Readout-Segmented Diffusion Tensor Imaging (RS-DTI) Acceleration Using Simultaneously Acquired Slices

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Target Audience: Researchers who are interested in accelerating readout-segmented EPI using simultaneously acquired slices.

Introduction: The advent of slice-accelerated (multiband) Echo Planar Imaging (EPI) has allowed for greatly accelerated diffusion tensor imaging (DTI)[1,2]. Multiband imaging poses a significant advantage in cases where the number of required slices increases the repetition time (TR) increased beyond what is ideal for T_1 relaxation. In readout-segmented EPI (RS-EPI)[3,4], a navigator echo is acquired in addition to the imaging echo, which increases the minimum TR. Coupled with the requirement of the additional segments in RS-EPI, the longer TRs of RS-EPI compared to EPI can result in long acquisitions – particularly in cases requiring high-resolution acquisitions. In these cases, multiband accelerations of 2 or 3 can be used to reduce the TR from ~10s to about 3-5s on a 3T scanner. **This work shows that accelerations of 2-3 can be used to reduce the otherwise long scan time of RS-EPI DTI to clinically feasible durations.**

Methods: Acquisitions: Multiband RS-EPI DTI scans on 2 volunteers were acquired on a 3T scanner using a 32-channel head coil (Nova Medical, Wilmington, MA, USA). Acquisition parameters which were identical for all scans were: blind matrix of 64x192, 7 blinds, final matrix of 192x192, a FOV/z-FOV= 24/16 cm. Acquisition parameters which changed for each scan are listed in table 1. For a set of accelerations of 1-3, 40, 4mm thick slices were used to optimize coverage, however with multiband acceleration, simply reducing the TR results in a TR of 2.5s which is too short to allow complete T_1 recovery. Therefore, another set of accelerated scans were acquired with 64, 2.5 mm thick slices. Matching EPI calibration scans which took less than a minute without simultaneously acquired slices was used for ghost correction and GRAPPA calibration. Reconstruction: SENSE-GRAPPA[5] implemented in MATLAB (Mathworks, Natick, MA, USA) was used to reconstruct the final images. Processing: Diffusion processing and visualization was performed in ExploreDTI[6].

	Subject 1			Subject 2	
Slice acceleration	1	2	3	2	3
# slices	40	40	40	64	64
Slice thickness (mm)	4	4	4	2.5	2.5
TR (s)	7.1	4.9	3.0	7.1	5
Scan time (minutes)	6	4	2.5	6	4

Table 1: Parameters changed between scans.

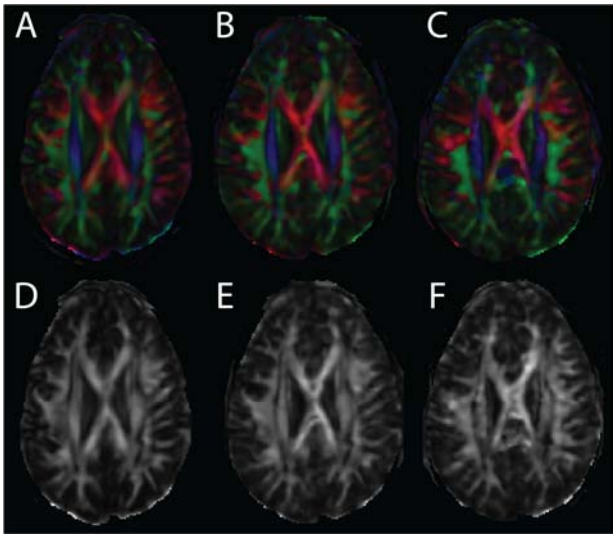

Figure 1: Comparison of slice accelerations for RS-DTI images with colored principal eigenvectors (A-C) and FA (D-F) for slice accelerations of 1 (A,D), 2 (B,E), and 3 (C,F) for subject 1 (40 slices). As is to be expected with parallel imaging, the SNR decreases as the parallel imaging factor is increased from left to right.

Results and Discussion: Figure 1 shows comparisons of the same slices for slice accelerations of 1-3 in subject 1. The most significant development is that an RS-DTI scan can be acquired very rapidly with only a slight drop in image quality when compared to non-slice-accelerated RS-EPI-DTI. In figure 2, FA maps from the 64-slice scans with accelerations of 2 and 3 are compared (Fig 2a,b respectively). As expected, the SNR decreases with acceleration, however, in both FA maps the anatomy is well depicted. Note that in this inferior-located slice, near the eyes and the sinuses, that there is low geometric distortion, a key benefit of RS-EPI. This benefit typically comes at the cost of increased scan time, however, as demonstrated here, the use multiband acceleration can offset these costs with little penalty in SNR.

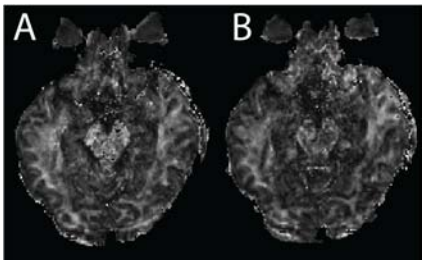

Figure 2: FA maps from 2.5 mm thick slice RS-EPI-DTI (subject 2). This shows 2 (A) and 3 (B) slice acceleration. These images were acquired approximately 3.5 and 5.5 minutes faster respectively than a fully sampled dataset (12 minutes).

Conclusion: Using slice-acceleration allows the reduction of scan time in DTI-EPI by two- or three-fold. This reduction allows the significant acceleration of imaging types that take longer to acquire, such as RS-EPI. Therefore, slice acceleration can allow for the use of scans such as RS-EPI in situations where they were not previously available, such as in the clinic where both the scanner and patient time is extremely valuable.

References: 1. Setsompop et al. NeuroImage 2012; 63:569-80. 2. Setsompop et al. MRM 2012; 67:1210-24. 3. Holdsworth et al. MRM 2009; 62(6):1929-40. 4. Porter et al. MRM 2009; 65:36-46. 5. Moeller et al. MRM 2010; 63:1144-53. 6. Leemans et al. ISMRM 2009 p3536

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