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Learning and Memory: The Remember-Know Task

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Overview

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Our experience of memory is varied and complex. Sometimes we remember events in vivid detail, while other times we may only have a vague sense of familiarity. Memory researchers have made a distinction between memories that are recollected versus those that are familiar. A recollected item is one that is not only remembered, but carries with it details of the time at which it was learned or encoded. Like a recollected item, a familiar item is also remembered, but is void of any details about the circumstances surrounding its encoding. Many studies of recollection and familiarity have focused on the medial temporal lobe (MTL), specifically the hippocampus, since its involvement in memory encoding, consolidation, and retrieval is well-known and well-studied.[1-3]

This video shows how to administer the Remember-Know task[4] to compare brain activation in these two types of memory retrieval. In this context, *remember* is another term for recollection, while *know* refers to memories that are familiar but not explicitly recollected. In this version of the Remember-Know task, participants are exposed to a series of color images, and asked to remember what they see. Inside an fMRI scanner, they will be exposed to both images that were studied and to novel images, and they will make a "remember," "know," or "new" judgment about each image, indicating what kind of memory they have for that item. Following the scan, whole brain and hippocampal activity will be examined to determine differential activity related to recollection and familiarity. This study is based on a study performed by Gimbel and Brewer.[5]

Procedure

1. Participant recruitment

1. Recruit 20 participants.
    1. Participants should be right-handed and have no history of neurological or psychological disorders.
    2. Participants should have normal or corrected-to-normal vision to ensure that they will be able to see the visual cues properly.
    3. Participants should not have metal in their body. This is an important safety requirement due to the high magnetic field involved in fMRI.
    4. Participants should not suffer from claustrophobia, since the fMRI requires lying in the small space of the scanner bore.

2. Pre-scan procedures

1. Fill out pre-scan paperwork.
2. When participants come in for their fMRI scan, instruct them to first fill out a metal screen form to make sure they have no counter-indications for MRI, an incidental-findings form giving consent for their scan to be looked at by a radiologist, and a consent form detailing the risks and benefits of the study.
3. Have the participant sit in front of a laptop computer, and show them 256 color pictures of namable objects (*e.g.*, fan, apple, baseball), each for 3 s.
    1. For each object, the participants press a button to indicate if it was a living or non-living object. This task ensures their attention to the stimuli.
4. Prepare participants to go in the scanner by removing all metal from their body, including belts, wallets, phones, hair clips, coins, and all jewelry.

3. Provide instructions for the participant.

1. In the scanner, show the participant all 256 pictures that were studied before the scan, and an additional 256 novel pictures.
2. Participants judge each picture with "remember", "know", or "novel" responses via an MR-safe button-box.
    1. Instruct participants to respond "remember" if they saw the image during the study session and could recall specific details about its presentation.
    2. Instruct participants to respond "know" if the image was familiar but they did not recall specific details about seeing it before.
    3. Instruct participants to respond "new" if they had not seen the image before.
3. Stress to the participant the importance of keeping their head still throughout the scan.

4. Put the participant in the scanner.

1. Give the participant ear plugs to protect their ears from the noise of the scanner and ear phones to wear so they can hear the experimenter during the scan, and have them lie down on the bed with their head in the coil.
2. Give the participant the emergency squeeze ball and instruct them to squeeze it in case of emergency during the scan.

3. Use foam pads to secure the participants head in the coil to avoid excess movement during the scan, and remind the participant that it is very important to stay as still as possible during the scan, as even the smallest movements blur the images.

5. Data collection

1. Collect high-resolution anatomical scan.
2. Begin functional scanning.
    1. Synchronize the start of stimulus presentation with the start of the scanner.
    2. Present pictures via a laptop connected to a projector. The participant has a mirror above their eyes, reflecting a screen at the back of the scanner bore.
    3. Present each picture for 3 s.
        1. Picture presentation is interspersed with 1.5-4.5 s of a fixation cross baseline, as this is an event-related task. Differential overlap in the hemodynamic response to each trial makes the signals more separable.

6. Post-scan procedures

1. Bring the participant out of the scanner.
2. Debrief the participant.

7. Data analysis

1. Preprocess the data.
    1. Perform motion correction to reduce motion artifacts.
    2. Perform temporal filtering to remove signal drifts.
    3. Smooth the data to increase signal-to-noise ratio.

2. Model the data for each participant.
    1. Create a model of what the expected hemodynamic response should be for each task condition.
    2. Fit the data to this model, resulting in a statistical map, where the value at each voxel represents the extent to which that voxel was involved in the task condition.
    3. Register the participant's brain to a standard atlas in order to combine data across participants.

3. Combine statistical maps across subjects for a group-level analysis of the data.
    1. Threshold the statistical maps, taking into account correction for multiple comparisons. Since statistical tests are performed at every voxel in the brain, we expect a considerable number of false-positive results with standard statistical thresholds. One way to deal with this is to only accept significant voxels if they also occur within a cluster of a given size.

Results

Regions more active for *remember* responses than for *know* responses are shown in **Figure 1**. Notably, the hippocampus, a structure located in the MTL and known to be involved in many stages of memory formation and retrieval, showed greater activity for *remember* compared with *know* trials.

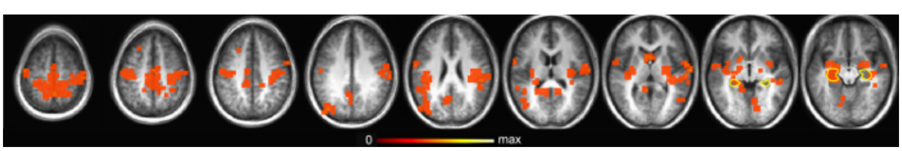

Figure 1: Cluster maps of Remember minus Know. Hippocampus is outlined in yellow. Clusters are overlaid on an average anatomical brain of the study participants ($p < 0.01$, corrected for multiple comparisons). Please click here to view a larger version of this figure.

Inspection of the time-course of activity in the hippocampus (**Figure 2**) shows that this structure is selectively responding when participants report explicitly remembering the stimuli, and is not responding when they only have feelings of familiarity, or when they do not remember the stimuli at all.

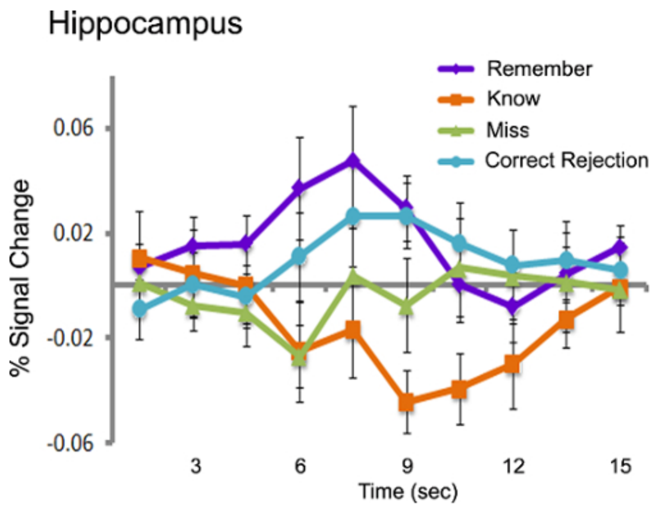

Figure 2. Hippocampal activity over time. Each line shows activity in the hippocampus over the course of trials of each type. "Remember" and "Know" are trials in which participants correctly reported remembering the stimuli. "Miss" trials refer to stimuli that were presented before but not correctly remembered by the participant. "Correct Rejections" are new stimuli that participants correctly identified as new. *Y*-axis is percent signal change from baseline; *X*-axis is time (s) after the onset of the stimulus.

These results suggest that the hippocampus is involved in the process of memory retrieval, but that it does not contribute to feelings of familiarity, supporting a dual-process theory. According to this view, a second cognitive process, one that does not depend on the hippocampus, generates familiarity. However, in the Remember-Know task, memory strength may be confounded with memory type. In other words, it is possible that hippocampal activity is greater for *remember* trials because those memories are stronger, and not because they are qualitatively different from *know* trials. To distinguish between these explanations, memory strength would have to be equated across trial types.

Applications and Summary

This experiment demonstrates how cognitive neuroscientists attempt to tease apart the specific contributions of a brain region to a cognitive task. Isolating subtle variations within a cognitive domain, in this case the different subjective experiences associated with memory retrieval, can reveal dissociations in the neural systems that support those functions. Understanding how the brain functions during different types of memory retrieval is important for understanding memory impairments such as those that result from traumatic brain injury or from degenerative diseases. Furthermore, an understanding of the cognitive neuroscience of memory retrieval may also inform strategies for improving memory.

References

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