Older adults' use of metacognitive knowledge in source monitoring: Spared monitoring but impaired control

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Abstract:

While episodic memory declines with age, metacognitive monitoring is spared. The current study explored whether older adults can use their preserved metacognitive knowledge to make source guesses in the absence of source memory. Through repetition, words from two sources (italic vs. bold text type) differed in memorability. There were no age differences in monitoring this difference despite an age difference in memory. Older adults used their metacognitive knowledge to make source guesses but showed a deficit in varying their source guessing based on word recognition. Therefore, older adults may not fully benefit from metacognitive knowledge about sources in source monitoring.

Keywords: Age Differences | Aging | Metacognition | Source Monitoring | Episodic Memory

Article:

Imagine you remember something but you cannot remember where you learned about it. Could you still judge what the source of that information is? Chances are you can, based on your knowledge about possible sources. According to the source-monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993), if you cannot base a source judgment on memory for source features you may still be able to reason that there is only one plausible source (e.g., your friend who always tells odd facts like the one you are remembering). Knowing the source of information can be highly important, such as knowing if health advice came from your doctor (a good source) or your neighbor (usually a bad source). With age you become less likely to remember sources, so source judgment processes drawing on (accurate) knowledge about sources gain importance.

Prior research demonstrates that young adults rely on political stereotypes (e.g., Mather, Johnson, & De Leonardis, 1999), learned correlations (e.g., Meiser & Hewstone, 2004), and schematic knowledge about professions (e.g., Bayen, Nakamura, Dupuis, & Yang, 2000) when making source judgments in the absence of source memory. Recently, Meiser, Sattler, and von Hecker (2007) added reliance on metacognitive knowledge to this line of research. They experimentally created differences in word memory between two sources. Using model-based analysis they then examined source responses in the absence of memory for source features (i.e., source guesses). Student participants monitored the source differences in item memory and were more likely to guess that an unrecognized item came from the source with lower item-memory than a recognized item.

Source memory is particularly impaired in old age, more so than simple item memory (see Old & Naveh-Benjamin, 2008, for a meta-analysis). Therefore, older adults will often have to rely on their knowledge about sources when making source judgments. In contrast to the age deficits in memory, older adults are able to monitor their memory performance as well as young adults (see Hertzog & Hultsch, 2000, for a review). Can older adults use their preserved metacognitive knowledge when making source attributions without memory for source features? This seems likely given that older adults have been shown to rely on general knowledge (e.g., stereotypes) when making source attributions (Mather et al., 1999). But older adults have not always been found to use their metacognitive knowledge effectively (e.g., when allocating study time, Dunlosky & Connor, 1997; but see Hines, Touron, & Hertzog, 2009). That is, there may be impairment in the use of metacognitive knowledge, possibly rendering older adults unable to use this preserved knowledge in source monitoring.

The purpose of the current study was to examine older adults' use of metacognitive knowledge in a source monitoring task. By selectively repeating words from one source we created differences in word memory between two sources (cf. Meiser et al., 2007). We expected older adults to monitor this source difference in word memory as well as young adults. Replicating Meiser et al., we further expected young adults to use this metacognitive knowledge when making source attributions in the absence of source memory by varying their source guessing between recognized and unrecognized words. Specifically, we expected them to be highly biased to guess that unrecognized words came from the source with lower word memory while this bias should be reduced for recognized words. We also included a control condition with words of each text type studied only once to demonstrate that such a bias only occurs when word memory differs between sources. We expected older adults to monitor source differences in word memory as well as young adults but given mixed prior findings it was unclear whether they would be able to use this knowledge for source guessing.

METHOD

Design and Participants

The design was a 2 (source) × 2 (condition) × 2 (age group) mixed factorial. Source (italic vs. bold text type) was manipulated within participants. Condition was manipulated between participants. In the all-once condition all words were studied once. In the once-thrice condition italic words were studied once and bold words were studied three times, creating source differences in word memory that participants may rely on during source judgments. Sixty young adults and 60 older adults were randomly assigned to the two conditions. Young adults (18–22 years of age, M = 18.5) were undergraduates participating for course credit. Older adults (60–75 years of age, M = 67.2) were community-dwelling volunteers receiving monetary compensation ($10 per hour). Participants were prescreened for sufficient visual acuity (at least 20/50) and health-related impediments. Sample characteristics were consistent with typical findings.

Materials and Procedure

After signing a consent form, participants completed a few short measures to assess sample characteristics. Then the computerized source-monitoring task presented instructions on the screen. Before studying, participants received detailed information about the memory test, emphasizing the importance of remembering not only the words but also their text type. In the study phase, 50 words were randomly sampled from a word pool of 100 high frequency, one- or two-syllable English nouns. Half of the sampled words were then randomly assigned to either text type (italic or bold). In the all-once condition, the order of presentation of the words was random with the restriction that there were no more than three consecutive words in the same text type. For the once-thrice conditions, order of presentation of the words was random with the restriction that there were at least two intervening words between the repetitions of a bold word and that there were no consecutive italic words for the first three quarters of the lists (to equally distribute non-repeated italic words throughout the study list). Words appeared at the center of the screen in 30 pt bolded or italicized Arial font for 3 seconds. After studying a word, participants were prompted to indicate how confident they were that they would remember the just seen word at the end of the experiment on a scale from 0% (*definitely will not remember*) to 100% (*definitely will remember*). During these self-paced judgments of learning (JOLs) the previously studied word was not visible. A 200-ms centered fixation cross appeared before the next word. After the study list, participants were prompted to count backwards in 3's for 1 min. Then participants entered the last number they were at and continued with the memory-test instructions.

In the self-paced memory test, the 50 studied words and the 50 remaining (i.e., unstudied) words from the word pool appeared one at a time in the center of the screen in a random order. Words were presented in standard text type and in a different font than at study. Participants first determined whether a word had been on the studied lists of words. Two response fields labeled “Yes (old word)” and “No (new word)” appeared side by side underneath the test word. Once participants clicked a response field with the computer mouse it turned red. Participants then clicked a field labeled "RECORD" at the center bottom of the screen knowing that once recorded no further change could be made. If a word was judged to be old, participants were asked to determine whether it had been presented in italic or bold text. Responses were made as before with two response fields underneath the test word. In the all-once condition these were labeled "italic" and "bold." In the once-thrice condition this judgment was equivalent to judging if a word had been studied once or thrice; consequently response fields were labeled as "once/italic" and "thrice/bold." Once the text type response was logged, the next test word appeared. If a word was judged to be new, the next test word appeared immediately. All response field positions were counterbalanced across participants. Upon completing the memory test, participants filled out a paper-based questionnaire containing difficulty ratings for making the old-new and text-type judgment for bold and italic words, with a Likert scale from 1 (*not at all difficult*) to 7 (*very difficult*)).

RESULTS

Metacognitive Monitoring

For each participant the mean JOLs for italic and bold words were calculated, averaged across the three repetitions of bold words in the once-thrice condition. Means are displayed in Table 1. The mean JOLs were then submitted to a 2 (source) × 2 (condition) × 2 (age group) repeated-measures analysis of variance (ANOVA). There was a main effect of age group because older adults gave higher JOLs than young adults, $F(1, 116) = 7.53$, $p < .01$, $\eta p^2 = .05$. There was a main effect of source with lower JOLs for italic than for bold words, $F(1, 116) = 113.93$, $p < .01$, $\eta p^2 = .5$. This effect was qualified by an interaction of source and condition indicating that the mean difference in JOLs for italic and bold words was larger in the once-thrice condition than in the all-once condition, $F(1, 116) = 27.99$, $p < .01$, $\eta p^2 = .19$. That is, participants in the once-thrice condition detected the source differences in word memory and gave lower JOLs for italic than for bold words. The absence of an interaction with age group implies that both age groups were equally sensitive to the once-thrice manipulation. This was also supported by a lack of age differences in relative accuracy of JOLs as measured by mean gamma correlations between JOL and recognition accuracy (see Table 1).

Table 1 also lists participants' estimates of item recognition difficulty for italic and bold words, which were in line with the JOL analyses. In addition participants' perceived difficulty of making the source judgment for bold and italic words (Table 1) was analyzed with a 2 (source) × 2 (condition) × 2 (age group) mixed ANOVA. Older adults perceived the source judgment as more difficult, $F(1, 115) = 11.46$, $p < .01$, $\eta p^2 = .09$. A significant main effect of source reflected higher perceived difficulty of making the source judgment for italic words than for bold words, $F(1, 115) = 31$, $p < .01$, $\eta p^2 = .21$. This effect was qualified by a source x condition interaction with a bigger difference in perceived difficulty of the source judgment for italic relative to bold words in the once-thrice condition, $F(1, 115) = 9.63$, $p < .01$, $\eta p^2 = .08$. That is, participants believed that it would be more difficult to remember the source of italic words compared with bold words and this difference in perceived difficulty was stronger in the once-thrice condition. This pattern did not differ between age groups.

Table 1

Means and SEs of Metacognitive Measures and Parameter Estimates for the Two-High Threshold Multinomial Processing Tree (MPT) Model of Source Monitoring by Age Group and Condition

	Young adults		Older adults	
	All once	Once-thrice	All once	Once-thrice
Metacognitive monitoring				
JOL (italic words)	45.54 (2.85)	41.32 (3.22)	57.85 (4.18)	51.50 (4.50)
JOL (bold words)	52.31 (2.73)	52.84 (3.26)	61.91 (4.28)	62.15 (4.0)
γ (JOL-Recognition)	.19 (.05)	.51 (.05)	.21 (.05)	.38 (.08)
Item difficulty–italic	4.23 (.27)	4.70 (.19)	4.55 (.31)	4.70 (.22)
Item difficulty–bold	3.27 (.21)	2.97 (.19)	4.37 (.27)	3.87 (.22)
Source difficulty–italic	4.97 (.24)	4.27 (.23)	5.52 (.23)	4.97 (.21)
Source difficulty–bold	4.70 (.20)	3.33 (.23)	5.27 (.21)	4.23 (.24)
Parameter estimates				
D_{italic}	.70 (.02)	.70 (.02)	.63 (.02)	.54 (.02)
D_{bold}	.75 (.02)	.95 (.01)	.67 (.02)	.90 (.01)
d	.37 (.03)	.80 (.02)	.25 (.03)	.62 (.02)
b	.27 (.02)	.24 (.02)	.30 (.02)	.20 (.01)
a	.48 (.03)	.62 (.05)	.54 (.02)	.80 (.04)
g	.55 (.05)	.84 (.04)	.55 (.04)	.84 (.03)

Note. JOL = judgment of learning. JOLs may range from 0 to 100. In the once-thrice conditions, JOLs were averaged across the three repetitions of a bold word. Item and source difficulty may range from 1 (*not at all difficult*) to 7 (*very difficult*). Because of experimenter error one older participant in the all-once condition did not complete the item and source difficulty judgments. Mean γ correlations are between JOLs and recognition accuracy. The fitted six-parameter model was saturated, thus the fit was perfect, $G^2(0) = 0$, $p = 1$, in all conditions. Parameter estimates are probability estimates that can range from 0 to 1. $D_{\text{italic}}/D_{\text{bold}}$ = probability of recognizing a word previously studied in italic/bold text; d = probability of remembering the source; b = probability of guessing that an unrecognized word is old; a = probability of guessing "italic" for recognized words; g = probability of guessing "italic" for unrecognized words.

Model-Based Analyses of Source Judgments

Primary analyses were conducted with the two-high threshold multinomial processing tree (MPT) model of source monitoring (Bayen, Murnane, & Erdfelder, 1996; Figure 1). This model allows the separate estimation of source memory and source-response biases that are confounded in hit-based measures (cf. Murnane & Bayen, 1996). In Figure 1, participant responses at test (right side) are linked to the test stimuli (left side) via parameters reflecting distinct cognitive processes. Imagine a participant is tested on a word previously studied in italic text type (top tree). With probability D_{italic} the participant recognizes the word. With probability d_{italic} the participant also remembers the source (italic) of the word. If the source is not remembered, the participant has to make a guess since the task requires a source judgment for every old word. With probability a, the guess is "italic." With the complementary probability $(1 - a)$, the guess is "bold," a false response. If the word is not recognized (with probability $(1 - D_{\text{italic}})$), the participant may guess that the word is old (with probability b) or new (probability $(1 - b)$). The model assumes that there is no source memory if there is no memory for the word. Hence, if the participant guesses a word is old the source must be guessed as well. With probability g the guess is "italic"; with the complementary probability $(1 - g)$ the guess is "bold." This demonstration shows that there are several cognitive paths to the correct answer ("italic") based on distinct cognitive processes. Parameter interpretation is equivalent for bold test items (middle tree) and distracters (bottom tree). Parameters are estimated via maximum-likelihood estimation from the response frequencies aggregated across words and participants (Batchelder & Riefer, 1990, 1999; raw data in Appendix). Goodness of fit of the model to empirical data is evaluated with the χ^2-distributed log-likelihood ratio statistic G^2 (Hu & Batchelder, 1994). All analyses were conducted with the multiTree software (Moshagen, 2010).

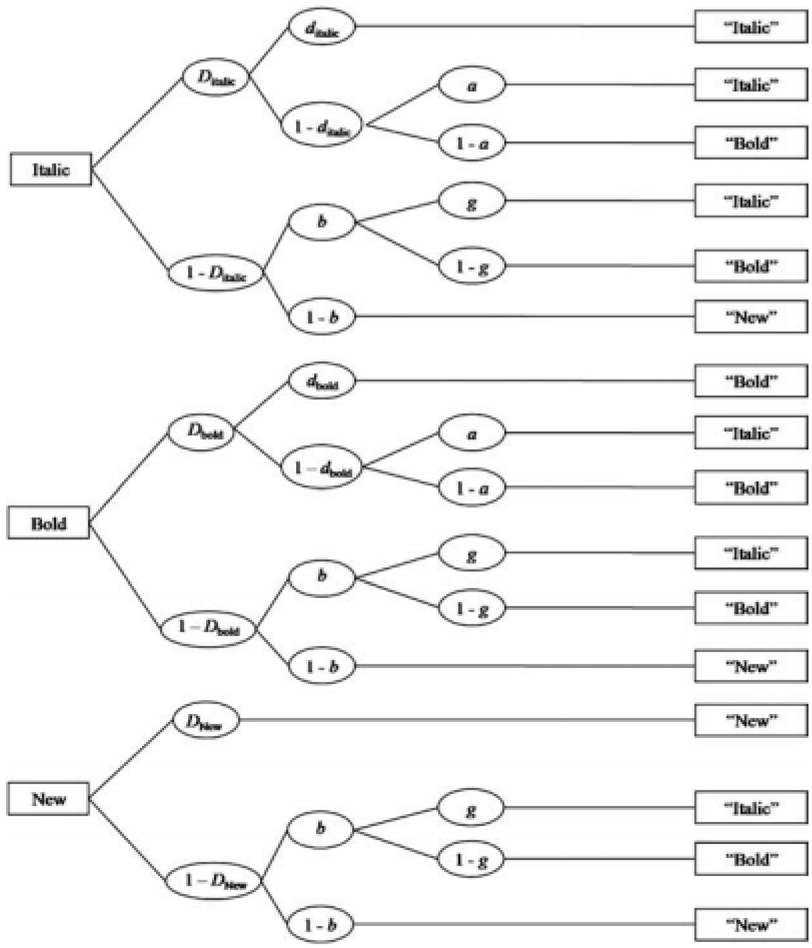

Figure 1. Two-high-threshold multinomial processing tree (MPT) model of source monitoring. D_{italic}/D_{bold} = probability of recognizing a word previously studied in italic/bold text; D_{New} = probability of knowing that a distractor item is new; d_{italic}/d_{bold} = probability of remembering the source of an italic/bold word; b = probability of guessing that an unrecognized word is old; a = probability of guessing "italic" for recognized words; g = probability of guessing "italic" for unrecognized words. Adapted from "Source discrimination, item detection, and multinomial models of source monitoring" by U. J. Bayen, K. Murnane, and E. Erdfelder, 1996, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, p. 202.

The model as depicted in Figure 1 has more parameters than degrees of freedom in the data and is thus mathematically not identifiable. Two parameter restrictions were made for the analysis of the present data (cf., Meiser et al., 2007): (1) Word memory was expected to be higher for bold/thrice words (D_{bold}) as opposed to italic/once words (D_{italic}) in the once-thrice conditions, thus requiring free word memory parameters. Distractor detection (D_{New}) was assumed to be limited by the lower bound of recognition memory and thus set equal to D_{italic}.[1] (2) Equal source memory for the two text types was assumed ($d_{italic} = d_{bold} = d$). The final model has six free parameters: Word memory for italic words ($D_{italic} = D_{New}$), word memory for bold words (D_{bold}), source memory (d), old-new guessing (b), source guessing for recognized words (a), and source guessing for unrecognized words (*g*). With six degrees of freedom in the data, this model is saturated and will thus always fit the data perfectly with $G^2(0) = 0$, $p = 1.00$. Parameter estimates are displayed in Table 1. No further parameter restrictions could be made in all conditions so this saturated model was used as a common baseline model. However, additional analyses ensured that testable overidentified submodels (see Bayen et al., 1996) fit the data from each condition well.[2] Parameter estimates from these overidentified models were in line with those in the saturated model. The fit of an overidentified model in each condition assures that the 2 HT MPT model is adequate for the present data. Because we cannot assess fit for the saturated model, we cannot compare alternative models for this data but we can nonetheless use this model as a measurement tool for the cognitive processes of interest.

As expected, word memory for italic and bold words did not differ in the all-once conditions for any age group, both $G^2(1) \leq 3.24$, $p > .07$. In the once-thrice conditions, word memory was significantly lower for italic/once as opposed to bold/thrice words, $G^2(1) = 129.94$, $p < .01$ for young adults and $G^2(1) = 191.63$, $p < .01$, for older adults. That is, the once-thrice manipulation was successful in creating source differences in word memory. In all conditions, older adults' word memory was lower than young adults', all $G^2(1) \geq 7.11$, $p < .01$. Older adults' source memory was also lower than young adults' in both conditions, both $G^2(1) \geq 4.53$, $p \leq .03$.

Of main interest to the present analysis are the source-guessing probabilities for recognized and unrecognized words because these reflect source judgments in the absence of source memory. In the all-once condition these were not expected to differ from each other and to be unbiased (.5). In the once-thrice condition participants relying on metacognitive knowledge should be more likely to attribute unrecognized (but guessed to be old) words to the source with low word memory (i.e., italic/once; parameter *g*) than recognized words (parameter *a*). As expected, source-guessing did not differ for unrecognized and recognized words in the all-once condition for either age group, both $G^2(1) \leq 1.82$, $p \geq .18$. All source-guessing parameters were at .5, meaning that participants split guesses equally between the two text types, all $G^2(1) \leq 2.9$, $p \geq .09$. For young adults in the once-thrice condition, guessing “italic/once” was significantly higher for unrecognized than for recognized words, $G^2(1) = 8.92$, $p < .01$. Both source-guessing parameters were significantly above .5, $G^2(1) = 5.99$, $p = .01$, for recognized words (parameter *a*) and $G^2(1) = 54.45$, $p < .01$, for unrecognized words (parameter *g*). This means, in the absence of source memory, young adults in the once-thrice condition were more likely to attribute words to the source with lower word memory (i.e., italic/once) and this bias was stronger for unrecognized words. For older adults in the once-thrice condition, guessing “italic/once” did not differ for unrecognized and recognized words, $G^2(1) = 0.42$, $p = .52$. Both source-guessing parameters were significantly above .5, $G^2(1) = 72.5$, $p < .01$, for recognized words (parameter *a*), and $G^2(1) = 68.15$, $p = .01$, for unrecognized words (parameter *g*). That is, in the absence of source memory, older adults in the once-thrice condition were more likely to attribute words to the source with lower word memory (i.e., italic/once) and this bias was equally strong for unrecognized and recognized words. In other words, older adults made their source judgments as if unrecognized and recognized words were equally likely to come from the italic/once source while young adults took into account that unrecognized words were more likely to come from this source than recognized words.

DISCUSSION

The biased source guessing in the once-thrice conditions shows that both young and older adults use their metacognitive knowledge when making source judgments. When sources differed in word memory young adults attributed most unrecognized items to the source with lower word memory if they could not remember the source. This bias was reduced for recognized items, which are less likely to stem from the source with lower word memory. Older adults did not differentiate their source guessing strategy based on word memory and were equally biased towards the source with lower item memory for recognized and unrecognized words. Source guessing was not biased towards either source in the all-once conditions.

The metacognitive monitoring data suggest spared monitoring in the older adult sample (e.g., Hertzog & Hultsch, 2000). JOLs were reasonably calibrated with gamma correlations above 0 in all conditions for both age groups (gammas were a bit lower numerically for older adults in the once-thrice condition compared to younger adults, but the difference was not reliable). Older adults' overall higher JOLs suggest they are more confident in their recognition ability than younger adults but for both age groups mean JOLs are well below the objective level of recognition (parameter D). Of even more current importance than age comparisons of overall monitoring accuracy and memory confidence is the finding that older adults assigned higher average JOLs to bold than to italic items in the once-thrice condition. This pattern of JOLs as well as the global difficulty judgments suggests that older adults monitored the difference in item memory between sources in the once-thrice condition well, which is most crucial for the interpretation of our source guessing results.

Despite similar metacognitive beliefs, young and older adults differ in their source-guessing pattern. Older adults fail to differentiate their source guessing for unrecognized and recognized words. Knowing that memory will be worse for italic items implies a larger guessing bias towards guessing “once/italic” for unrecognized than for recognized items. Since older adults are equally biased towards the source with low item memory for unrecognized as for recognized items, their source guessing is suboptimal given their metacognitive beliefs. Young adults show this reduction in bias based on the level of item recognition but are still slightly biased towards guessing “italic/once” for recognized items. This residual bias was also found in Meiser et al. (2007; Experiments 1 and 2). If sources are only believed to differ in item memory, guessing for recognized items should be biased towards the source with higher item memory (thrice/bold here). A residual bias towards the source with lower item memory for recognized items would only be warranted if participants also believed that source memory is worse for this source. Participants of both age groups likely believed that the repetition manipulation affected source memory similarly to item memory because making the source judgment was perceived to be more difficult for the italic than the bold source in the once-thrice condition. Although we did not include a measure directly assessing beliefs about source memory, a measure directly assessing beliefs about item memory (JOLs) and the related post-task difficulty judgment were similar. It is mathematically impossible to estimate both source memory for italic and bold items and source guessing for unrecognized and recognized words freely in the MPT model. In the analyses, source memory was restricted to be equal across text types (cf., Meiser et al.). For older adults in the once-thrice condition we could actually confirm that source memory did not differ since source guessing was equal for recognized and unrecognized words, $d$italic = 0.54, $d$bold = 0.64, $G^2(1) = 0.42$, $p = .52$. That is, young and older adults' source guessing was possibly influenced by false beliefs about source memory. Regardless of whether source memory differs between text types, knowledge about the source differences in word memory implies a change of guessing strategy for unrecognized and recognized words which was only observed in young but not in older participants.

A core assumption in our analysis and all multinomial models of source memory is that in the absence of item memory participants also cannot have source memory and must guess the source (e.g., Bayen et al., 1996; Dodson, Holland, & Shimamura, 1998; Klauer & Wegener, 1998; Meiser & Bröder, 2002; Riefer, Hu, & Batchelder, 1994). Recently, Starns, Hicks, Brown, and Martin (2008) demonstrated that source memory for unrecognized items can be above chance if participants are encouraged to adopt a very strict recognition criterion. Cook, Marsh, and Hicks (2006) provide evidence for some source memory on unrecalled items for which participants generally had substantial recognition memory. This partial item memory for unrecalled items likely contributed to the source memory results. Indeed, Cook et al. conclude that context information is very strongly bound to item information (see also Starns & Hicks, 2008). In the current study, we did not influence our participants' recognition criterion and our obtained source guessing parameter (parameter g) is equivalent for unrecognized items and distractor items for which there cannot be any source memory. Therefore, we conclude that source memory for unrecognized items in our paradigm is unlikely to be substantial and that source attributions for unrecognized items are mainly driven by source guessing.

The present findings are in line with the view of spared metacognitive monitoring but impaired use of such knowledge with age (e.g., Dunlosky & Connor, 1997). In the present experimental set up full use of metacognitive knowledge required a switch of guessing strategy between recognized and unrecognized words. Given that older adults show greater costs associated with switching between tasks (e.g., Mayr, 2001), they may have avoided switching response strategies in this experiment. If this is the case, older adults may only effectively use their metacognitive knowledge in source monitoring if it implies one overall consistent response strategy. The once-thrice manipulation inevitably made the study list longer (by 2.5 minutes). Though processing of repeated items should be easier this longer study duration may have particularly impacted older adults, possibly leaving them less capable to engage in more effortful strategy switching at test. Alternatively, the beliefs about source memory may have caused older adults' lack of differentiation. Possibly, older adults focused on the lack of source rather than word memory when making source attributions. In this case, older adults might be able to vary their response strategy for recognized and unrecognized words if they only perceive source differences in word (but not source) memory. Finally, while our results support the assumption of spared metacognitive monitoring during study (see Hertzog & Hultsch, 2000) there is evidence that older adults' monitoring during a memory test may be impaired (e.g., Kelley & Sahakyan, 2003, but also see MacLaverty & Hertzog, 2009). Older adults may have resorted to a non-changing strategy because they were not able to distinguish unrecognized from recognized items at test.

Older adults can reject a source based on recollected evidence incompatible with it (recall-to-reject) and can use the absence of expected distinct recollections to infer a source (*distinctiveness heuristic*; Gallo, Cotel, Moore, & Schacter, 2007). In our paradigm, participants were required to monitor the level of item recognition to infer the source in the absence of recollection. Older adults might have more problems monitoring familiarity-based recognition as opposed to monitoring recollection-based memory. Older adults' recollection-based memory monitoring is not completely spared either and varies with task aspects (Gallo, Bell, Beier, & Schacter, 2006; Gallo et al., 2007). In Gallo et al. (2007), older adults used both recollection-monitoring strategies within one task; however, use of the strategies was highly supported by the task format (prompted with differing test questions), which was not the case in our paradigm.

In summary, the current findings suggest that older adults rely on metacognitive knowledge when making source judgments. However, older adults appear unable to vary their response strategy based on level of word memory, resulting in less efficient use of their metacognitive knowledge. Consequently, older adults might benefit mostly from metacognitive knowledge in source monitoring if this knowledge implies a consistent source-response strategy.

FOOTNOTES

[1] Following Meiser et al. (2007), we assume that distractor detection is limited by the lower bound of target item recognition; that is, item recognition for italic items that is expected to be lower than for bold items in the once-thrice conditions. Setting distractor detection equal to the higher item recognition parameter D_{bold} in the once-thrice conditions leads to problems in fitting the model with the saturated model's $G^2(0) > 0$ because parameters would be at the boundary of the parameter space and thus inestimable. It is noteworthy that item recognition was fairly successful even for once presented items so that the lower bound for distractor detection was still allowed to be rather good despite this restriction. In the all-once conditions item recognition is equal for italic and bold items and results are the same if the alternative restriction ($D_{\text{New}} = D_{\text{bold}}$) is chosen.

[2] Both all-once conditions: Good fit of model with restrictions $D_{italic} = D_{bold} = D_{New}$, $d_{italic} = d_{bold}$, and $g = a$, $G^2(2) = 5.23$ for young and $G^2(2) = 1.51$ for old, both $p > .05$, $G^2(2)\text{crit} = 5.99$. Young, once-thrice condition: Good fit of model with restrictions $D_{italic} = D_{New} = D$ in all-once condition (.72); and $d_{italic} = d_{bold}$, $G^2(1) = 1.19$, $p > .05$, $G^2(1)\text{crit} = 3.84$. Old, once-thrice condition: Good fit of model with restrictions $D_{\text{italic}} = D_{New}$, $d_{\text{italic}} = d_{bold}$, and $g = a$, $G^2(1) = 1.83$, $p > .05$, $G^2(1)\text{crit} = 3.84$. Tests conducted on source guessing parameters in these overidentified models lead to the same conclusions as in the saturated model.

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Appendix

Raw Response Frequencies

	Participant response					
	Younger adults			Older adults		
Source	"Italic"	"Bold"	"New"	"Italic"	"Bold"	"New"
All-once condition						
Italic	385	199	166	353	200	197
Bold	195	417	138	245	328	177
New	67	54	1379	92	74	1334
Once-thrice condition						
Italic	530	49	171	429	41	280
Bold	95	627	28	216	472	62
New	92	18	1390	114	22	1364