Representational Similarity Analysis in Cognitive Neuroscience: Written practical report

In the written practical report, your task is to conduct a representational similarity analysis (RSA) on some real fMRI data and to write a report about your findings (see Assessment Brief for further details).

The data were collected on a 3T fMRI Siemens Trio fMRI scanner. Participants were completing a context-dependent navigation task. This task required them to search for two rewards that were located under boulders that were placed in the corners of 4 interconnected rooms (see figure 1 below). At the end of each trial, subjects would receive a monetary bonus that would scale negatively with the time it took them to find the two rewards (so they had an incentive to find them as quickly as possible).

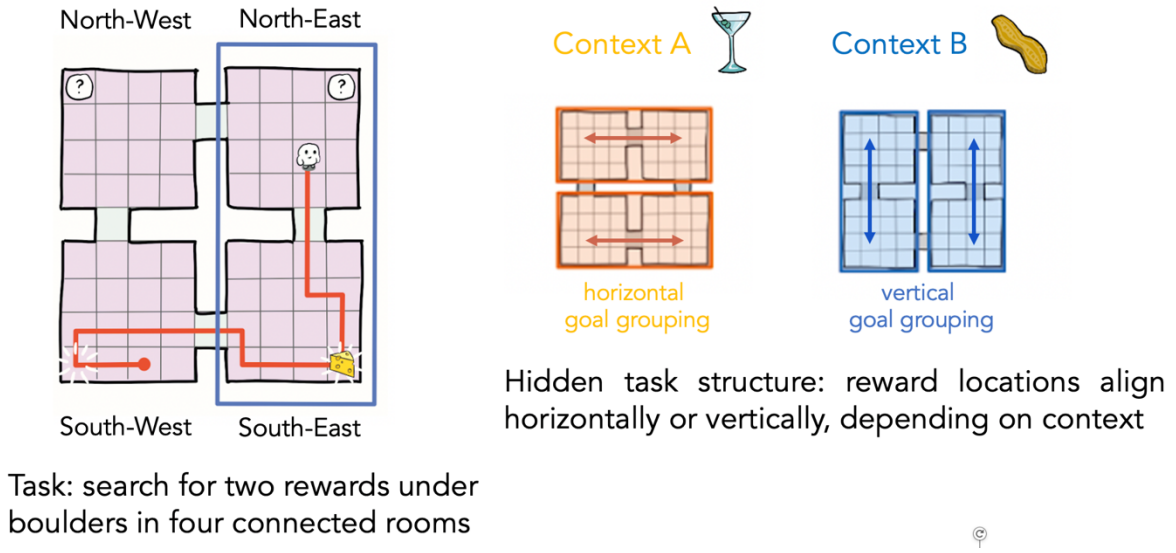

Figure1: Illustration of the spatial layout of the navigation task (left) and the latent task structure with horizontal and vertical goal grouping (right).

Across trials, participants were looking for different reward stimuli that were cued at the start of the trial via an image of a food item (e.g., a pineapple or a peanut). Unbeknownst to participants, the task contained a hidden structure that was cued by the identity of the reward stimulus: for half of the stimuli, the two reward locations would be aligned vertically (e.g., if the first reward on the given trial was found in the southwest (SW) room, the second one would be located in the northwest (NW) room) and the remaining rewards would be aligned horizontally (e.g., if the first reward is found in the SW room, the second one would be located in the southeast (SE) room). Learning this hidden task structure would enable participants to rapidly infer the location of the second reward and maximise their payoff.

The question I would like you to answer is how different brain regions encode space (i.e., the geometry of the 4 rooms) in this task? How do representations change and what kind of readout do they afford?

To answer these questions, you will analyse a data set that contains activity patterns from two regions in the visual and parietal cortex that were recorded while subjects performed the context-dependent navigation task. The two files are called 'HomeworkData_Visual.mat' and 'HomeworkData_Parietal.mat' respectively. Overall, the files contain the data of 27 participants and each participants completed 6 scanning runs of the task.

Both files have 27 cells, each of which contain the data from individual participants. Each cell contains a voxels x conditions x runs matrix. The conditions are ordered in the following way:

Southwest Room – vertical context
Northwest Room – vertical context
Northeast Room – vertical context
Southeast Room – vertical context
Southwest Room – horizontal context
Northwest Room – horizontal context
Northeast Room – horizontal context
Southeast Room – horizontal context

Instructions: Perform a basic RSA on the data and characterize the resulting representations.

1) Load the data into MatLab and create independent data splits (e.g., based on odd vs. even runs).
2) Compute cross-validated representational dissimilarity matrices (RDMs) of the data (by correlating all pairs of conditions between the two data splits).
3) Create three model RDMs that encode (i) the identity of each room (independently of context), (ii) the structure of the map (i.e., the similarity of the rooms with each other in physical space), (iii) the hidden task context (vertical vs. horizontal). Save figures of the cross-validated data RDM and the three model RDMs.
4) Regress the three model RDMs competitively against the data RDM for each subject and save the resulting beta coefficients.
5) Plot the resulting beta coefficients (e.g., using a boxplot) and test their significance (e.g., using a one-sample t-test).
6) Average the data RDMs across subjects (already implemented in the code) and visualise the resulting representations via multidimensional scaling. Please label each data point according to the room label and use different colours for data from vertical and horizontal context. Please also use lines to connect the neighbouring rooms with each other.
7) Interpret the results of your visualization. What are the noticeable features of the representational geometry of each brain region? How do they differ? And what information do they make explicit (i.e., what kind of information can downstream brain regions read out from those representations)?

Instructions for the report: Overall, the report should contain no more than 2,000 words (see assessment brief for details). Provide a brief summary of the task and the data and motivate and explain the use of your analysis method (i.e., what insights does RSA permit that

conventional univariate methods do not?). Detail the different steps of the analysis and describe the results. Briefly interpret and discuss your findings.