An fMRI study of autobiographical memory: Multivariate analyses using Partial Least Squares

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Retrieval of Autobiographical Memories

Maguire group (1999, 2000, 2001)

Activation of a predominantly medial and left-lateralized memory network

Retrieval of Autobiographical Memories

Addis et al. (submitted)

Activation of a predominantly medial and left-lateralized memory network

Preferential activation of the hippocampus

Maguire group (1999, 2000, 2001)

Retrieval of autobiographical events: activation of the left hippocampus

Preferential activation of the hippocampus

Ryan et al. (2001)

Retrieval of autobiographical events: bilateral hippocampal activation
Preferential activation of the hippocampus
Addis et al. (submitted)

Temporal specificity?
Addis et al. (submitted)

Level of Recollection?
Addis et al. (Submitted)

Multivariate Imaging Analyses

- **Functional connectivity**
  - Networks of regions whose activity covaries together
  - Partial Least Squares (PLS)

- **Effective connectivity**
  - Networks of regions in which the influences of one region upon another are specified
  - Structural equation modeling
Predictions / hypotheses

• Using PLS analyses, we predicted:

  • We would find a functional network for AM retrieval, that comprises the same regions identified in our univariate analyses
  • We would find differential functional networks associated with specific and AM retrieval, if these are in fact distinct types of memory

Participants

• 7 male and 7 female participants
• Age range 20 – 40 years
• All right-handed

Pre-Scan Interview

• 20 specific events and 20 general events
  – General events = events repeated 10 times
  – All events more than 1 year old

  • Rated for:
    – Detail
    – Emotionality
    – Personal significance

Scanning Protocol

AM Tasks:
• Retrieve general OR specific event (6 sec)
• Rate for detail, personal significance OR emotion (4 sec)
• Rest (6 sec)
Scanning Protocol

Control Tasks:
• Task 1: Sentence completion (4 sec)  
  OR
• Task 2: Size discrimination (4 sec)  
• Rate for difficulty  
• Rest

THE DOG ATE THE _______

RATE DETAIL  1  2  3  4  5

BIGGEST?  CD or COIN

RATE DETAIL  1  2  3  4  5

Post-Scan Interview
• Rated AMs retrieved during scanning for level of  
  – Detail  
  – Emotionality  
  – Personal significance  
• Highly correlated with in-scan ratings ($r = .80$)  
• AMs grouped into post-hoc conditions:  
  - events with the highest and lowest ratings for a subject = High and Low conditions

PLS Analyses

Task PLS
• Correlates whole-brain patterns of covariance with different combinations of tasks (conditions)  
• Significance: determined by permutation testing and bootstrapping (to get confidence intervals)  
• Can identify patterns of brain activity common to or distinguishing different tasks  
• Outputs a new set of orthogonal variables (LV’s)  
• Individual brain scores reflect the extent to which each subject in each condition expresses the pattern represented by the LV
**Task PLS**

1. Experimental Design Matrix $X$
2. Correlation of $X$ and $Y$ Matrix $B$
3. Singular Value Decomposition of Matrix $B$

**Seed PLS**

- Analysis of covariance between all of the brain voxels and the seed-voxel (hippocampus)
- Identifies functional networks of regions that covary with the VOI that are common to, or distinguish tasks
- Outputs a new set of orthogonal variables (LV’s)
- Individual brain scores reflect the extent to which each subject in each condition expresses the pattern represented by the LV

**Task PLS analysis of AM and control tasks**

- Our univariate contrast of AM tasks and control tasks revealed activation of the memory network.
- Questions: Are there functional neural networks that distinguish AM tasks from control tasks? Are these networks consistent with our univariate results?

**Task PLS analysis of AM and control tasks**

- LV1: Patterns of activation distinguishing AM tasks from control tasks
- $p < .00001$; explains 67.0% covariance
Task PLS analysis of AM and control tasks

Task PLS of General and Specific AMs

- LV1: Patterns of activation distinguishing specific and general AM retrieval
- $p < .008$; explains 100% covariance

- Univariate contrasts revealed no differences between specific and general AM retrieval.

- Despite this, are there patterns of brain activation that distinguish general and specific AM retrieval?
Specific AM retrieval
General AM retrieval

Seed PLS Analysis of General and Specific AMs

Our univariate results show the left and right hippocampus active during retrieval of both general and specific AMs.

Question: Is the left and/or right hippocampus correlated with different regions during the retrieval of general and specific AMs?

• LV1: Pattern of whole brain activation correlated with activity in the left and right hippocampus during both specific and general AM retrieval
• p < .008; explains 39.2% covariance

Task PLS Analysis of AMs high and low in recollective qualities

Our parametric analyses revealed that regions across the brain, including the hippocampus, varied with the level of detail, emotionality and personal significance.

Questions: Are AMs high and low in recollective qualities associated with different functional networks? Are they associated with more or less activation of the same functional network?

Seed PLS Analysis of General and Specific AMs

Regions correlated with left and right hippocampus during specific and general AM retrieval
Anti-correlated regions

Task PLS Analysis of AMs high and low in recollective qualities

• LV1: Patterns of activation distinguishing retrieval of AMs high and low in recollection
• p < .0001; explains 46.6% covariance
Task PLS Analysis of AMs high and low in recollective qualities

- Retrieval of AMs high in recollection
- Retrieval of AMs low in recollection

Level of Recollection
Interaction between specific and general AMs

- Specific AM retrieval
- General AM retrieval

Seed PLS Analysis of AMs high and low in detail

- LV2: Patterns of activation correlated with right hippocampal activity that distinguish retrieval of AMs high and low in detail
- $p < .022$; explains 47.5% covariance

Question: Are there regions which are functionally related to the right hippocampus when retrieving AMs high and low in detail?
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<th>Summary</th>
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<td>• We replicated findings of a functional network including the hippocampus which is engaged during AM retrieval.</td>
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<td>• We found that <strong>specific and general AMs</strong> engage differential neural networks</td>
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<td>- Specific AMs: visuospatial network</td>
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<td>- General AMs: semantic network</td>
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<td>• However, these types of AMs are not distinct with regard to the regions whose activity correlates with the left and right hippocampus</td>
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<tr>
<td>• Retrieval of <strong>high and low recollection AMs</strong> associated with activation of distinct networks</td>
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<td>• Retrieval of low-recollection AMs:</td>
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<td>- inferior frontal gyrus, R. fusiform gyrus</td>
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<td>• Retrieval of high-recollection AMs:</td>
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<td>- Lateral temporal (specific-general interaction)</td>
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<td>• <strong>High and low detail AMs</strong> engage distinct networks that correlate with the hippocampus</td>
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<td>- Low detail: bilateral PFC, precuneus, cingulate</td>
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<td>- High detail: Lateral temporal, L. fusiform</td>
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<th>Conclusions</th>
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<td><strong>What is the value of multivariate analyses?</strong></td>
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<td>• Exploratory – no prior hypothesis biases the analysis</td>
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<td>• Temporal aspect of event-related fMRI data</td>
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<td>• Can identify which regions comprising functional networks common to, or distinguishing, certain tasks</td>
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<td>• Can identify which regions are correlated with a VOI (seed)</td>
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