Journal Club

Editor's Note: These short, critical reviews of recent papers in the *Journal*, written exclusively by graduate students or postdoctoral fellows, are intended to summarize the important findings of the paper and provide additional insight and commentary. For more information on the format and purpose of the Journal Club, please see http://www.jneurosci.org/misc/ifa_features.shtml.

Familiarity and Recollection in the Medial Temporal Lobe

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Review of Kirwan et al. (<http://www.jneurosci.org/cgi/content/full/28/42/10541>)

Everyday experience informs us that there are two ways to recognize a stimulus as having been encountered on a previous occasion. In some cases, we experience a general feeling of memory, or familiarity, which indicates that the presented event has been experienced before. On other occasions, we remember or recollect contextual details from a previous encounter. Both routes, namely familiarity and recollection, lead to recognition, but the way they operate is a matter of great dispute in the field of cognitive neuroscience (Parks and Yonelinas, 2007; Squire et al., 2007).

Despite agreement that at the functional level, recognition draws on familiarity and recollection, there is minimal consensus regarding the participation of medial temporal lobe (MTL) structures in supporting these two components. According to one view, different MTL structures, albeit highly interconnected, are responsible for accomplishing distinct computations during recognition. Familiarity has been reported to rely on the perirhinal cortex, whereas recollection is thought to be mediated by the hippocampus (Yonelinas et al., 2002; Ranganath et al., 2004). Functional

magnetic resonance imaging (fMRI) studies using a scanned encoding phase and a subsequent memory test [i.e., subsequent memory effect paradigm; Paller and Wagner (2002)], have shown differential activations within the MTL. The hippocampus has shown a greater response to later recollected events, whereas the perirhinal cortex appears more important for encoding later familiar stimuli. It also responds more to variations in item memory strength (Ranganath et al., 2004).

Other researchers, however, regard familiarity and recollection as products of a single underlying variable characterized by varying degrees of strength. On this scale, familiarity reflects the lower memory strength and recollection the higher (Squire et al., 2007). According to this view, all MTL structures contribute equally to familiarity and recollection. For example, Shrager et al. (2008) have shown that activity in the MTL (including both the hippocampus and the perirhinal cortex) during encoding of words predicts the strength of later memory. In this study, a subsequent recognition test using a confidence rating (1–6) for general memory feeling was used, without discriminating between familiar and recollected events. Many controversies concerning the roles of the different MTL subregions can be attributed to the lack of an acceptable measure to discriminate familiarity and recollection processes at the functional level. Similarly, many of

the measures that have been used so far to discriminate these two processes are confounded with memory strength.

To remedy these controversies, Kirwan et al. (2008) attempted to measure item memory strength and source memory strength independently within the same paradigm. To achieve this, they used confidence ratings of both item and source memory decisions. fMRI data were acquired while participants studied a set of 360 words, which were randomly superimposed on two background colors. A red background instructed subjects to make a size decision (i.e., whether the named object would fit in a shoebox), whereas a green background signaled an animacy decision (whether the named object was animate or inanimate). After a delay, participants completed, outside the scanner, a surprise recognition task. The 360 studied words were presented again, intermixed with new foil words in an item memory test and participants used a scale of 1–6 to give an old/new confidence rating (1 = sure new; 6 = sure old) for each word. “Old” responses (choices 4–6) were then followed by a source memory question in which participants rated their confidence of recollecting the encoding instruction (1–6 scale; 1 = sure animacy; 6 = sure size).

Similar to the classic subsequent memory paradigm, study trials were sorted according to later item and source memory strength. The authors found that activity in the right perirhi-

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nal cortex and in the hippocampus bilaterally varied parametrically as a function of later item memory strength (1–6 item memory rating). However, when confidence ratings of item memory were confined only to 1–5 responses (which has been suggested to reveal familiarity-based responses), activation in the right perirhinal cortex was predictive of item memory strength. More importantly, Kirwan et al. (2008) illustrated that when source memory ratings were kept at chance levels (by excluding trials that produced moderate and strong source memory accuracy), both perirhinal cortex and hippocampal activity predicted later item memory strength.

A similar approach was adopted for measuring activation related to source memory strength. Consistent with previous findings (Ranganath et al., 2004), trials that produced accurate source memory showed greater activity during encoding in the right hippocampus than those trials where source memory was inaccurate. Nevertheless, as the authors reasoned, accurate source memory is characterized by higher item memory strength than inaccurate source memory. This makes possible that the observed hippocampal activation is due to variations in item memory strength and not due to recollection-based memory. When item memory was kept at high levels (item memory confidence of 6), activation in the medial and right ventrolateral prefrontal cortex (but not activation in the hippocampus) was predictive of later source memory strength. The authors conclude that activity in the MTL structures map the strength of later familiarity, whereas prefrontal activation is predictive of later recollection.

The findings of Kirwan et al. (2008) challenge previous studies that used a similar methodology (Ranganath et al., 2004) by raising and attempting to resolve the confounding effect of memory strength on measures of familiarity and recollection. The use of confidence judgments for both item and source memory decisions enabled the researchers to independently map linear variations in activation predicting familiarity and recollection, when source memory and item memory strength (respectively) were kept constant.

There is, however, an alternative interpretation of the results which stems from the use of the specific source memory task. Recollection experience was limited to only one dimension of the study episode (size or animacy deci-

sion). This means that even when source memory strength was kept at chance, other sources of episodic recollection were not controlled. These additional recollections may include information related to the encoding event, such as contextual cues (like noises etc.) or thoughts and mental images induced by the first encounter with a stimulus, which may support retrieval. Therefore variations in hippocampal activity might not be predictive of later item memory strength but might be related to these extra-source recollections. This is particularly possible for stimuli producing stronger item memory. Indeed, items rated as 6 (i.e., the highest item memory rating) were correlated with a sharp increase in hippocampal activity [see Kirwan et al. (2008), their Fig. 3 (<http://www.jneurosci.org/cgi/content/full/28/42/10541/F3>)] which might underline the operation of recollections not due to the source task. The effect of these extra-source recollections could possibly be reduced by excluding items rated as 6 and measuring hippocampal activity, as a function of later item memory, using only confidence ratings of 1–5 when source memory is constant.

The confounding effect of extra-source recollections is also relevant when recollection-specific activations are measured independently from item memory. Specifically, in the source memory trend analysis (where prefrontal but not hippocampal variations to source memory strength were found) the only trials used were those with an item memory rating of 6, for which participants have a stronger memory and presumably more recollections. Therefore, any hippocampal activity related to variations in source memory strength might have been obscured by hippocampal activity related to extra-source episodic recollections that accompanied items lying at the high end of the item memory scale.

A previous fMRI study has also attempted to disentangle activation dedicated to familiarity from recollection-related activity using confidence ratings. Montaldi et al. (2006) used an adaptation of the remember/know procedure. Participants reported their familiarity feelings (weak, moderate or strong) without trying to recollect anything about the presented stimulus, but they reported any inadvertent recollections. Recollection levels were very low (0.08), leaving a large number of familiarity responses, spread across three lev-

els of memory strength. Increasing familiarity confidence was accompanied by a parametric modulation of perirhinal but not hippocampal activity and the hippocampus was only active for effortless recollections.

The disparity between the studies by Montaldi et al. (2006) and Kirwan et al. (2008) could be attributed to a number of factors, such as different stimulus materials (scenes versus words), different scanning points (encoding versus retrieval) or different recollection tasks (source memory task versus self-reported recollection). Nevertheless, a useful template for resolving the inconsistent results might be the combination of uncontaminated (from recollection) familiarity responses (as in the study by Montaldi et al., 2006) with confidence ratings of recollection responses as in the study by Kirwan et al. (2008), albeit with the use of a richer source memory task. For example, in one task, participants might rate the confidence of any self-reported recollection that occurred. Alternatively, levels of recollection could be separated based on the amount of information recollected rather than on confidence in a single recollected task-specific feature (Kirwan et al., 2008). Whether these two types of recollective experience (confidence levels versus amount of information) will produce similar effects is another important question for future research.

Kirwan et al. (2008) adopted a promising methodology for measuring familiarity and recollection independently. However, all methodologies that propose to estimate familiarity and recollection remain controversial (e.g., use of the remember/know procedure or use of a two-choice source memory task as a pure recollection decision) and they have particular problems when applied to fMRI experiments (e.g., identifying task specific recollections). Although careful design will contribute to determine the functional anatomy of recognition memory, it is unlikely that fMRI evidence will be able to resolve all the controversies given the limitations of the measures used and the complexity of the issue (for review, see Wais, 2008). Therefore, convergent evidence from different methodologies, such as neuroimaging, neuropsychological, and electrophysiological studies, is needed to understand the functional role of different MTL structures.

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