**Rapid and tissue specific susceptibility imaging with multi-echo multi-shot EPI acquisition**

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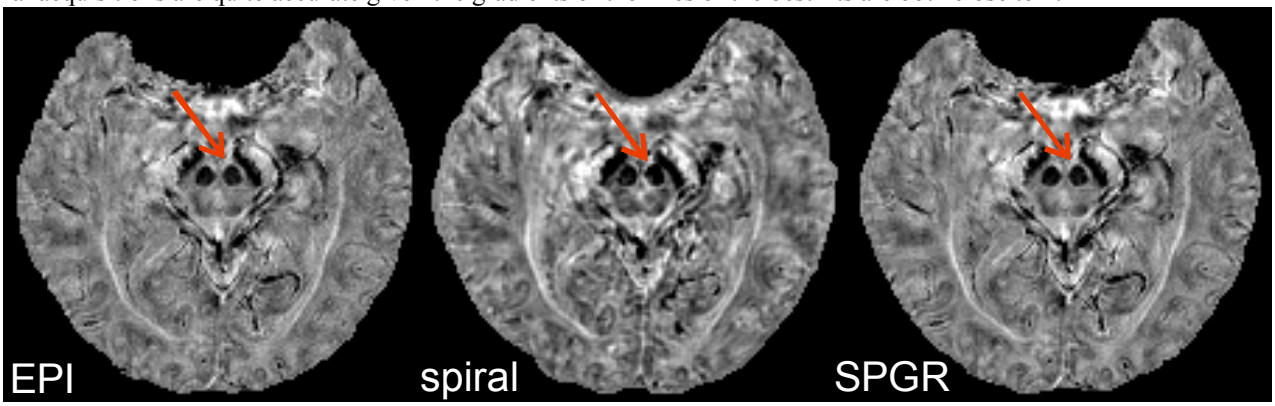
**Introduction** Quantitative susceptibility mapping potentially allows in vivo tissue composition to be quantitatively assessed. Conventionally, susceptibility maps are calculated using the phase information obtained using 3D gradient echo sequence with a Cartesian sampling, i.e. 3D SPGR. Due to the long echo time used and the line-by-line data acquisition nature, data acquisition covering a sufficiently large brain volume is a considerably long process. 3D stack-of-spiral has been proposed as a substitute to the 3D SPGR to achieve fast acquisition of the image phase (1), and multi-echo acquisition has been employed to improve the SNR of the resulting phase map (2). However, the drawback of the spiral acquisition is the demanding requirement for the gradient coil as well as its sensitivity to susceptibility variation, which usually leads to blurring artifacts and image distortions. In addition, spiral is usually not available on commercial scanners. In this work, we utilize 3D EPI acquisition instead of spiral for (1 EPI is less demanding on the gradient coil and less sensitive to B0 field inhomogeneity (2 EPI is widely available on scanners from different vendors.

**Method** In vivo brain imaging of a healthy adult volunteer was performed with a GE 3T 750 scanner equipped with a 8 channel head coil. A 3D GRE based multi-shot multi-echo EPI acquisition with 16 shots and 4 echoes was implemented. The following parameters were used: TR = 80 ms, min TE = 10ms, echo spacing = 17ms, Flip angle = 20, FOV = 19.2, matrix size = 192x192x120 to give a 1 mm isotropic resolution. As a comparison, another scan with multi-echo multi-shot spiral acquisition with the same parameters was made, however for the same TR and minimum TE, we were able to make 5 echo acquisitions due to the shorter read out time for spiral. As a bench mark, a standard SPGR acquisition was made with TE/TR = 40/50ms and otherwise identical setup. The overall scan time for the 3D EPI, 3D spiral and 3D SPGR acquisitions were 2.5, 2.5 and 20 minutes. In the EPI reconstruction, individual phase correction was performed for data acquired at different echo times using self-acquired reference data as well as the phase cycling technique (2). The resulting phase maps (from single or multiple echo acquisitions) were processed as described as in (1).

**Results** An axial plane slice of the calculated susceptibility map from the 3D EPI, 3D spiral and 3D SPGR are shown and compared in Fig.1.(a). It is seen that the susceptibility maps derived all three types of acquisitions are seen to be visually similar despite the former two used much shorter scan time. A close comparison shows that the EPI acquisition features lower level of blurring and less susceptibility related distortion than spiral (as arrowed in the delineation of the deep nuclei regions) than the spiral but slightly degraded SNR. Also, the distortion at the object boundary in the susceptibility map from the EPI acquisition is barely noticeable taking that of SPGR as a reference, due to the short readout time used (3). In Fig.1.(b) the susceptibility values obtained from EPI and spiral acquisition are plotted against those from the SPGR acquisition, it is seen that the susceptibility measurements from both EPI and spiral acquisitions are quite accurate given the gradients of the lines of the best fits are both close to 1.



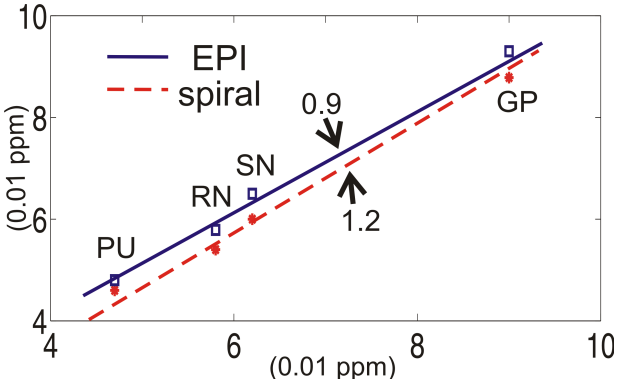




Figure 1: (a) axial plane of the susceptibility maps derived from EPI, spiral and SPGR acquisitions; (b) scatter plot of the susceptibility values of deep nuclei regions from EPI and spiral acquisitions against those from the SPGR acquisitions, lines of best fit for each case are also shown.

**Conclusion** We have shown that multi-shot multi-echo 3D EPI may be a suitable substitute for 3D SPGR to achieve fast susceptibility imaging. Compared to 3D spiral, it has the advantage of less blurring as well as wide availability on commercial scanners. The downside of EPI acquisition as seen from preliminary dataset is the degraded SNR. This may be improved by employing partial-k acquisitions so that within the same TR, the center of k-space is acquired more often.

**Reference** (1) Wu, et al., Neuroimage 2011 (2) Chen, et al., MRM 2011 (3) Zwanenburg et al., Neuroimage 2011