Is there a change in spin density associated with fMRI ?

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Introduction

Recently, the observation of a change in spin density upon neuronal activation has been reported in SE fMRI with short echo-times [1]. It is important for the interpretation of many fMRI studies to determine whether such a mechanism exists. These experiments are therefore repeated and compared with the initial experiments.

Materials and Methods

To study the fMRI contrast as a function of echo-time, SE experiments with a varying TE were measured in an interleaved fashion. In addition, a third pulse is applied subsequently with a fixed mixing-time (Fig. 1) to acquire a stimulated-echo (STE) with the same effective TE and the same sensitivity to changes in spin density, but different weighting of perfusion and diffusion. The EPI readout covers 59% of k-space (partial Fourier) with a bandwidth of 200 kHz and TE values of 9, 19, 29, 39 ms and TR = 1050 ms. A FOV of 190 mm was imaged with a matrix size of 64x64 and 4 mm slice thickness. Spoiler gradients, which were used to exclude unwanted coherence pathways, introduce small diffusion weighting, more pronounced in the STE experiment ($b = 0.1$ s / mm^2). A total of 8 subjects were examined with 3 measurements per session on a Siemens 3T Trio. Visual stimulation was achieved by presenting a pattern of randomly rotating L-shaped objects for 30 s and a period of rest with the same duration. This block was repeated 10 times per trial. After each series of different TEs, a regular SE measurement with 100 kHz and a TE = 80 ms is appended to create a fixed mask of activated regions by linear correlation with $p < 0.001$ to compute comparable signal changes for the remaining experiments. To decrease the relative number of false positive voxels, all points with less than two activated neighbours were discarded from the maps.

Results and Discussion

The course of fMRI contrast in Fig. 2, fitted to a straight line, provides the relations

- SE: $\Delta S/S0[\%] = (26\pm2)\ TE/s + (0.02\pm0.05)$
- STE: $\Delta S/S0[\%] = (21\pm2)\ TE/s - (0.11\pm0.05)$

The linear coefficient of SE is in good agreement with [1], but the extrapolated intercept at TE = 0 differs significantly: A remaining signal change at TE = 0 is not observed, which is consistent with the BOLD model. In addition, the increased sensitivity of the STE experiment to perfusion and diffusion decreases the fMRI contrast, confirming recent results [2] that the intravascular compartment is the dominant source at short TE. The difference in intercept in comparison to [1] might be caused by different strategies to evaluate the signal changes: The use of an independently measured mask with a high statistical significance provides values which are not affected by the inclusion of false-positives which would result in an artificial baseline fMRI contrast. The interpretation that SE signal changes at short TE are mainly due to changes in spin density [1] is contradicted by the decreased contrast in the STE experiment, which would otherwise remain unchanged. The small negative intercept can be explained by the non-linear behaviour of venous blood signal for TE->0.

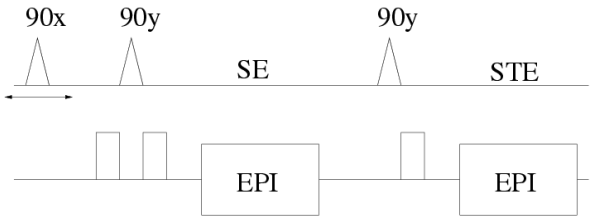

Fig. 1: Single-shot acquisition scheme for the simultaneous acquisition of spin-echo and stimulated-echo data

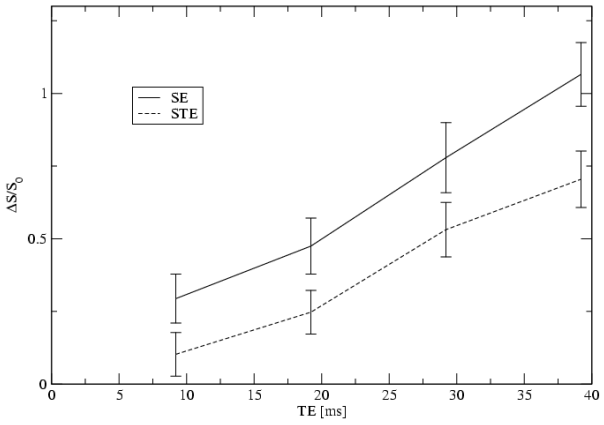

Fig. 2: Signal changes as a function of TE

References

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