



Are all judgments created equal? An fMRI study of semantic and episodic metamemory predictions

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ABSTRACT

Metamemory refers to the ability of individuals to monitor and control their own memory performance. Although little theoretical consideration of the possible differences between the monitoring of episodic and of semantic knowledge has been published, results from patient and drug studies that used the “feeling of knowing” (FOK) paradigm show a selective impairment in the accuracy of episodic monitoring but not in its semantic counterpart. Similarly, neuroimaging studies provide indirect evidence for separate patterns of activation during episodic or semantic FOKs. However, the semantic–episodic distinction hypothesis has not been directly addressed. In the current event-related fMRI study, we used a within-subject, within-experiment comparison of the monitoring of semantic and episodic content. Whereas the common neural correlates of episodic and semantic FOKs observed in this study generally replicate the previous neuroimaging findings, several regions were found to be differentially associated with each task. Activity of the right inferior frontal gyrus was modulated by the semantic–episodic factor only during the negative predictions of retrieval, suggesting that negative predictions are based on partially distinct mechanisms during each task. A posterior midline network, known to be activated during episodic retrieval, was activated during episodic and not semantic monitoring, suggesting that episodic FOKs rely, to some extent, on common episodic retrieval processes. These findings suggest that theoretical accounts of the etiology and function of FOKs may benefit from incorporating the prediction directionality (positive/negative) and the memory domain (semantic/episodic) distinctions.

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1. Introduction

Metamemory, which is broadly defined as individuals' knowledge about their own memory and about strategies that aid memory processes (Shimamura, 1994), has been systematically studied since the mid 1960s (Brown & McNeill, 1966; Hart, 1965; Koriat & Levy-Sadot, 2001; Nelson & Narens, 1990). One form of metamemory function, known as the “feeling of knowing” (FOK), refers to a prospective decision during which subjects are asked to predict whether they would be able to later provide an answer to a given cue after being unable to recall it at the present moment (Schwartz, 1994; Schwartz, Benjamin, & Bjork, 1997).

Two heuristic-based accounts explaining the basis of FOK judgments have garnered considerable support in recent years. The

cue-familiarity account (Metcalf, Schwartz, & Joaquim, 1993; Reder, 1987; Schwartz & Metcalfe, 1992) suggests that FOK judgments rely on the familiarity of the memory cue in question. Thus, if a cue is highly familiar, the FOK rating will be high. Similarly, when the cue is not familiar, the FOK rating will be low or there will be no feeling of knowing at all. In contrast, the accessibility account suggests that the judgments are based on an overall ease of access and the quantity of partial information obtained during the search for the target in question, regardless of its accuracy (Koriat, 1993, 1995). Thus, if a cue elicits a considerable amount of information, the FOK rating for it will be high (Koriat, 1993). Although the two accounts can be seen as competing with one another, a more recent approach suggests that they may, in fact, interact with one another to create the FOK phenomenon (Koriat & Levy-Sadot, 2001).

1.1. Episodic and semantic metamemory

One aspect of the current theories of metamemory that is largely overlooked is the distinction between judgments made about semantic and episodic materials, which we term the SE distinction. Episodic FOKs are usually collected in tests of paired associate items. The paired associates for these tasks are typically

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studied in the particular context of the experiment, in a paradigm that controls various features pertaining to encoding, retention and retrieval (Hertzog, Dunlosky, & Sinclair, 2010). Semantic FOKs, on the other hand, are typically given after a failure to retrieve world knowledge or facts (Nelson, Gerler, & Narens, 1984). Such information is assumed to have been learned prior to the conducted experiment, possibly at multiple repeated occasions. Thus, episodic FOKs are typically given for context- and self-dependant memories, whereas semantic FOKs refer to predictions for context-free factual cues. Although the semantic/episodic distinction has been widely accepted in the memory literature (Tulving, 1985), metamemory models typically do not consider this aspect and its possible influence on FOKs (see Hart, 1967; Koriat & Levy-Sadot, 2001; Nelson et al., 1984; Nelson & Narens, 1990). Nevertheless, a careful review of several published studies, mainly from the neuropsychological and neuroimaging literatures, suggests that there may be differences between judgments made in response to episodic or semantic cues. The main relevant findings are briefly outlined below.

1.2. Neuropsychological findings

Studies including patients with various forms of brain damage are one source of evidence for the existence of SE differences in FOK judgments (Janowsky, Shimamura, & Squire, 1989; Modirrousta & Fellows, 2008; Pannu, Kaszniak, & Rapcsak, 2005; Schnyer et al., 2004; Shimamura & Squire, 1986). Janowsky et al. (1989), for example, found that patients suffering from frontal lobe lesions exhibited similar episodic recall and recognition performance compared to controls; however, these patients also exhibited an impaired episodic FOK accuracy. A second experiment in that study found that this pattern was not observed when the patients performed semantic metamemory judgments.

Similar results were obtained from schizophrenia patients, whose performance in metamemory tasks differed when semantic or episodic contents were used. Souchay, Bacon, and Danion (2006) found that patients' accuracy on an episodic FOK task was lower than that of control subjects. In a parallel study measuring schizophrenic patients' accuracy on a semantic FOK task, Bacon, Danion, Kauffmann-Muller, and Bruant (2001) did not observe such a difference. Studies conducted with Alzheimer's patients (Lipinska & Backman, 1996; Souchay, Isingrini, & Gil, 2002), Parkinson's disease patients (Souchay, Isingrini, & Gil, 2006), and subjects induced with lorazepam (Bacon et al., 1998) all revealed a similar pattern: a dissociation between the accuracy levels of judgments that were made in response to episodic cues and those made in response to semantic cues.

In the aforementioned studies, the evaluations of the accuracy of the FOK judgments made for episodic or semantic cues were based on data from separate experiments. Souchay, Moulin, Clarys, Tacconat, & Isingrini (2007) examined a possible SE distinction in a controlled within-subject design by probing for differences in FOK accuracy across the SE domains for younger and older participants. They found that younger and older participants exhibited similar levels of accuracy in a semantic metamemory task, but when tested with episodic materials, the older participants showed a deficit in their accuracy compared to younger adults. Thus, this previous study provides compelling evidence for an SE dissociation in metamemory. It should be noted, however, that a similar pattern of SE differences in memory performance was also observed; this observation renders the conclusion about an SE distinction in metamemory less straightforward.

In summary, results from the neuropsychological literature imply that although no differences are typically observed between patients and controls in terms of their ability to predict their memory performance in a semantic memory domain, the patients'

ability to accurately predict their memory performance is reduced when episodic materials are used.

It should be noted that because predictions can either be positive ("I will be able to recall/recognize the answer later or when I am given several options to choose from") or negative ("I will not be able to recall/recognize the correct answer"), patients' lower accuracy in episodic metamemory judgments can stem from an overestimation of their future performance, an underestimation of their ability to recall/recognize the elusive target, or both. However, metamemory studies typically report composite measures of accuracy, which take into account both positive and negative predictions and compare them to actual memory performance on a criterion test. This composite measure does not allow for inferences about the causes of the SE difference. We will revisit this issue in the discussion.

1.3. Neuroimaging findings

In terms of the SE distinction, neuroimaging data concerning prospective metamemory judgments for episodic and semantic materials provide evidence that is consistent with the aforementioned neuropsychological findings. The comparison of interest in the metamemory imaging literature includes the neural patterns associated with positive predictions (FOK) and those associated with negative predictions (typically given as a "don't know" response, or DK). Similar to what is commonly examined in the cognitive literature addressing metamemory judgments, this comparison, which we term the FOK/DK contrast, ignores the non-predictive responses, such as spontaneous recall (given as a "Know" response). The comparisons of an episodic FOK/DK contrast and the parallel semantic contrast are of specific interest in the current study, as they might shed some light on the brain regions and cognitive functions that are differently involved in the monitoring of episodic and semantic materials.

Various imaging studies that investigated episodic FOK (Chua, Schacter, & Sperling, 2009; Luo, Niki, & Luo, 2003; Luo, Niki, Xiaoping, & Luo, 2004; Maril, Simons, Mitchell, Schwartz, & Schacter, 2003; Schnyer, Nicholls, & Verfaellie, 2005) or semantic FOK (Kikyo & Miyashita, 2004; Kikyo, Ohki, Ishiura, & Sekihara, 2001; Kikyo, Ohki, & Miyashita, 2002; Maril, Simons, Weaver, & Schacter, 2005; Maril, Wagner, & Schacter, 2001) found that different areas of activation are associated with the FOK/DK contrast in the different memory domains. For example, Maril et al. (2005) used semantic questions as cues and found that the FOK/DK contrast was associated with activity in parietal and frontal areas. Some of these areas were specifically associated with a tip-of-the-tongue (TOT) response, (sometimes referred to as a strong FOK, and other times as a unique predictive metamemory state; see Brown & McNeill, 1966; Schwartz, 1999).¹ A different study from the same laboratory (Maril et al., 2003) examined the neural correlates of episodic FOK judgments using similar scanning parameters and a similar design, with previously learned noun pairs as test materials. In contrast to the previous study, the FOK/DK contrast was only associated with activity in the middle frontal gyrus. This pair of studies, although consistent with a possible SE differentiation, still does not allow for a direct comparison between the judgments made in response to episodic vs. semantic cues because the paradigms and the materials were substantially different in these

¹ The inclusion of all findings relevant to positive predictions does not imply we take a theoretical position on the question concerning whether the differences between FOK and TOT are quantitative or qualitative in their nature; rather, with an emphasis on the semantic/episodic comparison that is of interest to our study, we note that currently there is no theoretical ground for the hypothesis of a TOT/FOK and semantic/episodic interaction.

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