# Distortion Matching Echo Planar Images at Different Field Strengths

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**Introduction:** Echo planar imaging (EPI) is widely used to study the functional behavior of the brain. It generates images extremely rapidly, although the data is often distorted due to susceptibility artefacts, and images have a low resolution. Results from such studies are therefore often presented on high resolution volume scans that are much less sensitive to the distortions caused by susceptibility differences at tissue interfaces. Although EPI data can be warped to structurally match the volume scan, such post processing methods can lead to the misinterpretation of data. We have previously demonstrated that it is possible to match the distortions in a high resolution EPI scan to those in a low resolution EPI scan. This allows functional data to be presented on a high resolution acquisition where a fair assessment of results can be made. Distortions are matched in two EPI images with different resolution by matching the relative bandwidths (BW) of the two acquisitions in the phase encoding direction (1). This is achieved by matching the effective echo spacings (EESP) in the same ratio as the two fields of view (FoV) of the two images (1). EESP is given by the EPI readout echo spacing (ESP) divided by the number of shots.

**Matching Distortions at Different Field Strengths:** Situations may arise which require distortions to be matched at different fields, for example during longitudinal studies that occur across a scanner upgrade. Simply matching image bandwidths across fields will generate images that are equally sensitive to the same field offset. This is satisfactory for a fixed offset (like a fixed shim offset for example), but susceptibility and chemical shift artefacts are directly proportional to field strength. Therefore, the larger the field strength the bigger the field offset and the larger the distortion. Consequently, the bandwidth in the phase encode direction must increase in proportion to field strength in order to match image distortions from susceptibility (and chemical shift) artefact, so that

$$BW_1/BW_2 = (FoV_1/FoV_2).(B0_1/B0_2) = EESP_2/EESP_1$$

where $B0_1$ and $B0_2$ represent the flux density of the two fields.

**Method:** 1.5T data was collected on a GE Excite II platform running with 11x software. “functional” data was acquired with a 24cm FoV, 4.5mm slice thickness, 1 shot, 128x128, EESP=ESP=768us. High resolution data was also acquired with a 24cm FoV, 2 shots, ESP=1536us, EESP=768us. 3.0T data was collected on a GE Excite II platform running with G3M4 software. To match distortions to the 1.5T data required an EESP=384us. Assuming single shot data, this implies an ESP of 384us, which is beyond the capabilities of our scanner, even employing a 32x32 matrix. However it is possible to acquire 128x128 and 256x256, 4 shot data with an ESP of 1536us, and an EESP of 384us. An oil-water phantom acts as an effective model to assesses and compare an image’s sensitivity to distortions (1). The oil shift relative to water was measured at both field strengths and at different resolutions. Data was also acquired on the same normal control at both field strengths for qualitative assessment.

**Results:** Table 1 shows the measured shift of the oil relative to the water for different conditions. Figures 2-4 have all been registered to Figure 1 using a rigid body registration. The red contour was generated on Figure 1 and manually overlaid onto Figures 2-4 to give an indication of any substantial differences in distortions between the data

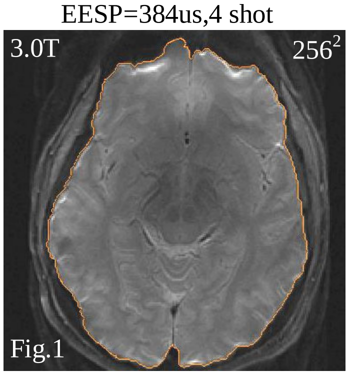
**Table 1**

| Flux Density(T) | Matrix | ESP (us) | Shots | EESP (us) | $EESPxB_0$ (usT) | Shift (Pix) | Shift (mm) | Shift (Hz) |
|---|---|---|---|---|---|---|---|---|
| 1.5 | 128x128 | 768 | 1 | 768 | 1152 | 24±2 | 45.6±3.4 | 244±20 |
| 1.5 | 256x256 | 1536 | 2 | 768 | 1152 | 47±2 | 43.1±1.8 | 234±10 |
| 3.0 | 128x128 | 1536 | 4 | 384 | 1152 | 23±2 | 43.7±3.4 | 467±40 |
| 3.0 | 256x256 | 1536 | 4 | 384 | 1152 | 43±2 | 40.3±1.8 | 438±20 |

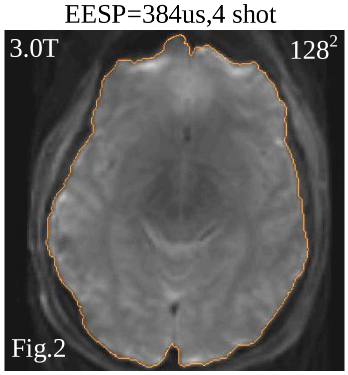
**Conclusions:** The measured oil shifts indicate that distortions can be matched at the two field strengths. The qualitative *in vivo* data appears to support this (good matching is observed in the frontal lobes for example). Matching at the same field strength is excellent. Discrepancies between 1.5T and 3T (Eg occipital lobe) may be due to differences in shimming on the different scanners. Distortion matching can be performed between images acquired at the same or different field strengths, and with different FoV’s, although differences in field offset that are not proportional to field strength may not be matched using this method. Matching distortions across field strengths would be particularly useful for longitudinal studies that occur across scanner upgrades, or for example pre/post operative studies that are bisected by such an event, or else during cross scanner comparisons.

**References:** Boulby PA, Symms MR, Barker GJ. A simple method for matching distortions in functional and structural data. ISMRM 12th Scientific Meeting, 2004, Kyoto, p2196. PAB is funded by Action Medical Research

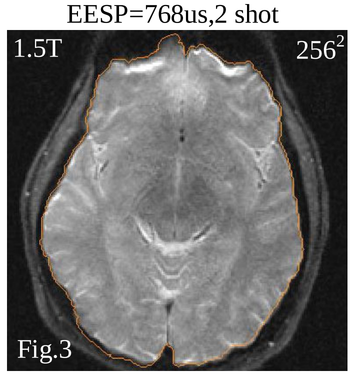
EESP=384us,4 shot




EESP=384us,4 shot




EESP=768us,2 shot




EESP=768us, 1 shot