INTRODUCTION

• Diffusion tensor imaging (DTI) contrasts, including fractional anisotropy (FA) and mean diffusivity (MD), have been widely applied to characterize white matter changes in diseases and stroke.

• Typical in vivo human DTI studies span a range of signal to noise ratio (SNR) where, at the low end of clinical SNR, the eigenvalues tend to systematically diverge from their true (high SNR) value, which leads to clinically significant changes in FA while MD is relatively less affected.

• Consequently, the optimization of DTI acquisitions is an important effort and previous studies have investigated the effects of noise, diffusion weighting scheme, and tensor estimation method both in simulation and in vivo.

• Yet, considerable uncertainty remains as to how to properly evaluate the tradeoffs between these three parameters, compare results, and ultimately select an appropriate DTI protocol.

This study provides a simple, quantitative metric to evaluate the tradeoffs made when choosing these parameters in DTI experiments.

FA BIAS IS NON-MONOTONIC AND TENSOR DEPENDENT

• A high resolution, high SNR dataset with 15 repetitions of 30 diffusion weighted (DW) and one scanner average of 5 minimally weighted (b0) acquisition at 1.5T was used as ground truth to assess the effects tensor estimation method.

• Simulations were performed using the Stejskal-Tanner model of diffusion, as previously described (6,7).

• An axial slice at the level of the lateral ventricles was selected to be representative of human brain anatomy.

• Four methods of tensor estimation were compared to demonstrate the practical consequences of applying a few of the many widely available choices.

1. Direct application of the Stejskal-Tanner tensor model of diffusion, as previously described (6,7).
2. Replacing any DW values that were greater than the b0 value with the b0 value prior to LL-MMSE, denoted LL-MMSE (clip DWI).
3. Replacing negative eigenvalues with zero-values, denoted LL-MMSE (clip eigenvalues).
4. Non-linear tensor fitting method provided with the AFNI toolkit [2].

• SNR is reported relative to non-diffusion weighted (b0) volumes.

RESULTS

The low SNR limiting mean values of FA and MD depended on tensor estimation method. At very low SNR (<0 dB), there was little contribution from the underlying ground truth data on the estimated contrasts. At low SNR (0-20 dB), the bias in underlying contrasts rapidly increased with decreasing SNR, while the rate of change was much reduced at moderate SNR (20-40 dB). At high SNR (>40 dB), there was little change with SNR or dependence on estimation method. The positive definite method showed reduced bias in FA, but increased bias in MD. In terms of RMS error, the positive definite method outperformed the three LL-MMSE methods for estimating FA, but showed reduced performance in MD estimation. The modified LL-MMSE algorithms demonstrated improvements in all FA measures over the LL-MMSE method and nominal MD improvements.

REFERENCES