Neural Correlates of Emotional Episodic Memory Encoding and Retrieval: Neuroimaging Meta-analyses using Seed-based *d* Mapping

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Introduction

- Emotional episodic memories are typically more accurate, vivid, and persistent than neutral memories[1].
- Neuroimaging meta-analysis methods such as Seed-based *d* Mapping (SDM) and Activation Likelihood Estimation (ALE) summarize brain regions consistently activated across many studies[2].
- A previous (ALE) meta-analysis of **successful encoding** of emotional episodic memory in 2010 identified the amygdala, hippocampus, and a small set of neocortical regions[3].
- Here we revisited **successful encoding** of emotional episodic memory using a substantially **improved SDM method**[4] and a substantially **larger set of papers**.
- We report for the first time, an **SDM meta-analysis** characterizing activations associated with the **successful retrieval** of emotional memory, and the overlap between encoding and retrieval activations.
- In summary, our goals were to determine the brain regions consistently activated during
  - **Successful encoding** of emotional episodic memory
  - **Successful retrieval** of emotional episodic memory

Predictions

- Some of the major previous findings would be replicated.
- Novel regions may be detected with additional studies and the use of the SDM meta-analysis method.
- Smaller regions based on fewer studies may not be robust to these changes and may disappear

Methods

Study Identification

- PubMed, Review Articles, Reverse Citation Search, Google Scholar
  - **Encoding: (emotion OR emotional OR affective OR arousal OR valence) AND (memory OR recognition) AND (encoding OR encode OR encoded) AND fMRI.**
    - **(526 results)**
  - **Retrieval: (emotion OR emotional OR affective OR arousal OR valence) AND (memory OR recognition) AND (retrieve OR retrieval OR retrieved) AND fMRI.**
    - **(419 results)**

Inclusion Criteria

- Event related fMRI
- Emotional (positive or negative) stimuli included any of the following:
  - Pictures, words, or sounds
  - Neutral objects encoded in emotional contexts
- Emotional successful memory contrast
- Recognition or free recall tasks
- Healthy young adult population
- Report voxel-wise whole brain coordinates

Included studies of successful emotional memory encoding:

- 25 studies, 285 foci, 516 participants

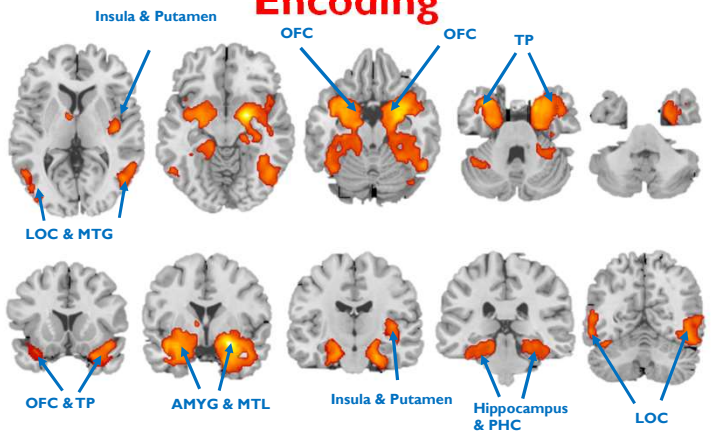
Included studies of successful emotional memory retrieval:

- 17 studies, 210 foci, 310 participants

Statistical Analysis

- Seed Based *d* Mapping Permutation of Subject Images[4] (SDM-PSI) v6.21
- Threshold free cluster enhancement family wise error corrected (TFCE-FWE) $p<.05$
- 1000 permutations

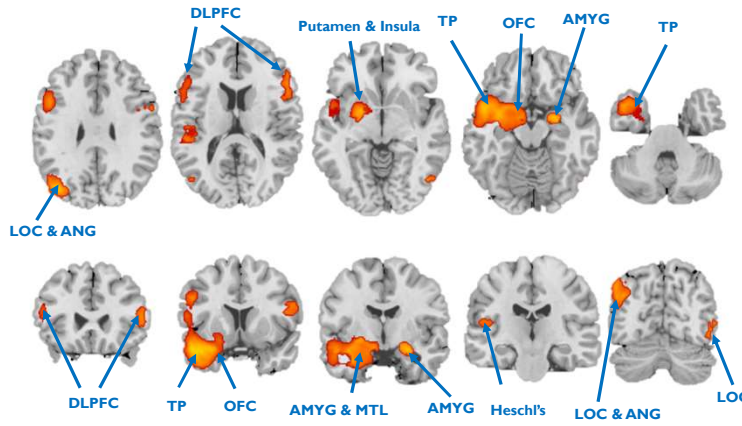
Encoding



Successful **emotional memory encoding** recruits brain regions involved in:

- **Episodic memory encoding**[5]**:** medial temporal lobe (**MTL**) regions including hippocampus, entorhinal cortex, perirhinal cortex, parahippocampal cortex (**PHC**)
- **Emotion processing:** amygdala[6] (**AMYG**), orbitofrontal cortex[7] (**OFC**), temporal pole[8] (**TP**), putamen[9], insula[10]
- **Perceptual processing:** lateral occipital cortex[11] (**LOC**), inferior temporal gyrus[12], middle temporal gyrus[12] (**MTG**), temporal occipital fusiform cortex[11], temporal fusiform cortex[11], occipital fusiform gyrus[11]).

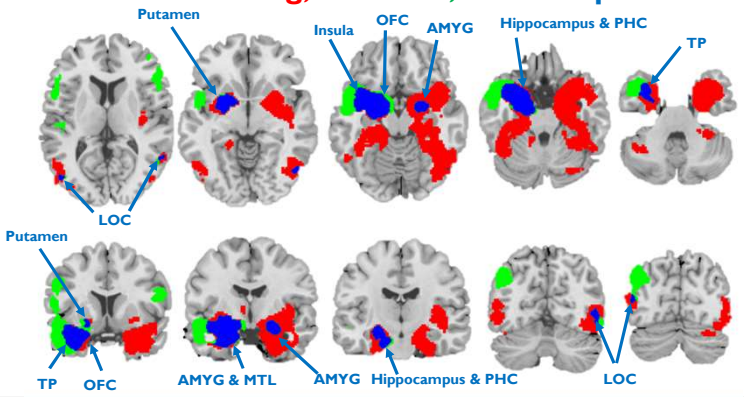
Retrieval



Successful **emotional memory retrieval** recruits brain regions involved in:

- **Episodic memory retrieval:** hippocampus[5], entorhinal cortex[5], perirhinal cortex[5], dorsolateral prefrontal cortex[13] **(DLPFC)** , angular gyrus[14] **(ANG)**
- **Emotion processing:** amygdala[6] **(AMYG)** , orbitofrontal cortex[7] **(OFC)**, temporal pole[8], putamen[9], Insula[10]
- **Perceptual processing:** lateral occipital cortex[11] **(LOC)**, middle occipital cortex[11], middle temporal gyrus[12], Heschl's gyrus[15].

Encoding, Retrieval, & Overlap



SDM maps for successful encoding and retrieval of emotional memory overlapped in regions associated with:

- **Episodic memory**[5]**:** medial temporal lobe (MTL) regions including hippocampus, entorhinal cortex, perirhinal cortex)
- **Emotion processing:** amygdala[6] (**Amyg**), orbitofrontal cortex[7] (**OFC**), temporal pole[8] (**TP**), putamen[9], insula[10]
- **Perceptual processing:** lateral occipital cortex[11] (**LOC**), middle temporal gyrus[12] (**MTG**)

Red regions = Encoding SDM map
Green regions = Retrieval SDM map
Blue regions = Encoding/Retrieval overlap

- 5 clusters of overlap: 2555 voxels
- Dice similarity score between encoding and retrieval = .279

Conclusions

- **Successful emotional memory encoding** recruited brain regions associated with **episodic memory encoding** (medial temporal lobe memory system), **emotional processing** (amygdala, orbitofrontal cortex, insula, putamen), and **perceptual processing** (ventral visual stream).
- **Successful emotional memory retrieval** recruited many of the same brain regions recruited during **successful emotional episodic memory encoding** (medial temporal lobe memory system, amygdala, orbitofrontal cortex, temporal pole, putamen, insula, ventral visual stream)
- **Successful emotional memory retrieval** also recruited brain regions that were **specific to emotional memory retrieval** (dorsolateral prefrontal cortex, angular gyrus, dorsal visual stream)
- These findings support the idea that **some of the processes present during emotional memory encoding are recapitulated** to some extent during emotional memory retrieval; however, emotional memory retrieval also involves **retrieval specific processes that are not shared with encoding**
- Some activations found in the previous emotional memory encoding meta-analysis were not identified in the current study (prefrontal cortex, parietal cortex) and new activations were identified in the current study that were not present in the previous meta-analysis (insula)

References

1 LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience, 7*(1), 54–64.
2 Albajes-Eizagirre, A., & Radua, J. (2018). What do results from coordinate-based meta-analyses tell us? *Neuroimage, 176*, 550-553.
3 Murty, V. P., Ritchey, M., Adcock, R. A., & LaBar, K. S. (2010). fMRI studies of successful emotional memory encoding: A quantitative meta-analysis. *Neuropsychologia, 48*(12), 3459-3469.
4 Albajes-Eizagirre, A., Solanes, A., Vieta, E., & Radua, J. (2019). Voxel-based meta-analysis via permutation of subject images (PSI): Theory and implementation for SDM. *NeuroImage, 186*, 174–184.
5 Eichenbaum, H., Sauvage, M., Fortin, N., Komorowski, R., & Lipton, P. (2012). Towards a functional organization of episodic memory in the medial temporal lobe. Neuroscience & Biobehavioral Reviews, 36(7), 1597-1608.
6 Phelps, E. A., & LeDoux, J. E. (2005). Contributions of the Amygdala to Emotion Processing: From Animal Models to Human Behavior. Neuron, 48(2), 175–187.
7 Beer, J. S., John, O. P., Scabini, D., & Knight, R. T. (2006). Orbitofrontal cortex and social behavior: integrating self-monitoring and emotion-cognition interactions. *Journal of Cognitive Neuroscience, 18*(6), 871-879.
8 Olson, I. R., Plotzker, A., & Ezzyat, Y. (2007). The Enigmatic temporal pole: a review of findings on social and emotional processing. Brain, 130(7), 1718–1731.
9 Sprengelmeyer, R. (2007). The neurology of disgust. *Brain, 130*(7), 1715-1717.
10 Kurth, F., Zilles, K., Fox, P.T., Laird, A. R., & Eickhoff, S. B. (2010). A link between the systems: functional differentiation and integration within the human insula revealed by meta-analysis. Brain Structure and Function, 214(5–6), 519–534.
11 Kanwisher, N., & Dilks, D. D. (2013). The functional organization of the ventral visual pathway in humans. *The new visual neurosciences*, 733-748.
12 Kravitz, D. J., Saleem, K. S., Baker, C. I., Ungerleider, L. G., & Mishkin, M. (2013). The ventral visual pathway: an expanded neural framework for the processing of object quality. *Trends in cognitive sciences, 17*(1), 26-49.
13 Achim, A. M., & Lepage, M. (2005). Dorsolateral prefrontal cortex involvement in memory post-retrieval monitoring revealed in both item and associative recognition tests. *Neuroimage, 24*(4), 1113-1121.
14 Rugg, M. D., & King, D. R. (2018). Ventral lateral parietal cortex and episodic memory retrieval. *Cortex, 107*, 238-250.
15 Schneider, P., Scherg, M., Dosch, H. G., Specht, H. J., Gutschalk, A., & Rupp, A. (2002). Morphology of Heschl's gyrus reflects enhanced activation in the auditory cortex of musicians. *Nature neuroscience, 5*(7), 688-694.

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