Final Project

At the Hillsides of the Scientific Method: Hypothesize Like You Never Did Before!

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1 Task Description 1
2 Data Format 3
3 Problem Description . . . 3
4 Submission Notes 4

Cognitive science as a scientific branch deals with the dynamics of the complex processes of biological entities; such great endeavor would not be realized had there not existed sophisticated technical structures entwined with profound theoretical knowledge. Such closely interrelated interaction of technique and theory is achieved by the delicacies of scientific method, or generally speaking, the scientific thinking. Throughout the present course, it was our intention for you to develop skills not only related to the technical aspects of practice in the field of cognitive science, but also to the common perplexities of moving the scientific body of knowledge forward. As for the final project of the present course, we have provided two datasets of data modalities so common in cognitive science, i.e., EEG and fMRI data. You have to develop one hypothesis based on the theoretical literature behind the task design in these experiments, and find evidence in the data to back up your claims. Good luck!

Keywords: cognitive science, neuroscience, fMRI, EEG, scientific thinking

1 Task Description

*Note: The following descriptions is for the task used in the fMRI experiment. There are minor differences between the EEG and fMRI task and the difference is indicated in the text where it applies.

The task consists of 1344 (EEG: 1800 trials) trials divided into four blocks, each employing a specific trial structure. Subjects are required to observe the presented images while seated. Each trial commences with a 1-second (EEG: 800-1200 ms) presentation of a fixation cross, followed by a 250 ms display of an image. After a

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500 ms delay (blank screen), a second image is presented for 250 ms. The images are comprised of three categories, faces, inverted faces, and houses. The types of the first and the second image within each trial is the same.

Two of the blocks are categorized as "match blocks" while the remaining two are referred to as "non-match blocks". The match blocks primarily consist of pairs of identical images, which account for 80% of the trials (5 (EEG: 4) pairs per each category); we call this type of trial "Match Trials". The remaining trials involve non-identical pairs within the same category; we call this type of trial "Non-Match Trials". Conversely, the non-match blocks predominantly feature non-identical image pairs. Additionally, 10% of the trials in each block involve the presentation of colored images (green or red), prompting subjects to press the a key on the joystick (EEG: space bar) to indicate their detection in within the fixation presentation of the next trial. These colored trials are intended to sustain subjects' attention and are excluded from subsequent data analysis.

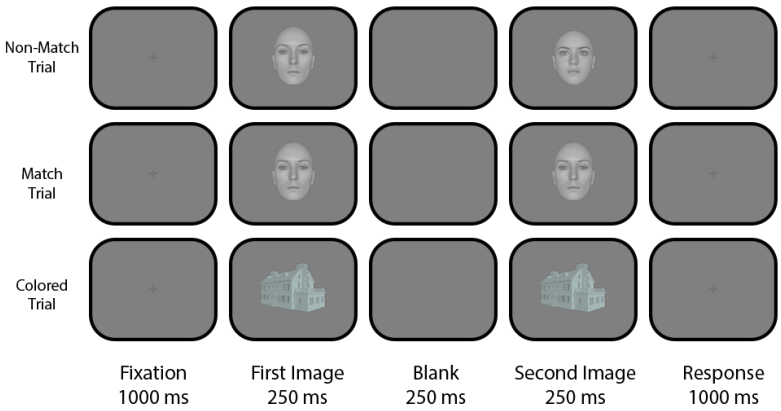

Figure 1: Experimental paradigm schematic

To ensure an equal distribution of image presentations, we employ a set of 12 (EEG: 15 images) images (4 (EEG: 5) per category) for each consecutive match and non-match block. We use 4 (EEG: 5) identical pairs of images for each category to prepare our match trials. To construct the non-match trials, we randomly select 4 (EEG: 5) non-identical combinations of images for each category. In the match blocks, identical pairs are presented 24 times, whereas non-identical pairs are repeated 6 times. Conversely, in the non-match blocks, the presentation frequencies are reversed. Identical pairs are shown 6 times, while non-identical pairs receive 24 presentations.

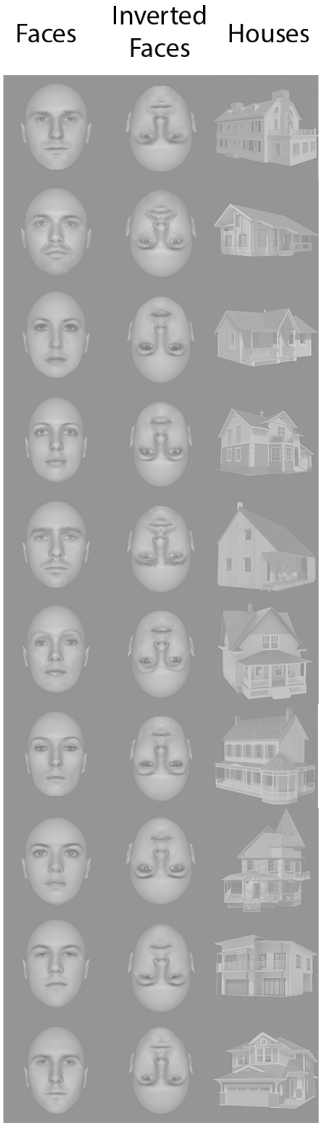

Figure 2: Images used in the task

2 Data Format

We will be using a dataset provided in both CSV and MAT formats, which includes a table of per-trial information called "data", which contains details that differentiate each individual trial.

1. **trialType**: "Match" for trials in which the presented images are the same. "nonMatch" for trials in which the presented images are not the same.
2. **fimgName**: The name of the first presented image.
3. **simgName**: The name of the second presented image.
4. **colored**: 1 indicates that the images in a given trial were colored, 0 indicates the opposite.
5. **colorType**: If a trial's images are colored, the type of the color is indicated in this field. "Green" or "Red" *(for EEG data file, we don't have this column)*.
6. **subResp**: 1 Indicates that the subject has responded in that trial. *(for the fMRI data, we do not have this column)*.
7. **fiOn**: The onset time for the presentation of the first image relative to the onset of imaging.
8. **fiOff**: The offset time for the presentation of the first image relative to the onset of imaging.
9. **siOn**: The onset time for the presentation of the second image relative to the onset of imaging.
10. **siOff**: The offset time for the presentation of the second image relative to the onset of imaging.
11. **fixOn**: The onset time for the presentation of the fixation cross relative to the onset of imaging
12. **fixOff**: The offset time for the presentation of the fixation cross relative to the onset of imaging
13. **blockType**: "Match" for blocks that include predominantly match trials and "nonMatch" for blocks that include predominantly non-match trials

*Note: The EEG and fMRI data format are the same as the data used in Ex.3 and Ex.4.

3 Problem Description

For this project, you are required to choose at least one of the datasets (EEG or fMRI) and perform your analyses on them. Note that you can choose both datasets to test cross-modality-based hypotheses.

Make a Hypothesis!

You should formulate a hypothesis. Clearly define the problem as a hypothesis, describe the methods you use to test the hypothesis,

and fully describe the results of hypothesis testing. This is an opportunity to use your creativity and explore different aspects of the dataset. This is a place for your creativity, so don't be afraid to dive into the depths of the dataset!

4 Submission Notes

1. All analysis for this assignment must be completed using R, Python, or MATLAB. The choice of programming language will not affect the assignment grade and is solely based on the student's preference.
2. In addition to the analysis scripts, a well-styled PDF report must be submitted for grading. The report should not include detailed explanations of the code, as it is focused on reasoning and discussing the results (we will provide a template for the report).
3. You should also present your results in the form of slides and discuss them in 5 minutes. A recording of your presentation must also be submitted.
4. It is **not required** to record a video of yourself.
5. The recorded video format should preferably be .mp4 (720p). You can reduce the size of the video with software such as StaxRip.
6. Students may not write report or develop the analysis scripts in groups.
7. When referencing figures, tables, or formulas in the report, they should be referred to by their unique label.
8. For each question in the assignment description, there should be a separate script. Scripts should not be submitted in the format of live scripts or notebooks, but rather as standalone code that can run on the grader's system.
9. The submitted file should be a ZIP file containing a PDF named "report.pdf", a video named "presentation.mp4", and a folder named "scripts" that includes the analysis codes.

References

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