Assessing Signal Stability in Diffusion Tensor Imaging

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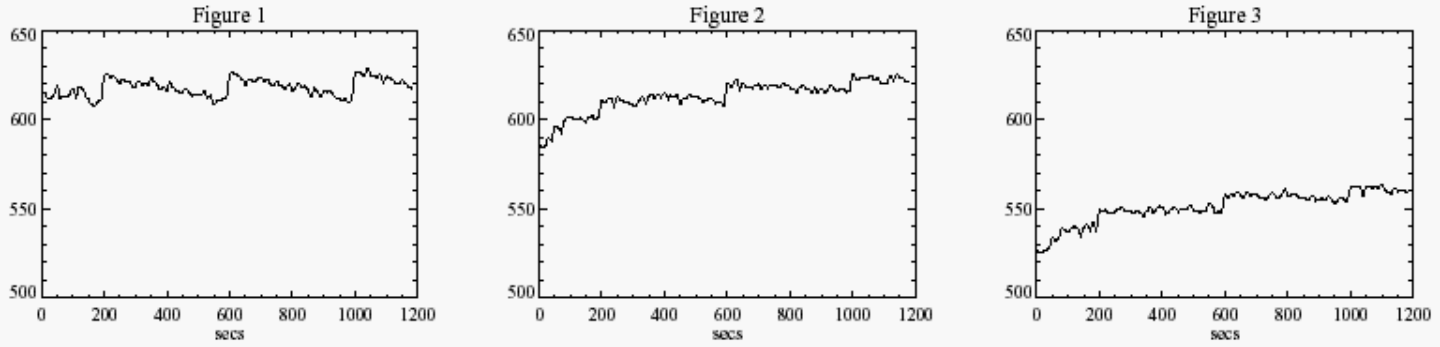
Introduction: Diffusion Tensor Imaging (DTI) data is typically collected using a spin echo pulse sequence with echo planar readout and high amplitude pulsed magnetic gradients for diffusion weighting. As such, DTI acquisition places considerable stress on scanner hardware that can lead to changes in the measured signal. Methodologies have been developed for assessing signal stability in fMRI because of its importance in the interpretation of collected data [1]. Signal stability is also important for DTI since the computation of the apparent diffusion is based directly on the measured signal intensity. Signal drift between the collection time of the no-gradient image and the diffusion weighted image would introduce errors in the diffusion measurement. To date, there has not been much attention paid to assessing signal stability in DTI. The typical DTI collection involves averaging of multiple acquisitions to improve SNR. When averaging is done as part of the reconstruction, then the resultant intermediate images are no longer available to assess potential changes in signal over time. DTI acquisition times can extend over several minutes, for our scans around 8 minutes. In this work, we acquired DTI data in a phantom, without averaging in order to assess signal stability over a 20 minute period.

Methods: DTI data from a fluid filled 7300cc cylindrical Siemens phantom were collected with a Siemens 3T Trio whole body scanner using the standard single channel head coil. A pulsed gradient, single shot EPI imaging sequence was used that had two spin echos to minimize eddy current effects. Six 2mm slices were collected (TR=1.3 sec, TE=100 msec, 128x128 matrix) with no gradient weighting (B=0) and with six non-collinear gradient directions for a total of 42 images every 10 secs. This sequence was repeated 120 times for a total data collection time of 20 minutes. Acquisitions were performed with high (B=1000) and low (B=50) diffusion weighting to assess the effect of gradient load on signal intensity. Custom image analysis software was written in IDL (Research Systems Inc., Boulder CO) to allow the assessment of signal from the same 10x10 ROI in different slices with different gradient directions and gradient strengths.

Results: Signal intensity time courses were similar across the six slices for each condition so data from slice 3 are presented. Figure 1 illustrates the signal from the 120 B=0 images over a period of 20 minutes with gradient strength of B=1000. A 5% jump and then slow decrease in signal is observed at 200, 600 and 1000 secs. This same timing pattern in signal jump was observed on multiple scans performed on different days. To determine the effect of reducing gradient duty cycle on signal, the experiment was repeated with a gradient strength of B=50; Figure 2 illustrates the signal inform the B=0 images increasing 7% over 20 minutes with signal jumps at 200, 600 and 1000 secs. Figure 3 plots the signal from the gradient weighted images using the first direction (B=50 acquisition) showing the same jump in signal at 200, 600 and 1000 secs.



Discussion: Examining the time course of signal during sequential DTI acquisitions uncovered variations and patterns of signal not observed in fMRI signal stability tests performed on this scanner. This may be a useful strategy for monitoring and troubleshooting potential DTI acquisition problems. In our case, the observed signal jumps, time locked to the beginning of the scan, suggest this is linked to some characteristic of the hardware. A modified DTI acquisition that saves intermediate images and also has signal monitoring navigator scans occurring approximately every 10 sec, may be an approach to identify and adjust for signal variation in DTI acquisitions.

References: [1] Weisskoff RM, MRM, 1996 Oct 36(4):643-5

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