Portfolio 5 - Study Group 2

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Portfolio_assignment5_model_specification

fMRI design matrix excercise

In this exercise, we will make a model for the analysis of the data that we preprocessed in exercise 4. The model is specified by onsets for the different stories and by their duration. During the experiment, the participant also rated each story for emotional content. We will add the onsets for ratings as well. We will also add a covariate to each story condition with the ratings obtained. Deadline

Details: TR=3.5 Number of scans: 400

Load the data

```
#Onsets for "story1" in seconds:
story1 <- c(3, 117, 203, 278, 375, 442, 513, 616, 723, 807, 910, 1003, 1093, 1186,
1282)

#Onsets for "story2" in seconds: [
story2 <- c(50, 157, 242, 326, 414, 471, 555, 670, 768, 873, 944, 1054, 1149, 1242
, 1316)

#Onsets for "ratings" in seconds:
ratings <- c(39, 106, 146, 191, 231, 267, 315, 364, 403, 431, 460, 502, 544, 605,
659, 711, 757, 796, 862, 899, 933, 992, 1042, 1082, 1138, 1175, 1231, 1271, 1305,
1348)

#Durations for "story1" in seconds:
duration1 <- c(35, 27, 27, 36, 26, 16, 29, 42, 33, 54, 22, 38, 43, 43, 21)

#Durations for "story2" in seconds:
duration2 <- c(55, 33, 23, 37, 16, 30, 48, 40, 26, 24, 46, 27, 25, 27, 30)

#Durations for "ratings" in seconds: 10

#Rating values for "story1":
rating1 <- c(7, 4, 4, 5, 3, 1, 6, 2, 1, 4, 2, 3, 2, 4, 1)
```

```
#Rating values for "story2":
rating2 <- c(8, 2, 3, 2, 5, 7, 7, 3, 3, 2, 3, 3, 2, 4, 3)
```

1. Checking input using R

Test the following hypotheses:

1.a. There was a signifiant difference between the durations of the two story types.

```
#Conducting a t-test to see if the two stories differs significantly from one anot
her

t.test(duration1, duration2)

##
##  Welch Two Sample t-test
##
## data:  duration1 and duration2
## t = 0.087292, df = 27.922, p-value = 0.9311
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -7.489661  8.156327
## sample estimates:
## mean of x mean of y
##  32.80000  32.46667
```

The two stories (story 1 and story 2) does not differ significantly in duration. t(27.92) = 0.09, p = .93

1.b. There was a significant difference between the ratings of the two story types

```
t.test(rating1, rating2)

##
##  Welch Two Sample t-test
##
## data:  rating1 and rating2
## t = -0.76031, df = 27.767, p-value = 0.4535
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.9707779  0.9041112
## sample estimates:
## mean of x mean of y
##  3.266667  3.800000
```

The rating of the two stories (story 1 and story 2) does not differ significantly in duration. t(27.77) = 0.76, p = .45
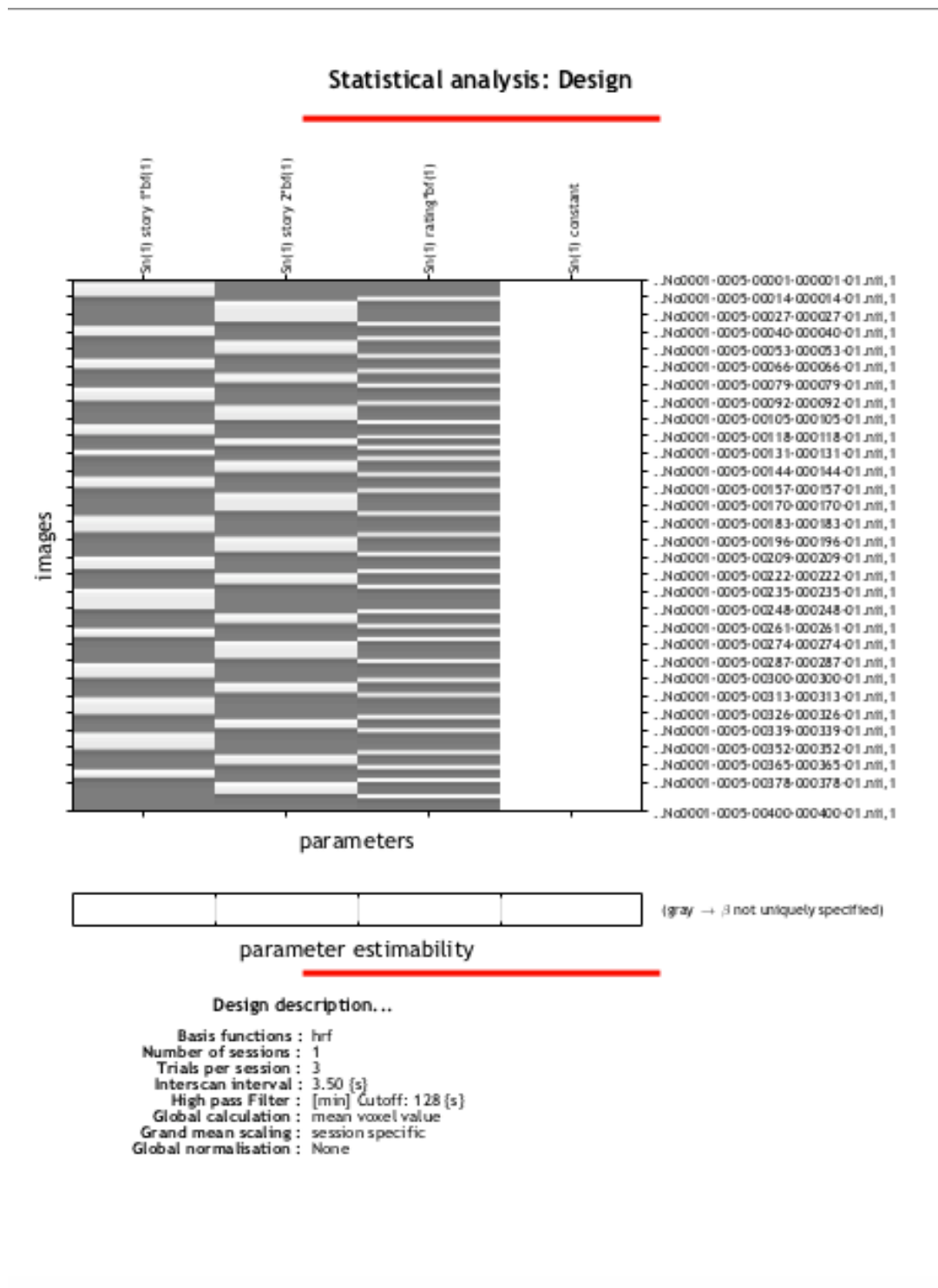
2. Create the model in SPM.

Create a model with three different conditions: "story1", "story2"" and "rating" using details above and the description in the SPM12 manual p. 229, but use "seconds" as timing rather than "scans".

Remember to save the batch file with the detail of the model. You will need it later. It is also a good idea to have the model and its output in a different folder than the data.

If you created a batch for the preprocessing assignment, you can also add the model to that batch. This will enable you to use dependency for selecting the smoothed images.

But it will also cause the script to run the whole preprocessing every time you run the model, which may take some time.

2.a. Make a screenshot and report the design matrix figure generated by SPM. How many columns does it have?

Statistical analysis: Design

images

parameters

parameter estimability

(gray → β not uniquely specified)

Design description...

Basis functions : hrf
Number of sessions : 1
Trials per session : 3
Interscan interval : 3.50 {s}
High pass Filter : [min] Cutoff: 128 {s}
Global calculation : mean voxel value
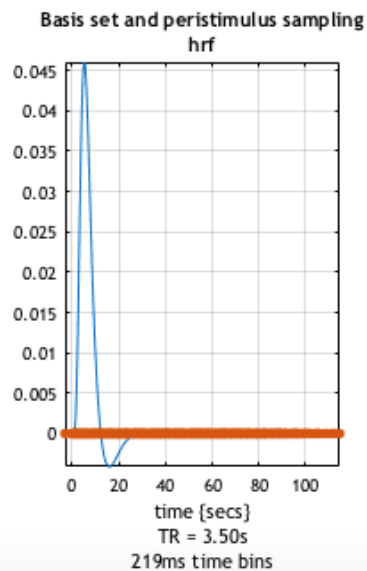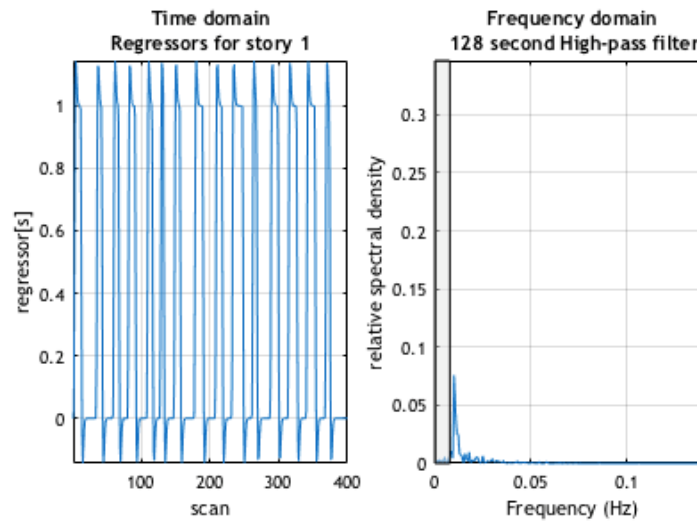Grand mean scaling : session specific
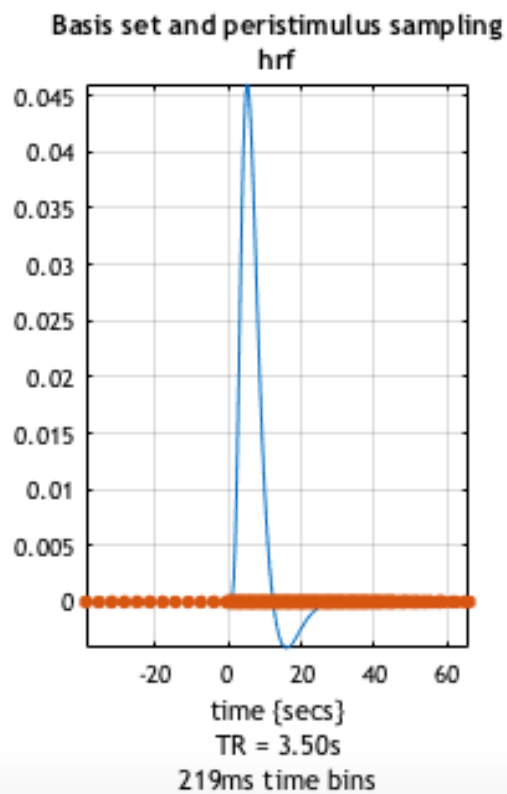Global normalisation : None

2.a response

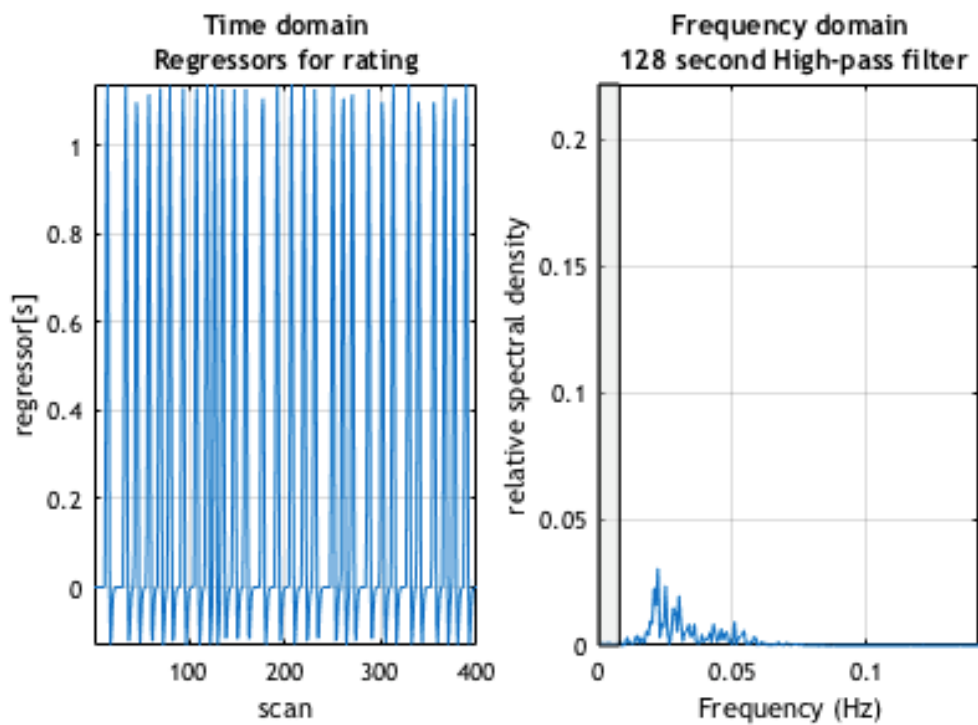4 columns. One for each story, one for the ratings and one for constant.

3. Checking the model

Explore the design matrix using the "review" function (see p. 229-231 in the manual).

3.a Report periodogram plots of the Frequency domain for the three conditions.

Time domain
Regressors for story 1

Frequency domain
128 second High-pass filter

Basis set and peristimulus sampling
hrf

time (secs)
TR = 3.50s
219ms time bins

Time domain
Regressors for rating

Frequency domain
128 second High-pass filter

Basis set and peristimulus sampling
hrf

TR = 3.50s
219ms time bins

Time domain
Regressors for story 2

Frequency domain
128 second High-pass filter

Basis set and peristimulus sampling
hrf

time {secs}
TR = 3.50s
219ms time bins

3.b.Eye-balling task: What are the most predominant frequencies for the three condition, as seen from these plots?

For all three conditions the most predominant frequencies seem to be at the very low end of the frequency (Hz). The rating condition shows a higher frequency of spikes.

4. Adding covariates

Under "Conditions" in the "fMRI model specification", add the rating values as "Parametric Modulations" (i.e. covariates) for each of the story types. Choose 1st order "Polynomial Expansion" (this simply means that you are modelling linear effects of the covariate).

4.a. Make a screenshot and report the new design matrix figure. How many columns does it have?

Response 4.a The design matrix now have 6 columns.

(The parametric modulation is basically an interaction between the modeled response and the mean centred covariate (i.e. where the mean has been subtracted)).

Statistical analysis: Design
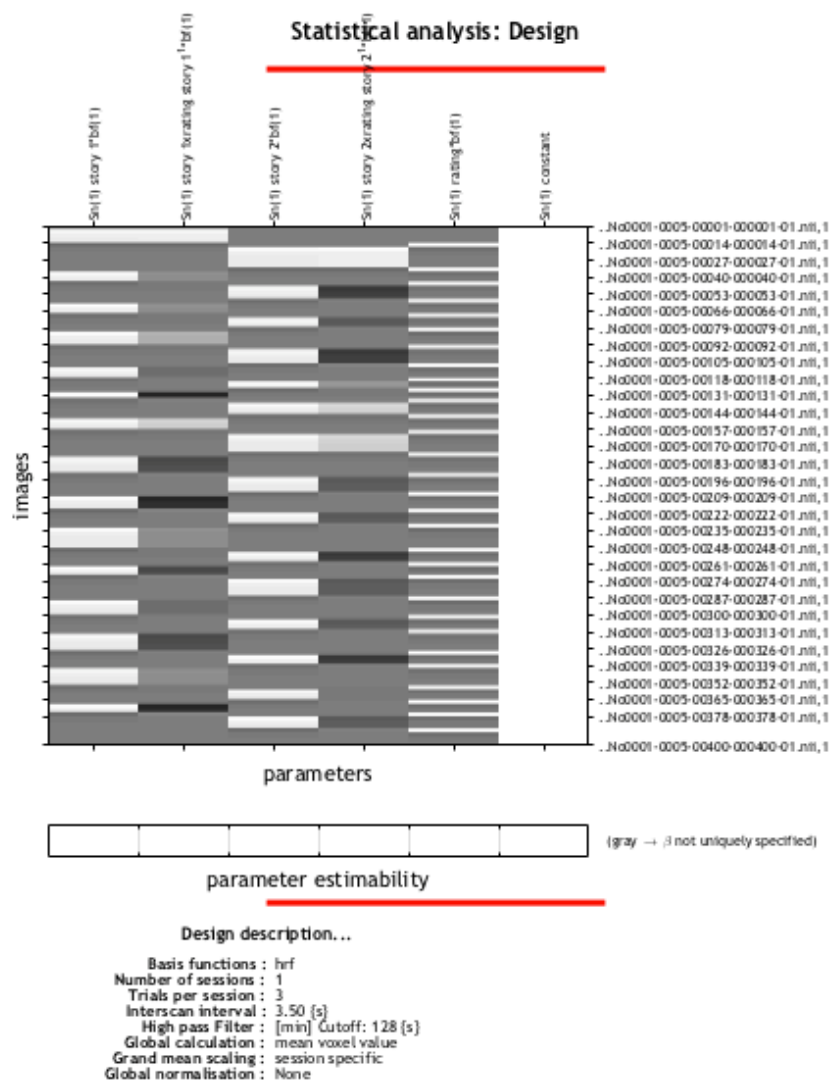
4.b. Interpretation task: Why is it important to subtract the mean?

By mean centering the interpretation of the data makes more sense and gives us an interpretation of how much each data point deviates from the mean. If we do not mean center we are looking at the mean of the group when the rating is zero.

Under "Multiple regressors" in the "fMRI model specification", add the motion parameters from the realignment procedure (simply attach the rp_....txt file produced by the realignment procedure).

4.c. Make a screenshot and report the new design matrix figure. How many columns does it have?

The new design matrix has 12 columns now.

Statistical analysis: Design

Column headers (top, vertical):
- Sn(1) story 1*bf(1)
- Sn(1) story 1xrating story 1^1*bf(1)
- Sn(1) story 2*bf(1)
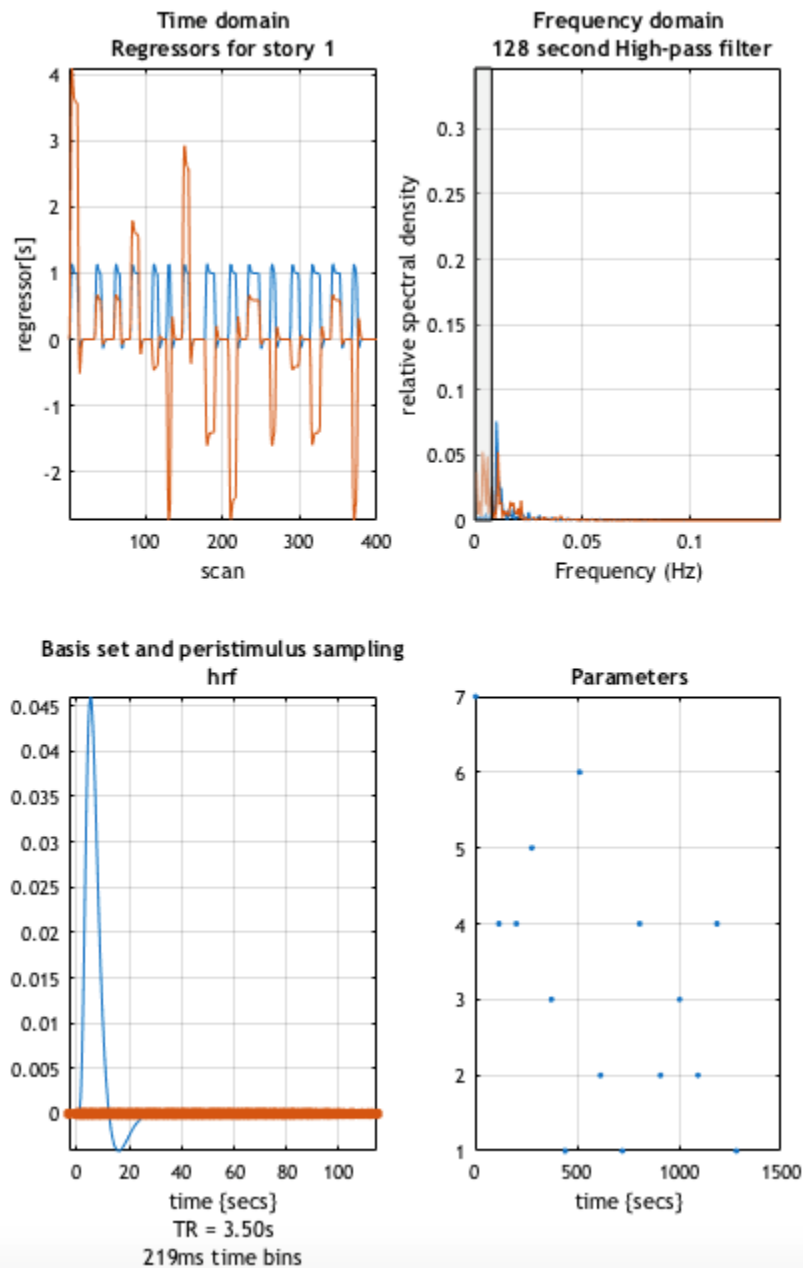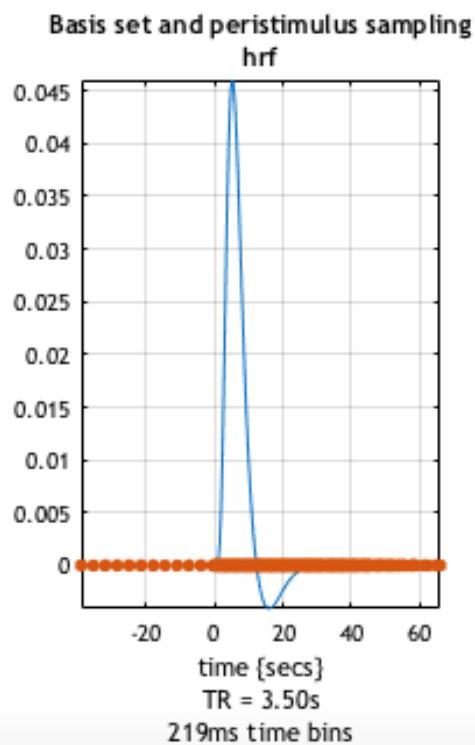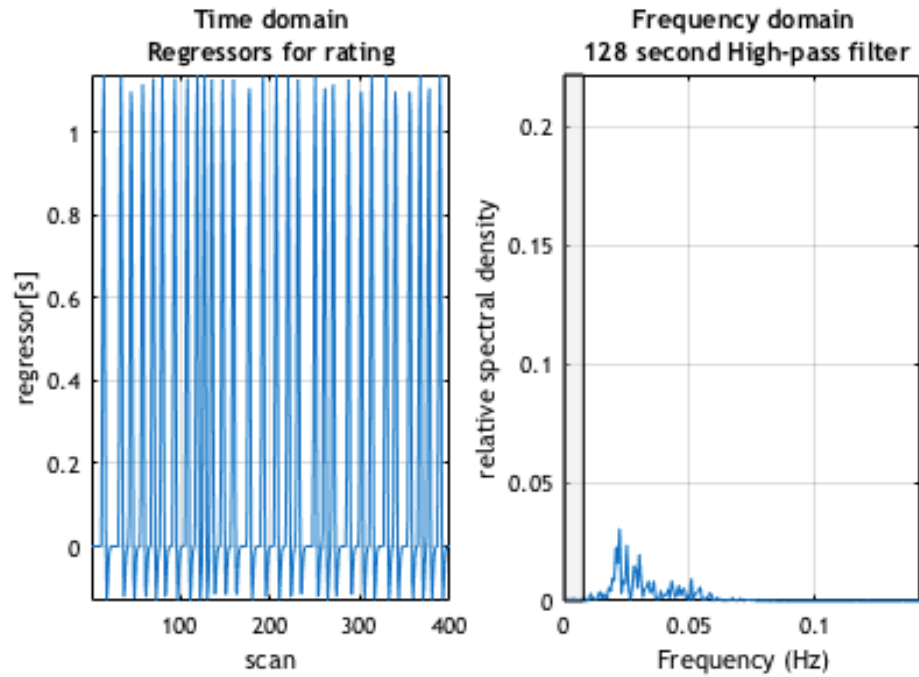- Sn(1) story 2xrating story 2^1*bf(1)
- Sn(1) rating*bf(1)
- Sn(1) R1
- Sn(1) R2
- Sn(1) R3
- Sn(1) R4
- Sn(1) R5
- Sn(1) R6
- Sn(1) constant

images (y-axis)

parameters (x-axis)

Image file labels (right side):
- . .Na0001-0005-00001-000001-01.nfi, 1
- . .Na0001-0005-00014-000014-01.nfi, 1
- . .Na0001-0005-00027-000027-01.nfi, 1
- . .Na0001-0005-00040-000040-01.nfi, 1
- . .Na0001-0005-00053-000053-01.nfi, 1
- . .Na0001-0005-00066-000066-01.nfi, 1
- . .Na0001-0005-00079-000079-01.nfi, 1
- . .Na0001-0005-00092-000092-01.nfi, 1
- . .Na0001-0005-00105-000105-01.nfi, 1
- . .Na0001-0005-00118-000118-01.nfi, 1
- . .Na0001-0005-00131-000131-01.nfi, 1
- . .Na0001-0005-00144-000144-01.nfi, 1
- . .Na0001-0005-00157-000157-01.nfi, 1
- . .Na0001-0005-00170-000170-01.nfi, 1
- . .Na0001-0005-00183-000183-01.nfi, 1
- . .Na0001-0005-00196-000196-01.nfi, 1
- . .Na0001-0005-00209-000209-01.nfi, 1
- . .Na0001-0005-00222-000222-01.nfi, 1
- . .Na0001-0005-00235-000235-01.nfi, 1
- . .Na0001-0005-00248-000248-01.nfi, 1
- . .Na0001-0005-00261-000261-01.nfi, 1
- . .Na0001-0005-00274-000274-01.nfi, 1
- . .Na0001-0005-00287-000287-01.nfi, 1
- . .Na0001-0005-00300-000300-01.nfi, 1
- . .Na0001-0005-00313-000313-01.nfi, 1
- . .Na0001-0005-00326-000326-01.nfi, 1
- . .Na0001-0005-00339-000339-01.nfi, 1
- . .Na0001-0005-00352-000352-01.nfi, 1
- . .Na0001-0005-00365-000365-01.nfi, 1
- . .Na0001-0005-00378-000378-01.nfi, 1
- . .Na0001-0005-00400-000400-01.nfi, 1

parameter estimability

(gray → β not uniquely specified)

Design description...

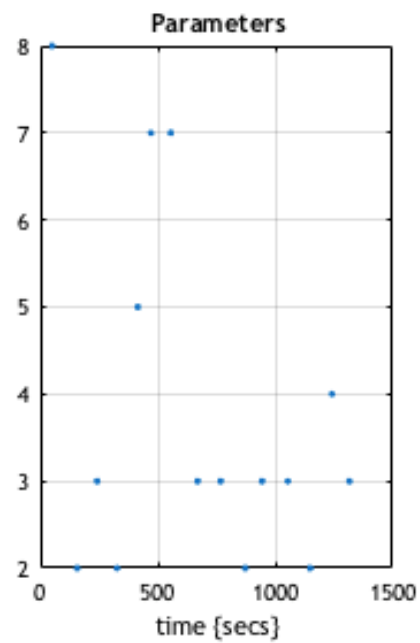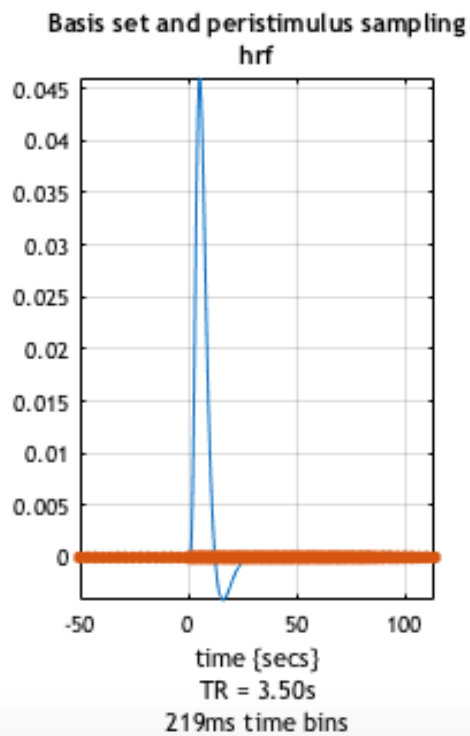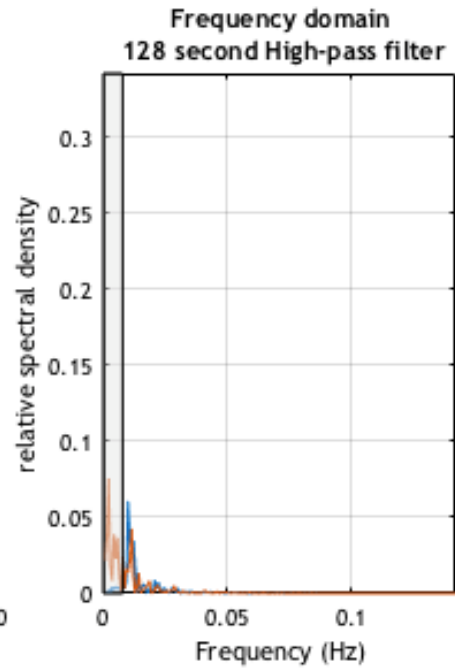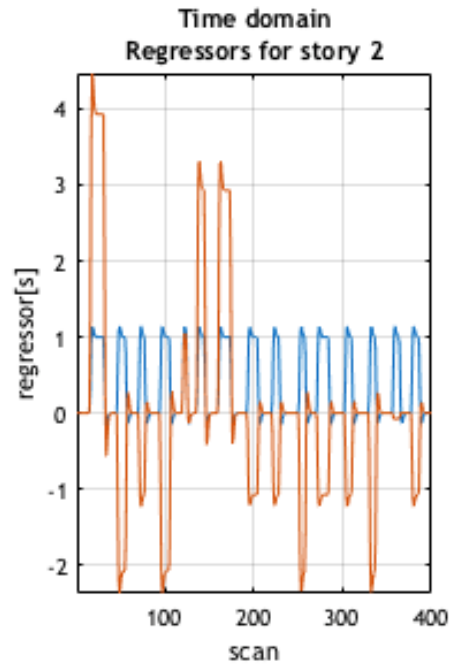|	
Basis functions :	hrf
Number of sessions :	1
Trials per session :	3
Interscan interval :	3.50 {s}
High pass Filter :	[min] Cutoff: 128 {s}
Global calculation :	mean voxel value
Grand mean scaling :	session specific
Global normalisation :	None

5. Checking the new model

Explore the design matrix using the "review" function (see p. 229 in the manual).

5.a. Report plots of the Frequency domain for the three conditions.

Time domain — Regressors for story 1

Frequency domain — 128 second High-pass filter

Basis set and peristimulus sampling — hrf

TR = 3.50s
219ms time bins

Parameters

Time domain
Regressors for rating

Frequency domain
128 second High-pass filter

Basis set and peristimulus sampling
hrf

time {secs}

TR = 3.50s

219ms time bins

Time domain
Regressors for story 2

regressor[s]

scan

Frequency domain
128 second High-pass filter

relative spectral density

Frequency (Hz)

Basis set and peristimulus sampling
hrf

time {secs}

TR = 3.50s

219ms time bins

Parameters

time {secs}

5.b. Eye-balling task:

What are the most predominant frequencies for the covariates, as seen from these plots?

5.b response

The frequencies seems to be quite similar

The lowest frequencies in the design are filtered out using a "high pass" filter in the analysis. This is the part of the spectrum marked by gray in the frequency/density plot. What does this filter do to the covariates?

The filter "filters" away a lot of the lowest frequencies of the covarite.

5.c. The high-pass filter consists of low-frequency cosine-waves, which together can model any fluctuation below the specified frequency.

Plot and report figures of the high-pass filter using these two lines in MatLab (you need to have loaded the SPM.mat file):
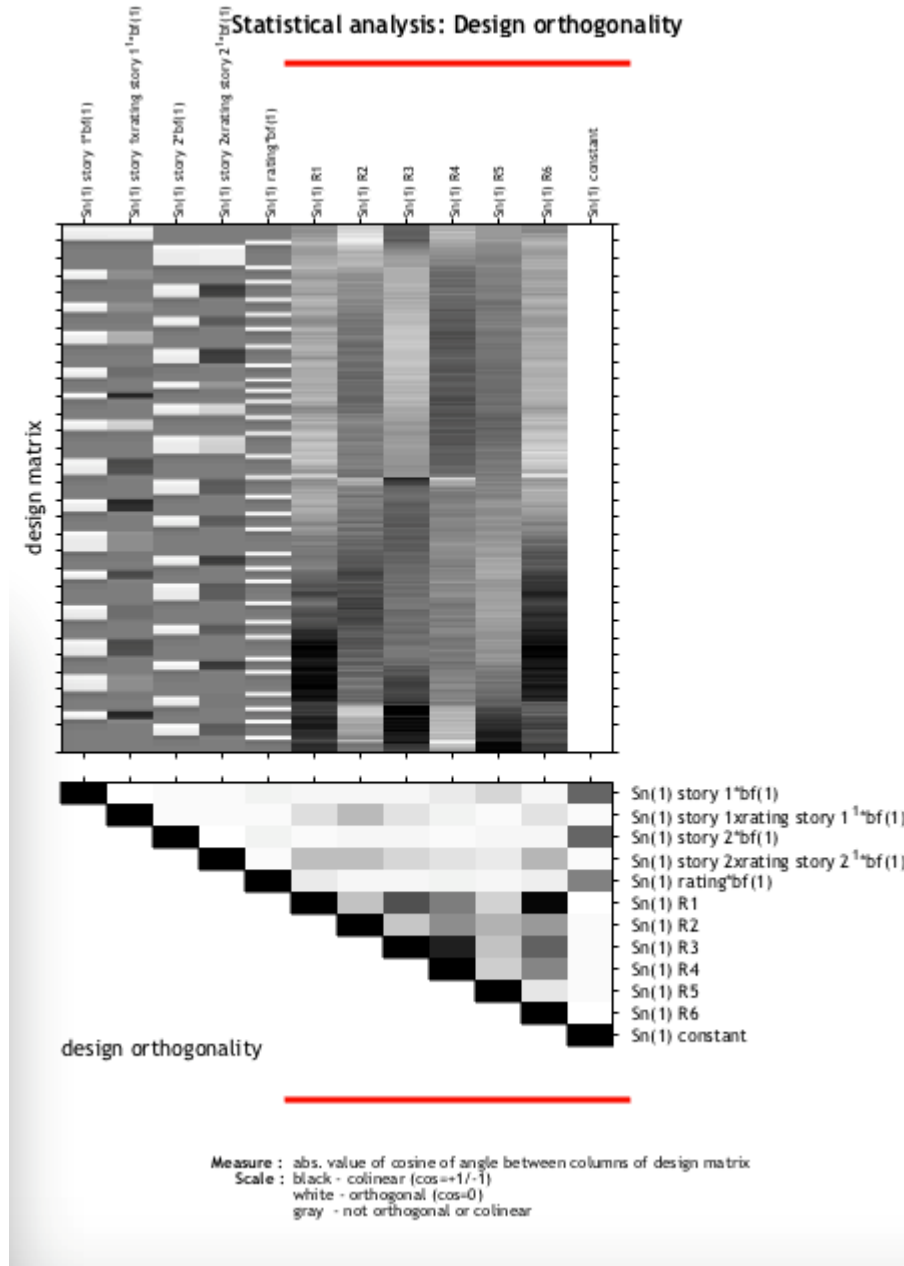
figure, imagesc(SPM.xX.K.X0) figure, plot(SPM.xX.K.X0)
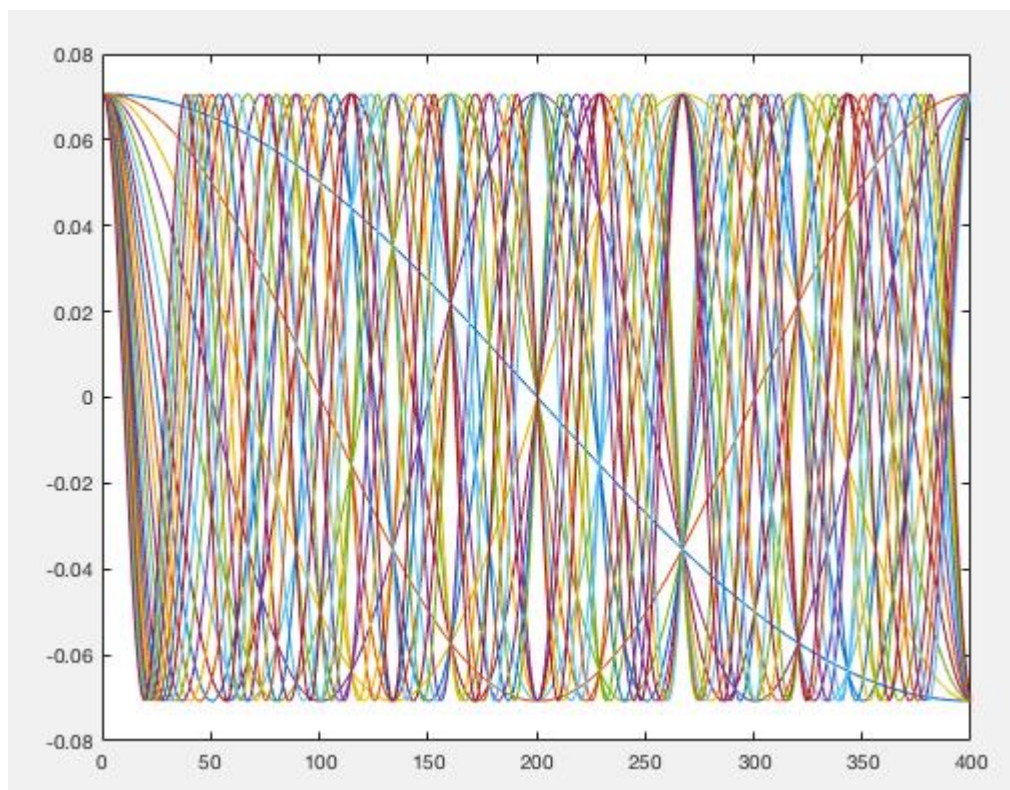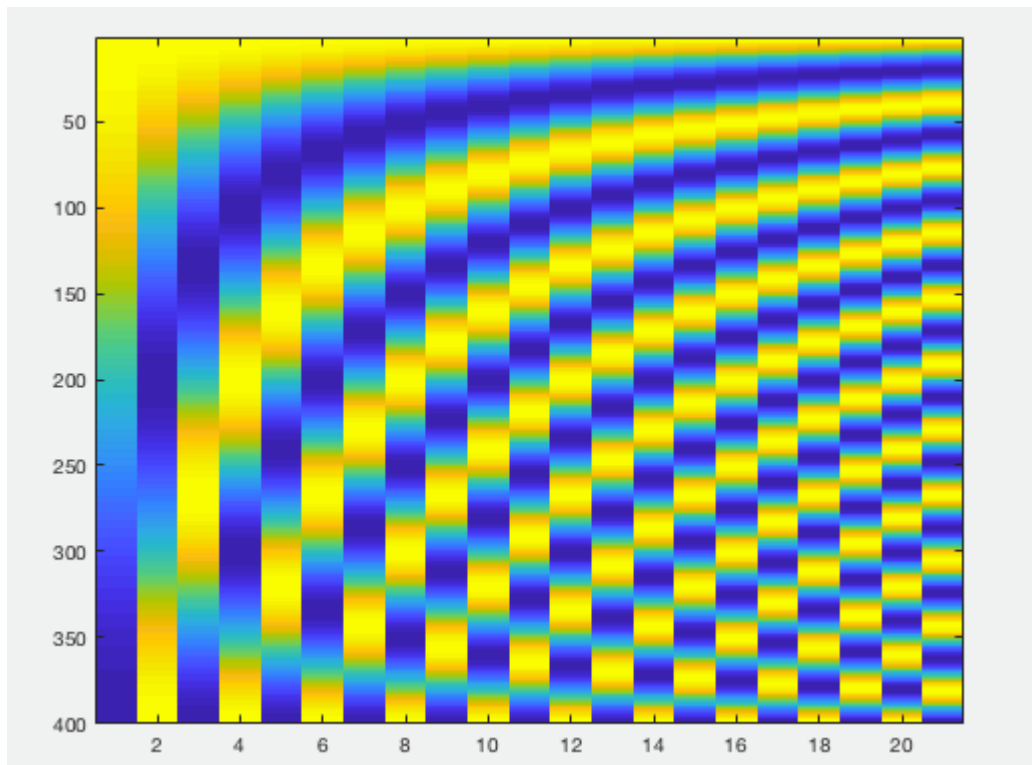
5.d. How many cosine waves are in this specific high-pass filter?

From the figures we can see that there are 21 cosine waves.

5.e. Eyeballing the bottomless pit of despair: Explore "design orthogonality" (in the "review" function).

Dark colors in the design "orthonogality matrix" (include it in report) indicate that different covariates are correlated. Which covariates are most correlated in the current design?

Statistical analysis: Design orthogonality

design matrix

Sn(1) story 1*bf(1)
Sn(1) story 1xrating story 1¹*bf(1)
Sn(1) story 2*bf(1)
Sn(1) story 2xrating story 2¹*bf(1)
Sn(1) rating*bf(1)
Sn(1) R1
Sn(1) R2
Sn(1) R3
Sn(1) R4
Sn(1) R5
Sn(1) R6
Sn(1) constant

design orthogonality

Measure : abs. value of cosine of angle between columns of design matrix
Scale : black - colinear (cos=+1/-1)
white - orthogonal (cos=0)
gray - not orthogonal or colinear

5.e Response

The motion parameters from the realignment procedure are the most correlated. This makes sense movement in one direction often will imply motion in another direction as well.

5.f. Plot and report the hemodynamic response function (HRF) using this call in Matlab (you need to have loaded the SPM.mat file):

figure, plot(SPM.xBF.dt:SPM.xBF.dt:SPM.xBF.length,SPM.xBF.bf)