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Inferring sizes of compartments using oscillating gradient spin echo magnetic resonance imaging

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The measurement of brain axon diameter distributions is important in neuroscience, because axon diameter is directly proportional to nerve conduction velocity. Recent studies indicate possible changes in axon diameter distributions associated with diseases such as Alzheimer's disease, autism, diabetes, dyslexia, fetal alcohol spectrum disorders and schizophrenia. The methods currently available for measuring axon diameters are highly invasive, requiring sectioning of brain tissue for electron microscopy, and are limited due to fixation and cutting artifacts, the need to use post mortem tissue, and the use of only small tissue sample sizes.

Combining oscillating gradient spin-echo sequences (OGSE) with models for axon distributions allowed us to infer sizes of structures, similar to axons, in phantoms, more accurately than previously done. For instance, capillary tubes were inferred to have diameters of 184 ± 25 μm. Methods to reduce imaging time while maintaining measurement precision will be discussed. For instance, reducing the number of diffusion gradient measurements made can shorten imaging time by a factor of 2.5 which results in a decrease in precision of 18%.

This work provides experimental evidence for using OGSE to infer the size of small structures. and lays the foundation for inferring the size of tissue structures, such as axon diameters in samples using MRI.

Primary authors: MARTIN, Melanie (University of Winnipeg); HERRERA, Sheryl (University of Manitoba); MERCREDI, Morgan E (University of Manitoba)

Presenter: MARTIN, Melanie (University of Winnipeg)

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