Separation of the vascular and tissue contributions to the $T_1\rho$ change induced by brain activation

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Introduction

$T_1\rho$ is the spin-lattice relaxation time in the rotating frame during application of an on-resonance spin-locking pulse. Recently, we reported an activation induced decrease of $R_1\rho (=1/T_1\rho)$ at the parenchyma of cat visual cortex [1]. It has been proposed by Hulvershorn et al. in a previous human visual stimulation study at 3 T that such functional $T_1\rho$ change can largely be attributed to an increase of cerebral blood volume (CBV), though other effects may also contribute [2]. Since $T_1\rho$ of tissue water has been found to be sensitive to many physiological parameters such as intracellular pH level [3], macromolecular composition and density, it is of particular interest to investigate whether the functional decrease of $R_1\rho$ at the parenchyma has a significant contribution from the extravascular tissue, which may have a different signal source from the hemodynamic response. In this work, we measured the functional response of $T_1\rho$ with and without the suppression of the intravascular blood signal by injecting a contrast agent.

Materials and methods

All MR experiments were carried out on a 9.4T/31-cm magnet (Magnex) interfaced to a Unity INOVA console (Varian). Four adolescent cats were anesthetized and kept under normal physiological conditions. A 1.6-cm diameter surface coil was used for high spatial resolution and high sensitivity. To achieve spin-locking (SL), the pulse sequence utilizes a non-selective adiabatic SL preparation [4], where after a 2-ms adiabatic half passage pulse the RF amplitude is decreased to the desired SL amplitude is decreased to the desired SL activity. To achieve spin-locking (SL), the study at 3 T that

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Fig. 1 Functional maps of SE-BOLD (A) and the $T_1\rho$-weighted fMRI (B) without MION show signal increase at the gray matter (outlined in green). $R_1\rho$ decreases at the parenchyma while increases at the cortical surface for both experiments without (C) and with (D) MION.

Fig. 2 The normalized time courses ($n=4$) of $R_1\rho$ at the middle cortical ROI show small relative changes before and after MION injection.