



# Alzheimer's disease and feeling-of-knowing in episodic memory

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## Abstract

Episodic memory feeling-of-knowing (FOK) was examined in 16 patients with Alzheimer's disease (AD), 16 elderly participants, and 16 younger adults. Participants were given cued recall and recognition tests of 20 critical cue-target words. Subsequently, they judged their FOK for non-recalled words in terms of how likely they thought they would be to recognize the keywords on a subsequent recognition test. The results indicated dementia-related deficits on both the recall and recognition tests. Compared to older adults, AD patients exhibited impaired FOK accuracy. This pattern of outcome indicates that early AD is associated with a deficit in episodic memory and a deficit in memory monitoring for newly learned information. Furthermore, our observation revealed that in AD, episodic memory may be a more important factor than executive function in explaining the FOK inaccuracy.

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Metamemory is a multi-faceted concept which deals with the individual's knowledge and control of his or her own memory system. It encompasses a variety of higher-order cognitive abilities, including understanding of the functioning and capabilities of one's own cognitive system, knowledge about strategies that can aid cognitive performance, evaluation of judgments, and predictions of future performance [20]. One metacognitive ability that has considerable importance in everyday life is the ability to monitor information stored in memory. A common and useful method for measuring monitoring accuracy is to ask individuals to predict how well they will remember items during an upcoming memory test. The assumption made is often as follows: the more accurate the prediction, the better one's knowledge of one's memory. Two different types of predictions have been frequently elicited in developmental research: global predictions, in which participants judge how many items they will subsequently recall from an entire study list, and item-by-item predictions, in which they predict the likelihood of subsequent recall separately for each item. Two types of item-by-item monitoring have been assessed, judgment-of-learning (JOL), in which predictions are made about the likelihood of subsequent recollection of recently studied items, and feeling-of-knowing (FOK), in which predictions are made about the likelihood of subsequent recog-

niton of non-recalled information. In the JOL procedure, at the end of a learning trial, participants make judgments regarding the likelihood of remembering the acquired information on a subsequent test. The FOK procedure was proposed by Hart [28]. In this procedure, subjects are asked to estimate the likelihood that they will subsequently recognize a piece of information that they had failed to recall, either from long-term knowledge (or semantic memory) [28,51] or from recently learned episodic memory information [65]. The issue of main interest is the relationship between such FOK and subsequent recognition performance. From such judgments, FOK performance indexes can be computed to operationalize the degree to which FOK judgments match correct and incorrect recognition performance. The results of the initial studies by Hart indicated a positive relationship between FOK and accuracy in normal young subjects. Subsequent research using different versions of this procedure has replicated the basic finding that FOK judgments reliably predict performance [27,52].

Few studies have examined the capacity of AD patients to monitor information that is stored in memory. Moulin et al. [46] recently assessed JOL accuracy in Alzheimer's disease (AD). No significant difference was found between the AD group and age matched controls in the Gamma scores. However, in AD patients this accuracy score was not reliably different from zero, which suggests that these patients had trouble predicting their likelihood of remembering the acquired information. In regard to the FOK,

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Bäckman and Lipinska [2] examined normal old adults and patients in an early phase of AD using a semantic memory FOK and found no group difference in FOK accuracy. Moreover, Lipinska and Bäckman [41] provided additional evidence pertaining to whether the ability to monitor general knowledge is preserved in early AD. In agreement with Bäckman and Lipinska [2], the authors found that AD patients showed intact monitoring of stored knowledge, as indicated by intact FOK accuracy. In a related study, however, Pappas et al. [55] found deficient monitoring of stored general information in a group of AD patients. In their experiment, Pappas et al. [55] examined FOK on an episodic memory task. Nevertheless, for episodic memory FOK, the AD patients were unable to correctly use the six-category scale to predict their recognition performance. Thus, to our knowledge, there are no published experiments on AD patients' FOK judgment accuracy on episodic memory task.

As suggested by Fernandez-Duque et al. [19] and Shimamura [69], the frontal lobes are important for memory monitoring. Direct evidence in support of this hypothesis was provided by Janowsky et al. [30], who demonstrated that patients with frontal lobe lesions exhibited a decline in FOK on an episodic memory task. The FOK for stored memorized knowledge has also been investigated to determine whether the ability to monitor information in memory is affected in different groups of neurological patients. Research with frontal lobe patients ([30], exp. 2) and with patients suffering from various subcortical diseases, such as Huntington's disease [7] and Parkinson's disease [13,29] who often perform poorly on frontal tests, demonstrates normal monitoring of general knowledge. These neuropsychological findings lead to the idea that FOK accuracy in episodic memory and FOK accuracy in semantic memory are dissociated processes, with episodic FOK associated to frontal functions but not semantic FOK. Frontal functions are also generally associated to executive control or executive function [62,64,75]. Surprisingly, although several authors have suggested that linking metacognition to aspects of executive control offers opportunities to better define the cognitive components of metacognition [19,70], the relationship between metacognition and executive control has not yet been fully assessed. In a recent study, Souchay et al. [72], used a correlational analysis of older participants, and found a specific relationship between measures of executive function (WCST, verbal fluency) and episodic FOK accuracy. In patients with AD, several studies have indicated that executive dysfunction occurs early in the course of the disease [5,6,11,24,38,57]. This finding is of interest, given the observed association between frontal or executive function and metamemory. AD patients show deficits affecting planning, as indicated by their poorer performance on the Tower of London task [60]. The presence of inhibition deficits has been demonstrated by their poorer performance on the Stroop task [6,73], the Hailing task [8,10], and the Wisconsin card sorting task [6,7]. In the light of the Janowsky et al. [30] and Souchay et al. [72] results showing that episodic memory FOK accuracy depends on the frontal

cortex and executive function, it can be hypothesized that AD patients who perform poorly on executive tasks are also impaired in episodic FOK accuracy.

According to Koriat's model [33], FOK judgment is based on an inferential process that uses a variety of cues (i.e. mnemonic cues) to determine the likelihood that the target is retained in memory and will be recognized in the future. These cues may include the familiarity of the cue that serves to probe memory [45,63], but also retrieval of relevant structural, semantic, or contextual attributes and fragments of the target [32] and retrieval fluency, that is, the ease with which information is accessed [37]. In this view, then, FOK judgment is a computation process which depends on retrieval processes, whose by-product is used to evaluate the future ease of access to the answer. Koriat's [36] information retrieval model of FOK judgment leads to the assumption that FOK judgments depend on the effort made during the retrieval process. According to several researches, a number of variables that affect memory traces affect metacognitive performance as well [9,31,36], suggesting that metacognitive accuracy (i.e. FOK) and memory are not independent processes [37]. In the Janowsky et al. study [30], FOK inaccuracy in frontal lobe patients occurred in delayed recall whenever the patients exhibited an episodic memory impairment. Moreover, Shimamura and Squire [70] showed that their Korsakoff's syndrome patients suffering from anterograde amnesia exhibited altered episodic memory FOK. These findings converge with that reported by Koriat [37], who found that deficits on an episodic memory FOK task are associated with episodic memory difficulties. However, some results suggest that impaired FOK is not necessarily a correlate of impaired episodic memory. Using an episodic memory FOK procedure, Shimamura and Squire [70] showed that amnesic patients suffering from anterograde amnesia were not inaccurate in their FOK judgments. Data from Schacter [65] also indicated that young subjects' FOK accuracy was not affected after a 1 week delay, although a substantial decrement in recognition performance was found. In AD, a repeated clinical observation is that memory impairment is the most noticeable cognitive deficit during the early stages of the disease. Formal testing of memory function has revealed substantial impairment on a range of tasks, including free recall of word lists [16–18,76] and recognition of word lists [18,76]. Thus, in regard to Koriat's model [37], it can be suggested that AD patients who exhibit a memory deficit are also impaired in episodic FOK accuracy.

Our main goal was to extend prior research by obtaining further evidence pertaining to whether FOK ability in episodic memory is impaired in early AD. To do so, groups of AD patients and elderly participants were compared on FOK accuracy. A second aim of this study was to determine whether the assumed episodic memory FOK accuracy deficit in AD is reliably related to impaired executive functions or to impaired memory functions. To do so, all participants were administered standard neuropsychological tests

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