MP2RAGE in mice

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Target Audience: Neuroscientists, Physicists interested in structural imaging in animals.

Introduction: Recently an optimized version of the magnetization prepared rapid gradient echo sequence, the MP2RAGE sequence[1,2,3] has shown a lot of potential for obtaining bias field free T_1-weighted images at ultra high field in the human brain. This technique allows important improvements in structural brain imaging in terms of contrast and spatial resolution at high fields[2]. In the present work, the MP2RAGE sequence was implemented 14.1T in animal scanners. MP2RAGE T_1-weighted images and T_1 maps of a mouse brain are presented.

Methods: The MP2RAGE sequence was implemented at 14.1T in a horizontal bore magnet (Varian, Agilent) as described by Marques et al[1]. A phantom consisting of a 26G-syringe filled with demineralized water and 10 $MnCl_2$ doped NMR tubes (0-500µM) was imaged using a in-house made volume coil using an inversion-recovery fast spin echo sequence (IRFSEMS) (TR=15000ms; 20 TIs=100-1800ms; ESP=8.30ms; ETL=8; FOV=40x40mm^2; Matrix=128x128; 4 slices; THK=2mm; Acqtime=2 hours) after manual shimming. 3D MP2RAGE images were then acquired with the following parameters: $TR_{MP2RAGE}$= 4000ms;TR_{GRE}/TE=10/2.1ms; FOV=40x40x40mm^3; Matrix=128x128x32; TI1=320ms; TI2=2280ms; flip angle1=4° or 10°; flipangle2=4, 5, 11 or 15°. 3D stacks of 256 images were obtained in 4min16s. Images were reconstructed offline and analyzed with in-house written Matlab routines (The Mathworks, USA). T1 values obtained with IRFSEMs and MP2RAGE were correlated. In rats and mice, MP2RAGE images were obtained with identical parameters to the phantom's after shimming with FAST(est)MAP[4] over a centered voxel covering the rat or mouse brain. A quadrature surface coil was used to receive/transmit signals to and from the brain of animals fixed in a stereotactic holder and anaesthetized with isoflurane. The choice of flipangles was based on the combination of flipangles giving the best agreement between T_1s measured with IRFSEMS and MP2RAGE techniques. The FOV and matrix size were 25x25x25mm^3 and 128x128x128 respectively in mice. T1 maps were calculated as described by Marques et al[1].

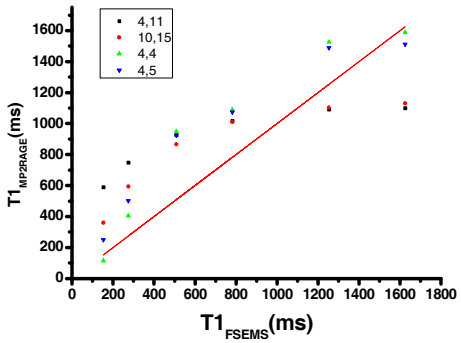
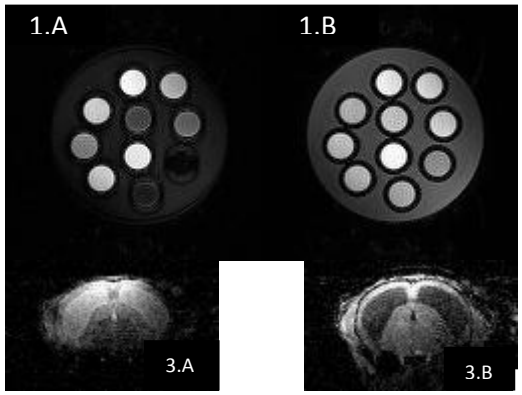


Fig.2: Correlation of T_1 values measured with MP2RAGE and IR FSEMS sequences for various combinations of flip angles

Fig.1A&B: MP2RAGE T1-weighted images of the phantom used for calibrating T_1s (Cf. Fig2) at TI1=320ms, Flip angle1=4° and TI2=2280ms, flip angle2=5°. Fig3A&B: MP2RAG images of a KO mouse with enlarged ventricles with same parameters as in Fig1.



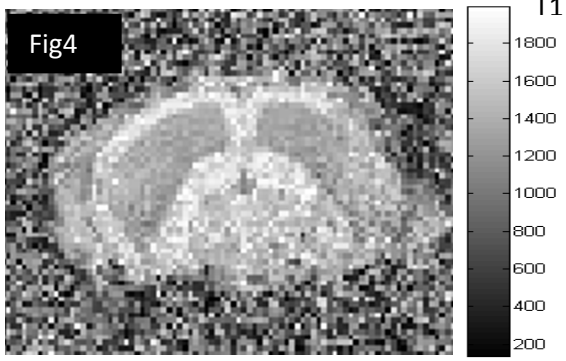


Fig.4: T1 map of a mouse brain obtained using MP2RAGE images shown in Fig3.A&B

Results and Discussion: Fig1A and B depict T_1-weighted images of the phantom acquired at 14.1T with the MP2RAGE sequence for TI1=320ms and TI2=2280ms respectively and flip angles 4 and 5°. In Fig2, T_1 values acquired with MP2RAGE in the phantom for various combinations of flip angles were correlated to T_1s measured with IRFSEMS. The best combination of flip angles was 4, 5° although these values will need further validation. These values were chosen to acquire T1-weighted images of knock-out mice demonstrating important increases in ventricular volumes (Fig3.A &.B). An example of T_1 map is given in Fig4. The MP2RAGE sequence was successfully implemented at 14.1T for the acquisition of 3D T1-weighted structural images of the mouse (and rat) brain and for T1 mapping. Currently the spatial resolution remains low (195x195x195µm^3) but the technique will be optimized in conjunction with the implementation of B1 mapping techniques. We showed the translational value of the MP2RAGE sequence which will of value for high spatial resolution structural imaging of transgenic animals in the future.

References: 1. Marques JP, Kober T, Krueger G et al. MP2RAGE, a self bias-field corrected sequence for improved segmentation and T1-mapping at high field. Neuroimage. 2010;49(2):1271-81. **2.** Marques JP, Gruetter R.New developments and applications of the MP2RAGE sequence--focusing the contrast and high spatial resolution R1 mapping. PLoS One. 2013;8(7):e69294. **3.** Kober T, Granziera C, Ribes D et al. MP2RAGE multiple sclerosis magnetic resonance imaging at 3 T. Invest Radiol. 2012 Jun;47(6):346-52. **4.** Gruetter R, Tkác I.Field mapping without reference scan using asymmetric echo-planar techniques.Magn Reson Med. 2000 Feb;43(2):319-23.