parallel imaging incurs loss of SNR efficiency – unless relaxation behavior and timing constraints change the SNR dynamics, as is the case in sshSE-EPI.

## REFERENCES:

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