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HST.583 Functional Magnetic Resonance Imaging: Data Acquisition and Analysis  
Fall 2008

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## 2. T1, T2 and T2\* Measurements

### Background

To calculate T1 values of the tissue we will be using an inversion recovery turbo spin echo sequence. We will be sampling the magnetization as a function of the inversion time (TI). The observed signal intensity is given by the following equation:

$$S(t) \propto [1 - 2\exp(-TI/T1)] \quad (1)$$

To obtain the transverse relaxation time, T2, values in the brain a series of spin echo images will be acquired by stepping through a range of TEs. The image intensity is given by the following equation:

$$S(t) \propto \exp(-TE/T2) \quad (2)$$

T2star (T2\*) is the time constant that describes the decay of the transverse magnetization including local magnetic field inhomogeneities. T2\* is an important relaxation time for functional studies because it is related to the amount of deoxygenated hemoglobin present in the brain. To determine the T2\* values in gray, white matter and CSF, we will be using a gradient echo sequence and the signal is described by:

$$S(t) \propto \exp(-TE/T2^*) \quad (3)$$

## Experiments

In this exercise we will acquire and evaluate human data in order to characterize T1, T2 and T2\* values in brain tissue compartments. Various sequences will be used with the imaging parameters manipulated so that they provide the appropriate contrast weightings.

### T1 measurements

Acquisition: Total scan time: *5m 38sec*

A. Inversion Recovery Turbo Spin Echo (tse\_IR) sequence with TR=3000ms, FOV=240x240, matrix=96x128, repeated for multiple inversion times TI=200, 300, 400, 500, 600, 700, 800, 1000, 1300, 1500, 1700, 2000, 2200 ms.

1. Load all the images on the viewer.
2. Draw ROIs in gray matter areas.
3. Record the mean signal values in Table 1 for each inversion time and ROI.
4. Repeat steps 1-3 for regions of white matter and CSF.

❖ **Lab Question 6 :** Draw the measured signal as a function of inversion time for each of the tissue compartments. Calculate the T1 for gray, white matter and CSF by fitting Eq. (1) to your data. Hint: you will need to use a nonlinear fitting function such as `nlinfit` in matlab to accomplish this.

### T2 measurements

Acquisition: Total scan time: *9m 42sec*

B. SE sequence with TR=4000ms, FOV=220x220, matrix=192x192, 8 echo times in a range between 14.3ms and 114.4ms and inter-echo spacing 14.3 ms.

5. Load all the images on the viewer.
6. Draw ROIs in gray matter areas.
7. Record the mean signal values in Table 2 for each echo time and ROI.
8. Repeat steps 1-3 for regions of white matter and CSF.

❖ **Lab Question 7 :** Draw the measured signal as a function of echo time for each of the tissue compartments. Calculate the T2 for gray, white matter and CSF by fitting Eq. (2) to your data.

### T2\* measurements

Acquisition: Total scan time: *11sec*

C. 2D FLASH sequence with TR=100msec, FOV=256x256, matrix=128x128, and multi contrast with echo times TE=6, 10, 15, 20, 30, 50, 70, 80 msec.

9. Load all the images on the viewer.

10. Draw ROIs in gray matter areas.
11. Record the mean signal values in Table 3 for each echo time and ROI.
12. Repeat steps 1-3 for regions of white matter and CSF.

- ❖ **Lab Question 8 :** Draw the measured signal as a function of echo time for each of the tissue compartments. Calculate the  $T2^*$  of gray and white matter and CSF by fitting Eq. (3) to your data.
- ❖ **Lab Question 9 :** According to your measurements how do  $T2$  and  $T2^*$  compare for the same tissue compartment? Did you expect these findings? Explain why.

**Table 1 – T1 Measurements**

| <b>TI (ms)</b> | <b>Gray Matter</b> | <b>White Matter</b> | <b>CSF</b> |
|----------------|--------------------|---------------------|------------|
| 200            |                    |                     |            |
| 300            |                    |                     |            |
| 400            |                    |                     |            |
| 500            |                    |                     |            |
| 600            |                    |                     |            |
| 700            |                    |                     |            |
| 800            |                    |                     |            |
| 1000           |                    |                     |            |
| 1300           |                    |                     |            |
| 1500           |                    |                     |            |
| 1700           |                    |                     |            |
| 2000           |                    |                     |            |
| 2200           |                    |                     |            |

**Table 2 – T2 Measurements**

| <b>TE (ms)</b> | <b>Gray Matter</b> | <b>White Matter</b> | <b>CSF</b> |
|----------------|--------------------|---------------------|------------|
| 14.3           |                    |                     |            |
| 28.6           |                    |                     |            |
| 42.9           |                    |                     |            |
| 57.2           |                    |                     |            |
| 71.5           |                    |                     |            |
| 85.8           |                    |                     |            |
| 100.1          |                    |                     |            |
| 114.4          |                    |                     |            |

**Table 3 – T2\* Measurements**

| <b>TE (ms)</b> | <b>Gray Matter</b> | <b>White Matter</b> | <b>CSF</b> |
|----------------|--------------------|---------------------|------------|
| 6              |                    |                     |            |
| 10             |                    |                     |            |
| 15             |                    |                     |            |
| 20             |                    |                     |            |
| 30             |                    |                     |            |
| 50             |                    |                     |            |
| 70             |                    |                     |            |
| 80             |                    |                     |            |

### 3. Distortion in EPI due to B0 Inhomogeneity

#### Background

The echo-planar image (EPI) is distorted due to local field gradients present in the head during imaging. Since the acquisition of k-space data is very asymmetric in EPI, with the readout direction points ( $k_x$ ) collected quickly and the phase encode steps ( $k_y$ ) relatively slowly, the distortion is essentially entirely in the y direction (phase encode direction).

The relative distortion between the two directions can be estimated from the relative speed of the acquisition. In  $k_x$ , at a typical readout BW (say 2.2kHz/pixel or 140kHz in frequency across the 64 pixel image), the dwell time (time between  $k_x$  samples) is 7.1 $\mu$ s. The  $k_y$  sampling rate is slower because of the zig-zag trajectory, and is about 64 times slower. This gives a sampling spacing of  $64 * 7.1\mu\text{s} = 0.45\text{ms}$ . We call this the "echo-spacing", ( $esp$ ), of the sequence, the time between gradient echos (acquisition of the  $k_x=0$  point).

The effective "bandwidth" in the phase encode direction is therefore  $\frac{1}{esp}$  across the image or  $1/64 * esp = 34.7\text{Hz/pixel}$ . Therefore a B0 shift which induces a 34.7Hz frequency shift will induce a shift in this region of 1pixel. The frequency shifts in the "bad susceptibility" regions of the brain are easily in the 100Hz range. Therefore, the principle metric of how distorted the EPI sequence will be is its effective echo-spacing. For conventional echo-planar imaging, this is basically limited by the gradient slew rate and amplitude. Using parallel acceleration such as SENSE or GRAPPA effectively decreases the  $esp$  by a factor of the acceleration factor, (i.e. 2 or 3 fold).

## Experiments

In this lab we will acquire images with different effective esp and compare the distortion in the brain.

### Acquisition :

- 1) epi\_esp730: voxel size =  $3.1 \times 3.1 \times 3.1$ , Matrix size =  $64 \times 64$ , BW=1502Hz/px, ESP=0.73ms, effective esp =0.73ms
- 2) epi\_esp460: voxel size =  $3.1 \times 3.1 \times 3.1$ , Matrix size =  $64 \times 64$ , BW=2520Hz/px, ESP=0.46ms, effective esp =0.46ms
- 3) epi\_esp480\_grappa: voxel size =  $3.1 \times 3.1 \times 3.1$ , Matrix size =  $64 \times 64$ , BW=2520Hz/px, ESP=0.48ms, effective esp =0.46ms

❖ **Lab Question 10:** Estimate the distortion in frontal lobes by measuring distance on the scanner to some reference feature. Plot the distortion in mm as a function of effective esp.

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\tse\_IR1

TA: 0:26    PAT: Off    Voxel size: 1.9x1.9x5.0 mm    Rel. SNR: 1.00    SIEMENS: tse

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                  |
|--------------------|------------------|
| Slice group 1      |                  |
| Slices             | 1                |
| Dist. factor       | 50 %             |
| Position           | R0.7 A10.8 H12.2 |
| Orientation        | T > C-10.3       |
| Phase enc. dir.    | R >> L           |
| Rotation           | 90.00 deg        |
| Phase oversampling | 0 %              |
| FoV read           | 240 mm           |
| FoV phase          | 75.0 %           |
| Slice thickness    | 5.0 mm           |
| TR                 | 3000 ms          |
| TE                 | 12 ms            |
| Averages           | 1                |
| Concatenations     | 1                |
| Filter             | None             |
| Coil elements      | HEA;HEP          |

## Contrast

|                          |                  |
|--------------------------|------------------|
| MTC                      | Off              |
| Magn. preparation        | Slice-sel. IR    |
| TI                       | 200 ms           |
| Freeze suppressed tissue | Off              |
| Flip angle               | 180 deg          |
| Fat suppr.               | None             |
| Fat sat. mode            | Strong           |
| Water suppr.             | None             |
| Restore magn.            | Off              |
| -----                    |                  |
| Averaging mode           | Short term       |
| Reconstruction           | Real             |
| Measurements             | 1                |
| Multiple series          | Each measurement |

## Resolution

|                       |           |
|-----------------------|-----------|
| Base resolution       | 128       |
| Phase resolution      | 100 %     |
| Phase partial Fourier | Off       |
| Trajectory            | Cartesian |
| Interpolation         | Off       |
| -----                 |           |
| PAT mode              | None      |
| Matrix Coil Mode      | Auto (CP) |
| -----                 |           |
| Image Filter          | Off       |
| Distortion Corr.      | Off       |
| Prescan Normalize     | Off       |
| Normalize             | Off       |

|                   |     |
|-------------------|-----|
| Raw filter        | Off |
| Elliptical filter | Off |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Interleaved |
| Series           | Interleaved |
| -----            |             |
| Special sat.     | None        |

## System

|                          |                  |
|--------------------------|------------------|
| Body                     | Off              |
| HEP                      | On               |
| HEA                      | On               |
| -----                    |                  |
| Positioning mode         | REF              |
| Table position           | H                |
| Table position           | 0 mm             |
| MSMA                     | S - C - T        |
| Sagittal                 | R >> L           |
| Coronal                  | A >> P           |
| Transversal              | F >> H           |
| Save uncombined          | Off              |
| Coil Combine Mode        | Adaptive Combine |
| Auto Coil Select         | Default          |
| -----                    |                  |
| Shim mode                | Tune up          |
| Adjust with body coil    | Off              |
| Confirm freq. adjustment | Off              |
| Assume Silicone          | Off              |
| Ref. amplitude 1H        | 337.166 V        |
| Adjustment Tolerance     | Auto             |
| Adjust volume            |                  |
| Position                 | Isocenter        |
| Orientation              | Transversal      |
| Rotation                 | 0.00 deg         |
| R >> L                   | 350 mm           |
| A >> P                   | 263 mm           |
| F >> H                   | 350 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
| -----           |      |
| Dark blood      | Off  |
| -----           |      |
| Resp. control   | Off  |

## Inline

|                      |     |
|----------------------|-----|
| Subtract             | Off |
| Std-Dev-Sag          | Off |
| Std-Dev-Cor          | Off |
| Std-Dev-Tra          | Off |
| Std-Dev-Time         | Off |
| MIP-Sag              | Off |
| MIP-Cor              | Off |
| MIP-Tra              | Off |
| MIP-Time             | Off |
| Save original images | On  |

## Sequence

|                     |           |
|---------------------|-----------|
| Introduction        | On        |
| Dimension           | 2D        |
| Compensate T2 decay | Off       |
| Reduce Motion Sens. | Off       |
| Contrasts           | 1         |
| Bandwidth           | 130 Hz/Px |
| Flow comp.          | No        |
| Allowed delay       | 0 s       |
| Echo spacing        | 11.7 ms   |



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|                       |              |
|-----------------------|--------------|
| Define                | Turbo factor |
| Turbo factor          | 15           |
| Echo trains per slice | 7            |
| RF pulse type         | Normal       |
| Gradient mode         | Fast         |

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\se\_mc

TA: 9:42    PAT: Off    Voxel size: 1.1x1.1x5.0 mm    Rel. SNR: 1.00    SIEMENS: se\_mc

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                  |
|--------------------|------------------|
| Slice group 1      |                  |
| Slices             | 1                |
| Dist. factor       | 100 %            |
| Position           | R0.7 A10.8 H12.2 |
| Orientation        | T > C-10.3       |
| Phase enc. dir.    | A >> P           |
| Rotation           | 0.00 deg         |
| Phase oversampling | 0 %              |
| FoV read           | 220 mm           |
| FoV phase          | 100.0 %          |
| Slice thickness    | 5.0 mm           |
| TR                 | 4000 ms          |
| TE 1               | 14.3 ms          |
| TE 2               | 28.6 ms          |
| TE 3               | 42.9 ms          |
| TE 4               | 57.2 ms          |
| TE 5               | 71.5 ms          |
| TE 6               | 85.8 ms          |
| TE 7               | 100.1 ms         |
| TE 8               | 114.4 ms         |
| Averages           | 1                |
| Concatenations     | 1                |
| Filter             | Raw filter       |
| Coil elements      | HEA;HEP          |

## Contrast

|                   |                  |
|-------------------|------------------|
| MTC               | Off              |
| Magn. preparation | None             |
| Flip angle        | 180 deg          |
| Fat suppr.        | None             |
| Fat sat. mode     | Strong           |
| Water suppr.      | None             |
| -----             |                  |
| Averaging mode    | Short term       |
| Reconstruction    | Magnitude        |
| Measurements      | 1                |
| Multiple series   | Each measurement |

## Resolution

|                       |           |
|-----------------------|-----------|
| Base resolution       | 192       |
| Phase resolution      | 100 %     |
| Phase partial Fourier | 6/8       |
| Interpolation         | Off       |
| -----                 |           |
| PAT mode              | None      |
| Matrix Coil Mode      | Auto (CP) |
| -----                 |           |
| Image Filter          | Off       |

|                   |      |
|-------------------|------|
| Distortion Corr.  | Off  |
| Prescan Normalize | Off  |
| Normalize         | Off  |
| Raw filter        | On   |
| Intensity         | Weak |
| Slope             | 25   |
| Elliptical filter | Off  |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Interleaved |
| Series           | Interleaved |
| -----            |             |
| Special sat.     | None        |

## System

|                          |                  |
|--------------------------|------------------|
| Body                     | Off              |
| HEP                      | On               |
| HEA                      | On               |
| -----                    |                  |
| Positioning mode         | REF              |
| Table position           | H                |
| Table position           | 0 mm             |
| MSMA                     | S - C - T        |
| Sagittal                 | R >> L           |
| Coronal                  | A >> P           |
| Transversal              | F >> H           |
| Save uncombined          | Off              |
| Coil Combine Mode        | Adaptive Combine |
| Auto Coil Select         | Default          |
| -----                    |                  |
| Shim mode                | Tune up          |
| Adjust with body coil    | Off              |
| Confirm freq. adjustment | Off              |
| Assume Silicone          | Off              |
| Ref. amplitude 1H        | 337.166 V        |
| Adjustment Tolerance     | Auto             |
| Adjust volume            |                  |
| Position                 | Isocenter        |
| Orientation              | Transversal      |
| Rotation                 | 0.00 deg         |
| R >> L                   | 350 mm           |
| A >> P                   | 263 mm           |
| F >> H                   | 350 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
| -----           |      |
| Dark blood      | Off  |

## Inline

|                      |     |
|----------------------|-----|
| Subtract             | Off |
| Liver registration   | Off |
| Std-Dev-Sag          | Off |
| Std-Dev-Cor          | Off |
| Std-Dev-Tra          | Off |
| Std-Dev-Time         | Off |
| MIP-Sag              | Off |
| MIP-Cor              | Off |
| MIP-Tra              | Off |
| MIP-Time             | Off |
| Save original images | On  |

## Sequence

|               |           |
|---------------|-----------|
| Introduction  | On        |
| Contrasts     | 8         |
| Bandwidth     | 202 Hz/Px |
| Allowed delay | 0 s       |
| -----         |           |
| RF pulse type | Normal    |

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| Gradient mode

Fast

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\T2star\_8echos

TA: 0:11    PAT: Off    Voxel size: 2.0x2.0x5.0 mm    Rel. SNR: 1.00    SIEMENS: gre

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                  |
|--------------------|------------------|
| Slice group 1      |                  |
| Slices             | 1                |
| Dist. factor       | 20 %             |
| Position           | R0.7 A10.8 H12.2 |
| Orientation        | T > C-10.3       |
| Phase enc. dir.    | A >> P           |
| Rotation           | 0.00 deg         |
| Phase oversampling | 0 %              |
| FoV read           | 256 mm           |
| FoV phase          | 100.0 %          |
| Slice thickness    | 5.0 mm           |
| TR                 | 100 ms           |
| TE 1               | 6.00 ms          |
| TE 2               | 10.00 ms         |
| TE 3               | 15.00 ms         |
| TE 4               | 20.00 ms         |
| TE 5               | 30.00 ms         |
| TE 6               | 50.00 ms         |
| TE 7               | 70.00 ms         |
| TE 8               | 80.00 ms         |
| Averages           | 1                |
| Concatenations     | 1                |
| Filter             | Raw filter       |
| Coil elements      | HEA;HEP          |

## Contrast

|                   |                  |
|-------------------|------------------|
| MTC               | Off              |
| Magn. preparation | None             |
| Flip angle        | 15 deg           |
| Fat suppr.        | None             |
| Water suppr.      | None             |
| Averaging mode    | Long term        |
| Reconstruction    | Magnitude        |
| Measurements      | 1                |
| Multiple series   | Each measurement |

## Resolution

|                       |           |
|-----------------------|-----------|
| Base resolution       | 128       |
| Phase resolution      | 100 %     |
| Phase partial Fourier | 6/8       |
| Interpolation         | Off       |
| PAT mode              | None      |
| Matrix Coil Mode      | Auto (CP) |
| Image Filter          | Off       |
| Distortion Corr.      | Off       |

|                   |      |
|-------------------|------|
| Prescan Normalize | Off  |
| Normalize         | Off  |
| Raw filter        | On   |
| Intensity         | Weak |
| Slope             | 25   |
| Elliptical filter | Off  |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Sequential  |
| Series           | Interleaved |
| Saturation mode  | Standard    |
| Special sat.     | None        |

## System

|                          |                  |
|--------------------------|------------------|
| Body                     | Off              |
| HEP                      | On               |
| HEA                      | On               |
| Positioning mode         | REF              |
| Table position           | H                |
| Table position           | 0 mm             |
| MSMA                     | S - C - T        |
| Sagittal                 | R >> L           |
| Coronal                  | A >> P           |
| Transversal              | F >> H           |
| Save uncombined          | Off              |
| Coil Combine Mode        | Adaptive Combine |
| Auto Coil Select         | Default          |
| Shim mode                | Tune up          |
| Adjust with body coil    | Off              |
| Confirm freq. adjustment | Off              |
| Assume Silicone          | Off              |
| Ref. amplitude 1H        | 337.166 V        |
| Adjustment Tolerance     | Auto             |
| Adjust volume            |                  |
| Position                 | Isocenter        |
| Orientation              | Transversal      |
| Rotation                 | 0.00 deg         |
| R >> L                   | 350 mm           |
| A >> P                   | 263 mm           |
| F >> H                   | 350 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
| Segments        | 1    |
| Dark blood      | Off  |
| Resp. control   | Off  |

## Inline

|                      |     |
|----------------------|-----|
| Subtract             | Off |
| Liver registration   | Off |
| Std-Dev-Sag          | Off |
| Std-Dev-Cor          | Off |
| Std-Dev-Tra          | Off |
| Std-Dev-Time         | Off |
| MIP-Sag              | Off |
| MIP-Cor              | Off |
| MIP-Tra              | Off |
| MIP-Time             | Off |
| Save original images | On  |
| Wash - In            | Off |
| Wash - Out           | Off |
| TTP                  | Off |

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|            |     |
|------------|-----|
| PEI        | Off |
| MIP - time | Off |

## Sequence

|                     |            |
|---------------------|------------|
| Introduction        | On         |
| Dimension           | 2D         |
| Phase stabilisation | Off        |
| Asymmetric echo     | Off        |
| Contrasts           | 8          |
| Bandwidth 1         | 300 Hz/Px  |
| Bandwidth 2         | 300 Hz/Px  |
| Bandwidth 3         | 300 Hz/Px  |
| Bandwidth 4         | 300 Hz/Px  |
| Bandwidth 5         | 300 Hz/Px  |
| Bandwidth 6         | 300 Hz/Px  |
| Bandwidth 7         | 300 Hz/Px  |
| Bandwidth 8         | 300 Hz/Px  |
| Flow comp. 1        | No         |
| Flow comp. 2        | No         |
| Flow comp. 3        | No         |
| Flow comp. 4        | No         |
| Flow comp. 5        | No         |
| Flow comp. 6        | No         |
| Flow comp. 7        | No         |
| Flow comp. 8        | No         |
| Readout mode        | Bipolar    |
| Allowed delay       | 0 s        |
| -----               |            |
| RF pulse type       | Normal     |
| Gradient mode       | Fast       |
| Excitation          | Slice-sel. |
| RF spoiling         | On         |

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\epi\_esp730

TA: 2.0 s    PAT: Off    Voxel size: 3.1x3.1x3.1 mm    Rel. SNR: 1.00    USER: ep2d\_bold\_MGH\_pro\_tb

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                 |
|--------------------|-----------------|
| Slice group 1      |                 |
| Slices             | 9               |
| Dist. factor       | 67 %            |
| Position           | R0.3 A11.0 F2.1 |
| Orientation        | T > C-10.4      |
| Phase enc. dir.    | A >> P          |
| Rotation           | 0.34 deg        |
| Phase oversampling | 0 %             |
| FoV read           | 200 mm          |
| FoV phase          | 100.0 %         |
| Slice thickness    | 3.10 mm         |
| TR                 | 2000 ms         |
| TE                 | 30 ms           |
| Averages           | 1               |
| Concatenations     | 1               |
| Filter             | None            |
| Coil elements      | HEA;HEP         |

## Contrast

|                 |           |
|-----------------|-----------|
| MTC             | Off       |
| Flip angle      | 90 deg    |
| Fat suppr.      | Fat sat.  |
| -----           |           |
| Averaging mode  | Long term |
| Reconstruction  | Magnitude |
| Measurements    | 1         |
| Delay in TR     | 0 ms      |
| Multiple series | Off       |

## Resolution

|                       |           |
|-----------------------|-----------|
| Base resolution       | 64        |
| Phase resolution      | 100 %     |
| Phase partial Fourier | Off       |
| Interpolation         | Off       |
| -----                 |           |
| PAT mode              | None      |
| Matrix Coil Mode      | Auto (CP) |
| -----                 |           |
| Distortion Corr.      | Off       |
| Prescan Normalize     | Off       |
| Raw filter            | On        |
| Elliptical filter     | Off       |
| Hamming               | Off       |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Interleaved |
| Series           | Interleaved |
| -----            |             |
| Special sat.     | None        |

## System

|                          |                 |
|--------------------------|-----------------|
| Body                     | Off             |
| HEP                      | On              |
| HEA                      | On              |
| -----                    |                 |
| Positioning mode         | FIX             |
| Table position           | H               |
| Table position           | 0 mm            |
| MSMA                     | S - C - T       |
| Sagittal                 | R >> L          |
| Coronal                  | A >> P          |
| Transversal              | F >> H          |
| Coil Combine Mode        | Sum of Squares  |
| Auto Coil Select         | Default         |
| -----                    |                 |
| Shim mode                | Standard        |
| Adjust with body coil    | Off             |
| Confirm freq. adjustment | Off             |
| Assume Silicone          | Off             |
| Ref. amplitude 1H        | 337.166 V       |
| Adjustment Tolerance     | Auto            |
| Adjust volume            |                 |
| Position                 | R0.3 A11.0 F2.1 |
| Orientation              | T > C-10.4      |
| Rotation                 | 0.34 deg        |
| R >> L                   | 200 mm          |
| A >> P                   | 200 mm          |
| F >> H                   | 45 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
|-----------------|------|

## BOLD

|                         |          |
|-------------------------|----------|
| GLM Statistics          | Off      |
| Dynamic t-maps          | Off      |
| Starting ignore meas    | 0        |
| Ignore after transition | 0        |
| Model transition states | Off      |
| Temp. highpass filter   | Off      |
| Threshold               | 4.00     |
| Paradigm size           | 1        |
| Meas                    | Baseline |
| Motion correction       | Off      |
| Spatial filter          | Off      |

## Sequence

|                   |            |
|-------------------|------------|
| Introduction      | Off        |
| Bandwidth         | 1502 Hz/Px |
| Free echo spacing | Off        |
| Echo spacing      | 0.73 ms    |
| -----             |            |
| EPI factor        | 64         |
| RF pulse type     | Normal     |
| Gradient mode     | Fast       |
| -----             |            |
| Dummy Scans       | 0          |

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\epi\_esp460

TA: 2.0 s    PAT: Off    Voxel size: 3.1x3.1x3.1 mm    Rel. SNR: 1.00    USER: ep2d\_bold\_MGH\_pro\_tb

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                 |
|--------------------|-----------------|
| Slice group 1      |                 |
| Slices             | 9               |
| Dist. factor       | 67 %            |
| Position           | R0.3 A11.0 F2.1 |
| Orientation        | T > C-12.5      |
| Phase enc. dir.    | A >> P          |
| Rotation           | 0.34 deg        |
| Phase oversampling | 0 %             |
| FoV read           | 200 mm          |
| FoV phase          | 100.0 %         |
| Slice thickness    | 3.10 mm         |
| TR                 | 2000 ms         |
| TE                 | 30 ms           |
| Averages           | 1               |
| Concatenations     | 1               |
| Filter             | None            |
| Coil elements      | HEA;HEP         |

## Contrast

|                 |           |
|-----------------|-----------|
| MTC             | Off       |
| Flip angle      | 90 deg    |
| Fat suppr.      | Fat sat.  |
| -----           |           |
| Averaging mode  | Long term |
| Reconstruction  | Magnitude |
| Measurements    | 1         |
| Delay in TR     | 0 ms      |
| Multiple series | Off       |

## Resolution

|                       |           |
|-----------------------|-----------|
| Base resolution       | 64        |
| Phase resolution      | 100 %     |
| Phase partial Fourier | Off       |
| Interpolation         | Off       |
| -----                 |           |
| PAT mode              | None      |
| Matrix Coil Mode      | Auto (CP) |
| -----                 |           |
| Distortion Corr.      | Off       |
| Prescan Normalize     | Off       |
| Raw filter            | On        |
| Elliptical filter     | Off       |
| Hamming               | Off       |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Interleaved |
| Series           | Interleaved |
| -----            |             |
| Special sat.     | None        |

## System

|                          |                 |
|--------------------------|-----------------|
| Body                     | Off             |
| HEP                      | On              |
| HEA                      | On              |
| -----                    |                 |
| Positioning mode         | FIX             |
| Table position           | H               |
| Table position           | 0 mm            |
| MSMA                     | S - C - T       |
| Sagittal                 | R >> L          |
| Coronal                  | A >> P          |
| Transversal              | F >> H          |
| Coil Combine Mode        | Sum of Squares  |
| Auto Coil Select         | Default         |
| -----                    |                 |
| Shim mode                | Standard        |
| Adjust with body coil    | Off             |
| Confirm freq. adjustment | Off             |
| Assume Silicone          | Off             |
| Ref. amplitude 1H        | 337.166 V       |
| Adjustment Tolerance     | Auto            |
| Adjust volume            |                 |
| Position                 | R0.3 A11.0 F2.1 |
| Orientation              | T > C-12.5      |
| Rotation                 | 0.34 deg        |
| R >> L                   | 200 mm          |
| A >> P                   | 200 mm          |
| F >> H                   | 45 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
|-----------------|------|

## BOLD

|                         |          |
|-------------------------|----------|
| GLM Statistics          | Off      |
| Dynamic t-maps          | Off      |
| Starting ignore meas    | 0        |
| Ignore after transition | 0        |
| Model transition states | Off      |
| Temp. highpass filter   | Off      |
| Threshold               | 4.00     |
| Paradigm size           | 1        |
| Meas                    | Baseline |
| Motion correction       | Off      |
| Spatial filter          | Off      |

## Sequence

|                   |            |
|-------------------|------------|
| Introduction      | Off        |
| Bandwidth         | 2520 Hz/Px |
| Free echo spacing | Off        |
| Echo spacing      | 0.46 ms    |
| -----             |            |
| EPI factor        | 64         |
| RF pulse type     | Normal     |
| Gradient mode     | Fast       |
| -----             |            |
| Dummy Scans       | 0          |

# SIEMENS MAGNETOM TrioTim syngo MR B15

\\USER\INVESTIGATORS\HST\_583\Physics2\epi\_esp480\_grappa2

TA: 8.0 s    PAT: 2    Voxel size: 3.1x3.1x3.1 mm    Rel. SNR: 1.00    USER: ep2d\_bold\_MGH\_pro\_tb

## Properties

|   |        |
|---|--------|
| Prio Recon                                    | Off    |
| Before measurement                            |        |
| After measurement                             |        |
| Load to viewer                                | On     |
| Inline movie                                  | Off    |
| Auto store images                             | On     |
| Load to stamp segments                        | Off    |
| Load images to graphic segments               | Off    |
| Auto open inline display                      | Off    |
| AutoAlign Spine                               | Off    |
| Start measurement without further preparation | On     |
| Wait for user to start                        | Off    |
| Start measurements                            | single |

## Routine

|                    |                 |
|--------------------|-----------------|
| Slice group 1      |                 |
| Slices             | 9               |
| Dist. factor       | 67 %            |
| Position           | R0.3 A11.0 F2.1 |
| Orientation        | T > C-12.5      |
| Phase enc. dir.    | A >> P          |
| Rotation           | 0.34 deg        |
| Phase oversampling | 0 %             |
| FoV read           | 200 mm          |
| FoV phase          | 100.0 %         |
| Slice thickness    | 3.10 mm         |
| TR                 | 2000 ms         |
| TE                 | 30 ms           |
| Averages           | 1               |
| Concatenations     | 1               |
| Filter             | None            |
| Coil elements      | HEA;HEP         |

## Contrast

|                 |           |
|-----------------|-----------|
| MTC             | Off       |
| Flip angle      | 90 deg    |
| Fat suppr.      | Fat sat.  |
| -----           |           |
| Averaging mode  | Long term |
| Reconstruction  | Magnitude |
| Measurements    | 1         |
| Delay in TR     | 0 ms      |
| Multiple series | Off       |

## Resolution

|                       |               |
|-----------------------|---------------|
| Base resolution       | 64            |
| Phase resolution      | 100 %         |
| Phase partial Fourier | Off           |
| Interpolation         | Off           |
| -----                 |               |
| PAT mode              | GRAPPA        |
| Accel. factor PE      | 2             |
| Ref. lines PE         | 32            |
| Matrix Coil Mode      | Auto (Triple) |
| Reference scan mode   | Separate      |
| -----                 |               |
| Distortion Corr.      | Off           |
| Prescan Normalize     | Off           |
| Raw filter            | On            |
| Elliptical filter     | Off           |
| Hamming               | Off           |

## Geometry

|                  |             |
|------------------|-------------|
| Multi-slice mode | Interleaved |
|------------------|-------------|

## Series

|              |      |
|--------------|------|
| Special sat. | None |
|--------------|------|

## System

|                   |                |
|-------------------|----------------|
| Body              | Off            |
| HEP               | On             |
| HEA               | On             |
| -----             |                |
| Positioning mode  | FIX            |
| Table position    | H              |
| Table position    | 0 mm           |
| MSMA              | S - C - T      |
| Sagittal          | R >> L         |
| Coronal           | A >> P         |
| Transversal       | F >> H         |
| Coil Combine Mode | Sum of Squares |
| Auto Coil Select  | Default        |

|                          |                 |
|--------------------------|-----------------|
| Shim mode                | Standard        |
| Adjust with body coil    | Off             |
| Confirm freq. adjustment | Off             |
| Assume Silicone          | Off             |
| Ref. amplitude 1H        | 337.166 V       |
| Adjustment Tolerance     | Auto            |
| Adjust volume            |                 |
| Position                 | R0.3 A11.0 F2.1 |
| Orientation              | T > C-12.5      |
| Rotation                 | 0.34 deg        |
| R >> L                   | 200 mm          |
| A >> P                   | 200 mm          |
| F >> H                   | 45 mm           |

## Physio

|                 |      |
|-----------------|------|
| 1st Signal/Mode | None |
|-----------------|------|

## BOLD

|                         |          |
|-------------------------|----------|
| GLM Statistics          | Off      |
| Dynamic t-maps          | Off      |
| Starting ignore meas    | 0        |
| Ignore after transition | 0        |
| Model transition states | Off      |
| Temp. highpass filter   | Off      |
| Threshold               | 4.00     |
| Paradigm size           | 1        |
| Meas                    | Baseline |
| Motion correction       | Off      |
| Spatial filter          | Off      |

## Sequence

|                   |            |
|-------------------|------------|
| Introduction      | Off        |
| Bandwidth         | 2520 Hz/Px |
| Free echo spacing | Off        |
| Echo spacing      | 0.48 ms    |
| -----             |            |
| EPI factor        | 64         |
| RF pulse type     | Normal     |
| Gradient mode     | Fast       |
| -----             |            |
| Dummy Scans       | 0          |