Brain Region Activation From Sports Viewing

Jeremy Nurding and Brad Powell
University of California, San Diego
March 14th, 2023

Abstract

The goal of the paper was to partially reproduce some of the ideas, analyses, and results from an original published paper, Antony et al., 2020. Through second-level analysis of 20 subjects, fMRI data that was used in the original paper was analyzed to determine if there is significant region activation during viewing and recall tasks.

Introduction

In the past, work has been done in a prior study that contained eye tracking data and fMRI data of 20 subjects who viewed and recalled the last 5 minutes of 2012 March Madness basketball games (Antony et al., 2020). The researchers used the ending of basketball games as a stimulus for surprise. The paper looked at the effects that surprise had on brain region activation. The paper found that surprise was positively correlated with brain activation in subcortical regions associated with dopamine, game enjoyment, and long-term memory. In addition, significant voxel activity was found in reward-related regions of the brain: ventral tegmental area (VTA), nucleus accumbens (NAcc), and prefrontal cortex. They were also able to find a strong correlation between surprise and long-term memory.

The dataset was found from the database OpenNeuro at https://openneuro.org/datasets/ds003338/versions/1.1.0 and the pre-processed (smoothed/trimmed) fMRI data that was used for analysis can be found at https://app.globus.org/file-manager?origin_id=dc43f461-0ca7-4203-848c-33a9fc00a464&origin_path=%2Fr8b8-k094%2F.
The fMRI data of 20 subjects who viewed and recalled the end (last 5 minutes) of 2012 March Madness basketball games is present. Each subject viewed and recalled from memory a set of three games from a total of nine selected games. This data was used in the original paper. The dataset is from 2019. Of the 20 subjects, 14 are males and 6 are females. The subjects' ages ranged from 18 - 35. The data contains functional scans for each subject for each task (view/recall) for each run (i.e. one game). In addition, there are event files which detail when the task started and how long it lasted in seconds. The event files provide a description of the experiment. There are also confound files

which detail possible factors that need to be accounted for as they could affect the significance results and conclusions of analyses. The time-series fMRI data of each subject while they recalled and viewed the end of three basketball games allows for the analysis of brain regions that are activated during recall and viewing tasks to be accomplished. A group analysis was conducted because it allows for greater generalizability to a much larger sample since the results are more precise and accurate than compared to just a single-subject analysis.

Each subject had approximately 10 GBs of preprocessed (smoothed/trimmed) fMRI data. This results in about 200 GBs of usable information for this project. This data was used to represent approximately 271,000 voxels for every subject.

Methods

The pre-processed fMRI data for all 20 subjects was used for this project. There are three runs for each subject, where each run contains a view task and a recall task for an individual basketball game.

For each run, the events file for view and recall were combined to create a first level design matrix. The design matrix was built from timings of view and recall phases. Next, a contrast matrix was formed by finding the difference between view and recall tasks.

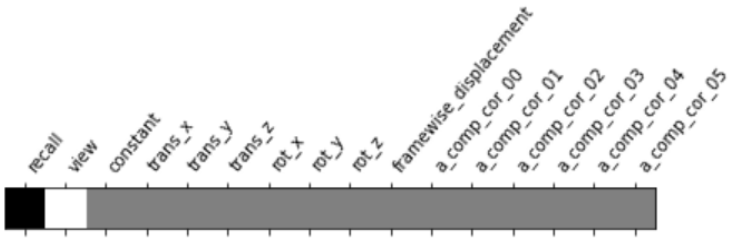

Fig 1: Plot of the contrast matrix

Then, the contrast matrix (Fig 1) was used to fit a first level General Linear Model (GLM). Finally, the nilearn.glm.compute_contrast method was used to compute the effect size and effect variance of the contrast of the model. Effect size represents the magnitude of difference between the view and recall runs. Effect variance represents the variance of the differences between the view and recall tasks. These results were saved as .nii files.

For each subject, the variance across all three runs was computed by using the compute_fixed_effects method. The three runs for each subject were combined into a single average run. Then, these results were used to compute the effect size and the effect variance between all 20 subjects, also

known as random effects. Random effects looks at each voxel and runs a regression across subjects using the difference between each subject. We then stored these effect sizes and effect variances into a folder and deleted the original pre-processed fMRI data. This was done for storage purposes. Instead of having to store all 200 GBs of data at once, we only needed to store 87 MBs of data as contrasts.

The design matrix was made using a column of ones of length 20, which is the number of subjects used in the dataset. Nilearn's SecondLevelModel method was used to create the GLM for multiple subject fMRI data. Then, a second level GLM was fitted using the effect size for each subjects' average run and the design matrix. Finally, a z-map was made using the second level GLM and multiple plots were created. These plots (shown in the results section) all used the same z-map and used various methods to set different thresholds for the z-map. These methods include uncorrected, false discovery rate correction, and Bonferroni correction.

Results

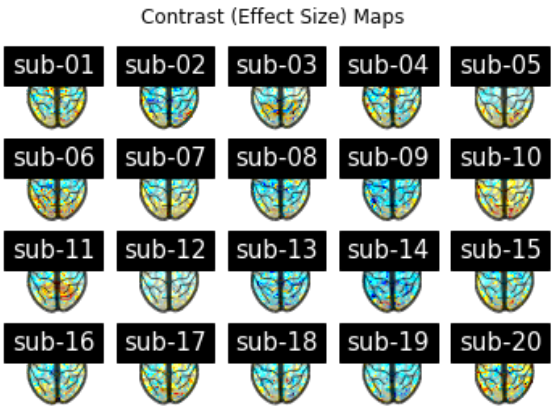

Fig 2: Effect Size contrasts of each subject

In Fig 2, the contrast maps (z-scores maps) corresponding to the effect size were plotted to visualize activation during viewing and recall tasks for each of the 20 subjects. There are similar general regions of activation between the 20 subjects.

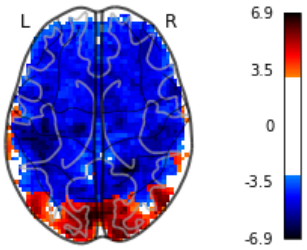

Fig 3: Plot cuts of a mask image using an uncorrected $p < 0.001$

First, a second level contrast (z-map) from the second level GLM was thresholded at an uncorrected p-value of 0.001 ($p < 0.001$) shown above in Fig 3. There is a 0.1%

chance of returning an inactive voxel as active.

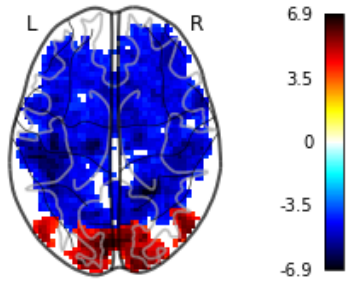

Fig 4: Plot cuts of a mask image using false discovery rate correction and set cluster threshold to 50 voxels

To remove some of the random data noise in the previous contrast, another second level contrast was created using a false discovery rate correction. Since a p-value of 0.001 was used, there is again a 0.1% chance of returning an inactive voxel as active. Clusters smaller than 50 voxels were removed, leading to greater confidence that the voxels identified as active are truly active. The plot is shown above in Fig 4.

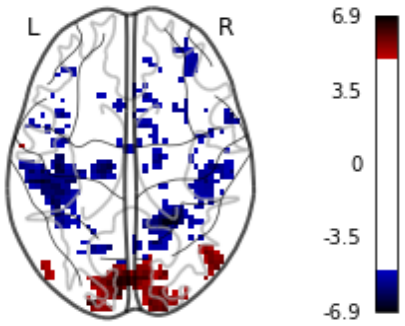

Fig 5: Plot cuts of a mask image using Bonferroni correction

Last, a second level contrast was performed using a strict Bonferroni correction in Fig 5 where the p-value is equal to (0.05) / (# of voxels in overall z-map) = (0.05) / (61 x 73 x 61) = 0.05 / 271633 = $1.841 * 10^{-7}$. This strict correction decreases the probability of obtaining false-positive results. There is a $1.841 * 10^{-5}$ probability of making any false detections.

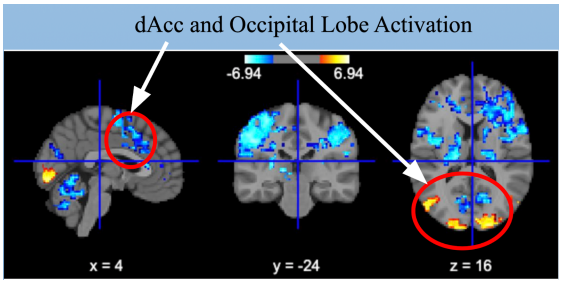

Fig 6: Interactive view of mask image slice using false discovery rate correction

Of the z-maps created for each of the 3 methods, the z-map created using false discovery rate correction was analyzed since it was the second most strict of the methods. An (x, y, z) position was chosen to look for significant regions of activation. The chosen position was (4, -24, 16). Voxel activity was found in the occipital lobe (Fig 6), which is the visual processing area of the brain. In addition, there is significant voxel activity in the Dorsal anterior cingulate cortex (dAcc), which is associated with “executive control, learning, adjustment, economic choice, and self-control” (Voloh et al., 2021).

Conclusion

In conclusion, we got different results from the original study. In Antony et al., 2020, the paper found neural activity in the ventral tegmental area (VTA), nucleus accumbens (NAcc), and prefrontal cortex. In this project, we found voxel activity in the occipital lobe and the Dorsal anterior cingulate cortex. We didn't find any significant voxel activity in the prefrontal cortex, VTA, or in the NAcc. This may be due to the paper using different thresholds for their plots. Another explanation could be that Antony et al., 2020 used a contrast other than effect size or effect variance.

References

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