Lab 2 Basic Pulse sequences and contrast

Purpose: In this lab experiment, students will get hands-on experiences by running basic pulse sequences, including spin echo and gradient echo, and observing image details (contrast, signal/noise intensity change, imaging time, etc.).

I. Familiar with MRI console and imaging terms/terminology
A console snapshot is shown in the following picture.

II. MRI exam set-up
1. Patient/subject information screening
2. MRI room setup
   a. RF coil setup
   b. Patient/subject setup (localizer, ear plug, etc.)
3. Ready to scan
   Practice: set up a QA phantom

III. Running MRI: Basic pulse sequences
1. Spin echo sequence
   a. T1-weighted image
      TR = 1000ms
      TE = 10ms
b. T$_2$-weighted image
   TR     =4000ms
   TE     =60ms
   NEX    =2
   BW     =12.5KHz
   FOV    =8cm
   Slice thickness=4mm with 1.5mm gap
   Matrix size: 128 x 128
   Zoom mode
   Shim    auto

2. Gradient echo sequence
   Note that with strong T$_1$ weighting (TR<<T$_1$), the contrast will be affected by the excitation. In the following experiments, a gradient echo sequence will be used with single excitation pulse. The excitation flip angle is varied. The TR is very short relative to the T$_1$’s. It will be seen that with strong T$_1$ weighting, the small flip angle image is mostly spin density weighted.

   Flip-Angle (FA) dependence with T$_1$ weighting
   TR     =150ms
   TE     =5ms
   NEX    =4
   FOV    10cm x 5cm
   Slice thickness=4mm with 1.5mm gap
   Matrix size: 256 x 128
   Zoom mode
   Shim    auto

   Change Flip Angle (FA): 90, 45, 22, and 11 degree, respectively.

3. Chemical shifting
   Examine the T$_1$-weighted image of step 1, and notice the shadowing at the interface between egg white and yolk.

   Repeat step 1 but increase the BW
   TR     =1000ms
TE = 10ms  
BW = 31KHz  
NEX = 2  
FOV = 8cm  
Slice thickness = 4mm with 1.5mm gap  
Matrix size: 128 x 128  
Zoom mode  
Shim auto  

4. Questions?
Lab assignments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Image 1</th>
<th>Image 2</th>
<th>Image 3</th>
<th>Image 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR (ms)</td>
<td>1000</td>
<td>4000</td>
<td>1000</td>
<td>4000</td>
</tr>
<tr>
<td>TE (ms)</td>
<td>10</td>
<td>60</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td># of excitation (NEX)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bandwidth (Hz)</td>
<td>25,000</td>
<td>12,500</td>
<td>25,000</td>
<td>12,500</td>
</tr>
<tr>
<td>Total acquisition time</td>
<td>4 m 16s</td>
<td>17 m 4s</td>
<td>4 m 16s</td>
<td>17 m 4s</td>
</tr>
<tr>
<td>Image matrix size</td>
<td>128 x 128</td>
<td>128x128</td>
<td>128x128</td>
<td>128x128</td>
</tr>
<tr>
<td>FOV (cm)</td>
<td>5x5</td>
<td>5x5</td>
<td>7.5x5</td>
<td>7.5x5</td>
</tr>
<tr>
<td>Slice orientation</td>
<td>Axial</td>
<td>Axial</td>
<td>Sagittal</td>
<td>Sagittal</td>
</tr>
<tr>
<td>Slice thickness (mm)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Slice thickness (Hz)</td>
<td>2548</td>
<td>2548</td>
<td>2548</td>
<td>2548</td>
</tr>
<tr>
<td>Slice gap (mm)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of slices</td>
<td>30</td>
<td>30</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Slice scheme</td>
<td>Interleaved</td>
<td>interleaved</td>
<td>sequential</td>
<td>Sequential</td>
</tr>
</tbody>
</table>

Image 1

Image 2

Image 3
For each of the images above, determine the following

1. Characterize the image contrast into one of the following
   a) T₁-weighted
   b) T₂-weighted

2. calculate the image in-plane resolution
   a) read-out direction resolution
   b) phase-encode direction resolution
   c) slice direction resolution
3. calculate the bandwidth per image-data-pixel in the read-out direction

4. Derive the total acquisition time (in seconds) from the parameters of each image. Show details.

Answer the following questions
5. Comparing scan 1 and 3, which will have the higher signal-to-noise ratio? Why?

6. Comparing scan 2 and 4, which will have the higher signal-to-noise ratio? Why?

7. If it were possible to measure scan 1 and scan 2 with the same TR, TE, and total acquisition time, while keeping all other parameters the same, would these scans have the same signal-to-noise ratio? Why?

8. Discuss the difference in the two slice-schemes used for scans 1 and 2 as opposed to scans 3 and 4.

Note: For each image, the read-out direction is horizontal and phase-encode is vertical. The matrix size and field of view are written as read-out by phase-encode.