Portfolio assignment8 fMRI sentence experiment

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Overview

In this assignment you are going to analyse 1) the behavioral effects of an experiment using repeated measures methodology in R, 2) Preproces and analyse fMRI data from individual participants on the same experiment, 3) Collect summary statistics (contrast images) from each participant and submit them to a 2nd level group analysis.

Deadline

May 1st, 2018 (this is a mega assignment, thus the prolonged deadline).

Experimental design

The experiment was a 2x2x2 factorial repeated-measures fMRI experiment.

Sentence stimli were made using:

- a static/motion verb (e.g. "stand" vs "run"). In the behavioral data this is the factor variable: "verbtype"
- a static/dynamic preposition ("in" vs "into"). In the behavioral data this is the factor variable: "preposition"
- a concrete/abstract object noun (e.g. "house" vs "system").In the behavioral data this is the factor variable: "locationtype"

Participants thus viewed 8 different types of sentences, e.g.

"We run into the house"

"We stand in the system"

"We sit into the culture"

Some combinations will make sense, others will sound strange.

Number of stimuli

Each Participant viewed a total of 144 sentences, displayed for 700 ms.

Responses

For each sentence the task was to judge if the sentence made sense or not and respond with a button-press.

sensible -> index finger response

strange -> middle finger response

Responses ('b' for sensible, 'y' for strange) are saved in a variable called "response"

Response time is saved in a variable called "rt"

Behavioral hypotheses

Overall: Strange meanings take longer time...

1) Concreteness effect. Sentences with concrete nouns are easier to judge. A main effect of locationtype is expected.
2) Motion verbs go with both types of prepositions (e.g. "run in", "run into") while static verbs only go with static prepositions (e.g. "stand in", *"stand into"). An interaction between verbtype and preposition is expected.

Participants and data

11 students participated during the 2018 fMRI lab workshop.

One participant was scanned twice. For this exercise, we will treat this extra scan as an additional participant, yielding a total of 12 participants.

All behavioral data is collected in a csv-file on Blackboard.

All fMRI data can be found on Blackboard in a zip-file:

-fMRI raw data for each participant, including a structual scan and functional data, is placed in separate folders.

-fMRI paradigm files which contain condition onsets for the model for each participant are placed in another folder.

-SPM batch files for data analysis is also provided. This can be opened in the SPM batch manager.

fMRI analysis details

Due to the relatively low number of trials and participants, we will only look at the "verbtype" and the "preposition"" conditions in the analysis of fMRI data. i.e. treat the experiment as a 2x2 factorial design.

Paradigm files for generating the statistical model

A paradigm file per participant is provided (to be added to the batch where it says "parfilename"). This includes:

- onsets neded to make a model of each of the four conditions
- durations for each trial for each condition
- names for the four conditions Motion-Into, Motion-In, Still-Into, Still-In
- a parametric regressor (called pmod) for each condition with the response time for each trial. These covariates will be positioned after each ordinary condition column, yielding a total of 8 columns in the design matrix (movement parameters will add another 6).

Additional information

Duration of the experiment: 12 minutes

Number of fMRI volumes per participant: 360

TR: 2 s

Time specification: seconds

fMRI hypotheses

Based on Dehaene and others, we hypothesise that reading will evoke activation in the Visual Word Form Area (reported to be around the MNI coordinates [-45, -45, -20]).

Based on Wallentin, we hypothesise that reading sentences with motion content (both motion verbs and prepositions indicating movement), will evoke activation in the left posterior middle temporal gyrus (reported to be around the MNI coordinates [-50, -50, 10]).

Based on multiple sources, we will hypothesise that increased response time will yield increased activation in the anterior cingulate/supplementary motor cortex.

Tasks

1. Inspect and analyse behavioral data in R

Load behavioral data:

```
# #something like this code (uncomment first):
# sentence<- read.csv("sentence_exp_behavior_all_2018.csv")
```

1.a. Inspect the data, making use of the scripts from assignment 7. Consider if you want to transform the data. Justify your choice.

1.b. Report descriptive statistics for the different conditions. Include at least one informative (and pretty) plot, summarizing the response time data across the independent variables. Based on this, do you see any obvious effects?

1.c. Make a plot of the responses across the different conditions. Based on this, do you see any obvious effects?

1.d. Use a repeated-measures model to model the response time data using 'verbtype', 'preposition' and 'locationtype' as independent variables, including interactions. Include participants (variable 'ID') as random effects with trial number (variable 'trial_nr') as random slope. Report the marginal effects, either using summary() or anova().

1.e. The actual responses are binomial (i.e. consist of 'b's and 'y's, not numbers). In order to analyse these, you need to use a repeated-measures logistic regression (not covered in lectures, but recall logistic regression from the 1st semester). Use the glmer() function in lme4. Use "response" as outcome variable. Set family=binomial.

1.f. Make a very brief report and interpretation of the results, if you found any.

2. Preprocessing and modeling of fMRI data from 12 individual participants in SPM.

2.a. Make two folders for each participant, one for data, and one for the model/results. Nothing to report.

2.b. Investigate the batch file that your nice teacher has supplied and add the missing pieces for each participant. The batch includes:

- Dicom (add functional images) -> .nii conversion
- Dicom (add structural image) -> .nii conversion
- Realignment (estimate and reslice (mean image only))
- Coregistration (estimate. Reference image: mean image, source: structural image)
- Segmentation (Deformation Fields: Forward; You will also need to update the path to the TPM.nii files to your local SPM path)
- Normalization (write: realigned functional images)
- Normalization (write: coregistered structural image)
- smoothing (8 mm FWHM)
- named file selector (here you add the paradigm file (a .mat file) for the participant to be used in the modelling step)
- fMRI model specification (add the model directory; paradigm files with onsets are supplied in the previous step. Remember to also include movement (realignment) parameters in the model under "multiple regressors")
- model estimation
- contrasts (inspect to see which contrasts are prespecified)

It may be an advantage to run the different participants on different computers to save time. You may also wish to embed the batch into a loop in MatLab. Saskia's dataset has no structural image. Your nice teacher has added different batch files for her.

2.c. Check if the preprocesing went well, by loading a normalized image from each participant into "check reg" together with a standardized image of the brain (look in the "canonical" folder in SPM). Include an image of these images in your report. At least one dataset has problems. Which participant is this? What are the advantages and disadvantages of excluding this dataset?

2.d. Investigate the results of the different contrasts from your participants. Choose one participant and report results at $p<0.001$ uncorrected for multiple comparisons with a nice overlay. What do you see?

3. Group analysis in SPM

3.a. All positive condition

Take the contrast images for the "all positive" contrast (con_0001) Use them to conduct a one-sample t-test (under "Factorial design" in stats in the batch manager - see ch.32.3 in the SPM12 manual for an example of how to do this), testing if any regions were consistently activated when reading sentences.

Report data (image and coordinates) at $P<0.05$ FWE-corrected for multiple comparisons.

If significant, include a nice overlayed image, displaying the most significant/interesting effects. Write a few sentence, interpreting the findings (e.g. is the visual word form area activated?).

3.b. Effect of motion verb

Take the contrast images for each participant for the motion-still condition (con_0002). Use them to conduct a one-sample t-test, testing if any region consistently has more activation for the motion verbs than the still verbs across participants.

Report data (image and coordinates) at $P<0.001$ uncorrected or $P<0.05$ FWE-corrected.

If significant, include a nice overlayed image, displaying the most significant/interesting effects.

Write a few sentence, interpreting the findings.

3.c. Effect of preposition

Take the contrast images for each participant for the into-in condition (con_0003). Use them to conduct a one-sample t-test, testing if any region consistently has more activation for the motion verbs than the still verbs across participants.

Report data (image and coordinates) at $P<0.001$ uncorrected or $P<0.05$ FWE-corrected.

If significant, include a nice overlayed image, displaying the most significant/interesting effects.

Write a few sentence, interpreting the findings.

3.d. verb x preposition interaction

Take the contrast images for each participant for the interaction between verb and preposition (con_0004). Use them to conduct a one-sample t-test, testing if any region consistently has more activation for the motion verbs than the still verbs across participants.

Report data (image and coordinates) at $P<0.001$ uncorrected or $P<0.05$ FWE-corrected.

If significant, include a nice overlayed image, displaying the most significant/interesting effects.

Write a few sentence, interpreting the findings.

3.e. response time modulation

Take the contrast images for each participant for the parametric modulation across conditions of response time (con_0008), i.e. areas that across the board increase their activation, when response time goes up.

Use them to conduct a one-sample t-test, testing if any region consistently has more activation for the motion verbs than the still verbs across participants.

Report data (image and coordinates) at $P<0.001$ uncorrected or $P<0.05$ FWE-corrected.

If significant, include a nice overlayed image, displaying the most significant/interesting effects.

Write a few sentence, interpreting the findings.

Reporting:

Report the output coordinate table for both significant and non-significant contrasts (I suggest using the save function in the "SPM Figure" menu).

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