M219, Winter 2018 - Laboratory #2

A terrible, terrible MRI protocol...Help!

Due Wednesday, March 14th via E-mail by 10pm via E-mail (10-points)

Your laboratory report must be typed and submitted via e-mail as a PDF document. Include sections entitled Introduction, Methods, Results, Discussion, and Conclusion. Maximum report length is two pages (12-point font, 1-inch margins). The data is shared, but the data analysis and reports are written individually.

The goal of the laboratory is to produce an artifact-free, high quality spoiled gradient echo image of the provided phantom. The initially provided scanning protocol will be (very) non-optimal. By adjusting various imaging parameters you will compete against the other group (using the same scanner) for the highest overall image quality. The winners will be awarded two extra points. In order to assess the best image quality an objective score will be derived using the following point system:

1. 1-point for the best image quality and most artifact free images (subjectively scored).

2. 1-point for least chemical shift (calculated pixel shift).

3. 1-point for best SNR-efficiency in "fat" ($SNR/\sqrt{\text{scan time}}$).

4. 1-point for the highest CNR-efficiency ($CNR/\sqrt{\text{scan time}}$) between water and "fat" in the phantom.

5. 1-point for the highest resolution (smallest voxel volume).

After the lab is done, your group needs to select the protocol they deem the *best*. Only this protocol should be used for analysis by the group. Please clearly report your group measures for #2 to #5 in your report. The final images must have isotropic in-plane resolution between 1.0mm x 1.0mm and 2.0mm x 2.0mm and a slice thickness between 5-10mm. You are otherwise free to select the following parameters: TR, TE, bandwidth, field of view, flip angle, matrix size (N_{k_x} and N_{k_y})and the number of averages. Other imaging parameters should remain unaltered (e.g. no parallel imaging, spin echo pulse sequences, etc.).

We will be using a multi-channel coil and you should ensure that it is functioning properly. The initial and final imaging parameters and image analysis will be reported in your written report. When calculating SNR efficiency, use regions of interest no smaller than 1 cm^2. Justify your choice of each imaging parameter. There are always trade-offs.

Additionally you should answer the following question in the lab report: Why is the comparison made using SNR-efficiency, rather than simply SNR?

The following equations may be useful. The transverse magnetization for a spoiled gradient echo sequence is:

$$M_{xy}^{ss} = \frac{M_z^0 \left(1 - e^{-\frac{TR}{T_1}}\right)}{1 - \cos\alpha e^{-\frac{TR}{T_1}}} \sin\alpha$$

The optimum flip angle can be computed from the TR and T_1 as follows:

$$\alpha_{Ernst} = \cos^{-1}\left(e^{-\frac{TR}{T_1}}\right)$$

A basic SNR relationship that includes parameters easily changed on the scanner console:

$$SNR \propto \frac{FOV_x}{N_{k_x}} \frac{FOV_y}{N_{k_y}} h \sqrt{\frac{N_{k_x} N_{k_y} N_{avg}}{BW}}$$