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Frontally Mediated Control Processes Contribute to Source Memory Retrieval

Remembering is a cognitively demanding task that requires the strategic selection of information from memory. In this issue of *Neuron*, Dobbins et al. present functional MRI (fMRI) data that shed insight into the specific, dissociated contributions of frontal regions to remembering.

It is an astounding cognitive feat that, when cued appropriately, we can retrieve content details of a specific conversation long after it has occurred, in the presence of numerous intervening conversations and other events that have been encoded in the interim. Studies of patients with frontal lobe damage suggest a role for frontal cortex in strategic, control processes associated with retrieval. Frontal damage, for example, can cause confusion among stored information sources and even the attribution of whether something has really occurred in the past (e.g., Moscovitch, 1989; Burgess and Shallice, 1996; Milner et al., 1985; Schacter et al., 1996; Shimamura et al., 1989). Dobbins et al. (2002), in this issue of *Neuron,* shed insight on the contributions of frontal cortex to control processes during memory retrieval. Using functional MRI (fMRI), they employ a particularly clever set of retrieval tasks that hold constant the training history and the stimuli administered to the subjects but vary the instructions associated with the retrieval task to encourage or discourage the requirement for strategic processing. At the root of their experiments is the well studied distinction between item and source retrieval.

Item retrieval (or recognition) refers to the simplest form of retrieval task that can be administered. The exact item to be remembered is presented as a copy to the subject, and the subject's task is to recognize whether the item is old or new. For example, having studied the word "ketchup," the subject might be shown the words "refrigerator" and then "ketchup" during the retrieval test. The answers would be new and then old. Such a decision can be solved by using a general sense of familiarity that the item is old without constructing a vivid representation of the past episode.

In source retrieval, the task directly requires the subject to remember context-specific details surrounding the items prior occurrence. For example, the subject might be asked to remember whether the word ketchup was presented on the right or left side of a computer monitor or whether one person or another said the word. Unlike simple item recognition, recollection of the study episode is required to solve the source retrieval task because content details must be remembered. Source retrieval tasks typically take more time and are accompanied by a perception that the original study episode is being reexperienced.

In their study, Dobbins et al. manipulated the source of studied information by having subjects learn words in the context of two different kinds of task. In the first, subjects decided whether the words were abstract or concrete. In the second, the decision was whether the words were pleasant or unpleasant. At the time of the retrieval, the subjects were presented with three words: one word that was new, a second that was from the abstract/concrete study task, and a third that was from the pleasant/unpleasant study task. This test procedure, using word triads, set the stage for an elegant manipulation of item and source memory. In the item retrieval condition, the subjects identified the new item—a decision that could rely on a simple sense of which item among the three was unfamiliar. In the source retrieval condition, the subjects identified the word that was specifically from one of the study tasks. In this second condition, the subjects were required to determine between the two familiar words the source of their original presentation. By contrasting the source and item retrieval conditions, Dobbins et al. were able to characterize frontal regions preferentially activated by the source retrieval task, among other regions also discussed in the paper.

Contrasted with item retrieval, source retrieval was associated with increased activation in a number of prefrontal regions in left inferior prefrontal cortex (LIPC), extending anteriorally into frontopolar cortex. To further characterize the role of these regions, the magnitude of activation was examined in the two retrieval tasks (item and source) and also in the study conditions where subjects were required to perform meaning-based elaboration. Multiple frontal regions showed functional dissociation with a specific set of regions near the anterior extent of LIPC active during meaning-based elaboration at study and also during source retrieval at test, but not during item retrieval. This is a particularly intriguing finding because the dissociation is carried by differences in strategic processing requirements between tasks within the retrieval domain. These regions in LIPC appear to contribute to control processes associated with remembering source.

One open issue is how best to specify the nature of the operations subserved by the frontal structures active during remembering—in particular, the role of the anterior portion of LIPC (near BA 45/47). Early neuroimaging work (e.g., Petersen et al., 1989) noted the presence of activation in this region when subjects performed elaborate word generation tasks and semantic monitoring tasks, but not during automated generation tasks,

leading to the suggestion that the processes subserved were executive/strategic in nature (see also Fletcher et al., 2000; Duncan and Owen, 2000). Thompson-Schill and colleagues (1997, 1998), in a series of imaging and neuropsychological studies, expanded these ideas by specifically suggesting that regions within prefrontal cortex (just adjacent to anterior LIPC) are involved in the selection of information when competing alternatives are present. Source retrieval, as indicated by the results of Dobbins et al., may be another example of a task calling upon controlled processing when a cue does not directly specify the requisite representation, in this instance in the service of an episodic memory retrieval task.

In this regard, it is important to point out an alternative interpretation of the findings of Dobbins et al. associated with anterior LIPC. Their results suggest that anterior LIPC is activated during both semantic (meaning-based) encoding and retrieval of source during remembering. One possibility, which Dobbins et al. favor, is that the presence of anterior LIPC reflects the use of semantic elaboration, as a strategy, during source retrieval. Such an account implicitly makes a strong assumption about the nature of anterior LIPC processing—effectively using its presence as a proxy marker for processing within the semantic domain. Alternatively, both semantic encoding tasks and source retrieval tasks may call upon common control processes that activate anterior LIPC, which are not invariantly linked to the semantic domain (Gold and Buckner, 2002). Thus, while the precise nature of anterior LIPC contributions to retrieval will have to await further study, Dobbins et al. quite convincingly demonstrate that retrieval of source is a task that is mediated by anterior LIPC and its still mysterious contribution to controlled processing.

Randy L. Buckner
Department of Psychology
Washington University
One Brookings Drive
St. Louis, Missouri 63130
Howard Hughes Medical Institute
Department of Radiology and
Department of Anatomy and Neurobiology
Washington University School of Medicine
St. Louis, Missouri 63110

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