The Effect of Age on Metamemory for Working Memory

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It has been proposed that deficits in metamemory may underlie the performance deficits shown by older adults in a variety of memory tasks. The present study examined metamemory accuracy of older adults ($n = 21$) and younger adults ($n = 32$) in a working memory task. On each of 18 trials, 6 words were presented for immediate serial recall. Recall level was predicted and postdicted, and compared with actual recall. Older adults recalled fewer words than younger adults, but both age groups showed characteristic phonological similarity and word length effects.

Metamemory accuracy was lower for older adults, who overestimated their recall performance. However, both age groups showed least accurate metamemory for phonologically similar words, and larger correlations between postdictions and recall than between predictions and recall. The results support the hypothesis that metamemory deficits in older adults may contribute to performance deficits in a working memory task.

It is commonly believed that memory declines with age. Because memory processes make an important contribution to many other cognitive processes, deterioration in memory function may underlie other cognitive decrements associated with age. Such decrements can have significant negative consequences for older adults, making it difficult to perform many daily activities. Memory failures can compromise the personal safety of older adults, and of those in their environment, and can create difficulties in the maintenance of interpersonal relationships. Understanding the changes in memory that are associated with aging is a necessary precursor to the development of strategies to counteract, or compensate for, age-related changes in memory.

A considerable body of research has addressed the issue of age related changes in memory, and has demonstrated that older adults often (but not invariably) show poorer performance in a variety of memory tasks. However, age differences are generally modest, and different types of memory seem to be affected to different degrees (Craik & Jennings, 1992; Schaie & Willis, 1996). In general, older adults show more decrements when the task is more effortful: recall is more impaired than recognition, explicit memory tasks are more impaired than implicit, and speeded tasks are more impaired than unspeeded (Craik & Jennings, 1992; Light & Albertson, 1989, Light & Singh, 1987; Rodgers & Herzog, 1987). Various explanations have been proposed to account for age related deficits in memory; the one of particular interest in the present context is the suggestion that metamemory deficits in older adults may underlie the observed memory deficits (Light, 1991).

Metamemory is a term used to describe what people know about their own memory and its functioning. Metamemory involves both an individual's knowledge about their personal attributes, memory abilities, and available memory strategies, and their perception of the memory demands of various tasks and situations (Dixon, 1989; Flavell & Wellman, 1977; Hertzog, Dixon, & Hultsch, 1990). If older adults are less able than younger adults to assess the demands of a memory task, then they may not allocate sufficient resources, or they may apply inappropriate strategies. Poor performance on a memory task could result from such strategic failures, even when memory abilities are intact. If changes in metamemory contribute to the memory deficits shown by older adults, then it may be possible to develop strategies for improving metamemory, and thus improve memory performance. Alternatively, if metamemory processes are not impaired in older adults, then it may be possible to capitalise on existing metamemory skills to alleviate the memory deficits. For these reasons, it has become important to investigate the contributions of metamemory to memory performance in older adults.

A number of studies have examined metamemory in older adults, using a variety of memory tasks and a variety of metamemory measures. One way of assessing metamemory involves self-report of global memory abilities; this is sometimes referred to as off-line assessment, since it is temporally separated from any particular memory task. Off-line assessment is typically accomplished through a questionnaire or interview (see, for example, Gilewski, Zelinski, & Schaie, 1990) in which people are asked to describe their memory beliefs, knowledge, and practice. When metamemory has been assessed in this way, it has been found that older adults report more memory difficulties than younger adults, believe that their memory ability has declined, and attribute memory failures to lack of personal control or ability (Hertzog et al., 1990; Lachman, 1991; Lachman & Leff, 1989). However, these self reports may (at least in part) reflect heightened sensitivity to memory lapses amongst older adults.

A second way of assessing metamemory is known as on-line assessment, and it also involves self-report. However, on-line assessment is more specific than off-line assessment, because people are asked to estimate or monitor their performance on a particular task, and the estimates are made in close temporal proximity to the memory task. Estimated performance is then compared with actual performance to determine metamemory accuracy.

Predictions, which are estimates made prior to task performance, involve estimation along both the external dimension of task difficulty and the internal dimension of available memory resources. Inaccurate predictions could reflect faulty estimation of task difficulty, of personal memory ability, or both. Postdictions, which are estimates made following task performance, provide an index of the accuracy of memory monitoring, as people are asked to judge how well (in either absolute or relative terms) they have performed a memory task (Lovelace, 1990).

A number of studies have compared estimation accuracy of different age groups in various memory tasks. Several studies have examined estimation accuracy in what could be called "medium-term" memory tasks, involving the recall of word lists. These studies typically find that young participants both perform better and show higher estimation accuracy than older participants. In fact, the estimates are often similar across age groups, resulting in overprediction for older participants, since their performance is lower. (Brigham & Pressley, 1988; Bruce, Coyne, & Botwinick, 1982; Lovelace & Marsh, 1985; Perfect & Stollery, 1993). However, there are exceptions to this trend: Hertzog, Saylor, Fleece, and Dixon (1994) observed higher prediction accuracy for older adults than for younger adults, both for predictions made prior to study and for predictions made after study but prior to recall.

Other studies have examined estimation accuracy of different age groups in memory span tasks. Here, the usual result is that although younger adults show larger memory spans that older adults, their prediction accuracy is similar. For example, Murphy, Sanders, Gabriesheski, and Schmitt (1981) found that memory span was larger in the young adults (7.7 items) than in the older adults (4.7 items). Prediction accuracy was similar in the two age groups, with a mean prediction error of 0.7 items for both young and old. However, the direction of the error was different: the younger adults underpredicted and the older adults overpredicted their actual memory spans.

A more comprehensive study of metamemory accuracy in older adults was reported by Devolder, Brigham, and Pressley (1990). They investigated metamemory differences between older and younger participants in a range of memory tasks. For each of the seven tasks, half the participants predicted performance, and half postdicted performance. In terms of actual performance, younger participants performed better than the older for word recall, face-name matching, and prose recall, whereas older participants were better than younger for appointment keeping. (There were no age differences in the word recognition, vocabulary, or digit span tasks.) The age groups differed in their prediction accuracy for three tasks: younger adults showed higher prediction accuracy for word recognition, face-name matching, and vocabulary task. In contrast, there were no age differences in postdiction accuracy for any task. For all tasks and both age groups, postdictions were more accurate than predictions.

The goal of the present study was to extend the study of metamemory in older adults, by comparing the metamemory accuracy of older and younger adults in a working memory task. Working memory is a short-term, transient memory which is involved in the temporary maintenance of information for further processing. Deficits in working memory have been identified as an underlying cause of many of the deficits in cognitive functions that are observed in older adults (Salthouse, 1992). Despite the important role attributed to working memory as a determinant of overall cognitive function, and the fairly extensive study of working memory in different age groups, little attention has been given to metamemory for working memory. Thus, very little is currently known about awareness or self-monitoring of working memory function, or whether such awareness changes with age.

The working memory task used in the present study involved the presentation of a set of words for immediate serial recall. Such a task resembles a memory span task, except that there is no variation across trials in the number of words presented; instead the type of words are varied. A brief overview of working memory will elucidate the rationale underlying the working memory task.

One particularly influential model of working memory is that developed by Baddeley (1986, 1992). According to Baddeley, working memory consists of three components: a phonological loop which handles short term storage of auditory and verbal information, a visuo-spatial sketch pad which is responsible for short term storage of visual and spatial information, and a central executive which monitors and coordinates the subsystems.

Several characteristic patterns of performance have been observed in working memory tasks with verbal material. The two that are of interest here are the phonological similarity effect and the word length effect. The phonological similarity effect refers to the decrement in recall that is observed when words are phonologically similar, relative to dissimilar words, and the word length effect refers to the decrement in recall that is observed for long words relative to short words. Both effects reflect the operation of the phonological loop component of working memory; when phonological loop activity is blocked by articulatory suppression, the effects are eliminated.

The central focus of the present study was to examine the extent to which younger and older adults were able to predict and postdict the changes in recall performance induced by variations in the type of words presented. Older and younger adults completed a standard working memory task, in which the nature of the words varied across trials. Measures of actual, predicted, and postdicted recall were made, in order to investigate age differences in metamemory accuracy.

Method

Participants

The sample of older adults comprised 21 participants, 13 women and 8 men. All older participants were in the age range of 60 to 74 years, with a mean age of 65.8 years. Older adults were recruited at a church-based senior citizen group and a fitness centre in Palmerston North, New Zealand. Data from one additional female participant were discarded because her age was outside the target range.

There were 32 young adult participants, 24 women and 8 men. The mean age of the younger participants was 23.0 years. Younger adults were undergraduate psychology students at Massey University, Palmerston North, and received course credit or a small honorarium for participation.

No attempt was made to match the two age groups for educational background, vocabulary, or general intelligence. Although such variables may influence performance, we felt that the costs of matching (in terms of restricting the pool of potential participants) outweighed the benefits. Moreover, matching for educational background would probably have produced non-representative samples, because tertiary participation rates have changed substantially between the 1930s (when the older adults would have been of tertiary age) and the 1990s.

All participants completed a consent form and brief screening questionnaire prior to participation. The screening questionnaire solicited information about the participant's medical history, and memory difficulties previously experienced by the participant. Visual acuity was not explicitly tested, but none of the participants reported difficulty in seeing the stimulus words or the instructions on the screen.

Materials and Apparatus

Three sets of ten English words were used: phonologically similar words, long words, and control words. The phonologically similar words were single syllable rhyming words; the words which comprised this set were *bug, dug, drug, hug, mug, jug, plug, rug, slug,* and *tug*. The long words, which were three syllables in length, were *adventure, basketball, carpenter, chocolate, committee, happiness, industry, magazine, protection,* and *settlement*. Control words were both short (one syllable) and phonologically dissimilar, so that they served as controls for both the long and the similar words. The ten control words were *broom, chain, dip, fine, hut, lie, pad, sale, sock,* and *trick*. On any given trial, six different words were selected from one of the sets of ten words. The frequency with which each word occurred across trials was approximately equal.

The experimental trials were presented on either an Excel IBM-clone personal computer with a low resolution CGA screen (younger adults) or a Toshiba T1600 laptop computer with monochrome LCD screen (older adults). The software used to present the instructions and stimuli, and to record predictions and postdictions, was designed by the authors and programming staff in the School of Psychology.

Procedure

All participants completed 18 trials of a simple working memory task. The experimental trials were preceded by four practice trials for the younger adults, and six practice trials for the older adults. The practice trials allowed participants to become familiar with the sequence of events that constituted a trial, to become familiar with the location and operation of the spacebar and numeric keys, and to adjust viewing distance and room illumination so that the computer screen could be easily seen.

On each trial a series of six words was presented visually for subsequent written recall. Presentation rate was self paced; participants were instructed to press the spacebar to trigger the display of the next word. (Time spent viewing each word was recorded, but the viewing time data are not reported here.) Presentation of the six words was followed by a 15 second recall period, during which participants were instructed to write the words they remembered in their correct serial positions. Appropriate response sheets were provided for this purpose.

At the beginning of each trial, participants were informed about the type of words that would be used on that trial, and asked to estimate (predict) the number that they would be able to recall in the correct order. When the recall period ended, participants were asked to estimate (postdict) the number of words they had recalled in the correct position. Participants used the keyboard to enter their predictions and postdictions.

All participants completed the experimental task individually. Younger adults completed the experiment in a small laboratory room within the School of Psychology. Most of the older adults were tested in their own homes, although some chose to complete the experiment at the School of Psychology or at another convenient location. Different experimenters tested the younger and older participants.

Results

Two-way mixed ANOVAs were conducted on actual recall, predicted recall, and postdicted recall. In all three analyses, age was a between-subjects factor, and word type was a within-subjects factor. Figure 1 shows predicted, actual, and postdicted recall for the two age groups.

The first important feature of the results is that word type influenced all three recall measures. Control words were better recalled than were phonologically similar or long words, $F(2, 102) = 54.64$, $p = .0001$. Likewise, predicted recall was higher for control words than for the other word types, and postdicted recall was higher for control words than for the other word types; $F(2, 102) = 22.65$, $p = .0001$ for predictions, and $F(2, 102) = 26.01$, $p = .0001$ for postdictions.

The second important feature is that both actual recall and postdicted recall showed an age effect. Across the three word types, older adults recalled fewer words ($M = 3.07$, $SD = 0.73$) than younger adults ($M = 3.89$, $SD = 0.90$), $F(1, 51) = 12.32$, $p = .0009$. Postdictions varied as a function of age, $F(1, 51) = 4.71$, $p = .0346$, with older adults postdicting 3.42 words ($SD = 0.77$) and younger adults postdicting 3.94 words ($SD = 0.91$). With respect to predicted recall, although older adults predicted fewer words ($M = 3.57$, $SD = 0.54$) than did younger adults ($M = 3.96$, $SD = 0.88$), the difference was not significant, $F(1, 51) = 3.22$, $p = .0787$.

None of the recall measures (actual, predicted, postdicted) showed an interaction between age and word type; for actual recall, $F(2, 102) = 1.36$; for predicted recall, $F(2, 102) = 0.90$; and for postdicted recall, $F(2, 102) = 0.03$.

Correlations were also computed between the metamemory measures and actual recall. These are shown in Table 1, separately for the two age groups and the three word types. All of the correlations were positive, and all except one were significant. However, the correlations between postdictions and actual recall were consistently larger (for all word types and both age groups) than the correlations between predictions and actual recall. Younger adults produced higher correlations for postdictions than the older adults, although the differences were not significant when compared using Fisher's r to z transformation. There was little difference between the two age groups in the magnitude of the correlations between predictions and actual recall.

Inspection of Figure 1 also suggests that, although both age groups showed variations in predictions and postdictions that followed the variations in actual recall, younger adults showed higher metamemory accuracy than older adults. This possibility was investigated by calculating two measures of metamemory accuracy, prediction error and postdiction error. Prediction error was the signed difference between predicted and actual recall, and postdiction error was the signed difference between postdicted and actual recall. Table 2 shows prediction error and postdiction error for the two age groups and the three word types. (Note that positive error values indicate that the estimate was higher than the actual recall, and hence represent overprediction; conversely, negative error values indicate that the estimate was lower than the actual recall, and hence represent underprediction.)

Prediction error and postdiction error were analysed using a three way mixed ANOVA, with age as a between-subjects factor, and error measure and word type as within-subjects factors. Older adults were less accurate in their estimates than younger adults, $F(1, 51) = 4.55$, $p = .0378$. The mean estimation error for older adults was 0.43 words ($SD = 0.49$), whereas the mean estimation error for younger

Figure 1. Predicted recall, actual recall, and postdicted recall for older and younger adults as a function of word type.

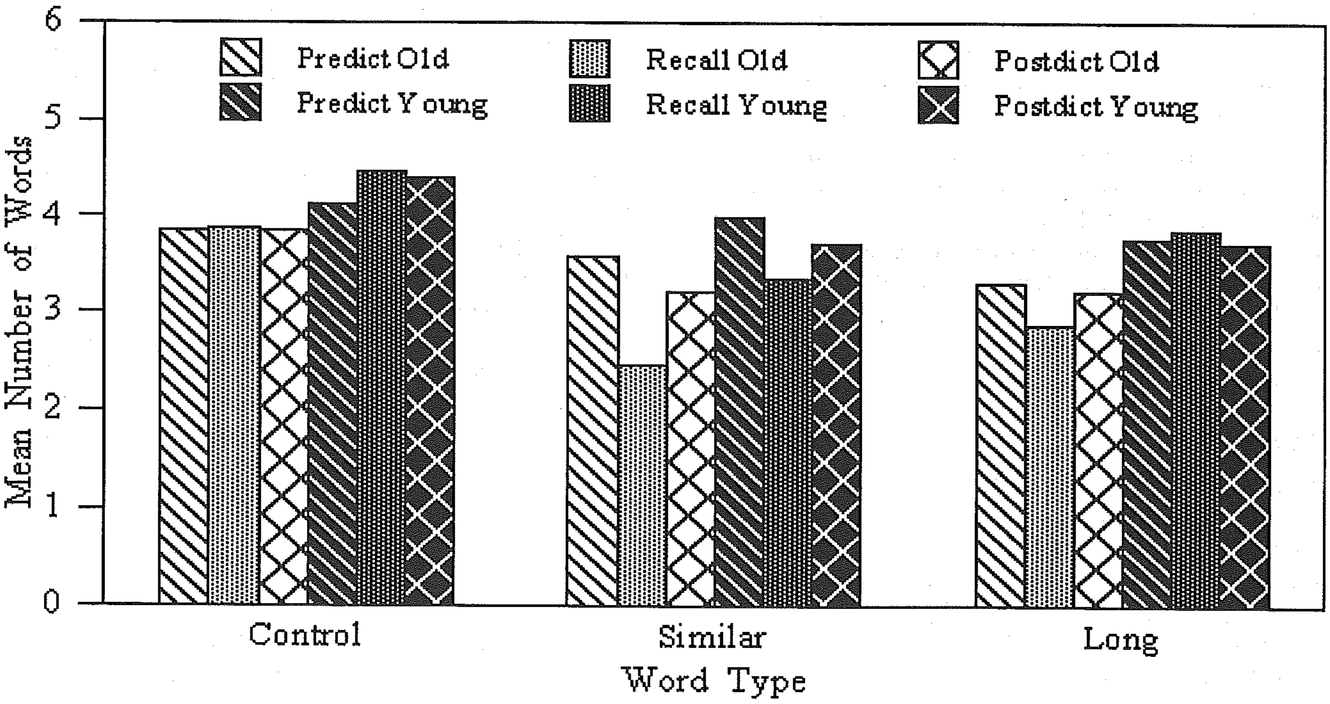

Table 1. Correlations between (a) predicted and actual recall and (b) postdicted and actual recall, for older and younger adults, as a function of word type.

Correlation between actual recall and	Older Adults (n = 21)	Younger Adults (n = 32)
(a) Predicted recall		
Control words	.541 *	.531 **
Similar words	.503 *	.378 *
Long words	.418	.403 *
(b) Postdicted recall		
Control words	.710 **	.789 **
Similar words	.600 **	.742 **
Long words	.687 **	.718 **

* $p < .05$, ** $p < .01$

Table 2. Mean (SD) prediction and postdiction errors for older and younger adults, as a function of word type

	Older Adults (n = 21)		Younger Adults (n = 32)	
Prediction error	Mean	(sd)	Mean	(sd)
Control words	-0.031	(0.83)	-0.348	(0.99)
Similar words	1.119	(0.75)	0.636	(1.07)
Long words	0.437	(0.77)	-0.094	(1.07)
Postdiction error				
Control words	-0.030	(0.73)	-0.079	(0.72)
Similar words	0.746	(0.75)	0.361	(0.70)
Long words	0.349	(0.62)	-0.136	(0.77)

Note: Positive error values indicate overprediction of recall, negative error values indicate underprediction of recall.

adults was 0.06 words (SD = 0.70). There were no interactions involving age.

The mean prediction error of 0.24 words (SD = 0.83) was not significantly different from the mean postdiction error of 0.17 words (SD = 0.58), $F < 1$. However, word type significantly affected estimation error, $F(2, 102) = 33.85$, $p = .0001$, and there was a significant interaction between word type and error measure, $F(2, 102) = 10.82, p = .0001$. Estimation error was greater for similar words (M = 0.67, SD = 0.79) than for long words (M = 0.09, SD = 0.81) or control words (M = -0.14, SD = 0.73), and the magnitude of the difference between prediction error and postdiction error varied across the three word types.

Discussion

The purpose of the present study was to compare metamemory for working memory in older and younger adults. Before considering metamemory, some comments about actual recall performance in the working memory task are appropriate.

Older adults were both similar to and different from younger adults in their working memory performance. Older adults were similar to younger adults in their pattern of performance: both age groups showed characteristic word length and phonological similarity effects. Control words, which were short and dissimilar, were better recalled than either long words or phonologically similar words. Baddeley's model of working memory, which features a phonological loop responsible for the temporary maintenance of verbal material, predicts such effects (Baddeley, 1986, 1992). Phonological similarity and word length effects have been demonstrated in numerous studies, and across different age groups (Baddeley, Lewis, & Vallar, 1984; Baddeley, Thompson, & Buchanan, 1975; Morris, 1984).

However, older adults were different from younger adults in the absolute level of their performance. Across the three word types, the older adults recalled fewer words than the younger adults. This result is consistent with prior studies of memory span, which have usually shown that older adults have a smaller span capacity than do younger adults (Kausler & Puckett, 1979; Murphy et al., 1981; Salthouse & Babcock, 1991; Wingfield, Styne, Lahar, & Aberdeen, 1988). Although the absolute decrement in recall for older adults relative to younger adults of 0.82 words appears small, a better appreciation can be obtained by considering the percentage of words correctly recalled. Younger adults recalled 64.8% of the words, whereas older adults recalled 50.3% of the words, indicating an age related decrement of 14.5%. If the performance achieved by the younger adults is treated as the maximum recall value, then the decrement of 0.82 words represents a 21% drop in performance for older adults. These decrements in performance are similar to those reported in the studies cited above.

Turning to the topic of metamemory, a similar conclusion to that regarding performance can be made: older adults were both similar to and different from younger adults. Older adults were similar to younger adults in several respects: the variation in estimates as a function of word type, the larger correlations for postdictions than for predictions, and the differences in estimation accuracy for different word types. The major difference between older and younger adults was the decreased estimation accuracy shown by the older adults.

Both age groups showed variations in predictions and postdictions as a function of word type, and the variations in estimates corresponded to the variations in actual recall. The parallel effects of word type on the three measures (actual, predicted, and postdicted recall) indicates that both older and younger participants were aware of the variations in their recall performance, and implies a similarity in metamemorial processes across age groups.

An additional indication that metamemorial processes are similar in the two age groups is the finding that the postdiction-recall correlations were larger than the prediction-recall correlations for both older and younger adults, and age did not influence the magnitude of the correlations. As noted earlier, predictions and postdictions reflect different aspects of metamemory, and involve different types of judgments. Predictions require estimation of both task difficulty and memory ability, whereas postdictions require a single judgement along the dimension of performance accuracy. It appears that both age groups find the latter judgement an easier one to make.

A more precise assessment of metamemory accuracy was provided by the prediction error and postdiction error measures, calculated by subtracting estimated recall from actual recall. The two age groups did show a difference in their overall estimation error: the older adults overestimated their recall by 0.43 words, whereas the younger adults' estimate was only 0.06 words greater than their actual recall of 3.89 words. The overestimate made by older adults, although small in absolute terms, corresponds to a 14% overestimation of their actual recall performance of 3.07 words.

This result resembles those reported in other studies of metamemory for recall of word lists, where overestimation of performance by older adults is often reported. Studies of metamemory for supra-span word lists have traced the overestimations made by older adults result to a combination of similar estimates across age groups, but decreased performance by the older adults (Brigham & Pressley, 1988; Bruce et al., 1982; Lovelace & Marsh, 1985; Perfect & Stollery, 1993). Murphy et al. (1981) found that both performance and estimates were lower for older adults in a word span task; however, older adults overestimated performance whereas younger adults underestimated performance. In the present study, older adults showed a decrement in both performance and estimates, but the decrease in actual recall was greater than the decrease in estimated recall.

The task used in the present study was a simple working memory task, using a small number of familiar words and self paced presentation. A more complete understanding of metamemory for working memory in older adults would necessitate the use of a complex working memory task (see, for example, Daneman & Carpenter, 1980; Light & Anderson, 1985; Salthouse & Babcock, 1991), coupled with speeded presentation and other types of stimuli. Using a more difficult version of the working memory task is particularly important, since age deficits in performance are often more marked when a more difficult task is employed. It may be the case that metamemory accuracy also covaries with task difficulty, and that the small inaccuracies shown in the kind of task used here are magnified in a more difficult task.

The observation of reliable age differences in both performance and metamemory in the simple task employed here demonstrates that age affects working memory functioning and awareness of that functioning. However, although these results indicate that both performance and metamemory accuracy in a working memory task show some decreases as a function of age, the patterns of recall performance and of variations in metamemory are consistent across age groups. There is a quantitative difference between older and younger adults, but not a qualitative one. This implies that the underlying memory and metamemory processes are not fundamentally different in older adults, although efficiency may be reduced.

Furthermore, because the decrement in actual performance is greater than the decrement in metamemory accuracy, it would seem that a deficit in metamemory cannot explain completely the poorer recall performance shown by the older adults. Looking at this finding from another angle, it appears that metamemory is better preserved than actual memory ability in older adults. Such a conclusion is cause for optimism, because the ability of older adults to utilize metamemory strategies may help to compensate for age-related declines in memory processes. It may even be possible to build on metamemory skills when impairments in memory are the result of injury or degenerative disease. Given the centrality of memory to everyday activities, and the increasing proportion of older adults in the population, developing a better understanding of metamemory functioning in older adults has important practical implications.

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