Prospective motion correction based on ultra-fast whole head navigators acquired with Multi-Band EPI.

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TARGET AUDIENCE: Clinicians and researchers interested in prospective motion corrected neuroimaging.

PURPOSE: Image based navigators acquired with an EPI readout have previously been proposed for prospective motion corrected morphometric [1], diffusion [2], and spectroscopic [3] neuroimaging. Both 2d and 3d versions of EPI navigators have been used depending on the underlying sequence, for e.g. 3d EPI navigators for 3d morphometric imaging and 2d EPI navigators for 2d multi-slice diffusion imaging. One of the limitations of the EPI navigator approach is the additional time required to collect the navigator images which typically ranges from 170 to 300 ms depending on the number of slices and type of navigator. This makes it harder to insert EPI navigators into sequences without any dead time (e.g. T1-weighted tse/se or diffusion imaging). The relatively long acquisition time also makes the technique susceptible to motion during navigator acquisition. Simultaneous-multislice or Multi-Band (MB) imaging has recently been proposed for accelerated EPI acquisition [4]. This technique relies on exciting multiple slices simultaneously and reconstructing them individually using the slice GRAPPA method. The goal of this work was to demonstrate the feasibility of prospective motion corrected neuroimaging using ultra-fast EPI navigators acquired with the multi-band technique.

METHODS: 2d multi-slice EPI navigator images were acquired with the following parameters: FOV: 256x256x80 mm^3, matrix: 32x32x10 (10 slices with 8 mm thickness), spatial resolution: 8x8x8mm^3, flip angle = 10°. To accelerate the navigator acquisition 5 slices were excited simultaneously (MB=5). In order to minimize g-factor related SNR losses, a phase encoding shift of FOV/4 was applied between simultaneously acquired slices using the blipped CAIPIRINHA technique [4]. The acquisition time for each slice group consisting of 5 slices was 14 ms., leading to a total acquisition time of 28 ms. for the entire navigator volume (2 shots of 5 slices each). For demonstration purposes the ultra-fast EPI navigator was inserted into the TI gap of an inversion prepared gradient echo (MPRAGE) sequence. During each TR a low resolution volume was created from the EPI navigator slices and used for prospective motion correction based on the 3DPACE [5] technique. The entire navigator processing and reconstruction including slice GRAPPA based unaliasing, registration with 3D PACE, feedback to scanner, and field-of-view update was completed in ~ 100 ms. 2 healthy volunteers were scanned with the proposed motion corrected MPRAGE sequence and with a standard non motion corrected sequence. To evaluate the efficacy of motion correction, subjects were deliberately instructed to follow a predefined motion protocol during both scans. Imaging was performed on a 3T scanner (MAGNETOM Skyra, Siemens Healthcare) with a 32 channel receive coil. Parameters for the MPRAGE scan were: spatial resolution: 1x1x1mm^3, GRAPPA acceleration factor = 3, scan time = 4 mins.

RESULTS: Fig 1 shows sample MB=5 EPI navigator images acquired in both subjects. In spite of the high MB acceleration good image quality is seen without any residual slice leakage. Although the slice GRAPPA reconstruction indirectly uses spatially dependent coil sensitivity information to separate the slices, good reconstruction fidelity was observed over a range of head positions (results not shown). Fig. 2 shows results of prospective motion correction in subject 1. The detected rotation and translation values indicate that similar amount of motion is present in both scans. The maximum detected rotation and translation values are: moco scan: 6.3 deg, 4.2 mm, and, no moco scan: 6.0 deg, 3.4 mm. However, the scan with prospective motion correction shows significantly improved image quality. Fig. 3 shows similar results in subject 2, where once again the motion corrected scan shows vastly improved image quality.

DISCUSSION AND CONCLUSION: We demonstrated an EPI navigator technique which acquires a low spatial resolution (8x8x8mm^3) brain volume in ~28 msec. The efficacy of using this ultra-fast navigator for prospective motion correction was shown by inserting it into a MPRAGE sequence. Residual ringing observed in the motion corrected images is attributed to motion acquired during the MPRAGE echo train, which can be mitigated with reacquisition [1]. With such a short acquisition time the EPI navigator block can easily be inserted into sequences without any dead time (e.g. T1 tse/se). Future work will focus on: i) establishing a range of motion within which the slice GRAPPA method gives acceptable image quality, and, ii) comparison with other established non-accelerated navigator techniques.

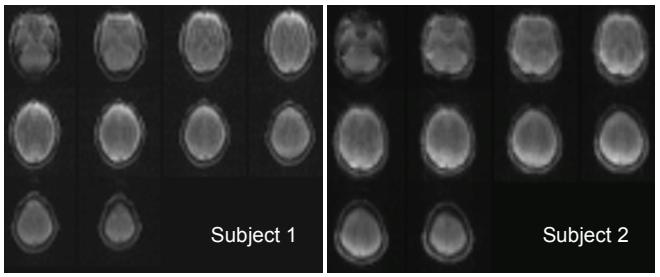

Fig 1: Sample EPI navigator images acquired in 28 msec (MB=5)

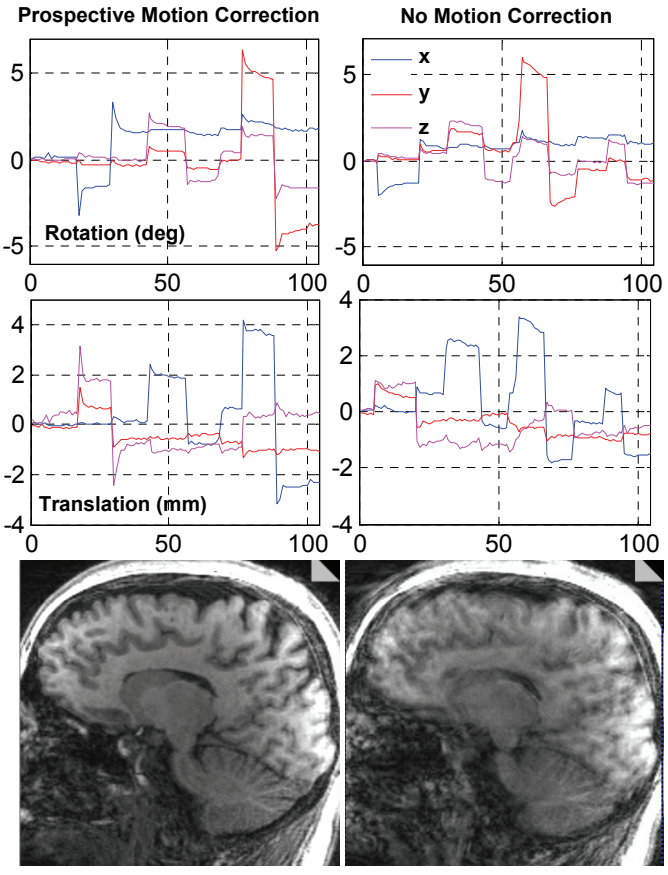

Fig 2: Results of prospective motion correction in subject 1

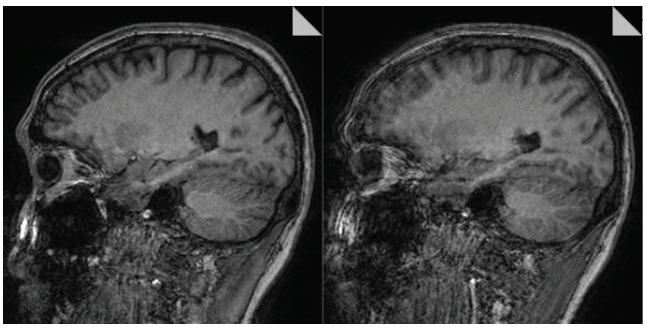

Fig 3: Results of prospective motion correction in subject 2

REFERENCES: [1] Tisdall et. al. MRM 68:389-99. [2] Bhat et al. ISMRM 2012, #113. [3] Hess et. al. MRM 66: 314-23. [4] Setsompop et. al. MRM 67:1210-24. [5] Thesen et al. MRM 44:457-65.