

Dissociation of Memorability and Memory Encoding in the Brain

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Some images, upon first glance, are more easily remembered than others. Such *memorability* is highly consistent across people, and thus can be used as an image property for exploring the interaction of perception and memory. We conducted two fMRI experiments to investigate perception of memorable versus forgettable faces and scenes (controlled for possible confounds, including color, spatial frequency, emotion, attractiveness, objects). In Experiment 1 (N=16), participants viewed these images in a block design, while in Experiment 2 (N=16), another participant group viewed these images in an event-related design. Every image was completely novel and presented only once. In both experiments, participants performed an orthogonal image categorization task (i.e., male/female; indoor/outdoor), and were unaware of the experiments' memory-related nature. After scanning, the participants then completed an unexpected memory test. Visual perceptual regions of interest (e.g., fusiform face area, parahippocampal place area) were defined using independent functional localizers, while memory-related regions (medial temporal lobe, MTL) and attention-related regions (intraparietal sulcus, IPS; dorsolateral prefrontal cortex, DLPFC) were anatomically defined. In both experiments, we found significantly greater activation for the memorable than forgettable images in the visual perceptual regions and several MTL regions (perirhinal cortex, PRC; parahippocampal cortex, PHC; amygdala; anterior hippocampus). Further, this memorability effect was found regardless of whether the image was later remembered or forgotten, indicating a dissociation of memorability and subsequent memory. No memorability effect was found in early visual cortex, IPS, or DLPFC, indicating that this effect is not due to visual or attentional confounds. An additional multivariate analysis revealed significantly higher classification for memorable versus forgettable images in PRC. By contrast, activity for memory encoding (remembered versus forgotten images in the subsequent memory task) was only present in the PHC. These results indicate that image memorability may be a dissociable phenomenon from memory encoding, particularly within the PRC.

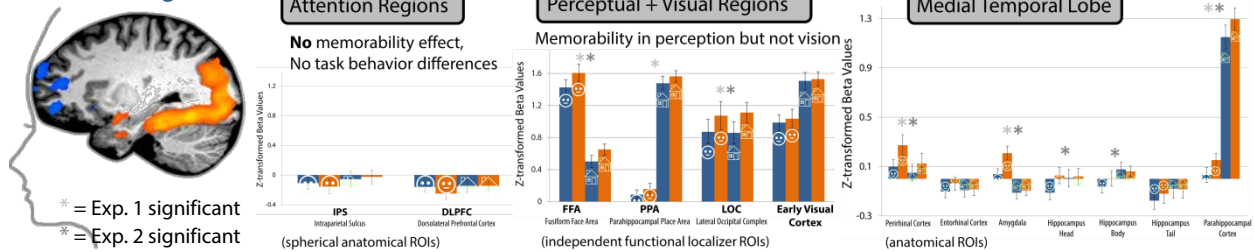
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Supplemental Figures



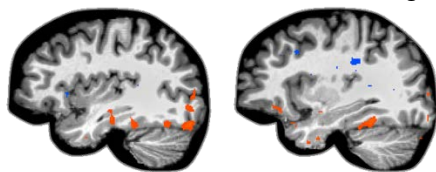
Example stimuli from the study, selected at the opposite ends of memorability, yet controlled for several attributes (see abstract, as well as false alarm rate). Similarity in the visual features can be seen in the similarity of the conditions' average images. 180 images were collected for each condition from databases of images with memorability scores (i.e., hit rates, HR) from a large-scale memory experiment (Bainbridge et al., 2013; Isola et al., 2011).

Memorable > Forgettable

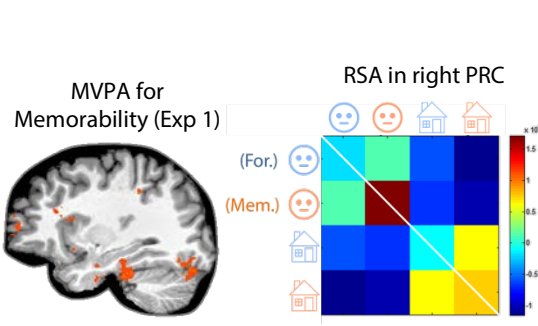


(Left) Exp. 1 univariate contrast of memorable (orange) versus forgettable (blue) images. Fixed effects, FDR < 0.05, right hemisphere. There is both a large perceptual swath and several MTL regions (here: PRC and amygdala), however no early visual cortex.
(Right) Average beta values for various regions of interest, confirming the whole-brain contrast. Bars are plotted for Exp. 1, but Exp. 2 results are similar, and asterisks indicate significance for each experiment.

Memorability for Forgotten Images vs. Memorability for Remembered Images



(Left) Memorable (red) > Forgettable (blue) for forgotten images. (Right) Same contrast for remembered images. Both contrasts have significant perceptual stream and MTL (particularly PRC and PHC) activity, showing a dissociation between memorability and subsequent memory. Both images from Exp. 2, $p < 0.01$



(Left) Exp. 1, Multivoxel pattern analysis using a whole-brain searchlight (7-voxel diameter) SVM (9-folds) for classifying memorable versus forgettable images. Posterior PRC in particular shows significant classification accuracy (also present in Exp. 2).
(Right) Representational similarity matrix between conditions for the right PRC (Exp. 2), with higher similarity in red. Memorable stimuli compared with other memorable stimuli have the highest pattern similarity.