Proton MR Spectroscopy at 7 Tesla in the Macaque monkey

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First MR spectroscopy results in the anaesthetized and the awake trained monkey (*Macaca mulatta*) are reported using a novel vertical bore 7T/60cm MR system. The setup was custom-designed for MR imaging and spectroscopy of monkeys in upright position and simultaneous electrophysiological recording. Using fast gradients and custom RF coils, the benefits of high magnetic field with increased spectral resolution are demonstrated.

Introduction

In vivo 1H spectroscopy in animal and humans was demonstrated to provide significant sensitivity and resolution gains at high magnetic field [1,2]. MR imaging and spectroscopy in monkeys promises to build a bridge between brain research in humans and the large body of systems neuroscience work in animals. Simultaneous fMRI and electrophysiology was recently used in macaques to elucidate the neural activity underlying the fMRI signal [3]. In this context, MR spectroscopy can provide access to valuable neurochemical information which can be linked to functional and electrophysiological results. Here, the feasibility of high spectral quality in the anaesthetized and awake trained monkey is demonstrated.

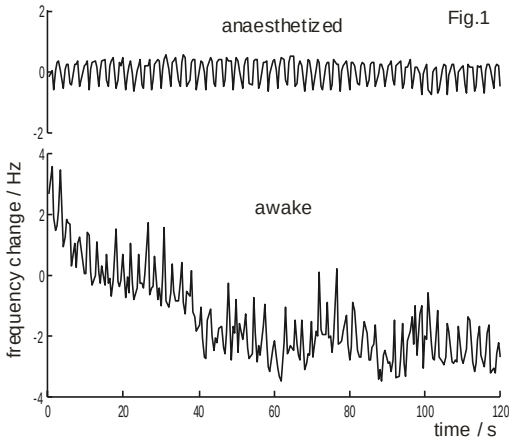

Fig.1

Methods

Single-voxel ^{1}H spectroscopy was performed on a *vertical* 7T/ 60cm system (Bruker BioSpec) with a 38-cm inner diameter gradient insert (80 mT/m in 130 μs). Upright positioning of the animal, being used over the last 50 years in all alert-monkey laboratories, was chosen for fMRI and MRS, to minimize discomfort in the animals, expedite their training process, and ensure longer cooperation during the demanding psychophysical testing. The MR system is NF and RF shielded to ensure noise-free electro-physiological recording of both local field and action potentials inside and outside the magnet bore. A prototype of primate chair was custom-designed and built to accommodate for the positioning of the electrophysiology assortments, the reward of the animal, the stimulus presentation, and the control of unwanted movement. A similar chair was built for the experiments on anaesthetized animals.

Single-voxel localization was achieved with a short echo time STEAM sequence and VAPOR water suppression [2], coded in Bruker's new PVM platform. Shimming was done with FASTMAP. 12 Hz water linewidth was achieved in the anaesthetized animal in a 10 mm cube, and about 20 Hz in the awake animal. A 3-cm RF surface coil was used for T/R, which was placed laterally on the left hemisphere over the area MT. The voxel was placed about 20-mm deep in a relatively large area of gray matter of about 8x8x3 mm^3. Frequency tracking was necessary especially in the *awake* monkey due to breathing, chewing and peripheral movement etc. Dynamic off-resonance changes were more than 3 Hz p-p (Fig. 1).

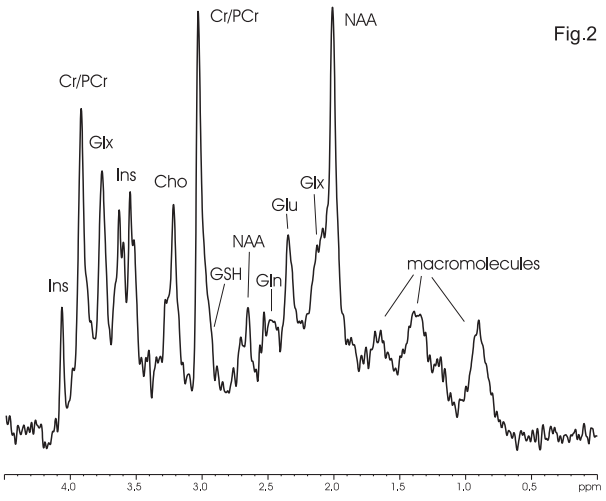

Fig.2

Results

Fig. 2 shows a ^{1}H spectrum of a 1 cc voxel (TE 5 ms, TM 10 ms, TR 4 s, NA 512) with excellent baseline definition. Metabolite concentrations were quantified by frequency-domain fitting using LCModel (CR lower bounds in brackets): NAA+NAAG 8.2 mM (3%), Ins 7.3 mM (2%), Glu 6 mM (3%), PE 3.2 mM (6%), GSH 2.1 mM (5%), Gln 1.8 mM (10%), Tau 1.6 mM (13%), Lac 1.1 mM (10%), and Cho 0.5 mM (12%) relative to Cr/PCr at 8 mM (3%). Similar concentrations but with about 2% increased error were found in the spectra of the awake monkey.

References

1. Gruetter R et al. *JMR* 135:260, 1998. 2. Tkac I et al. *MRM* 46:451, 2001. 3. Logothetis NK et al. *Nature* 412:150, 2001.

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