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OLDER AND YOUNGER ADULTS' STRATEGIC CONTROL OF METACOGNITIVE MONITORING: THE ROLE OF CONSEQUENCES, TASK EXPERIENCE, AND PRIOR KNOWLEDGE

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Background/Study Context: *Although explicit memory abilities decline during older adulthood, there is evidence that suggests that metacognitive capabilities are relatively well preserved. However, it is unclear what effect aging, consequences of forgetting, prior knowledge, and task experience have on the strategic control and use of one's metacognitive capabilities.*

Methods: *In the current study, older and younger adults were presented with six unique lists of words (Experiment 1), related and unrelated word pairs (Experiment 2), or items within specific scenarios (e.g., items to bring on a picnic; Experiment 3). For each item, participants assigned it a point value (from 0 to 10) that was akin to "betting" on the likelihood the item would be remembered. If the item was recalled (free recall in Experiments 1 and 3, cued recall in Experiment 2), participants received the points they had assigned to it, but if the item was forgotten they lost those points. Participants were told to maximize their point score and were told their score at the end of each list.*

Results: *Although younger adults remembered more words in Experiment 1, older and younger adults were equally able to remember items assigned higher values, and accuracy of predictions and point scores increased with task experience. In Experiments 2 and 3, when participants were able to rely on semantic knowledge, age-related differences in memory performance were eliminated.*

Conclusion: *The results suggest that both younger and older adults achieve accurate metacognitive insight and are able to use this knowledge strategically in order to maximize goal-related memory outcomes and performance.*

Metamemory refers to one's awareness of and insight into his or her own memory and how it works. Metamemory includes beliefs about one's memory abilities and task demands, insight into memory changes, and knowledge of memory functioning (Dunlosky & Metcalfe, 2009). As memory abilities decline during aging, the role that metamemory can assume during the learning process becomes even more important (Hertzog & Dunlosky, 2011), and the ability to accurately monitor one's memory is vital to efficient cognitive functioning. If one is aware of what information might be remembered or forgotten, then actions can be taken to increase the odds of remembering, such as engaging additional cognitive and attentional resources. The current study examines whether older and younger adults are able to learn, with task experience, to exert strategic control over metacognition monitoring when there are consequences tied to metacognitive judgments.

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Studies of metamemory often require participants to make judgments of learning (JOLs) about what they will later remember, and accuracy of these JOLs can be assessed. Relative accuracy examines whether the JOLs assigned by an individual can distinguish between what information is later remembered versus forgotten (Nelson, 1984, 1996), and better relative accuracy occurs when higher JOLs are given to information later recalled, and lower JOLs are given to information forgotten at test. Investigations into the effects of aging on the relative accuracy of JOLs have often found little to no age-related differences (Connor, Dunlosky, & Hertzog, 1997; Hertzog, Sinclair, & Dunlosky, 2010; Hines, Touron, & Hertzog, 2009; see Hertzog & Dunlosky, 2011, for a recent review), or even slightly more accurate performance by older adults (Hertzog, Kidder, Powell-Moman, & Dunlosky, 2002). This sparing suggests that older adults may be able to use metacognitive strategies or awareness to help overcome or compensate for age-related declines in memory performance.

The ability to use metacognitive insight in a strategic manner is consistent with selective optimization with compensation (Baltes & Baltes, 1990), which suggests that successful aging is linked to older adults' ability to selectively invest limited cognitive resources into areas that yield optimal returns. Thus, accurate metacognitive insight might have a more direct impact on memory performance in its ability to modify attention and goal-directed processing in a strategic manner (Castel, McGillivray, & Friedman, 2012; Hertzog & Dunlosky, 2011).

The investigation of strategy usage is usually examined as a topic of metacognitive control (e.g., study time allocation, study choices, etc.). Prior research has shown that younger and older adults rely on similar strategies such as choosing to spend more time studying or restudying items deemed less well learned (e.g., Dunlosky & Hertzog, 1997; Hines et al., 2009); for an exception see Dunlosky & Connor, 1997), or more valuable items (i.e., items worth more points; Castel, Murayama, Friedman, McGillivray, & Link, 2013; Price, Hertzog, & Dunlosky, 2010). These results suggest that older adults are able to effectively monitor their memory as well as younger adults and can also effectively exert control over strategic study behaviors.

Strategy usage is often a product of goal-directed behavior, an element that is typically absent when one forms a JOL. In a standard JOL task, participants passively assign a numerical judgment of how likely they will remember an item, with no direct consequence or outcome tied to these predictions. However, the current studies bridge the gap between metacognitive monitoring and control through the introduction of consequences tied to metacognitive predictions. That is, in the current studies, participants were asked to "bet" on the likelihood they would recall an item, and there were consequences associated with the accuracy of those bets. This use of bets as opposed to more passive JOLs allows for the examination of potential age-related differences in strategic control within one's metacognitive monitoring behavior.

The current studies extend upon a novel paradigm employed by McGillivray and Castel (2011), in which participants were presented with lists of words paired with varying point values that indicated how much that word was worth. As participants were shown each item, they had to "bet" (yes or no) which items they would be able to remember. For any given item, if a participant bet on it, they would receive whatever points were associated with that item if they were later able to recall it but would lose those points if they failed to recall it. Thus, there were rewards associated with

accurately monitoring and predicting which items would be recalled, and penalties if one failed to do so. It was found that both younger and older adults strategically bet on and recalled more of the high-point-value relative to the low-point-value items, and there were no age differences in memory performance for the highest valued items, consistent with previous literature (Castel, Benjamin, Craik, & Watkins, 2002; Castel, Farb, & Craik, 2007). Both younger and older adults were highly overconfident on initial lists (i.e., they bet on more items than they were actually able to recall), but this was significantly reduced with task experience.

Forgetting important information can have consequences, such as if one forgets to take certain critical medication, or if one forgets to bring his or her passport for an international trip. The introduction of consequences tied to metacognitive monitoring judgments utilized by McGillivray and Castel (2011) is a departure from standard metacognition paradigms. It is, however, ecologically valid given that there are often consequences tied to our metacognitive predictions in daily life. For example, a student may choose to stop studying if she believes she has mastered the material, or an older adult may fail to write down important information given to him by a doctor if he thinks he will be able to remember it later.

The use of consequences introduces an important aspect of risk and could potentially create a more stressful situation that could impact performance. However, the incorporation of incentives, can also enhance participants' vigilance and awareness (Persaud, McLeod, & Cowey, 2007), resulting in increased motivation to accurately calibrate their predictions to their actual performance abilities. Motivation, incentives, and accountability have been shown to increase performance on various cognitive tasks (e.g., Germain & Hess, 2007; Hess, Germain, Swaim, & Osowski, 2009; Touron, Swaim, & Hertzog, 2007), and older adults in particular may benefit from these added incentives (Adams, Smith, Pasupathi, & Vitolo, 2002; Hess, Rosenberg, & Waters, 2001).

In addition, the use of multiple trials in the investigation of strategic metacognitive monitoring is necessary, and there is evidence that selectivity may only emerge with task experience (Castel, Balota, & McCabe, 2009; McGillivray & Castel, 2011). Some studies have found that older adults' ability to accurately update metacognitive predictions are impaired relative to younger adults (Matvey, Dunlosky, Shaw, Parks, & Hertzog, 2002; Price, Hertzog, & Dunlosky, 2008); however, other studies have found comparable benefits of task experience by both younger and older adults (Dunlosky & Hertzog, 2000; Hertzog & Dunlosky, 2011; McGillivray & Castel, 2011; Tullis & Benjamin, 2012). From a more general standpoint, all of the research suggests that both older and younger adults lower their predictions and correct initial overconfidence with task experience.

The role of task experience and feedback may be particularly important for older adults (e.g., Jacoby, Wahlheim, Rhodes, Daniels, & Rogers, 2010) in order to learn to calibrate predictions with actual performance. Online monitoring needed for accurate predictions may tax attentional and working memory systems that can become compromised in old age (Bieman-Copland & Charness, 1994; Craik, 2002; Craik & Byrd, 1982; Hasher & Zacks, 1988), and older individuals may require more time and experience to adopt appropriate strategies and reach levels of performance on par with younger adults (McGillivray & Castel, 2011; Rogers, Hertzog, & Fisk, 2000; Touron, Hoyer, & Cerella, 2004).

EXPERIMENT 1

It is important to accurately assess what information will later be remembered, as well as what information might later be forgotten. Point values associated with items are a salient cue younger and older adults use to guide metacognitive predictions (McGillivray & Castel, 2011; Price et al., 2010). However, it is unclear, when under the control of participants, whether older and younger adults will be able to strategically allocate value (i.e., points) relative to their own memory abilities. In the current study, participants viewed items one at a time and had to assign a value from 0 to 10. The value assigned was how many points participants received if they later recalled the item, but also how many points they lost if the item was not recalled. Participants engaged in six study-test cycles (with unique items on each list) and were given feedback regarding their overall point score at the end of each list.

Requiring participants to assign value is similar to standard JOL paradigms and allows for more direct comparisons with prior metacognitive monitoring and aging research. The "bet" (i.e., point value) assigned in the current studies is similar to a JOL in that if one thinks an item will be recalled later, a higher value should be given. However, the bets also need to be strategic and require the use of metacognitive control processes in that individuals have to learn to only assign high values to items that they actually are able to later recall. If metacognitive monitoring and control are relatively intact across adulthood, then older adults, while potentially recalling fewer items, should achieve comparable levels of metacognitive resolution as do younger adults. Alternatively, if cognitive resources are utilized in the process of attempting to strategically assign values, this might create a situation that is potentially detrimental to some measures of performance, particularly for older adults.

METHODS

Participants

The participants consisted of 28 older adults (16 females, M_{age} = 76.1, SD = 6.8) and 24 younger adults (19 females, M_{age} = 20.8, SD = 3.1). Older adults were all living in the Los Angeles area and recruited through community flyer postings as well as through the University of California, Los Angeles (UCLA) Cognition and Aging Laboratory Participant Pool. Older adults had participated in prior, unrelated studies within the laboratory an average of 1.2 times before (range: 0–2). Older adults had good self-reported health ratings (M = 8.4 on a scale of 1–10, with 1 indicating extremely poor health and 10 indicating excellent health) and had an average of 17.4 years of education. Older adults were screened in terms of being able to understand instructions and performed within normal age- and education-adjusted ranges on the forward (M = 7.11, SD = 1.20) and backward (M = 5.32, SD = 1.02) digit spans (Choi et al., 2014; Wechsler, 1997). Older adults were paid $10 an hour for their time and reimbursed for parking expenses. Younger adults were all University of California, Los Angeles undergraduates and received course credit for their participation.

Materials

The materials utilized in Experiment 1 were identical to those used in McGillivray and Castel (2011), and consisted of 72 common nouns. All of the words were four or five letters in length (e.g., lion, radio, train). The words were randomly assigned without replacement into one of six different lists, and each list contained 12 words. The list length of 12 words was chosen because it has been shown to be of sufficient length to prevent both floor and ceiling effects among younger and older adults (Castel et al., 2002; McGillivray & Castel, 2011).

Procedure

Participants were told that they would be presented with six different lists of words on a computer, and that each list contained 12 words. They were told that for each word they would need to assign a point value from 0 to 10. If they were later able to remember that word on an immediate free recall test, they would receive the points they had indicated they wanted it to be worth. However, if they failed to recall the word, they would lose those points. Participants were informed to think of it like they were betting on their memory. Participants were told they could use the values as many times as they wanted (e.g., assign numerous words "8"), and they were told that a value assignment of "0" should be given if they did not think they would be able to recall an item. Participants saw each word for the same amount of time, regardless of the point value assigned. Participants were also told the goal was to try to get as many points as possible and were encouraged to try to maximize gains and to minimize any losses.

Participants were shown the words one at a time on a computer, each for 5 seconds. Pilot data revealed that 5 seconds was sufficient for participants to read the word and make a judgment. As each word was presented, participants had to indicate how many points they wanted that word to be worth. All responses were made verbally and were recorded by an experimenter. After all 12 words were presented, a 30-second free recall test was given in which participants had to verbally recall as many words as they could from the list (they did not need to recall the point values). Immediately following recall, participants were informed of their score for the list but were not given feedback about specific items. Scores were calculated by summing the points associated with the words successfully recalled and then subtracting the number of points associated with the words that were not recalled. The next list began immediately after the scores were calculated and the feedback was given, and this procedure was repeated for all six lists.

RESULTS AND DISCUSSION

Recall Performance

The average number of words recalled as a function of list are presented in Figure 1A. All analyses conducted on task experience (i.e., list) were done collapsing across lists 1–2, 3–4, 5–6, creating the variables "initial lists," "middle lists," and "later lists." A 2 (age group) × 3 (list) analysis of variance (ANOVA) was conducted, and Mauchly's test of sphericity indicated no violations, $\chi^2(2) = 0.68$, $p = .71$. Older adults recalled fewer words

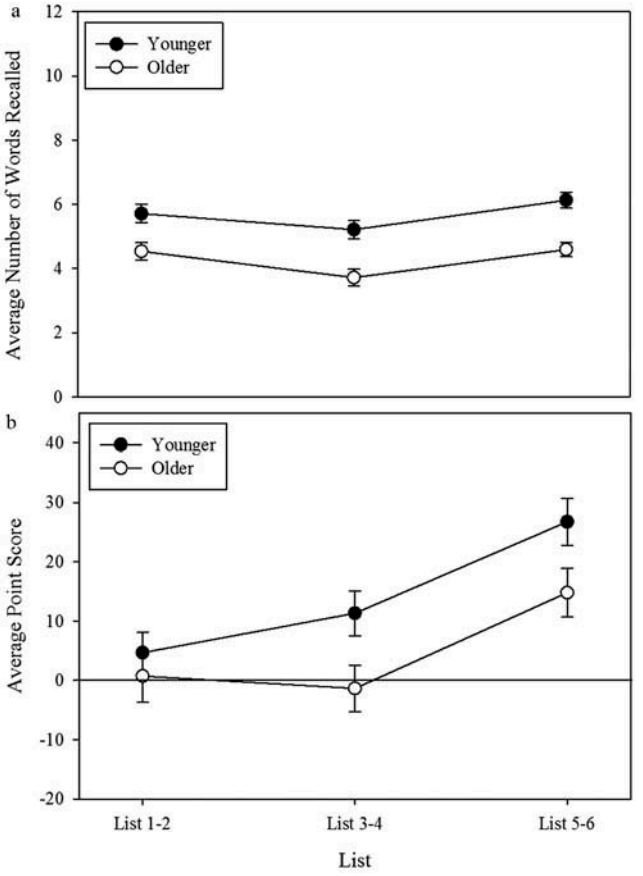

Figure 1. (*A*) The average number of words recalled by both older and younger adults across the six study-test lists in Experiment 1. (*B*) The average overall point score achieved on each list by both older and younger adults in Experiment 1. Error bars represent standard error of the mean.

than younger adults, $F(1, 50) = 19.64$, $MSE = 3.87$, $p < .001$, $\eta_p^2 = .28$, there was an effect of list, $F(2, 100) = 14.19$, $MSE = 0.79$, $p < .001$, $\eta_p^2 = .22$, but no significant age group by list interaction ($p = .53$).

Point Score

The average point scores, a measure of overall performance, for both younger and older adults are displayed in Figure 1B. A 2 (age group) × 3 (list) ANOVA was conducted, and Mauchly's test of sphericity indicated no violations, $\chi^2(2) = 0.15$, $p = .93$. Older adults had lower scores compared with younger adults, $F(1, 50) = 4.09$, $MSE = 861.21$, $p < .05$, $\eta_p^2 = .08$. Importantly, scores increased with task experience, $F(2, 100) = 26.04$, $MSE = 192.36$, $p < .001$, $\eta_p^2 = .34$, and no significant interaction was observed ($p = .21$).

Metacognitive Accuracy

Metacognitive accuracy was assessed through gamma correlations, a measure of resolution between the point value bets and recall, and the results are presented in Figure 2. A gamma correlation was computed for each participant, and these correlational values served as the dependent variable in a 2 (age group) × 3 (list) ANOVA. Mauchly's test of sphericity indicated no violations, $\chi^2(2) = 1.36$, $p = .51$. Gamma correlations between point value bets and recall were similar for older ($\gamma = .57$) and younger ($\gamma = .53$) adults, $p = .65$, and metacognitive resolution increased on the later trials, $F(2, 96) = 12.85$, $MSE = 0.08$, $p < .001$, $\eta_p^2 = .21$. There was a significant age group by list interaction, $F(2, 96) = 3.73$, $MSE = 0.08$, $p < .05$, $\eta_p^2 = .07$. Post hoc t tests revealed that older adults had better resolution than younger adults on initial lists, $t(50) = 2.13$, $p < .05$, but no age differences were observed on middle or later lists (all ps > .45).

Point Value Strategy

Potential differences in the assignment of value and strategic changes in value assignment by older and younger adults across lists were examined. Only three values were assigned, on average, at least once per list (more than 8.3% of the time). These higher frequency values were the 0, 5, and 10 point values, and the frequencies that these values were assigned by younger and older adults are presented in Table 1. A 2 (age group) × 3 (list), × 3 (value: 0, 5, 10) ANOVA was conducted, and Mauchly's test of sphericity indicated no violations for value, $\chi^2(2) = 3.36$, $p = .19$, but violations for list, $\chi^2(2) = 10.00$, $p < .01$, $\varepsilon = .85$. There was a significant effect of age, $F(1, 50) = 15.14$, $MSE = 0.06$, $p < .001$, $\eta_p^2 = .23$; an effect of list (Huynh-Feldt corrected), $F(1.78, 177.11) = 19.71$, $MSE = 0.02$,

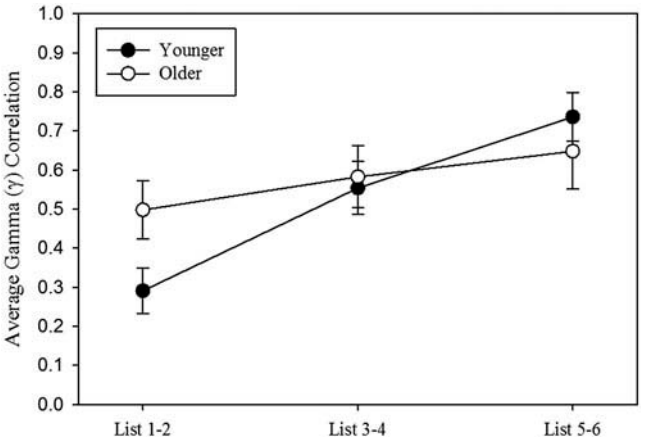

Figure 2. The average gamma (γ) correlations for both younger and older adults on each of the six study-test trials in Experiment 1. Error bars represent standard error of the mean.

Table 1. Mean (and *SD*) proportional usage of the frequently assigned values in Experiments 1, 2, and 3

			Lists 1–2		Lists 3–4		Lists 5–6	
Experiment	**Point value**	**Relatedness**	**Younger**	**Older**	**Younger**	**Older**	**Younger**	**Older**
Experiment 1	0		.14	.19	.24	.35	.27	.38
			(.16)	(.25)	(.21)	(.27)	(.21)	(.28)
	5		.15	.20	.14	.22	.10	.15
			(.09)	(.19)	(.11)	(.29)	(.10)	(.22)
	10		.14	.34***	.16	.23	.25	.33
			(.16)	(.22)	(.17)	(.23)	(.24)	(.24)
Experiment 2	0	Unrelated	.29	.42	.29	.61**	.31	.68***
			(.25)	(.34)	(.31)	(.37)	(.34)	(.33)
		Related	.05*	.01	.07	.05	.05	.01
			(.07)	(.03)	(.09)	(.06)	(.06)	(.05)
	10	Unrelated	.08*	.02	.15	.05	.18*	.05
			(.13)	(.04)	(.24)	(.11)	(.24)	(.09)
		Related	.48	.52	.64	.64	.72	.66
			(.31)	(.35)	(.32)	(.34)	(.31)	(.39)
Experiment 3	0		.22	.26	.23	.26	.24	.26
			(.18)	(.25)	(.21)	(.25)	(.24)	(.26)
	5		.16	.20	.18	.21	.16	.20
			(.11)	(.16)	(.14)	(.15)	(.15)	(.17)
	10		.18	.28	.23	.33	.23	.33
			(.17)	(.20)	(.20)	(.22)	(.20)	(.22)

Note. Significantly higher proportional usage of the values by younger or older adults are indicated by *$p < .05$; **$p < .01$; and ***$p < .001$.

$p < .001$, $\eta_p^2 = .28$; an effect of value, $F(2, 100) = 3.51$, $MSE = 0.13$, $p < .05$, $\eta_p^2 = .07$; but a nonsignificant Age Group × List × Value interaction, $F(4, 200) = 2.31$, $p = .06$.

Summary

Both younger and older adults were able to successfully recall words they had assigned higher values, and they displayed high metacognitive accuracy with task experience. Despite achieving comparable levels of metacognitive accuracy, older adults did have significantly lower scores compared with younger adults. However, this finding is not unexpected given the fact that older adults recalled fewer words than younger adults, and recall was correlated with overall point score ($r = .42$, $p < .01$).

In regard to the strategic use of value, in order to maximize performance (score) in this particular paradigm, the most effective strategy would be to assign 0 points to words that one could not recall, and 10 points to words recalled. Both younger and older adults did display large initial overconfidence (i.e., assigning point values other than 0 to items not recalled), but they increased the number of 0 values assigned with task experience, demonstrating sensitivity to potential losses. The use of the value 5 could be considered less strategic, and both age groups did show a significant decrease in the number of 5 values assigned on later lists. Both age groups utilized the 10 point value more frequently on later lists. Overall, older adults adopted more effective value assignment strategies with

enough task experience and displayed an extremely similar pattern compared with younger individuals.[1]

EXPERIMENT 2

Experiment 2 was conducted in order to extend the findings from Experiment 1 and investigate whether utilizing stimuli that provide stronger intrinsic cues could potentially aid value assignment and the development of appropriate strategies with task experience. In Experiment 1, the stimuli (all simple, unrelated nouns) did not lend themselves to aiding in the assignment of value given that, presumably, the words were all equally salient and memorable. Despite this inherent challenge of the task, it may have led participants to base the assignment of value less on intrinsic cues of the items (i.e., features of the words themselves) and instead rely more on extrinsic or mnemonic cues such as the task demands and how many words they learned they were able to recall.

Semantic relatedness between word pairs is an extremely salient cue used by individuals in the assignment of JOLs, and it is also strongly related to recall (Connor et al., 1997; Dunlosky & Matvey, 2001; Hertzog, Dunlosky, Powell-Moman, & Kidder, 2002; Hertzog et al., 2010). For example, Hertzog and colleagues (2002) have found that younger and older adults recall more and give higher JOLs to related pairs compared with unrelated pairs, although older adults' JOLs may be slightly more responsive to cues of semantic relatedness than are younger adults.

Experiment 2 adapted the paradigm described in Experiment 1 and utilized semantically related and unrelated word pairs. It was hypothesized that the use of word pairs could aid in both the subjective assignment of point values as well as in the adoption of more effective strategies (e.g., assigning high values to related word pairs, and low or 0 point values to the unrelated word pairs). Previous research suggests that older and younger adults are aware that they are more likely to recall semantically related compared with unrelated items (Connor et al., 1997; Hertzog & Dunlosky, 2011; Hertzog et al., 2002, 2010); thus, in the present study, individuals could learn to capitalize on this knowledge in order to maximize goal-related outcomes (i.e., achieve high scores) and enhance metacognitive accuracy.

METHODS

Participants

Participants consisted of 24 older adults (10 females, M_{age} = 68.0, SD = 6.7) and 24 younger adults (12 females, M_{age} = 20.4, SD = 1.1). Older adults had participated in prior, unrelated studies within the laboratory an average of 0.4 times before (range: 0–3). Older adults had good self-reported health ratings (M = 8.5), had an average of 17.4 years of education, and performed within normal age- and education-adjusted ranges on the

[1] All ANOVAs were conducted with and without gender included as a factor. Gender did not have any main or interactive effects on the dependent variables; thus, the analyses without gender are reported. However, due to the small number of males, particularly in Experiments 1 and 3, there may have been a lack of statistical power to detect the potential effects of gender.

forward (M = 7.46, SD = 1.32) and backward (M = 5.92, SD = 1.25) digit spans (Choi et al., 2014; Wechsler, 1997). The inclusion, recruitment, and compensation procedures were identical to those described in Experiment 1.

Materials

The stimuli were 144 word pairs. Half of the word pairs were unrelated (e.g., handle-blanket, roof-beach), and the other half were related word pairs with moderate levels of associative strength (e.g., dish-bowl, lemon-sour). The unrelated word pairs were adapted from Connor et al. (1997). The related word pairs were created using the University of South Florida Free Association Norms database (Nelson, McEvoy, & Schreiber, 1998). The related word pairs were selected such that the target word never had the highest associative strength with the cue word and on average had an associative strength of .14 (range: .11–.18). This was done to specifically lower the probability that an individual would simply be able to guess the correct target word when given the cue at test.

The related and unrelated word pairs were each randomly assigned, without replacement, to one of the six lists. Each list contained 12 related word pairs, and 12 unrelated word pairs, presented in a fixed, random order. Order of the lists was counterbalanced between participants.

Procedure

The procedure was similar to Experiment 1, and the instructions regarding assignment of point values and calculation of point score were identical to those described in Experiment 1. Participants were told they would see six lists of word pairs, with 24 word pairs in each list. Participants were informed that during the test, they would always be shown the first word of the pair and would need to try to recall the second word.

As in Experiment 1, participants were shown the word pairs one at a time for 5 seconds and assigned each word pair a point value. After all 24 word pairs were presented, they were given a cued recall test. During the test, they were shown each of the cue words one at a time and had to recall, out loud, the word that went with it. They were told if they could not remember the word, they could "pass" and move onto the next item. The cued recall test was self-paced. Participants were informed of their point score at the end of each list, and scores were calculated in the same manner as described in Experiment 1.

RESULTS AND DISCUSSION

Recall Performance

Recall performance was examined in a 2 (age group) × 2 (relatedness) × 3 (lists) ANOVA, and the results are displayed in Figure 3A. Mauchly's test of sphericity revealed no violations, all χ^2s < 2.00, all ps > .36. Older adults recalled fewer target words compared with younger adults, $F(1, 46) = 27.36$, $MSE = 9.43$, $p < .001$, $\eta_p^2 = .37$, and related word pairs were remembered better than unrelated word pairs, $F(1, 46) = 561.22$, $MSE = 5.63$, $p < .001$, $\eta_p^2 = .92$. There was also a slight trend toward higher recall on later lists, $F(2,$

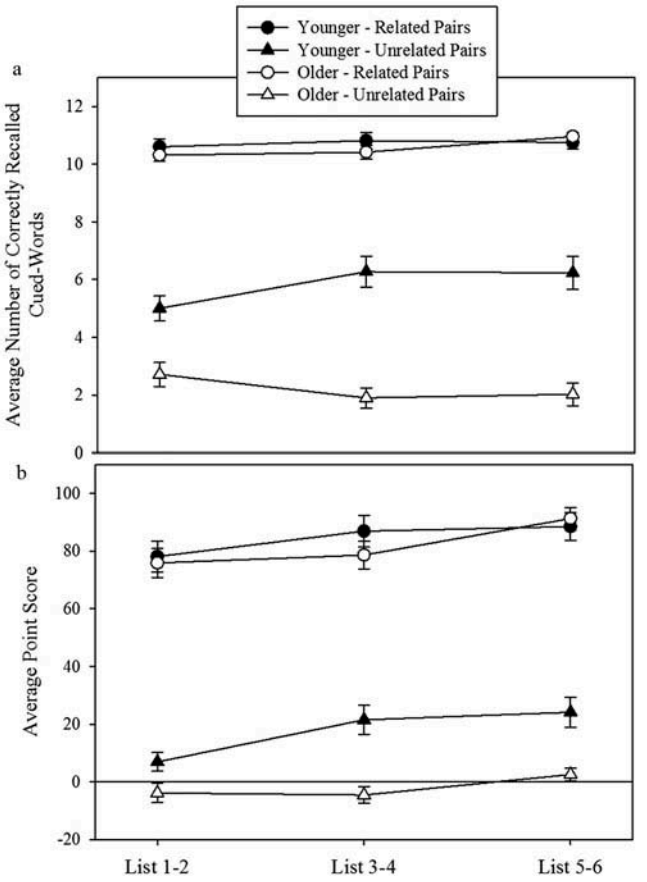

Figure 3. (*A*) The average number of related and unrelated word pairs recalled by younger and older adults for each of the six study-test lists in Experiment 2. (*B*) The average point score achieved for related and unrelated word pairs by both older and younger adults, in each of the study-test lists in Experiment 2. Error bars represent standard error of the mean.

92) = 2.61, *MSE* = 1.03, $p = .08$, $\eta_p^2 = .05$. A significant Age Group × Relatedness × List interaction was also obtained, $F(2, 92) = 10.55$, *MSE* = 0.94, $p < .001$, $\eta_p^2 = .19$.

Post hoc *t* tests revealed that younger adults recalled more unrelated pairs compared with older adults across all lists (all *p*s < .001), but younger and older adults recalled a similar number of the related word pairs on all lists (all *p*s > .29). Older adults recalled fewer unrelated items on the middle lists, $t(23) = 2.45$, $p < .05$ and later lists, $t(23) = 3.03$, $p < .01$, compared with the initial lists. Older individuals also recalled more related items on the later lists compared with both the initial lists, $t(23) = 3.77$, $p = .001$, and the middle lists, $t(23) = 2.78$, $p = .01$. Younger adults recalled more unrelated items on the middle lists, $t(23) = 3.41$, $p < .01$, and later lists, $t(23) = 2.85$, $p < .01$, compared with the initial lists, but recall of related items by younger adults remained constant across lists (all *p*s > .28).

Point Score

Point scores were analyzed in a 2 (age group) × 2 (relatedness) × 3 (list) ANOVA, and the results are presented in Figure 3B. Mauchly's test of sphericity revealed no violations, all χ^2s < 4.30, all *p*s > .12. Older adults obtained lower scores compared with younger adults, $F(1, 46) = 5.71$, $MSE = 1533.71$, $p < .05$, $\eta_p^2 = .11$; scores improved with task experience, $F(2, 92) = 19.48$, $MSE = 188.88$, $p < .001$, $\eta_p^2 = .30$; and scores were higher for related compared with unrelated word pairs, $F(1, 46) = 718.27$, $MSE = 570.50$, $p < .001$, $\eta_p^2 = .94$. Although a significant Age Group × Relatedness × List interaction was not obtained, $F(2, 92) = 2.31$, $p = .11$, both an Age Group × List interaction, $F(2, 92) = 3.88$, $MSE = 188.88$, $p < .05$, $\eta_p^2 = .08$, and an Age Group × Relatedness interaction, $F(1, 46) = 9.02$, $MSE = 570.50$, $p < .01$, $\eta_p^2 = .16$, were observed.

Post hoc *t* tests examining the Age Group × Relatedness interaction revealed that older adults had significantly lower point scores for the unrelated items, $t(46) = 4.34$, $p < .001$. However, both younger and older adults obtained similar scores for the related items ($p = .68$). *t* tests on the Age Group × List interaction revealed that younger and older adults had similar point scores on initial lists ($p = .17$), but older adults had lower scores on the middle lists, $t(46) = 3.09$, $p < .01$, and only marginally lower scores on the later lists, $t(46) = 1.79$, $p = .08$. Furthermore, older adults scores remained relatively constant on the initial and middle lists but improved on the later lists, $t(23) = 3.33$, $p < .01$. Younger adults demonstrated improvement earlier, and scores increased on middle lists compared with initial lists, $t(23) = 4.81$, $p < .001$, and remained stable between the middle and later lists ($p = .41$).

Metacognitive Accuracy

A majority of individuals assigned all related items the same point value (i.e., 10); thus, gamma correlations were not examined as a function of relatedness. Metacognitive accuracy by younger and older individuals was assessed in a 2 (age group) × 3 (list) ANOVA, and the results are displayed in Figure 4. Mauchly's test of sphericity was not violated $\chi^2(2) = 3.41$, $p = .18$. Older adults had significantly higher gamma correlations than younger adults, $F(1, 45) = 11.49$, $MSE = 0.05$, $p = .001$, $\eta_p^2 = .20$, although both older and younger adults' gammas were high ($\gamma = .88$ and .75, respectively). Furthermore, metacognitive accuracy increased on later lists, $F(2, 90) = 3.86$, $MSE = 0.01$, $p < .05$, $\eta_p^2 = .08$. A very marginal interaction was also obtained, $F(2, 90) = 2.46$, $MSE = 0.01$, $p < .10$, $\eta_p^2 = .05$. Post hoc *t* tests revealed that younger adults' average gamma correlation remained relatively constant (all *p*s > .17), whereas older adults' gamma correlations increased on the later trials, $t(23) = 3.26$, $p < .01$.

Point Value Strategy

Potential differences in the assignment of value by older and younger adults across lists as a function of relatedness were examined, and the results are presented in Table 1. As in Experiment 1, many of the values were rarely utilized. Only two values (the 0 and 10 point value) were assigned at least 2 out of the 24 times per list (more than 8.3% of the time). A 2 (age group) × 3 (list) × 2 (relatedness) × 2 (value: 0 and 10) ANOVA was conducted.

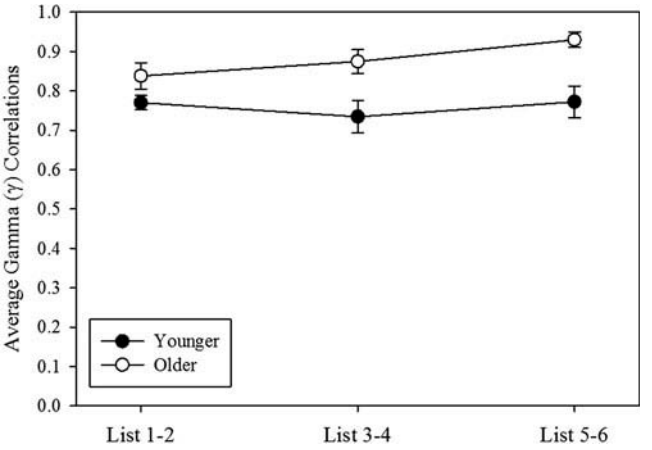

Figure 4. The average gamma (γ) correlations for both younger and older adults on each of the six study-test trials in Experiment 2. Error bars represent standard error of the mean.

Mauchly's test of sphericity indicated violation for list, $\chi^2(2) = 7.01$, $p = .03$, $\varepsilon = .87$. There was no overall effect of age group, $F(1, 46) = 1.4$, $p = .24$; a significant effect of list (Huynh-Feldt corrected), $F(1.85, 46) = 54.31$, $MSE = 0.01$, $p < .001$, $\eta_p^2 = .54$; a marginal effect of relatedness, $F(1, 46) = 3.67$, $MSE = 0.15$, $p = .06$, $\eta_p^2 = .07$; an effect of value, $F(1, 46) = 6.25$, $MSE = 0.29$, $p < .05$, $\eta_p^2 = .12$; as well an Age Group × List × Relatedness × Value interaction, $F(1.42, 68.01) = 7.71$, $MSE = 0.01$, $p < .01$, $\eta_p^2 = .14$.

Post hoc *t* tests revealed that older adults assigned more 0 values to unrelated word pairs on the middle and later lists compared with initial lists, $t(23) = 4.16$, $p < .001$, whereas younger adults' 0 value assignments did not change as a function of list (all *p*s > .22). Thus, although no age-related difference was present on initial lists, older adults assigned more unrelated items 0 on the middle and later lists compared with younger adults (*p*s < .01). Older adults rarely assigned unrelated word pairs 10 point values, and this pattern did not change over lists (all *p*s > .12). Alternatively, younger adults displayed an increase in the number of 10 values assigned to unrelated pair after the initial lists, $t(23) = 2.43$, $p < .05$, and assigned the 10 value more often than older adults on each list (all *p*s < .06). For related word pairs, neither age group utilized the 0 value often. However, both younger and older adults displayed a slight increase in 0 values assigned to unrelated items on middle lists compared with both initial and later lists (all *p*s < .07). Both age groups assigned the 10 point value equally as often to related word pairs on all lists (all *p*s > .56). Younger and older adults also increased the number of 10 values assigned to related word pairs from the initial lists to the middle lists, $t(23) = 3.93$, $p = .001$ and $t(23) = 2.98$, $p < .01$, respectively. Younger adults demonstrated an additional increase in the assignment of 10 values to related word pairs on later lists compared with middle lists, $t(23) = 2.73$, $p < .05$.

Summary

The introduction of stimuli that contained cues to accurately guide value judgments produced quite striking effects. Although, overall, older adults recalled fewer items and

achieved lower point scores compared with younger adults, age-related differences were eliminated for the related word pairs. The finding that age-related differences were prominent for the unrelated word pairs is consistent with older adults' deficits in associative learning (Naveh-Benjamin, 2000; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; Old & Naveh-Benjamin, 2008). However, age-related associative deficits for the related word pairs were not present, as the related words pairs likely allowed older individuals to rely more on verbal or semantic knowledge, which is less susceptible to age-related declines (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010; Naveh-Benjamin et al., 2003). Both younger and older adults demonstrated a strategic use of point values with task experience by assigning more 10 point values with task experience, particularly for related pairs. Furthermore, older adults, who had larger initial overconfidence, utilized the 0 point value more frequently on later lists and assigned lower values to the unrelated word pairs.

Older adults displayed better metacognitive accuracy than younger adults, although both age groups were quite accurate. This finding that older adults have better relative accuracy than younger adults is somewhat inconsistent with previous research (Connor et al., 1997; Hertzog & Dunlosky, 2011; Hertzog et al., 2002, 2010). However, Herzog et al. (2002) have reported that older individuals were more likely than younger adults to utilize semantic relatedness as a cue when making JOLs. In the current study, it is clear that younger adults bet on unrelated pairs more often than older adults and gave higher values to these unrelated word pairs. However, younger adults were able to recall more of the unrelated word pairs than older adults.[1] Thus, for younger adults, who presumably have intact associative memory abilities, associative strength may not be as good of a cue as it is for older adults to utilize when making metamemory judgments.

A recent meta-analysis indicates that the average gamma correlation for immediate JOLs is .42 (Rhodes & Tauber, 2011). In the current study, gamma correlations were .88 for older adults and .75 for younger adults. This high degree of accuracy for immediate judgments could be due to the use of consequences (gaining or losing points) associated with these judgments and thus perhaps increased effort employed by participants to recall information assigned a higher point value. Importantly, it suggests that one's ability to accurately predict what information will be remembered, or ability to recall information that one indicates he or she will be able to, may have been underestimated in prior studies that have examined JOL accuracy.

EXPERIMENT 3

Experiment 3 was conducted in order to further explore the influence semantic knowledge has on memory, measures of performance, and metacognitive accuracy in younger and older adults using more naturalistic, ecologically valid, materials. Experiment 3 introduced context, such that each list centered around a different, specific scenario. For example, one focused on going on a picnic, and all of the items could be taken on a picnic (see Appendix A for a complete list of materials). In addition, the lists were created such that it was likely that most people would judge some items as more vital to taking on the picnic (e.g., basket, plates), whereas other items might be seen as less relevant (e.g., frisbee, radio).

The introduction of context could increase the amount of schematic support available to participants. Schematic support refers to the idea that schemas or prior knowledge within a domain can serve to enhance memory by supporting encoding and retrieval operations

within that domain. The presence of schematic support can reduce the need for self-initiated processing (which may be impaired in older adults), and this can improve memory performance, particularly for older adults (Besken & Gulgoz, 2009; Castel, 2008; Craik & Bosman, 1992; Soederberg-Miller, 2003; Umanath & Marsh, 2014). In Experiments 1 and 2, the amount recalled was significantly correlated with point score, a central measure of performance that participants were encouraged to focus on. Given that prior knowledge may facilitate older adults' memory performance (Umanath & Marsh, 2014), it was hypothesized that the utilization of scenarios, and thus the increase in which one can rely on prior knowledge and schemas, could reduce age-related discrepancies in memory performance and offer a more realistic context in which participants could decide what is important (i.e., assignment of point values).

METHODS

Participants

Participants consisted of 24 older adults (18 females, M_{age} = 77.3, *SD* = 7.1) and 24 younger adults (17 females, M_{age} = 20.4, *SD* = 1.0). Older adults had participated in prior, unrelated studies within the laboratory an average of 1.3 times before (range: 0–3). Older adults had good self-reported health ratings (*M* = 8.4), had an average of 16.7 years of education, and performed within normal age- and education-adjusted ranges on the forward (*M* = 6.71, *SD* = .95) and backward (*M* = 5.33, *SD* = 1.34) digit spans (Choi et al., 2014; Wechsler, 1997). The inclusion, recruitment, and compensation procedures were identical to those described in Experiment 1.

Materials

The materials consisted of six lists, each with 20 items each. There were six scenarios: going camping, going on a vacation, going on a picnic, planning a child's birthday party, going to a class, and cooking lasagna. Items within each list were chosen to realistically reflect what could be used or needed within each of these contexts but also varied on how vital or central they were to the scenario. For a complete list of items within each scenario, see Appendix A.

Procedure

Each list contained 20 items related to a different scenario, the items were presented in fixed random order, and the order of the lists was counterbalanced between participants. The instructions given to participants were largely similar to those described in Experiment 1. Participants informed of the number of lists and items, and that each list centered around a specific scenario. In addition, participants were told the scenario immediately prior to the start of each list. Participants were shown the items one at a time for 5 seconds each, and during that 5 seconds had to assign the item a point value (from 0 to 10). After the immediate free recall test, which lasted approximately 1 minute, participants were given

their score and the next list began. Scores were determined in the manner described in Experiment 1.

RESULTS AND DISCUSSION

Recall Performance

The number of items correctly recalled were examined as a function of list, and the results are presented in Figure 5A. A 2 (age) × 3 (list) ANOVA was conducted, and Mauchly's test of sphericity indicated no violations, $\chi^2(2) = 4.35$, $p = .11$. Older adults correctly recalled a similar number of items compared with younger adults, $F(1, 46) = 0.00$, $p = .99$. There was no effect of list, $F(2, 92) = 0.91$, $p = .41$, nor was there an interaction, $F(2, 92) = 0.31$, $p = .74$.

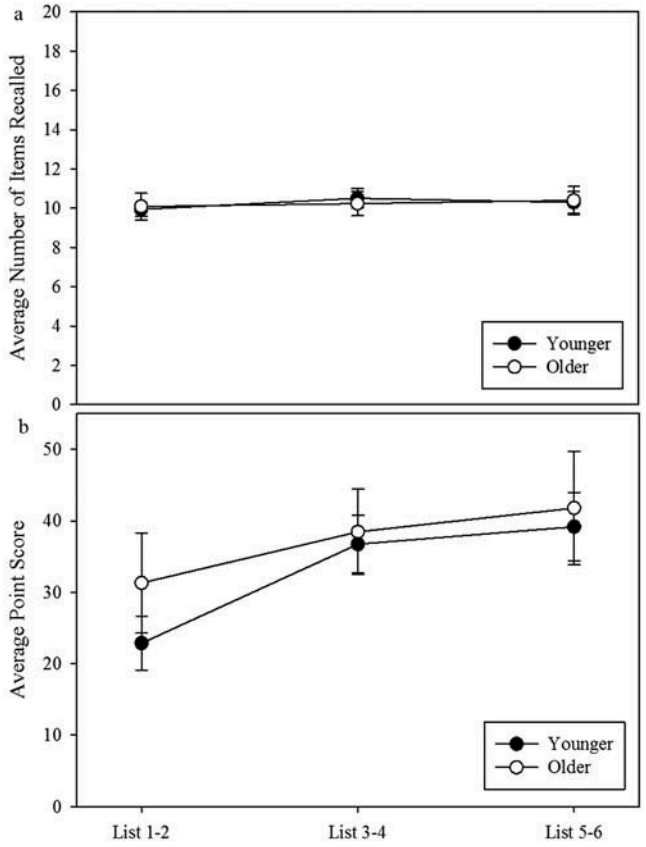

Figure 5. (*A*) The average number of items recalled by older and younger adults across the six study-test lists in Experiment 3. (*B*) The average overall point score achieved on each list by both older and younger adults in Experiment 3. Error bars represent standard error of the mean.

Point Score

The average point scores for both younger and older adults are displayed in Figure 5B. A 2 (age group) × 3 (list) ANOVA was conducted, and Mauchly's test of sphericity indicated violations for list, $\chi^2(2) = 11.04$, $p < .01$. Older and younger adults obtained comparable scores, $F(1, 46) = 0.37$, $p = .55$, and that scores increased on the later trials (Huynh-Feldt corrected), $F(1.73, 79.69) = 7.32$, $MSE = 376.48$, $p < .01$, $\eta_p^2 = .14$. No interaction was observed ($p = .59$).

Metacognitive Accuracy

The effect of task experience on the average gamma correlations for younger and older individuals was assessed in a 2 (age group) × 3 (list) ANOVA, and Mauchly's test of sphericity indicated no violations, $\chi^2(2) = 2.60$, $p = .127$. The average gamma correlations were similar for younger and older adults, $F(1, 46) = 0.09$, $p = .77$, and both older and younger adults' gammas were relatively high ($\gamma = .57$ and .54, respectively). There was no effect of list, $F(2, 92) = 1.58$, $p = .21$, nor was there an interaction, $F(2, 92) = 0.06$, $p = .94$.

Point Value Strategy

Although gamma correlations remained constant across lists, as did recall, the fact that overall point scores increased on later lists suggests potential differences in the strategic assignment of value with task experience. Only three values (0, 5, and 10 point value) were assigned more than 10% of the time (i.e., more than 2 out of the 20 items per list), and the proportional usage of these values is presented in Table 1. A 2 (age group) × 3 (list) × 3 (value: 0, 5, 10) ANOVA was conducted, and Mauchly's test of sphericity indicated no violations for value, $\chi^2(2) = 1.80$, $p = .41$, but violations for list, $\chi^2(2) = 10.71$, $p < .01$, $\varepsilon = .83$. There was an effect of age group $F(1, 46) = 4.07$, $MSE = 0.08$, $p = .05$, $\eta_p^2 = .08$, and an effect of list, with the 0, 5, and 10 point values assigned more often on later lists (Huynh-Feldt corrected), $F(1.74, 80.10) = 6.02$, $MSE = 0.01$, $p < .01$, $\eta_p^2 = .12$. There was also significant quadratic effect of Value, $F(1, 46) = 4.09$, $MSE = 0.13$, $p < .05$, $\eta_p^2 = .08$, with the 5 point value assigned less frequently than the 0 or 10 point value. However, no interactions were significant (all ps > .17).

Summary

The use of scenarios that potentially served to increase contextual and schematic support seemed to aid in older adults' ability to effectively recall the items, resulting in equivalent performance by younger and older adults in regard to recall performance, point score, and metacognitive accuracy. Unlike what was observed in Experiments 1 and 2, task experience led to only minor improvements in performance in overall score, whereas improvements in metacognitive accuracy did not occur.[1] It may be the case that task experience is less necessary for individuals to learn to identify and predict what information is likely to

be later remembered when all of the information is presented within the frame of a familiar context.

GENERAL DISCUSSION

The current studies were designed to examine whether older and younger adults could utilize strategic control when making value-based metacognitive monitoring judgments, and also whether semantic knowledge impacted any potential age-related differences in metacognitive accuracy and memory performance. In general, no age-related differences in metamemory accuracy were observed, metamemory accuracy was quite good, and accuracy tended to improve with task experience in both Experiments 1 and 2. Older adults, at times, had better metamemory accuracy compared with younger adults (Experiment 2). Furthermore, when the stimuli allowed the participants to utilize schematic or semantic knowledge (Experiment 3; the related word pairs in Experiment 2), no age-related differences were observed in recall performance or overall point score. This lack of age differences in memory performance, although rare, is consistent with evidence that schemas and prior knowledge can serve to mitigate typically observed age-related memory deficits (e.g., Castel, 2005; Castel, McGillivray, & Worden, 2013; Umanath & Marsh, 2014). It is possible that being able to rely on prior knowledge reduces the cognitive resource demands associated with processing and recalling of information, and this may be particularly beneficial for older adults. However, when schematic support was absent (Experiment 1; the unrelated word pairs in Experiment 2), older adults recalled fewer items and obtained somewhat lower point scores, consistent with typical age-related memory deficits (e.g., Kausler, 1994; Naveh-Benjamin & Ohta, 2012) and associative-memory deficits (e.g., Naveh-Benjamin, 2000; Old & Naveh-Benjamin, 2008). Critically, both younger and older adults demonstrated that they either were able to use their metacognitive knowledge of what was more or less likely to be recalled to assign values in a strategic manner or were able to recall information they indicated they would be able to based on point values assigned.

Although schematic support and semantic knowledge aided overall memory performance, there seemed to be a trade-off in regard to the benefits of task experience observed in Experiment 1. When semantic support was available (related word pairs in Experiments 2 and 3), there was less of an effect of task experience on metamemory accuracy. Point scores, a central measure of performance, increased with task experience for both younger and older adults in all the experiments, despite, at times, negligible changes in overall recall and metacognitive accuracy. This suggests task experience was helpful to both younger and older adults in terms of being more strategic in how they assigned and recalled information.

In the current studies, participants did not assign typical JOLs to items but instead "bet" on the likelihood that an item would be recalled. This utilization of consequences may have made individuals more accountable for their judgments, which likely increased motivation for accuracy. Furthermore, it was more strategic in terms of the goal (i.e., high point scores) to assign 0 to items that would not be recalled, and 10 to items that would be later recalled, and both younger and older adults were largely successful in adopting this strategy. However, the actual role that the point scoring system had on motivation and effort to recall information given higher values cannot be directly assessed given that there were no conditions where points were not given, although prior research

using a similar paradigm has implemented a control condition with no point values (Castel et al., 2002) and this does result in similar levels of recall. Future research could further address the motivational component that the use of a gain-and-loss point value system has on metacognitive accuracy. It would also be worthwhile to directly assess the degree of effort exerted by participants and how that is related to performance in order to better understand the relationship between effort and accurate metacognitive insight.

Studies utilizing standard JOLs typically find that individuals frequently assign values that center around the mean of the scale (e.g., 50 on a scale from 0 to 100). In the current "betting" paradigm, where overall point score was emphasized and there were penalties and rewards tied to the judgments, extreme values were more commonly assigned by participants, and use of these values increased with task experience. The findings suggest that when judgments are formed utilizing both one's metacognitive monitoring and metacognitive control abilities, younger and older adults display a high degree of accuracy and strategic use of memory and metacognitive abilities.

In Experiment 3, very few improvements with task experience were apparent and metacognitive accuracy was lower compared with Experiments 1 and 2. It may be that all or most of the items in Experiment 3 seemed relatively important or memorable within the given context (i.e., all fit with one's schema) and in a sense were more analogous to the related word pairs in Experiment 2. Some research has suggested that overreliance on schemas or prior knowledge can have a negative impact on monitoring accuracy (Toth, Daniels, & Solinger, 2011). In Experiment 2, there was either a presence or lack of a semantic relationship between the cue and target word, and participants were likely aware that the unrelated word pairs were more difficult to recall than the related word pairs (Berry, Williams, Usubalieva, & Kilb, 2013; Connor et al., 1997; Hertzog & Dunlosky, 2011; Hertzog et al., 2002, 2010). However, this distinction between items was somewhat lacking in Experiment 3.

Although previous research has shown that explicit, experimenter-defined point values influence both memory (Castel et al., 2002; Friedman & Castel, 2013) as well as metacognitive judgments (McGillivray & Castel, 2011; Soderstrom & McCabe, 2011), in the current experiments, the value that each item was "worth" was decided by the participant. The consistently high accuracy in remembering the items assigned higher values by both younger and older adults indicates that the ability to recall what one assigns higher values remains intact in older adulthood. It is precisely the change in the way in which monitoring judgments were approached that likely contributed to the metacognitive accuracy. Typical JOLs are somewhat passive, and there is no actual reward or penalty for accuracy or lack thereof. By implementing consequences tied to metamemory judgments, these judgments became more important and likely enhanced the effort employed and the need to accurately monitor one's memory.

The results of the current studies suggest that strategic metamemory monitoring and control capabilities are present in older adults, and with some motivation or incentive, older adults can utilize their understanding of their own memory in a strategic manner in order to achieve goal-relevant outcomes. This finding has implications not only for memory training programs but also speaks to older adults' ability to utilize metacognitive strategies and awareness to help compensate for age-related changes in memory abilities and maintain healthy cognitive functioning in everyday life.

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Appendix A. Items used in each of the scenario lists in experiment 3

Going camping	Going on vacation	Child's party	Going to class	Making lasagna	Going on a picnic
bug spray	pants	cake	calculator	butter	plates
soap	shampoo	games	notebook	parmesan	blanket
cups	socks	presents	snack	ground beef	coleslaw
tarp	shorts	cooler	watch	olive oil	thermos
tent	book	video camera	highlighter	spinach	basket
wood	camera	face paint	chapstick	onions	cookies
table cloth	sunscreen	music	pencil	salt	juice
chair	shirts	clown	cell phone	fennel seeds	jacket
cards	razor	streamers	kleenex	eggs	napkins
boots	towel	pens	sweater	parsley	cheese
lantern	toothbrush	band aids	paper	milk	radio
ax	batteries	juice	keys	basil	candles
marshmallows	swimwear	pretzels	comb	flour	bread
whistle	medication	pizza	eraser	noodles	apples
hot dogs	snorkel	balloons	water	tomatoes	watermelon
clock	map	flowers	wallet	oregano	potato salad
sleeping bag	sandals	grapes	glasses	garlic	pillows
shovel	passport	piñata	tape recorder	mushrooms	frisbee
matches	Ziploc bags	invitations	ruler	ricotta	chicken
trash bags	sewing kit	tables	textbook	bell pepper	knife