Effect of Smoothing on High Resolution fMRI Experiments at Higher Field Strengths

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INTRODUCTION

Sensitivity and specificity of BOLD fMRI maps are expected to improve with increasing field strength due to favorable increases in BOLD contrast, BOLD localization, and improved image sensitivity. The increase in image sensitivity with higher field, however, is not fully utilized at conventional spatial resolutions since the fMRI time-course noise is dominated by physiological noise. As higher image sensitivity is achieved through the use of better RF coils or bigger magnets, the physiological noise increases proportionally. The result is that for high field fMRI at conventional image resolutions ($27mm^3$), increases in image SNR (SNR_0) result in only marginal increases in the SNR of the fMRI time-course (tSNR) [1].

Our previous work showed that it is possible to take better advantage of high field image SNR by acquiring the functional images at higher spatial resolutions and thus operating in a regime where thermal image noise dominates physiological noise [2]. The goal of this study is to attempt to better utilize high field image SNR when high spatial resolution is not needed, such as many cognitive studies where large areas of the cortex are activated. While these studies are expected to benefit from the contrast and localization improvements at high field, analysis of the time-course SNR shows that they receive only marginal benefit from the increases in sensitivity.

In this study, we examine the effect of spatially smoothing 7T and 3T high resolution EPI images down to conventional resolutions. The **goal** is to obtain the best of both worlds; **thermal noise dominated images at acquisition which benefit from the sensitivity of high field, and increased tSNR from spatial smoothed images with largely spatially uncorrelated time-course noise**. Our findings demonstrate that in contrast to conventional penalties associated with smoothing Fourier data, the resulting time-course SNR can be improved compared to direct acquisition at the desired resolution.

METHODS

- Comparative studies were performed at two different field strengths; a 3T (Siemens Allegra) and a prototype 7T Siemens systems (Siemens, Erlangen, Germany).
- Images from 3 healthy volunteers were acquired at each scanner.
- A transmit-receive volume coil (TEM design) used at 7T and a high-pass birdcage design at 3T.
- **IMAGING PROTOCOL**

➢ ***GRE- EPI sequence with variable in-plane resolution***

TR=5400msec, 10 slices, slice thickness=3mm, flip angle=90°, 60 measurements, TE_{3T}=30msec, TE_{7T}=20msec, in-plane resolution=**1mm x 1mm, 1.5mm x 1.5mm, 2mm x 2mm, 3mm x 3mm, 4mm x 4xmm, 5mm x 5mm**.

- **DATA ANALYSIS**

➢ ***Smoothing analysis with variable kernel size***

Post-processing spatial smoothing was employed to generate additional low resolution images by convolving the 1.5mm x 1.5mm high resolution scan with a Gaussian smoothing function. The FWHM of the smoothing kernel was chosen so that the resolution of the resulting smoothed data matched the nominal voxel size of the lower resolution acquired images, FWHM=2x2, 3x3, 4x4, 5x5, 6x6, 7x7, 8x8, 9x9, 10x10.

Resolution (mm^2)	tSNR Sm. / tSNR Acq. 7T	tSNR Sm. / tSNR Acq. 3T
2x2	1.07	1.02
3x3	1.15	1.14
4x4	1.32	1.22
5x5	1.66	1.40

Table 1: Time-course SNR of the smoothed data over the time-course SNR obtained from acquiring low resolution data directly.

RESULTS

➢ **Figure 1** illustrates the dependence of both the tSNR and SNR_0 on spatial resolution. As shown in previous work [2] the tSNR has reached an asymptote; increasing SNR_0 from larger voxels result in only marginal increases in tSNR.

➢ For the smoothed data, tSNR increased monotonically with voxel size at each field strength, and is always higher than the corresponding voxel size of the acquired data.

➢ **Table 1** shows the tSNR gain of the smoothed high resolution data over the acquired data obtained at the same resolution .

CONCLUSION

This work suggests that if a low spatial resolution high field fMRI study is desired such that physiological noise dominates the time-course SNR, it might be advantageous for the time-course SNR to acquire at a high enough resolution so that thermal noise dominates and then smooth to the desired low resolution.

Effect of Smoothing on High Resolution fMRI time-course

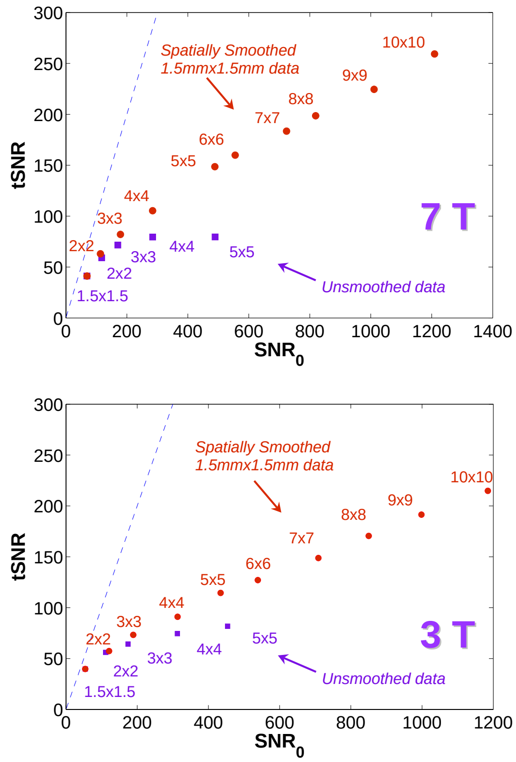

Figure 1: fMRI time-course SNR as a function of image SNR (SNR_0) at various spatial resolutions at 7T and 3T. Squares represent the acquired data at different in-plane resolutions. Circles indicate different degrees of spatial smoothing of the high resolution (1.5mm x 1.5mm) data. Measurements derived from areas of cortical gray matter at each resolution.

REFERENCES:

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