Neuroimaging data analysis

Classical Statistical Inference in SPM12

Sunghyon Kyeong, PhD

Severance Biomedical Science Institute,

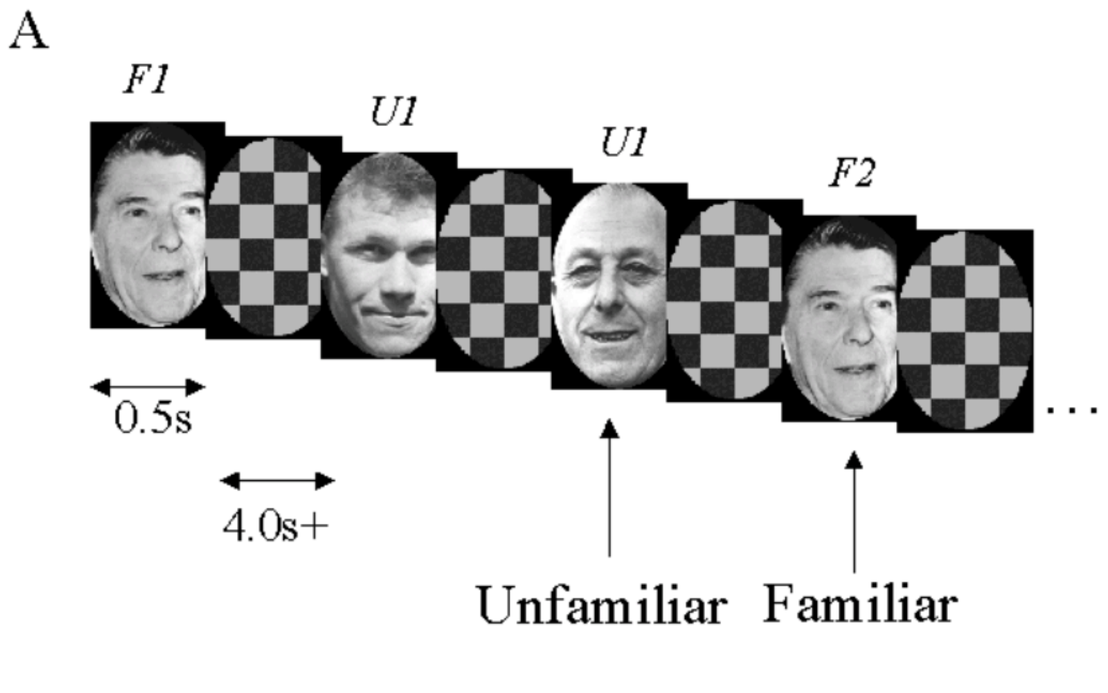
Yonsei University College of Medicine

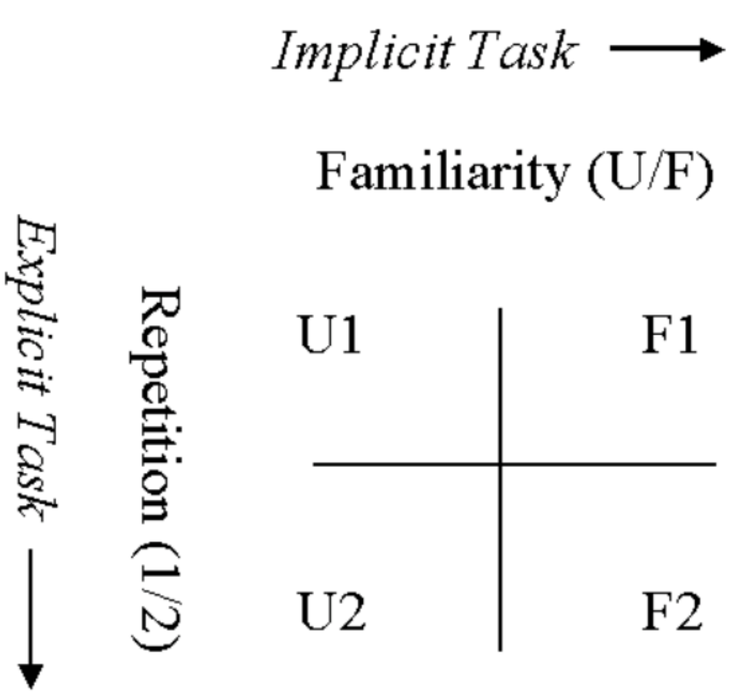
실습 데이터 다운로드

download:
http://www.fil.ion.ucl.ac.uk/spm/download/data/face_rep/face_rep.zip

어떤 데이터 일까?

Face repetition fMRI task





Reference) Henson, R.N.A., Shallice, T., Gorno-Tempini, M.-L. and Dolan, R.J. (2002), Face repetition effects in implicit and explicit memory tests as measured by fMRI. Cerebral Cortex, 12, 178-186.

점화현상

Priming effects

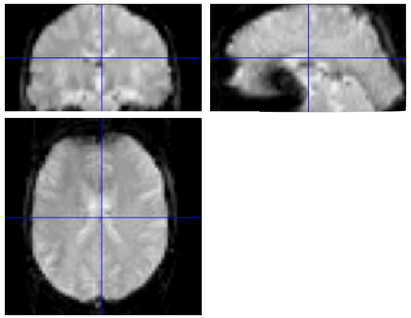
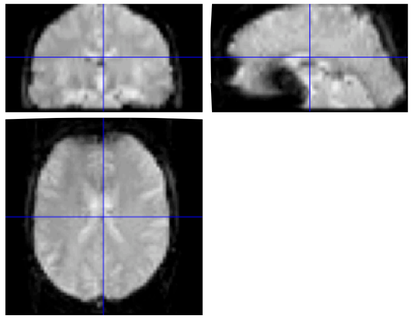
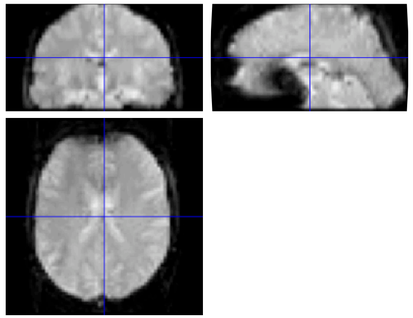
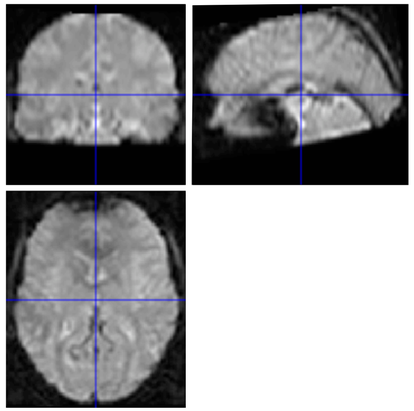
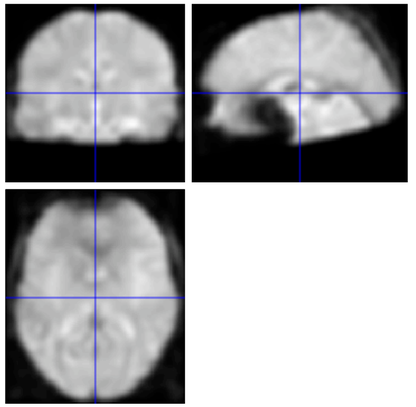
‘먼저 본 정보에 의해 떠올려진 개념으로 인해
이후에 접한 정보를 해석할 때 영향’을 받게 되는 현상.

Experiment Information

- 2x2 factorial event-related fMRI
- One session (one subject)
- (Famous vs. Nonfamous) x (1st vs 2nd presentation) of faces against baseline of chequerboard
- 2 presentations of 26 Famous and 26 Nonfamous Greyscale photographs, for 0.5s, randomly intermixed, for fame judgment task (one of two right finger key presses).
- Parameteric factor "lag" = number of faces intervening between repetition of a specific face + 1
- Minimal SOA=4.5s, with probability 2/3 (ie 1/3 null events)
- Continuous EPI (TE=40ms,TR=2s), 24 descending slices (64x64 3x3mm^2), 3mm thick, 1.5mm gap

Reference) http://www.fil.ion.ucl.ac.uk/spm/data/face_rep/

Summary of Preprocessing

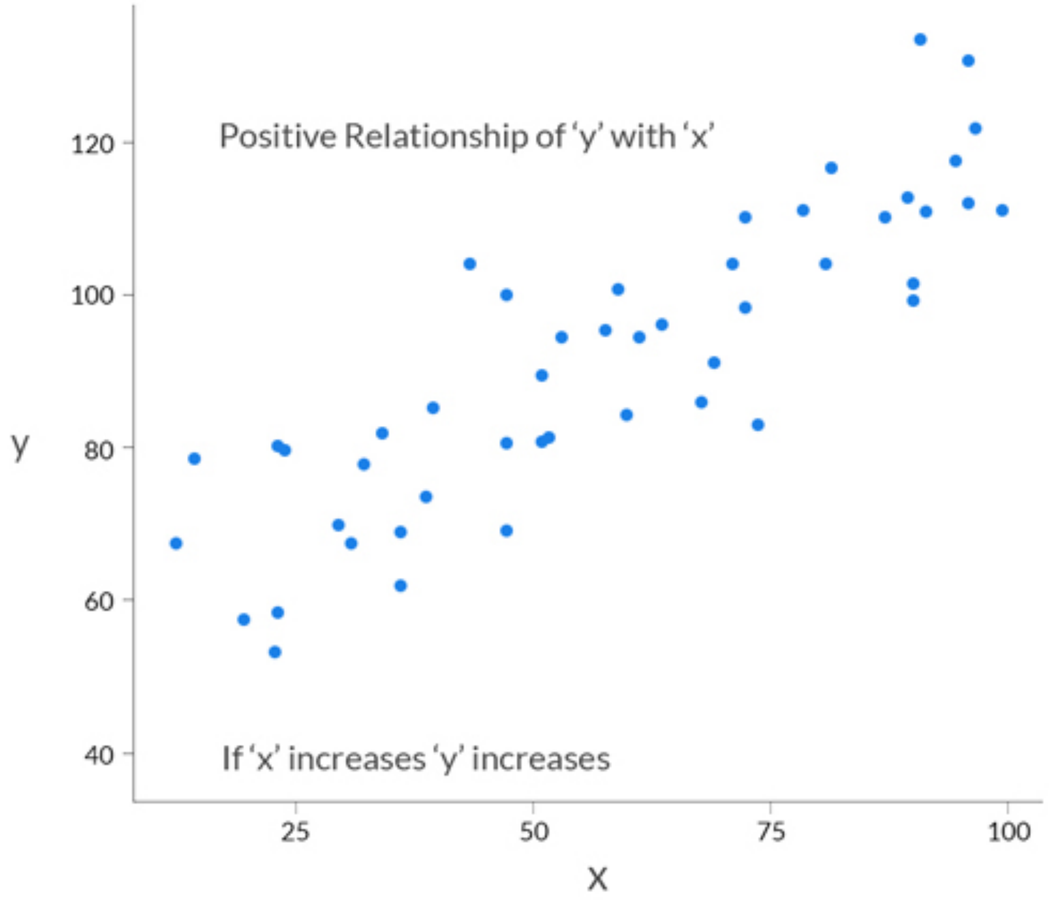
EPI	rEPI	arEPI	warEPI	swarEPI
				
File: ./sM03953_0005_0100.img	File: ./rsM03953_0005_0100.img	File: ./arsM03953_0005_0100.img	File: ..arsM03953_0005_0100.img	File: ..arsM03953_0005_0100.img
Dimensions: 64 x 64 x 24	Dimensions: 64 x 64 x 24	Dimensions: 64 x 64 x 24	Dimensions: 79 x 95 x 79	Dimensions: 79 x 95 x 79
Datatype: int16	Datatype: int16	Datatype: int16	Datatype: int16	Datatype: int16
Intensity: Y = 0.050325 X	Intensity: Y = 0.050325 X	Intensity: Y = 0.050325 X	Intensity: Y = 0.050325 X	Intensity: Y = 0.050325 X
SPM compatible	spm - realigned	spm - realigned acq-fix ref-slice 14	Warped	Warped - conv(6,6,6)
Vox size: -3 x 3 x 4.5	Vox size: -3 x 3 x 4.5	Vox size: -3 x 3 x 4.5	Vox size: -2 x 2 x 2	Vox size: -2 x 2 x 2
Origin: 32.6 32.3 12.5	Origin: 32.5 32.3 12.5	Origin: 32.5 32.3 12.5	Origin: 40 57 36	Origin: 40 57 36
Dir Cos: 1.000 -0.003 0.005	Dir Cos: 1.000 0.000 0.000	Dir Cos: 1.000 0.000 0.000	Dir Cos: 1.000 0.000 0.000	Dir Cos: 1.000 0.000 0.000
0.003 1.000 -0.001	0.000 1.000 0.000	0.000 1.000 0.000	0.000 1.000 0.000	0.000 1.000 0.000
-0.005 0.001 1.000	0.000 0.000 1.000	0.000 0.000 1.000	0.000 0.000 1.000	0.000 0.000 1.000

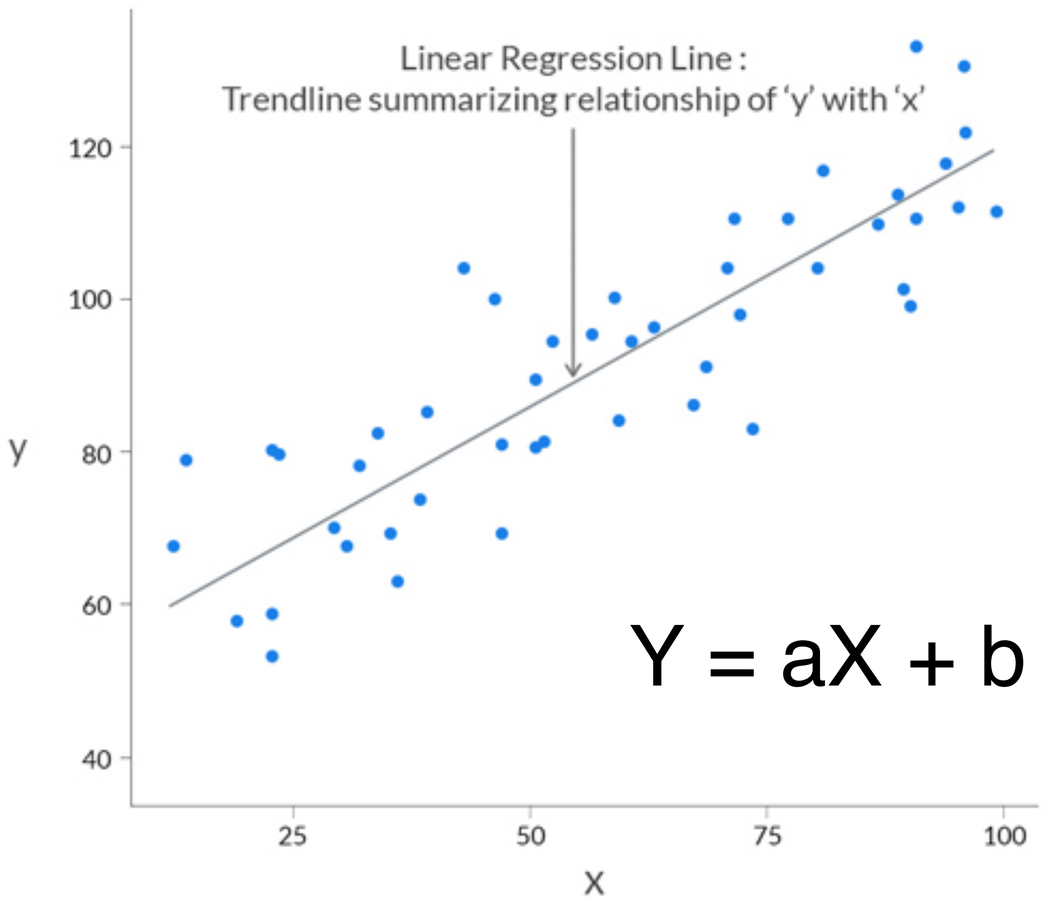
In this tutorial,

we need 351 swar*.img files and rp_motion.txt

회귀분석

회귀분석은 과학적인 체계로 Quantities 사이의 관계에 대하여
추론을 내리는데 사용되는 통계기술의 집합을 뜻함.



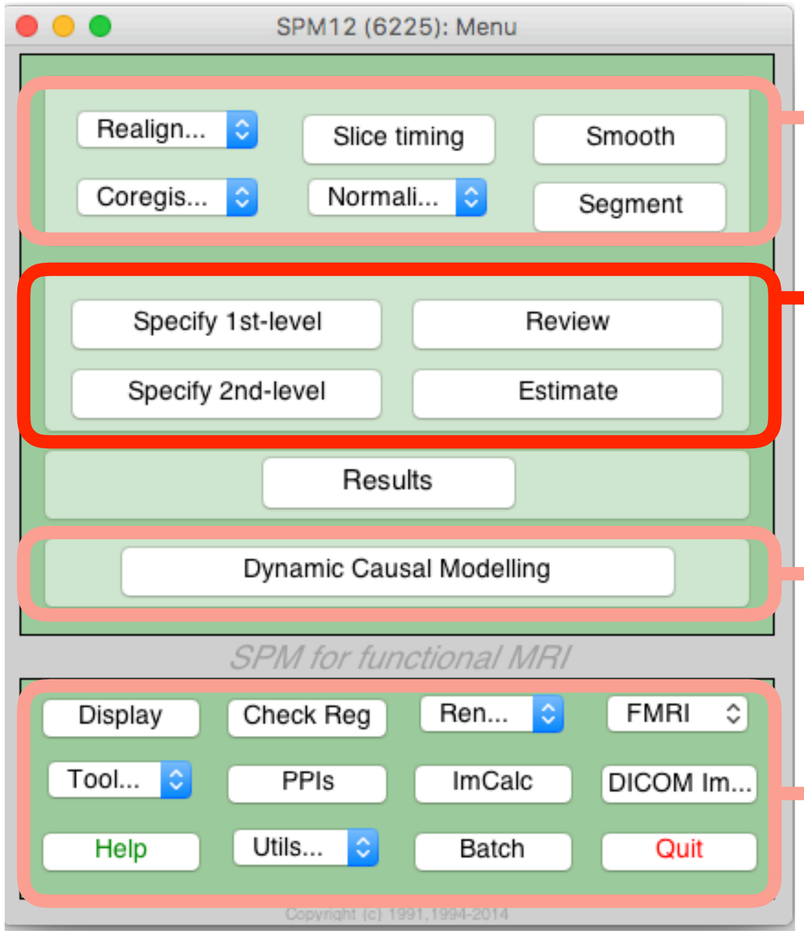


실습

Modelling categorical responses

Reference) Chapter 31.2 in SPM12 manual

Exploring SPM12 Manu



Preprocessing

Classical Statistical Inference

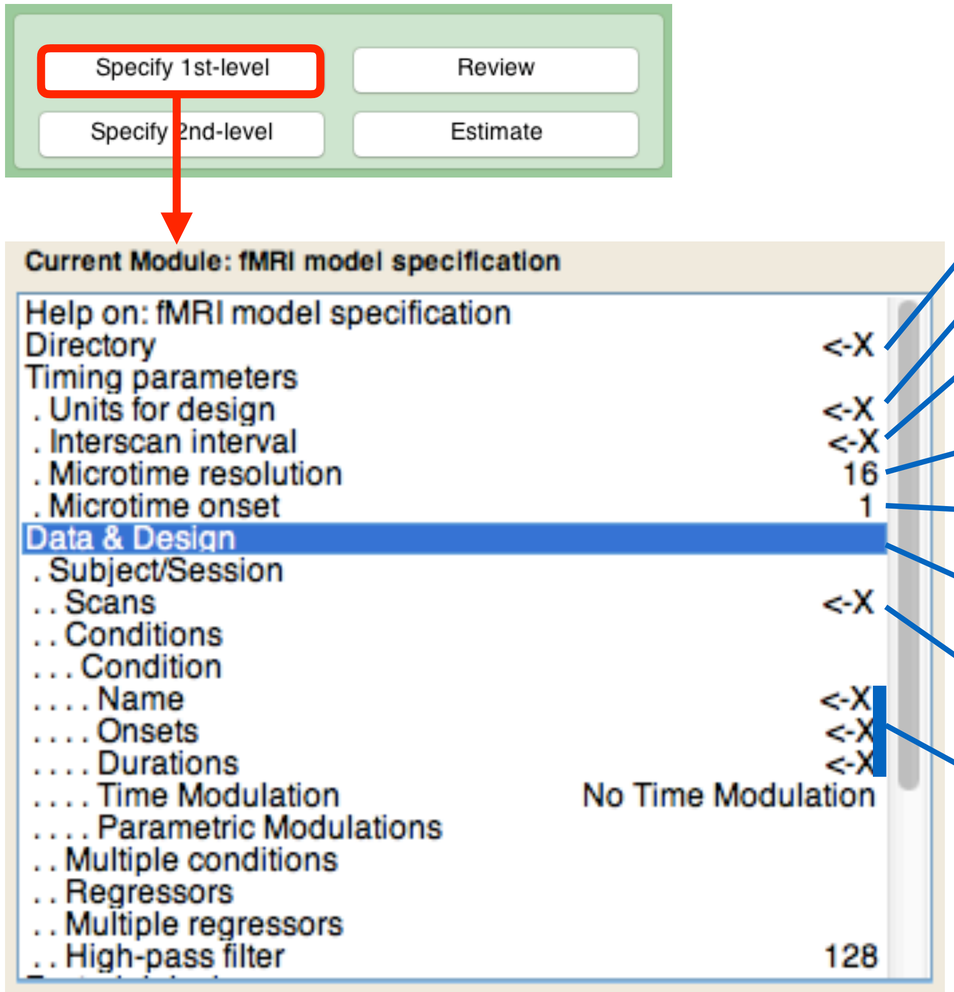
1st-level: individual-level inference

2nd-level: group-level inference

Bayesian Inference

Various Utilities

1st-level UI 설명



Directory: Specify 1st-level의 결과가 저장될 폴더명

Units for design: Select '**Scans**' ('초' 단위로 기록된 onset time 정보를 갖고 있다면, scans 대신에 seconds를 선택)

Interscan Interval: inter-volume interval과 같은 의미이며 fMRI protocol parameter 중에서 TR에 해당되는 것을 seconds unit으로 입력.

Microtime resolution: Slice timing correction을 수행한 경우, number of slices로 변경함. 그외는 default 값 유지.

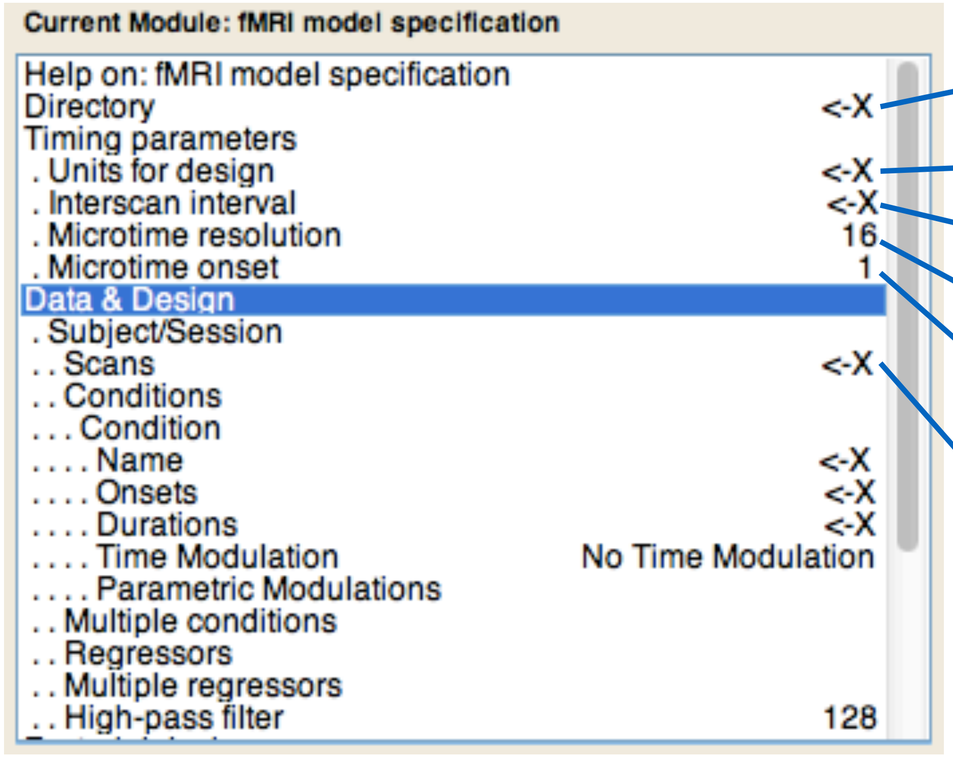
Microtime onset: Slice timing correction을 수행한 경우 reference image의 slice 번호로 변경함. 그외는 default 값 유지.

Data & Design: fMRI 데이터와 자극 제시 시간을 입력하는 부분. New:Subject/Session을 통해서 Session을 추가할 수 있음.

Scans: 전처리가 완료된 fMRI 데이터(swar*)를 모두 선택.

각각의 조건에 대한 정보 입력: 각 조건에 대한 이름Name, 자극제시 시간Onsets, Durations 정보를 입력함. Event related design의 경우에는 duration을 0으로 함.

실습 - Specify 1st-level (1/3)



Directory
ex) c:\fMRI\FirstLevel_Start

Units for design
Choose ‘Scans’

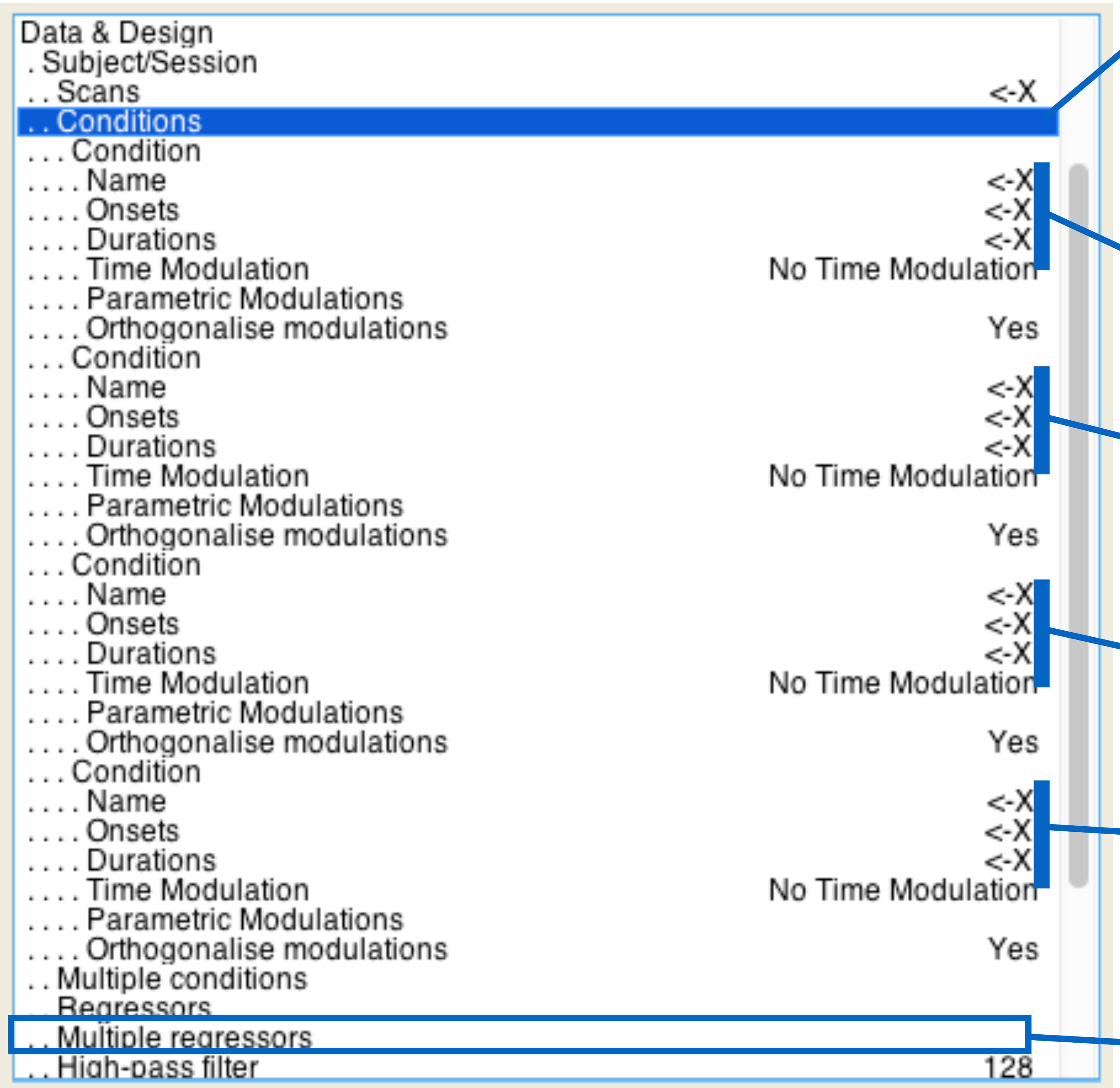
Interscan Interval
Put ‘2’ if your TR of fMRI data is 2

Microtime resolution
enter 24 (← Number of slices)

Microtime onset
enter 12 (← Reference slice when slice-timing correction)

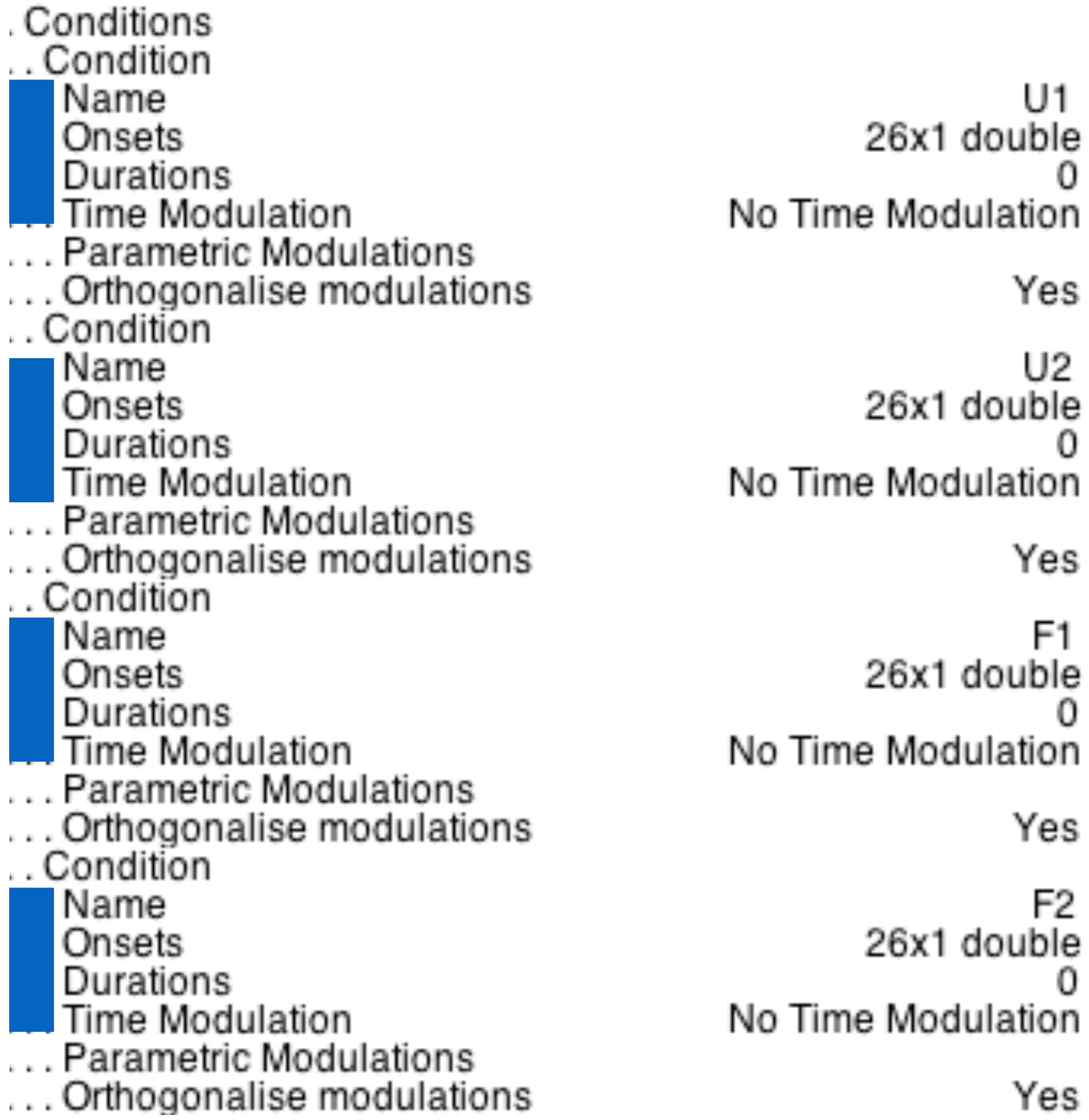
Scans
face_rep fMRI 데이터의 대한 전처리가 완료된 swar* 파일을 모두 입력

실습 - Specify 1st-level (2/3)



Conditions

4개의 Condition을 생성한다.
(자동으로 HRF convolution 됨)



Multiple regressors

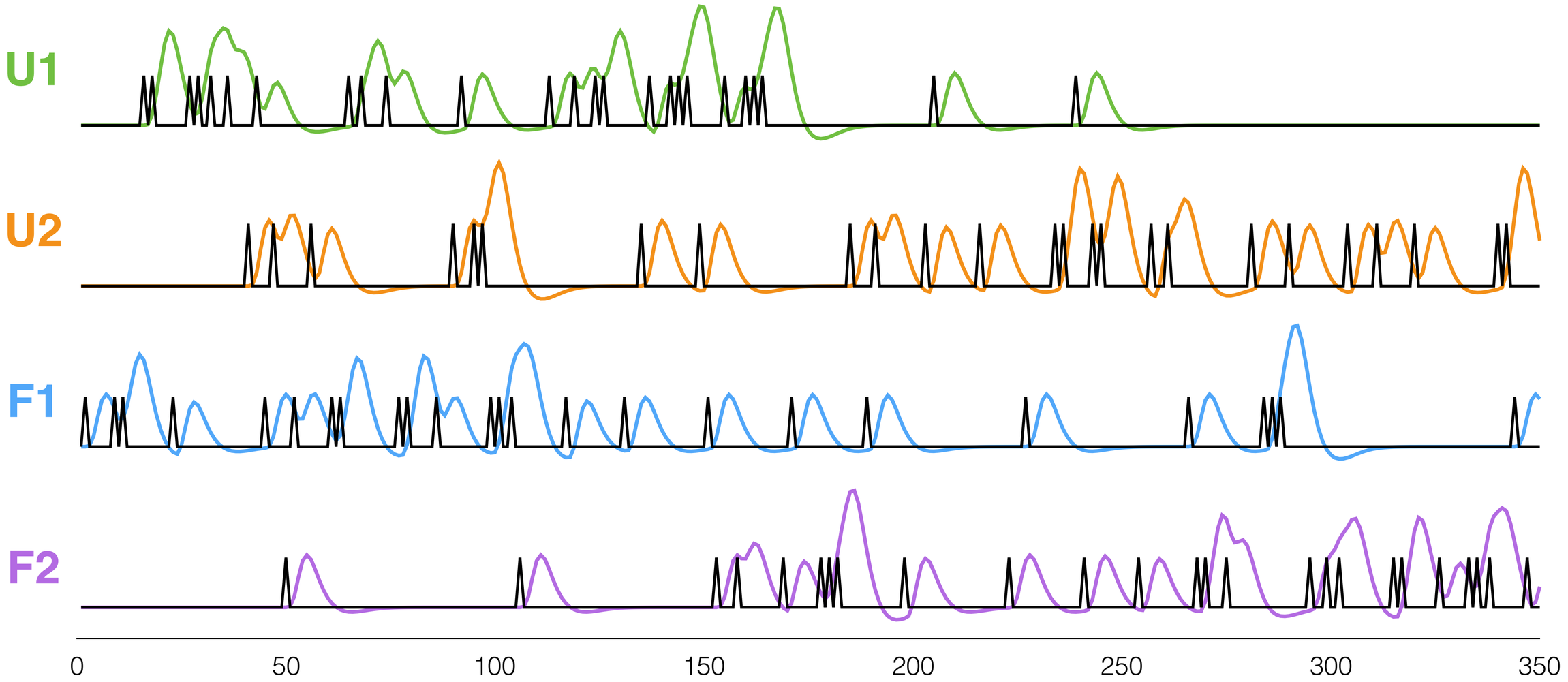
realignment 이후에 생성되는 rp_xxxx.txt 선택 (HRF convolution 되지 않음).

TrialID	U1	U2	F1	F2
1	6.75	13.5	0	33.75
2	15.75	40.5	2.25	49.5
3	18	47.25	9	105.75
4	27	56.25	11.25	153
5	29.25	90	22.5	157.5
6	31.5	94.5	45	168.75
7	36	96.75	51.75	177.75
8	42.75	135	60.75	180
9	65.25	148.5	63	182.25
10	67.5	184.5	76.5	198
11	74.25	191.25	78.75	222.75
12	92.25	202.5	85.5	240.75
13	112.5	216	99	254.25
14	119.25	234	101.25	267.75
15	123.75	236.25	103.5	270
16	126	243	117	274.5
17	137.25	245.25	130.5	294.75
18	141.75	256.5	150.75	299.25
19	144	261	171	301.5
20	146.25	281.25	189	315
21	155.25	290.25	227.25	317.25
22	159.75	303.75	265.5	326.25
23	162	310.5	283.5	333
24	164.25	319.5	285.75	335.25
25	204.75	339.75	288	337.5
26	238.5	342	344.25	346.5

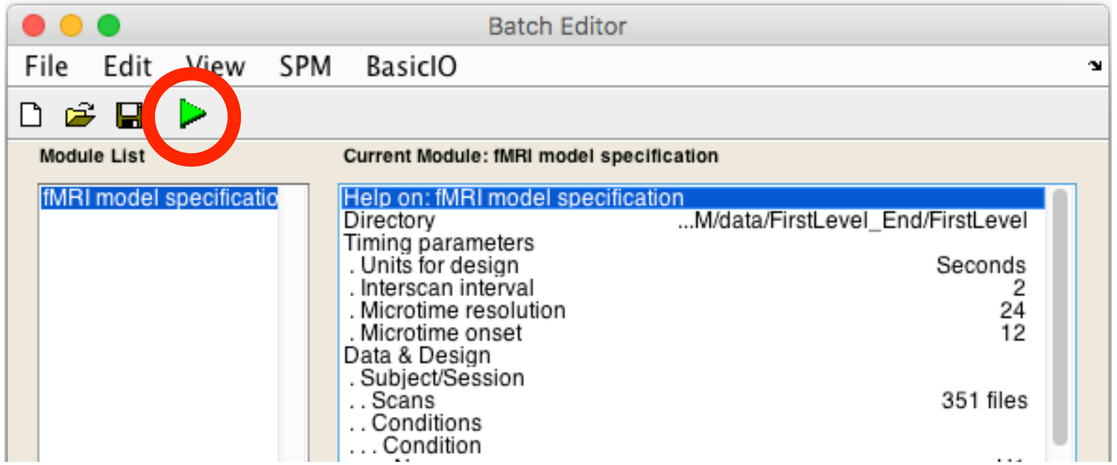
<Onset 정보가 있는 엑셀 파일>

Stimulus Convolved with HRF

Hemodynamic response function



실습 - Specify 1st-level (3/3)



- 1st-level 분석에 필요한 모든 정보가 입력 되었으면 "▶Run Batch" 버튼이 활성화 됨.
- ▶ 버튼을 클릭하여 개별 fMRI 데이터의 General Linear Model을 만든다.

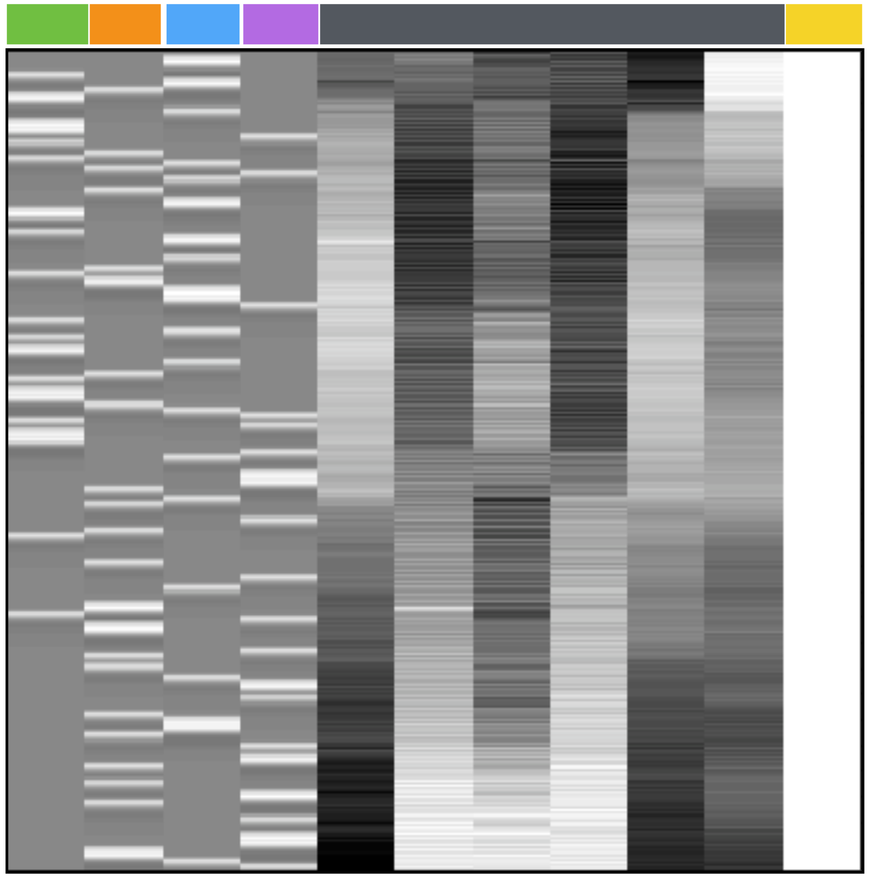
- Specify 1st-level은 뇌영상 데이터를 다음의 모델로 분석하겠다고, 정의 하는 과정임.

$$Y = \beta_0 + \beta_{\mathrm{U1}} X_{\mathrm{U1}} + \beta_{\mathrm{U2}} X_{\mathrm{U2}} + \beta_{\mathrm{F1}} X_{\mathrm{F1}} + \beta_{\mathrm{F2}} X_{\mathrm{F2}}$$

unknown parameters: β_i

onset vectors: X_i

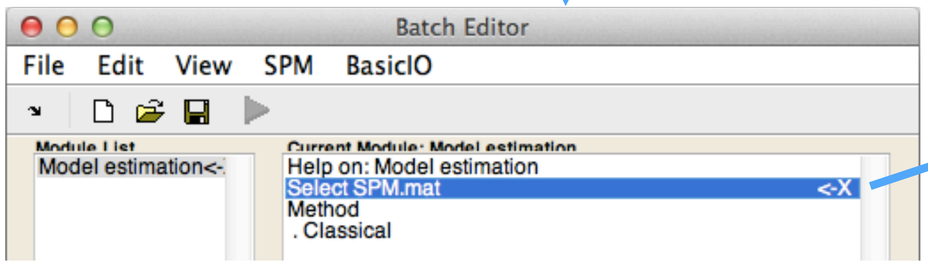
Voxel-wise 1st-level model



- **U1**: HRF convolved U1 condition
- **U2**: HRF convolved U2 condition
- **F1**: HRF convolved F1 condition
- **F2**: HRF convolved F2 condition
- **Head motion** parameters (HRF convolution 되지 않음.)
- **Constant** term: 상수항!

실습 - (Parameter) Estimation

Estimate
Specify 1st-level 을 통해서 구성한 General Linear Model의 unknown parameters의 값을 추정(계산)함.



Select SPM.mat
Slide의 11페이지에서 지정했던 **Directory**에 생성된 SPM.mat 파일을 선택함.

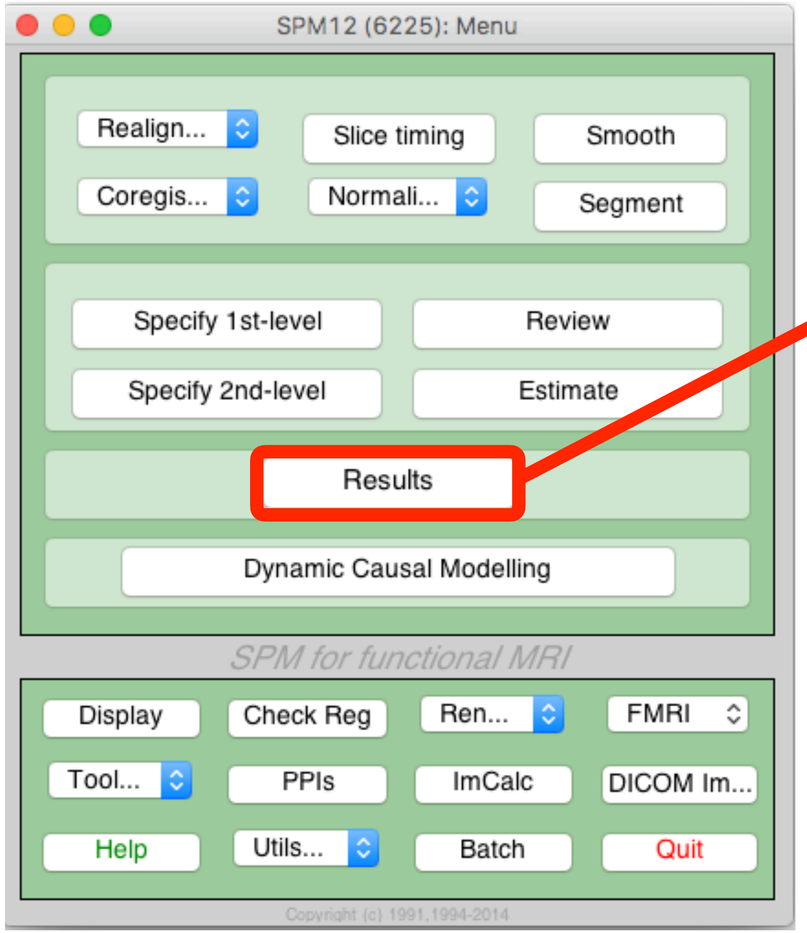
$$Y = \beta_0 + \beta_{U1}X_{U1} + \beta_{U2}X_{U2} + \beta_{F1}X_{F1} + \beta_{F2}X_{F2} + \sum \beta_k X_k$$

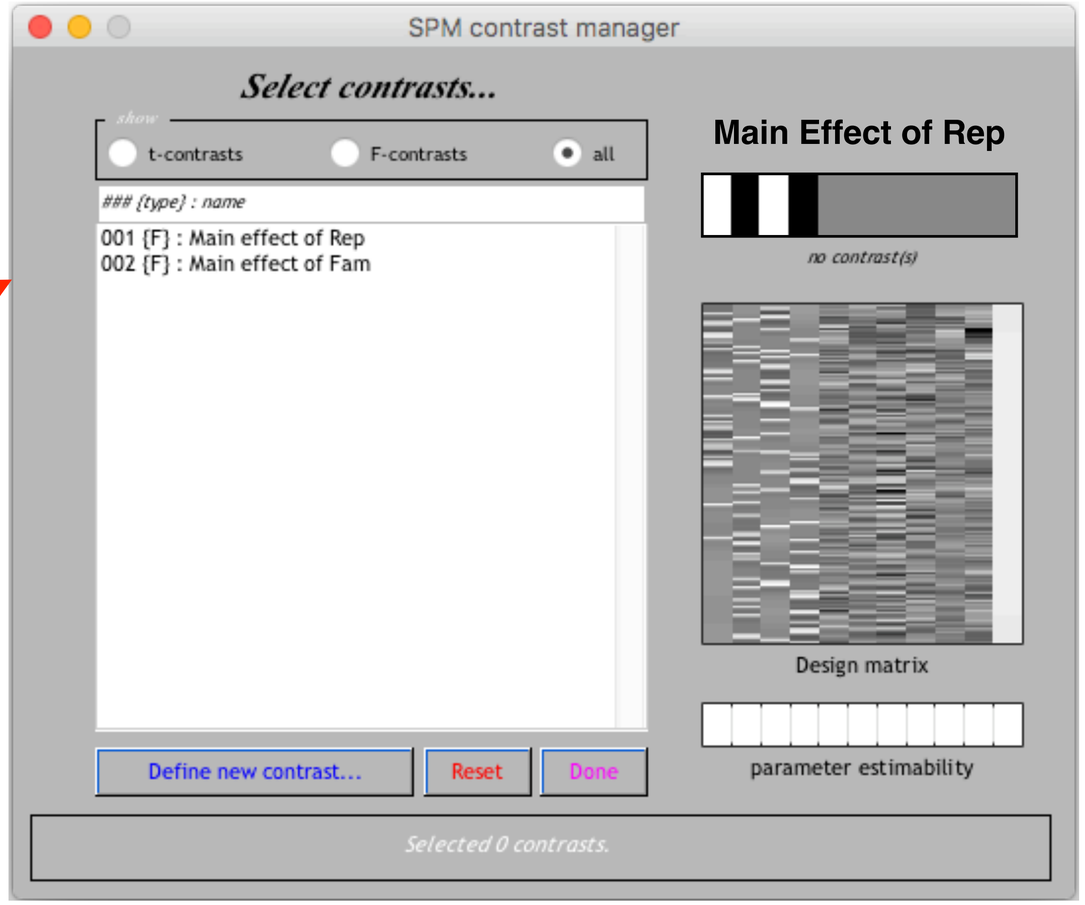
unknown parameters: β_i

onset vectors: X_i

Regressors of no interest

실습 - Results (Create *F*-contrasts)





Main Effect of Rep

[1 -1 1 -1 0 0 0 0 0 0]

or

[-1 1 -1 1 0 0 0 0 0 0]

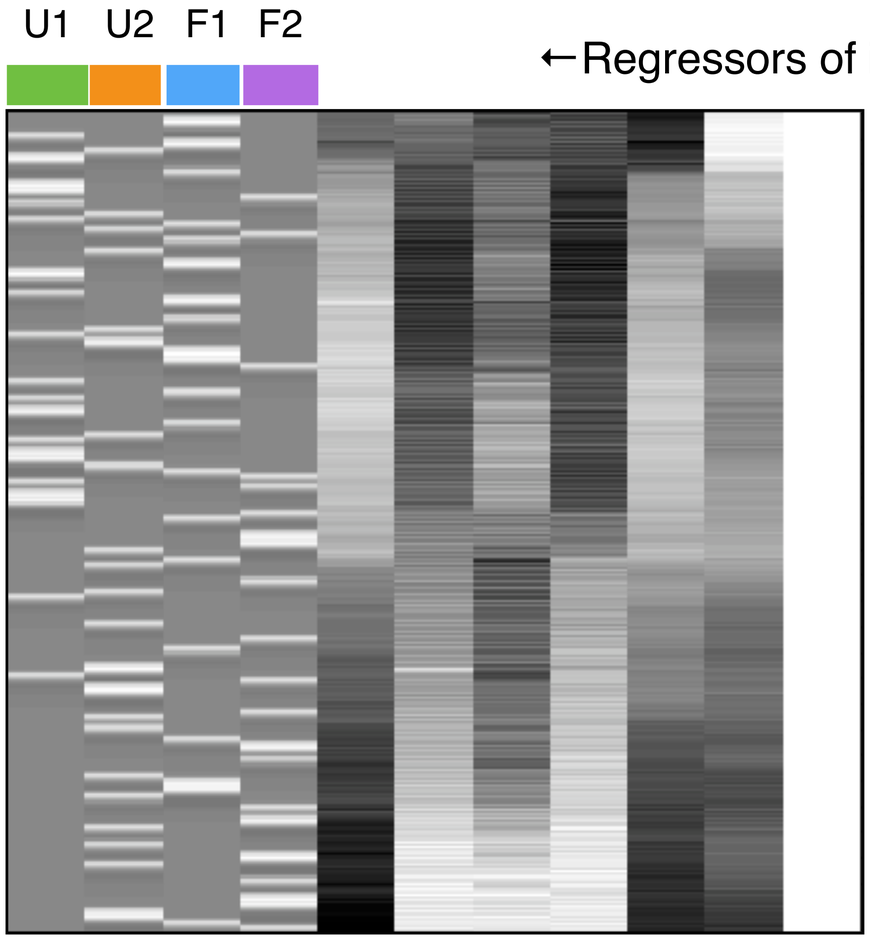
Main Effect of Fam

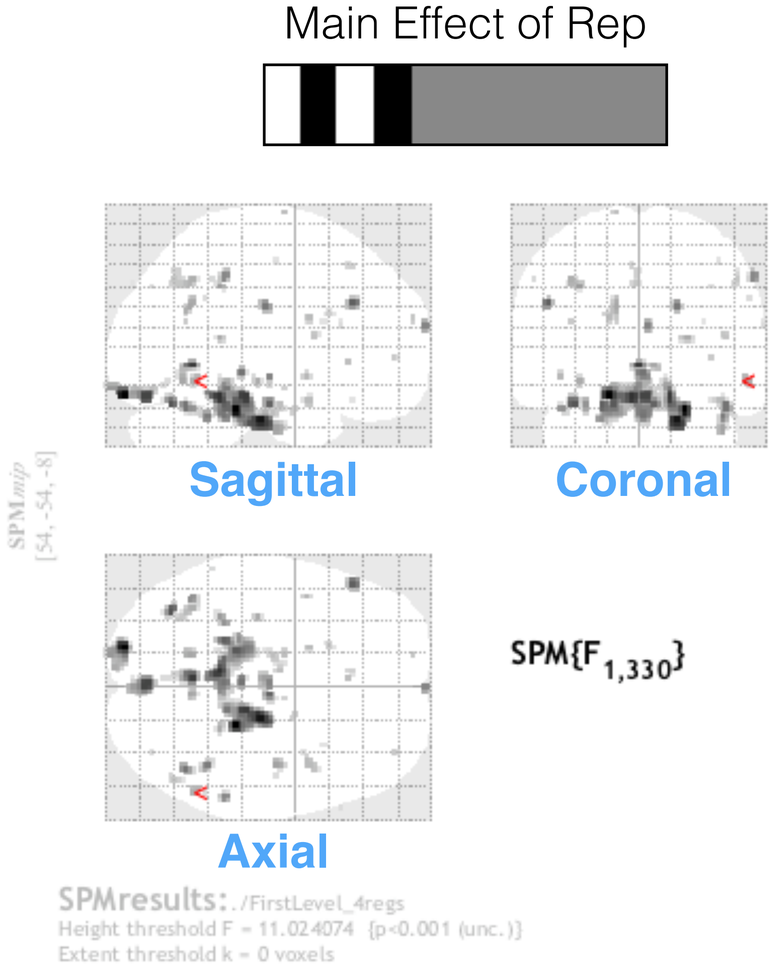
[1 1 -1 -1 0 0 0 0 0 0]

or

[-1 -1 1 1 0 0 0 0 0 0]

실습 - Visualization

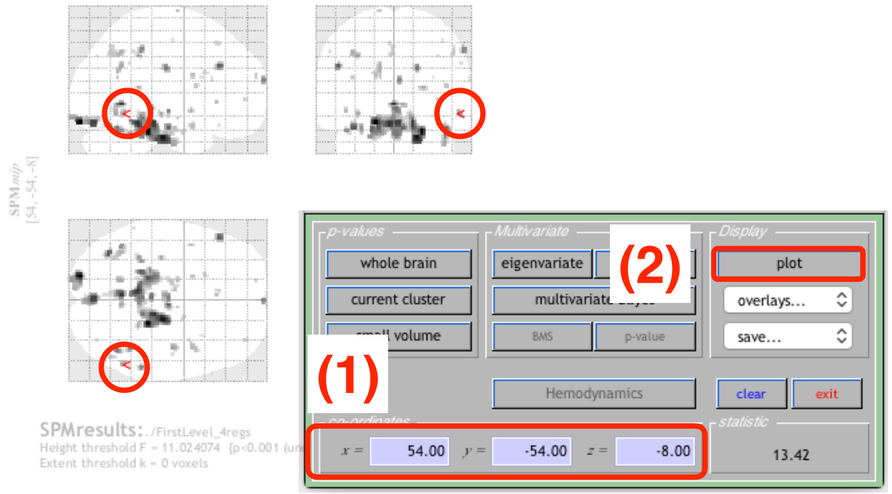




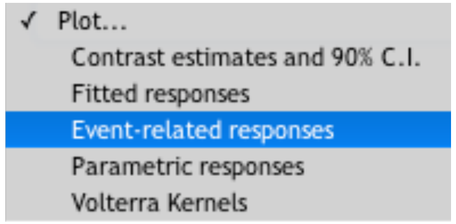
실습 - Plotting Time-courses

Ventral temporal cortex

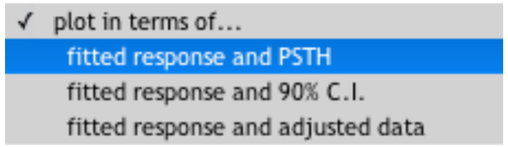
MNI: [54, -54, -8]



(3)

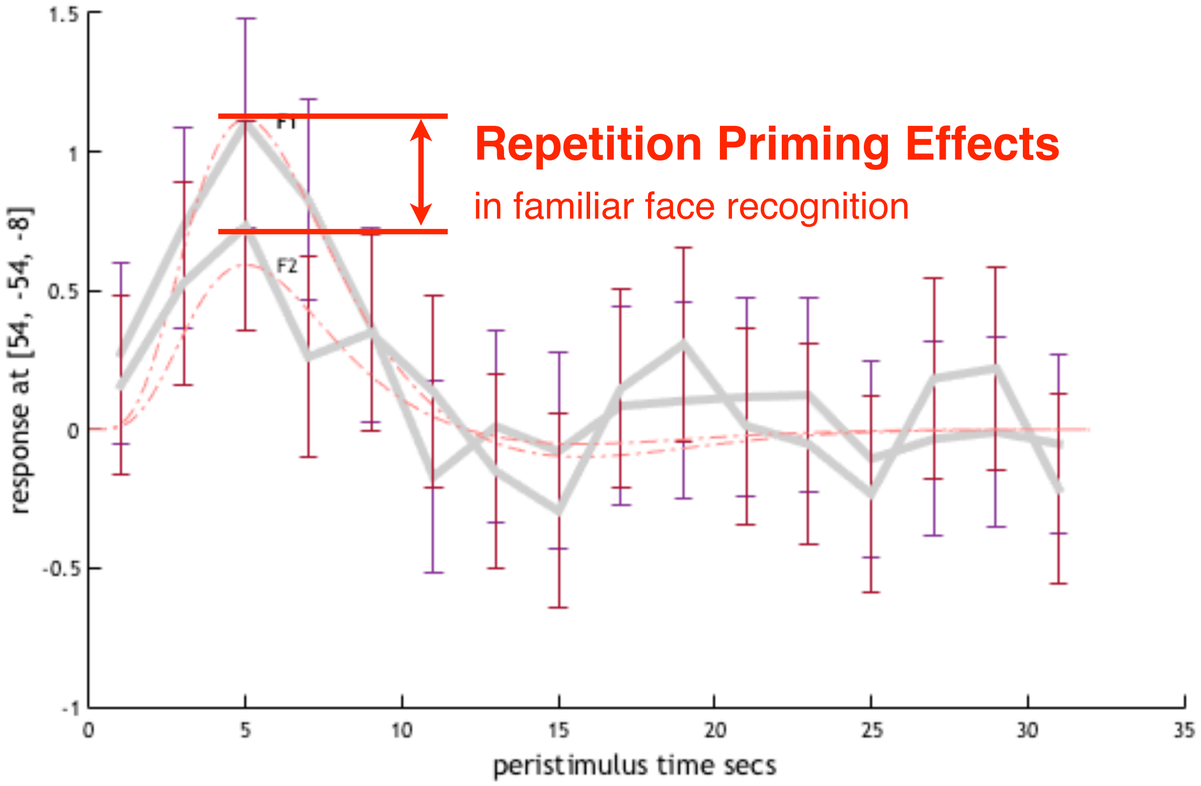


(4)

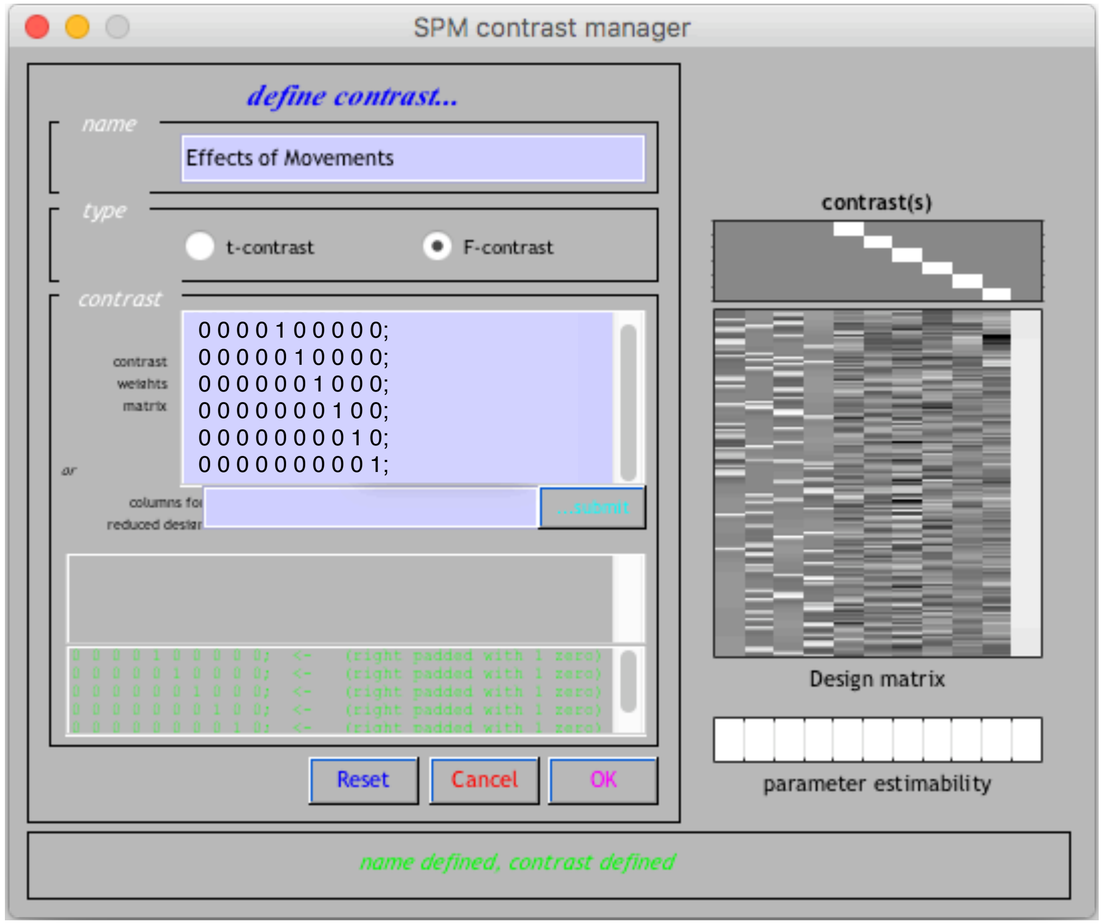


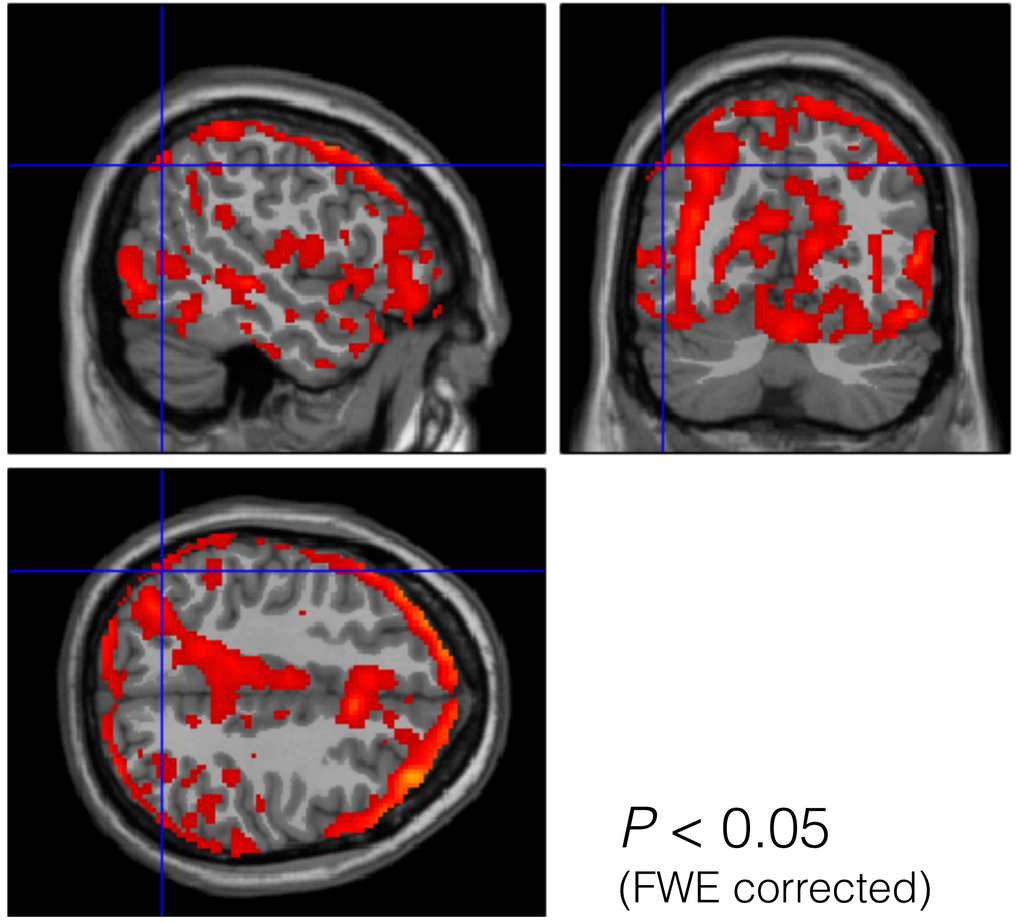
where, **PSTH** indicates peri-stimulus histogram.

Fitted response and PSTH



F-contrasts for testing effects of movement



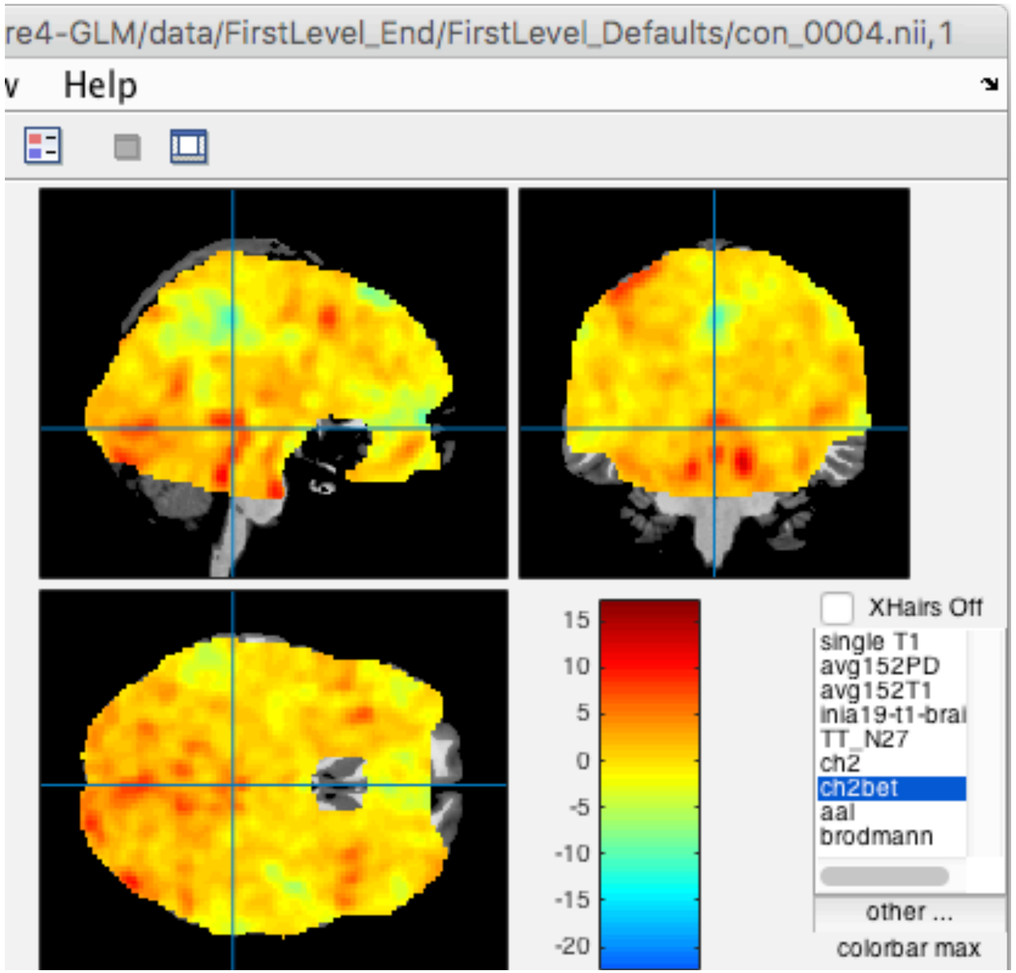


$P < 0.05$
(FWE corrected)

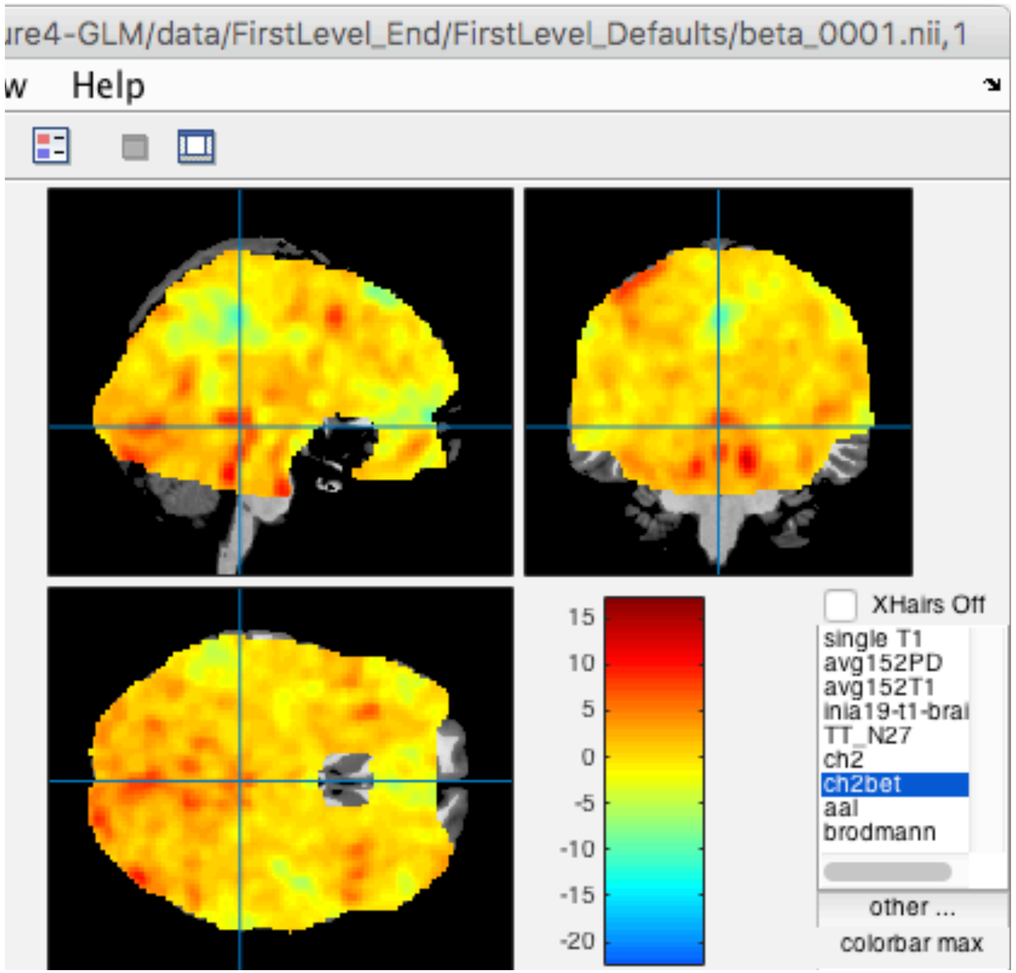
Con vs Beta files

T-contrast: 1 0 0 0 0 0 0 0 0 0;

첫번째 Regressor (U1) 에 대한 beta



=

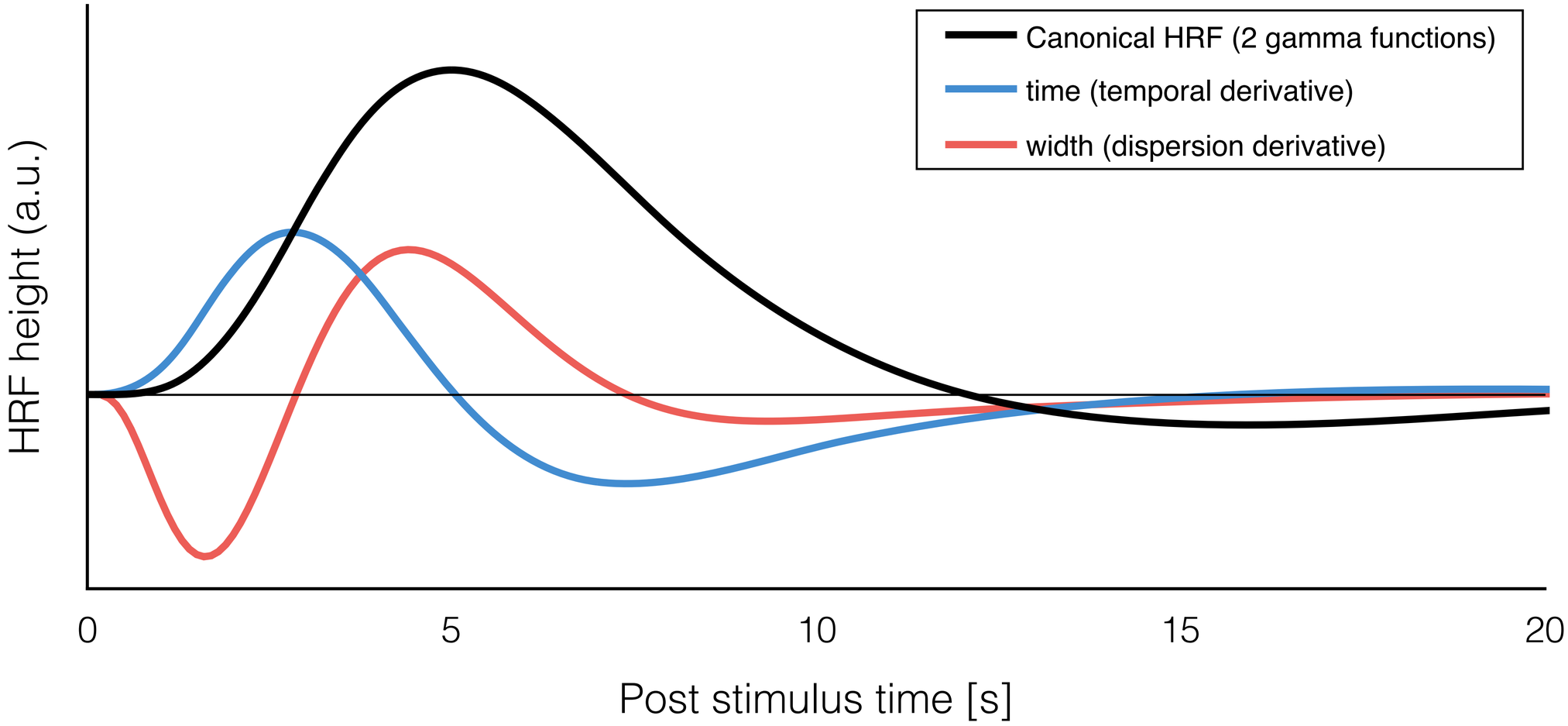


Con vs Beta files

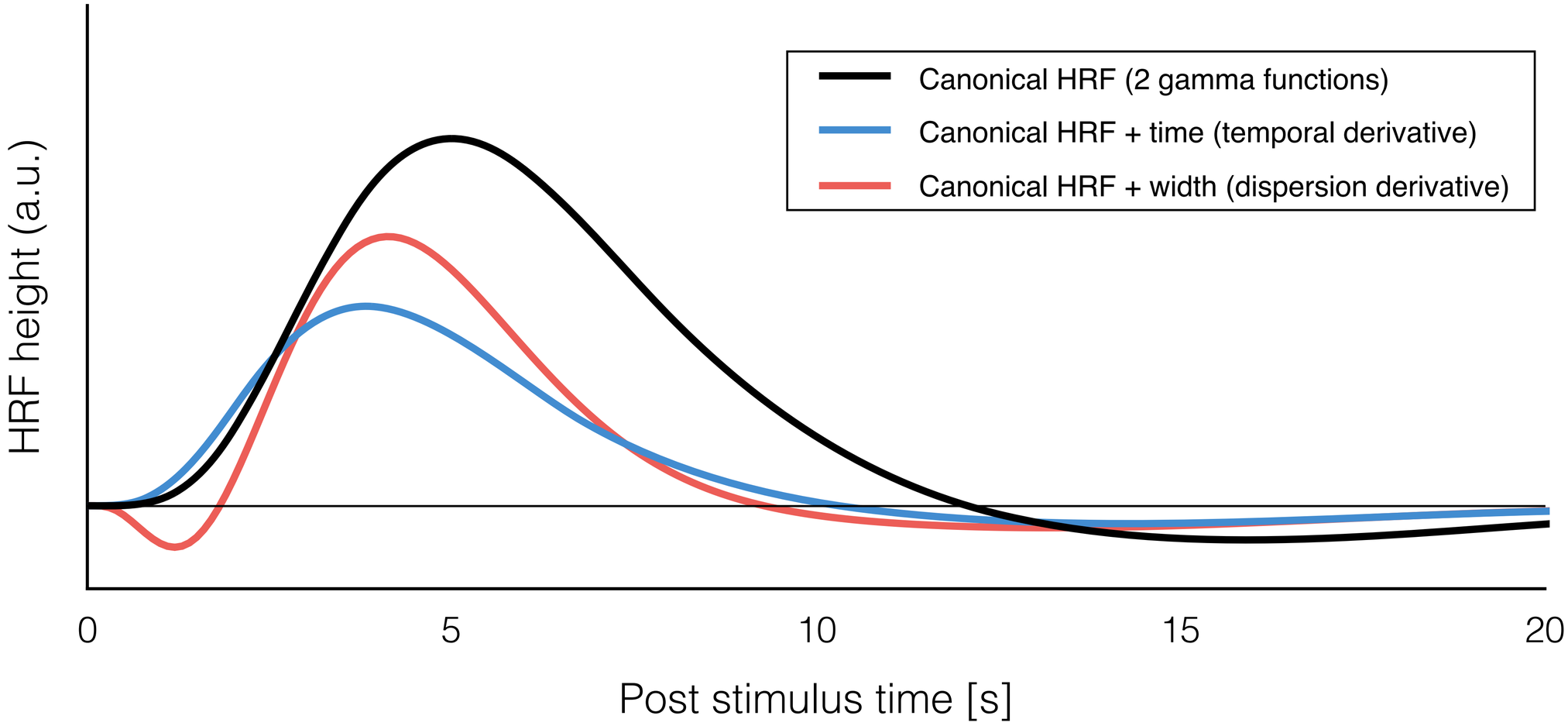
- 왜 같을까?
- 만약 세션이 2개라면, 2 세션에서 각각 estimated된 평균 beta 값이 con 파일로 생성될 것임.
- 만약, 서로 다른 조건의 beta에 대한 contrast를 만든다면 조건간 차이값이 con 파일로 생성될 것임.

Inclusion of
Higher Order Canonical HRF

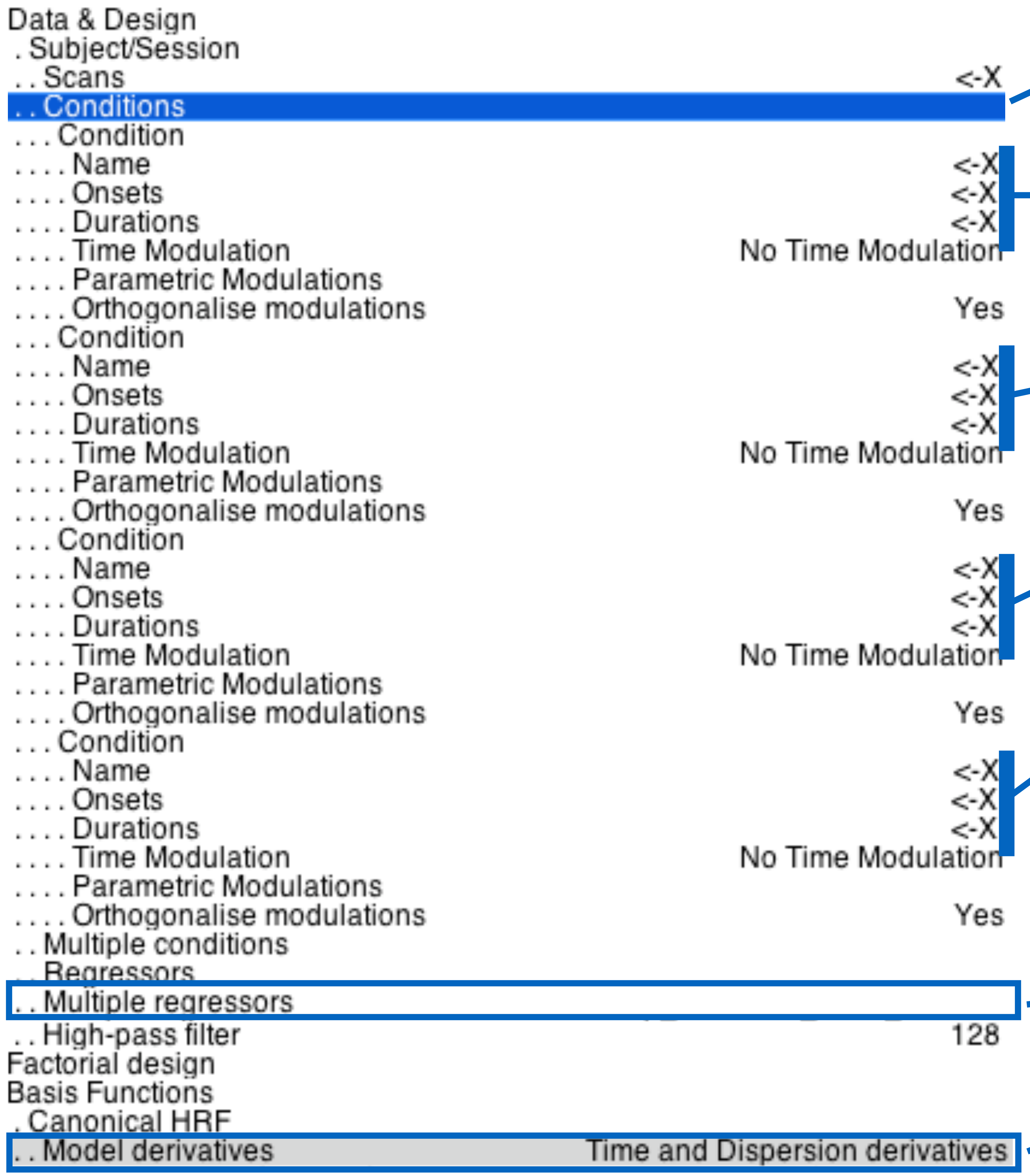
What are HRFs?



Variants of Canonical HRF

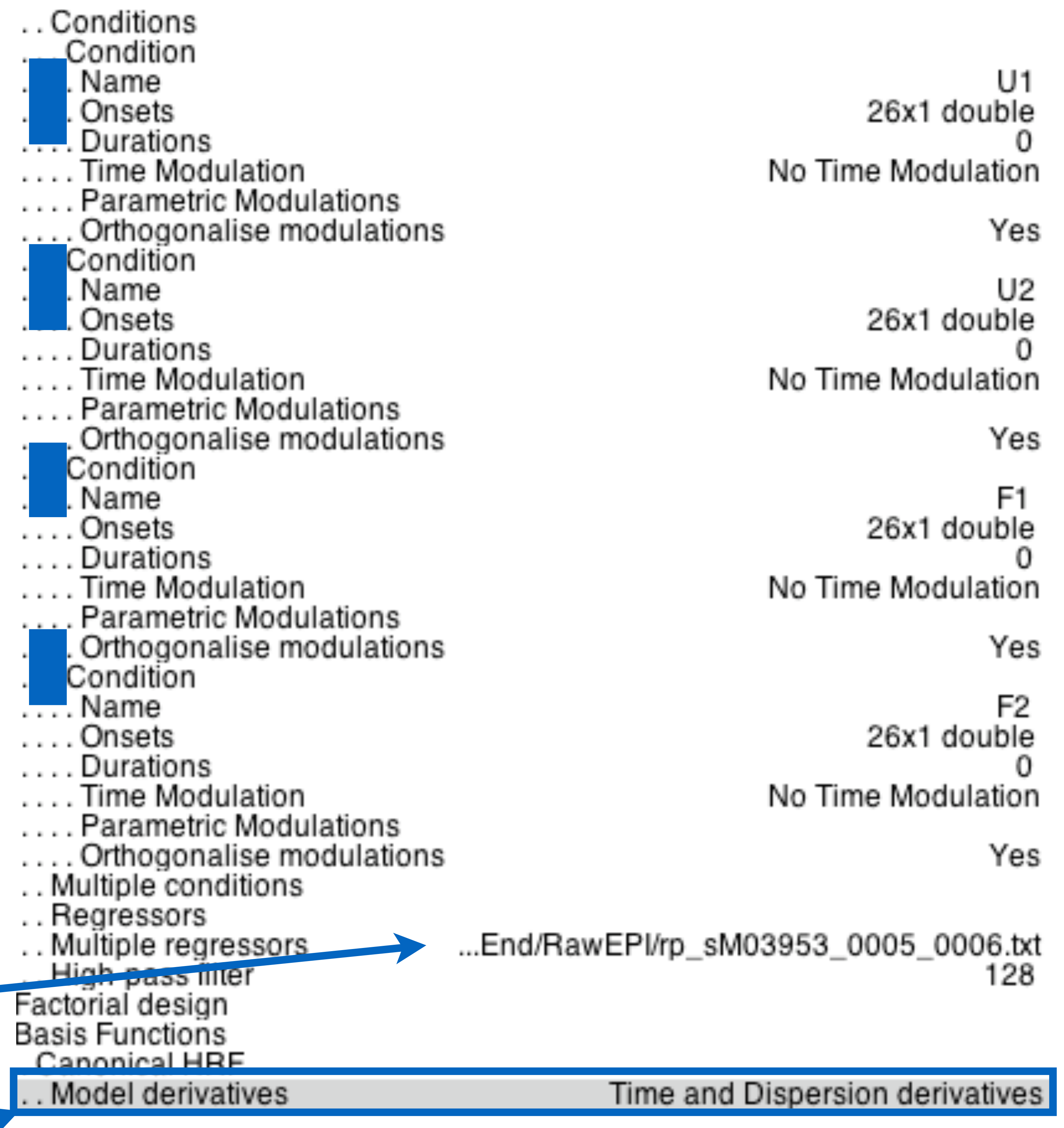


실습 - Specify 1st-level (time modulation)



Conditions

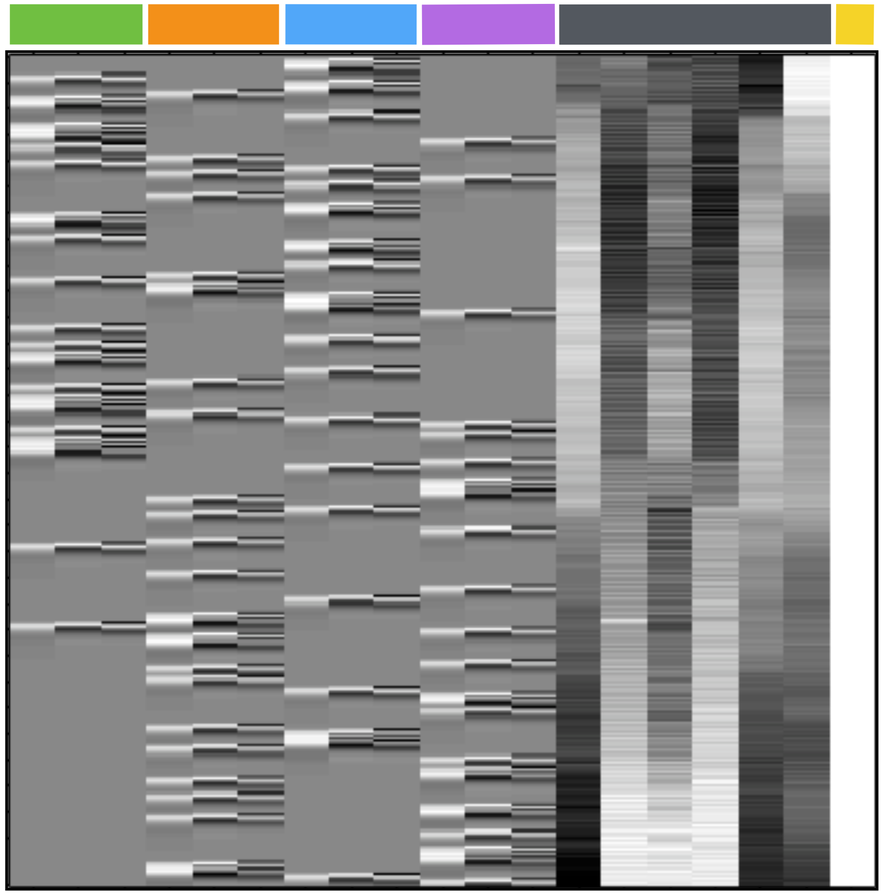
4개의 Condition을 생성한다.
(자동으로 HRF convolution 됨)



TrialID	U1	U2	F1	F2
1	6.75	13.5	0	33.75
2	15.75	40.5	2.25	49.5
3	18	47.25	9	105.75
4	27	56.25	11.25	153
5	29.25	90	22.5	157.5
6	31.5	94.5	45	168.75
7	36	96.75	51.75	177.75
8	42.75	135	60.75	180
9	65.25	148.5	63	182.25
10	67.5	184.5	76.5	198
11	74.25	191.25	78.75	222.75
12	92.25	202.5	85.5	240.75
13	112.5	216	99	254.25
14	119.25	234	101.25	267.75
15	123.75	236.25	103.5	270
16	126	243	117	274.5
17	137.25	245.25	130.5	294.75
18	141.75	256.5	150.75	299.25
19	144	261	171	301.5
20	146.25	281.25	189	315
21	155.25	290.25	227.25	317.25
22	159.75	303.75	265.5	326.25
23	162	310.5	283.5	333
24	164.25	319.5	285.75	335.25
25	204.75	339.75	288	337.5
26	238.5	342	344.25	346.5

<Onset 정보가 있는 엑셀 파일>

Voxel-wise 1st-level model



U1: HRF convolved U1 condition and 1st and 2nd order derivatives of HRF

U2: HRF convolved U2 condition and 1st and 2nd order derivatives of HRF

F1: HRF convolved F1 condition and 1st and 2nd order derivatives of HRF

F2: HRF convolved F2 condition and 1st and 2nd order derivatives of HRF

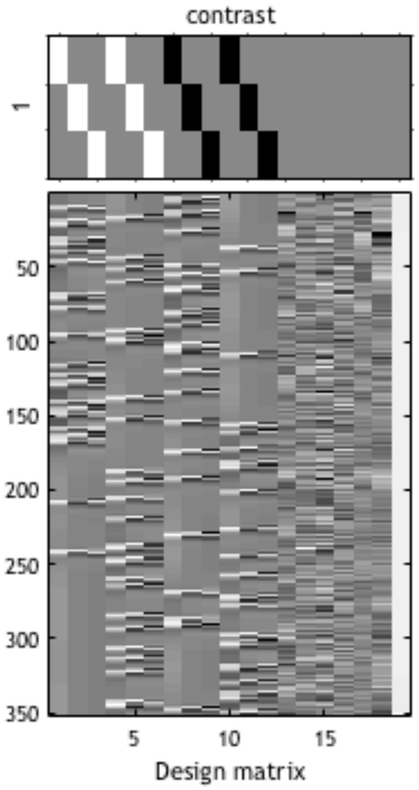
Head motion parameters (HRF convolution 되지 않음.)

Constant term: 상수항!

Time modulations?
For example, 1st order modulation would model the stick functions and a linear change of the stick function heights over time. Higher order modulation will introduce further volumes that contain the stick functions scaled by time squared, time cubed etc.

실습 - Results (Create *F*-contrasts)

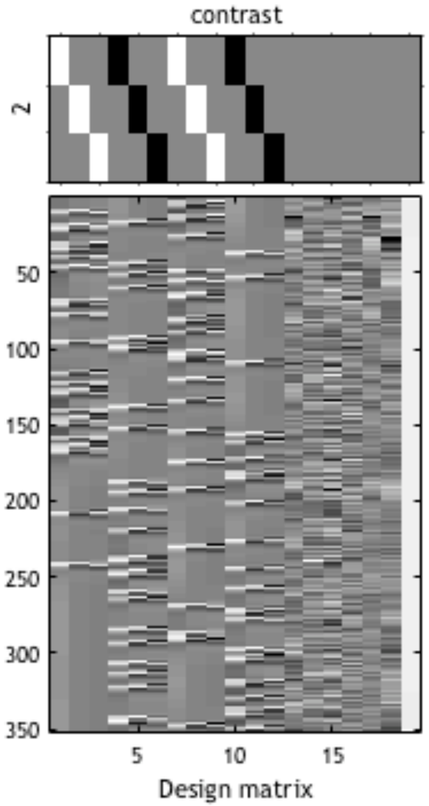
Effects of Familiarity



1 0 0 1 0 0 -1 0 0 -1 0 0;
0 1 0 0 1 0 0 -1 0 0 -1 0;
0 0 1 0 0 1 0 0 -1 0 0 -1;

↑
contrast vector

Effects of Repetition

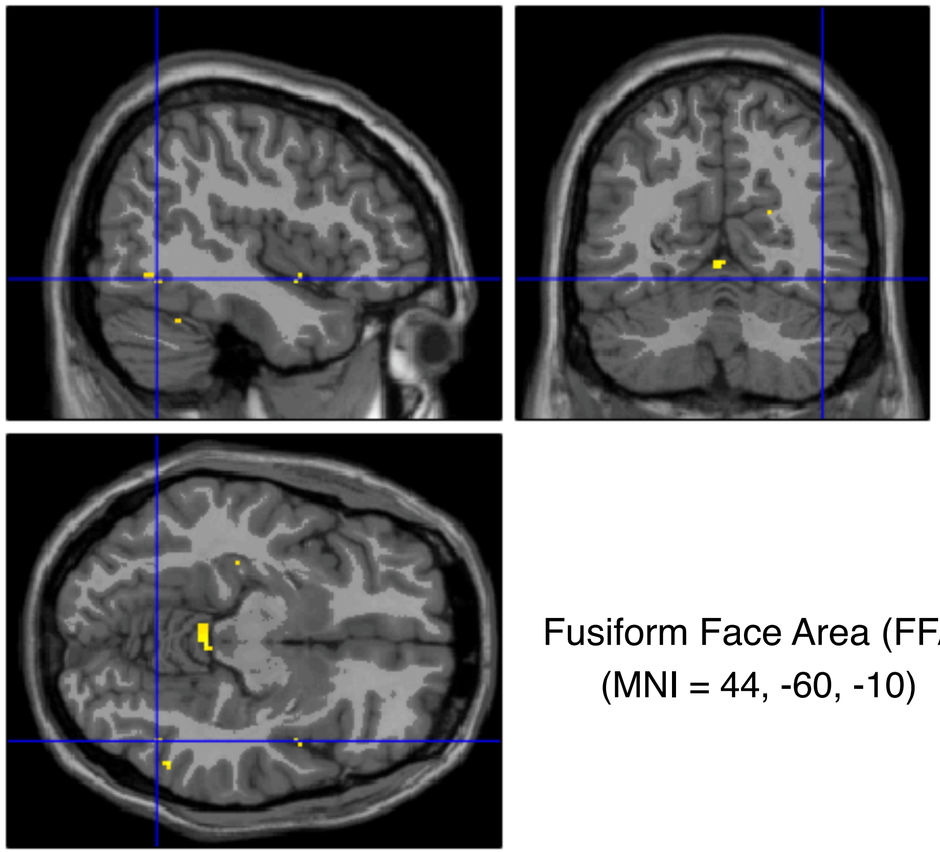


1 0 0 -1 0 0 1 0 0 -1 0 0;
0 1 0 0 -1 0 0 1 0 0 -1 0;
0 0 1 0 0 -1 0 0 1 0 0 -1;

↑
contrast vector

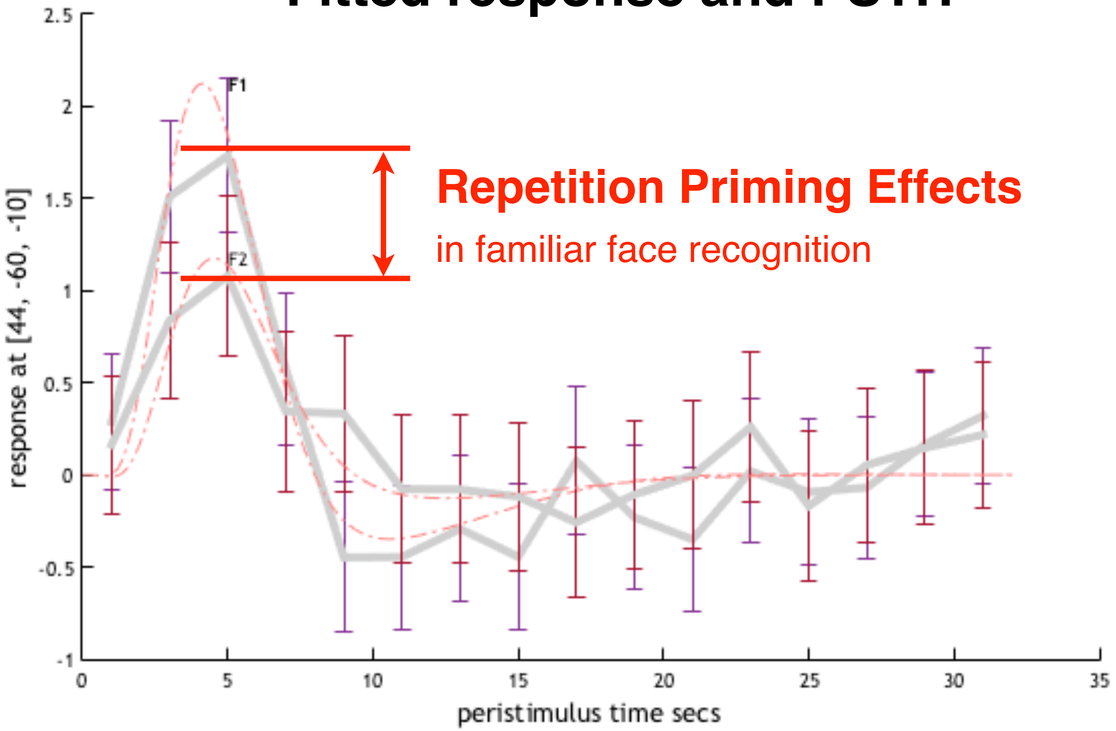
실습 - Plotting Time-courses

Effects of Repetition (F-contrast)



Fusiform Face Area (FFA)
(MNI = 44, -60, -10)

Fitted response and PSTH

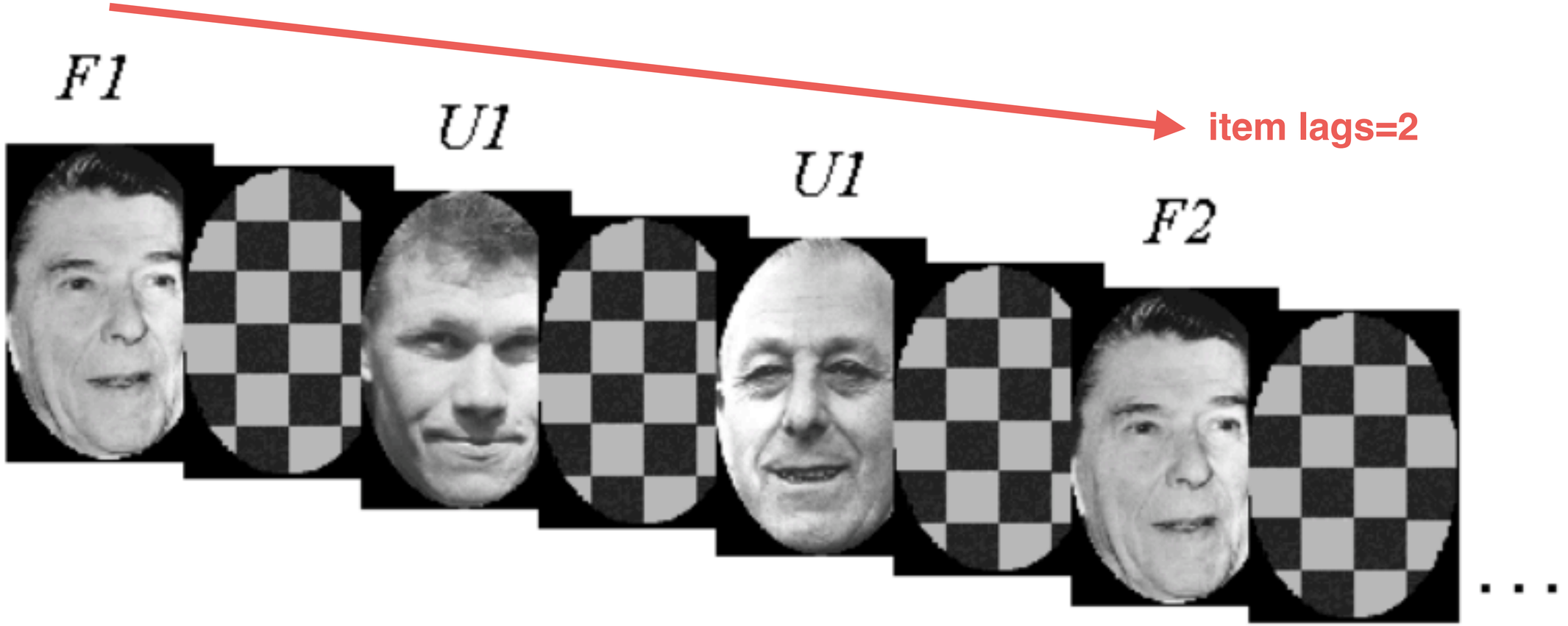


Neural activity in the right FFA decreases for repeated familiar face recognition.

Modeling parametric responses

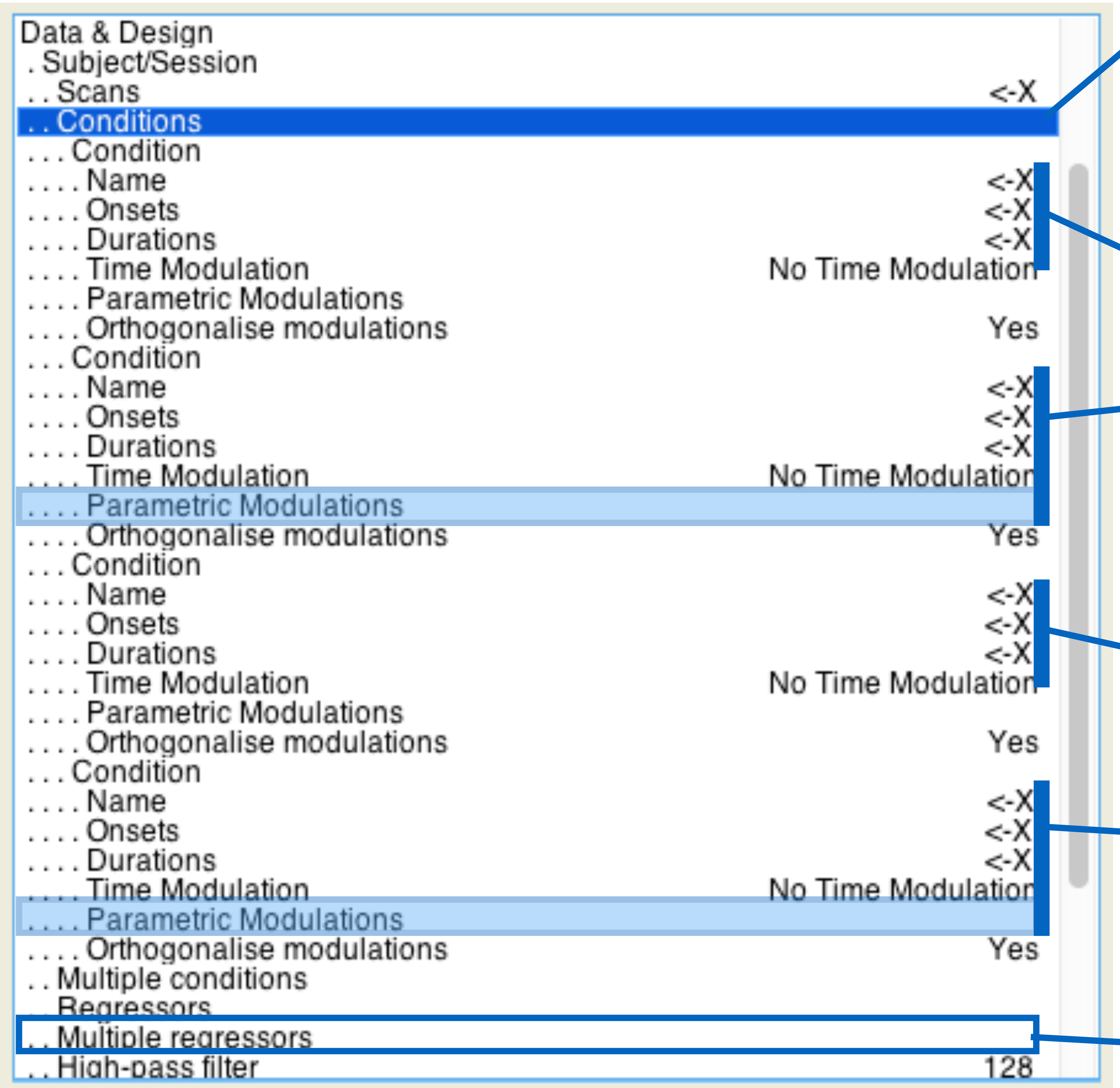
Item Lags

Number of other faces intervening between this (repeated) presentation and its previous (first) presentation



TrialID	U1	U2	U2 (item lags)	F1	F2	F2 (item lags)
1	6.75	13.5	3	0	33.75	11
2	15.75	40.5	3	2.25	49.5	14
3	18	47.25	10	9	105.75	2
4	27	56.25	10	11.25	153	47
5	29.25	90	14	22.5	157.5	36
6	31.5	94.5	1	45	168.75	18
7	36	96.75	23	51.75	177.75	37
8	42.75	135	3	60.75	180	59
9	65.25	148.5	3	63	182.25	11
10	67.5	184.5	37	76.5	198	56
11	74.25	191.25	10	78.75	222.75	33
12	92.25	202.5	42	85.5	240.75	4
13	112.5	216	61	99	254.25	57
14	119.25	234	33	101.25	267.75	18
15	123.75	236.25	27	103.5	270	59
16	126	243	61	117	274.5	55
17	137.25	245.25	28	130.5	294.75	46
18	141.75	256.5	22	150.75	299.25	61
19	144	261	39	171	301.5	4
20	146.25	281.25	37	189	315	67
21	155.25	290.25	62	227.25	317.25	9
22	159.75	303.75	37	265.5	326.25	63
23	162	310.5	20	283.5	333	13
24	164.25	319.5	54	285.75	335.25	19
25	204.75	339.75	34	288	337.5	42
26	238.5	342	50	344.25	346.5	1

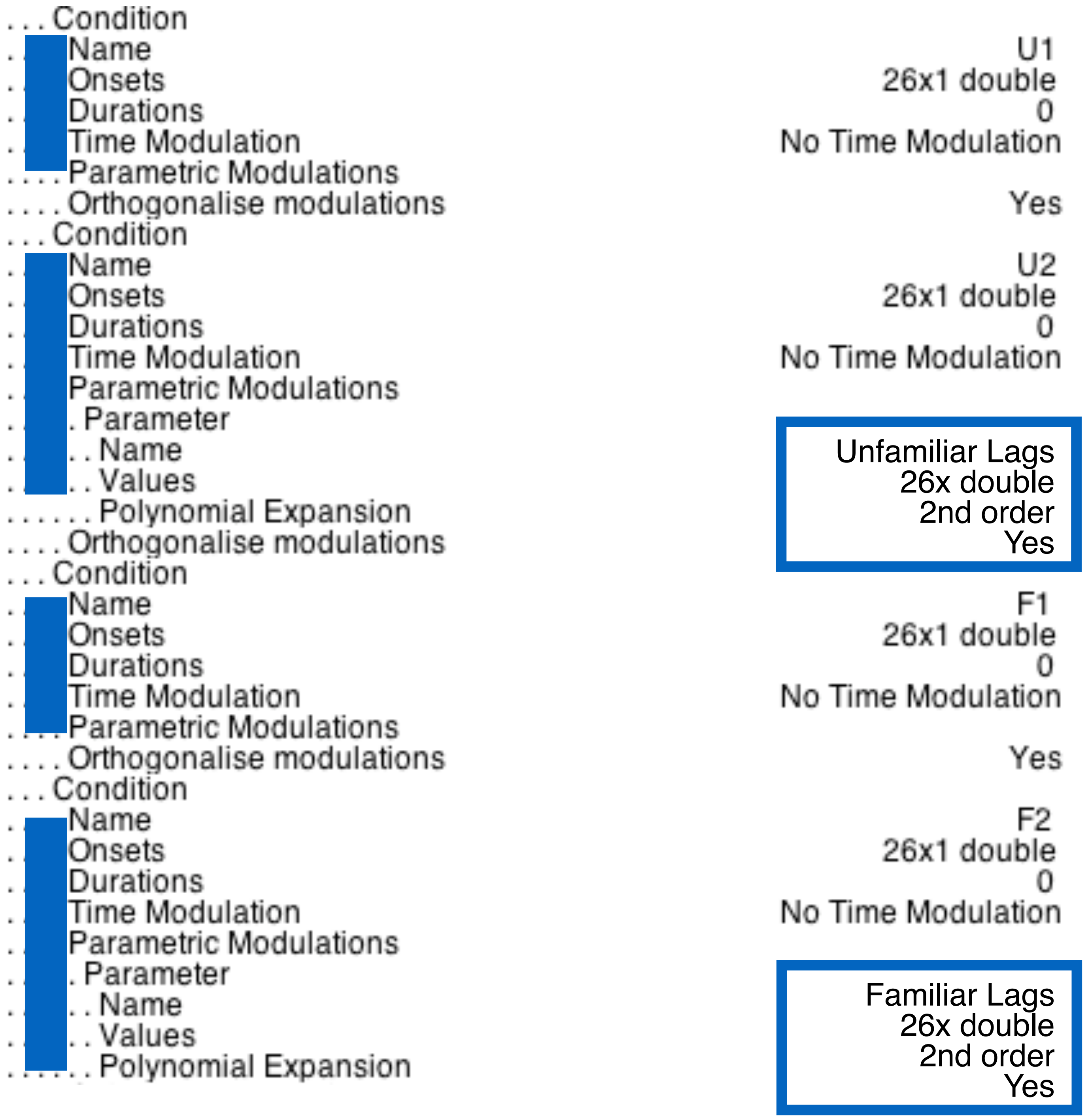
실습 - Specify 1st-level (Item Lags)



Conditions

4개의 Condition을 생성한다.

(자동으로 HRF convolution 됨)

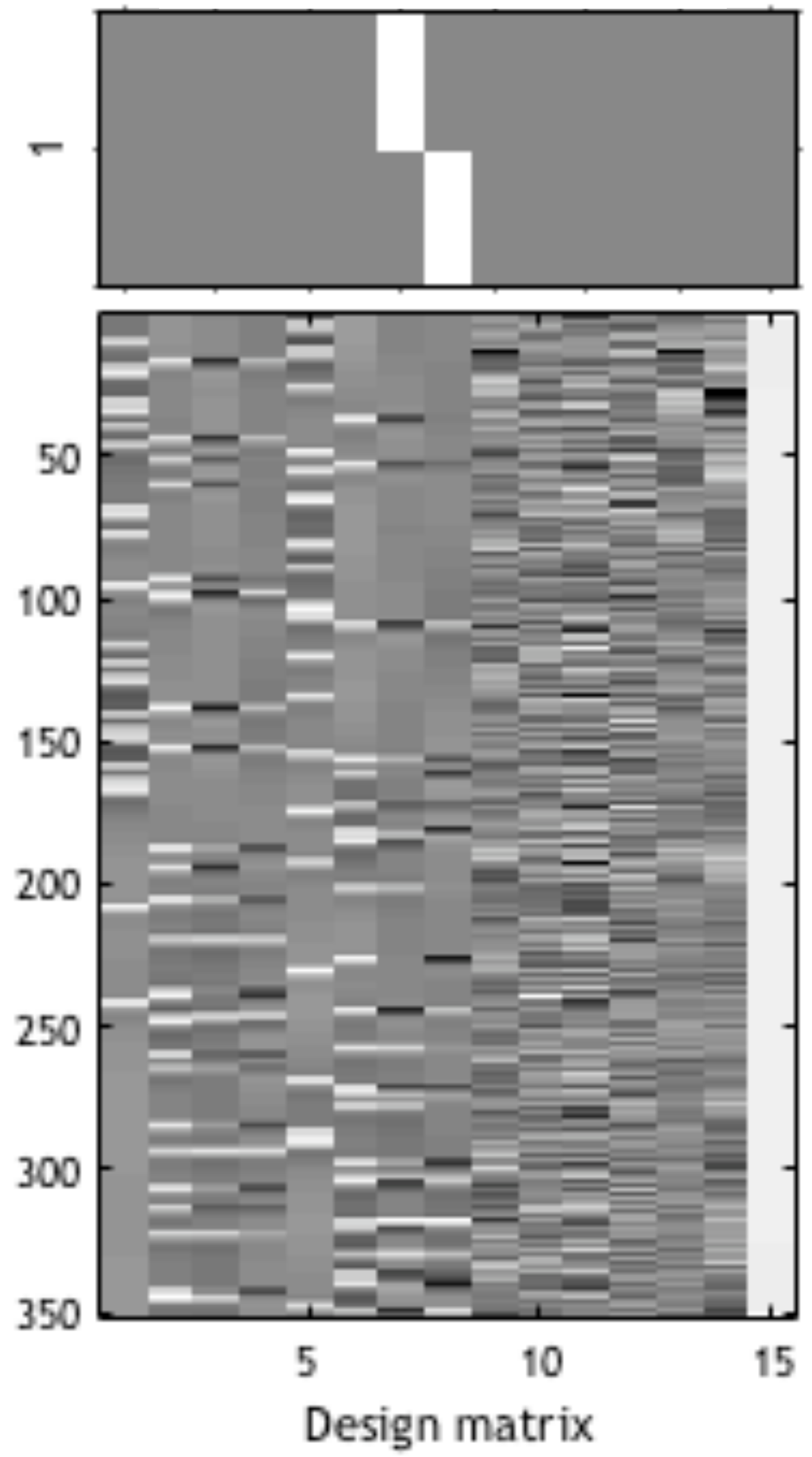


Multiple regressors

realignment 이후에 생성되는 rp_xxxx.txt 선택 (HRF convolution 되지 않음).

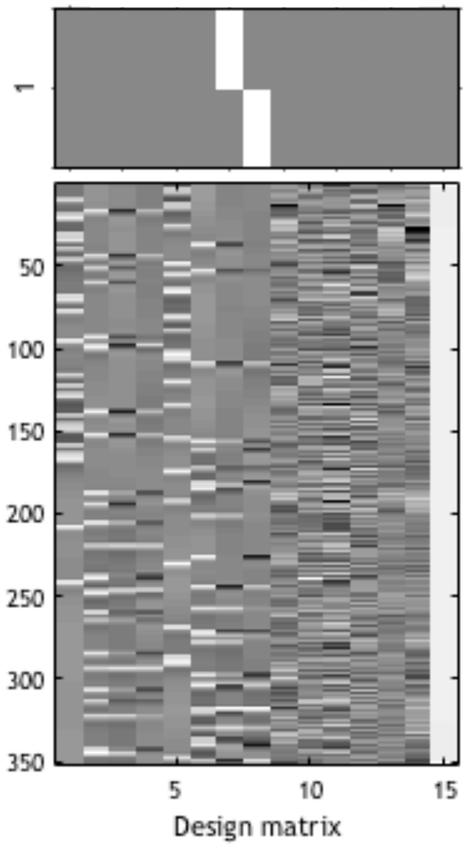
F-contrast

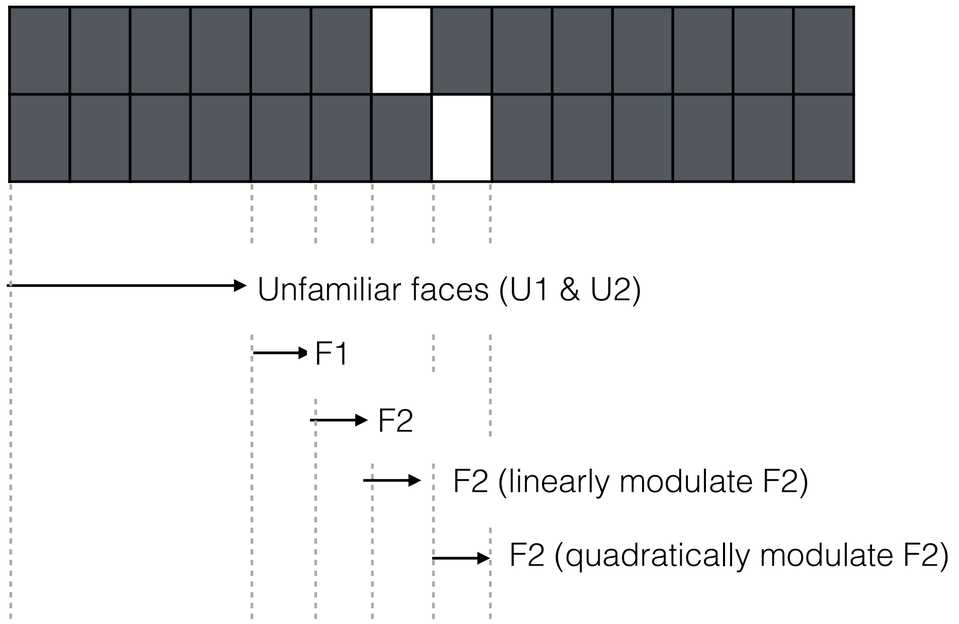
(for familiar lags)



F-contrasts for familiar lags

F-contrast
(for familiar lags)



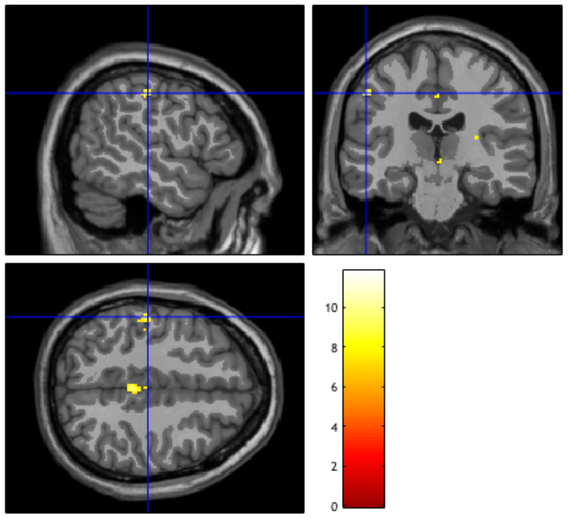


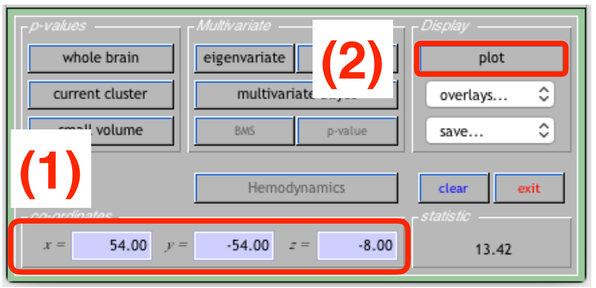
0 0 0 0 0 0 1 0 0 0 0 0 0 0;
0 0 0 0 0 0 0 1 0 0 0 0 0 0;

↑
contrast vector

실습 - Plotting Parametric Responses

Left parietal region
MNI: [-52, -22, 46]



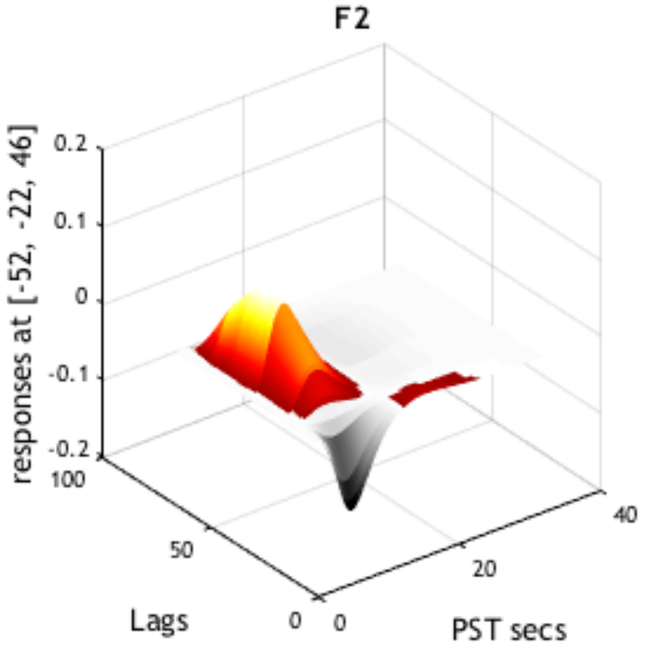


(3)

Parametric responses

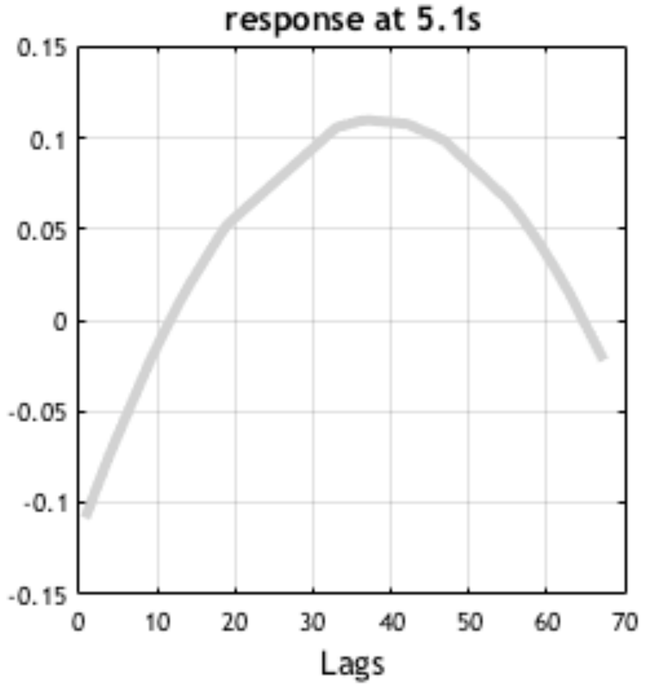
F2

Lags



where **PST** represents peri-stimulus time

Quadratic effects of lag



Removal of linear and quadratic trends

RESEARCH ARTICLE

International Journal of Geriatric Psychiatry

Peripheral inflammation related to lower fMRI activation during a working memory task and resting functional connectivity among older adults: a preliminary study

Sheena I. Dev[1,2], Raeanne C. Moore[1,3], Benchawanna Soontornniyomkij[1], Cristian L. Achim[1], Dilip V. Jeste[1,3] and Lisa T. Eyler[1,3,4]

[1]Department of Psychiatry, University of California, San Diego
[2]Joint Doctoral Program in Clinical Psychology, San Diego State University/University of California, San Diego, CA
[3]Sam and Rose Stein Institute for Research on Aging, University of California, San Diego, CA
[4]VA San Diego Healthcare System, San Diego, CA
Correspondence to: Lisa T. Eyler, Ph.D., E-mail: lteyler@ucsd.edu

ranges of quality
ay accuracy and
ole and accurate

Image acquisition

Imaging data were acquired using a research dedicated 3 Tesla General Electric Excite MRI scanner with an 8-channel head coil. High resolution structural T1-weighted MRI images were acquired using a magnetization-prepared rapid acquisition gradient echo (MPRAGE) sequence. The resulting images were utilized to localize the functional signal. BOLD signal was acquired during the n-Back functional scan using gradient echo planar imaging (TR = 2500 msec, TE = 32 ms, 4-mm slice thickness/no gap, FOV = 25.6 cm, bandwidth = 125, 195 repetitions). The BOLD signal for the resting state connectivity scan was measured with T2*-weighted echo planar

NeuroImages (AFNI) software package (Cox, 1996), using a streamlined pathway that included (i) removal of the first time point to account for signal stabilization; (ii) removal of skull and surrounding tissue; (iii) spatial smoothing to 6 full-width-to-half-maximum; (iv) grand mean scaling; (v) application of high-pass temporal filter and low-pass temporal filter; and (vi) removal of linear and quadratic trends. Each participant's anatomical scan underwent cerebral spinal fluid, white matter (WM) and grey matter (GM) segmentation using the Oxford Centre for Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library (FSL) FMRIB Linear Image Registration Tool (FLIRT) program and were subsequently registered to functional maps. Automated motion correction was then applied to all participants to correct for excessive motion during scan time. A visual inspection was conducted and remaining data points with excessive motion were rejected.

Neuron
Article

Neural Predictors of Purchases

Brian Knutson,[1,*] Scott Rick,[2] G. Elliott Wimmer,[1] Drazen Prelec,[3] and George Loewe
[1] Psychology and Neuroscience, Stanford University, Building 420, Jordan Hall, Stanford, CA 94305
[2] Social and Decision Sciences, Carnegie Mellon University, 208 Porter Hall, Pittsburgh, PA 15213,
[3] MIT Sloan School of Management, Massachusetts Institute of Technology, E56-320, Cambridge,
*Correspondence: knutson@psych.stanford.edu
DOI 10.1016/j.neuron.2006.11.010

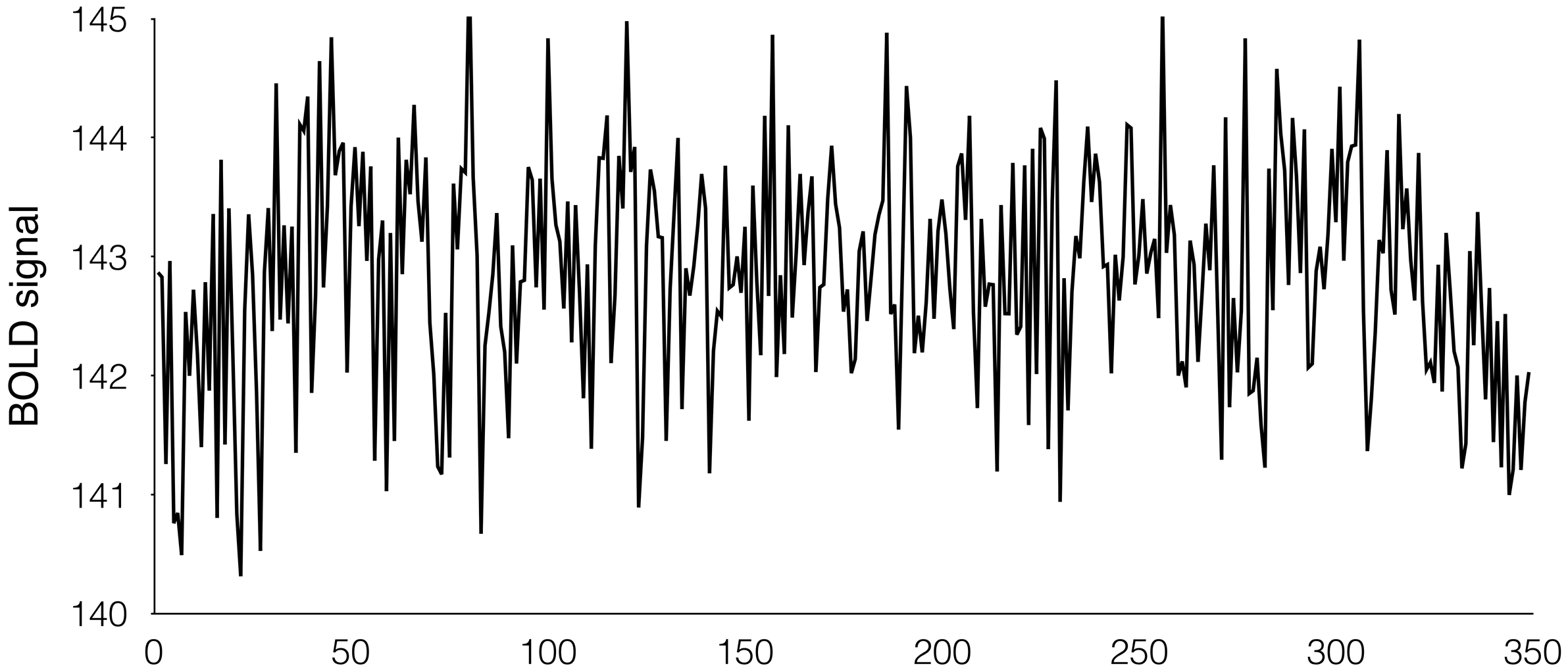
fMRI Acquisition and Analysis

Images were acquired with a 1.5-T General Electric MRI scanner using a standard birdcage quadrature head coil. Twenty-four four-millimeter-thick slices (in-plane resolution 3.75 × 3.75 mm, no gap) extended axially from the mid-pons to the top of the skull, providing whole-brain coverage and adequate spatial resolution of subcortical regions of interest (e.g., midbrain, NAcc, OFC). Whole-brain functional scans were acquired with a T2*-sensitive spiral in-/out- pulse sequence (TR = 2 s, TE = 40 ms, flip = 90°) designed to minimize signal dropout at the base of the brain (Glover and Law, 2001) (Supplement 3). High-resolution structural scans were also acquired to facilitate localization and coregistration of functional data using a T1-weighted spoiled grass sequence (TR = 100 ms, TE = 7 ms, flip = 90°).

Analyses were conducted using Analysis of Functional Neural Images (AFNI) software (Cox, 1996). For preprocessing, voxel time series were sinc interpolated to correct for nonsimultaneous slice acquisition within each volume, concatenated across runs, corrected for motion, high-pass filtered (admitting frequencies with period <90 s), and normalized to percent signal change with respect to the voxel mean for the entire task. Visual inspection of motion correction estimates confirmed that no subject's head moved more than 2.0 mm in any dimension from one volume acquisition to the next. All regression models included six regressors indexing residual motion and six regressors modeling baseline, linear, and quadratic trends for each of the two runs.

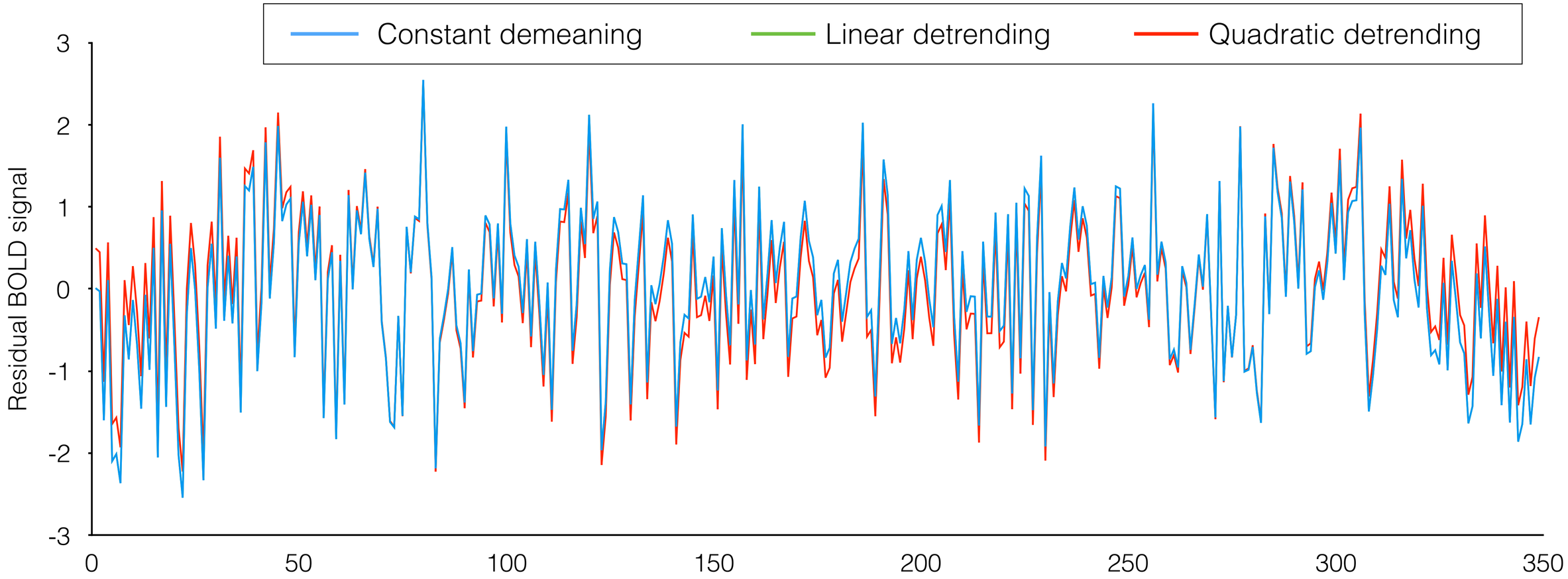
BOLD fMRI time-series

at MNI = [44,-60,-10]

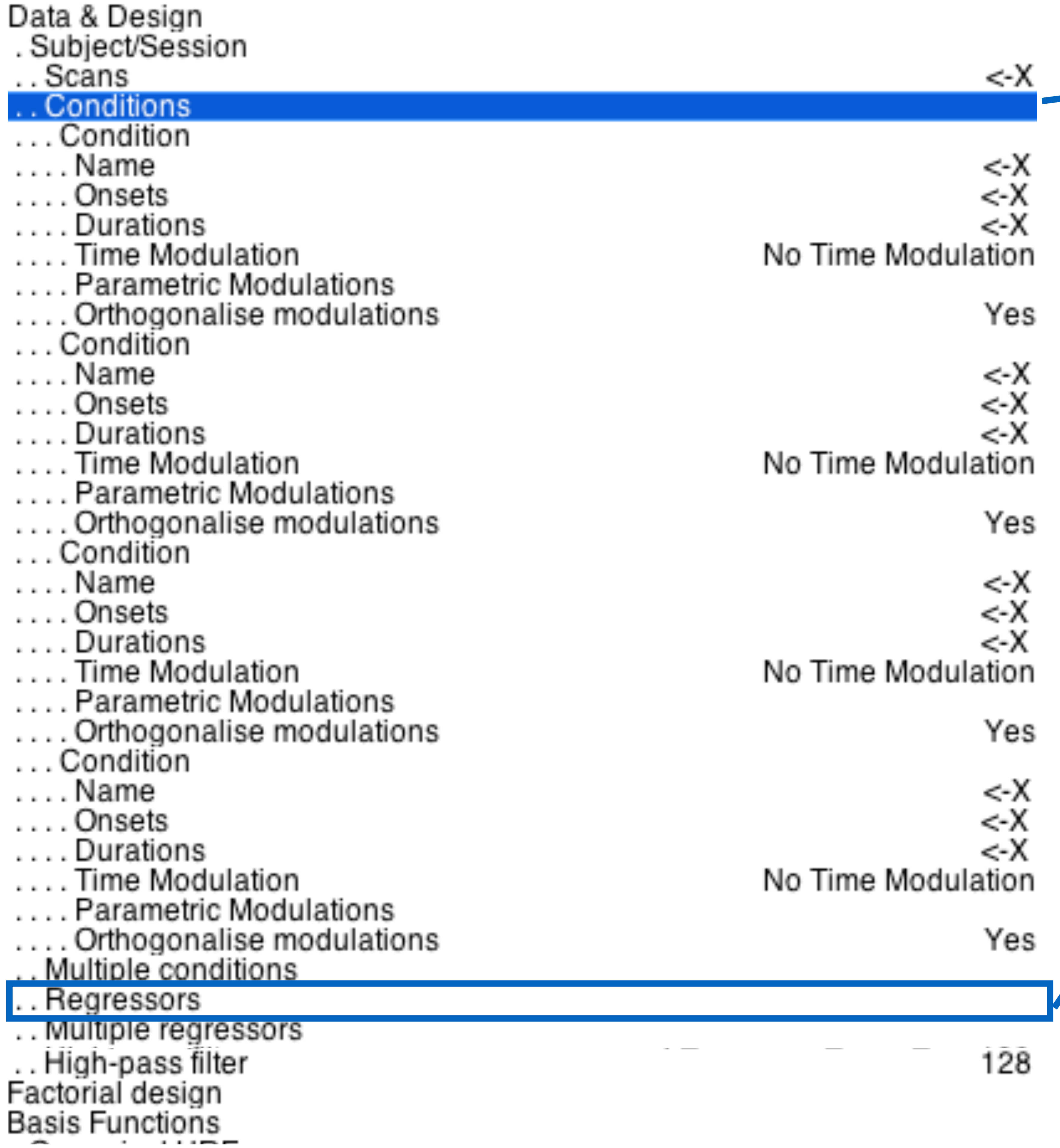


Constant, linear, quadratic detrending

Linear Regression Model: $Y_0 = \beta_0 + \beta_1 x + \beta_2 x^2 + \varepsilon$

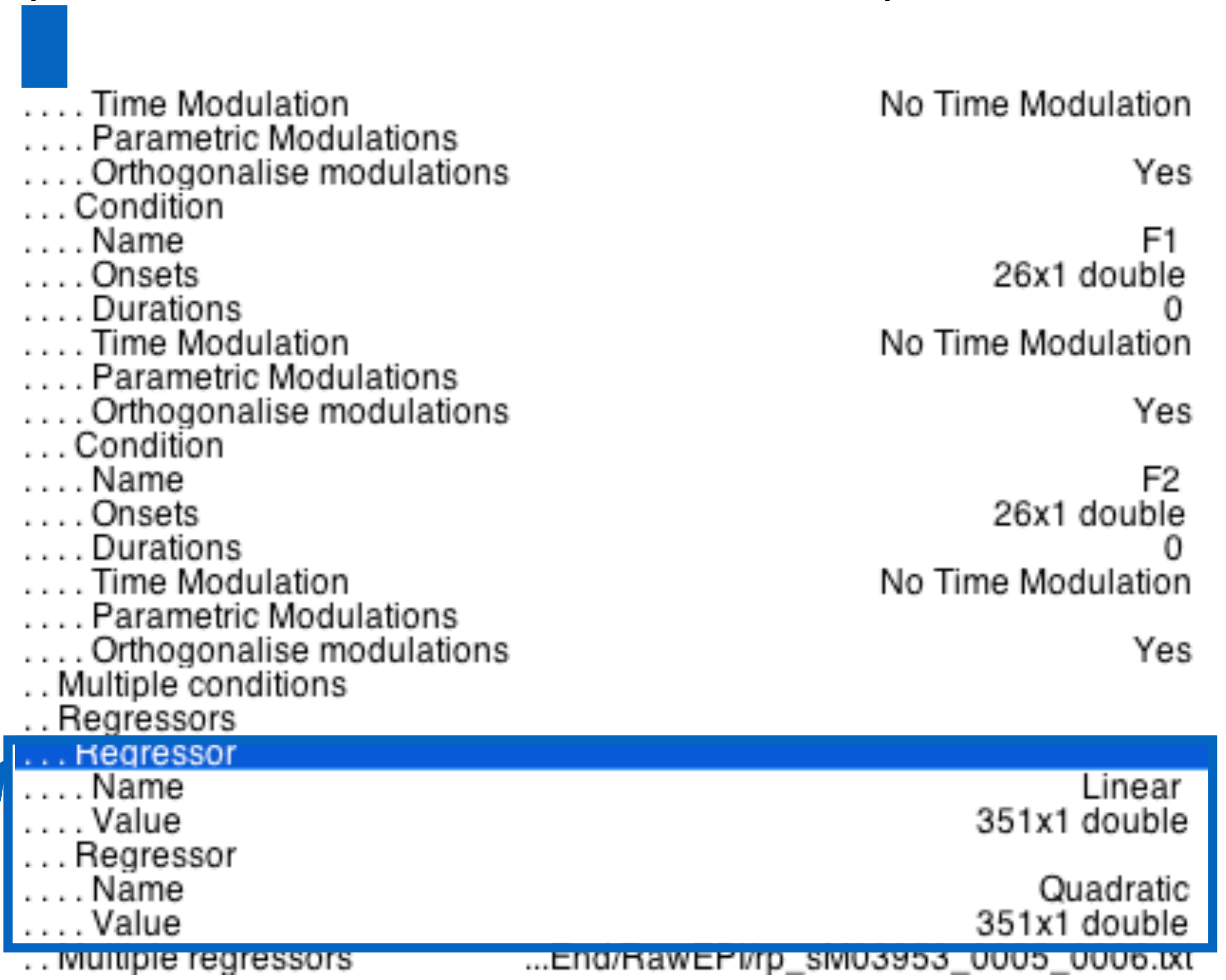


실습 - Specify 1st-level (detrending)



Conditions

4개의 Condition을 생성한다.
(자동으로 HRF convolution 됨)



Regressors

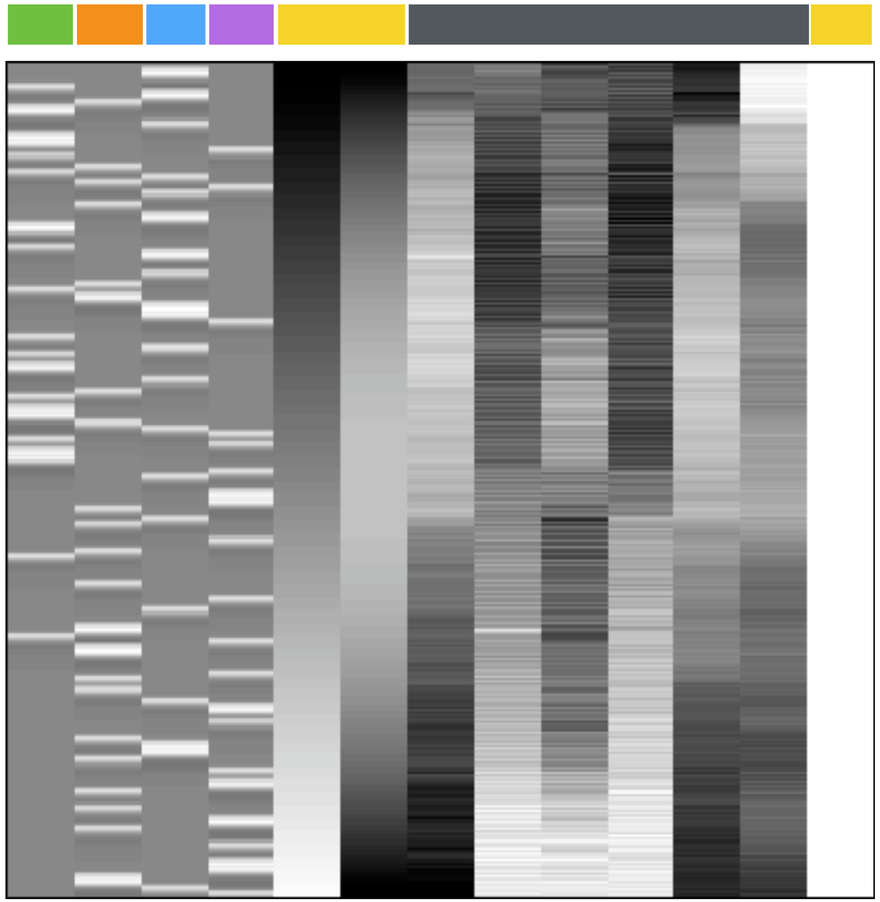
Condition과는 달리 HRF convolution을
하지 않음.

In tutorial directory,

Linear function:
y = *regressor_linear* (nscan)

Quadratic function:
y = *regressor_quadratic* (nscan)

Voxel-wise 1st-level model



U1: HRF convolved U1 condition

U2: HRF convolved U2 condition

F1: HRF convolved F1 condition

F2: HRF convolved F2 condition

Head motion parameters (HRF convolution 되지 않음.)

Constant, linear, quadratic term: 상수항, 1차항, 2차항!

Summary

- SPM12 를 이용한 개별 fMRI 데이터 통계 분석 방법을 익힘.
- Specify 1st-level에서 Conditions에 Onset으로 입력한 vector값은 자동으로 HRF 함수가 convolution 되어 선형회귀분석에 모델링 됨.
- HRF의 1st-order derivatives and 2nd-order derivatives를 모델에 포함하는 방법을 공부함. 포함하지 않은경우와 비교하여, 결과가 어떻게 달라지는지 확인함.
- Head motion과 관련된 잡음은 어떤 패턴으로 활성화 맵에 표시 되는지 확인함.
- Parametric modulation을 관찰하기 위한 1st-level 분석을 어떻게 하는지 공부함.
- Constant(default), linear, quadratic trending signals을 SPM에서 제거하는 방법 공부함.

Coming soon!

2nd-level (or group-level) statistical inference in SPM12