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Adult Age Differences in the Effects of Goals on Self-Regulated Sentence Processing

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Abstract

We examined age differences in the allocation of effort when reading text for either high levels of recall accuracy or high levels of efficiency. Older and younger adults read a series of sentences, making judgments of learning before recalling the information they had studied. Older adults showed less sensitivity than the young to the accuracy goal in terms of both reading time allocation and memory performance. Memory monitoring (i.e., the correspondence between actual and perceived learning) and differential allocation of effort to unlearned items were age-equivalent, so that age differences in goal adherence were not attributable to these factors. However, comparison with data from a judgment task neutral with respect to memory monitoring showed that learning gains among the old across trial were reduced relative to young by memory monitoring, suggesting that active memory monitoring may be resource-consuming for older learners. Regression analysis was used to show that age differences in the responsiveness to (cognitive/information-acquisition) goals could be accounted for, in part, by independent contributions from working memory and memory self-efficacy. Our data suggest that both processing capacity (“what you have”) and beliefs (“knowing you can do it”) can contribute to individual differences in engaging resources (“what you do”) to effectively learn novel content from text.

Age-graded declines in fluid abilities (e.g., working memory capacity, attentional processes, processing speed) can impact the outcomes of reading, most notably memory for the information in the text that was read (Johnson, 2003; Wingfield & Stine-Morrow, 2000). Poor discourse memory among older adults is often attributed to age-graded changes in processing efficiency (e.g., Hartley, Stojack, Mushaney, Annon, & Lee, 1994; Stine & Hindman, 1994), resulting in a degradation in the strength or fidelity of the text representation garnered from time allocated to the task. The effects of this decrease in processing efficiency on recall performance may be exacerbated by a neglect in the allocation of attentional resources to overcome changes in cognitive ability (Ratner, Schell, Crimmins, Mittelman, & Baldinelli, 1987; Stine-Morrow, Miller, & Leno, 2001; Stine-Morrow, Ryan, & Leonard, 2000; Zabrocky & Moore, 1994), essentially a self-regulatory phenomenon in which reading strategies do not fully accommodate to age-graded change in capacity.

This study was motivated by the desire to understand why this accommodation may not occur. We considered the viability of three (not mutually exclusive) explanations. First, it could be that older readers’ reduced working memory capacity impairs the executive control of self-regulatory processing (e.g., Thiede & Dunlosky, 1999). Second, it could be that fundamental components of metacognitive control (e.g., the ability to monitor the current status of memory and allocate effort appropriately) are compromised with age (e.g., Dunlosky & Connor, 1997; Hertzog & Dunlosky, 2004). Finally, it could be that age-related change in motivational

¹The measures of association reported are partial eta-squared, as provided by SPSS 11.0. These indices are the ratio of the variance attributable to the effect and the sum of the variance attributable to the effect and the variance not explained in the model. They are not classic measures of eta-squared, do not reflect proportion variance accounted for, and do not sum to one (Pierce et al., 2004).

factors, like memory self-efficacy (Berry, 1999; West & Yassouda, 2004), compromises the effective engagement of cognitive resources (West, Thorn, & Bagwell, 2003; West, Bagwell, & Dark-Freudeman, 2005). As noted, these are not mutually exclusive, and all or a subset may play a role, perhaps interdependently.

In our study, participants read short passages of text for recall with varying weight given to recall accuracy versus speed of encoding. A judgment of learning (JOL) paradigm (e.g., Nelson, Dunlosky, Graf, & Narens, 1994), in which participants make explicit judgments about how well they learned the material at each of two learning trials, provided a window into the metacognitive control used in flexibly responding to differing goal conditions. Finally, participants were assessed on independent estimates of working memory and memory self-efficacy. Assuming that older adults would under-accommodate to the goal, this approach allowed us to assess contributions of metacognitive control, working memory, and memory self-efficacy to performance. Before detailing our hypotheses, we provide further background on age differences in language processing and self-regulated learning from text.

Aging and Text Processing

Discourse processing requires computations on multiple levels. As we decode orthography to create lexical representations of words, we assign meaning to these words and place them within the appropriate context. The interrelationships among these concepts are represented as “idea units,” or “propositions,” that are organized to represent the content of the text, or the “textbase” (Kintsch & van Dijk, 1978). Language that is informationally dense (i.e., high in propositions relative to the number of words) generally requires that readers increase processing time to establish the textbase representation (Kintsch & Keenan, 1973). When listeners encounter propositionally dense speech, in which processing time cannot be controlled, their memory performance suffers (Stine, Wingfield, & Poon, 1986). Construction of the textbase is limited by working memory capacity generally, and may be particularly vulnerable as a function of the age-related declines in working memory noted above (Kemper & Mitzner, 2001; Wingfield & Stine-Morrow, 2000). Older adults’ poorer working memory capacity, then, means they require more time per proposition in reading to achieve recall that is comparable to that of the young, suggesting a relative impairment in encoding efficiency (Hartley et al., 1994; Stine & Hindman, 1994), and that they can show disproportionate declines in memory for speech that is propositionally dense (Stine & Wingfield, 1990). Old and young may, in principle, create a textbase representation effectively given enough effort (e.g., Stine-Morrow et al., 2001; Johnson, 2003), however, as noted earlier, it is often found that this effort is not recruited (e.g., Stine, 1995).

Self-Regulated Learning

The mechanisms underlying self-regulated processing of text may operate in much the same way that learning in general is believed to be self-regulated, that is, through cognitive processes guided by a metacognitive system. For example, Hacker (1998) has described self-regulated learning as the ability to monitor the status of memory and to effectively allocate effort to future learning (i.e., an allocation policy). At the metacognitive level, an individual possesses understanding of *how* to use strategies in the context of domain knowledge, abilities, and task demands, while the cognitive level involves the actual implementation of computations (see also Dunlosky & Hertzog, 1998; Hertzog & Dunlosky, 2004). There is a growing literature suggesting that there are individual differences in the ability to self-regulate learning, though the factors that contribute to these differences are not well understood (Boekaerts, Pintrich, & Ziedner, 2000).

Selective allocation of effort to unlearned items (i.e., *discrepancy reduction*) is often an effective heuristic for enhancing learning (Nelson et al., 1994; Thiede, 1999; Hertzog &

Dunlosky, 2004). However, depending on the goal, the time available, the format of the presentation, and the knowledge of the learner (Thiede & Dunlosky, 1999; Dunlosky & Thiede, 2004; Metcalfe, 2002; Metcalfe & Kornell, 2003; Koriat, Ma'ayan, & Nussinson, 2006), both the selection of items to be studied and the time allocated may demonstrate a shift in attention toward easier items. In fact, learners often selectively allocate effort to material that is on the verge of being learned (i.e., within a *region of proximal learning (RPL)*; Metcalfe, 2002; Metcalfe & Kornell, 2005). According to this RPL model, learners will persevere in study as long as they perceive progress in learning, and will terminate study when they perceive diminished returns. Some have argued that monitoring and the self-regulated control of effort (regardless of the particular heuristic selected) can be resource-consuming, so that self-regulation of effort in learning may be constrained by working memory capacity (Thiede & Dunlosky, 1999; Dunlosky & Thiede, 2004).

Another factor that may contribute to effective regulation of effort is the set of self-referent beliefs about one's ability to effectively mobilize cognitive resources (e.g., Bandura, 1989). An argument that is frequently made in the literature is that perceived age-related changes, as well as aging stereotypes, reduce cognitive self-efficacy, so that older adults may be less likely to recruit processing resources when faced with a cognitive task (e.g., Berry, West, & Dennehey, 1989; Miller & Lachman, 1999; Welch & West, 1995; West et al., 2005). Older adults are often reported to show reduced levels of cognitive self-efficacy (e.g., West et al., 2005), and individual differences in memory self-efficacy have been related to memory performance (Berry et al., 1989).

Self-Regulated Language Processing

The Self-Regulated Language Processing Model (SRLP, Stine-Morrow, Miller, & Hertzog, 2006) is a theoretical framework that attempts to account for age differences in discourse processing in terms of these cognitive/metacognitive components. The basic unit of this model is the "negative feedback loop," as described by Carver and Scheier (1998, 2000), who conceptualize self-regulation as any behavior that aligns the perceived current state of the system with the desired state ("reference value"). Evidence from their research suggests that individuals will work to reduce discrepancy between the perceived current state and the reference value, and this engenders positive affect and the experience of success (and, as in Metcalf and Kornell's (2005) model, continued effort toward learning).

One important aspect to consider within these models, then, is the degree to which self-regulation is driven by factors that define the reference values (or "standards of coherence"; van den Broek, Lorch, Linderholm & Gustafson, 2001), such as the goal of the reader. A key assumption of the SRLP model is that cognitive, social, and emotional goals differentially contribute to the relative levels of the reference values for linguistic computations at different levels of analysis (i.e., word, textbase, and discourse-level). This array of reference values, in turn, helps to determine the reader's allocation policy (i.e., effort towards computations needed to represent language at these different levels), which is implemented so as to reduce the discrepancy between the perceived levels of coherence and the reference values. Evidence suggests that cognitive performance, and reading in particular, is driven by cognitive goals (e.g., acquisition of information, achieving set amount of learning; van den Broek et al., 2001), social goals (e.g., reading to engage in social activities; Adams, Smith, Pasupathi, & Vitolo, 2002), and emotional goals (e.g., ludic reading; see Nell, 1988). The reader's goal, then, plays a vital role in setting the reference values, driving the self-regulatory mechanisms governing the comprehension of discourse and the creation of multidimensional representations of text.

Older adults have been shown, in certain circumstances, to be sensitive to all three classes of goals. For example, in a study reported by Stine-Morrow et al. (2001), participants read a series of sentences with either a goal of comprehension or recall. Assuming that reading for good recall performance requires a more elaborated retrieval structure relative to comprehension performance (e.g., Kieras, 1981), it was not surprising that when the retrieval goal was recall, readers showed a more exaggerated allocation policy, relative to when the goal was comprehension. These data showed primarily a quantitative shift in allocation from comprehension to recall, with proportional slowing of all text processes (e.g., orthographic decoding, instantiation of new concepts, conceptual integration). Interestingly, older readers (who achieved comparable levels of performance to the young) showed greater slowing for a recall goal relative to a comprehension goal than did the young (a slope of 2.64 vs. 2.10). Such results demonstrate that older readers can be responsive to cognitive goals. However, the instructions in this study were to remember as much as possible while still reading at a natural and comfortable rate, and may not have challenged readers to achieve high levels of cognitive performance. While these data show that older adults can be responsive to cognitive goals, the larger literature noted above showing under-recruitment of effort in text processing (e.g., Ratner et al., 1987; Zabrucky & Moore, 1994; Stine-Morrow et al., 2000) suggests that the functional significance of cognitive goals may be reduced (see also the argument by Craik (1994; Craik & Jennings, 1992) that older adults are less likely to self-initiate processing).

Older readers can also be responsive to social and emotional goals, and in this arena, perhaps differentially so. For example, older readers may be less likely to show memory deficits for emotionally salient text content (Carstensen & Turk-Charles, 1994) or when retelling a story to a child (relative to recalling that same story to an experimenter; Adams et al., 2002), suggesting that older readers may have a more stringent reference value for textbase processing in order to meet emotional or social goals. Such data formed the basis for one of the tenets of the SRLP model, that the relative salience of cognitive, social, and emotional goals for text processing shifts through the life span, so that purely cognitive goals are relatively less effective in setting the reference values for older adults (while social/emotional goals become relatively more prominent; see Carstensen, 1995). Given the reduction in processing efficiency with aging, this reduced attentiveness to cognitive goals may well be, in part, a by-product of the age difference in the rate of progress toward reaching the cognitive goal (Metcalf & Kornell, 2005).

In the current study, our focus was on age differences in the effects of cognitive goals in shifting the allocation policy. We manipulated the goal for memory: in one condition, readers were encouraged to take as long as they needed to achieve near-perfect levels of recall for text content (high-accuracy goal); in the other condition, readers were encouraged to remember the key ideas as well as they could while reading quickly (high-efficiency goal). Propositional density of the texts was manipulated to increase the demands for linguistic analysis of the textbase. If older readers are able to monitor the status of memory and allocate resources accordingly to meet these goals, one would expect that they would allocate disproportionately more time to reading for the more stringent recall goal, especially as text became more complex. A self-regulatory shift, e.g., a reduced responsiveness to cognitive goals, as hypothesized above, would be manifested in a smaller effect of goal stringency on time allocation for older readers relative to younger readers. If this were due to a difficulty with metacognitive control, one would expect poor monitoring (e.g., overestimating the level of performance achieved under the stringent goal) and/or a reduction in the use of a discrepancy reduction heuristic among older readers (and that age differences in indices of monitoring and discrepancy reduction would account for age difference in performance). On the other hand, if such a self-regulatory shift were due to changes in working memory that reduce executive control, one would expect that older adults would also have differential difficulty in meeting the high-efficiency goal as well (as measured by effective reading time, the time allocated per proposition recalled, Stine

& Hindman, 1994). Furthermore, a working memory/executive control deficit would predict that age differences in performance for the high-accuracy goal and in effective reading time under the high-efficiency goal would be accounted for by an independent measure of working memory. A parallel logic would apply in testing the idea that that age-related differences in self-referent beliefs, such as memory self-efficacy (MSE; e.g., Berry, 1999; West et al., 2003), limit the recruitment processing resources for text processing.

EXPERIMENT 1

Method

Participants—Participants were 33 older (ages 51 to 80, $M = 64.33$, $SE = 1.42$) and 40 younger (ages 19 to 26, $M = 21.05$, $SE = .23$) adults. An additional one younger and three older adults participated but their data were excluded because of excessive numbers of outliers in the reading times. The older adults were recruited from the surrounding community and were paid a small honorarium for their participation. The younger adults were recruited from courses at the University of Illinois at Urbana-Champaign and were given course credit for participating. All individuals were native speakers of English, and were screened via interview prior to participation for any severe neurological or medical impairments (e.g., stroke in the last five years; inability to use hands). Age groups did not significantly differ in level of education ($M_o = 15.47$ yr, $SE = .48$; $M_y = 14.53$ yr, $SE = .23$), $t(71) = 1.78$, $p = .08$. The sample of participants was 91.7% Caucasian, 6.8% African American, 1.4% Alaska Native/American Indian; and 1.4% Hispanic.

On a five-point scale (1 = “excellent”; 5 = “poor”), participants rated their overall health ($M_o = 2.33$, $SE = .21$; $M_y = 1.65$, $SE = .14$), vision ($M_o = 2.42$, $SE = .16$; $M_y = 1.98$, $SE = .16$), and hearing ($M_o = 2.18$, $SE = .20$; $M_y = 1.65$, $SE = .14$) as good. Younger adults reported better levels of health and hearing, $t(71) = 2.69$, $p < .05$; $t(71) = 2.22$, $p < .05$, and marginally better levels of vision, $t(71) = 1.94$, $p = .06$.

Older ($M = 49.00$, $SE = 1.81$) and younger ($M = 48.05$, $SE = 1.14$) participants’ scores on the WAIS-R Vocabulary subtest (Wechsler, 1981) did not significantly differ, $t(71) = .45$. Participants were also administered both reading and listening working memory span tasks (see Stine & Hindman, 1994; Daneman & Carpenter, 1980). Younger adults scored significantly higher on the mean of these two measures ($M_o = 3.98$, $SE = .16$; $M_y = 5.44$, $SE = .17$), $t(71) = 6.21$, $p < .001$.

Finally, participants were administered the Metamemory in Adulthood Questionnaire (MIA; Dixon, Hultsch, & Hertzog, 1988), which assesses metamemory along seven dimensions (characterized in terms of positive end of the scale): (1) Strategy (knowledge and reported use of memory strategies), (2) Task (knowledge of basic memory processes), (3) Capacity (belief that one has relatively good memory capacity), (4) Change (perceived stability in memory capacity), (5) Anxiety (perceived relationship between anxiety and memory performance), (6) Achievement (strong motivation to perform well on memory tasks), and (7) Locus (perceived internal control of memory skills). Capacity and Change scales were combined to form a single indicator of Memory Self-Efficacy (MSE; cf. Dixon et al., 1988). Younger and older adults did not differ, $p > .1$, in Anxiety ($M_o = 43.0$, $SE = 1.4$; $M_y = 44.6$, $SE = 1.10$), Achievement ($M_o = 61.8$, $SE = .9$; $M_y = 60.0$, $SE = .7$), or Locus ($M_o = 29.9$, $SE = .8$; $M_y = 29.1$, $SE = .7$), but older participants scored significantly lower, $p < .05$, on Task ($M_o = 61.4$, $SE = .7$; $M_y = 64.3$, $SE = 1.0$), Strategy ($M_o = 65.7$, $SE = 1.6$; $M_y = 72.0$, $SE = 1.3$), and Change ($M_o = 45.9$, $SE = 2.0$; $M_y = 58.7$, $SE = 1.5$) scales, and marginally lower, $p < .1$, on the Capacity scale ($M_o = 53.5$, $SE = 1.6$; $M_y = 57.2$, $SE = 1.3$) relative to the younger adults. Not surprisingly, then, the age difference in MSE ($M_o = 99.4$, $SE = 19.2$; $M_y = 115.9$, $SE = 16.4$) was reliable, $t(71) = 3.95$, $p < .001$.

Materials and Design—Sentence complexity and goal were both manipulated within-subject in a 3 (Density: low, medium, high) \times 2 (Goal: accuracy, efficiency) design. Stimulus materials consisted of 36 sentences, adapted from those used by Miles and Stine-Morrow (2004), covering topics involving nature, science, and history. These sentences each contained 18 words and were similar in lexical and syntactic complexity, but varied in the number of propositions or “idea units” (Kintsch & van Dijk, 1978). To ensure variability in difficulty level, these included 12 “low-density” (5–6 propositions), 12 “medium-density” (8 propositions), and 12 “high-density” (9–10 propositions) sentences. Each sentence was followed by a short filler sentence, related to the first, to ensure that our reading time estimates for the critical target sentences reflected comprehension and encoding processes rather than preparation to make JOLs or retrieval planning. Sentences were blocked for presentation within each instructional condition and randomly ordered so that sentences of different densities were interspersed. Materials were counterbalanced across instructional condition and the order of instructional conditions was counterbalanced across subjects, creating four experimental conditions.

Procedure—Each session lasted approximately two hours. Participants were first administered the WAIS-R Vocabulary, followed by the sentence learning task. Loaded span tasks were administered at the end of the session, along with the MIA.

Sentences were presented one at a time on a Macintosh G3 computer using PowerLaboratory software (Chute & Westall, 1996) in Courier New size 36 font. To continue to each subsequent screen on the computer, the participant was instructed to push the space bar. Each trial began with a “READY?” signal. This was followed on the next screen by the target sentence. After the target sentence, the following screen displayed the filler sentence, followed by a screen on which participants were asked “How Much Will You Remember?” They responded by selecting a value from the following: 0%, 20%, 40%, 60%, 80%, 100% (Judgment of Learning), and clicking the corresponding button on the screen using the mouse. This was followed by the prompt “Recall?” at which point participants said aloud all they could remember from the passage. Recall was recorded and later transcribed. After finishing recall, the participant pressed the space bar to begin the next trial. After completing a set of nine passages, participants were presented the same set in a different random order, so that within each instructional block, subjects read and recalled each sentence pair twice. There were two sets of nine sentences in each instruction condition. Trials were eliminated from the data analysis if the participant initiated recall prior to making the JOL or produced a very fast sentence reading time (<300 ms) indicating a slip on the keyboard (this resulted in a loss of 2.2% of the data points).

In the Accuracy condition, participants were instructed to “take your time and read the passages accurately, so that you will remember as much information as possible, but do not memorize the text word for word ... try to remember both the main ideas and the details.” They were also instructed to “... aim to remember 80–100% of the information in the passage... it is more important to read carefully than to finish quickly.” In the Efficiency condition, participants were instructed to “read the passages quickly ... try to remember the main ideas, but it is not as important to focus on remembering the details.” They were also instructed to “read as rapidly as possible while still making sure you can remember the main ideas ... aim to remember 40–60% of the information in the passage ... it is more important to read quickly than carefully.” In both goal conditions, subjects were also reminded that when they were asked to make a JOL, they should “be as precise as possible in their judgment, even if it is different from 80–100% [Accuracy condition] or 40–60% [Efficiency condition] of the information.”

Results and Discussion

Reading Time and Recall Performance—Sentence reading times were screened for outliers prior to data analysis; values exceeding three standard deviations from the mean reading time for each participant within each goal condition were replaced with the reading time at the third standard deviation (resulting in replacements for 0.6% of the data points). In addition, mean reading times for each condition were inspected for outlying values. One young adult and three older adults had mean reading times which were outliers (i.e., greater than three standard deviations away from the mean) on at least two of the four study trials; their data were excluded from analysis. Both reading time and recall data were analyzed in a 2 (Age) \times 2 (Trial) \times 2 (Goal) \times 3 (Density) repeated measures analysis of variance (ANOVA) in which the latter three variables were repeated measures. Reading times are reported in seconds.

Reading time: There was a main effect of Goal on reading time, $F(1,71) = 74.51, p < .001, \eta_p^2 = .51^1$, confirming that participants allocated more time to reading with a goal of Accuracy than with a goal of Efficiency ($M_{AC} = 14.06, SE = .82; M_{EF} = 8.50, SE = .35$). Younger and older adults did not significantly differ in overall reading time ($M_y = 10.86, SE = .73; M_o = 11.69, SE = .80$), $F(1,71) < 1$, though we will show that the main effect of Age was moderated by task conditions. A main effect of Trial, $F(1,71) = 90.96, p < .001, \eta_p^2 = .56$, showed that reading time decreased across the two trials ($M_1 = 13.34, SE = .71; M_2 = 9.22, SE = .41$), while a Goal \times Trial interaction, $F(1,71) = 33.07, p < .001, \eta_p^2 = .32$, indicated that this decrease was greater in the Accuracy condition ($M_{T1} = 17.05, SE = 1.09; M_{T2} = 11.08, SE = .64$) than in the Efficiency condition ($M_{T1} = 9.64; M_{T2} = 7.35, SE = .31$), possibly a greater rereading benefit (e.g., Levy et al., 1986) accrued from a more careful linguistic analysis engendered by the high-accuracy instructions on the first trial.

A significant Goal \times Age interaction (shown by the solid lines in Figure 1), $F(1,71) = 7.08, p < .01, \eta_p^2 = .09$, indicated that older adults showed less differentiation between the goals relative to their younger counterparts. While both younger and older adults increased their time allocation for the Accuracy condition relative to the Efficiency condition, $t(39) = 6.86, p < .001$, and $t(32) = 6.36, p < .001$, for young and old, respectively, this difference was larger for the younger ($M_{AC} = 14.51, SE = 1.10; M_{EF} = 7.22, SE = .48$) than the older readers ($M_{AC} = 13.62, SE = 1.21; M_{EF} = 9.77, SE = .53$). Interestingly, older adults allocated more reading time than the young in the Efficiency condition, $t(71) = 3.46, p < .01$, but were similar in time allocation in reading in the Accuracy condition, $t(71) = .54$.

Reading times increased with propositional density (see solid lines in Figure 1), $F(2,71) = 96.85, p < .001, \eta_p^2 = .58$, ($M_L = 10.27, SE = .49; M_M = 11.51, SE = .56; M_H = 12.06, SE = .59$), an effect that was moderated by goal and by trial. The Goal \times Density interaction, $F(2,71) = 8.44, p < .001, \eta_p^2 = .11$, reflected the fact that participants' reading times were more responsive to density for the Accuracy goal ($M_L = 12.67, SE = .72; M_M = 14.40, SE = .83; M_H = 15.13, SE = .93$) than for the Efficiency goal ($M_L = 7.88, SE = .35; M_M = 8.61, SE = .38; M_H = 8.99, SE = .36$). This interaction suggests that when reading for higher accuracy, subjects were especially attentive to textbase processing, allocating more time for propositional encoding. Interestingly, this interaction was highly reliable for the young, $F(2,78) = 9.77, p < .001, \eta_p^2 = .20$, but not significant for the old, $F(2,64) = 1.39, p = .26, \eta_p^2 = .04$ (in spite of the apparently large age difference in the reliability of the Goal \times Density interaction, the Age \times Goal \times Density interaction did not reach significance, $F(2,142) = 1.11, p = .33, \eta_p^2 = .02$). To the extent that young adults did show an increased sensitivity to density under an Accuracy goal, this finding suggests that when faced with a more stringent criterion for recall performance, younger readers more thoroughly encoded the textbase, which would presumably result in a more elaborated, distinctive representation of meaning and give rise to better text memory performance. Older adults not only allocated relatively less reading time when reading

for Accuracy, but also did not adjust their allocation policy to the linguistic processes underlying textbase construction. Finally, the Trial \times Density interaction, $F(2,71) = 6.73, p < .01, \eta_p^2 = .09$, showed that participants' time allocation was more sensitive to density on the first trial ($M_L = 12.10, SE = .65; M_M = 13.56, SE = .75; M_H = 14.36, SE = .75$) than the second trial ($M_L = 8.44, SE = .37; M_M = 9.45, SE = .41, M_H = 9.75, SE = .48$).

Recall Performance: Five raters contributed to the scoring of recall protocols. After an initial training session and practice, a single set of 10 protocols (five from young and five from old) was randomly selected and scored by all five raters. Correlations between the numbers of propositions credited across the ($10 \times 36 = 360$) sentences ranged from .90 to .95 across pairs of raters.

There were main effects of Goal on the proportion of correctly recalled propositions, $F(1,71) = 87.96, p < .001, \eta_p^2 = .55$, and Trial, $F(1,71) = 351.01, p < .001, \eta_p^2 = .83$, verifying that participants recalled more in the Accuracy condition than the Efficiency condition ($M_{AC} = .74, SE = .02; M_{EF} = .63, SE = .02$), and recalled more after the second trial than the first ($M_{T2} = .75, SE = .02; M_{T1} = .62, SE = .02$). A marginal effect of Age was also found, $F(1,71) = 3.43, p = .07, \eta_p^2 = .05$, such that younger adults recalled slightly more ($M_Y = .71, SE = .02; M_O = .66, SE = .02$). These main effects were moderated in a series of two-way interactions.

A Trial \times Age interaction, $F(1,71) = 12.63, p < .001, \eta_p^2 = .15$, showed that younger adults ($M_{T2} = .80, SE = .02; M_{T1} = .63, SE = .02$) took more advantage of the second trial than the old ($M_{T2} = .71, SE = .02; M_{T1} = .60, SE = .03$) to increase recall, $t(71) = 2.64, p < .05$, replicating findings from Miles and Stine-Morrow (2004). This is important in showing that age deficits in text recall for text can actually increase with exposure because of younger adults' relative facility in encoding the propositional content.

A Goal \times Trial interaction, $F(1,71) = 15.70, p < .001, \eta_p^2 = .18$, showed participants' recall performance benefited less from a second trial when reading for Accuracy ($M_1 = .68, SE = .02; M_2 = .80, SE = .01$) than when reading for Efficiency ($M_1 = .55, SE = .02; M_2 = .70, SE = .02$). The latter finding is consistent with the reading time data in suggesting that greater allocation initially yielded a more distinctive representation, which facilitated subsequent processing and yielded smaller gains with reprocessing.

Finally, the Goal \times Age interaction (shown in the upper left panel of Figure 2) was reliable, $F(1,71) = 14.19, p < .001, \eta_p^2 = .17$, which indicated that the young recalled more than the old in the Accuracy condition ($M_Y = .79, SE = .02; M_O = .69, SE = .02$), $t(71) = 3.45, p < .01$, while recall was age-equivalent ($M_Y = .64, SE = .03; M_O = .62, SE = .03$) in the Efficiency condition, $t(71) = .36$. Note that both groups recalled more when instructions stressed high levels of memory performance, $t(32) = 8.72, p < .001$ and $t(39) = 4.56, p < .001$, for young and old, respectively, but the older readers showed a smaller effect of goal. Also note that the young, but not the old, got within reach of the 80–100% goal of the high-accuracy condition, while neither group performed within the 40–60% range for the low-accuracy/high-efficiency condition. As expected, recall performance decreased as density increased ($M_L = .73, SE = .02; M_M = .68, SE = .02; M_H = .65, SE = .02$), $F(2,71) = 76.05, p < .001, \eta_p^2 = .52$. A marginal Density \times Age interaction, $F(2,71) = 2.88, p = .06, \eta_p^2 = .04$, indicated that the largest age differences in recall performance were for the lowest ($M_Y = .76, SE = .02; M_O = .70, SE = .03$), $t(71) = 1.91, p = .06$, and highest density sentences ($M_Y = .68, SE = .02; M_O = .61, SE = .02$), $t(71) = 2.18, p < .05$. The age difference for medium density sentences was not significant, ($M_Y = .70, SE = .02; M_O = .66, SE = .02$), $t(71) = 1.31, p = .20$. None of the remaining interactions reached statistical significance.

Together, the reading time and recall performance data suggest that younger and older adults differentially responded to the task demands inherent in the different goal conditions. Though both age groups shifted their allocation as a function of retrieval goal, the older adults appeared to be less likely to work toward complete compensation (to accommodate either the increase in goal stringency or text difficulty). Assuming age-graded limitations in processing capacity, it is understandable why age equivalence in time allocation under the Accuracy goal produced age deficits in memory performance and why age equivalence in recall was achieved under the Efficiency goal given the older adults' relatively greater time allocation (cf. Hartley et al., 1994)

Effective Reading Time: To more specifically explore age differences in how time allocation paid off in terms of memory performance, a single index of Effective Reading Time (ERT) was computed by dividing reading time by the number of propositions recalled to yield a measure of text encoding efficiency, or the time (in seconds) required to encode one proposition (cf. Stine & Hindman, 1994). The main effect of Goal was reliable, $F(1,71) = 19.33, p < .001, \eta_p^2 = .21$, indicating that participants were more efficient in encoding text when given an Efficiency goal relative to an Accuracy goal ($M_{EF} = 2.15, SE = .15; M_{AC} = 2.70, SE = .15$). This is interesting because it suggests that the extra time allocated to reading did not pay off proportionately in recall performance – an example of a “labor-in-vain” effect (Nelson & Leonesio, 1988). Under the Efficiency goal, readers allocated less time, but also appeared to pick up relatively more “on the fly.” In addition, a main effect of Trial, $F(1,71) = 192.03, p < .001, \eta_p^2 = .73$, indicated that participants became more efficient on the second trial ($M_1 = 3.10, SE = .18; M_2 = 1.75, SE = .10$). This is not surprising because there was presumably some savings at the second reading due to the textbase representation created on the first reading (i.e., a “rereading” benefit; see Stine-Morrow, Gagne, Morrow, & DeWall, 2004). In addition, younger adults were more efficient, requiring less encoding time per proposition ($M_Y = 2.09, SE = .18; M_O = 2.76, SE = .20$), $F(1,71) = 6.20, p < .05, \eta_p^2 = .08$, though the degree to which readers' efficiency was enhanced by a second reading did not vary with age, $F(1,71) = 1.06$. Finally, the main effect of density, $F(2,71) = 42.95, p < .001$, showed contextual facilitation (i.e., greater efficiency with increased semantic context), such that participants became more efficient as density increased ($M_L = 2.78, SE = .16; M_M = 2.27, SE = .12; M_H = 2.23, SE = .14$). These main effects were moderated in a series of interactions.

The upper right panel of Figure 2 shows the significant Age \times Goal interaction, $F(1,71) = 5.53, p < .05, \eta_p^2 = .07$, in which the goal effect on ERT was more exaggerated for the young. In fact, while younger readers showed a reliable difference in ERT between the two conditions, $t(71) = 5.29, p < .001$, older readers did not, $t(71) = 1.81, p = .08$. Thus, younger adults were relatively better at the more speeded encoding of ideas in the Efficiency condition, but by the same token, they were also more vulnerable to the “labor in vain” effect, allocating more time than they apparently needed in the Accuracy condition for effective encoding.

The main effect of density on ERT was moderated by other factors. The Age \times Density interaction, $F(2,71) = 5.27, p < .01, \eta_p^2 = .07$, showed that younger adults became steadily more efficient at propositional coding as sentence density increased ($M_L = 2.33, SE = .22; M_M = 2.04, SE = .16; M_H = 1.90, SE = .18$), $p < .01$ for each comparison. Older adults, on the other hand, showed a large increase in efficiency from low- to medium-density sentences, $t(32) = 5.00, p < .001$, but did not become more efficient as density increased from medium to high ($M_L = 3.22, SE = .24; M_M = 2.50, SE = .17; M_H = 2.56, SE = .20$). The Density \times Trial interaction, $F(2,71) = 6.67, p < .01, \eta_p^2 = .09$, indicated that participants became especially more efficient as density increased within Trial 2 ($M_L = 2.01, SE = .11; M_M = 1.66, SE = .09; M_H = 1.57, SE = .10$), $p < .05$ for each comparison. Within Trial 1, however this effect was only present in the difference between low- and medium-density sentences ($M_L = 3.54, SE = .22; M_M = 2.87, SE = .15; M_H = 2.89, SE = .18$), $t(72) = 5.95, p < .001$; there was no difference between

medium- and high-density ERTs on Trial 1, $t(72) = .09, p = .93$. No other interactions reached significance.

Collectively, the reading time and recall data suggest there were age differences in allocation policy and effectiveness as a function of goal. Under a goal stressing high levels of memory accuracy, both younger and older adults allocated similar amounts of time, yet younger adults recalled more. Assuming that aging brings reduced processing efficiency, one might expect that older adults would have spent more time to be accurate, yet they did not. Furthermore, older readers were less efficient in encoding textbase content than the young, who interestingly became more efficient under task conditions promoting time constraints. These results suggest that, relative to the young, older adults were less flexible in responding to shifting task constraints both with respect to sheer allocation of time (raw RT) and intensity of effort (ERT). The findings to this point are consistent with the notion that age deficits in memory for textbase content may, in part, reside in older readers' relative difficulty in self-regulating effort (i.e., underallocation of effort), and that a contributing factor may be working memory deficits (i.e., reduced processing effectiveness).

The Role of Metacognition in Age Differences in Self-Regulation—As noted earlier, one plausible explanation for the age differences in underallocation of effort resides in metacognitive control; perhaps older readers were not effectively monitoring the status of the constructed memory representation and allocating effort accordingly. To assess how well participants could monitor the status of what they had learned, we calculated Goodman-Kruskal gamma (γ) correlations between sentence JOLs and percentage of propositions recalled for each subject. Representing the ordinal relationship between actual and perceived memory for individual items, this index of *relative accuracy* (or *resolution*; Koriat, 1997) gauges how well readers could discriminate between learned and unlearned sentences (without respect to performance in absolute terms). We also examined *absolute accuracy* (or *calibration*; Koriat, 1997) by directly comparing actual memory and perceived learning as a within-subjects factor in an ANOVA. Finally, we examined self-regulation in the allocation of effort by calculating gamma correlations between sentence JOLs on Trial 1 and subsequent reading time, and Pearson correlations between recall on Trial 1 and subsequent reading time (cf. Dunlosky & Connor, 1997; Miles & Stine-Morrow, 2004); these measures index the degree to which readers used a discrepancy reduction heuristic (i.e., greater allocation of effort on the second trial to items less well learned on the first).

Memory Monitoring: Relative and Absolute Accuracy: Both younger and older adults demonstrated memory monitoring, as indicated by mean gamma correlations between JOLs and recall performance ($M_Y = .28, SE = .04; M_O = .29, SE = .04$) that were significantly greater than zero (all p 's < .004). Gammas were analyzed in a 2 (Age) \times 2 (Trial) \times 2 (Goal) repeated measures ANOVA (note that density could not be included in this analysis due to the small number of data points per cell (i.e., six from each goal-density-trial condition)). There was a main effect of trial, $F(1, 45) = 5.28, p < .05, \eta_p^2 = .11$, showing that participants were better at assessing relative differences in learning among items on the first trial than the second ($M_1 = .34, SE = .03; M_2 = .23, SE = .04$). However, memory monitoring was unaffected by age or goal condition, $F(1, 45) < 1$, and $F(1, 45) = 1.75$, respectively. Thus, it does appear that older adults were able to accurately monitor the contents of memory as well as their younger counterparts. This age-equivalence is consistent with much other literature (Hertzog & Hulstsch, 2000; Hertzog & Dunlosky, 2004), but not with Miles and Stine-Morrow (2004), who used similar materials and showed age deficits in memory monitoring. A nontrivial methodological difference between the Miles and Stine-Morrow study and the current one was the way in which materials were blocked. In the earlier study, sentences of similar propositional density were blocked for presentation, while in the current study items were blocked by goal, but were heterogeneous with respect to propositional density within goal. The blocking by density in

Miles and Stine-Morrow (thus, locally increasing homogeneity of item difficulty) may have made it relatively difficult to discriminate among the learnability of items, a factor that might have pushed older adults' monitoring abilities to their limits. In fact, mean gammas were somewhat lower in the earlier study ($M_{T1} = .28$, $M_{T2} = .21$), relative to those of the current study.

To measure how perceived learning compared to actual memory performance in absolute terms, we examined the relationship between average recall and JOLs within each condition in a 2 (Measure: actual recall vs. JOLs) \times 2 (Age) \times 2 (Trial) \times 2 (Goal) \times 3 (Density) analysis. A main effect of Measure, $F(1,71) = 16.05$, $p < .001$, $\eta_p^2 = .18$, showed that overall, participants underestimated their actual recall performance ($M_{REC} = .69$, $SE = .02$; $M_{JOL} = .61$, $SE = .02$). Absolute accuracy varied across trial and density, as shown by Trial \times Measure and Density \times Measure interactions, $F(1,71) = 20.15$, $p < .001$, $\eta_p^2 = .22$; $F(2,71) = 45.07$, $p < .001$, $\eta_p^2 = .39$. The Trial \times Measure interaction indicated that participants underestimated their performance more in the second trial ($M_{REC} = .75$, $SE = .02$; $M_{JOL} = .66$, $SE = .02$) than the first ($M_{REC} = .62$, $SE = .02$; $M_{JOL} = .57$, $SE = .02$), an example of the "underconfidence with practice" effect reported by Koriat, Sheffer, and Ma'ayan (2002) (though we note that, unlike Koriat et al., we also found practice effects on relative accuracy). The Density \times Measure interaction supported the observation that actual recall ($M_L = .73$, $SE = .02$; $M_M = .68$, $SE = .02$; $M_H = .65$, $SE = .02$) was highly sensitive to sentence density, $F(2,72) = 74.53$, $p < .001$, but that perceived recall ($M_L = .62$, $SE = .02$; $M_M = .61$, $SE = .02$; $M_H = .61$, $SE = .02$) was comparatively insensitive, though this small difference in means was reliable, $F(2,72) = 11.08$, $p < .001$. The interaction is interesting because, in reality, readers allocated more time with increasing density, suggesting that readers, at least implicitly, recognized text difficulty. The apparent implication of the small effect of density on JOLs is that readers perceived that the effort they had allocated to more difficult texts had largely compensated for the difficulty such that their allocation policies had produced similar levels of recall across density conditions. This perception, of course, was not completely veridical.

Finally, the Goal \times Measure interaction, $F(1,71) = 15.52$, $p < .001$, $\eta_p^2 = .18$, which did not vary with age, $F(1,71) < 1$, showed that participants underestimated their performance more when given an Efficiency goal ($M_{REC} = .63$, $SE = .02$; $M_{JOL} = .53$, $SE = .02$) than an Accuracy goal ($M_{REC} = .74$, $SE = .02$; $M_{JOL} = .70$, $SE = .02$). This is interesting because it suggests that more stringent performance goals (which one might expect to focus attention on the quality of the memory representation) not only increased performance levels, but also increased absolute accuracy of monitoring. Alternatively, readers greatly underestimated what they could glean from a quick read. Although this interaction did not reach significance in our analysis of relative accuracy, it is interesting in suggesting that monitoring may have been better in the condition that generated the better performance, and hence, may have contributed to the achievement of higher accuracy in this condition.

The analyses of monitoring show that readers are fairly good at estimating what they will recall from text, as measured in both absolute terms and in terms of relative differences among items. Furthermore, there was no evidence for age differences in either of these measures of memory monitoring (Connor et al., 1997; Hertzog & Hultsch, 2000; Hertzog & Dunlosky, 2004). These findings make it unlikely that older adults failed to allocate effort under the more stringent goal for recall because they did not realize that they were not achieving the goal.

Selective allocation to unlearned items: Both age groups demonstrated discrepancy reduction, indicated by significantly negative gamma correlations ($M_Y = -.30$, $SE = .04$; $M_O = -.24$, $SE = .05$) and Pearson correlations ($M_Y = -.32$, $SE = .03$; $M_O = -.30$, $SE = .03$, all t -tests significant, p 's $< .01$). Neither of these measures varied with age or goal condition, all

$F_s < 1$, indicating that younger and older adults made similar use of a discrepancy-reduction heuristic, regardless of goal.

Collectively, these data suggested that age differences in responsiveness to the goals in terms of reading time allocation or recall performance could not be attributed to age differences in monitoring or differential use of a discrepancy reduction heuristic. Thus, we found no evidence for age differences in metacognition that could account for the observed age differences in resource allocation in reading (though we take up this point in a second experiment).

The Roles of Working Memory and Self-Efficacy—Another set of explanations for older adults' relative insensitivity to goals has to do with a failure to recruit the resources to meet task demands. Recall that our older sample showed lower levels of both memory self-efficacy and working memory capacity than the younger sample. As noted earlier, age-related deficits in working memory capacity may have diminished the ability of older readers to reach the more stringent recall goal and/or to increase reading efficiency. Alternatively, age differences in memory self-efficacy may have made it less likely that older readers make full use of their capacities.

Table 1 presents the correlations between ability measures (vertically) and measures of recall performance, reading time allocation, and effective reading time in each accuracy condition averaged across trial (horizontally). (For the moment, we focus our discussion on the analysis of the sample as a whole.) These data show that WM and MSE were predictive of recall performance, and that these relationships were somewhat stronger when the goal for recall was more stringent. WM and MSE were also negative predictors of reading time and effective reading time, but most clearly when instructions stressed efficiency of encoding. Note that we hypothesized earlier that if self-regulatory differences were attributable to central executive resources in working memory, as well as the belief that the recruitment of these resources would affect outcomes, then these individual differences would have the greatest impact on outcomes targeted by the goal. In fact, the pattern of correlations in Table 1 is consistent with this idea. Individuals with larger working memory spans and stronger efficacy beliefs produced the highest levels of recall performance when the goal stressed accuracy. In this goal condition, neither WM nor MSE was related to reading time because high-span readers (with effective central executive function) and individuals with strong efficacy beliefs (who persevere) allocate whatever time was necessary to meet the goal, even though, at least in the case of high-span subjects, their cognitive capacity would have presumably allowed them to allocate less time. Even though high-span and high-efficacy readers appear to be generally more efficient, this is especially true when the goal stressed efficiency.

These findings suggest that both working memory and self-efficacy contribute to flexible processing in text memory, enhancing accuracy when task conditions emphasize memory for content and enhancing efficiency when task conditions emphasize speed. These correlations within age groups showed that while these individual differences contributed to text processing for both age groups, their effects were more sporadic among the young, but quite robust in the older group. In particular, self-efficacy was more important among the older learners for achieving high recall in the accuracy condition and high levels of efficiency in the speeded condition.

Hierarchical regression was used to examine the extent to which these predictors contributed independently to performance measures. This was important because, not surprisingly, there was a weak but reliable correlation between WM and MSE in the sample as a whole ($r = .315$, $p < .001$, though not reliable in either age group). In these analyses, vocabulary, WM, and MSE were entered on the first step, and then age was regressed onto the residuals. These results, presented in Table 2, show that, in fact, all three factors do independently contribute to recall

performance. Vocabulary was a reliable predictor regardless of goal or measure of performance. For recall in the accuracy condition and effective reading time in the efficiency condition (i.e., goal-targeted outcomes), working memory and memory self-efficacy were separate and independent influences on performance. In other words, for those outcomes that presumably most reflected controlled processing used to meet task demands, what was important for good performance was both working memory capacity (executive function that provided resources for regulation of effort), as well as self-efficacy beliefs (that engendered the engagement of these resources). Thus, the regressions confirmed the patterns suggested by the correlations that working memory and self-efficacy each engender a more flexible approach to text processing demands, and showed that these were independent contributors. When these individual differences were partialled out, age was no longer a significant predictor (cf. Table 1).

To further examine the hypothesis that more effective central executive processing (WM) and a stronger sense of MSE each contributed to the differential responsiveness of the young to the more stringent condition, we performed hierarchical regression analyses on the proportion shift in reading time allocation and recall performance across task conditions ((Accuracy-Efficiency)/Efficiency). As expected, both of these were negatively related to age, $r = -.41$, $p < .001$ for proportion shift in reading time, and $r = -.27$, $p < .05$ for proportion shift in recall. The regression predicting the proportion shift in recall from WM and MSE was not significant, $F < 1$, but for reading time allocation, age differences in the proportion shift was accounted for by both WM, $\beta = .313$, $p < .01$, and MSE, $\beta = .283$, $p < .05$, $\text{AdjR}^2 = .19$, so that with these variables in the equation, age was no longer a significant predictor, $\beta = -.183$, $p = .22$. Thus, working memory capacity and positive self-referent memory beliefs, which presumably engender the engagement of working memory resources each contributed to a flexible allocation policy.

To get a clearer picture of the factors underlying proficient recall performance under the more stringent goal conditions, we used regression to model recall in the Accuracy condition in terms of both process and ability variables. Recall that age deficits in this condition were reliable, $r = -.38$, $p < .001$, but could be accounted for in terms of age differences in WM and MSE (cf. Table 2). We considered the additional effects of two processing variables, efficiency of propositional encoding, as measured by ERT in the Efficiency condition (i.e., a gauge of how quickly ideas could be extracted from text when readers were pressed for time), and the time allocated when the recall goal was more stringent, as measured by RT in the Accuracy condition. These were strong independent predictors, $\beta = -.602$, $p < .001$ for ERT-Efficiency, and $\beta = .404$, $p < .001$ for RT-Accuracy, suggesting that efficiency of propositional encoding and allocation of time independently contributed to text recall (cf. Hartley et al., 1994) when the reference value for textbase encoding was set at a relatively high level through instructions. With these in the equation, WM remained a significant predictor, $\beta = .180$, $p < .05$, and vocabulary was marginally significant, $\beta = .139$, $p < .1$, but neither MSE, $\beta = .023$, nor age, $\beta = -.080$, contributed to prediction. With $\text{AdjR}^2 = .63$, a substantial amount of variance was accounted for with this model. Interestingly, in a hierarchical regression in which processing variables were entered first, and vocabulary, WM, and MSE were regressed onto residuals, ERT-Efficiency and RT-Accuracy alone showed almost the same level of variance accounted for, $\text{AdjR}^2 = .61$, with vocabulary, WM, MSE, and age, adding nothing to the equation.

This set of analyses suggest that older readers were less sensitive to the stringency of the recall goal because such an adjustment is resource-consuming, and age-related decreases in both working memory and memory self-efficacy make such a shift less likely. This plays out in terms of older adults encoding ideas at a slower rate and not allocating sufficient time to compensate for this change.

Conclusion

Collectively, findings from this experiment suggest that older readers may be less sensitive to goals oriented toward the acquisition of textbase content. When faced with more stringent recall goals emphasizing accuracy over speed, younger adults shifted their allocation policy such that they increased reading time and allocated particularly more time for linguistic processes that would support the encoding of a complete and distinctive textbase representation, and consequently, showed substantial improvement in text recall. By contrast, when faced with less stringent recall goals that emphasized speed of encoding over accuracy, younger readers became especially efficient. Older readers were generally less flexible in their reading strategies, showing less of an increase in reading time and recall when the goal for memory was stringent, and virtually no increase in efficiency of encoding when the emphasis was placed on speed.

This reduced flexibility among older readers in adjusting to cognitive goals could be accounted for, in part, by working memory deficits that compromise executive control, as well as age differences in memory self-efficacy. The argument, then, is that the cause of age differences in responsiveness to cognitive goals is attributable to (a) a deficit in the processing resources needed to regulate task control and to meet the computational demands (e.g., propositional analysis in the high-accuracy condition), as well as to (b) self-referent memory beliefs that do not favor the recruitment of the processing resources that may be available.

Perhaps surprisingly, we found no evidence that age differences in metacognition contributed to task performance. Given the suggestions in the literature that metacognitive control can be resource-consuming, one might have expected that age differences in monitoring (e.g., Miles & Stine-Morrow, 2004) and/or the use of discrepancy reduction heuristic (Dunlosky & Connor, 1997) might have occurred and contributed to age differences in memory performance. However, both younger and older adults showed evidence of both effective monitoring and use of discrepancy reduction, with no age differences apparent. We wondered whether older adults might, in fact, be allocating attention to monitoring at some cost to actual processing. That was the focus of our second experiment.

EXPERIMENT 2

In order to assess the impact of the judgments of learning themselves on learning information from sentences, we exactly replicated the first experiment, with the exception of the judgments: instead of making JOLs, which focus attention on the status of memory, participants were asked to judge how interested they were in each sentence. Our reasoning was that such judgments are neutral with respect to metacognition. To the extent that interest represents one's affective engagement with the text (e.g., Hacker, 1998), we expected such reactions to be relatively free in terms of resource requirements, and perhaps might even favor the older readers in increasing the salience of affective engagement (e.g., Carstensen & Turk-Charles, 1994; Meyer, Talbot, Stubblefield, & Poon, 1998). If metacognitive monitoring of learning draws resources away from cognitive processes needed to achieve adequate performance, we expected that the individuals in this experiment would show better performance relative to those in the first experiment, especially when the recall goal was stringent, and that older adults' performance would show differential benefit.

Method

Participants—Participants were 20 older (ages 51 to 84, $M = 66.95$, $SE = 1.84$) and 19 younger (ages 19 to 25, $M = 20.21$, $SE = .33$) adults drawn from the same populations as those in the first experiment (an additional two younger and three older participants were tested, but their data were excluded from analysis because of excessive outliers in the reading time data).

Older participants had participated in more years of formal education than the young sample ($M_o = 16.60$, $SE = .63$; $M_y = 13.68$, $SE = .32$), $t(37) = 3.93$, $p < .001$. The sample of participants was 95% Caucasian, 2.5% African American, and 2.5% Alaska Native/American Indian. On a five-point scale (1 = "excellent"), participants rated their overall health ($M_o = 1.65$, $SE = .13$; $M_y = 1.63$, $SE = .14$), vision ($M_o = 1.85$, $SE = .15$; $M_y = 1.74$, $SE = .18$), and hearing ($M_o = 2.10$, $SE = .22$; $M_y = 1.63$, $SE = .16$) as good to excellent. There were no age differences in these ratings, $t(37) < 1.74$, $p > .09$ for all. Older adults had an advantage on the WAIS-R Vocabulary subtest ($M_o = 53.25$, $SE = 1.83$; $M_y = 44.25$, $SE = 1.83$), $t(37) = 3.93$, $p < .001$, but young had the advantage in working memory span ($M_o = 4.47$, $SE = .24$; $M_y = 5.52$, $SE = .29$), $t(37) = 2.83$, $p < .01$.

Materials and Procedure—The experimental session was identical that described in the first experiment, with the exception of the form of the judgments. After reading each passage, participants were asked to make a judgment of interest (JOI) on a scale of 0 (not interesting at all) to 5 (extremely interesting).

Results and Discussion

Reading time data were screened as in the first experiment (1.9% of the data were lost because subjects spoke, initiated recall prior to the recall cue, or inadvertently pressed the key before reading the sentence; 0.9% of the data points were replaced as outliers). In describing our findings, we focus on the ways in which judgment type (a between-subjects variable across the two experiments) did and did not moderate effects. Because the older sample in this study was relatively more educated and somewhat higher in verbal ability relative to those in the first experiment, analyses were conducted with vocabulary as a covariate. We report the results from the covariate analysis when it made a substantive difference in the analysis.

Recall Performance and Reading Time—As seen in Figure 1, patterns of reading time allocation as a function of density, goal, and age were similar to those of the first experiment. In particular, the interaction between age and goal was robust, $F(1,108) = 12.16$, $p < .001$, $\eta_p^2 = .10$. The type of judgment had no effect on reading times, $F(1,108) < 1$, nor did judgment type reliably interact with any other variables (e.g., what appears to be interactions between age and judgment type and among age, judgment type, goal, and density were not reliable, both $F_s < 1$). Nevertheless, we note that within Experiment 2 (dotted lines in Figure 1), both younger adults, $F(2,36) = 4.19$, $p < .05$, $\eta_p^2 = .19$, and older adults, $F(2,38) = 3.47$, $p < .05$, $\eta_p^2 = .15$, showed a reliable interaction between goal and density, reflecting differential attention to linguistic analysis of the textbase when reading for high levels of accuracy.

Comparing the proportion of propositions recalled across the two experiments, overall performance tended to be higher when participants judged interest rather than perceived learning, however, this difference was not statistically reliable ($M_{JOL} = .68$, $SE = .02$; $M_{JOI} = .72$, $SE = .02$), $F(1,108) = 2.61$, $p = .11$. The only interaction with judgment type was the three-way interaction among trial, age, and judgment type, $F(1,108) = 12.60$, $p < .001$, $\eta_p^2 = .10$. In contrast to the results of the first experiment, these data showed no young advantage in gain across trials; rather, the trial by age interaction tended in the other direction, $F(1,37) = 3.69$, $p = .062$, $\eta_p^2 = .09$, so that the age differences were smaller on the second trial ($M_Y = .81$, $SE = .03$; $M_O = .77$, $SE = .03$) than on the first ($M_Y = .70$, $SE = .03$; $M_O = .63$, $SE = .03$). As shown in the left panel of Figure 2, the interaction between age and goal, $F(1,108) = 13.18$, $p < .001$, $\eta_p^2 = .11$, did not significantly vary with judgment type, $F(1,108) < 1$.

Effective reading time tended to be shorter when readers made JOIs relative to when they made JOLs ($M_{JOL} = 2.42$, $SE = 1.1$; $M_{JOI} = 2.12$, $SE = 1.4$), however, this effect was not reliable, $F(1,108) = 2.24$, $p = .14$, and did not interact with age, $F(1,108) = 1.87$, $p = .17$. As shown in the right

panel of Figure 2, across both experiments, effective reading time for younger adults was differentially faster in the efficiency instructional condition, $F(1,108)=7.21$, $p<.001$, $\eta_p^2 = .06$; this interaction did not significantly vary as a function of judgment type, $F(1,108)<1$. We note, however, that within the second experiment, age differences in effective reading time did not reach significance, $F(1,37)<1$, and $F(1,36)=2.06$, $p=.17$, with vocabulary covaried out.

Metacognitive Monitoring and Control—Readers tended to show better recall for sentences they judged to be more interesting ($\gamma = .17$ and $.20$ for Trials 1 and 2, respectively), but the correlations between recall and judgments were somewhat lower for interest relative to learning, $F(1,74)=4.87$, $p<.05$, $\eta_p^2 = .06$. We measured discrepancy reduction as the Pearson correlation between recall on the first trial and time allocation on the second trial. As in the first experiment, participants showed reliable discrepancy reduction both when reading for accuracy, $r = -.37$, $t(38)=6.41$, $p<.001$, and when reading for efficiency, $r = -.26$, $t(38)=9.58$, $p<.001$. Interestingly, in contrast to the first experiment in which goal had no effect on discrepancy reduction, in this case, discrepancy reduction was greater when reading for efficiency relative to when reading for accuracy $F(1,37)=4.33$, $p<.05$, $\eta_p^2 = .10$. The diminished discrepancy reduction when reading for high levels of accuracy but making JOIs may have to do with the relative incompatibility of the goal (attention to memory accuracy) and the focus of the judgment on affective response to the material.

Conclusion

Collectively, data from the second experiment showed some modest support for the idea that the requirement for explicit memory monitoring inherent in the JOL paradigm may alter processing. In the second experiment, older readers were similar to the young in showing increased responsiveness to demands for textbase processing (i.e., a larger density effect) when the goal was a high level of accuracy. In this experiment, older adults also showed similar recall gains over trial that were similar to those shown by the young. These findings suggest that memory monitoring may draw resources away from encoding.

GENERAL DISCUSSION

Older readers showed poorer memory for the propositional content of sentences (cf. Johnson, 2003). The question addressed in this paper was why these deficits occur. Age differences were exaggerated as the goal for recall accuracy was increased. As a manipulation that increased performance for younger readers, the instantiation of a cognitive goal may be considered a form of “testing-the-limits” (Baltes, 1987). As with other examples of testing-the-limits, while both younger and older adults showed improved performance, age differences became exaggerated as performance generally improved. We attribute this age difference to two key factors. First, age-related decreases in working memory capacity reduced the quality of the text representation constructed during reading so that retrieval was then dependent on a more fragmented, less distinctive trace. At the same time, relative to the young, older readers allocated disproportionately less time as the stringency of the recall goal was increased, particularly when attention was drawn to the memory goal through explicit judgments of learning. Thus, a second factor contributing to age differences was a failure to self-initiate processing. However, this self-initiation deficit was attributable to executive control (another working memory function), as well as to self-referent beliefs, i.e., memory self-efficacy, which hindered the engagement of available resources. Working memory and self-efficacy beliefs made independent contributions in explaining the age differences in memory performance when the goal was high levels of accuracy.

The relative lack of responsiveness of older readers to increased stringency in the accuracy goal did not appear to reside in any difficulty with memory monitoring or selective allocation

of attention to unlearned material. In fact, we found no age differences in our measures of metacognitive monitoring or control. However, insofar as the judgment-of-learning paradigm exaggerates the resource requirement for monitoring, it appears that explicit monitoring of the memory representation may be particularly resource-consuming for older adults, perhaps consuming attention that would otherwise be used for the computations needed to construct the linguistic representation. Another caveat in dismissing a metacognitive account is that even though age differences in monitoring were not detectable, it is possible that older adults may have had less confidence in these judgments, and so rely on them less to allocate effort. A similar phenomenon has been reported by Touron and Hertzog (2004), who found in a paired-associate memory task that older adults looked up targets during testing (which took longer than memory retrieval) even though an objective test of memory indicated that they could have relied on their memory.

At the same time, patterns of performance obtained when younger and older adults read under a goal emphasizing speed suggest that when younger adults allocated time in the accuracy condition, they may in fact, have allocated more time than they actually required (reflecting reduced efficiency, i.e., a “labor-in-vain” effect). In other words, given the level of efficiency the younger adults were capable of when pressed, it may have been possible, in principle, for them to have achieved high levels of accuracy with less time allocation. Older adults were less vulnerable to this labor-in-vain effect. Nevertheless, it is important to note that the ultimate result of such an allocation policy was poorer performance relative to the young when the goal was to be accurate and greater time allocation when the goal was to be efficient (Figure 2). These data, therefore, provide support for one facet of the SRLP model, that cognitive goals exert relatively less influence on the allocation policy of older readers. These findings further suggest that the reduced functional significance of cognitive goals may be due in part to working memory limitations that make it difficult to meet processing requirements (“what you have”), as well as to individual differences in memory self-efficacy that limit the recruitment of resources that are available (“what you believe you can do”). Together, these factors may contribute to an allocation policy that is not favorable to good memory performance (“what you do”; e.g., reduced effort in the face of stringent recall goals, less attention to linguistic analysis, reduced adaptability with changing task demands).

The intentional focus in this study on effects of the stringency of cognitive, information-acquisition goals illuminated certain constraints in the ability of older adults to learn from text. However, these constraints must be contextualized in terms of a system that may be relatively more sensitive to socioemotional goals in learning (e.g., Adams et al., 2002), more attuned to situational features (e.g., Dijkstra, Yaxley, Madden, & Zwaan, 2004; Stine-Morrow, Morrow, & Leno, 2002; Stine-Morrow et al., 2004), and more adept at exploiting knowledge (Miller & Stine-Morrow, 1998; Miller, Cohen, & Wingfield, in press; Miller, Stine-Morrow, Kirkorian, & Conroy, 2004) and the higher-order structures of discourse (Stine-Morrow, Miller, Gagne, & Hertzog, submitted).

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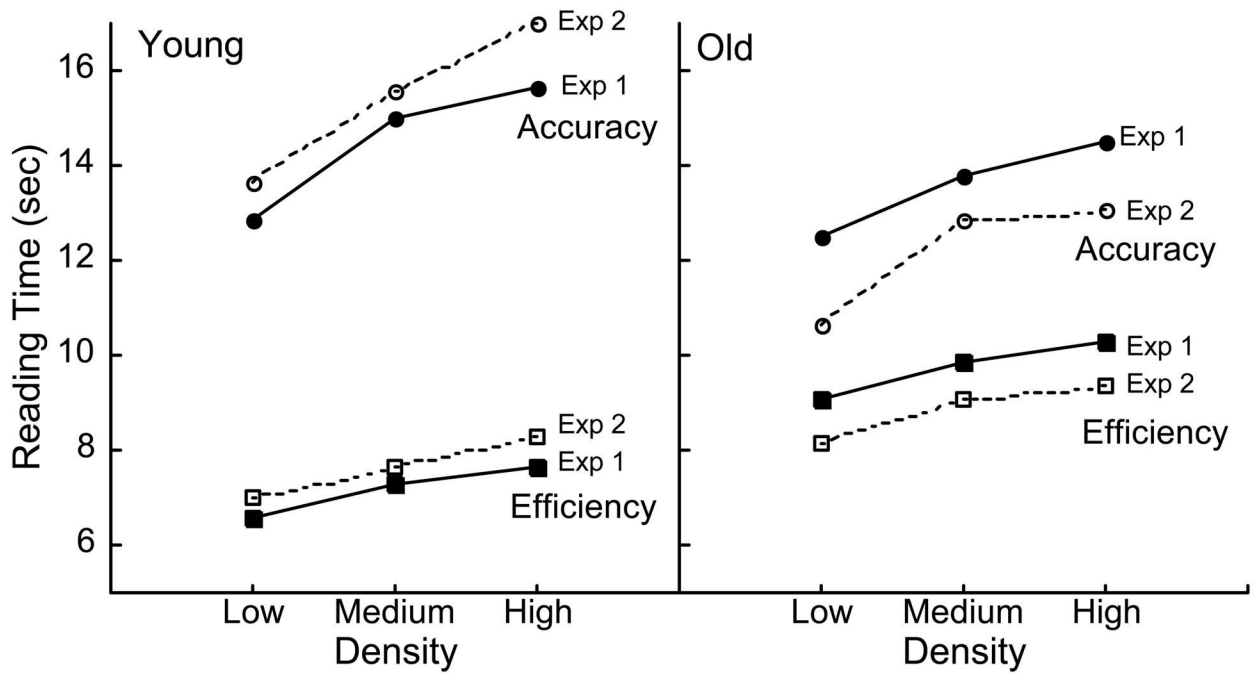


Figure 1. Reading Time as a function of Density and Goal for Younger (left) and Older (right) Adults (solid lines show data from Experiment 1; dotted lines, from Experiment 2).

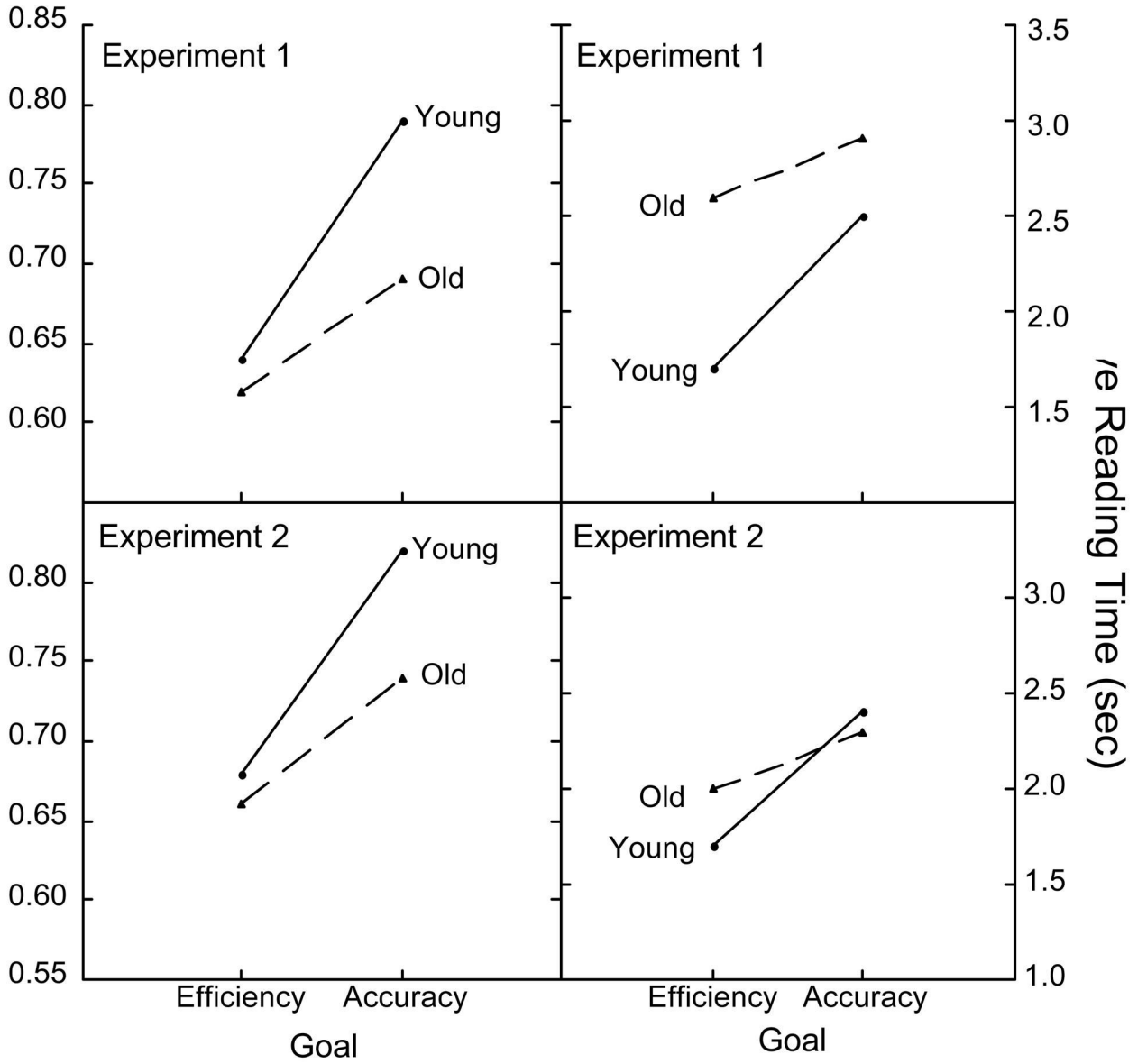


Figure 2. Proportion Propositions Recalled (left) and Effective Reading Time (right) as a function of Goal and Age (upper panel shows data from Experiment 1; lower panel, from Experiment 2).

Table 1

Pearson correlations between Measures of Text Memory Performance and Individual Differences in Vocabulary Level, Working Memory, and Memory Self-Efficacy

	Recall			RT			ERT			Age
	Accuracy	Efficiency	Accuracy	Efficiency	Accuracy	Efficiency	Accuracy	Efficiency		
ALL SUBJECTS										
Vocabulary	0.38***	0.40***	-0.22 [†]	-0.28*	-0.43***	-0.48***	0.09			
WM	0.53***	0.32**	0.09	-0.32***	-0.22 [†]	-0.47***	-0.57***			
MSE	0.45***	0.27*	-0.01	-0.39***	-0.30**	-0.57***	-0.44***			
Age	-0.38***	-0.03	-0.08	0.37***	0.15	0.34				
YOUNG										
Vocabulary	0.31 [†]	0.17	-0.19	-0.22	-0.31 [†]	-0.38*	0.25			
WM	0.44**	0.35*	0.21	0.10	0.08	-0.18	0.03			
MSE	0.12	0.04	-0.02	-0.24	-0.06	-0.33*	-0.02			
Age	0.17	0.14	0.00	-0.26	-0.07	-0.46				
OLD										
Vocabulary	0.51**	0.58***	-0.27	-0.39*	0.56***	-0.61***	0.17			
WM	0.39*	0.41*	-0.21	-0.33 [†]	-0.44**	-0.50**	0.00			
MSE	0.53***	0.49**	-0.08	-0.29	-0.46**	-0.60***	-0.17			
Age	-0.10	0.04	-0.11	-0.04	0.01	0.03				

[†] $p < .10$,
 * $p < .05$,
 ** $p < .01$,
 *** $p < .001$

Table 2
Hierarchical Regressions Predicting Recall Performance and Encoding Efficiency

Dependent Variable	Complete Model				Age Alone
	Vocabulary Std beta	WM Std beta	MSE Std beta	Age Std beta	
RECALL					
Accuracy	0.23*	0.41***	0.26*	-0.10	0.39
Efficiency	0.33**	0.23*	0.10	0.22	0.22
ERT					
Accuracy	-0.37***	-0.08	-0.16	0.10	0.23
Efficiency	-0.31***	-0.29**	-0.37***	0.08	0.50

† $p < .10$,
 * $p < .05$,
 ** $p < .01$,
 *** $p < .001$