Published in final edited form as:

Memory. 2009 November ; 17(8): 860–873. doi:10.1080/09658210903374537.

Do Age-Related Differences in Episodic Feeling of Knowing Accuracy Depend on the Timing of the Judgment?

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Abstract

The current study investigated whether there were age-related differences in episodic feeling-of-knowing (FOK) accuracy and whether accuracy was influenced by when the FOK judgments were made. Younger and older participants were randomly assigned to 1 of 4 conditions that manipulated the timing of the FOK in relation to cued-recall and associative recognition. Age-related differences in FOK accuracy were not reliable either when the FOK was immediate or when it was delayed. Moreover, FOK accuracy was above chance for both age groups. Remember/Know (RK) judgments correlated reliably with FOKs for unrecalled words for both age groups and did not vary by FOK timing. The invariance in FOK accuracy occurred despite robust age differences in associative cued recall and associative recognition, as well as age differences in recollection as measured by RK judgments. The findings are inconsistent with the argument that there is a general age deficit in episodic FOK accuracy. Possible reasons for discrepant findings in the literature are discussed.

Metacognition involves knowledge and monitoring of one's cognitive processes (Dunlosky & Metcalfe, 2009; Nelson, 1996). Feeling-of-knowing (FOK) judgments are used to assess monitoring of memory retrieval processes (Nelson & Narens, 1990). People may experience a feeling of knowing when they are unable to retrieve a piece of information, such as a word or a name, yet are confident that the information is in memory and could be recognized or recalled at a later point in time (Hart, 1965).

A critical question is whether FOKs are accurate when they occur. Following Hart (1965), FOK accuracy is validated by correlating FOK judgments with later recognition memory performance. Nelson (1984) recommended assessing FOK accuracy, or resolution, with intraindividual Goodman-Kruskal gamma correlations that determine whether the rank order of FOKs is related to likelihood of recognition success (but see Masson & Rotello, 2009).

Young and older adults have been reported to have equivalent resolution of FOKs for information in semantic memory (e.g., Allen-Burge & Storandt, 2000; Butterfield, Nelson, & Peck, 1988; Marquie & Huet, 2000). However, recent studies have suggested age-related differences in episodic FOK accuracy (Souchay, Isingrini, & Espagnet, 2000; Souchay, Moulin, Clarys, Taconnat, & Isingrini, 2007). For instance, Souchay et al. (2000) found that younger adults (mean gamma correlation = .40) made much more accurate FOK ratings than older adults (mean gamma correlation = -.06). Souchay et al. (2000) linked older adults' poor performance in this task to low performance on the Wisconsin Card Sorting Task (WCST; Berg, 1948), a test used clinically to assess frontally-mediated executive functioning. Subsequent studies have replicated the finding that older adults with low frontal function scores show poorer episodic FOK resolution (Perrotin, Isingrini, Souchay, Clarys, & Taconnat,

2006; Perrotin, Tournelle, & Isingrini, 2008; Souchay, Isingrini, Clarys, Taconnat, & Eustache, 2004).

A goal of this study was to evaluate whether and under what circumstances age-related differences in episodic FOK accuracy may appear.

Theoretical Accounts of FOKs and FOK accuracy

Explanations of FOKs and FOK accuracy have focused on two major heuristics, *cue familiarity* (Metcalf, Schwartz, & Joaquim, 1993; Reder & Ritter, 1992; Schwartz & Metcalf, 1992) and *accessibility* (Koriat, 1993, 1995). Cue familiarity is proposed to operate very quickly, even before any attempt to retrieve the target, with FOKs being based on the familiarity of the cue, not the target itself. From the accessibility perspective, FOKs are made based on the total amount of information that is activated during retrieval, regardless of whether that information is correct. Moreover, activated information can influence FOKs without being consciously accessible; for instance, Jameson, Narens, Goldfarb, and Nelson, (1994) demonstrated that sub-threshold priming influenced FOK magnitudes without explicit awareness.

Koriat and Levy-Sadot (2001) proposed that each heuristic influences the FOK at different points in the judgment process. Cue familiarity operates initially, allowing one to decide whether the information is familiar enough to warrant a retrieval search. If retrieval is attempted but unsuccessful, the judged accessibility of an item in memory is determined based on the overall amount of related information activated during the memory search. Essentially, this perspective suggests that the quality of information accessed as a basis for the FOK, and therefore FOK accuracy, depends on the extent of the search of memory for potential information about the to-be-recalled target.

Delayed versus Immediate FOK and Recognition Tests

Hart (1965) first used the recall-judge-recognize (RJR) procedure that has influenced subsequent FOK studies to this day. The primary goal of this study was to systematically vary the timing of the FOK judgments and the recognition test to determine the extent to which FOK accuracy and age-related differences in FOK accuracy were affected. To do this, we manipulated (a) whether FOKs immediately followed a recall attempt or were delayed to be collected in a separate block of FOK judgments after a recall test had been completed for all items, and (b) whether recognition memory tests immediately followed FOKs for each item or were delayed and presented in a separate block of tests after all FOKs had been collected. We shall denote immediate FOKs after each item as RJ, and delayed FOKs as R-J. Likewise, we shall denote immediate recognition tests after each FOK as JR and delayed recognition tests as J-R. Our crossed design created 4 groups: immediate FOK and recognition (RJR); immediate FOK and delayed recognition (RJ-R); delayed FOK with immediate recognition (R-JR); and delayed FOK with delayed recognition (R-J-R).

The extensive literature on a different metacognitive judgment, the judgment of learning (JOL), shows that delaying the JOL improves their resolution (e.g., Nelson & Dunlosky, 1991) in large part because delayed JOLs can be based on retrieval outcomes (see Dunlosky & Metcalf, 2009). In contrast, we assumed that delaying FOKs might impair their accuracy, based on the accessibility hypothesis. We assumed that immediate FOKs would benefit from cues generated during the memory search for the recall test, whereas delayed FOKs might be based on cue familiarity or a less exhaustive search of memory in which less diagnostic information about the target was accessed. Work on source monitoring has suggested that older adults' source monitoring deficits may be less likely to be based on frontally-mediated retrieval searches to verify the accuracy of initial source attributions (e.g., Johnson, 2006). By analogy, it could be

the case that episodic FOK deficits occurred because older adults were less likely to engage in extensive retrieval search as the basis for an FOK, an effect that could be amplified by delaying the FOK.

On the other hand, it could be the case that temporary flux in accessibility of information from memory is responsible for older adults' poor episodic FOK accuracy. If that were true, then contrasting recognition tests that immediately followed the FOK against a condition with delayed recognition tests might show a greater age difference in FOK accuracy for delayed recognition tests.

FOKs and Remember-Know Judgments

Although FOKs are typically validated against recognition memory accuracy, it is also possible to validate FOKs by correlating them with other aspects of the recognition memory experience. Hicks and Marsh (2002) showed that FOKs following a failed retrieval attempt correlated with remember-know (RK) ratings for correct recognition test items. The typical criterion for a Remember rating is that recognition is accompanied by some specific details about the original study episode, with the goal being to separate out these recollective experiences from correct recognitions based on familiarity or guesses. The fact that FOKs for unrecalled items correlate with RK judgments for correct recognitions suggests a graded accessibility of target information that does not generate correct recall influences FOKs yet still predicts later recollective experiences during recognition. Such effects could be due to noncriterial recollection (e.g., Parks, 2007), that is, explicit remembering of details of the study episode (e.g., an encoding strategy that had been employed) in the absence of memory for the target itself.

It is well known that older adults are less likely to experience recollection in yes-no recognition memory tests (e.g., Perfect & Dasgupta, 1997; see Light, Prull, La Voie, & Healy, 2000). Souchay et al. (2007) also found age differences in the likelihood of Remember ratings and showed that statistical control for likelihood of Remember ratings reduced age-related variance in FOK accuracy. Souchay et al. (2007) assessed FOK and RK in different tasks in the same persons. We included RK judgments in our FOK task so that we could evaluate relationships of RK and FOK at the item level, as in Hicks and Marsh (2002). If there is an age-related episodic FOK deficit, then one might expect FOKs to have a lower correlation with subsequent RK judgments, especially in the delayed recognition conditions.

Method

Participants

Participants included 206 ($M = 20.6$, $SD = 8.10$, age range 17 to 27) undergraduate students enrolled at the Georgia Institute of Technology who participated either for course credit or were compensated in the amount of \$20. The older adult participants were 200 volunteers recruited from a pool of participants who reside in and around metropolitan Atlanta. The older adults were screened on age and education level, such that all participants were between 60 and 80 years of age ($M = 69.50$, $SD = 5.42$) and had a minimum of 12 years of schooling ($M = 14.90$, $SD = 2.32$). They were compensated \$25 for their time. Table 1 reports detailed sample characteristics. Our older sample was similar to other community-dwelling older samples in the literature, showing slightly better vocabulary performance than younger adults, rating themselves in reasonably good health (on a 1–5 scale), and performing worse than younger adults on a test of perceptual speed.

Materials

Experimental task—This study was conducted on standard PCs with the experimental portions programmed using E-prime v1.1 (Psychology Software Tools, Inc., 2003). Three lists were created that were composed of 36 unrelated, concrete cue-target pairs of the form *Noun-Noun*. All words were selected from the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998) based on word length (4–8 characters) and concreteness (5–7, on a scale of 1–7 where 1 is highly abstract, and 7 is highly concrete). The ListChecker Pro 1.2 program (Eakin, Schreiber, & Nelson, 2005)¹ was used to ensure low to no semantic relatedness, both forward and backward, among the selected words. For use as foils in the 4-item forced-choice associative recognition test, 108 foil word pairs were created for each list using different combinations of the experimental cues and targets (i.e., recombined pairs). At study, the word pairs were presented in a white, 36-point Arial font centered on a blue background.

Additional materials—Participants completed a short demographic questionnaire designed in our lab that contained a subjective rating of their current health status. They also completed the Shipley Institute of Living Scale (Shipley, 1946), a recognition vocabulary test used to assess verbal ability. Participants were given 10 minutes to complete as many of the 36 items as possible. A paper and pencil Pattern Comparison task (Salthouse & Babcock, 1991) was used as a measure of perceptual speed. In this task, participants must decide whether pairs of patterns are the same or different. There were 2 pages of items, and participants had 30 s per page to complete as many items as they could. As a non-verbal filler task in the conditions with delays, participants also performed a computer-based, simple reaction task created in our lab. They were instructed to press the spacebar as quickly as possible whenever the word NOW appeared. This was repeated for 40 trials. Following completion of the experiment, participants were asked to report how they made their FOK ratings; specifically, they were asked whether they actively tried to recall the word that would complete the pair before giving their FOK.

Design & Procedure

We used an Age (Younger, Older) $\times$ FOK (Immediate, Delayed) $\times$ Recognition (Immediate, Delayed) between-subjects design, with older and younger adults randomly assigned to the four experimental conditions. Younger adults completed the tasks in 1 session lasting approximately 1.5 hours, while older adults took approximately 2 hours to complete the session.

The experimenter gave participants a detailed explanation of all of the phases of the experiment before the computer portion began. This allowed time for questions or clarification before getting started, and participants were encouraged to ask any questions they had throughout the experiment. In addition, all instructions were provided on the computer screen at the beginning of each phase. In the study phase for all conditions, participants were instructed to study the word pairs for a later memory test. They were not given explicit encoding instructions. Participants were presented with the 36 word pairs, one at a time, at a rate of 8 s per pair with a 1 s fixation between presentations.

The remaining tasks differed for each of the conditions as follows (see Figure 1). In the R-J-R (delayed FOK, delayed recognition) condition, immediately following the study phase participants received instructions on how to complete the cued-recall test (cued-recall phase). The instructions explained that the first word from every studied pair would be presented one

¹The ListChecker Pro 1.2 program uses the South Florida word association norms (Nelson et al., 1998) to make a variety of comparisons that are helpful in list construction, especially in regard to within-list and between-list associations. For more information on ListChecker Pro 1.2, contact Deborah Eakin, Assistant Professor, Department of Psychology, Mississippi State University, P.O. Box 6161, Mississippi State, MS 39762, Office: 662-325-7949.

at a time in the center of the computer screen and that their task would be to recall from memory the target that was associated with that cue. Participants were asked to type the corresponding target when prompted. The prompt was of the format *Cue* - ???, with the sentence “Please type the word that makes this pair complete” given above the prompt. There was no time limit for responding. Participants were encouraged to type a response even if they were unsure of the correctness of the response.

After completing the cued-recall phase, participants completed the Pattern Comparison task, lasting approximately 3 minutes.

Following the Pattern Comparison task, participants were instructed how to make FOK predictions (FOK phase). Predictions were made for every word pair. Participants were instructed that when given the first word of each pair they studied, they should indicate by typing their response the likelihood of later recognizing the correct pair when given 4 choices. The instructions explained that the response scale ranges from 25% – 100%, where 25% is chance recognition (making a guess) and 100% is definitely would recognize. For this and all other conditions, they were encouraged to use the entire scale to make their judgments as accurate as possible. Participants were not limited in time to respond.

Upon completion of the FOK phase, participants then performed a simple reaction task on the computer for approximately 3 minutes. Participants were given a two-trial practice round to ensure they understood the task.

In the final portion of the experiment, participants were given a four-alternative, forced-choice associative recognition test (recognition and R/K phase). Foil pairs were recombinations of previously studied word pairs. That is, the foils were cue-target pairs whose targets had originally been studied with other cues. The pairs were numbered 1 – 4, and participants chose the word pair that they originally studied. The location of the correct pair was randomly assigned to locations across items. Immediately after each choice, participants indicated whether they very clearly remembered seeing that word pair at study. If yes, they were asked to type R (Remember) to indicate they remembered the pair. Otherwise, they selected K (Know) to indicate they did not clearly remember the pair. This process was completed for all 36 pairs, and there was no time limit to respond. The final task was to answer the FOK Questionnaire.

In the R-JR condition (delayed FOK with immediate recognition), immediately following the encoding phase participants completed the cued-recall test, followed by the Pattern Comparison task. Unlike the R-J-R condition, however, following the FOK rating participants completed the recognition test and R/K judgment for that same item. Finally, participants completed the simple reaction task and then the FOK Questionnaire.

In the RJ-R condition (delayed recognition), participants began the cued-recall phase immediately after encoding. After each cued-recall attempt, participants gave their FOK rating for that item. Upon completion of all items, participants completed the Pattern Comparison task, followed by the recognition and R/K phase, finishing up with the simple reaction task.

Finally, in the RJR (immediate all) condition, immediately following encoding participants received instructions for how to complete the remaining tasks. After the cued-recall attempt, participants gave their FOK rating for the same word they just tried to recall, immediately followed by the recognition and R/K tasks for that same item. The Pattern Comparison came next, followed by the simple reaction task.

Results

The significance level for all tests was set at $\alpha = .05$. In all analyses we collapsed over List if there were no reliable interactions with the experimental variables.

Memory Performance

Recall—Cued-recall accuracy was examined for age (younger, older) $\times$ FOK (immediate, delayed) $\times$ recognition (immediate, delayed). There was an effect of age, $F(1, 398) = 132.92$, $p < .001$, with younger adults ($M = .59$, $SE = .02$) recalling more than older adults ($M = .29$, $SE = .02$), $d = 1.15$, a large effect by Cohen's (1988) standards. Higher recall accuracy was achieved by those with a delayed FOK ($M = .47$, $SE = .02$) than by those with an immediate FOK ($M = .40$, $SE = .02$), $F(1, 398) = 7.05$, $p < .01$, $d = -.26$, a small effect (see Table 2). The timing of the recognition test showed recall to be higher with an immediate test ($M = .47$, $SE = .02$) than with a delayed test ($M = .41$, $SE = .02$), $F(1, 398) = 4.50$, $p < .05$, $d = .21$. No interactions were significant. While the delayed FOK effect might suggest that getting additional instructions before recall negatively impacted recall, the delayed recognition effect seems to argue against this. Rather than a failure of random assignment, this may be reflecting a reactive effect in the immediate FOK, immediate recognition condition due to experiencing the FOK and recognition test for each word before continuing to the next item to be tested.

Recognition—Recognition accuracy for all words was evaluated in an age $\times$ FOK timing $\times$ recognition test timing analysis. There was a significant age effect, $F(1, 398) = 82.34$, $p < .001$, with younger adults ($M = .86$, $SE = .02$) having more correct recognitions than older adults ($M = .66$, $SE = .02$), $d = .93$ (see Table 2). The main effect for recognition timing was also significant, $F(1, 398) = 4.33$, $p < .05$. Recognition accuracy was slightly higher with immediate recognition ($M = .78$, $SE = .02$) than delayed recognition ($M = .74$, $SE = .02$), $d = .21$. There was also a reliable age $\times$ recognition timing interaction, $F(1, 405) = 4.7$, $p < .05$. Younger adults had equal recognition accuracy for both immediate ($M = .86$, $SE = .02$) and delayed recognition ($M = .86$, $SE = .02$), $d = .00$, whereas older adults' recognition accuracy was higher with immediate ($M = .71$, $SE = .02$) than with delayed recognition ($M = .62$, $SE = .02$), $d = .42$. Neither the main effect for FOK timing nor the interactions involving FOK timing were significant.

Given their importance for evaluating FOK accuracy, we also analyzed recognition accuracy for items that were either recalled or not recalled (see Table 2). Recognition accuracy for unrecalled words followed the same pattern as across all words. There was a reliable age main effect, $F(1, 395) = 58.54$, $p < .001$, with younger ($M = .79$, $SE = .02$) correctly recognizing more words than older ($M = .61$, $SE = .02$), $d = .77$. The main effect for recognition timing was significant, $F(1, 395) = 4.02$, $p < .05$, wherein recognition accuracy was higher with immediate ($M = .73$, $SE = .02$) than with delayed recognition ($M = .68$, $SE = .02$), $d = .20$. The age $\times$ recognition timing interaction was also significant, $F(1, 395) = 4.51$, $p < .05$. Younger adults' recognition accuracy was equivalent for immediate ($M = .79$, $SE = .02$) and delayed recognition ($M = .79$, $SE = .02$), $d = -.01$; however, older adults' recognition accuracy was higher with immediate ($M = .66$, $SE = .02$) than with delayed recognition ($M = .57$, $SE = .02$), $d = .41$. The main effect for FOK timing and the interactions were not significant. Older adults correctly recognized fewer words than younger adults, and this effect was most pronounced when the recognition test was delayed. Recognition accuracy was at ceiling for previously recalled words for both groups.

Familiarity and Recollection

We evaluated whether Remember or Know judgments across all words indicated a differential contribution of familiarity to older adults' recognition memory. In an age $\times$ FOK timing $\times$

recognition timing analysis, younger adults ($M = .80, SE = .02$) gave more Remember responses than older adults ($M = .57, SE = .02$), $F(1, 398) = 89.60, p < .001, d = .94$. More Remember judgments were given following immediate recognition ($M = .71, SE = .02$) than following delayed recognition ($M = .66, SE = .02$), $F(1, 398) = 89.60, p < .05, d = .24$, but delaying the FOK did not show a difference, $F < 1$. None of the interactions were reliable. Thus, older adults reported less recollection-based recognition experiences than younger adults, but for both groups Remember responses were given more often when recognition immediately followed the FOK.

Mean Remember responses for unrecalled but correctly recognized words indicated a reliable age difference, $F(1, 395) = 16.83, p < .001$, with younger ($M = .69, SE = .02$) giving more Remember responses than older ($M = .58, SE = .02$), $d = .41$. The timing of the FOK also produced a significant effect, $F(1, 395) = 4.73, p < .05$. More Remember responses were given when the FOK immediately followed cued-recall ($M = .66, SE = .02$) than when it was delayed ($M = .61, SE = .02$), $d = .21$. The main effect for recognition timing and the associated interactions were not significant. In contrast to analysis for all words, unrecalled words later correctly recognized that had an immediate FOK were more likely to be given a Remember judgment at recognition.

Analysis of Remember ratings for unrecalled and incorrectly recognized words did not indicate a reliable age difference, $F(1, 297) = 1.01, p = .32$. Younger ($M = .23, SE = .02$) and older adults ($M = .21, SE = .02$) gave about equivalent numbers of Remember responses for words they had not recalled and later had not recognized, $d = .12$. Neither main effect nor the interaction terms were significant. Hence, older adults were not prone to give incorrect reports of remembering following an incorrect recognition more often than younger adults, suggesting they were not disproportionately experiencing high-confidence memory illusions.

FOK Accuracy

Our primary focus of this thesis was on FOK accuracy, as computed by correlating the FOK judgments with recognition memory performance. For completeness, however, mean FOKs are provided in Table 3. The pattern of mean FOKs for both age groups essentially tracks the pattern of cued recall performance. For instance, FOKs were much higher for recalled items than for unrecalled items. However, one interesting effect emerged: older adults' FOK ratings ($M = 80.5, SE = 1.3$) for recalled items were reliably lower than younger adults' FOKs ($M = 94, SE = 1.15$), $F(1, 355) = 61.83, p < .001, d = .82$. Older adults were less confident they could later recognize an item they had just correctly recalled.

Table 3 reports gamma correlations of FOK and recognition memory for all words and for unrecalled words. Although FOKs were obtained for all items, irrespective of recall outcome, it is typical to focus on FOK resolution for items that could not be recalled. There were no reliable age differences in resolution for unrecalled items, $F < 1$, with younger adults ($M = .23, SE = .05$) and older adults ($M = .23, SE = .05$) being equivalent, $d = .01$. The main effect of delayed FOK was not reliable, $F < 1$, with resolution for immediate FOKs ($M = .25, SE = .05$) just above that for delayed FOKs ($M = .21, SE = .05$), $d = .06$. Delaying recognition also did not show a reliable difference in resolution, $F < 1$. Immediate recognition ($M = .24, SE = .05$) was similar to delaying recognition ($M = .22, SE = .05$), $d = .03$. There were no significant interactions. Confidence intervals on both age groups' gammas did not include zero, indicating above-chance resolution for both younger and older adults (Figure 2).

Gamma Correlation for Recognition Accuracy with Remember or Know Judgments

Gamma correlations were computed across all words for recognition memory performance by post-recognition response (Remember or Know). There was no reliable age difference, $F < 1$,

with younger adults' resolution ($M = .74$, $SE = .04$) similar to older adults' ($M = .71$, $SE = .04$), $d = .06$. Neither the main effects nor the interactions were significant.

Analysis of Recognition-RK gamma correlations for unrecalled words again showed no age differences, $F < 1$. Younger adults ($M = .70$, $SE = .04$) had resolution equivalent to older adults ($M = .68$, $SE = .03$), $d = .07$. Neither the main effects for FOK or recognition test timing nor the interactions were significant. Despite lower levels of recall and recognition performance by older adults, older and younger adults' performance on an associative recognition test was equally in concert with their reports of remembering or knowing the pair they chose.

Gamma Correlation for FOK Rating with Remember or Know Judgments

Gamma correlations for FOKs with RKs were computed for unrecalled items.

The test of a zero population intercept (gamma = 0) was rejected, $F(1, 296) = 87.70$, $p < .001$, indicating that FOK magnitudes for unrecalled items were associated with later recollective experiences (marginal mean gamma = .31, $SE = .05$). The main effect for age was not significant, $F(1, 296) = 1.42$, $p = .24$, although younger adults ($M = .35$, $SE = .05$) had slightly better resolution than older adults ($M = .27$, $SE = .05$), $d = .14$. Neither the main effects nor the interactions were significant (Figure 3).

Gamma correlations for unrecalled but correctly recognized words (marginal mean for younger = .43, $SE = .06$; marginal mean for older = .31, $SE = .05$; $d = .19$) were slightly greater than those for unrecalled words only (Figure 4). The age difference was again not reliable, $F(1, 275) = 2.54$, $p = .11$, $d = .19$, but there was a trend for younger adults to have a higher association of FOKs with RKs for correctly recognized items. Neither the main effects nor the interactions were significant. Thus, the kinds of cues that both groups are using to make their FOKs are also related to whether they later have recollective recognition memory experiences, even for words they cannot recall.

Discussion

Until recently, the predominant evidence regarding aging and metacognitive accuracy appeared to indicate preservation of the ability to monitor elementary aspects of memory encoding and retrieval, including JOLs (e.g., Connor, Dunlosky, & Hertzog, 1997; Hertzog, Kidder, Powell-Moman, & Dunlosky, 2002; Souchay et al., 2004) and semantic FOKs (e.g., Butterfield et al., 1988). Recently, however, at least some studies have suggested that older adults' monitoring of retrieval successes and failures is less accurate (e.g., Dodson, Bawa, & Krueger, 2007), particularly when experimental conditions promote retrieval of inaccurate or misleading information (e.g., Jacoby, Bishara, Hessels, & Toth, 2005; Kelley & Sahakyan, 2003). Likewise, older adults appear to be less likely to correct initial misattributions about source memory, which may be due to a lower probability of recollective experiences at test (Henkel, Johnson, & deLeonardis, 1998; Johnson, 2006). Age deficits in associative binding mechanisms (e.g., Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003) may operate to create an impoverished representation of episodes in memory that are more susceptible to misrecollection (Dodson et al., 2007), especially without frontally-guided strategic search mechanisms that can correct source misattributions (Johnson & Raye, 2000).

Given this general literature on aging and retrieval mechanisms, it is highly plausible that one would detect age deficits in tasks requiring monitoring after retrieval failures, as is the case with episodic FOKs. Indeed, the episodic-FOK-deficit hypothesis has been supported by a number of recent studies (e.g., Perrotin et al., 2008; Souchay et al., 2004, 2007). However, the present study found no age differences in episodic FOK accuracy. Older adults had equivalent resolution of FOKs for predicting subsequent recognition memory for words they

could not recall in a cued recall test. The age effects, scaled as Cohen's d , were essentially zero. This fact, and our use of a relatively large sample of younger and older adults, rules out low statistical power as an issue. We conclude that for the older population defined by our sampling procedures there is no general age deficit in episodic FOK accuracy.

We also replicated the Hicks & Marsh (2002) demonstration that FOKs for unrecalled words correlate with recognition RK judgments. Consistent with our findings of no age differences in correlations of FOK with recognition memory accuracy, both older and younger adults had reliable mean FOK-RK gamma correlations that were above chance for words they had not recalled, as well as for words they had not recalled but later correctly recognized. There were weak trends in the sample data for lower correlations of FOKs and RKs in older adults (see Figures 3 and 4), but these effects were not of the magnitude that would support conclusions of substantial differences in the basis for FOKs in the two age groups. Instead, it appears that older adults were using the cues generated during the retrieval attempt to make FOKs and that these cues predict the future degree of recollection experiences at the time of the recognition test. This result seems consistent with the interpretation that, even when recall fails, older individuals have sufficient access to cues generated during the cued-recall test's memory search to enable modestly accurate FOKs. Our study was not designed to isolate the basis for above-chance FOK accuracy, but the FOK-RK relationship suggests it is likely either (a) graded levels of subthreshold activation from targets influence FOKs, perhaps without awareness (such as a nonanalytic feeling of familiarity) or (b) noncriterial recollection (Parks, 2007; Yonelinas & Jacoby, 1996) of aspects of the episode other than the target itself are diagnostic of later recognition states. Most important, with respect to aging, these outcomes suggest minimal age differences in how such cues are used to make FOKs, even though older adults have lower memory and are less likely to have recollective experiences during the recognition test.

Previous investigations finding age differences in episodic FOK accuracy have argued for frontally mediated deficits in FOK accuracy (e.g., Perrotin et al., 2006, 2008; Souchay et al., 2004). On the surface, this hypothesis is consistent with evidence of fMRI-based activation patterns in parts of frontal cortex for FOK states (Maril, Simons, Mitchell, Schwartz, & Schacter, 2003; Schnyer, Nicholls, & Verfallie, 2005) and neuropsychological evidence of impaired FOK accuracy in patient populations (e.g., Janowski, Shimamura, & Squire, 1989). Similar arguments have been made regarding the frontal lobe origins of age differences in memory for episodic sources (e.g., Johnson, 2006; Johnson & Raye, 2000) and false memories in a variety of tasks (Butler, McDaniel, Dornburgh, Price, & Roediger, 2004). Because source memory accounts often suggest the locus of the frontal deficit is in control over strategic retrieval search (e.g., Dodson & Schacter, 2002), we used a delayed FOK task in the attempt to identify and isolate age differences in conditions that would be prone to shallow retrieval searches and a reliance on evidence such as cue familiarity rather than access to diagnostic information in a controlled retrieval search. To the extent that older adults were prone to inaccurate FOKs due to constrained access to valid cues, the delay in FOK would have been expected to differentially impair older adults' FOK accuracy.

We found no effects of delaying FOKs on older adults' FOK accuracy. A post-task questionnaire indicated that most older and younger adults reported explicitly searching for targets, even with delayed FOKs. Delaying recognition tests which did influence older adults' recognition memory accuracy also did not influence FOK accuracy. Hence these data provide little support for the hypothesis of age-related impairments in the process of generating episodic FOKs.

Our results do not definitively identify the reasons why Souchay and colleagues find an age-related deficit in episodic FOK accuracy, whereas we did not. There are a number of procedural differences between our FOK tasks, but additional experiments in our lab examining task

features have not explained the discrepant findings. Souchay and colleagues have typically used yes-no target recognition tests rather than testing associative recognition. Yes-no tests may be more susceptible to misleading familiarity effects than forced choice tests of associative recognition and may invoke different strategies at retrieval that influence age differences in memory (Cohn, Emrich, & Moscovitch, 2008; Patterson & Hertzog, in press) and perhaps FOK accuracy. Be that as it may, an unpublished experiment we ran found no age differences in FOK accuracy for a forced-choice item recognition test, so our use of an associative recognition test rather than a target recognition test is unlikely to be the explanation. We did not explicitly evaluate yes-no criterion tests, so we cannot rule out the possibility that the yes-no target recognition test used by Souchay and colleagues accounts for the different findings. We argue that the associative recognition test, as we have used here, is the best criterion for validating FOKs for paired-associate items.

Another possible explanation is that we used an extremely ‘clean’ paired-associate list, using the USF free-association norms to minimize any associative relations between cues and target of different PA items. To the extent that others’ lists have appreciable between-item associations (e.g., using cues like sugar, salt, and table for different PA items in the same list), they may be more susceptible to retrieval interference effects that might differentially disadvantage older adults’ FOK accuracy, given that older adults are more interference-prone (Kausler, 1994; Zacks, Hasher, & Li, 2001). This is one reason we do not regard our findings as evidence against the metacognitive misrecollection phenomena reported by Dodson et al. (2007), Jacoby et al. (2005), Kelley and Sahakyan (2003), and others, because those effects often rely on creating stimuli that are specifically susceptible to false recollection. Our materials were constructed to avoid such possibilities. Thus age differences in FOK accuracy could interact with variables we chose to hold constant in our design and in our construction of the PA stimuli. Older adults may well manifest impairments in retrieval monitoring or cognitive control based on retrieval monitoring in other task environments. Our findings demonstrate that one cannot generally and necessarily expect to observe age deficits in episodic retrieval monitoring accuracy, prior literature to the contrary.

Another likely candidate explanation of the differences in outcomes is variation in sample characteristics. Extreme age group cross-sectional designs such as ours assume that there are no differences in the types of younger and older persons selected into the study, so that any age group differences imply aging effects (Hertzog, 1996). Because we were comparing university students to older adults, we excluded participants that did not have some secondary (high school) education to minimize confounds of education and age. In contrast, Souchay and colleagues have typically used a heterogeneous group of older and younger adults who have both a wide range of age and education level. For instance, Souchay et al. (2000) found age-related differences in episodic FOK accuracy when comparing an older sample ranging in age from 60–93 with a mean education level of 8.9 years against a younger adult sample ranging in age from 20–32 with a mean education level of 14 years. Similar heterogeneity exists in the other studies that have found correlations of frontal function measures with episodic FOK in older adults. Episodic FOK accuracy for verbal materials could be impaired in low functioning, poorly educated older adults, not because of aging per se but because of persistent low levels of function observable across the life span in poorly educated individuals (see Chan & McDermott, 2007). In addition to education, the inclusion of individuals in their 80’s and 90’s may also be responsible for the discrepancies. Our community-dwelling older adult sample did not include individuals above the age of 80, and it is possible that normative age changes in FOK accuracy occur after that point in the life span.

We propose that earlier studies suggesting age-related FOK deficits should not be generalized to the overall population of older adults. It may well be the case that major age-associated memory impairments, such as those associated with mild cognitive impairment or Alzheimer’s

disease, lead to reduced episodic FOK accuracy. However, it does not appear to be the case that high-functioning older adults demonstrate problems with episodic FOK accuracy before the age of 80. Further research explicitly evaluating FOK accuracy in heterogeneous adult populations would be needed to disentangle whether age-associated pathology in frontal (and medial temporal) brain structures causes reductions in FOK accuracy for some, but not all older adults. For now, our results indicate that episodic FOK accuracy is spared, at least into the 70's, for normal, healthy older adults with a past history of secondary-level or college-level schooling.

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Delayed FOK, Delayed Recognition (R – J – R)

Cued → Pattern → FOK → SRT → Recognition → FOK
 Recall Comparison + R/K Q'aire

Delayed FOK, Immediate Recognition (R – JR)

Cued → Pattern → FOK & → SRT → FOK
 Recall Comparison Recognition + R/K Q'aire

Immediate FOK, Delayed Recognition (RJ – R)

Cued → Pattern → Recognition → SRT
 Recall & FOK Comparison + R/K

Immediate FOK, Immediate Recognition (RJR)

Cued & FOK & Recognition → Pattern → SRT
 Recall + R/K Comparison

Figure 1.
 Procedure for Each of the Four Conditions.

Figure 2.
FOK Accuracy for Unrecalled Words by Age and Condition.

Figure 3.
FOK-RK Gamma Correlation for Unrecalled Words by Age and Condition.

Figure 4. FOK-RK Gamma Correlation for Unrecalled but Correctly Recognized Words by Age and Condition.

Table 1

Participant characteristics.

	Younger		Older	
	Immediate Recognition M (SD)	Delayed Recognition M (SD)	Immediate Recognition M (SD)	Delayed Recognition M (SD)
Age				
Immediate FOK	19.13 (1.24)	21.44 (10.30)	68.85 (5.49)	68.07 (5.57)
Delayed FOK	21.49 (10.71)	19.42 (1.57)	71.56 (4.87)	69.82 (5.32)
Health				
Immediate FOK	1.81 (.83)	2.06 (.80)	2.23 (.96)	2.11 (.92)
Delayed FOK	2.00 (.78)	1.80 (.77)	2.44 (1.07)	2.04 (.76)
Shipley				
Immediate FOK	30.91 (2.90)	31.46 (3.35)	32.85 (4.92)	33.20 (5.40)
Delayed FOK	31.80 (2.95)	31.64 (2.87)	34.19 (4.91)	33.16 (5.15)
Pattern Comparison				
Immediate FOK	43.91 (7.43)	44.35 (7.91)	32.40 (7.59)	28.70 (6.26)
Delayed FOK	45.33 (7.81)	44.54 (7.45)	31.90 (9.44)	31.48 (7.30)

Table 2

Memory performance.

	Younger		Older	
	Immediate Recognition M (SE)	Delayed Recognition M (SE)	Immediate Recognition M (SE)	Delayed Recognition M (SE)
Recall				
Immediate FOK	.52 (.04)	.56 (.04)	.36 (.04)	.26 (.04)
Delayed FOK	.63 (.04)	.59 (.04)	.40 (.04)	.29 (.04)
Recognition (All words)				
Immediate FOK	.82 (.03)	.85 (.03)	.77 (.03)	.68 (.03)
Delayed FOK	.89 (.03)	.86 (.03)	.75 (.03)	.65 (.03)
Recognition (Unrecalled)				
Immediate FOK	.75 (.03)	.79 (.03)	.71 (.03)	.62 (.04)
Delayed FOK	.82 (.03)	.79 (.03)	.70 (.04)	.58 (.03)
Recognition (Recalled)				
Immediate FOK	.98 (.02)	.98 (.02)	.97 (.02)	.97 (.02)
Delayed FOK	.99 (.02)	.97 (.02)	.96 (.02)	.96 (.02)

Table 3

Mean FOKs.

	Younger		Older	
	Immediate Recognition M (SE)	Delayed Recognition M (SE)	Immediate Recognition M (SE)	Delayed Recognition M (SE)
FOK Rating (All words)				
Immediate FOK	58.50 (3.02)	64.39 (3.02)	50.52 (2.86)	47.02 (2.86)
Delayed FOK	70.78 (3.41)	68.09 (3.07)	60.35 (2.90)	46.72 (2.68)
FOK Rating (Unrecalled)				
Immediate FOK	37.61 (2.56)	41.98 (2.56)	35.08 (2.42)	36.47 (2.42)
Delayed FOK	50.19 (2.89)	47.75 (2.60)	48.95 (2.46)	37.46 (2.27)
FOK Rating (Recalled)				
Immediate FOK	92.70 (3.19)	95.22 (3.19)	79.94 (3.01)	78.94 (3.01)
Delayed FOK	90.48 (3.59)	90.59 (3.24)	80.63 (3.06)	75.26 (2.83)
FOK Rating (Unrecalled, recognized)				
Immediate FOK	38.42 (2.60)	42.53 (2.60)	36.01 (2.46)	37.12 (2.46)
Delayed FOK	52.49 (2.93)	49.16 (2.64)	50.44 (2.49)	37.38 (2.31)
FOK Rating (Unrecalled, unrecognized)				
Immediate FOK	37.00 (2.93)	37.68 (2.93)	32.98 (2.78)	33.70 (2.78)
Delayed FOK	48.03 (3.31)	44.36 (2.98)	46.24 (2.81)	37.55 (2.60)

Table 4

Mean Gamma Correlations for FOKs with Recognition Memory Performance.

	Younger		Older	
	Immediate Recognition M (SE)	Delayed Recognition M (SE)	Immediate Recognition M (SE)	Delayed Recognition M (SE)
Gamma correlation (All words)				
Immediate FOK	0.59 (.09)	0.61 (.09)	0.50 (.08)	0.45 (.08)
Delayed FOK	0.38 (.10)	0.56 (.09)	0.54 (.08)	0.40 (.07)
Gamma correlation (Unrecalled words)				
Immediate FOK	0.16 (.11)	0.31 (.11)	0.34 (.10)	0.18 (.10)
Delayed FOK	0.21 (.12)	0.26 (.11)	0.24 (.09)	0.14 (.09)

Table 5

Mean Gamma Correlations for FOKs with RKs.

	Younger		Older	
	Immediate Recognition M (SE)	Delayed Recognition M (SE)	Immediate Recognition M (SE)	Delayed Recognition M (SE)
Gamma correlation(All words)				
Immediate FOK	0.81 (.06)	0.74 (.06)	0.64 (.06)	0.58 (.06)
Delayed FOK	0.76 (.06)	0.76 (.06)	0.68 (.06)	0.62 (.06)
Gamma correlation (Unrecalled words)				
Immediate FOK	0.31 (.10)	0.28 (.10)	0.31 (.10)	0.18 (.10)
Delayed FOK	0.49 (.10)	0.34 (.09)	0.39 (.09)	0.21 (.09)
Gamma correlation(Unrecalled but Correctly Recognized Words)				
Immediate FOK	.39 (.12)	.35 (.11)	.32 (.11)	.27 (.11)
Delayed FOK	.52 (.11)	.47 (.10)	.45 (.10)	.21 (.10)