Variable-Density Sensitivity Encoded Functional MRI

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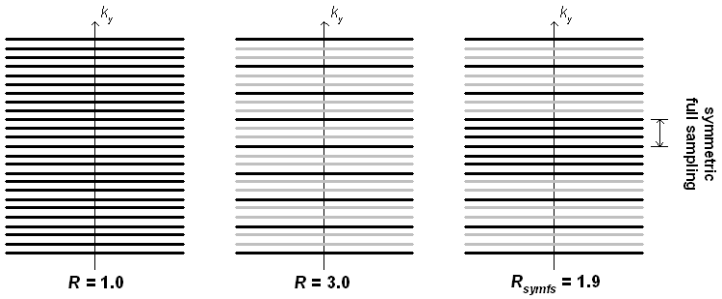
Introduction

The application of parallel MRI technique to functional brain imaging has been documented by using either PRESTO [1] or EPI [2, 3] sequence. These methods adopt equal-distant sampling in k-space in order to achieve spatiotemporal resolution enhancement and image distortion alleviation. The property of higher data power at the center of k-space inspired the variable-density parallel MRI, including VD-SMASH [4], and SHRUG [5]. In the past, these techniques were applied to cardiac dynamic imaging. In this study, we apply the variable density parallel MRI acquisition to functional brain imaging to study the effect of BOLD contrast-to-noise ratio (CNR) improvement. We used a 4-channel head array coil at 1.5T scanner and a finger flexion motor task. We found that CNR is improved when we increase the sampling at the center of k-space when we unfold parallel MRI data at 2.00-fold acceleration.

Methods

Blocked-design motor fMRI data were acquired from a 1.5T (GE medical, Milwaukee, WI) scanner using a 4-channel head array (Nova Medical, Wakefield, MA). The array wrapped around the periphery of the whole head with 4 equally curved rectangular surface coils. The subjects were asked to perform the finger flexion task using their thumb and other fingers of their right hand alternatively during the "on" block for 30 seconds continuously. The finger flexion was self-paced, and the subject randomly determined the fingers for the flexion task. Following the "on" block, the subject was asked to remain still without any hand movement during the "off" block for 30 seconds. 2 "on" and 2 "off" blocks were recorded. We used a 2D gradient echo EPI sequence with parameters: TR= 2500 msec, TE=50 msec, flip angle=90 deg, slice thickness=6 mm without gap, 8 slices, FOV= 240 mm x 240 mm, image matrix=128 x 128.



Since k-space data in general shows higher power at the center, we propose to sample symmetrically without skipping around the center of k-space during parallel MRI acquisition. The dense sampling region in k-space was termed "symmetric full sampling" (*symfs*). Figure 1 at left shows the k-space trajectory without parallel MRI (R=1.0), parallel MRI at 3.00-fold acceleration (R=3.0) and parallel MRI with *symfs* at 1.9-fold acceleration. In this study, all EPI images from the experiment were decimated to have *symfs* of 0, 4, 16, 32 to obtain 2.00, 1.88, 1.6 and 1.33 fold accelerations, respectively.

Using the motor task paradigm, *t* tests were performed on the reconstructed SENSE fMRI to contrast "on" and "off" conditions. The detection power of various SENSE reconstructions were computed using the receiver-operating characteristic (ROC) curves. In experimental data, we used EPI data with full k-space acquisitions to generate the relative "gold standard" of functional activation loci. All voxels with *t* statistics above 4.0 ($p<0.0001$) were considered to be estimate of functional activation. True positive rate and false positive rate of the detection were calculated separately.

Results and Discussion

Figure 2a shows the *t* statistics maps overlaid on the EPI images. Note that symmetric full sampling will increase the detection of BOLD activities around the motor region at the contralateral side. A larger significant active region was found at higher *symfs* at the same *t* statistics threshold. Quantification of the detection power using ROC analysis is shown in Figure 2b and 2c. We found that at the more *symfs* yielded a higher detection power. At the same acceleration rate R=1.88, *symfs* can slightly increase detection power. These simulations and experimental data demonstrate that higher sampling at the center of k-space can improve fMRI detection power when applying parallel MRI imaging technique to functional brain imaging.

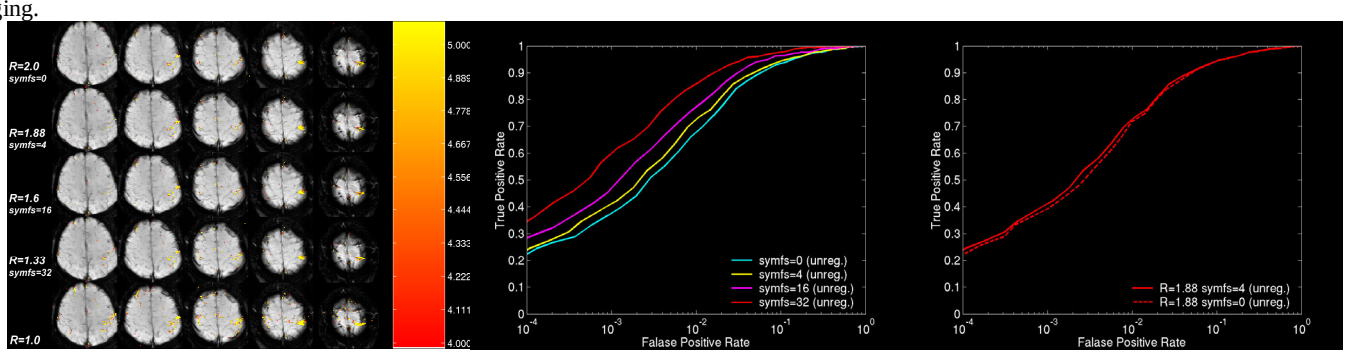


Figure 2a (left): t statistics maps on different *symfs*. 2b (middle): ROC curves at different *symfs*. Note that higher symfs yielded higher detection power. 2c (right): at the same acceleration rate (R=1.88), *symfs* increases detection power slightly compared to no *symfs*.

Acknowledgement

This project is supported by NIH R01 HD040712, NIH R01 NS037462, NIH P41 RR14075 and the MIND Institute.

References

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