# Experimental determination of the effect of T2' changes in spin-echo EPI

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Introduction:

Spin-echo Echo Planar Imaging (SE-EPI) has become more widely used for functional MRI in recent years, particularly at high field strengths. This sequence is generally presumed to better localize neuronal activation due to its lower sensitivity to static magnetic field gradients, such as those surrounding large vessels. In SE-EPI imaging, however, significant signal decay can occur during the relatively long readout window due to static magnetic field inhomogeneities ($\Delta B0$) – a T2' effect ($1/T2^* = 1/T2+1/T2'$). Modulation of extravascular gradients around large vessels and lasting during EPI readout can therefore cause additional modulation of the SE-EPI signal, particularly at the spatial frequencies that are encoded at the edges of the readout window. The spin echo signal changes observed during activation may therefore be due in part to changes in T2', not solely to changes in T2. A previous study has estimated that up to a 37% of the spin-echo signal change may be due to changes in T2' alone (1).

The goal of the present study is to experimentally measure the effect of changes in T2' on the spin-echo EPI signal. This was accomplished by imaging a phantom containing a current-carrying wire (2). The small electric current creates local magnetic field gradients that cause spins in the vicinity of the wire to dephase – a T2' effect. By varying the current amplitude, the amount of T2' decay can be modulated.

Methods:

Imaging was performed on a 3T General Electric Signa VH/i MRI scanner with standard transmit/receive head coil. Several series of either spin-echo or gradient-echo (GE) EPI images were acquired of a phantom containing a current-carrying wire (radius 30 um). The wire was placed perpendicular to the magnetic field, and coronal images were acquired. Electric currents of 200uA, 300uA, and 400uA, (leading to magnetic field changes of 40nT, 60nT, and 80nT at the 1mm distance from the wire) were applied for periods of 20s alternated with 10s periods of no current. EPI imaging parameters were: TR=1s, TE=30ms (GE) and 80ms (SE), voxel size: 5x5x2 mm^3, 180 images per run.

In order to study solely the effects of T2', without changes in T2, the current was applied only during the latter half of the echo-planar readout window. This was done 1) to avoid applying a current during the slice selection, which can lead to M0 changes (3); 2) to avoid changes in T2 resulting from the diffusion of water through the applied gradient, and 3) to study the spin-echo signal when only the higher frequencies in k-space are affected. For comparison, GE images were acquired with the current applied during the entire readout window. This was repeated for multiple TE's (30, 35, 40, 45, 50ms) to map current induced changes in T2'. The T2 with no applied current was mapped using multiple spin-echo sequences with TE's ranging from 50ms to 1500ms. Changes in the MR signal were estimated by fitting a square wave response to the measured signal in a voxel containing the wire. These measured changes were compared to simulated signal changes based on a single voxel being active, subject to the measured changes in T2'.

Results:

Significant signal changes were observed for both gradient-echo and spin-echo images in response to the applied current, even when the current was applied only during the latter half of the spin-echo acquisition. These signal changes reflect purely the modulations occurring when the higher frequencies in k-space are acquired. Currents of 200, 300, and 400uA produced signal decreases of 1.3%, 1.5%, and 1.8% in the SE, and 3.0%, 4.6%, and 5.6% in the GE. These currents correspond to measured T2* changes of 1.5ms 2.2ms, and 2.8ms, respectively. The T2* and T2 (at room temperature) in this water-filled phantom was measured as 31.6ms and 1350ms when no current was applied.

Discussion and Conclusion:

In this study, an electric current was used to modulate the static magnetic field gradients, and hence the T2', as an approximation of the change in magnetic field gradients surrounding a vessel during activation. The observed signal changes were slightly larger than predicted. This may be because the gradients surrounding the wire give rise to a range of T2' decays, rather than the 2 compartment model considered. This experiment clearly demonstrates that changes in T2' alone can cause changes in the spin-echo EPI signal.

References:

1. Birn et al., *Proc. ISMRM* 2002.
2. Bodurka et al. *J.Magn Reson.* 137:265 (1999).
3. Bodurka et al. *Proc. ISMRM* p. 397, (2000).

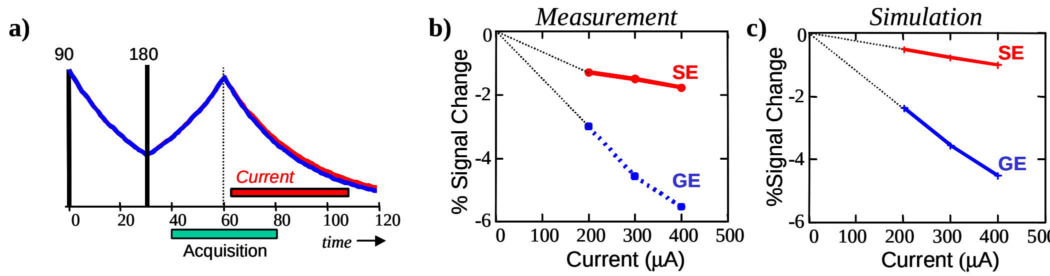


**Figure 1: a)** diagram illustrating T2' decay during a spin-echo acquisition. A current was applied during the latter half of the readout to create magnetic field gradients that modulate the T2' decay. **b)** Measured percent signal changes induced by the T2' change for spin-echo EPI and gradient-echo EPI. **c)** Simulated percent signal changes based on the measured changes in T2'.