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Thesis: Phantoms and Materials for Performance Testing, Quantitation and Development of 1H Magnetic Resonance

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Magnetic Resonance Spectroscopy (MRS) is a recently developed radiological modality which allows the detection and, with care, the quantitation of metabolites containing nuclei with non-zero spin. 1H MRS, the most commonly performed type, has been applied to the classification and detection of various pathologies in the human brain many of which appear normal to other imaging modalities including MRI.

In all areas of radiology, standards are needed to ensure accuracy and reproducibility of measurements. In MRS, the need exists for objects which mimic the magnetic properties of the human body. Such objects are called phantoms, and the development, manufacture, and characterization of two such phantoms forms the backbone of this thesis.

Both phantoms produced for this work simulate the human head in terms of size and magnetic inhomogeneities such as sinuses. Different regions of phantom one simulate various pathologies including Alzheimer's disease, multiple sclerosis, and astrocytoma tumor, with the rest of the phantom consisting of a material which mimics the magnetic properties of the normal brain matter, air-filled sinus and subcutaneous fat. Metabolite concentrations are equal to those found in vivo, with measured T1's and T2's which are a better match to in vivo values than any previously developed materials. This phantom can be used to verify quantitation of metabolites in the human brain in vivo as well as serving as a quality assurance (QA) tool.

The second phantom is similar to the first but, instead of having simulated pathologies, it has different regions which test spatial localization, sensitivity, and resolution of the MRS aspect of the MR scanner. Both phantoms have been scanned on clinical imagers and yield tissue-like spectra. The phantom materials have shown long-term stability of spectral peaks.

These phantoms will be of use for development of future MRS techniques, as a reference for quantitation of metabolic concentrations, and for performance testing. Their anthropomorphic configuration and in vivo-like magnetic properties (challenging the scanner as a real patient does) make them superior to previously developed phantoms. The materials developed also have the potential to be extended into other areas of MRS such as breast, prostate, and skeletal muscle.