

## Detection of Neural Activity using Magnetic Resonance Electrical Impedance Tomography

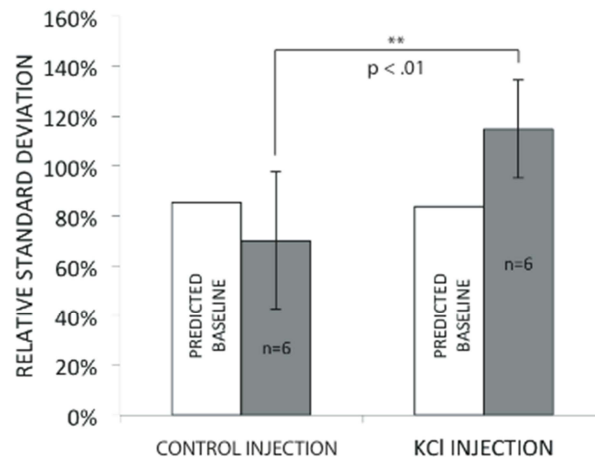
Rosalind J. Sadleir<sup>1,2</sup>, Corey A. Falgas<sup>3,4</sup>, Samuel C Grant<sup>3,4</sup>, and Eung Je Woo<sup>2</sup>

<sup>1</sup>J. Crayton Pruitt Department of Biomedical Engineering, University of Florida, Gainesville, FL, United States, <sup>2</sup>Biomedical Engineering, Kyung Hee University, Yongin, Gyeonggi-do, Korea, <sup>3</sup>Dept. of Chemical & Biomedical Engineering, The Florida State University, Tallahassee, Florida, United States, <sup>4</sup>The National High Magnetic Field Laboratory, Tallahassee, Florida, United States

**Introduction:** Magnetic resonance electrical impedance tomography (MREIT) is a method for low frequency imaging of tissue electrical conductivity. During action potentials, the cell membranes of active neural tissue undergo large changes in conductance. As a consequence, the intracellular conductivity of active cells appears very low when cells are inactive, and somewhat higher during activity. Because conductivity is a scalar quantity, measurement of conductivity changes is not subject to cancellations such as that predicted in direct measurements of neural currents perturbing the main magnetic field (ncMRI) [2]. While conductivity measurements should be somewhat more robust than ncMRI, signal to noise ratio should still be fairly small over short time scales [3]. Therefore, we performed our first test of this contrast mechanism using high magnetic fields (11.75 T).

**Materials and Methods:** Abdominal ganglia were dissected from living *aplysia Californica* intact and without chemical digestion. Studies were conducted at 11.75 T. Ganglia were placed within a 4-mm diameter chamber in artificial sea water (ASW) doped with Omniscan. MREIT scans were acquired with a 10 mm diameter birdcage coil and using 2D multi-slice spin echo (SE) sequences with TE/TR=14/330 ms, slice thickness = 500  $\mu\text{m}$ , and in-plane resolution = 70x70  $\mu\text{m}$ . A 1-mA MREIT imaging currents were injected synchronously with the spin-echo pulse sequence for 3 ms per lobe (6 ms total per scan) across paired ports to generate coherent  $B_z$  maps. Following initial MREIT scans, either a control (ASW) or a KCl-laced solution was injected into the chamber to induce excitotoxicity in the ganglion. Subsequent MREIT scans were acquired to assess changes in neural activation.

**Results and Discussion:** We compared the relative standard deviation of  $B_z$  data of intra- and extra-cellular regions of the phantom before and after administration of control or KCl solutions. We observed a large relative increase in the standard deviation within the ganglion when KCl was administered. An comparison of variance in intra and extra ganglion regions in each condition was significant at  $p < .01$ . We compared the signal strength found in the KCl injection cases with an active tissue model of the chamber and ganglion and predicted that the average spike rate change in the ganglion between the pre- and post-KCl states was around 2 Hz. We also measured the effect of KCl administration on the ganglion spiking rate using an extracellular multielectrode array. We found an average increase in spike rate of 1.8 Hz.



**Figure 1.** Result of comparing relative standard deviations between intra-and extra-ganglion regions before and after administration of an aliquot of background media (CONTROL, left) or an equal volume of excitotoxic agent (KCl, right). Predicted baseline values are those resulting from changes due to change in overall media volume alone.

**Conclusions:** High field MREIT was sensitivity to neural excitation *in vitro* by means of altered conductivity likely resulting from active ionic channels. This work is the first demonstration of MREIT as a direct functional imaging modality to noninvasively assess neural activity.

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### References:

- [1] Oh SH, et al. Magn Reson Med. 50(4):875-8. 2003.
- [2] A. M. Cassara, A. M., Hagberg, G. E., Bianciardi M. et al., NeuroImage **39** 87. 2008.
- [3] Sadleir RJ, Grant SC, Woo EJ. Neuroimage 52(1):205-16. 2010.