MI.	T OpenCourseWare
htt	p://ocw.mit.edu

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

For information about citing these materials or our Terms of Use, visit: http://ocw.mit.edu/terms.

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

Harvard-MIT Division of Health Sciences and Technology

Course Director: Dr. Randy Gollub.

INTRODUCTION

This Lab consists of three parts:

Part 1: SNR Measurements – Temporal and Spatial Characteristics in Signal and Noise

Part 2: Determination of MR parameters (T1, T2, T2*) across tissue types and regions of

Part 3: EPI distortions due to B0 Inhomogeneity

All experiments will be performed on a human subject. The SNR measurements will also be run on a phantom for comparison. Some of the data analysis will be performed on the scanner console, however you will be asked to note the measurements obtained as you will need them to solve the exercises given in the lab report.

The main goals of this lab are to:

- 1) Become familiar with basic principles of MRI Physics and measurements (i.e. SNR, relaxation times, etc).
- 2) Understand the T1, T2 and T2* properties of various tissue compartments.
- 3) Acquire and evaluate phantom data.
- 4) Perform a human scanning experiment and investigate the various sources of noise in the fMRI time series.
- 5) Evaluate EPI distortions through field maps and by varying the readout properties.

1. SNR Measurements

Background

At the most basic level, the SNR depends on the number of protons present in the voxel (proportional to Voxel Volume if we assume a constant density) and the $\sqrt{MeasurementTime}$. The latter is a standard aspect of signal averaging assuming the noise is uncorrelated and distributed in a Gaussian distribution. Each acquisition in the k-space matrix is essentially averaged when the Fourier Transform produces the image. Therefore the total measurement time is the total amount of time the digitizers are actually recording k-space samples. For a readout line of 256 samples acquired with a dwell time (time per sample) of 25 μ s, this yields an acquisition time of 6.4ms. Sometimes acquisition time for the readout is expressed in terms of the bandwidth of frequencies

present across the image (
$$BW_{read}$$
). $BW_{read} = \frac{1}{dwell \ time}$ equal to 40kHz for this example.

On the Siemens system the BW is expressed in Hz per pixel across the image, so for the 256 matrix above, this is a $BW_{read} = 156 \, \text{Hz/px}$. The total image acquisition time is the time per line multiplied by the number of lines (# phase encode steps N_{PE}) and the number of times each line was averaged (N_{AVG})

Equation 1 shows the dependence of SNR on some of the above parameters:

$$SNR \propto \frac{Voxel \, Volume \cdot \sqrt{N_{AVG}}}{\sqrt{BW_{read}}}$$
 (1)

For fMRI, it is the time-course SNR that is important. Functional MRI is restricted by multiple sources of variance, such as instrumental sources of error including thermal noise and shot-to-shot electronic instability, and subject dependent modulations of the MR signal associated with physiological processes. In addition to respiratory and cardiac cycle contributions, the physiological noise also consists of a noise element with BOLD-like TE dependence (Triantafyllou et al. 2005), (Krueger and Glover 2001), and spatial correlation within gray matter (Krueger and Glover 2001). The origin of this "BOLD noise" is still not fully understood, but is generally associated with hemodynamic and metabolic fluctuations in the gray matter. Since the physiological fluctuations represent a multiplicative modulation of the image signal (Krueger and Glover 2001) their amplitude scales with the MR image intensity. This is in contrast to the thermal noise sources which can be represented by the addition of a fixed amount of Gaussian noise power whose amplitude is determined primarily by the coil loading.

If the noise sources are assumed to be uncorrelated, the total noise in the image time-course (σ) is related to its thermal (σ_0) and physiological (σ_p) components via:

$$\sigma = \sqrt{\sigma_0^2 + \sigma_p^2} \,\,\,\,(2)$$

In our measurements, shot-to-shot scanner instabilities will contribute to both terms, σ_0 and σ_p , depending on their signal dependence. Phantom measurements, however, show that they comprise only a small fraction of the *in vivo* time course noise.

The time-course SNR (tSNR) is then defined as:

$$tSNR = \frac{\overline{S}}{\sqrt{\sigma_0^2 + \sigma_p^2}},$$
 (3)

where \overline{S} is the mean image signal intensity. Defining the SNR in an individual image as $SNR0 = \frac{\overline{S}}{\sigma_0}$ and combining with Eq. (3), we determine the relationship between tSNR and SNR0:

$$tSNR = \frac{SNR0}{\sqrt{1 + \lambda^2 \cdot SNR0^2}} \tag{4}$$

where λ is a constant.

References

- 1. Triantafyllou C., et al., Comparison of physiological noise at 1.5 T, 3 T and 7 T and optimization of fMRI acquisition parameters. NeuroImage 26, 243–250; 2005.
- 2. Krueger G, Glover GH. Physiological noise in oxygenation-sensitive magnetic resonance imaging. Magn Reson Med 46: 631-7; 2001.

Experiments

In this exercise we will acquire human MRI data in order to characterize image signal and noise characteristics and the time-course signal and noise characteristics. Data will be collected on a 3T Siemens Imager.

We will examine the spatial SNR, time-course SNR and their relationship for three different image resolutions, $5x5x5mm^3$, $3x3x3mm^3$ and $1.5x1.5x1.5mm^3$. In all cases, images with zero RF will also be obtained to capture the thermal image noise. For comparison, time series data using the same parameters will also be acquired on a loading phantom.

Acquisition:

- 1) Localizer.
- 2) EPI time series at low resolution 5mm x 5mm x 5mm, 10 slices, 100 time points, TR=2000ms, TE=30ms, (see protocol epi 5x5x5 signal).
- 3) Same as #2 but with no RF excitation (just thermal noise)
- 4) EPI time series at medium resolution 3mm x 3mm x 3mm, 10 slices, 100 time points, TR=2000ms, TE=30ms (see protocol epi 3x3x3 signal).
- 5) Same as #4 but with no RF excitation (just thermal noise).
- 6) EPI time series at higher resolution 1.5mm x 1.5mm x 1.5mm, 10 slices, 100 time points, TR=2000ms, TE=30ms (see protocol epi 1.5x1.5x1.5 signal).
- 7) Same as #6 but with no RF excitation (just thermal noise).

Note 1: Typically, thermal noise would be calculated by drawing an ROI outside the signal area in an image. However in EPI acquisition there are a lot of artifacts present. To avoid misreading the noise we thus acquire a separate image without an RF that provides a better representation of thermal noise.

Note 2: Since the thermal noise is random we need to characterize it in terms of its mean, and standard deviation (or variance). Before we can calculate these quantities, we also need to know what kind of statistical distribution this noise belongs to. For example, the most common type of statistical distribution is the Gaussian or normal distribution but the spatial MRI noise outside of the brain has been empirically determined to follow a *Rayleigh* distribution. It is thus simple to compute the mean and variance of the thermal noise by first computing its variance and mean as though it were Gaussian and applying a Rayleigh correction factor to account for this difference.

Spatial SNR (SNR0)

The SNR in an individual image (SNR0) is a measure or the image quality. In our experiments we will evaluate the impact of the spatial resolution on the SNR0. In human data, ROIs will be defined in cortical gray matter. The SNR0 for a given pixel will be calculated as the mean pixel value for all the images in the time-series divided by the standard deviation of the thermal noise of the time-series acquired with no RF excitation (zero flip angle images).

- 1. Load the EPI images and the Noise time-courses on the mean curve task card (2 separate windows).
- 2. Select the EPI time-course, draw an ROI within the signal area, and record the mean signal value.
- 3. Select the Noise time-course, draw an ROI and record the standard deviation.
- 4. Record your measures in Table 1 and calculate the SNR0.
- 5. Repeat steps 1-4 for all three spatial resolutions.
- 6. Repeat steps 1-4 for the phantom data at all three resolutions and record results on Table 2.
 - ❖ Lab Question 1: Draw the calculated SNR0 as a function of voxel size and comment on your findings. Describe the differences if any, between the human and phantom data.

Temporal SNR (tSNR)

Temporal SNR is defined as the image-to-image variance in the time-course and will be measured on a ROIs based analysis in the cortical gray matter. Temporal SNR in a given pixel will be determined from the mean pixel value across the 100 time points divided by its temporal standard deviation.

- 1. Load the EPI time series images on the viewer.
- 2. Calculate the Standard Deviation map from the EPI time series through the scanner UI. Open the Patient Browser, go to Evaluation -> Dynamic Analysis -> Standard Deviation. Press within series, test and assign a name to the new image (STD_mymap). A new series is created on your patient browser, named STD mymap.
- 3. Load the images on the mean curve task card. Select both the EPI time course and the standard deviation map and draw an ROI within the signal area.
- 4. Record the mean value within the ROI on the EPI images; that is your temporal mean of the signal.
- 5. Record the mean value within the ROI on the standard deviation map; that is your temporal noise.
- 6. Calculate the temporal SNR from the above quantities and note on Table 1.
- 7. Repeat steps 1-6 for all three spatial resolutions.
- 8. Repeat steps 1-6 for the phantom data at all three resolutions and record results on Table 2.
 - **❖ Lab Question 2:** Draw the calculated tSNR as a function of voxel size and comment on your findings. Describe the differences if any, between the human and phantom data.

Relationship between SNR0 and tSNR

The tSNR will be analyzed as a function of SNR0 for the given set of resolutions. Use the recorded values from Tables 1 and 2 incorporating the model for tSNR from Eq. 4 (where λ =0.0107).

- **❖ Lab Question 3 :** Show the relationship of tSNR as a function of SNR0 when SNR0 is modulated by the voxel size. Describe the differences, if any, between the human and phantom data. What is the asymptotic limit for tSNR?
- ❖ Lab Question 4: You are asked to perform an fMRI study of medial temporal lobe activation at a high field strength. Which acquisition parameters would you consider most important to optimize in order to achieve the best activation results? For a 3T scanner provide a suggested set of acquisition parameters.
- ❖ Lab Question 5 : Draw ROIS on various tissue types, generate the tSNR as a function of SNR0 in gray matter, white matter and CSF. Record mean signal and standard deviation of the noise. Comment on your findings.

Table 1 – Human Data - Gray Matter

Average values for SNR measurements as a function of image resolution. SNR0 corrected for Rayleigh distribution.

Resolution	Signal	Thermal	Time-Series	Spatial	Temporal
(mm^3)		Noise	Noise	SNR	SNR
1.5x1.5x1.5					
3x3x3					
5x5x5					

Table 2 – Phantom Data

Average values for SNR measurements as a function of image resolution. SNR0 corrected for Rayleigh distribution.

Resolution	Signal	Thermal	Time-Series	Spatial	Temporal
(mm ³)		Noise	Noise	SNR	SNR
1.5x1.5x1.5					
3x3x3					
5x5x5					

Table 3 – Human Data - White Matter

Average values for SNR measurements as a function of image resolution. SNR0 corrected for Rayleigh distribution.

Resolution	Signal	Thermal	Time-Series	Spatial	Temporal
(mm^3)		Noise	Noise	SNR	SNR
1.5x1.5x1.5					
3x3x3					
5x5x5					

Table 4 – Human Data - CSF

Average values for SNR measurements as a function of image resolution. SNR0 corrected for Rayleigh distribution.

Resolution (mm ³)	Signal	Thermal Noise	Time-Series Noise	Spatial SNR	Temporal SNR
1.5x1.5x1.5					
3x3x3					
5x5x5					

\\USER\INVESTIGATORS\\HST_583\\Physics1\localizer

TD 0 ms MTC Off Segments 1 Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. None Water suppr. None Averaging mode Short term Reconstruction Magnitude Result Magnitude Measurements 1 Multiple series Each measurement Flysio 1st Signal/Mode None Segments 1 None None Messy. control Off Subtract Liver registration Std-Dev-Sag Off Std-Dev-Cor Off	TA: 9.2 s PA	AT: Off Voxel size: 2.2×1.1×	_ ,	SIEMENS: gre
Prio Recon Off Prior Recon Off Bafore measurement After measurement Off Load to wever Off PAT mode None Auto storie images On Mone Mattic Soli Mode Auto (P) Load to stamp segments Off Uff Uff Uff Uff Auto open rilina display auto open rilina display segments Off Off Off Off Auto open rilina display Staff measurement without Off Off Normalize Off Staff measurement without Off Raw filter Off Staff measurements Off Saturation mode Saquantial Staff provided Automatic provided Saquantial Saquantial Staff provided Automatic provided	Dropostico		Base resolution	256
Before measurement		04	- Phase resolution	50 %
After measurement Off Load to lawer of Inline movie Off Auto store images On Load to stamp aggments Off Load to stamp aggments Off Load images to graphic Off Sagments Off Auto open inline display Auto open inline display Start measurement without further preparation Off Walto pay inline of the preparation of Walt for user to start Off Start measurement without further preparation Off Walt for user to start Off Start measurement without further preparation Off Walt for user to start Off Start measurement without further preparation Off Walt for user to start Off Start measurement without further preparation Off Walt for user to start Off Start measurement without further preparation Off Walt for user to start Off Stice group 1 Silce group 6 Silces moth for the preparation of the pr		Off	Phase partial Fourier	Off
Load to viewer Inline movie (nine movie) Off PAT mode None Inline movie (nine movie) Off Matrix Coll Mode Auto (CP) Auto Caster passements Off Image Filter Off Load insages to graphic segments Off Uniformation of the passement without further preparation Off Auto open inline display off Off Prescan Normalize Off Start measurement without further preparation Off Rawfilter Off Walt for user to start Off Rawfilter Off Start measurements single Geometry Geometry Routine Silce group 1 Salice illustration Sequential Silce group 1 Silce group 2 Sagital Sequential Silce group 2 1 Sagital st. None Phase enc. dir. A >> P Passition on the passe enc. dir. A >> P Passition on the passe enc. dir. A >> P Passition on the passe enc. dir. A >> P Passe on the passe enc. dir. A >> P Sagital on the passe enc. dir. A >> P Sagital on the passe enc. dir.			Interpolation	On
Inline movie		Off	DAT mode	None
Auto store images		_		
Load to stamp segments Off Image Filter Off Load images to graphic segments Off Distortion Corr. Off Auto open inline display Auto open inline display Start measurement without further preparation Off Normalize Off Wait for user to start Off Raw filter Off Slart measurements single Geometry Routine Total Sice group 1 Saturation mode Saturation mode Slices 1 Saturation mode Sandard Position Isocenter Special sat. Position None Special sat. Phase enc. dir. A >> P Body Slice group 2 Slice group 2 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3 Slice group 3				Auto (GF)
Load images to graphic segments Auto open inline display Off		_	Image Filter	Off
Segments				
Auto open inline display			_	_
AutoAlign Spine		Off		_
Start measurement without Off Wait for user to start Off Start measurements Single Geometry				
Turner T				- · · ·
Wait for user to start Off Mode Implane Start measurements single Geometry Routline Multi-slice mode Sequential Slices group 1 1 Saturation mode Standard Dist. factor 20 % Special sat. None Phase enc. dir. A >> P Body Off Rotation 0.00 deg HEP On Slices group 2 Body Off Slices group 2 HEP On Slices group 2 HEP On Slices group 2 Position REF Slices group 3 Silce slice group 3 Table position H Slice group 3 Silce group 3 Silce group 3 Sagittal R >> L Slices 1 1 Table position 0 mm Position Isocenter Coronal A >> P Orientation Isocenter Coronal A >> P Phase enc. dir. R >> L Save uncombined Off FoV phase 10.0		0.11		
Start measurements	1 -	Off	Mode	Inplane
Multi-silce mode Sequential Series Interleaved			Geometry	
Silice group 1	I	5g.c		Sequential
Silce group				•
Dist. factor				
Position				
Orientation Sagittal Phase enc. dir. A >> P Body Off Rotation 0.00 deg HEP On Slices group 2 1 HEA On Slices 1 1 Dist. factor 20 % Positioning mode REF Position Isocenter Table position 0 mm MMA S - C - T Rotation 0.00 deg Sagittal R >> L Coronal A >> P Slices oroup 3 1 Transversal R >> L Coronal A >> P Slices oroup 3 1 Transversal R >> L Saye uncombined Off Slices oroup 3 1 Transversal P > H Save uncombined Off Slices oroup 3 1 Transversal P > H Save uncombined Off Slices oroup 3 1 Save uncombined Off Off Off Position Isocenter Coil Combine Mode Sum of Squares Default On On On On On On			Special sat.	None
Phase enc. dir.				
Rotation Slice group 2 Slices 1			System	
Slice group 2 Slices 1			Body	Off
Silices		0.00 deg	HEP	On
Dist. factor			HEA	On
Position Orientation Orientation Orientation Isocenter Transversal Table position H Table position H Phase enc. dir. A > P Asagittal R > L Coronal S- C - T Rotation 0.00 deg Sagittal R >> L Coronal A >> P Slices group 3 1 Transversal F >> H F >> H Dist. factor 20 % Save uncombined Off Off Position Isocenter Coil Combine Mode Sum of Squares Orientation Coronal Auto Coil Select Default Phase enc. dir. R >> L Shim mode Sum of Squares Auto Coil Select Default Default Phase enc. dir. R >> L Shim mode Tune up Auto Coil Select Default Default Postition O.00 deg Adjust with body coil On Phase enc. dir. R >> L Shim mode Tune up Adjust with body coil On Orifmreq. adjustment Off FoV read 280 mm Adjust with body coil On A			Desitioning mode	DEE
Orientation Transversal A > P A > P MSMA S - C - T Sagittal R > L Coronal A > P A > P A > P Sagittal R > L Coronal A > P R > L Coronal A > P Transversal F > H Sagittal R > L Coronal A > P P Transversal F > H Sagittal R > L Coronal A > P Transversal F > H Sagittal R > L Coronal A > P Transversal F > H Sagittal R > L Coronal A > P Transversal F > H Sagittal R > L Coronal				
Phase enc. dir. A >> P Rotation 0.00 deg Slice group 3 Slices Slices 1 Dist. factor 20 % Position Isocenter Orientation Coronal Phase enc. dir. R >> L Rotation 0.00 deg Phase enc. dir. R >> L Rotation 0.00 deg Phase oversampling 0 % FoV read 280 mm FoV phase 100.0 % Slice thickness 10.0 mm TR 20.0 ms Slice thickness 10.0 mm Averages 1 Concatenations 3 Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP Physio TD 0 ms MTC Off Coil read adjust very composed None Filip angle 40 deg Pat suppr. None Magn, preparation None Flip angle				
Rotation None Sagittal R >> L				
Slice group 3 Slice s				
Silices 1 Dist. factor 20 % Corinatation Socenter Corinatation Coronal Phase enc. dir. Rotation Coronal Phase oversampling FoV read 280 mm FoV phase 100.0 % Silice thickness 10.0 mm TE 5.00 ms Averages 1 Concatenations 3 Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP TD 0 ms TTD 0 ms TTTransversal TTR F > H TTR F > H TTR Save uncombined of Off Tune up Adjust with body coil On Confirm freq. adjustment Adjustment Tolerance Adjustment Tolerance Adjustment Tolerance Adjust volume Position Isocenter Position D.00 deg R >> L 350 mm R >> L 350 mm TTR 350		0.00 deg		
Dist. factor 20 % Save uncombined Off Coil Combine Mode Sum of Squares Orientation Coronal Phase enc. dir. R >> L Shim mode Tune up Adjust with body coil On Confirm freq. adjustment Off Assume Silicone Off Resp. and None Tip angle 40 deg Dark blood Off Segments 1 Sibracy Factors of Magnitude Massurements 1 None Respectives of Std-Dev-Cor Off Std-De				
Position Isocenter Orientation Coronal Phase enc. dir. R > L Rotation 0.00 deg Phase oversampling 0 % FoV read 280 mm FoV phase 100.0 % Slice thickness 10.0 mm Averages 1 Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP P TD 0 ms TTC Off Magn. preparation None Flip angle 40 deg Fat suppr. None Water suppr. None Water suppr. None Water suppr. None Magnitude Measurements 1 Multiple series Rouse dir. R > L Shim mode Tune up Adjust with body coil Confirm freq, adjustment Off Assume Silicone Off Ref. amplitude 1H 318.659 V Adjustment Tolerance Auto Adjust volume Position Isocenter Adjust volume Position Isocenter Orientation Transversal Rotation 0.00 deg R >> L 350 mm Adjustment Tolerance Auto Adjust volume Position Isocenter Position Sizenter Auto Odf Ref. amplitude 1 1 318.659 V Adjustment Tolerance Auto Adjust volume Position Isocenter Position Isocenter Position Sizenter Auto Odf Assume Silicone Off Ref. amplitude 1 1 318.659 V Adjustment Tolerance Auto Adjust volume Position Isocenter Position Isocenter Position One Auto Adjustment Tolerance Auto Adjust volume Position Isocenter Position Isocenter Position Isocenter Position Isocenter Position One Auto Adjustment Tolerance Auto Auto Alto				
Orientation Orientation Phase enc. dir. Rotation Orientation Phase enc. dir. Rotation Orientation Orientation Phase enc. dir. Rotation Orientation Ori				- · · ·
Phase enc. dir. R >> L Rotation				
Rotation 0.00 deg Phase oversampling 0 %			Auto Coil Select	
Rotation 0.00 deg Phase oversampling 0 % Confirm freq. adjustment Off			Shim mode	Tune up
FoV read		<u> </u>	Adjust with body coil	_
FoV phase	1 -		Confirm freq. adjustment	Off
Slice thickness 10.0 mm TR 20.0 ms TR 20.0 ms TE 5.00 ms Adjustment Tolerance Adjust volume Position Isocenter Orientation Transversal Concatenations 3 Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP F>> H 350 mm Contrast TD 0 ms MTC Off Segments 1 Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. None Water suppr. Water suppr. Averaging mode Short term Reconstruction Magnitude Resp. control Magnitude Multiple series Each measurement Adjustment Tolerance Adjust volume Position Isocenter Orientation Transversal Rotation 0.00 deg R >> L 350 mm F>> H 350 mm Physio TD 0 ms 1st Signal/Mode None Segments 1 Dark blood Off Resp. control Off Liver registration Std-Dev-Sag Off Std-Dev-Cor Off			Assume Silicone	Off
TR TE 5.00 ms Adjust volume Position Adjust volume Position Adjust volume Position Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP Physio TD Off Magn. preparation Flip angle Fat suppr. Water suppr. Adjust volume Position None Position None Position Rotation None Position Rotation None Physio The segments Physio 1st Signal/Mode Segments 1 None Physio To Segments 1 More Resp. control Adjust volume Position Isocenter Nondege R >> L 350 mm Physio 1st Signal/Mode Segments 1 Mone Magn. preparation Physio 1st Signal/Mode Segments 1 Mone None Segments 1 Mone None None None None Adjust volume Position Isocenter Nondege R >> L 350 mm Physio 1st Signal/Mode Segments 1 Mone Segments 1 Mone None None None None None Adjust volume Position Isocenter Nondege R >> L 350 mm Physio 1st Signal/Mode Segments 1 Mone Segments 1 Mone None Segments 1 Mone None None None None Segments 1 Mone Segments 1 Mone Segments 1 More Segments 1 Mo			Ref. amplitude 1H	318.659 V
TE 5.00 ms Adjust Votality Averages 1 Position Isocenter Concatenations 3 Rotation 0.00 deg Filter Prescan Normalize, Elliptical filter R >> L 350 mm Coil elements HEA;HEP F >> H 350 mm Contrast Physio F >> H 350 mm TD 0 ms Physio Ist Signal/Mode None MTC Off Segments 1 None Flip angle 40 deg Dark blood Off Off Fat suppr. None Resp. control Off Off Averaging mode Short term Subtract Off Liver registration Off Reconstruction Magnitude Liver registration Off Std-Dev-Sag Off Multiple series Each measurement Std-Dev-Cor Off				Auto
Averages 1 Orientation Transversal Concatenations 3 Rotation 0.00 deg Filter Prescan Normalize, Elliptical filter Rotation 0.00 deg Coil elements HEA;HEP R >> L 350 mm Contrast Physio F >> H 350 mm Dontrast Physio Physio TD 0 ms 1st Signal/Mode None MTC Off Segments 1 Magn. preparation None Dark blood Off Fat suppr. None Resp. control Off Water suppr. None Resp. control Off Averaging mode Short term Subtract Off Reconstruction Magnitude Liver registration Off Liver registration Off Std-Dev-Sag Off Multiple series Each measurement Std-Dev-Cor Off			_	
Concatenations Filter Prescan Normalize, Elliptical filter Coil elements HEA;HEP Physio TD Off Magn. preparation Flip angle Fat suppr. Water suppr. Water suppr. Averaging mode Reconstruction Measurements Multiple series Rotation O.00 deg R >> L 350 mm A >> P 263 mm F >> H 350 mm Physio 1st Signal/Mode Segments 1 Segments 1 Dark blood Off Resp. control Off Liver registration Std-Dev-Sag Std-Dev-Cor Off Std-Dev-Cor Off Std-Dev-Cor Off		5.UU MS		Isocenter
Filter Prescan Normalize, Elliptical filter R >> L 350 mm Coil elements HEA;HEP F >> H 350 mm Contrast F >> H 350 mm TD 0 ms Physio MTC Off Segments 1 Magn. preparation None Segments 1 Filip angle 40 deg Dark blood Off Fat suppr. None Resp. control Off Water suppr. None Resp. control Off Averaging mode Short term Subtract Off R >> L 350 mm Off Subtract Off Off Liver registration Off Std-Dev-Sag Off Std-Dev-Cor Off	1	1	Orientation	
Coil elements		_		•
Contrast TD 0 ms MTC Off Magn. preparation None Flip angle 40 deg Fat suppr. None Water suppr. Averaging mode Reconstruction Measurements Multiple series HEA;HEP F >> H 350 mm Physio 1st Signal/Mode Segments 1 Dark blood Off Resp. control Off Mesp. control Off Liver registration Std-Dev-Sag Off Std-Dev-Cor Off Std-Dev-Cor Off	Filter	-		
Contrast TD 0 ms 1st Signal/Mode None Segments 1 Magn. preparation None Flip angle 40 deg Dark blood Off Resp. control Off Subtract Off Subtract Civer registration Off Subtract Civer registration Off Std-Dev-Sag Off Std-Dev-Cor Off Std-	Cail along series			
TD 0 ms MTC Off Segments 1 Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. None Water suppr. None Averaging mode Short term Reconstruction Magnitude Result Magnitude Measurements 1 Multiple series Each measurement Flysio 1st Signal/Mode None Segments 1 None None Messy. control Off Subtract Liver registration Std-Dev-Sag Off Std-Dev-Cor Off	Coil elements	пеа;пер	F >> H	350 mm
TD 0 ms MTC Off Segments 1 Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. None Water suppr. None Averaging mode Reconstruction Magnitude Reconstruction Magnitude Measurements 1 Multiple series Each measurement Tst Signal/Mode None Segments 1 None None Resp. control Resp. control Off Subtract Liver registration Std-Dev-Sag Off Std-Dev-Cor Off Std-Dev-Cor Off	Contrast		Physio	
MTC Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. Water suppr. None Averaging mode Reconstruction Measurements Multiple series Segments 1 None Dark blood Off Resp. control Off Noff Subtract Liver registration Std-Dev-Sag Off Std-Dev-Cor Off Std-Dev-Cor Off			•	None
Magn. preparation None Flip angle 40 deg Dark blood Off Fat suppr. None Water suppr. None Averaging mode Short term Reconstruction Magnitude Measurements 1 Multiple series Each measurement None Resp. control Resp. control Off Cultiver registration Std-Dev-Sag Std-Dev-Cor Off Std-Dev-Cor Off Std-Dev-Cor Off				
Fat suppr. None Resp. control Off Water suppr. None Averaging mode Short term Subtract Off Reconstruction Magnitude Liver registration Off Measurements 1 Std-Dev-Sag Off Multiple series Each measurement Std-Dev-Cor Off				·
Water suppr. None Inline Averaging mode Short term Reconstruction Magnitude Measurements 1 Multiple series Each measurement None Inline Subtract Off Liver registration Off Std-Dev-Sag Off Std-Dev-Cor Off		40 deg	Dark blood	Off
Water suppr. Averaging mode Short term Reconstruction Magnitude Measurements 1 Multiple series Each measurement None Inline Subtract Off Liver registration Off Std-Dev-Sag Off Std-Dev-Cor Off	Fat suppr.		Resp. control	Off
Averaging mode Short term Reconstruction Magnitude Liver registration Off Measurements 1 Subtract Off Liver registration Off Std-Dev-Sag Off Std-Dev-Cor Off	Water suppr.	None	•	5 11
Reconstruction Magnitude Liver registration Off Measurements 1 Std-Dev-Sag Off Multiple series Each measurement Std-Dev-Cor Off	Averaging mode	Short term		
Measurements 1 Std-Dev-Sag Off Multiple series Each measurement Std-Dev-Cor Off				_
Multiple series Each measurement Std-Dev-Sag Off Std-Dev-Cor Off		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		_
Std-Dev-Coi Oii		Fach measurement		_
Resolution Std-Dev-Tra Off	•	Laon measurement		
	Resolution		Std-Dev-Tra	Off

Std-Dev-Time MIP-Sag MIP-Cor MIP-Tra MIP-Time Save original images	Off Off Off Off Off On
Wash - In Wash - Out TTP PEI MIP - time	Off Off Off Off Off
Sequence Introduction Dimension Phase stabilisation Asymmetric echo Contrasts Bandwidth Flow comp. Allowed delay	On 2D Off Off 1 180 Hz/Px No 0 s
RF pulse type Gradient mode	Fast Normal

On

Slice-sel.

Excitation

RF spoiling

\\USER\INVESTIGATORS\HST_583\Physics1\epi_5x5x5_signal

Properties		System	
Prio Recon	Off	Body	Off
Before measurement	Oli	HEP	On
		HEA	On
After measurement	0.5	ПЕА	On
Load to viewer	On Off	Positioning mode	FIX
Inline movie	Off	Table position	H
Auto store images	On	Table position	0 mm
Load to stamp segments	Off	MSMA	S - C - T
Load images to graphic	Off		
segments		Sagittal	R >> L
Auto open inline display	Off	Coronal	A >> P
AutoAlign Spine	Off	Transversal	F >> H
Start measurement without	On	Coil Combine Mode	Sum of Squares
further preparation	011	Auto Coil Select	Default
Wait for user to start	Off		
		Shim mode	Standard
Start measurements	single	Adjust with body coil	Off
outine		Confirm freq. adjustment	Off
Slice group 1		Assume Silicone	Off
Slice group 1	10	Ref. amplitude 1H	318.659 V
	10	Adjustment Tolerance	Auto
Dist. factor	0 %	Adjust volume	
Position	R3.0 A3.0 H0.0	Position	R3.0 A3.0 H0.0
Orientation	T > C-12.5	Orientation	T > C-12.5
Phase enc. dir.	A >> P		
Rotation	0.00 deg	Rotation	0.00 deg
Phase oversampling	0 %	R >> L	240 mm
FoV read	240 mm	A >> P	240 mm
FoV phase	100.0 %	F >> H	50 mm
Slice thickness	5.00 mm	Physic	
TR	2000 ms	Physio	Nissas
		1st Signal/Mode	None
TE	30 ms	BOLD	
Averages	1	GLM Statistics	Off
Concatenations	1		Off
Filter	None	Dynamic t-maps	
Coil elements	HEA;HEP	Starting ignore meas	0
a material to		Ignore after transition	0
ontrast		Model transition states	Off
MTC	Off	Temp. highpass filter	Off
Flip angle	90 deg	Threshold	4.00
Fat suppr.	Fat sat.	Paradigm size	1
A	l on a town	Meas	Baseline
Averaging mode	Long term	Motion correction	On
Reconstruction	Magnitude	Interpolation	3D-K-space
Measurements	100	Spatial filter	Off
Delay in TR	0 ms		5 11
Multiple series	Off	Sequence	
		Introduction	Off
			- · ·
			3472 Hz/Px
esolution Base resolution	48	——— Bandwidth	3472 Hz/Px
Base resolution Phase resolution	100 %	Bandwidth Free echo spacing	Off
Base resolution	_	——— Bandwidth	
Base resolution Phase resolution	100 %	Bandwidth Free echo spacing Echo spacing	Off
Base resolution Phase resolution Phase partial Fourier Interpolation	100 % Off Off	Bandwidth Free echo spacing Echo spacing EPI factor	Off 0.36 ms 48
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode	100 % Off Off None	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type	Off 0.36 ms 48 Normal
Base resolution Phase resolution Phase partial Fourier Interpolation	100 % Off Off	Bandwidth Free echo spacing Echo spacing EPI factor	Off 0.36 ms 48
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode	100 % Off Off None Auto (CP)	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr.	100 % Off Off None Auto (CP)	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize	100 % Off Off None Auto (CP) Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize Raw filter	100 % Off Off None Auto (CP)	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize	100 % Off Off None Auto (CP) Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize Raw filter	100 % Off Off None Auto (CP) Off Off Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize Raw filter Elliptical filter Hamming	100 % Off Off None Auto (CP) Off Off Off On Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize Raw filter Elliptical filter Hamming eometry	100 % Off Off None Auto (CP) Off Off Off On Off Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast
Base resolution Phase resolution Phase partial Fourier Interpolation PAT mode Matrix Coil Mode Distortion Corr. Prescan Normalize Raw filter Elliptical filter Hamming	100 % Off Off None Auto (CP) Off Off Off On Off	Bandwidth Free echo spacing Echo spacing EPI factor RF pulse type Gradient mode	Off 0.36 ms 48 Normal Fast

Special sat.

\\USER\INVESTIGATORS\\HST_583\\Physics1\epi_5x5x5_noise

Rel. SNR: 1.00

USER: ep2d_bold_MGH_pro_tb

Voxel size: 5.0×5.0×5.0 mm

PAT: Off

TA: 0:24

Special sat.

Properties		System	
Prio Recon	Off	Body	Off
Before measurement		HEP	On
After measurement		HEA	On
Load to viewer	On	D 22 1	
Inline movie	Off	Positioning mode	FIX
Auto store images	On	Table position	H
Load to stamp segments	Off	Table position	0 mm
Load images to graphic	Off	MSMA	S - C - T
segments		Sagittal	R >> L
Auto open inline display	Off	Coronal	A >> P
AutoAlign Spine	Off	Transversal	F >> H
Start measurement without	On	Coil Combine Mode	Sum of Squares
further preparation	3.1	Auto Coil Select	Default
Wait for user to start	Off	Shim mode	Standard
Start measurements	single		
Start measurements	Sirigie	Adjust with body coil	Off
outine		Confirm freq. adjustment	Off
Slice group 1		Assume Silicone	Off
Slices	10	Ref. amplitude 1H	318.659 V
Dist. factor	0 %	Adjustment Tolerance	Auto
Position	R3.0 A3.0 H0.0	Adjust volume	
Orientation	T > C-12.5	Position	R3.0 A3.0 H0.0
Phase enc. dir.	A >> P	Orientation	T > C-12.5
Rotation	0.00 deg	Rotation	0.00 deg
Phase oversampling	0.00 deg 0 %	R >> L	240 mm
FoV read	240 mm	A >> P	240 mm
		F >> H	50 mm
FoV phase	100.0 %	Dhuai-	
Slice thickness	5.00 mm	Physio	N.
TR	2000 ms	1st Signal/Mode	None
TE	30 ms	BOLD	
Averages	1	GLM Statistics	Off
Concatenations	1	Dynamic t-maps	Off
Filter	None		
Coil elements	HEA;HEP	Starting ignore meas Ignore after transition	0 0
Contrast		Model transition states	
MTC	Off		Off
	90 deg	Temp. highpass filter	Off
Flip angle	S	Threshold	4.00
Fat suppr.	Fat sat.	Paradigm size	1
Averaging mode	Long term	Meas	Baseline
Reconstruction	Magnitude	Motion correction	On
Measurements	10	Interpolation	3D-K-space
Delay in TR	0 ms	Spatial filter	Off
Multiple series	Off	Sequence	
	5 11	Introduction	Off
esolution		Bandwidth	-
Base resolution	48		3472 Hz/Px
Phase resolution	100 %	Free echo spacing	Off
Phase partial Fourier	Off	Echo spacing	0.36 ms
Interpolation	Off	EPI factor	48
		RF pulse type	Normal
PAT mode	None	Gradient mode	Fast
Matrix Coil Mode	Auto (CP)		
Distortion Corr.	Off	Dummy Scans	2
		1 -	
Prescan Normalize	Off		
Raw filter	On Off		
Elliptical filter	Off		
Hamming	Off		
eometry			
Multi-slice mode	Interleaved		
Series	Interleaved		

 $\verb|\USER\INVESTIGATORS\HST_583\Physics1\epi_3x3x3_signal| \\$

Rel. SNR: 1.00

Voxel size: 3.0×3.0×3.0 mm

PAT: Off

TA: 3:24

USER: ep2d_bold_MGH_pro_tb

Properties		System	
Prio Recon	Off	Body	Off
Before measurement		HEP	On
After measurement		HEA	On
Load to viewer	On		—n/
Inline movie	Off	Positioning mode	FIX
Auto store images	On	Table position	H
Load to stamp segments	Off	Table position	0 mm
Load images to graphic	Off	MSMA	S - C - T
segments	0.11	Sagittal	R >> L
Auto open inline display	Off	Coronal	A >> P
	Off	Transversal	F >> H
AutoAlign Spine		Coil Combine Mode	Sum of Squares
Start measurement without	On	Auto Coil Select	Default
further preparation	0"		
Wait for user to start	Off	Shim mode	Standard
Start measurements	single	Adjust with body coil	Off
Routine		Confirm freq. adjustment	Off
Slice group 1		Assume Silicone	Off
Slices	10	Ref. amplitude 1H	318.659 V
Dist. factor	10 67 %	Adjustment Tolerance	Auto
		Adjust volume	
Position	R3.0 A3.0 H0.0	Position	R3.0 A3.0 H0.0
Orientation	T > C-12.5	Orientation	T > C-12.5
Phase enc. dir.	A >> P	Rotation	0.00 deg
Rotation	0.00 deg	R >> L	192 mm
Phase oversampling	0 %	A >> P	192 mm
FoV read	192 mm	F >> H	
FoV phase	100.0 %	r>>n	49 mm
Slice thickness	3.00 mm	Physio	
TR	2000 ms	1st Signal/Mode	None
TE	30 ms	1	
Averages	1	BOLD	
Concatenations	1	GLM Statistics	Off
Filter	None	Dynamic t-maps	Off
Coil elements	HEA;HEP	Starting ignore meas	0
Con diamenta	11274,1121	Ignore after transition	0
Contrast		Model transition states	Off
MTC	Off	Temp. highpass filter	Off
Flip angle	90 deg	Threshold	4.00
Fat suppr.	Fat sat.	Paradigm size	1
		Meas	Baseline
Averaging mode	Long term	Motion correction	On
Reconstruction	Magnitude	Interpolation	3D-K-space
Measurements	100	Spatial filter	Off
Delay in TR	0 ms	Opatial litter	Oli
Multiple series	Off	Sequence	
Resolution		Introduction	Off
	C.4	—— Bandwidth	2520 Hz/Px
Base resolution	64	Free echo spacing	Off
Phase resolution	100 %	Echo spacing	0.47 ms
Phase partial Fourier	Off		
Interpolation	Off	EPI factor	64
PAT mode	None	RF pulse type	Normal
Matrix Coil Mode		Gradient mode	Fast
Watrix Con Mode	Auto (CP)		
Distortion Corr.	Off	Dummy Scans	2
Prescan Normalize	Off		
Raw filter	On		
Elliptical filter	Off		
Hamming	Off		
rianining	Oil		
Geometry			
-	Interleaved		
Geometry Multi-slice mode Series	Interleaved Interleaved		

 $\verb|\USER\INVESTIGATORS\HST_583\Physics1\epi_3x3x3_noise| \\$

		0 1	
roperties	0"	System	0"
Prio Recon	Off	Body	Off
Before measurement		HEP	On
After measurement		HEA	On
Load to viewer	On	Positioning mode	FIX
Inline movie	Off	Table position	H
Auto store images	On	Table position	0 mm
Load to stamp segments	Off	MSMA	S - C - T
Load images to graphic	Off	Sagittal	R >> L
segments		Coronal	A >> P
Auto open inline display	Off	Transversal	F >> H
AutoAlign Spine	Off		
Start measurement without	On	Coil Combine Mode	Sum of Squares
further preparation		Auto Coil Select	Default
Wait for user to start	Off	Shim mode	Standard
Start measurements	single	Adjust with body coil	Off
	3 -	Confirm freq. adjustment	Off
outine		Assume Silicone	Off
Slice group 1		Ref. amplitude 1H	318.659 V
Slices	10	Adjustment Tolerance	
Dist. factor	67 %		Auto
Position	R3.0 A3.0 H0.0	Adjust volume Position	R3.0 A3.0 H0.0
Orientation	T > C-12.5		
Phase enc. dir.	A >> P	Orientation	T > C-12.5
Rotation	0.00 deg	Rotation	0.00 deg
Phase oversampling	0 %	R >> L	192 mm
FoV read	192 mm	A >> P	192 mm
FoV phase	100.0 %	F >> H	49 mm
Slice thickness	3.00 mm	Physio	
TR	2000 ms		None
TE	30 ms	1st Signal/Mode	None
		BOLD	
Averages	1	GLM Statistics	Off
Concatenations Filter	Ness	Dynamic t-maps	Off
	None	Starting ignore meas	0
Coil elements	HEA;HEP	Ignore after transition	0
ontrast		Model transition states	Off
MTC	Off	Temp. highpass filter	Off
Flip angle	90 deg	Threshold	4.00
Fat suppr.	Fat sat.	Paradigm size	1
············		_	•
Averaging mode	Long term	Meas Motion correction	Baseline
Reconstruction	Magnitude	Motion correction	On
Measurements	10	Interpolation	3D-K-space
Delay in TR	0 ms	Spatial filter	Off
Multiple series	Off	Sequence	
•		Introduction	Off
esolution		Bandwidth	2520 Hz/Px
Base resolution	64	Free echo spacing	Off
Phase resolution	100 %	Echo spacing	0.47 ms
Phase partial Fourier	Off		U.TI IIIU
Interpolation	Off	EPI factor	64
PAT mode	None	RF pulse type	Normal
	None	Gradient mode	Fast
Matrix Coil Mode	Auto (CP)		
Distortion Corr.	Off	Dummy Scans	2
Prescan Normalize	Off		
Raw filter	On		
Elliptical filter	Off		
Hamming	Off		
eometry			
Multi-slice mode	Interleaved		
Series	Interleaved		

Special sat.

\\USER	R\INVESTIGATORS\HST_58	3\Physics1\epi_1	.5x1.5x1.5_signal
PAT: Off	Voxel size: 1.5×1.5×1.5 mm	Rel. SNR: 1.00	USER: ep2d_bold_MGH_pro_tb

TA: 3:24

Properties		System	
Prio Recon	Off	Body	Off
Before measurement		HEP	On
After measurement		HEA	On
Load to viewer	On	Positioning mode	FIX
Inline movie	Off	Table position	H
Auto store images	On	Table position	0 mm
Load to stamp segments	Off	MSMA	S - C - T
Load images to graphic	Off	Sagittal	R >> L
segments		Coronal	A >> P
Auto open inline display	Off	Transversal	F >> H
AutoAlign Spine	Off	Coil Combine Mode	Sum of Squares
Start measurement without	On	Auto Coil Select	Default
further preparation			
Wait for user to start	Off	Shim mode	Standard
Start measurements	single	Adjust with body coil	Off
Routine		Confirm freq. adjustment	Off
Slice group 1		- Assume Silicone	Off
Slices	10	Ref. amplitude 1H	318.659 V
Dist. factor	233 %	Adjustment Tolerance	Auto
Position	R3.0 A3.0 H0.0	Adjust volume	
Orientation	T > C-12.5	Position	R3.0 A3.0 H0.0
Phase enc. dir.	A >> P	Orientation	T > C-12.5
Rotation	0.00 deg	Rotation	0.00 deg
Phase oversampling	0 %	R >> L	192 mm
FoV read	192 mm	A >> P	192 mm
FoV phase	100.0 %	F >> H	47 mm
Slice thickness	1.50 mm	Physio	
TR	2000 ms	1st Signal/Mode	None
TE	30 ms	1	None
Averages	1	BOLD	
Concatenations	1	GLM Statistics	Off
Filter	None	Dynamic t-maps	Off
Coil elements	HEA;HEP	Starting ignore meas	0
	,	Ignore after transition	0
Contrast	~"	_ Model transition states	Off
MTC	Off	Temp. highpass filter	Off
Flip angle	90 deg	Threshold	4.00
Fat suppr.	Fat sat.	Paradigm size	1
Averaging mode	Long term	Meas	Baseline
Reconstruction	Magnitude	Motion correction	On
Measurements	100	Interpolation	3D-K-space
Delay in TR	0 ms	Spatial filter	Off
Multiple series	Off	Sequence	
1		Introduction	Off
Resolution	400	- Bandwidth	1502 Hz/Px
Base resolution	128	Free echo spacing	Off
Phase resolution	100 %	Echo spacing	0.75 ms
Phase partial Fourier	5/8		
Interpolation	Off	EPI factor	128
PAT mode	None	RF pulse type	Normal
Matrix Coil Mode	Auto (CP)	Gradient mode	Fast
Distortion Corr		Dummy Scans	2
Distortion Corr.	Off	•	
Prescan Normalize Raw filter	Off		
	On Off		
Elliptical filter	Off Off		
Hamming	OII		
Geometry		_	
Multi-slice mode	Interleaved		
Series	Interleaved		
Special sat.	None		

\\USER\INVESTIGATORS\HST_583\Physics1\epi_1.5x1.5x1.5_noise				
TA: 0:24 PAT: Off	Voxel size: 1.5×1.5×1.5 mm	Rel. SNR: 1.00 USER: 6	p2d_bold_MGH_pro_tb	
Properties	0"	System		
Prio Recon	Off	Body	Off	
Before measurement		HEP HEA	On On	
After measurement Load to viewer	On		On	
Inline movie	Off	Positioning mode	FIX	
Auto store images	On	Table position	Н	
Load to stamp segments	Off	Table position	0 mm	
Load images to graphic	Off	MSMA	S - C - T	
segments		Sagittal	R >> L	
Auto open inline display	Off	Coronal	A >> P	
AutoAlign Spine	Off	Transversal	F >> H	
Start measurement without	On	Coil Combine Mode	Sum of Squares	
further preparation		Auto Coil Select	Default	
Wait for user to start	Off	Shim mode	Standard	
Start measurements	single	Adjust with body coil	Off	
Routine		Confirm freq. adjustment	Off	
Slice group 1		Assume Silicone	Off	
Slices	9	Ref. amplitude 1H	318.659 V	
Dist. factor	233 %	Adjustment Tolerance	Auto	
Position	R3.0 A3.0 H0.0	Adjust volume		
Orientation	T > C-12.5	Position	R3.0 A3.0 H0.0	
Phase enc. dir.	A >> P	Orientation	T > C-12.5	
Rotation	0.00 deg	Rotation	0.00 deg	
Phase oversampling	0 %	R >> L A >> P	192 mm 192 mm	
FoV read	192 mm	F>> H	192 HIII 42 mm	
FoV phase	100.0 %	Г >> П	42 11111	
Slice thickness	1.50 mm	Physio		
TR	2000 ms	1st Signal/Mode	None	
TE	30 ms	BOLD		
Averages	1	GLM Statistics	Off	
Concatenations Filter	1 None	Dynamic t-maps	Off	
Coil elements	HEA;HEP	Starting ignore meas	0	
Con elements	ПЕА,ПЕР	Ignore after transition	0	
Contrast		Model transition states	Off	
MTC	Off	Temp. highpass filter	Off	
Flip angle	90 deg	Threshold	4.00	
Fat suppr.	Fat sat.	Paradigm size	1	
Averaging mode	Long term	Meas	Baseline	
Reconstruction	Magnitude	Motion correction	On	
Measurements	10	Interpolation	3D-K-space	
Delay in TR	0 ms	Spatial filter	Off	
Multiple series	Off	Sequence		
Resolution		Introduction	Off	
Base resolution	128	Bandwidth	1502 Hz/Px	
Phase resolution	100 %	Free echo spacing	Off	
Phase partial Fourier	5/8	Echo spacing	0.75 ms	
Interpolation	Off	EPI factor	128	
		RF pulse type	Normal	
PAT mode	None	Gradient mode	Fast	
Matrix Coil Mode	Auto (CP)			
Distortion Corr.	Off	Dummy Scans	2	
Prescan Normalize	Off			
Raw filter	On			
Elliptical filter	Off			
Hamming	Off			
Geometry				

Multi-slice mode

Series

Special sat.

Interleaved

Interleaved

References

See Triantafyllou, C., R. D. Hoge, G. Krueger, C. J. Wiggins, A. Potthast, G. C. Wiggins, and L. L. Wald. "Comparison of physiological noise at 1.5 T, 3 T and 7 T and optimization of fMRI acquisition parameters." *NeuroImage* 26 (2005): 243-250.