Investigation of BOLD using CARR-PURCELL T2 Weighting with SPIRAL Readout

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Abstract It is demonstrated that a Carr-Purcell (CP) technique based on the fully adiabatic pulse sequence (CP-LASER) with SPIRAL readout can be used to generate zoomed images with relatively short acquisition window (at) for the investigation of the mechanisms of the BOLD effect. Based on the capability of the developed technique to refocus the dynamic dephasing, it is demonstrated that the BOLD effect is suppressed as the pulse interval t_p of CP-LASER sequence decreased.

Introduction MRI signal changes during neuronal activation are related to the changes in the content of deoxyhemoglobin, which plays a major role as an intravascular contrast agent for fMRI. During related to the changes in the content of deoxyhemoglobin, which plays

Methods MRI studies were conducted on a 4T whole body system. A 10 cm H surface-coil probe was used for the measurements. Each subject performed the fMRI study to determine the activation location in the visual cortex (V1) using visual stimulation. This information subject performed the fMRI study to determine the activation location in the visual cortex (V1) using visual stimulation. In this study, we utilize this property to investigate the mechanisms contributing to spin-echo BOLD using Carr-Purcell refocusing capability of the recently developed fast CP-LASER-SPIRAL technique. Changing t_p, the inter-echo interval, but holding n_{cp} constant (n=number of echo’s or refocusing pulses) it is possible to compare the variations of the decay of NMR signal on the transverse plane at the same echo time; for diffusion in a linear gradient this is described by:

Thus, changing t_p, but keeping n_{cp}, constant varies only the contribution of the diffusion term. In addition, the diffusion influence becomes more significant as the external static magnetic field increases due to increased local susceptibility gradients, G.

Results and Discussion Fig. 2 demonstrates the LASER-SPIRAL (a) and CP-LASER-SPIRAL (b) images that were detected in the activated V1 area from a representative subject during the visual stimulation along with the superimposed activation maps. A pronounced difference between the activation maps was obtained in every experiment. Namely: the number of activated pixels with CP-LASER-SPIRAL was less than with LASER-SPIRAL for the same statistical threshold and their distribution was different, indicating that the significant amount of Dynamic BOLD was suppressed. Fig. 2c represents the time-courses detected with CP-LASER-SPIRAL and LASER-SPIRAL techniques that were obtained by inter subject averaging (n = 3) at 4T.

Conclusion High resolution images were created using CP-LASER/LASER Spin Echo sequence with SPIRAL readout. The result indicate that the BOLD effect is suppressed with t_p= 2.5 ms. The suppressed signals are ascribed predominantly to the dynamic BOLD effect observed in extravascular compartment due to diffusion. The residual effect is thought to originate from blood where rapid exchange of water between red blood cells interior and exterior (i.e. plasma) is the predominant cause of the relaxation; suppression of this fast exchange would require shorter t_r and/or spin-locking B1 since it is characterized with rapid time constant (t_1 = 7 ms). This conclusion can and will be further validated by a detailed evaluation of the suppression observed as a function of t_p. The technique presented here provides a framework for the functional MRI experiments that can be used to investigate BOLD mechanisms and to design experiments from which quantitative physiological parameters can be obtained.

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References
1. S. Michaeli et al. Magn Reson Med (accepted for publication)