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Encoding and Recall: An fMRI analysis of differences in a face-name association task

Methods

Participants

There were 14 participants in total, all of whom undertook three scanning sessions, henceforth referred to as Scan1, Scan2, and Scan3. Each participant completed blocks of encoding and recall of face/name pairs, referred to as Encoding and Recall.

Preprocessing

All functional and structural runs were analysed with MATLAB (R2016b) running a compatible version of Statistical Parametric Mapping [1] (SPM12; Wellcome Department of Imaging Neuroscience, http://www.fil.ion.ucl.ac.uk/spm/). All images had the origin set to the Anterior-Commissure (AC-PC) in an attempt to improve coregistration performance. No brain-extraction tool was applied. Functional images were slice-time corrected from a 1x30 top-down interleaved slice order using the first slice as reference. They were then realigned to the first volume of each run independently. Next, these images were coregistered to the structural image of each matching participant. The structural image was segmented into corresponding issue probability maps using a standardised MNI template in stereotaxic space. This transformation was then used to perform the normalisation steps on the functional and structural images by utilising the generated forward deformation fields. Finally, the images were smoothed using a full-width-at-half-maximum (FWHM) Gaussian kernel approach at an order of 8mm. All represented data were using the neurological convention.

Single Subject Analysis

In an attempt to evaluate the differences between encoding and recall, data were analysed using a univariate fixed effects model. Encoding and Recall were used as regressors and movement parameters were multi-regressor covariates. The block order and trial times were used to differentiate between the two conditions. Model estimation was used to determine voxel-wise activation of both Encoding and Recall versus baseline (fixation) and an additional subtraction between them. This allowed for a within subjects design. On the single subject level the BOLD activation was the dependent variable and the condition types

(encoding and recall) were the independent variables, with the six movement parameters serving as variables of no interest. Scan1 had 48 time points (32 for Scan2 & Scan3) with a 5 second duration and an interscan interval of 2 seconds. A high-pass filter cutoff was applied of 128 seconds in order to eliminate slow signal drift. Figure 1 (*left*) illustrates the design matrix that was used for the first level analysis.

Group Level Analysis

The contrasts from the single-subject analysis were used to conduct a paired *t*-test examining Encoding and Recall across participants. Encoding and Recall were compared independently to fixation at the group level and a subtraction evaluation was performed of Encoding > Recall and Encoding < Recall. No mask was applied. Corrected *p*-values at a cluster level FWE-correction (0.05) were considered significant. The extent threshold was set to 20 voxels. Figure 1 (*right*) represents the design matrix for the group level.

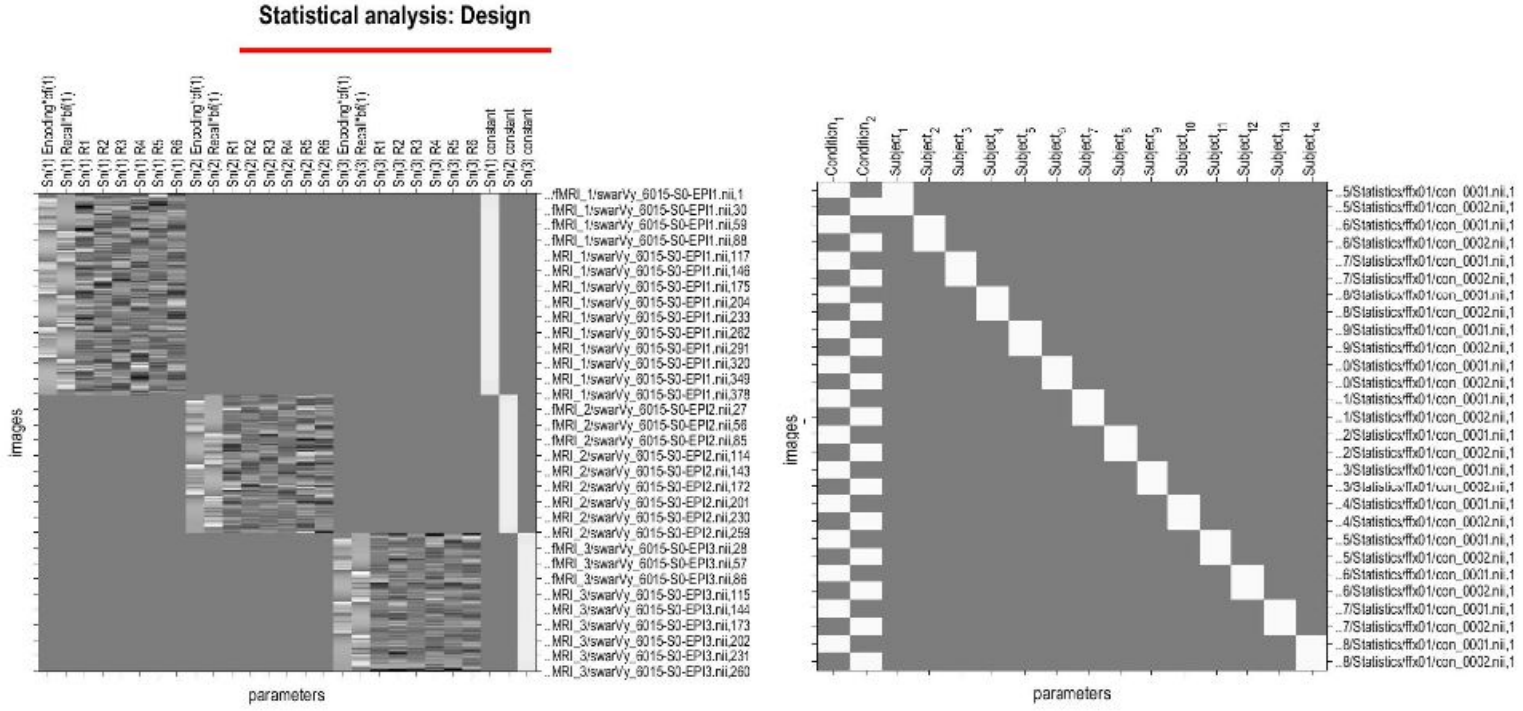


Figure 1: Left: A design matrix demonstrating the single subject analysis that was performed for this experiment. The three sessions (Scan1, Scan2, and Scan3) are represented as groupings of trial blocks (encoding/recall) and the six movement parameters. *Right:* A design matrix representing the group level paired *t*-test that was performed for the experiment. Condition 1 (Encoding) and Condition 2 (Recall) are shown to the left and the subjects corresponding to them.

Results

Encoding

Encoding was found to have significant activation in several areas when compared to fixation on the group level. Effects were demonstrated in the Postcentral Gyrus, Medial Temporal Lobe, Precuneus, and Sub-Gyral Temporal Lobe. Details of this are represented below (Table 1 & Figure 3, 4 , & 5).

Table 1: Cluster and coordinate information pertaining to the significant activation for Encoding versus fixation for the group analysis. Ordered from largest cluster.

Region	Cluster Size (^{K}e)	*T* value	x	y	z	Z value	FWE corrected *p* value
Postcentral Gyrus (R)	118	14.19	64	-4	22	5.95	$p < 0.001$
Medial Temporal Gyrus (L)	100~	13.16	-42	-60	26	5.79	$p < 0.001$
Putamen / Pallidum (R)	100~	14.48	26	-14	8	5.99	$p < 0.001$
Sub-Gyral Temporal Lobe (L)	41	15.27	-44	-34	-2	6.09	$p < 0.001$

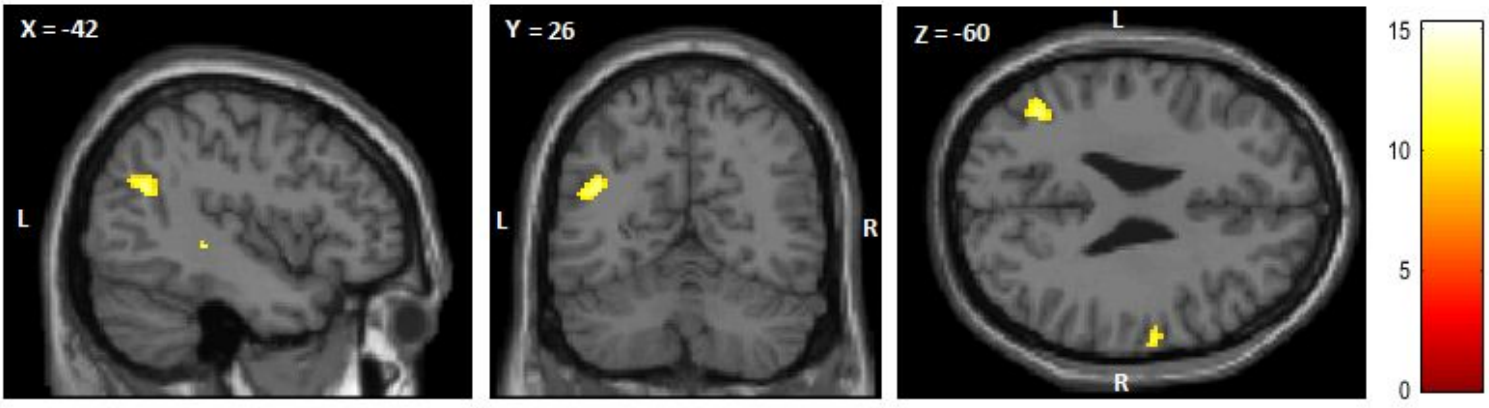
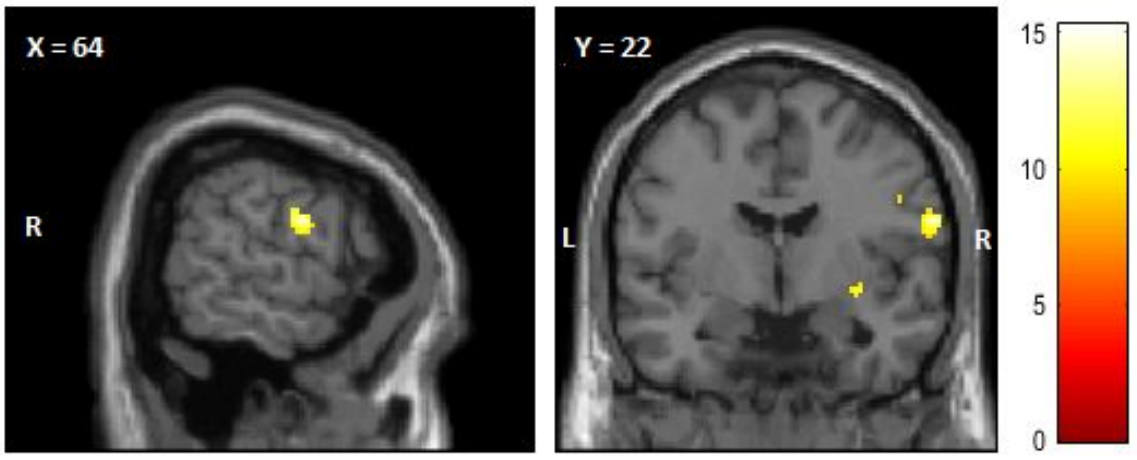


Figure 3: Cluster of activation in the Medial Temporal Gyrus within the Encoding trials in comparison to the baseline (fixation). Neurological convention was used, activation is shown on a single subject T1 MNI template anatomical image.

A



B

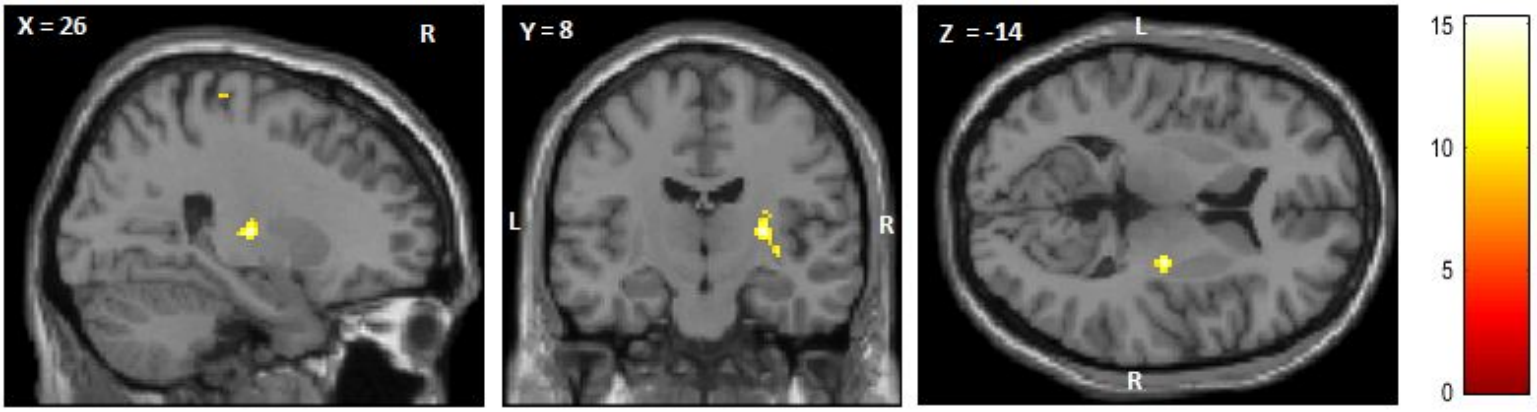


Figure 4: Cluster of activation in the right Postcentral Gyrus (**A**) and the right Putamen/Pallidum (**B**) within the Encoding trials in comparison to baseline (fixation). Neurological convention was used, activation is shown on a single subject MNI template anatomical image

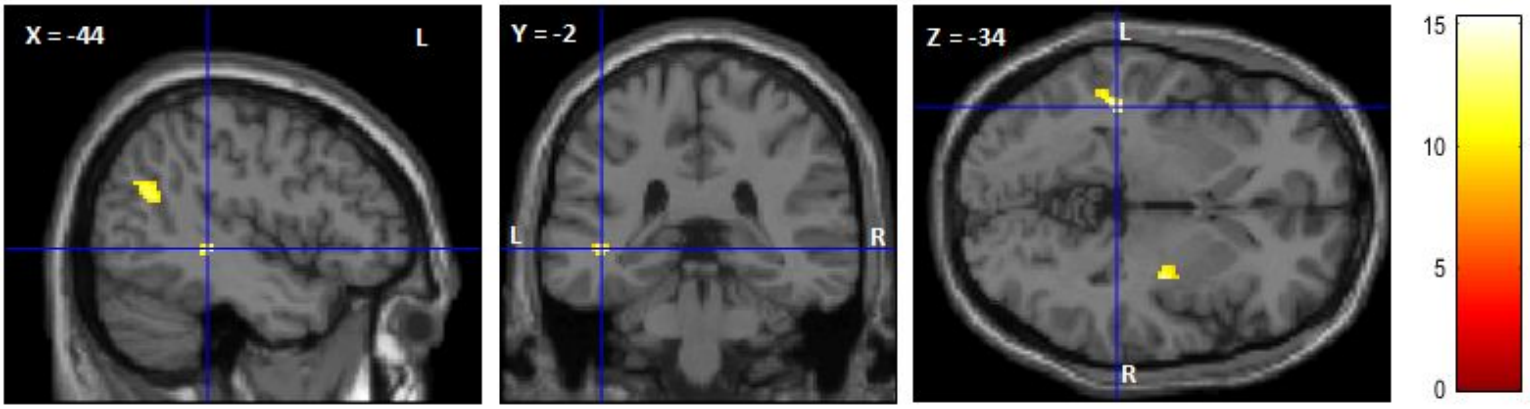


Figure 5: Cluster of activation in the left Sub-Gyral Temporal lobe within the Encoding trials in comparison to baseline (fixation). Neurological convention was sued, activation is shown on a single subject MNI template anatomical image.

Encoding ROI

A further ROI-small-volume coordinate sphere was applied to look more specifically at Medial Temporal Lobe activation (57 -3 -9, 10mm voxel diameter) based on a predefined MNI template [2]. This found a further uncorrected (but still thresholded at 20) effect (t = 5,70, Z = 3,97, $p < 0.001$ at cluster level) with a ^{K}e of 51.

Recall

Recall was found to have a small significant FWE corrected cluster in the Anterior Gyrus when comparing to baseline fixation. However, this result did not survive the extent threshold as there was on a very small ^{K}e of 1 (t = 8.97, Z = 4.98, p = 0.049).

Encoding vs. Recall

Contrasts were created to examine Encoding and Recall in a subtractive manner. Starting with Encoding > Recall, the major effects (first noted in the Putamen, Postcentral Gyrus, and Rolandic Operculum) did not survive the multiple comparison corrections (FWE). Incidentally, two clusters did survive the FWE correction, but were filtered out once the extent threshold was applied. These effects are nonetheless plotted on the table (Table 2) below.

Region	Cluster Size (Ke)	T value	x	y	z	Z value	FWE corrected p value
Lentiform Nucleus	*6*	*9.56*	*26*	*-16*	*6*	*5.12*	*p = 0.001*
Precentral Gyrus	*3*	*8.84*	*64*	*-2*	*22*	*5.18*	*p < 0.001*

Table 2: Table representing the cluster and coordinate information for the Encoding > Recall contrast, these effects did not survive thresholding (20 voxels).

A further analysis was conducted to look at Encoding < Recall which yielded no significant results once multiple comparison corrections were applied.

Encoding vs. Recall ROI

An additional ROI analysis was performed to look at both the Medial Temporal Lobe using the same parameters as before, but found not significant effects for both the Encoding > Recall and the Encoding < Recall conditions.

Conclusion and Limitations

To summarise, significant activation effects were demonstrated in various brain areas when looking at Encoding vs a baseline (in this case, fixation). Most prominently the MTL and Postcentral Gyrus. However, some limitations do exist in the way this experiment was conducted. Firstly, the sample size was relatively small meaning that the statistical power of the paired-*t* test was limited. Next, the conservative method of using both a extent threshold and FWE correction limited the results significantly. Many uncorrected results were found in large cluster sizes that did not withstand the correction methods applied. Ultimately, perhaps more lenient parameters could have been used. Furthermore, in hindsight it is possible that the high-pass filter of 128 could have been adjusted more rigorously in order to account for the large delay between trial type blocks. A number closer to 250 would have been more appropriate. Finally, it was noticed very late on that the slice-order (top-down) was actually incorrect (should have been bottom-up), meaning the interleaved fashion applied may have had unintended consequences, this would have been fixed if not for logistical constraints.

References

1. Penny WD, Friston KJ, Ashburner JT, Kiebel SJ, Nichols TE. *Statistical parametric mapping: the analysis of functional brain images*. Academic press. (Eds). (2011).
2. Cocosco CA, Kollokian V, Kwan RKS, Pike GB, Evans AC. Brainweb: Online interface to a 3D MRI simulated brain database. In *NeuroImage*. (1997).