# Observation of Functional Magnetic Resonance Elastography (fMRE) in Mouse Brain

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**Target Audience:** Researchers interested in both Magnetic Resonance Elastography (MRE) and fMRI.

**Purpose**: To implement noninvasive mouse brain MRE and demonstrate that changes in the shear modulus of the brain are affected by external functional stimuli.

**Methods 1**: The MRE apparatus is based on that previously described by Schregel et al. [1]. Briefly, a 1kHz vibration is transmitted into the magnet bore to a piston that is mechanically coupled to the external surface of a mouse head. The MRE sequence is a spin echo sequence with TR/TE = 804/30ms, 128x128 matrix, 11 slices, 8 phases in 3 orthogonal directions, as generally described previously [1]. Experiments were performed on a Bruker 7T system with gradient strength of 630mT/m. Data acquisition time = 40min.

**Results & Discussion 1**: Figure 1 shows initial results with isotropic spatial resolution of 250μm and velocity resolution of ~0.1m/s. The data is sufficient to allow identification of brain structures by differences in their stiffness. One observation noted during these measurements is an increased stiffness of the sensory cortex, which is responsible for hearing, relative to other cortical regions. We hypothesized that this is due to its stimulation from the loud 1kHz noise inside the magnet bore that is a consequence of the MRE apparatus itself and the pulse sequence. To test this, we performed a second experiment.

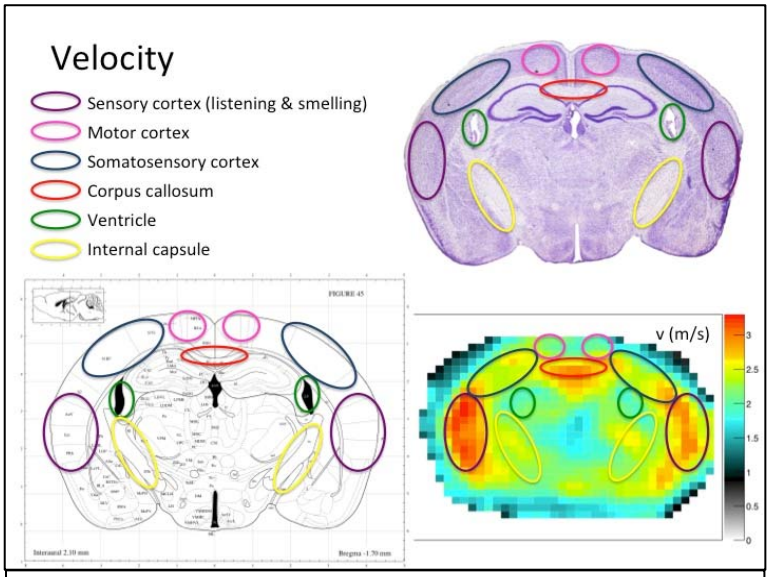


**Figure 1.** Example of mouse brain MRE velocity data (lower right) compared to a similar slice from a histological stain (upper right) and mouse atlas [2] (lower left).

**Methods 2:** The left ear was filled with gel to block sound waves to the left eardrum. A second MRE scan was then performed.

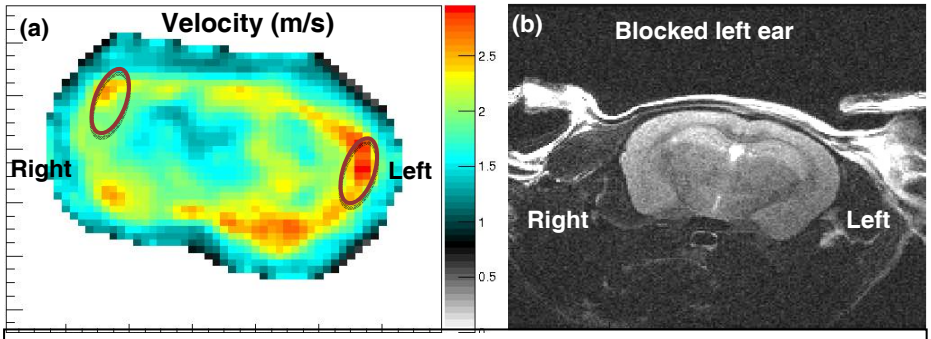


**Figure 2.** (a) MRE map after filling the left ear with surgical gel to reduce the acoustic noise heard by that ear. Due to the 1kHz mechanical vibration of the skull, there was a loud 1kHz sound inside the magnet bore. (b) Anatomical brain MRI of the same slice. **Sensory cortex shown in brown elliptical ROI in (a).**

**Results 2:** Figure 2 shows both an anatomical and an MRE scan following plugging of the left ear. One clearly observes that the stiffness of the right contralateral sensory cortex has been reduced by ~50%. After the MRI scans were completed, anesthesia was discontinued and the mouse was returned to its cage with no observable side effects from the MRI procedure.

**Discussion and Conclusion**: These results provide the first evidence of functional MRE (fMRE). The results are intriguing because the magnitude of the change in stiffness due to a change in external stimulus is much larger than that observed from the BOLD effect with fMRI. Much work needs to be done to further characterize the magnitude of fMRE as well as determine its sensitivity to other external stimuli. At the present time, we hypothesize the observed change in elastic moduli is due to a highly nonlinear shear modulus response to cerebral blood volume.

**NOTE:** A companion abstract by some of us has also been submitted to ISMRM 2015 and demonstrates fMRE in a human subject with finger tapping. Rather than observing an increase in motor cortex stiffness, a decrease was observed. Conditions that could account for the different fMRE response are: (i) The mouse data were acquired at experimental conditions one order of magnitude lower than the human data (shear wavelength ~3mm vs. ~3cm, pixel resolution 250μm vs 3mm. (ii) The scan time for the mouse/human studies was 40/3 minutes. This raises the issue of whether habituation is an issue. (iii) A different cortical region was measured. (iv) Mouse results were obtained under anesthesia with passive audio stimulation compared to an active finger tapping protocol for an awake human.

**References:** 1. Schregel et al., Proc Natl Acad Sci USA, 2012. **109**(17): p. 6650-5. 2. Paxinos and Franklin. *The Mouse Brain in Stereotaxic Coordinates*. 2001: Academic Press.