Portfolio assignment 05: Model specification

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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

March 17, 2020.

Details:

TR=3.5

Number of scans: 400

Onsets for "story1" in seconds: [3 117 203 278 375 442 513 616 723 807 910 1003 1093 1186 1282]

Onsets for "story2" in seconds: [50 157 242 326 414 471 555 670 768 873 944 1054 1149 1242 1316]

Onsets for "ratings" in seconds: [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: [35 27 27 36 26 16 29 42 33 54 22 38 43 43 21]

Durations for "story2" in seconds: [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": [7 4 4 5 3 1 6 2 1 4 2 3 2 4 1]

Rating values for "story2": [8 2 3 2 5 7 7 3 3 2 3 3 2 4 3]

Tasks

1. Checking input using R

Test the following hypotheses:

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

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

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 details 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? What do the different columns represent?

3. Checking the model

Explore the design matrix using the "review" function (see p. 229-331 in the manual).

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

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

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 now have? Which columns model the rating effects?

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

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

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 now have? Which columns are modeling the motion?

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.

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

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. Does this filter seem to affect the covariates?

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?

5.e. Make a hypothetical slow wave signal by creating a vector in Matlab (e.g. a=[2,1,4] for a row vector or a=[3;2;4] for a column vector) with the same length as the number of waves as in the high-pass filter. Multiply the vector with the filter (using "*") and plot the result (figure, plot(my_result_vector). Remember the matrix multiplication rules in order to figure out if the vector should be rows or columns. The plotted vector should have the same length as the number of fMRI images. Report the plot.

5.f. 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?

5.g. 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)

6. Voluntary extra task

A more flexible model of the hemodynamic response function can be obtained using the derivatives of the hemodynamic response function (i.e. the function plotted in 5.g) . In the model the “time”" and “dispersion” derivatives can be added under “Basis Functions”.

6.a. Inspect the design matrix and see what it does to the model when these are added.

Again, the response functions used in making the design can be plotted using:

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

The flexibility arises due to a linear combination of the three model functions. This can model BOLD responses that differ somewhat in shape from the standard.

6.b. Try changing and reporting the values in the contrast matrix below (looking like this: [1,1,1]) and see what it does to the response function.

figure, plot(SPM.xBF.dt:SPM.xBF.dt:SPM.xBF.length,SPM.xBF.bf*[1;1;1])

Reporting:

Collect material and submit as a single pdf-file to Blackboard.