Selecting Valuable Information to Remember: Age-Related Differences and Similarities in Self-Regulated Learning

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It is often necessary to selectively attend to important information, at the expense of less important information, especially if you know you cannot remember large amounts of information. The present study examined how younger and older adults select valuable information to study, when given unrestricted choices about how to allocate study time. Participants were shown a display of point values ranging from 1–30. Participants could choose which values to study, and the associated word was then shown. Study time, and the choice to restudy words, was under the participant's control during the 2-minute study session. Overall, both age groups selected high value words to study and studied these more than the lower value words. However, older adults allocated a disproportionately greater amount of study time to the higher-value words, and age-differences in recall were reduced or eliminated for the highest value words. In addition, older adults capitalized on recency effects in a strategic manner, by studying high-value items often but also immediately before the test. A multilevel mediation analysis

; Souchay & Isingrini, 2004). Thus, additional study time could potentially enhance learning and reduce age-related deficits in memory performance (Kausler, 1994). However, Dunlosky and Connor (1997) have shown that age differences in study time allocation can account for age differences in memory performance, suggesting that self-regulated learning, if implemented successfully, could enhance older adults' memory performance (see also Froger et al., in press).

In regard to self-regulation of study, Dunlosky and Hertzog (1997) examined younger and older adults' restudy selections of word pairs that varied in terms of difficulty of learning, after participants had studied and made initial judgments of learning for these pairs. Although older adults displayed poorer overall memory for the word pairs, both younger and older adults selected to restudy the word pairs that they had rated as least-well learned, demonstrating significant improvements in memory performance for these restudied items. Thus, both age groups had metacognitive awareness of the necessity to restudy information that was not well learned used additional study time to optimize learning. These results are consistent with a discrepancy-reduction hypothesis, in that people seek to restudy information that has yet to reach the desired level of learning. In addition, with task experience and sufficient training, older adults can learn to effectively study and test themselves such that they allocate necessary restudy to appropriate information (Dunlosky, Kubat-Silman, & Hertzog, 2003).

While previous research has examined age-related differences in self-paced learning in terms of item difficulty, very little work has examined age-related differences in self-regulated learning when item importance is manipulated. That is, can older adults strategically focus on remembering high-value or important information, given overall memory deficits? Price, Hertzog and Dunlosky (2010) found that both younger and older adults choose to study easier items first, relative to more difficult items, although this effect was reduced when more difficult items were assigned higher rewards for recall, consistent with both the region of proximal learning (Metcalfe & Kornell, 2005) and agenda-based regulation models of metacognitive control (Ariel, Dunlosky, & Bailey, 2009). Self-regulated learning typically involves a less constrained learning environment, where people can choose what, and how long, to study information for a later test (see also Bjork et al., in press). Under these conditions, older adults may need to be especially considerate of how many items should be studied in order to achieve optimal memory performance, if they are aware of their own memory constraints. In addition, efficient self-regulated learning strategies may be critical when encountering large amounts of information that vary in terms of importance to remember. Thus, to thoroughly study self-regulated learning and aging, it is important to consider the learning environment, value of the to-be-remembered items, and the metacognitive factors that can influence memory performance in younger and older adults.

Theoretical frameworks regarding selectivity and aging have stated that older adults engage in "selective optimization with when participants selected to restudy certain words. For example, recency effects can occur with immediate free recall such that participants remember the last few words that were studied, by maintaining these words in a short-term memory (STM) store (Murdock, 1962). Although recency effects are robust phenomena that can enhance memory (e.g., Murdock, 1962), only under certain circumstances are participants aware of the memorial benefits associated with recency items (Castel, 2008b; Crowder, 1969). We were specifically interested in whether younger and older adults might be aware of the benefits of studying high-value items immediately before the test (by monitoring the time-clock present on the display, see Figure 1) to capture the potential "high-yield" benefits of recency effects (see also Crowder, 1969), given that recency effects are often intact in older adults (Craik, 1994; Howard, Kahana, & Wingfield, 2006). In addition, we examined memory performance in terms of the mean value of the recalled items, to determine whether younger and older adults selectively remember high-value words relative to lower-value words, despite lower levels of recall by older adults (e.g., Castel et al., 2002; Castel, Balota & McCabe, 2009; Castel et al., 2011). Finally, we present a mediation analyses that attempts to illustrate how certain strategic factors (e.g., study time allocation to high value words and studying high-value words near the end of the study session) mediates value-directed remembering in younger and older adults. The examination of potential similarities and differences for younger and older adults on these measures of selectivity and

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$ps > .05$). These results indicate that, like study time, younger adults distributed their restudy attempt across low to high point values whereas older adults restricted their restudy attempts more toward the highest valued items.

Recall Rate and Point Value

The proportion recalled as a function of point value for younger and older adults is presented in Figure 2B A 2 (Age Group) × 10 (Point Value) mixed model ANOVA revealed a significant interaction, $F(9, 414) = 3.04$, $MSE = 0.03$, $p < .01$, $\eta^2_G = .05$, as well as the significant main effects of Point Value, $F(9, 414) = 104.51$, $MSE = 0.03$ $p < .01$, $\eta^2_G = .65$ and Age Group, $F(1, 46) = 41.06$, $MSE = 0.06$, $p < .01$, $\eta^2_G = .13$. Post hoc tests revealed that, whereas younger adults recalled medium-value items (values 7–9, 10–12, 13–15, 16–18, 19–21, 22–24, 25–27) more than older adults, $ts(46) > 2.15$, $ps < .05$, $ds = 0.62$–1.56, these significant differences were not present for the lowest-valued (1–3, 4–6) and the most valued items (values 28–30) items, $ps > .10$. In addition, the frequency of intrusions (recalling wordsuencyintrusions (recalling wordsuency wordsueroiv2((recalling)-3-28ificant–3extremel.6(i84-1

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of interest by making use of the full information contained in the data. All the analyses were performed by HLM 6 (Raudenbush, Bryk, & Congdon, 2004).

Multilevel mediation modeling takes three steps (Kenny, Bolger, & Korchmaros, 2003; Krull & MacKinnon, 2001). First, we regressed recall performance (1 recalled, 0 not recalled) on point value of the items to investigate whether items with high point values were well remembered. The full version of the model equation takes the following form:

Level 1 (item level):

$$ {}_{ijk} \qquad {}_{0jk} \qquad {}_{1ji}\ \text{Value}_{ijk} \qquad e_{ijk} $$

Level 2 (list level):

$$ {}_{0jk} \qquad {}_{00k} \qquad {}_{01k}\ \text{List}_{jk} \qquad r_{0jk}, $$

$$ {}_{1jk} \qquad {}_{10k} \qquad {}_{11k}\ \text{List}_{jk} $$

Level 3 (person level):

$$ {}_{00k} \qquad {}_{000} \qquad {}_{001}\ \text{Age}_{k} \qquad u_{00k}, $$

$$ {}_{01k} \qquad {}_{010} \qquad {}_{011}\ \text{Age}_{k}, $$

$$ {}_{10k} \qquad {}_{100} \qquad {}_{101}\ \text{Age}_{k}, $$

$$ {}_{11k} \qquad {}_{110} \qquad {}_{111}\ \text{Age}_{k} \qquad (1) $$

where Value_{ijk}

This may reflect the fact that younger adults can recall items fairly well relatively irrespective of study time, whereas older adults may need to strategically allocate longer study time to remember the items (cf., Craik & Rabinowitz, 1985; Dunlosky & Connor, 1997). Finally, the effect of point value on successful recall was still significant ($\gamma = 0.12$ for the first list and $\gamma = 0.21$ for the final list) even after controlling for study time and recently studied items. That is, even if two items were studied for the same amount of time and both items were studied at the end (or not studied at the end) of the list, the item with a higher point value was better remembered (and this effect was invariant across age groups). In sum, the multilevel mediation analysis indicated that participants strategically remembered items with higher point values, and older adults showed similar or even stronger strategic processes that may help to compensate for poorer memory.

Discussion

The results from the present study yielded several important insights regarding how aging and value influence self-regulated learning, and how strategic and compensatory processes may allow older adults to engage in efficient self-regulated learning, despite memory deficits. In general, both younger and older adults were highly sensitive to value, spending more time studying high-value items, and recalled more high value items, relative to lower value items. However, older adults spent considerably more time studying the higher value items, studied fewer items overall, and recalled fewer items relative to younger adults. Importantly, age-differences in recall were reduced or eliminated for the highest value words. In addition, older adults capitalized on recency ef-

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Appendix

Detailed Results From the Mediation Model

Three-level Hierarchical Linear Model of Study Time as a Function of Point Value, List, and Age

Fixed effects	
Intercept (γ_{000})	3.99**
Predictors of intercept	
Age (person-level) (γ_{001})	0.00
List (list-level) (γ_{010})	−0.00
Age × List interaction (γ_{011})	

Three-level Hierarchical Generalized Linear Model of Recall Performance Predicted by Point Value, Study Time, Last Three Items Studied, List and Age

Fixed effects	
Intercept (γ_{000})	−0.65**
Predictors of intercept	
Age (person-level) (γ_{001})	1.51**
List (list-level) (γ_{010})	0.03
Age × List interaction (γ_{011})	0.04
Value (γ_{100})	0.12**
Predictors of value	
Age (γ_{101})	−0.01
List (γ_{110})	0.02**
Age × List interaction (γ_{111})	−0.00
Study time (γ_{200})	0.16**
Predictors of Study time	
Age (γ_{201})	0.08**
List (γ_{210})	−0.02*
Age × List interaction (γ_{211})	0.01
Last studied three items (γ_{300})	0.66**
Predictors of last studied three items	
Age (γ_{301})	0.26
List (γ_{310})	0.02
Age × List interaction (γ_{311})	0.06
Random effects	**Variance**
Intercept (list-level) (r_{0jk})	0.00
Intercept (person-level) (u_{00j})	0.45**

Note. The dependent variable is recall performance coded as 0 (not recalled) or 1 (recalled). Logit link function was used to address the binary dependent variable.
* $p < .05$. ** $p < .01$.

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