Effects of 8 and 32-Channel Phase Array Coils on DTI Metrics

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Introduction
Phase array coils with an increased number of receiver channels improve signal-to-noise ratio (SNR) [1] although a number of authors have reported less improvement in SNR with increasing distance from the array [2,3]. This is important to understand when making measurements sensitive to noise such as with diffusion tensor imaging (DTI) , which measures anisotropic water molecular diffusion through diffusion encoded MRI pulse sequences and has been applied in particular mapping the white matter fibres in the brain [4]. Here, we have used the residual bootstrap approach [5] to determine the impact of coil choice on DTI metrics in different regions of the brain.

Methods
Five healthy volunteers (26 - 35 y) were scanned on a Philips Achieva TX 3T scanner (Philips, Best, The Netherlands). DTI was acquired using a single-shot spin-echo EPI sequence (b = 1000s/mm^2), 32 gradient directions, FOV 240 x 240 mm, matrix size 96 x 96 x 55, 2.5 mm isotropic, TR = 11.8 s, TE = 83 ms, SENSE factor = 2. Two DTI datasets were acquired with each paradigm using an 8 and a 32-channel head coil. The order of acquisition was randomized. Each diffusion weighted volume (DWI) was registered to the B0 image using FLIRT (FMRIB's Linear Image Registration Tool, Oxford, UK) [6] with a sinc interpolation full-width of seven voxels [7]. Diffusion tensors were reconstructed through linear regression, and fractional anisotropy (FA) was then calculated [5]. A residual bootstrap with 200 resampling iterations was used to estimate the uncertainties as measured by the standard error (SE) of FA. For the group analysis, the FA maps were firstly registered to MNI space. The transformation was estimated through applying a linear registration of B0 image to the MNI template with FLIRT, and the FA maps were registered with the same transformation. Non-linear registration was then conducted using FNIRT with an arbitrarily chosen FA map of a subject as the template. The same transformations were applied on the SE of FA maps, and the coefficient of variance (CV), which is the ratio between the SE and mean, was calculated as a normalized measure for the uncertainty.

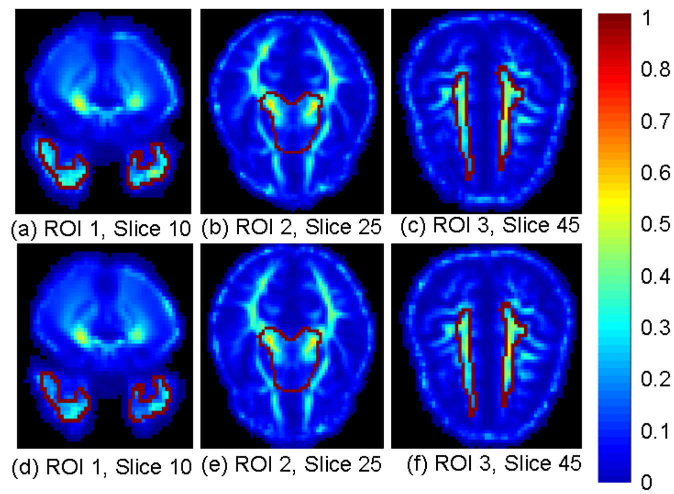

Figure 1: Averaged FA map with ROI. (a)-(c) for 8 channels, (d) – (f) for 32 channels.

Results and Discussion
Three regions of interests (ROIs) (Fig. 1) with high SE were drawn in different slices across the whole brain. The mean FA, SE of FA and CV (Table 1) for all subjects are shown with standard deviations (SD) for each ROI. The mean SE of FA was 13.81% and 11.03% less with the 32-channel (32CH) coil at the bottom (ROI 1) and the top (ROI 3) of the brain respectively compared to 8-channel (8CH), while the SE with 32CH was 0.55% higher in the central region (ROI 2). The CV was also reduced by 14.81% and 11.71% at ROIs 1 and 3, respectively. At ROI 2, however, the CV with 32CH was 0.37% higher than 8CH. A paired student's t-test ($P<0.05$) of CV showed a significant difference between the 8CH and 32CH at ROIs 1 ($P=0.03$) and 3 ($P=0.02$) but no significant difference at ROI 2 ($P=0.76$). Over all white matter voxels, the SE with 32CH was 10.86% less with a CV reduction of 9.53% (FA > 0.2). The scan time and SAR were 6 min 54 sec and less than 36% respectively for both coils. The less uncertainty as measured by the SE of FA and CV indicates improved reliability of DTI measurements with the 32 channel coil given the same scan time and SAR.

		ROI 1	ROI 2	ROI 3	WM
FA (x10^{-1})	**8CH**	2.08±1.17	1.98±1.53	2.87±1.54	2.22±1.17
	32CH	2.07±1.12	1.97±1.53	2.86±1.53	2.20±1.15
	% diff.	**-0.48%**	**0.51%**	**-0.35%**	**-0.90%**
SE of FA (x10^{-2})	**8CH**	1.81±1.09	1.81±0.80	1.36±0.37	2.67±3.23
	32CH	1.56±0.93	1.82±0.83	1.21±0.34	2.38±2.96
	% diff.	**-13.81%**	**0.55%**	**-11.03%**	**-10.86%**
CV (x10^{-2})	**8CH**	11.34±7.90	13.59±8.33	6.32±3.82	13.22±14.27
	32CH	9.66±7.74	13.54±8.18	5.58±3.48	11.96±13.39
	% diff.	**-14.81%**	**0.37%**	**-11.71%**	**-9.53%**

Table 1: FA, SE of FA and CV for 8 and 32-channel coils (% diff. was calculated with 8-channel results as 100%).

Conclusions
Reliability of DTI metrics was significantly improved by use of a 32-channel coil, apart from in the central region of the brain where there was no significant advantage in using 32 channels over 8 channels. This indicates that 32 channel coils may confidently be used over 8 channel coils for DTI metrics in any region of the brain.

References
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