Test-retest reliability assessment for longitudinal studies spanning a major MRI system upgrade

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Introduction

There comes a time in the lifecycle of an MRI research center when major scanner hardware and software upgrades become necessary. Scanner hardware upgrades, while greatly desirable for the increased capabilities they bring, may raise concerns for ongoing functional MRI studies. The TIM upgrade of Siemens Trio 3T systems has taken place in many centers around the world, including ours, in recent years. Other studies have looked at the effect of scanner model on MRI data through multi-center studies for anatomical data [1] and functional data [2]. Here, the effect of a major scanner upgrade on BOLD data at two different spatial resolutions was studied.

Methods

In this study, four scanning sessions, two before and after the upgrade, were done on the same five subjects. Sessions included anatomical 1mm^3 MPRage acquisitions (TR/TE/alpha = 2300ms/3ms/90° on a 256x240 matrix) and BOLD functional runs. To assess BOLD sensitivity under conditions of high and low SNR, we acquired at two different spatial resolutions (2x2x2mm and 4x4x4mm). TR/TE/alpha = 2000ms/30ms/90° were kept equal, with matrix sizes of 64x64 and 128x128, as well as 21 slices and 33 slices for high and low resolution acquisitions respectively. During functional runs, a visual stimulus was provided with alternating 30s blocks of rest and stimulation. Two types of visual stimuli were alternated: a low contrast, low intensity moving grating and a high contrast, high intensity flashing checkerboard stimulus. Data were analyzed with the Neurolens software package. Data were motion corrected and intensity normalized. A spatial smoothing Gaussian kernel of 4mm and 6mm was was applied to high and low resolution data respectively for group analysis. Data for individual region-of-interest (ROI) analysis were not smoothed. A linear model approach with canonical HRF including post-stimulus undershoot was applied to all datasets. Percent effects, t-maps and signal-to-noise ratio (SNR) maps were obtained for every functional runs. 3 sessions were excluded from the analysis due to excessive subject motion causing a large ring of spurious activations at the periphery of the brain. Occipital and V1 ROIs were defined for each subject at each resolution. The occipital ROI was defined using standard anatomical landmarks and restricted as much as possible to grey matter by manual editing. The second was defined by removing large veins from the activated voxels from the statistical maps.

Results

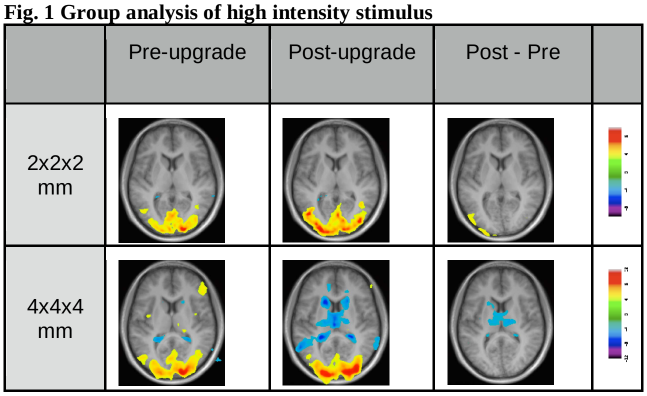
Overall, results show no significant differences due to the upgrade (Fig.1&2). This likely reflects the fact that our experiments were dominated by physiological as opposed to instrumental noise (Fig.3). Percent signal changes arising from simple visual tasks did not change significantly (Fig.2). Group analysis did not show any significant differences at high spatial resolution, but did show greater negative responses around frontal lobes and striatum at the lower resolution (Fig.1).

Discussion

The results shown here demonstrate that the differences in hardware coming from a major upgrade may not threaten the validity of functional studies done across the scanner upgrade. BOLD data at the spatial resolutions used here are dominated by physiological noise and hence not limited by scanner performance. However, the areas of more prominent negative change need to be further characterized and may reflect an area of higher SNR in the center of the brain following the upgrade.

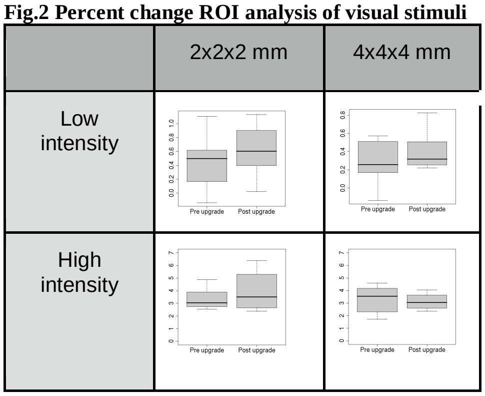
References[1] Jovicich, J. et al. *NeuroImage* 30, 436-43 (2006); [2] Friedman, L. & Glover, G.H. *NeuroImage* 33, 471-81 (2006)

Fig. 1 Group analysis of high intensity stimulus



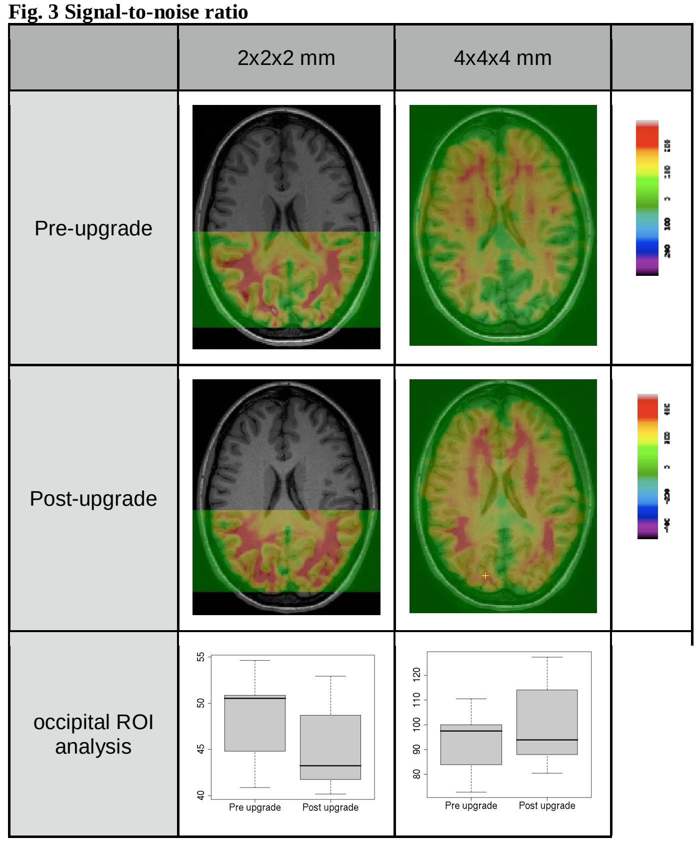
In the high resolution scans, a cluster of significant signal was found around visual areas. However, scans like this one are more sensitive to motion and this may be artifactual. The low resolution analysis shows a significantly greater deactivation pattern post-upgrade. This may reflect an increased sensitivity allowing detection of putative default network deactivation.

Fig.2 Percent change ROI analysis of visual stimuli



Box plots of ROI analysis over V1 for low and high intensity stimuli. There was no significant difference in percent signal change for any of the conditions examined across the upgrade.

Fig. 3 Signal-to-noise ratio



SNR maps overlay for an example subject. The last row shows box plots for ROI SNR quantification comparison for occipital cortex across the upgrade. There was no significant difference in SNR at either spatial resolution for occipital grey matter.