

Recognition Memory: Can You Teach an Old Dogma New Tricks?

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DOI 10.1016/j.neuron.2008.08.004

Familiarity and recollection are components of recognition memory. Whether these underlie two separate processes or a single process differing only in memory strength is a matter of continued debate. In this issue of *Neuron*, Haskins et al. provide further evidence in support of a dual-process perspective, whereas Shrager et al. provide evidence supporting a single-process viewpoint.

Most of us have experienced encountering a person whom we are certain we know, but are unable to place—that is, until we glimpse the nametag. At that moment, we are suddenly flooded with details about the person, the time we met, and our prior mutual history. This rapid transition from knowing to remembering is consistent with the largely agreed-upon notion that familiarity (knowing an item was previously encountered) and recollection (remembering details of the encounter itself) are separate mental processes. What is less certain is whether familiarity and recollection are separate *memory* processes and, if so, whether they are mediated by the same or different brain structures. Despite nearly three decades of research on recognition memory, many of the old questions remain unanswered, and new questions have emerged. Is recognition memory best explained as a single process (memory strength) or a dual process (familiarity and recollection)? Does familiarity play a role in associative recognition? What are the best measures of recognition memory process(es)? How many and which brain structures are involved? Two papers published in this issue of *Neuron* provide new insight into the nature of recognition memory. Haskins et al. (2008) report new evidence in support of the dual-process model and the role of the perirhinal cortex in associative recognition. Shrager et al. (2008) present the single-process viewpoint and suggest that the perirhinal cortex and hippocampus contribute to memory strength in the same way.

By far the most controversial issue is whether recognition memory is best un-

derstood as a single process or a dual process. Single-process models reigned in the 1980s and early 1990s, but dual-process models began to gain in favor in the mid-1990s (Yonelinas, 2001). By the beginning of the millennium, recognition memory was widely viewed to consist of recollection and familiarity; however, controversies still exist over whether these are two independent memory processes (Brown and Aggleton, 2001; Yonelinas, 2001) or a single process reflecting a continuum of memory strength (Slotnick and Dodson, 2005; Squire et al., 2007). Both theories assume that recognition memory relies on the medial temporal lobe (MTL) memory system (Figure 1); dual-process theories suggest functional specialization in the MTL, whereas single-process theories suggest a global contribution of MTL to recognition memory. As documented in this issue of *Neuron*, evidence continues to accrue on both sides of the argument.

It is fair to say that the predominant cognitive neuroscience view holds that the perirhinal cortex supports familiarity for individual items, and the hippocampus supports recollection for arbitrary associations (Davachi, 2006). This view has been challenged, however, by evidence that the perirhinal cortex is involved in learning associations between items (reviewed in Murray and Richmond, 2001). Haskins et al. present an exciting result from an event-related functional magnetic resonance imaging (fMRI) study of associative recognition that promises to reconcile discrepant findings. Based on a theory of “unitization” (Graf and

Schacter, 1989), Haskins et al. hypothesized that the perirhinal cortex can support familiarity-based strategies for encoding associated pairs of items if encoded as a single conjunctive item (Diana et al., 2008). Participants were scanned during encoding of word pairs in two conditions; the compound word condition was designed to promote unitization of a word pair, and the sentence condition was designed to preserve the individual meanings of the two words. At test, participants were presented with studied word pairs or rearranged pairs composed of two words, each of which had been studied as a part of a different word pair. In that way, each word presented in the subsequent memory test should be equally familiar. Participants made recognition confidence judgments based on whether or not the pair was intact or rearranged. If participants remembered specific details about the presentation, they were instructed to indicate that they remembered the pair with a rating of “R.” If nothing specific was remembered, participants rated pairs from 1 to 4 based on increasing confidence that the pair had been studied, from 1 indicating “sure the pair had not been studied” to 4 indicating “sure the pair had been studied.”

The associative memory strength, as indicated by the confidence judgments, was higher for words encoded in the compound condition than in the sentence condition. An ROC analysis showed that the familiarity estimates were higher in the compound condition, but that recollection estimates were about the same in both conditions. Because individual

words should have been equally familiar, increased familiarity of the compounds was interpreted as a function of unitization. Furthermore, the perirhinal cortex was implicated in this increased familiarity. Activation of the left perirhinal cortex was greater in the compound condition relative to the sentence condition, and perirhinal activation was predictive of subsequent familiarity. Notably, these effects were not observed in the hippocampus, thus providing evidence for functional specialization in the MTL.

Though personal experience may suggest that familiarity and recollection are separate cognitive processes, and substantial evidence suggests that they are supported by separate neural substrates, there is evidence against the dual-process view. Shrager et al. argue that recognition memory is best understood as a single process such that memory strength is a single continuous variable that determines the success or failure of recognition. By this view, familiarity is represented in the brain as a weak memory signal and recollection as a strong memory signal. Accordingly, the prediction is that all brain regions involved in recognition memory would show similar patterns of activation in a recognition memory paradigm. In an event-related fMRI study of single item recognition, Shrager et al. tested the relationship between brain activity during encoding and subsequent memory strength as defined by a recognition confidence judgment. During testing, participants were presented with previously studied words interspersed with foils (or distractors) and were asked to rate confidence on a scale of 1 to 6 such that 1 = "definitely new," 2 = "probably new," 3 = "maybe new," 4 = "maybe old," 5 = "probably old," and 6 = "definitely old." There was a positive linear relationship between confidence ratings from 4 to 6 and brain activity during encoding of items in the hippocampus and perirhinal cortex. Although the study did not distinguish between contributions of recollection and familiarity to recognition, Shrager et al. interpreted this finding as evidence that brain activity in the perirhinal

Perirhinal Cortex and Hippocampus: Familiarity and Recollection?

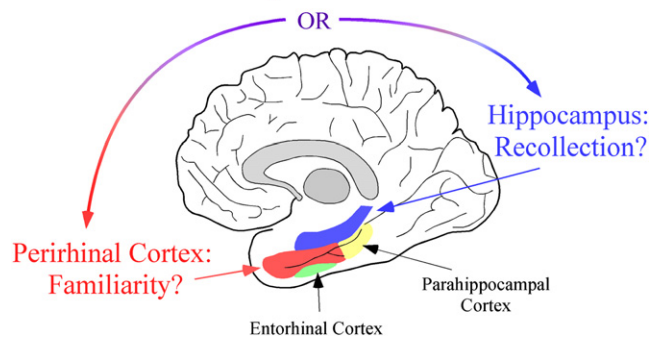


Figure 1. Recognition Memory in the Medial Temporal Lobe

nal cortex and hippocampus during learning predicts subsequent memory strength for recognized items regardless of whether memory is based on familiarity or recollection.

With regard to functional differentiation in the MTL, Shrager et al. suggest that the contribution of the perirhinal cortex and hippocampus to recollection-based and familiarity-based decisions is the same. Because the study does not distinguish between familiarity and recollective processes, however, it is not possible to rule out the interpretation that the brain activity in the perirhinal cortex reflects a memory process that supports familiarity, and the brain activity in the hippocampus reflects a memory process that supports recollection. Moreover, by this interpretation, any regions outside the MTL showing a different pattern of activation are not involved in recognition memory. With regard to the single- versus dual-process debate, one might argue that Shrager et al. provided evidence for two processes, though possibly not both residing in the MTL. When all levels of confidence were included in the analysis, activity in the perirhinal cortex and hippocampus across all memory strengths tended toward a U-shaped curve such that brain activity during encoding of items that were rated as new showed a negative relationship with confidence judgments. Shrager et al. suggested that this pattern of activity reflects a lack of attention to the study item during presentation. Indeed, several brain regions outside the MTL, thought to belong to a network that decreases its activity during perfor-

mance of a task and termed the default mode network (reviewed in Raichle and Snyder, 2007), showed a negative linear correlation across all confidence judgments. According to this explanation, participants were not performing the task during presentation of the items that were subsequently not recognized. What the authors do not clarify is why perirhinal and hippocampal activity would increase during subsequently not-remembered trials. They suggest that the activity in MTL structures during trials in which study words were not remembered reflects attention to mental activity unrelated to the task. The notion that the MTL is actively involved in attention is an interesting one that is worth further study.

It is tempting to conclude that the evidence for a dual process model of recognition memory and for functional specialization in the MTL is more compelling than the evidence for a single-process viewpoint. However, a cautionary note is in order. A primary issue in research on recognition memory addressing the single-versus dual-process controversy has to do with measurement. Neither paper addressed issues about response latencies. Indeed, a major strength of signal detection approaches is its ability to account for response latencies as well as accuracy. Given that familiarity discrimination is likely more rapid and automatic than responses based on recollection, the omission of a response latency analysis is a shortcoming of both papers. Even more important are the shortcomings of the measures themselves. Though both studies use state-of-the-art confidence rating measures, the measures typically used to dissociate recollection and familiarity, such measures tend to be confounded with memory strength. To make matters worse, stimulus sets are often composed of arbitrary stimuli already endowed with baseline levels of familiarity. Moreover, the subsequent memory tests likely tap memory processes that are entirely different from common subjective experiences of highly confident judgments of familiarity for people and places

in the complete absence of recollection. What is required to settle the open questions is an experimental approach that yields high confidence familiarity ratings similar in strength to high confidence recollection ratings that would permit distinguishing separate processes. Under those conditions, a single-process model would predict that familiarity and recollection ratings would be highly correlated and would exhibit a positive linear relationship both in the perirhinal cortex and hippocampus. In contrast, a dual-process model would predict that familiarity and recollection ratings could be decoupled and that familiarity ratings would be positively correlated with activity in the perirhinal cortex and recollection ratings would be positively correlated with hippocampal activity. Until these issues are addressed, a converging view in the field is unlikely to emerge.

In this issue of *Neuron*, Haskins et al. and Shrager et al. challenge accepted notions about recognition memory and provide us with new insight into old ques-

tions. Though the two papers come to different conclusions, they nevertheless advance our understanding of the MTL memory system. Whether or not the perirhinal cortex and hippocampus differentially support familiarity and recollection, it is an important fact that both of these regions interact to collectively determine memory confidence. Likewise, it is significant that familiarity may derive from bound associations, beyond the familiarity associated with each component, and that this function can be tied to the perirhinal cortex. All indications are that the next decade will produce important advances in our understanding of the neural bases of recognition memory. With apologies to Dorothy Parker, we must admit that it is possible to teach an old dogma new tricks.

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Consciousness Meets Neuroeconomics: What Is the Value of Stimulus Awareness in Decision Making?

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DOI 10.1016/j.neuron.2008.08.003

An important question in neuroeconomics is how consciousness affects decision making. In this issue of *Neuron*, Pessiglione et al. take an initial step toward addressing this question by showing that humans learn to make optimal choices in the absence of explicit knowledge about key parameters of the decision-making problem.

To the neuroeconomist, animals' brains evolved to be sophisticated and effective decision-making machines. This view stems from the fact that an animal that does not make good choices is less likely to have fit offspring, which significantly decreases the chances that its genes will survive the pressures of Darwinian competition. From this perspec-

tive, brain function can be understood in terms of how it helps organisms to make better decisions. An application of this logic suggests, for example, that the nervous system has evolved perceptual capabilities that are valuable for decision making (e.g., color vision allows animals to make finer distinctions between potential food sources) and

that cognitive features like declarative memory enhance our ability to make sound choices (e.g., remembering previous bad outcomes in similar choice situations helps us to avoid making similar mistakes). This leads to two important open questions: How does consciousness improve decision making? How does it change the computations