Semantic knowledge distorts episodic memory: Behavioral and neural investigations

Alexa Tompary[1], Alice Xia[1], Sharon L. Thompson-Schill[1]
[1]University of Pennsylvania, Department of Psychology

Introduction

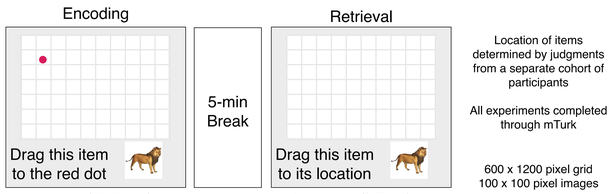
How does variation in the organization of prior knowledge influence new episodic memories?

Existing semantic knowledge changes how we learn new information by facilitating encoding of related items[1-2] and accelerating their cortical representation[3]. However, prior knowledge can also distort new encoding, resulting in false memories or confabulation[4-5].

Leveraging the organization of semantic memory may help us understand when new memories are facilitated or distorted. For instance, typical category members are thought to be more strongly associated with members of the same category, resulting in faster categorization, more efficient recognition, and less disruption from brain damage[6].

The anterior temporal lobes (ATL) are known to support semantic processing[7,8] and damage to these regions results in errors that reflect the structure of a category[6,9], like mis-naming items as more typical category members (e.g. 'horse' for 'zebra'). How prior knowledge influences new episodic memories may therefore depend on ATL function.

Design

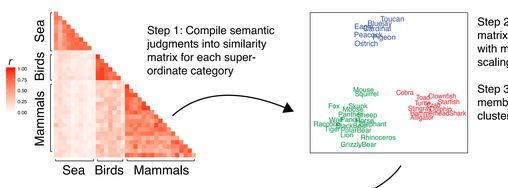


Location of items determined by judgments from a separate cohort of participants

All experiments completed through mTurk

600 x 1200 pixel grid
100 x 100 pixel images

Determining item locations (Experiment 1)



Step 1: Compile semantic judgments into similarity matrix for each super-ordinate category

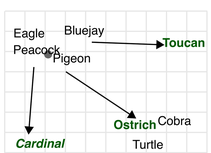
Step 2: Project similarity matrix into two dimensions with multi-dimensional scaling

Step 3: Determine category membership with k-means clustering

Step 4: Determine (a)typical members using distance between each item and its cluster center (gray dot)

Step 5: Move (a)typical items to pseudo-random locations

Step 6: Counterbalance side of screen for each superordinate category

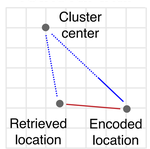


Conditions

Locations	Spatially Consistent [60%]	Spatially Inconsistent [40%]	
Category Membership		*Typical* [20%]	**Atypical** [20%]

Analysis

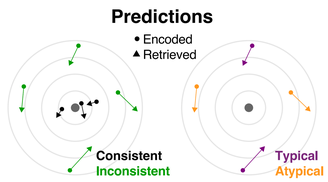
Example retrieval trial



Error
Distance between retrieved and encoded location

Bias
(Distance from center to encoded location - Distance from center to retrieved location) / Error

Predictions



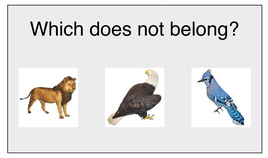
More **precise** memory for items near the cluster center

More **biased** memory towards cluster center for typical items

Experiment 1

How does category typicality influence the precision and bias of new episodic memories?

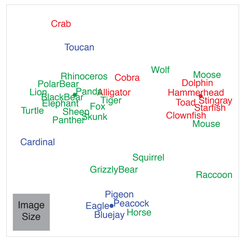
Semantic judgments



2620 trials per super-ordinate category
N = 21

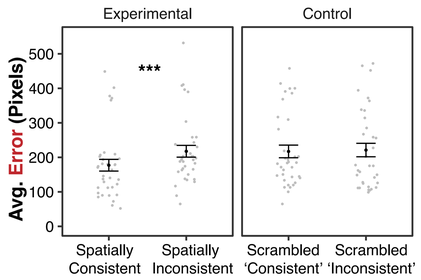
3 animal categories: birds, mammals, sea (35 images)
3 objects categories: kitchen, office, tools (35 images)

Item locations

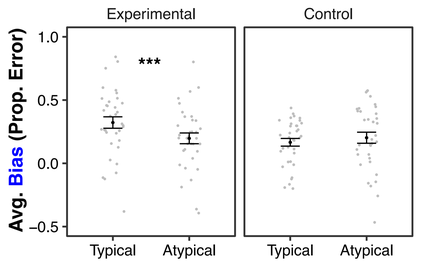


N = 35 per group

Colors indicate category membership, dots indicate center of category cluster
Control group: images shuffled across locations, within superordinate category



Memory is more precise for items located near category neighbors.

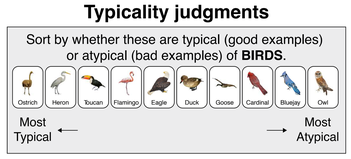


Relative to atypical members, memory for typical category members is more biased toward category neighbors.

Experiment 2

Can we replicate Expt 1 with validated categories[10,11] and a uniform distribution of encoding locations?

Typicality judgments



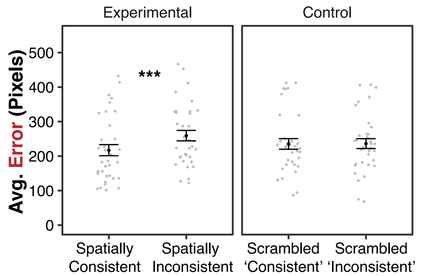
20 images per category
N = 27 per category

4 animal categories: birds, mammals, sea, insects (80 images)
4 object categories: kitchen, office, furniture, clothes (80 images)

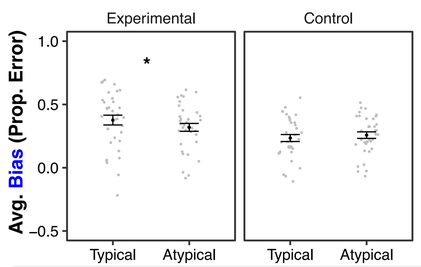
Item locations

N = 35 per group

Colors indicate category membership, dots indicate center of category cluster
Control group: images shuffled across locations, wthin superordinate category



As in Expt 1, memory is more precise for items located near category neighbors.

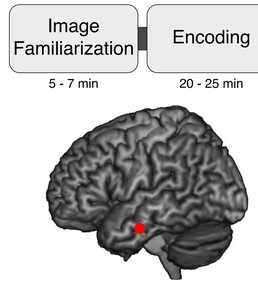


As in Expt 1, memory for typical category members is more biased toward category neighbors, relative to atypical members.

Preliminary TMS Results

Does use of prior semantic knowledge during retrieval depend on the anterior tempoal lobe (ATL)?

Does disruption to left ATL attenuate the influence of category knowledge on precision and bias observed in Experiments 1 & 2?



Left ATL: Inferior aspect of middle temporal gyrus, 10 mm from tip of temporal pole[13,14]

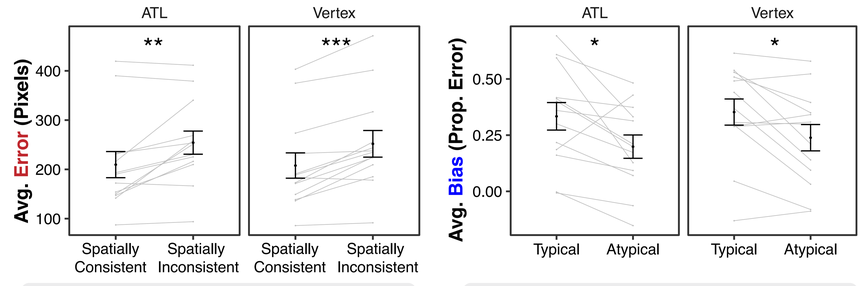
N = 13

2 TMS sites: left ATL, vertex (control)

2 sessions, 7-10 days apart

Same image locations as in Expt 2

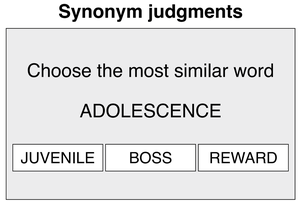
TMS coil parameters: 200 bursts of 3 5Hz pulses at 50Hz, 80% of RMT

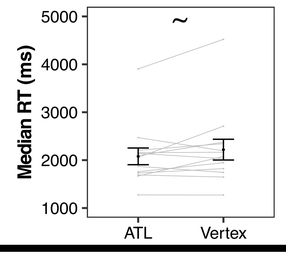


Spatially consistent images are more precisely retrieved, replicating Expts 1 & 2. This may be slightly weaker after ATL TMS.

Typical category members are more biased towards their category centers. This effect may be slightly stronger after ATL TMS.

Synonym judgments





Response times for synonym judgments are marginally faster after TMS to ATL relative to vertex, contrary to what has previously been observed.

Conclusions

Across three experiments, location memory was more **precise** for images near category neighbors, i.e., when location memory benefited from being consistent with semantic knowledge. For items in random locations, retrieval of typical category members was more **biased** towards category neighbors relative to atypical members.

These results are consistent with a reconstruction account of memory, which suggests that multiple sources of information are combined to support retrieval. Here, the use of prior semantic knowledge helped or distorted memory based on whether the spatial location of an image was consistent with the location of most of its category.

Preliminary TMS results suggest that the left anterior temporal lobe may change the retrieval of episodic memories based on their consistency with prior semantic knowledge. However, its role does not appear to fit our predictions. More data and analysis are needed to understand the neural mechanisms involved.

References

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