MRI Summer Course
Lab 2: Gradient Echo T1 & T2* Curves

Experiment 1
Goal: Examine the effect caused by changing flip angle on image contrast in a simple gradient echo sequence and derive T1-curves.

Image Sequence Parameters:
Use a gradient echo sequence and vary flip angle leaving all other parameters fixed.

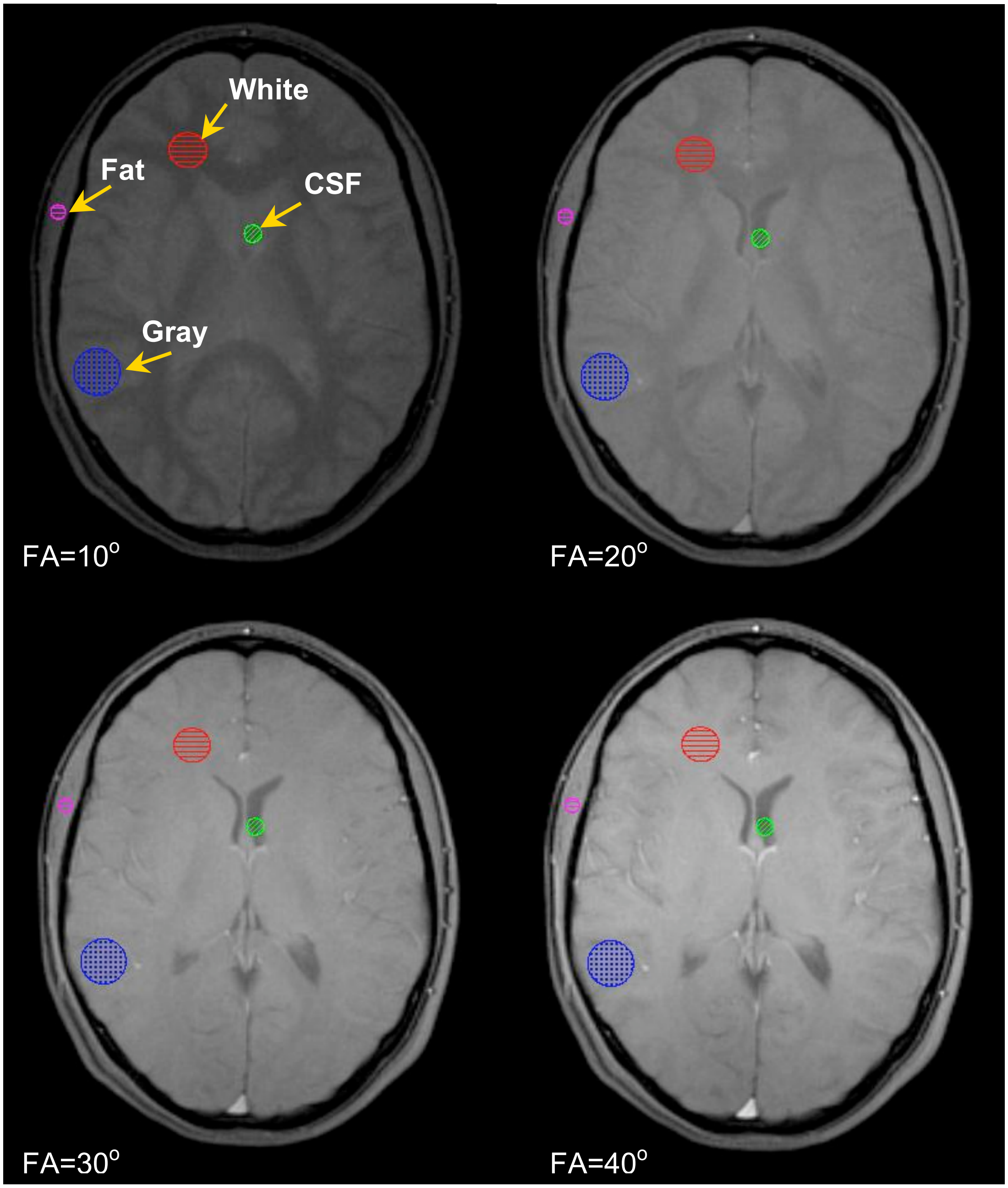
Base Sequence: Gradient Echo

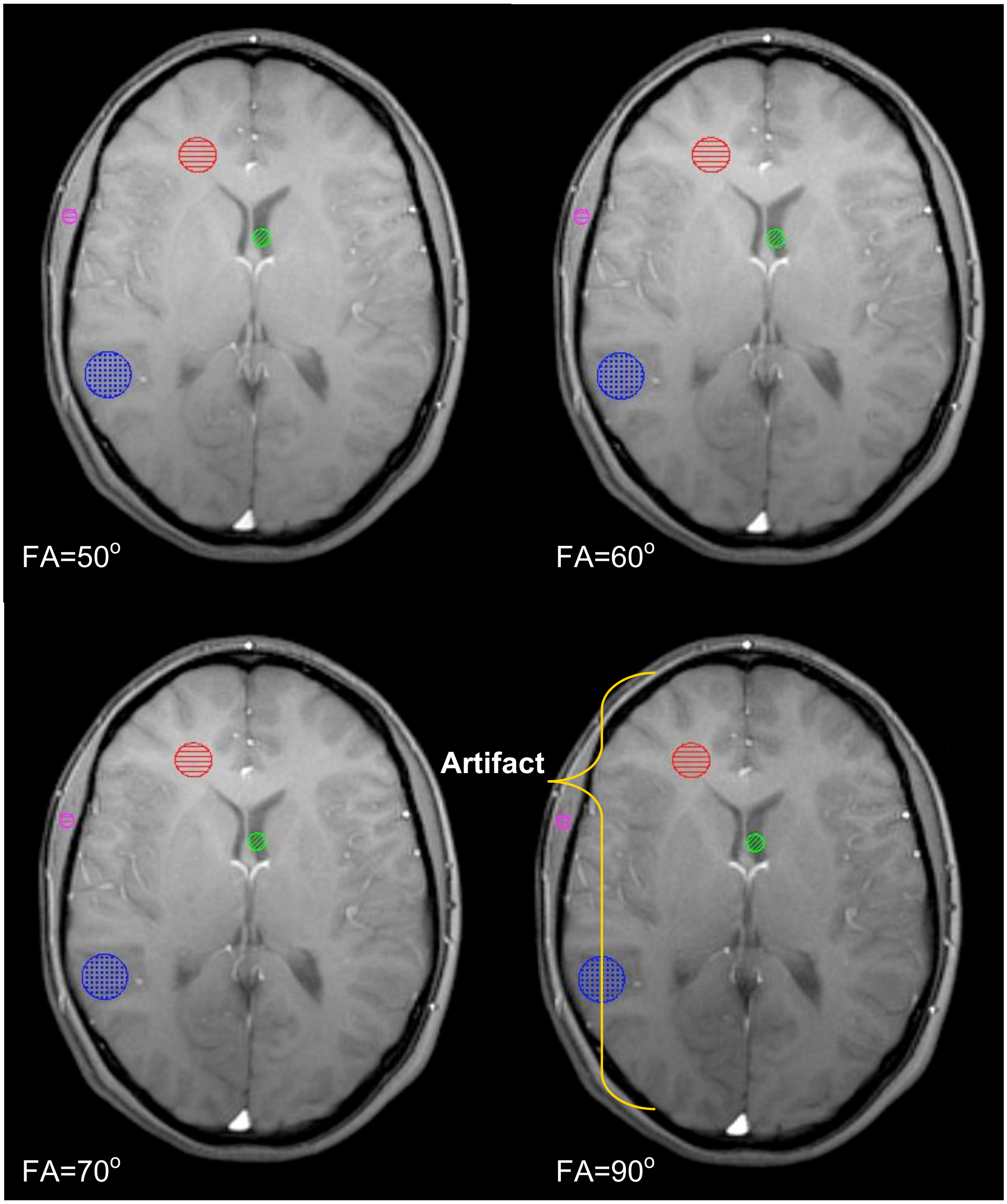
Parameter	Image 1	2	3	4	5	6	7	8
FOV Read (mm)	256	…	…	…	…	…	…	…
FOV Phase (mm)	256	…	…	…	…	…	…	…
Matrix	256x256	…	…	…	…	…	…	…
Slice Thickness (mm)	5	…	…	…	…	…	…	…
Distance Factor (%)	30	…	…	…	…	…	…	…
Number of Slices	5	…	…	…	…	…	…	…
Resolution (mm^3)	1.0x1.0x6.5	…	…	…	…	…	…	…
Flip Angle (degrees)	***10°***	***20°***	***30°***	***40°***	***50°***	***60°***	***70°***	***90°***
TR (ms)	150	…	…	…	…	…	…	…
TE (ms)	4.6	…	…	…	…	…	…	…
Scan Time (min)	0:38	…	…	…	…	…	…	…

Notice that the scan time remains unchanged as the Flip Angle increases.

Deriving T1-Curves:
1. Draw an ROI (region of interest) in each type of tissue (white matter, gray matter, CSF, and Fat). Ensure the ROI is in the same position on the same slice across all 4 of the images used in the experiment.
2. Get the mean intensity in each of these ROI's.
3. Plot the mean intensity in each tissue as a function of the change in flip angle.
4. Calculate the difference in signal intensity between white matter and gray matter to identify the optimal flip angle.

Resulting Images:





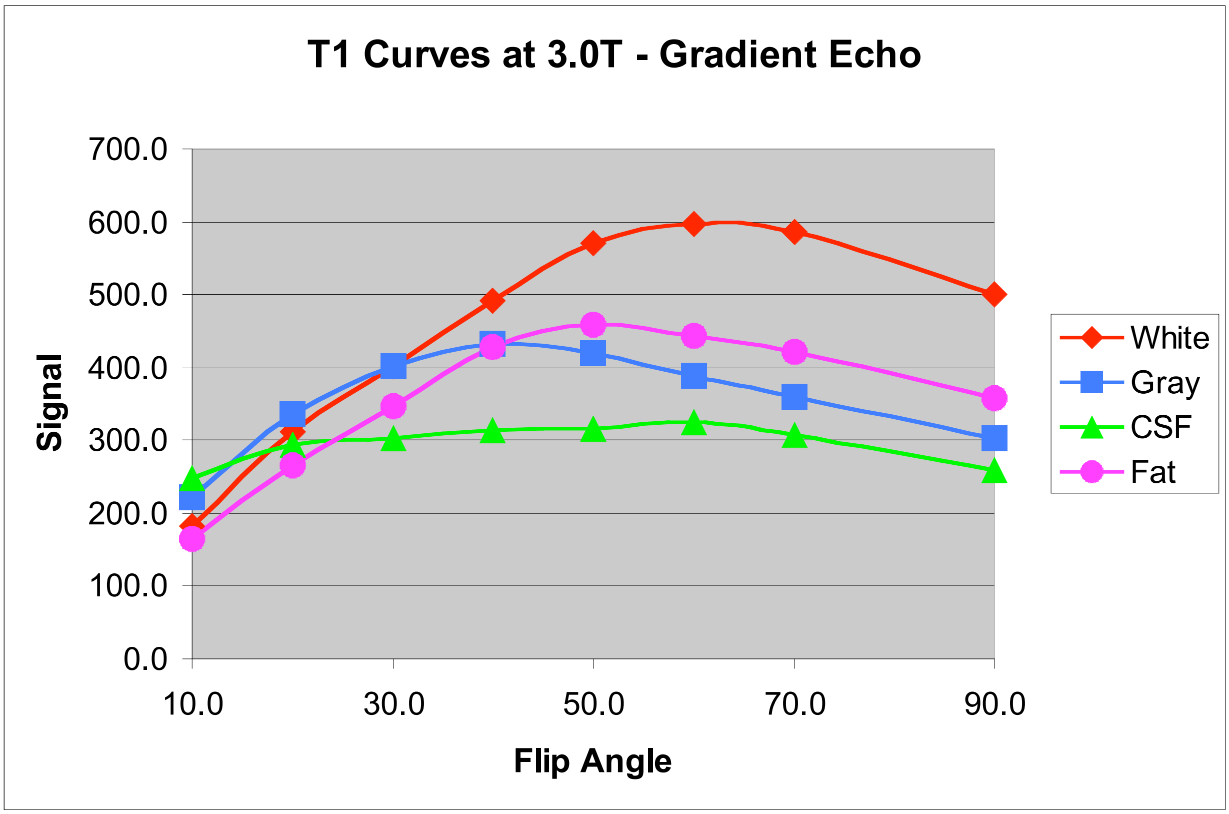
Notice how the tissue contrast of the image changes as flip angle changes. Recall that tissue contrast is our ability to distinguish different tissues within an image. As with a spin echo sequence, there is an overall ***increase*** in brightness as the flip angle increases. There also appears to be a relatively large intensity inhomogeneity artifact; the anterior part of the brain is brighter than the posterior part in this case. This artifact becomes first noticeable around a flip angle of 40° and increases in prominence as the flip angle increases.

Based on these images it appears that the best T1-weighted tissue contrast is achieved with Flip Angle=70° or 90°.

Data from ROI's:

Flip Angle	White	Gray	CSF	Fat	Δ WM-GM
10.0	181.6	221.4	247.5	164.1	-39.8
20.0	310.7	336.2	294.0	264.9	-25.5
30.0	400.5	401.5	302.3	347.8	-1.0
40.0	490.8	431.6	314.4	428.6	59.2
50.0	570.0	418.5	316.4	459.1	151.5
60.0	597.5	388.3	324.9	444.0	209.2
70.0	585.7	360.6	306.7	421.4	**225.1**
90.0	499.4	302.3	259.5	356.9	197.1

Resulting T1-Curves:



Based on these curves the optimal T1-weighted image would be produced when we use a Flip Angle=70^{o}. At this Flip Angle, the spread between the White matter and Gray matter curves is maximized and the spread between the Fat and Gray matter curves is still large.

Questions:

1. What type of relaxation is being measured in this experiment?
2. Why does the scan time remain unchanged as the flip angle is varied?

Experiment 2

Goal: Examine the effect caused by changing TE on image contrast in a simple gradient echo sequence and derive T2*-curves.

Image Sequence Parameters:

Use a gradient echo sequence and vary TE leaving all other parameters fixed.

Base Sequence: Gradient Echo

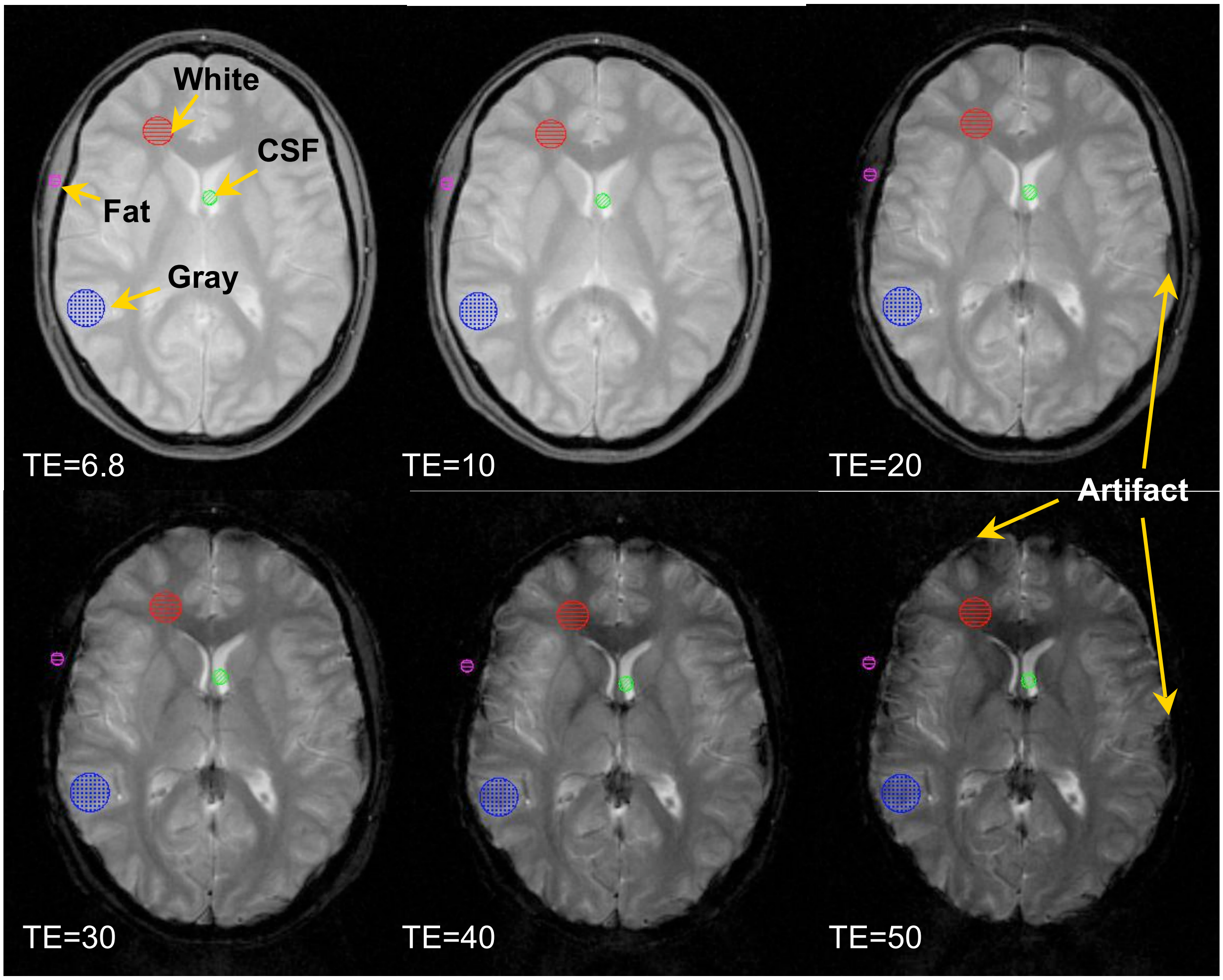
Parameter	Image 1	2	3	4	5	6
FOV Read (mm)	256	…	…	…	…	…
FOV Phase (mm)	256	…	…	…	…	…
Matrix	256x256	…	…	…	…	…
Slice Thickness (mm)	5	…	…	…	…	…
Distance Factor (%)	30	…	…	…	…	…
Number of Slices	5	…	…	…	…	…
Resolution (mm^3)	1.0x1.0x6.5	…	…	…	…	…
Flip Angle (degrees)	20^o	…	…	…	…	…
TR (ms)	4000	…	…	…	…	…
TE (ms)	***6.8***	***10***	***20***	***30***	***40***	***50***
Scan Time (min)	6:24	…	…	…	…	…

Notice that the scan time remains unchanged as the TE increases.

Deriving T2*-Curves:

1. Draw an ROI (region of interest) in each type of tissue (white matter, gray matter, CSF, and Fat). Ensure the ROI is in the same position on the same slice across all 4 of the images used in the experiment.
2. Get the mean intensity in each of these ROI's.
3. Plot the mean intensity in each tissue as a function of the change in TE.
4. Calculate the difference in signal intensity between CSF and gray matter to identify the optimal TE.

Resulting Images:



Notice how the tissue contrast of the image changes as TE changes. Recall that tissue contrast is our ability to distinguish different tissues within an image. In addition to the changes in the tissue contrast, there is an overall ***decrease*** in brightness as the TE increases. Also notice that there is a geometric distortion artifact that becomes more prominent as the TE increases.

Based on these images it appears that the best T2*-weighted tissue contrast is achieved with a TE=30ms.

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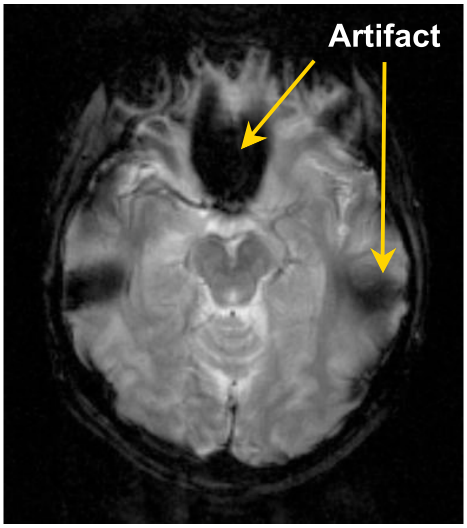
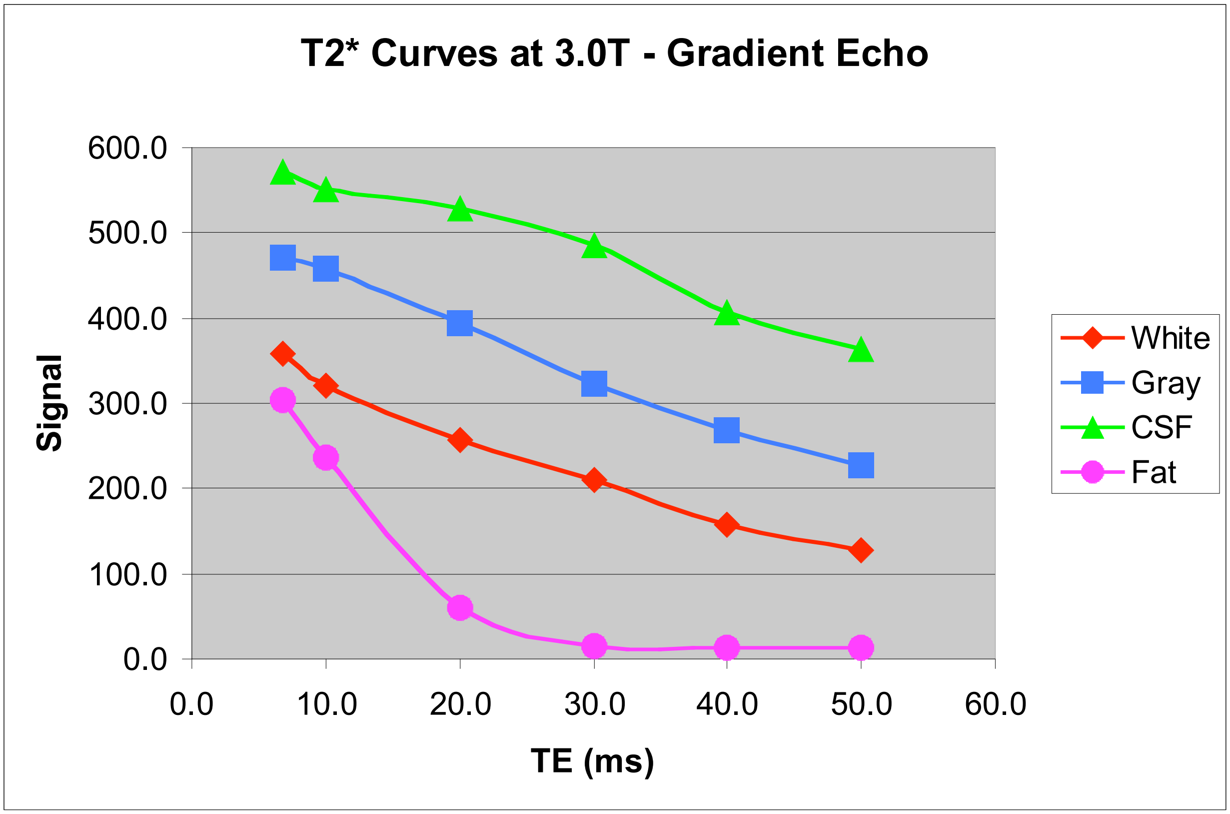


The geometric distortion artifact observed in the previous images is even more prominent in the slices lower down and closer to the sinuses as is shown in this slice from the TE=30ms scan.

Data from ROI's:

TE	White	Gray	CSF	Fat	Δ CSF-GM
6.8	357.5	471.3	571.5	303.9	100.2
10.0	321.1	457.5	550.6	236.9	93.1
20.0	256.9	394.6	529.1	59.9	134.5
30.0	210.2	322.3	484.9	14.8	**162.6**
40.0	156.7	269.0	407.1	13.6	138.1
50.0	128.4	226.5	364.4	13.1	137.9

Resulting T2*-Curves:



Based on these curves the optimal T2*-weighted image would be produced when we use a TE=30ms. At this TE the spread between the CSF and Gray matter curves is maximized and the spread between the White matter and Fat curves is still large.

Questions:

1. What type of relaxation is being measured in this experiment?
2. What is the cause of the geometric distortion artifact observed in these images?
3. Why do we refer to this contrast as T2* rather than T2?

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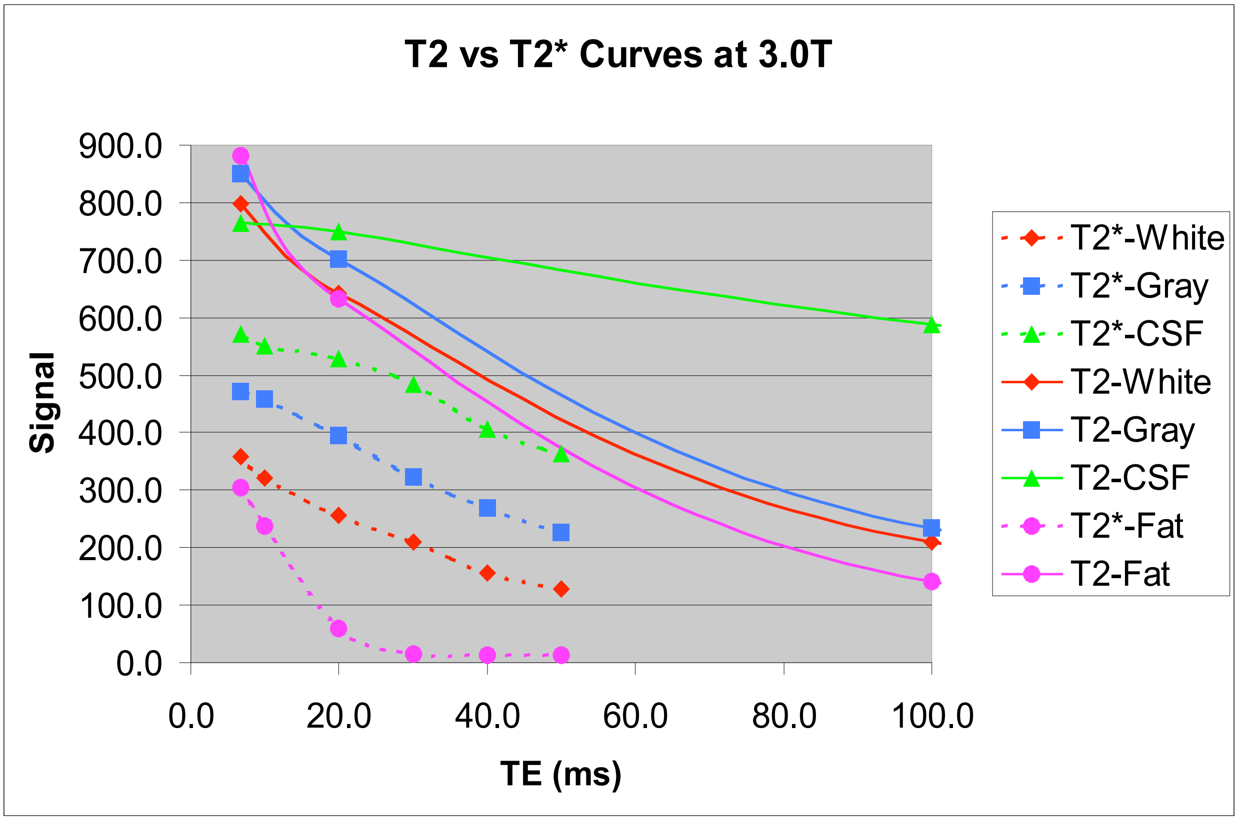
<u>Experiment 3</u>

Goal: Examine the difference between true T2-contrast obtained with a spin-echo sequence in comparison to T2*-contrast obtained with a gradient-echo sequence.

Comparison of Spin Echo T2 and Gradient Echo T2* Curves:



Notice how quickly the T2* curves decay in comparison to the T2 curves. In fact, the signal from Fat is almost completely gone at a TE=30ms in the T2* curve.