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Memory for general and specific value information in younger and older adults: Measuring the limits of strategic control

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The ability to selectively remember important information is a critical function of memory. Although previous research has suggested that older adults are impaired in a variety of episodic memory tasks, recent work has demonstrated that older adults can selectively remember high-value information. In the present research, we examined how younger and older adults selectively remembered words with various assigned numeric point values, to see whether younger adults could remember more specific value information than could older adults. Both groups were equally good at recalling point values when recalling the range of high-value words, but younger adults outperformed older adults when recalling specific values. Although older adults were more likely to recognize negative value words, both groups exhibited control by not recalling negative value information. The findings suggest that although both groups retain high-value information, older adults rely more on gist-based encoding and retrieval operations, whereas younger adults are able to remember specific numeric value information.

The ability to selectively encode and retrieve important units of information is a critical function of memory, and one that is especially important to older adults in light of the age-related decline that is often observed in many memory tasks (for recent reviews, see Kester, Benjamin, Castel, & Craik, 2003; Zacks & Hasher, 2006). William James (1890) commented on this need for selectivity in memory, arguing that, "Selection is the very keel on which our mental ship is built. And in the case of memory its utility is obvious. If we remembered everything, we should on most occasions be as ill off as if we remembered nothing" (p. 680). Although this quote puts the case for selectivity rather strongly, it is clear that in order to maximize memory performance, it is necessary to decide what information is important to remember, and such selection often comes at the expense of memory for less pertinent information. The present investigation examines how aging influences the ability to selectively encode and retrieve information on the basis of value or importance of the information.

The control of learning processes is clearly important for mental functioning, and selective encoding is presumably a central ingredient of this ability. Studies of cognitive aging have generally shown that executive control processes are less efficient in older adults (Hay & Jacoby, 1999; McDowd & Shaw, 2000; West, 1996). Specific examples of control processes that show an age-related decline include different aspects of working memory (Park et al., 2002), inhibitory control (Hasher, Zacks, & May, 1999; Kramer, Humphrey, Larish, & Logan, 1994), and task coordination (Kramer, Larish, Weber, & Bardell, 1999). Furthermore, older adults appear to have a specific impairment in remembering associative information (Castel & Craik, 2003; Naveh-Benjamin, 2000). In this context, the results of a recent study by Castel, Benjamin, Craik, and Watkins (2002) are somewhat surprising. In order to measure the degree to which younger and older adults are able to select the information that they remember, Castel and colleagues employed a procedure developed by Watkins and Bloom (1999) that involves remembering words paired with point values. Younger and older participants were presented with a list of words in which each word was paired with an arbitrary and unique point value. The participants were told that they should remember as many words as possible in order to maximize their score, which was the sum of the point values of recalled words. Thus,

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some words were "worth" more than other words, and it was under the participants' control to strategically encode and recall words of high value. The interesting finding was that although younger adults recalled more words overall than did older adults, both groups were equally good at remembering the high-value words, as evidenced by equally strong correlations between the probability of recalling a word and its point value. Thus, older adults were able to focus on and remember the high-value words, whereas younger adults could match older participants' performance and also recall additional lower value words. This finding suggests that older adults can selectively remember high-value information despite relatively limited memory resources, but the manner in which older adults use value information to guide memory processes remains unclear.

One possibility is that participants of all ages simply held two or three of the highest value words in mind and retrieved them first, thereby ensuring a good score. It is known that the ability to hold information in mind (in *primary memory*) declines little with age (Craik, 1977). This possibility was made less likely, however, by the finding that older adults continued to recall high-value items well and showed a strong correlation between value and recall across the entire list even when a distracting task was interpolated between list presentation and recall (Castel et al., 2002, Experiment 4). One purpose of the present study was to replicate this delayed recall design. Another possibility is that the older adults in the experiments by Castel and colleagues did not remember the exact values of recalled words but, rather, encoded them more generally as *high-value* items. This possibility is consistent with Craik's (2002) suggestion that older adults have difficulty remembering specific information but can recall more general or gist-based information. Along these lines, there is good evidence from the false memory literature to suggest that older adults rely on gist-based representations of the past. In the standard Deese/Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995), older participants are more likely to falsely remember the *critical semantic associate* (a highly related semantic associate word that was not presented during encoding), relative to younger adults, in both recognition and recall tasks (Koutstaal & Schacter, 1997; Norman & Schacter, 1997; Tun, Wingfield, Rosen, & Blanchard, 1998). Some explanations of this result emphasize the reliance on gist-based memory in old age (e.g., Brainerd & Reyna, 2001), as a result of impairments in the encoding and retrieval of the specific words that were originally presented.

In addition, Castel (2005) found that older adults were more likely to remember the general price range of arbitrarily priced grocery items but were less likely to remember their exact price, relative to younger adults. One possibility is that memory for general information is an adaptive strategy that reduces memory load and one that is, therefore, especially useful for older adults (e.g., Zacks & Hasher, 2006). Older adults may selectively attend to and organize information in order to maximize memory performance, but this may involve remembering gist information, as opposed to more specific (and peripheral) details. Thus, older adults may selectively attend to high-value information at the expense of not remembering lower value information, resulting in the observation of an age-related impairment in memory for peripheral details.

If older adults *do* rely on general, as opposed to specific, value information, a further question is whether older adults rely on gist-based processing because more precise representations of the past are not available (i.e., an *impairment* in memory for specific information), or whether older adults simply choose to rely on gist-based memory because this is a strategy that results in better performance (i.e., a *difference in strategy choice*). Thus, the difference in performance may be due not to a difference in ability to recall specific information but, rather, to other cognitive factors, such as an inability to sustain attention or a self-fulfilling prophecy about memory loss in old age. According to this notion, if older adults are *required* to recall certain details, access to more specific information may be achieved. Thus, it may be the case that when a memory task involves recollection of gist-based information, age differences are minimal. However, when participants must provide specific information about the past, age differences are magnified, because older adults either will not or cannot spontaneously engage in recalling specific details. Strategy differences may be assessed by examining response patterns when younger and older adults have the option to recall either specific or general information, whereas raw ability differences can be measured through accuracy rates when participants are required to recall either specific or general information in exclusive blocks. By measuring both strategy and ability differences, it may be possible to understand why the age-related reliance on gist-based information occurs.

A parallel question in this regard concerns the possible difference between the ability to recollect specific details of an event and the ability to use that information to guide behavior. In the present paradigm, older adults may not be able to recollect a word's specific value yet still may recognize the word as a high-value item. In these terms, the results reported by Castel et al. (2002) may be similar to the intriguing findings reported by Rahhal, May, and Hasher (2002; see also May, Rahhal, Berry, & Leighton, 2005). These researchers presented statements read in either a male or a female voice to younger and older adults, with the instruction that (in different conditions) statements read in the male voice were false and statements read in the female voice were true. In a later recall test, older adults were less able than their younger counterparts to recollect the voice in which a statement had been presented but were as good as the young adults at remembering whether a statement was true or false (despite the fact that voice and truth were logically equivalent!). One account of this result is that the older adults encoded each statement with the general semantic information that it was true or false, although they were less able to encode the specific association between each statement and the voice that presented it. Truth information in Rahhal and colleagues' experiment may have acted like general value information in the present paradigm, and voice information may have acted like specific value information.

In the present study, we examined the ability to selectively remember information according to the value of the information and the strategies and types of representations that are employed by younger and older adults. In order to examine how value is represented, participants were asked to either recall the exact value of each word or to specify its general range. We then looked at differences in the frequency of response options (specific vs. general) that were *chosen* by younger and older adults when retrieving value information (Experiment 1) and also examined memory accuracy both in this situation and when the participants were required to respond with either specific answers or range options (Experiment 2).

EXPERIMENT 1

The main objective of the first experiment was to examine how younger and older adults differ in their ability to encode information that varies in terms of value. In the first part of the experiment, the participants studied lists of 16 words that were paired with unique point values (1–16), having been told beforehand that the point value reflected the importance of remembering the word in a later recall task. Following the encoding of each list, the participants recalled as many words as they could in order to maximize their score, which was the sum of the point values of the recalled words. As in Castel et al. (2002), it was expected that the older adults would recall fewer words but would be as selective as the younger adults in terms of recalling high-value words. After six lists had been presented and recalled, the participants were given an unexpected recognition test, to determine whether the participants had simply ignored low-value words at encoding and whether the low- and high-value words were still accessible in long-term memory for both age groups. In a second block, the participants studied a list of words paired with values and, at test, were presented with each studied word and were given the option of recalling its specific point value or identifying its point value range (1–4, 5–8, 9–12, or 13–16). Thus, the participants had the choice of responding with a specific value or a range, and it was of interest to examine age-related differences in preferences for and accuracy of these response options. In order to examine situations in which the participants could not remember information about a word's value (and so provide an option in which they would not be penalized for incorrect guesses), the participants were also allowed to use a *can't remember* option. This was incorporated into the design in order to follow the perspective of Koriat and Goldsmith (1994, 1996; Koriat, Goldsmith, & Pansky, 2000), which emphasizes the use of both an accuracy-oriented and a quantity-oriented approach to studying memory performance, and to extend this to the examination of memory and aging. Thus, in order to study the strategic regulation of memory, it is important to measure how people choose to report on past events (e.g., general or specific), as well as when failures occur in attempts to remember the past.

Method

Participants

The younger participants were 20 undergraduate students from the University of Toronto (14 women and 6 men; mean age = 18.4 years, mean number of years of education = 13.0), who received course credit for participation. The older participants were 20 older adults (14 women and 6 men; mean age = 69.9 years, mean number of years of education = 14.5), who were offered $10 each for their participation. They were members of the community who were high functioning, reported themselves to be in good health, and made their own way to the laboratory to participate in the experiment.

Materials and Design

The stimulus words were nouns that contained between three and five letters and had an everyday occurrence of at least 30 times per million according to the Thorndike–Lorge count (Thorndike & Lorge, 1944). The words were randomly sorted into lists of 16 words. Seven different lists of unique words were used in each of two blocks; the first list in each set was used for practice, and the remaining six were used for the experiment proper. E-Prime, implemented on a Pentium II MS Windows based computer, was used to run the experiment. Within each list, each word was assigned a unique number between 1 and 16. The order of the numbers was random, with the Latin square constraint that each within-list position assumed each value no more than once throughout the seven lists in a set, including the practice list.

Procedure

The experiment was composed of two blocks: a free recall task and a cued value recall task. The order of the two blocks was counterbalanced across participants.

Free recall. The participants were tested individually. They were told that on each trial, they would be visually presented with a series of 16 words at a 3-sec rate and that each word would be paired with a unique number between 1 and 16. They were told that their task was to try to get as many points as possible and that this could be accomplished by remembering as many of the high point value words as they could. Examples of the scoring procedures were given. The participants were told that they would have 1 min to orally recall as many words as they could and would then be told their point value total for that trial. Between the study phase and recall, the participants performed a filler spatial size judgment task for 30 sec. Following this task, the participants were given 1 min to recall as many words as they could remember by saying them out loud. After being invited to ask any questions they had about the procedure, the participants performed a single practice trial, after which they were once again allowed to clarify the experimental instructions. After the practice trial, six consecutive test trials were performed.

At the end of the sixth and final test trial, the participants were given an unexpected recognition test. Half of the words used in the test trials from each value category and half of the words from an unused set of words (i.e., new words) were randomly selected for the recognition test. The participants were presented with these 96 words, one at a time, and were asked, "Did the word appear in ANY of the previous trials?" Responses were made by selecting either a *Yes* (*old word*) or *No* (*new word*) option that appeared on the screen by using either the mouse or the keyboard.

Cued value recall. In the second condition, the participants engaged in a study session similar to that in the free recall condition. Stimulus presentation and the filler size judgment task were performed in the same manner as in the free recall condition. The participants were told that after the size judgment task, they would be shown the words again in random order and would be asked to recall what number went with the word. Three response types were allowed: The participants could respond by selecting a specific number from 1 to 16; they could select a range response from low, medium-low, medium-high, or high, comprising point values of 1–4, 5–8, 9–12, and 13–16, respectively; or they could indicate that they could not remember. The participants were awarded 10 times the number value of a word for getting a specific value correct and 5 times the number value of a word for getting a range correct and neither received nor lost points for a *don't remember* response. Incorrect responses resulted in a loss of five points, with a participant's total score for a list presented at the end of the test period for that list. There was no time limit on responding. It was emphasized to each participant that specific responses were twice as valuable as range responses but that range responses would yield higher accuracy if the participant had only a vague recollection of a word–number pair. The participants were urged to respond if they had even partial memory of the word–number pair but to avoid guessing if they could not recall even range type information, since there was a five-point penalty for incorrect responses. The participants indicated their responses by selecting the appropriate answer box from the computer monitor, using a mouse, and response accuracy, frequency, and category of response (specific or range) were recorded by the computer. At the end of the sixth and final test trial, the participants were given a surprise recognition test in the same manner as that described at the end of the free recall portion of the experiment.

Results and Discussion

The present study yielded several measures of selectivity and strategic memory processing, and the results can be divided into three sections: free recall performance, cued recall of point values, and recognition memory performance.

Free Recall

For clarity of presentation, the 16 point values were collapsed into four categories, with values 1–4 being classified as *low*, 5–8 as *mid-low*, 9–12 as *mid-high*, and 13–16 as *high*, although analyses were run using all 16 point values. Figure 1 shows the probability of recall as a function of point value ranges for younger and older adults. The data from Figure 1 were entered into a 2 (age group) × 16 (point value) repeated measures ANOVA. There was a main effect of age group [$F(1,38) = 67.46$, $MS_e = 0.045$, $p < .001$], with younger adults recalling more words than did older adults, and point value [$F(15,570) = 41.69$, $MS_e = 0.037$, $p < .001$], with both groups recalling more high-value words than lower value words. The interaction between age group and point value was also significant [$F(15,570) = 2.22$, $MS_e = 0.037$, $p < .01$]. Figure 1 shows that the age difference was greater for low-value words than for high-value words. In fact, there was no significant age-related difference for high-value words [$t(38) = 1.31$, $p = .20$], whereas reliable age differences were found for the lower point value groups [low, mid-low, and mid-high; $t(38) = 5.81$, 6.19, and 2.15, respectively; $p < .001$, $p < .001$, and $p = .04$, respectively]. These results replicate the earlier findings of Castel et al. (2002), in that older participants were able to selectively attend to and recall high-value words as well as could younger participants but younger participants were able to recall more words overall.

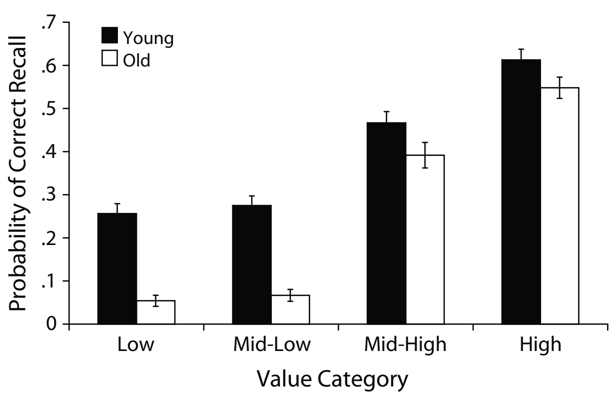

Figure 1. Probability of correct recall for each point value category for the younger and older adults in the free recall task in Experiment 1. Error bars represent the standard error of the mean.

As is suggested by Figure 1, both groups displayed significant positive correlations between the probability of recall and point value. The average intraindividual correlation for younger adults was .53 ($SD = .32$), whereas for older adults it was .72 ($SD = .18$), and this group difference was significant [$F(1,38) = 5.48$, $MS_e = 0.07$, $p = .03$]. These findings, which are consistent with previous investigations of selectivity and aging (Castel et al., 2002), suggest that although an overall age difference exists in terms of recall quantity, older adults can selectively remember certain amounts of information that are deemed to be of high value, likely at the expense of lower value information.

Cued Recall of Point Value

The manner in which high-value information is encoded and later retrieved was further examined by having the participants classify previously studied words according to either their specific or their approximate value. This procedure allowed for several measures of memory performance—namely, the selection of a recall option (choice of either specific or range) and recall accuracy (probability of correctly identifying the value, given the recall option), as well as an indirect measure of memory *confidence* in terms of how frequently the participants selected no-recall (*don't remember*) responses in the various conditions. Given that previous research has shown that older adults tend to rely on gist-based memory, it was hypothesized that older adults would choose the range option more frequently, stemming from either less precise memory for value or greater reliance on a response option that had a greater possibility of being correct. The response/recall options chosen by younger and older adults (regardless of accuracy) are displayed in Figure 2 and show that older adults used the range options more frequently when attempting to recall value, as opposed to the younger adults, who showed a preference for answering with specific values.

To allow for comparisons between response frequency for the range and specific value options, the specific recall data were grouped into the same four range response categories (low, mid-low, mid-high, and high). To analyze the data, a 2 between-subjects (age group) × 3 within-subjects (specific, range, or no-recall response type) × 4 (point

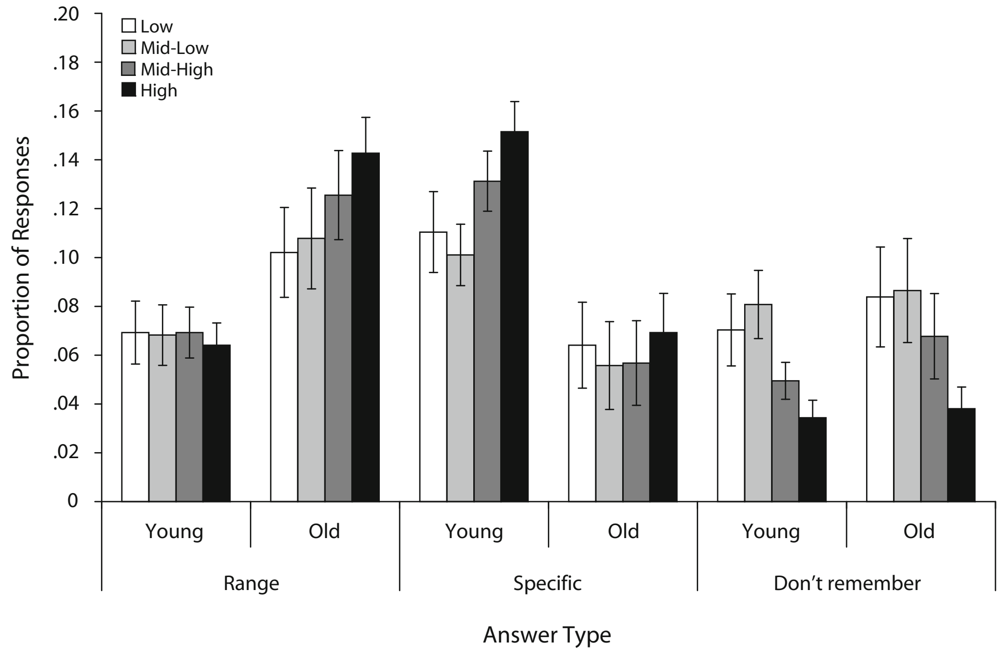

Figure 2. Proportions of responses, regardless of accuracy, for the four value classes (specific or range) for the younger and older adults in the cued recall task in Experiment 1. Error bars represent the standard error of the mean.

value) repeated measures ANOVA was run. It is important to note that this ANOVA on the data presented in Figure 2 included all responses, without regard to accuracy. Since there were equal numbers of responses for young and old (i.e., the participants could not withhold a response) and equal numbers of responses required for each point value, no main effects could be observed for response frequency, for age, or for value. In terms of strategy, no main effect of answer type was found [$F(2,76) = 2.01$, $MS_e = 0.023$, $p = .14$], since, in general, there were similar levels of specific, range, and no-recall responses. However, answer type was strongly influenced by age, and a two-way interaction was found [$F(2,76) = 5.87$, $MS_e = 0.023$, $p < .005$], suggesting that different strategies were employed by the young and the old participants in terms of how they chose to recall value information. Answer type and word value also showed a strong interaction [$F(6,228) = 8.41$, $MS_e = 0.002$, $p < .001$], indicating that for range and specific responses, high-value words were most frequent, whereas for *don't remember* responses, high-value words were least frequent. However, Figure 2 also shows that the choice of specific responses for high-value words was true for the young participants only and the choice of range responses for high-value words was true for the older participants only, and this asymmetry is reflected in a significant three-way interaction between age, answer type, and word value [$F(6,228) = 2.47$, $MS_e = 0.002$, $p < .05$].

Before the relations between the choice of response category and the accuracy of value recall are examined, it is worth noting from Figure 2 that the frequency and distribution of no-recall responses (*don't remember*) appear to be very similar in the younger and the older participants. This observation was confirmed in a 2 (age) $\times$ 4 (value) ANOVA on no-recall responses only, which yielded a highly significant effect of word value [$F(3,114) = 13.05$, $MS_e = 0.001$, $p < .001$] but no effect of age and no age $\times$ value interaction. It may thus be concluded (rather against our expectation) that the younger and the older adults used the no-recall option equally often and chose this option equivalently as a function of value. On the other hand, the younger participants chose specific responses most often, especially for high-value words, whereas the older participants chose range responses most often, again especially for high-value words (Figure 2).

The proportions of correct responses for different word values, conditionalized on the choice of range or specific, are shown in Figure 3. For the young adults, the accuracy of specific choices was uniformly high, declining from approximately 90% correct for low values to 80% correct for high values. For the older group, specific choices were less accurate, ranging from 44% for mid-low to 63% for both low and high values. For range choices, the two age groups performed similarly, except in the case of mid-low responses, where the young adults were more accurate. An ANOVA on the data shown in Figure 3 resulted in main effects of age [young greater than old; $F(1,24) = 20.82$, $MS_e = 0.07$, $p < .001$] and response type [specific greater than range; $F(1,74) = 71.31$, $MS_e = 0.07$, $p < .001$] but no overall effect of value. Response type interacted with age [$F(1,24) = 9.18$, $MS_e = 0.07$, $p < .01$], reflecting the larger age difference in specific than in range responses. Response type also interacted with value [$F(3,72) = 5.48$, $MS_e = 0.04$, $p < .01$], reflecting the different trends of specific and range responses across different word val-

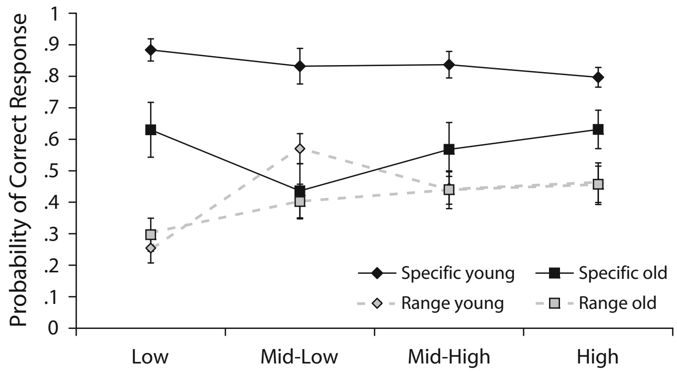

Figure 3. Probabilities of correct responses in the cued recall task for younger and older adults and type of response (specific or range) in Experiment 1. Error bars represent the standard error of the mean.

ues. Follow-up ANOVAs on specific responses revealed a main effect of age only [$F(1,28) = 29.13$, $MS_e = 0.10$, $p < .001$]. A corresponding ANOVA on range responses showed that there was no reliable effect of age [$F(1,28) = 2.67$, $p > .10$] but that value was significant [$F(3,96) = 5.92$, $MS_e = 0.05$, $p = .001$].

It is therefore clear that the older adults were substantially less accurate in their specific responses than were their younger counterparts, even allowing for the fact that all the participants freely chose to give a specific response. The absence of an effect of value in the analysis of specific responses is understandable, bearing in mind that the older participants used the specific category relatively infrequently and that the younger participants chose specific responses more for higher value words (Figure 2). In the case of range responses, both age groups performed poorly with low-value words, but the younger adults performed relatively well with mid-low words, yielding a significant effect of value. There was no effect of age on the accuracy of range responses, however, suggesting that older adults are as good as younger adults at remembering *general* information about an event, although less good at remembering specific details (Brainerd & Reyna, 2001; Craik, 2002).

Recognition Test Performance

Following the six study–test conditions of both free recall and cued recall, the participants were given an unannounced recognition memory test to assess the effect of value on long-term memory encoding. The results of these two recognition tests were very similar, so Figure 4 shows the combined data (hits minus false alarms) for the two tests. A 2 (age) × 4 (value) ANOVA on these data showed main effects of age [$F(1,38) = 21.70$, $MS_e = 0.05$, $p < .001$] and of value [$F(3,114) = 27.81$, $MS_e = 0.01$, $p < .001$]. There was also an interaction of age and value [$F(3,114) = 3.19$, $MS_e = 0.01$, $p < .03$], which Figure 4 shows was due to recognition performance being somewhat more sensitive to value in the younger group. It is worth noting that hit rates for the low-value condition were virtually identical for the younger and the older groups (.67 and .68, respectively), suggesting that neither group simply ignored low-value words. The false alarm rate was less for the younger than for the older participants, however (.22 and .31, respectively), yielding the age difference shown in Figure 4. An informal comparison of Figures 1 and 4 shows that word value had a much greater effect on recall than it had on recognition, especially for the older adults.

Overall, the results from the present study provide evidence that older adults can remember high-value information at a level comparable to that for younger adults. In Castel et al.'s (2002) study, a similar result was found, but in most of those experiments, the lists were mostly shorter (12 words), and there was no delay between presentation and responding, leaving open the possibility that participants of both age groups simply held the three or four highest valued words in primary memory, which has been shown to be relatively unaffected by aging (Craik, 1968, 1977). However, Castel et al. (2002, Experiment 4)

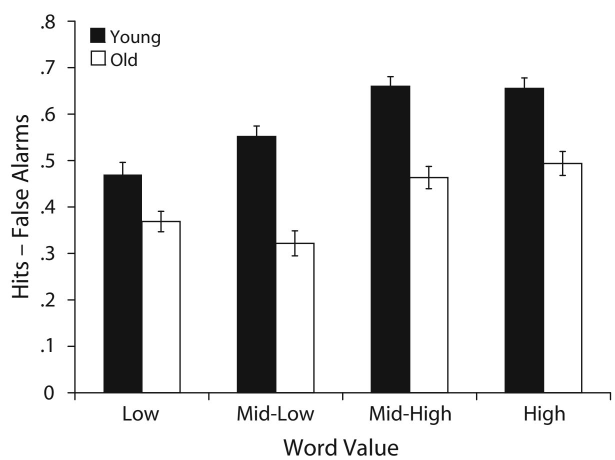

Figure 4. Recognition memory performance (hits minus false alarms) for the four value categories (averaged across the free recall and cued recall conditions) for the younger and older adults in Experiment 1. Error bars represent the standard error of the mean.

showed that older adults showed a correlation between value and recall that was at least as high as that shown by the younger participants even when a delay was present before final recall, suggesting that the effect is not driven purely by primary memory. It also may be the case that older adults experience retrieval inhibition or recall satiation when retrieving the initial few words, since they recall the high-value words first and then a satiation effect limits recall of lower value words. Although analyses of recall output indicate that both young and older adults recall high-value words first, this may differentially affect older adults, leading to a reduction in overall recall of lower value words, despite the fact that age differences are present in terms of later recognition of both high-value and lower value words.

In general, it appears that older adults *do*, in fact, exert substantial control over their encoding operations; they do not simply ignore lower valued words, as was shown by the results of the recognition test, but they do show an age-related impairment in recalling these lower valued words (Figure 1), possibly as a result of retrieval inhibition or deficits in secondary memory (e.g., Castel et al., 2002). Older adults chose to respond in terms of a general range, rather than by recalling the specific value. The accuracy of these range responses was equivalent in the two age groups, suggesting that the encoding and later recall of general *gist* information is unimpaired by aging. This conclusion may be somewhat premature, however, given the added complication of the free choice of range or specific responses and the clear age difference in these choices (Figure 2). It might be, for example, that the older participants were more cautious in their choices and recalled more specific information if required or forced to make a specific response. Alternatively, younger participants might raise their accuracy levels for range responses if they were required to choose a range, as opposed to give a specific value, and this issue was further examined in Experiment 2.

EXPERIMENT 2

Experiment 2 was designed to replicate some of the main features of Experiment 1, but with the major difference that, in separate blocks of cued recall tests, the participants were required to give either specific or range responses. That is, the element of strategy choice at retrieval was removed in order to focus on age differences in memory for value under more defined retrieval conditions. Also, in order to further examine the degree to which younger and older adults could control encoding and retrieval processes, a second condition was included in the experiment that involved both *positive* and *negative* value information. In this condition, the participants studied words paired with values ranging from negative (−16) to positive (+16), providing a strong incentive to remember words paired with positive values and to not remember negative value words. This paradigm is somewhat similar to the item-method directed-forgetting procedure (Bjork, LaBerge, & Legrand, 1968), in which older adults typically have less control over memory processes (Zacks, Radvansky, & Hasher, 1996), as well as the opposition procedure used by Jacoby and colleagues (e.g., Hay & Jacoby, 1999; Jennings & Jacoby, 1993), in which older adults show impairments in controlled recollection. One benefit of the selectivity paradigm is that it provides a graded or guided form of *directed remembering* and allows participants to utilize strategic control (see Castel, 2007). In the present paradigm, the participants are given an incentive not to encode certain items and to focus on high-value items. Thus, it was of particular interest to examine how older adults could control memory processing under these conditions, which emphasize the need for the controlled processing of positive value information and the ability to ignore or inhibit negative value information.

Method

Participants

The participants were 20 undergraduate students from the University of Toronto (13 women and 7 men; mean age = 18.61 years, mean number of years of education = 13.0), who received course credit for participation, and 20 older adults (14 women and 6 men; mean age = 69.9 years, mean number of years of education = 15.3), who were offered $10 each for their participation. The older adults were members of the community who were high functioning, reported themselves to be in good health, and made their own way to the laboratory to participate in the experiment.

Materials and Design

The stimulus words were nouns drawn from the same pool as that described in Experiment 1. These words were randomly assigned to create lists that contained 16 words, and seven of these lists were used for each of three sessions. The first list in each set was used for practice, and the remaining six were used for the experiment proper. For the first two sets of seven 16-word lists (the cued recall conditions), each word was assigned a unique number between 1 and 16 within each list. The order of the numbers was random, with the Latin square constraint that each within-list position assumed each value no more than once throughout the seven lists in a set, including the practice list. In the final set of seven 16-word lists (i.e., the free recall condition), words were assigned values ranging from 16 to −16 in steps of four and not counting zero (16, 12, 8, 4, −4, −8, −12, −16), so that there were 2 words at each of the eight possible point values. Once again, a Latin square design was used in order to prevent the same value from appearing in the same position in the lists.

Procedure

The experiment was divided into three within-group conditions: a free recall task and two cued number recall tasks, one for specific value recall and the other for recall using ranges of values. The conditions were counterbalanced by participant, with the free recall task always occurring at the beginning or end of the experiment (the two value recall tasks always ran consecutively, in order to prevent confusion regarding the task).

Free recall. The participants were told that on each trial, they would be visually presented with a series of 16 words and that each word would be paired with a positive or a negative numerical point value, between −16 and 16. They were told that their task was to score a high point total by remembering as many of the high, positive point value words as possible. The participants were given the example of gaining points by recalling positive value words and also an example of losing points by recalling negative value words. All other aspects of the task were similar to those in Experiment 1. At the end of the sixth and final test trial, the participants were given a surprise recognition test. Half of the words used in the test trials (i.e., half from each value category) and half of the words from an unused set of word lists were randomly selected for the recognition test. The participants were presented with 96 words, randomly selected from

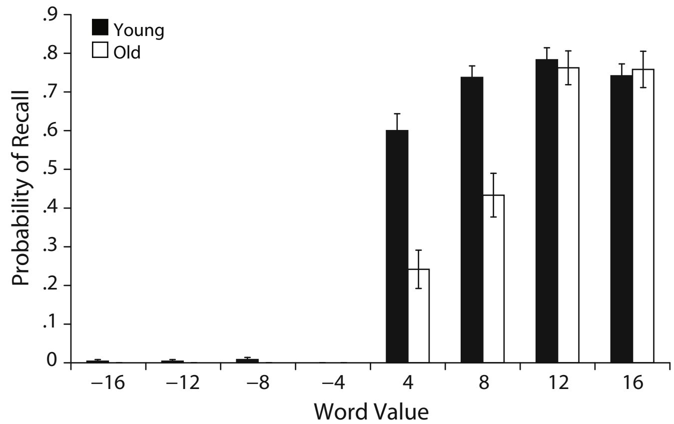

Figure 5. Probabilities of correct recall for the positive and negative value words for the younger and older adults in the free recall task in Experiment 2. Error bars represent the standard error of the mean.

this test list, 1 at a time, and were asked, "Did the word appear in ANY of the previous trials?" Responses were made by selecting either a *Yes* (*old word*) or *No* (*new word*) option that appeared on the screen by using either the mouse or the keyboard.

Cued number recall. This part of the experiment was identical to the cued number recall phase of Experiment 1, except that the design was run twice consecutively, with only range options allowed in one block and only specific value options available in the other block. The order of the two blocks was counterbalanced across participants. In both the specific and the range versions of the task, the participants were allowed to respond that they could not recall a value, rather than guessing.

Results and Discussion

Free Recall

Figure 5 shows the probability of recall as a function of point value for the younger and older adults. The data were entered into a 2 (age group) × 8 (point value) repeated measures ANOVA, revealing a main effect of value [$F(7,266) = 306.55$, $MS_e = 0.016$, $p < .001$], with only 2 participants ever recalling a negative value word and with increasing probabilities of recalling positive value words with higher values. A main effect of age was also observed [$F(1,38) = 18.71$, $MS_e = 0.031$, $p < .001$], with the younger participants recalling more words, on average, and a strong interaction between age and value [$F(7,266) = 14.31$, $p < .001$], with the advantage for the younger participants occurring predominantly for the lower value positive words. Post hoc tests confirmed significant differences for age only at the lower two positive point values [4 and 8; $t(38) > 4.7$, $p < .001$]. The results of the free recall data support the finding of highly selective recall abilities in both the young and the old participants, as was demonstrated in the first experiment, as well as confirming the trend of greater overall recall for the younger participants.

Recognition Test Following Free Recall

The recognition data (hits minus false alarms) are shown in Figure 6. The data were entered into a 2 (age group) × 8 (point value) ANOVA, revealing a main effect of value [$F(7,266) = 51.71$, $MS_e = 0.038$, $p < .001$]. Interestingly, there was no main effect of age [$F(1,38) = 0.019$, $MS_e = 0.294$, $p = .89$], but a significant interaction between age and word value was observed [$F(7,266) = 2.40$, $p < .05$]. To further examine the nature of this interaction, simple effects were conducted by taking all the data points for the negative and positive values for both age groups and entering them into separate ANOVAs. For the negative values, the age effect was marginally significant [$F(1,158) = 3.48$, $MS_e = 0.06$, $p = .06$], and the age effect was more robust for the positive values [$F(1,158) = 6.49$, $MS_e = 0.05$, $p = .01$]. That is, the younger participants showed lower mean recognition rates for negative value words and higher mean recognition rates for positive value words, as compared with the older participants. No difference between the young and the old participants was observed for the false alarm rates [$t(38) = 0.351$, $p = .73$]. Overall, the data from the recognition test support the conclusion that both young and old participants are able to attend selectively to important information; the data also demonstrate that both age groups are able to actively suppress responding to words that are coded for being ignored. The interaction further supports the idea that in comparison with older adults, younger participants are better able to inhibit the encoding of words that are of negative value.

Cued Recall of Value

Before examining the accuracy of the cued recall responses, the proportions of no-recall responses (*can't remember*) should be noted. These proportions are given for the two age groups and for the separate range and specific sessions in Table 1. Predictably, the no-recall option was used more for specific than for range responses, and this option was also used more, in general, by the older participants. The exception to the latter statement is the high-value category, where the proportions of no-recall responses in both range and specific sessions were essentially equivalent. An ANOVA on these data yielded main effects of value [$F(3,114) = 45.86$, $MS_e = 0.04$, $p < .001$], answer type [range or specific; $F(1,38) = 25.13$, $MS_e = 0.06$, $p < .001$],

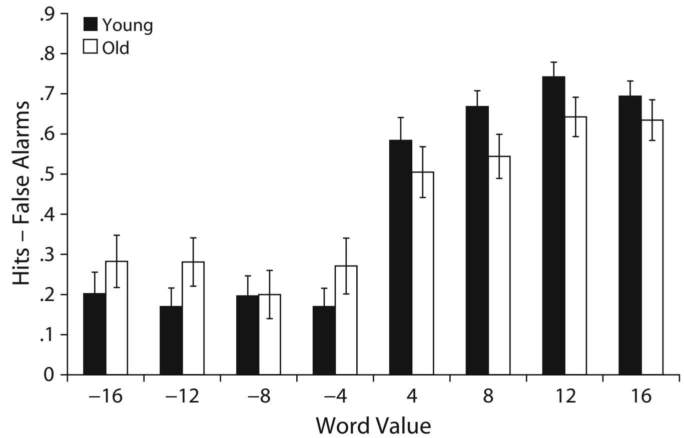

Figure 6. Recognition memory performance (hits minus false alarms) for the four value categories for the younger and older adults in Experiment 2. Error bars represent the standard error of the mean.

and age [$F(1,38) = 6.84$, $MS_e = 0.39$, $p < .02$], with higher frequencies of no-recall responses for low-value words, specific answers, and older participants, respectively. One significant two-way interaction was found between value and age [$F(3,114) = 6.24$, $MS_e = 0.04$, $p = .001$], with more no-recall responses for the older participants than for the younger participants for low-value words but equal no-recall responses at high values. In both the range and the specific conditions, the older adults showed higher no-recall responses than did the younger adults for the low, mid-low, and mid-high categories [$t(38) > 2.38$, $p < .05$]. However, for high values, no age difference was found in either the specific or the range condition [$t(38) < 0.64$, $p > .53$]. Thus, the older adults were more conservative in terms of providing a response, except for high-value information.

Given that range and specific options were allowed in different experimental sessions, the participants could choose either to provide a specific (or a range) response or to use the no-recall option. The proportions of range and specific proportions are, therefore, the complements of the no-recall responses shown in Table 1. Thus, for example, the young adults chose to give a range response on 72% of the occasions for low-value words, and the older participants gave a specific response for low-value words on 27% of the trials. The accuracy levels of these various choice categories are shown in Figure 7.

Table 1
Mean Proportions (and Standard Errors) of No-Recall Responses for Specific and Range Answer Conditions by Younger and Older Adults in Terms of the Value Category of the Words in Experiment 2

		Value Category							
		Low		Mid-Low		Mid-High		High	
Participants	Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Younger	Range	.28	.07	.32	.07	.21	.05	.14	.03
	Specific	.46	.07	.53	.07	.33	.05	.23	.04
Older	Range	.55	.08	.59	.09	.45	.07	.14	.03
	Specific	.73	.06	.71	.07	.55	.06	.26	.03

The pattern of specific responses looks similar to the pattern found in Experiment 1; that is, the young adults had high accuracy scores throughout the range of values and obtained higher scores than did the older adults, whose scores improved somewhat from low- to high-value words. The younger participants chose to make more range responses than specific responses at all levels of value (complements of the scores in Table 1) but were somewhat less accurate in the case of range. This observation is somewhat surprising and might be because the younger adults felt it was easier to provide a correct range response and, thus, were less likely to choose *no recall* in this condition (despite accuracy suggesting otherwise). On the other hand, the older participants also chose to make more range than specific responses (Table 1) but showed greater accuracy for range responses, especially for high-value words. An age × response type × value ANOVA showed no overall effects of response type or value but a significant effect of age [$F(1,27) = 29.25$, $MS_e = 0.23$, $p < .001$] and significant interactions between age and response type [$F(1,27) = 9.21$, $MS_e = 0.06$, $p = .005$] and between age and value [$F(3,81) = 3.69$, $MS_e = 0.03$, $p < .02$]. The age × response type interaction reflects the finding that the younger adults had higher accuracy scores for specific than for range scores, whereas the opposite was true for the older participants. The age × value interaction reflects the fact that accuracy scores declined slightly from low- to high-value scores for the young adults, whereas the scores for the older adults increased from low to high, especially in the case of range scores. Follow-up ANOVAs on the range and specific conditions separately showed that for specific responses, the only significant effect was age [$F(1,28) = 29.45$, $MS_e = 0.18$, $p < .001$] but that for range responses, there were significant effects of age [$F(1,32) = 18.51$, $MS_e = 0.11$, $p < .001$], value [$F(3,96) = 2.98$, $MS_e = 0.03$, $p < .05$], and a significant interaction of age and value [$F(3,96) = 3.77$, $MS_e = 0.03$, $p = .01$].

When the participants were required to respond with either a range or a specific response or to use the no-recall option, the younger participants outperformed the older

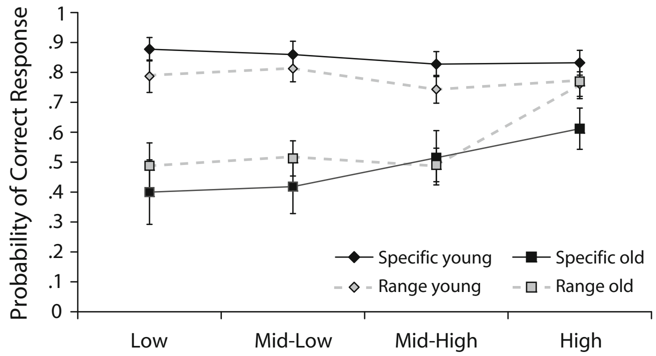

Figure 7. Probabilities of correct responses in the cued recall task for younger and older adults and type of response (range or specific) in Experiment 2. Error bars represent the standard error of the mean.

participants in the accuracy of both specific and range choices, with the notable exception of range responses for high-value words (Figure 7). This age-related superiority of young adults holds despite the fact that older adults withhold responses to a much greater degree (Table 1). The finding of age-equivalent accuracy scores for range responses at the highest level of value, given that both age groups chose to respond on 86% of the trials (Table 1), confirms the finding from Experiment 1 that memory for *general* information about value is as good in older adults as it is in their younger counterparts. The present findings suggest, however, that this age-related equivalence is restricted to high-value words; the accuracy of range responses at lower values is substantially higher for the young group.

Experiment 2 confirmed that whereas older participants recall fewer words overall than do younger participants, the age groups are broadly comparable in their recall of higher valued words. The free recall results also showed that the older adults were as successful as the younger group at inhibiting the recall of negatively valued items, despite being able to recognize these items in a subsequent test. The recognition test showed that the older adults in fact recognized *more* negative value words than did the younger adults, suggesting that the older participants were less able to inhibit encoding processes at the time of list presentations (comparable to findings from Zacks et al., 1996). However, impaired inhibition cannot completely account for these data, since the older adults were successful at not recalling negative value words and, as was mentioned previously, retrieval inhibition and recall satiation might influence memory performance.

GENERAL DISCUSSION

The goal of the present study was to understand how younger and older adults control memory processes strategically and how numerical value of to-be-remembered information is represented in old age. Various measures of strategic control over encoding and retrieval operations were employed, as well as an analysis of how younger and older adults chose to report on past events. The discussion of the results will focus on the control of memory in light of value, how value is represented in younger and older adults, and how these observations contribute to theories of cognitive aging.

The findings from the free recall tasks showed that both younger and older adults can strategically encode and retrieve high-value information and that older adults are comparable to younger adults in terms of how value influences memory performance. Both groups displayed high correlations between value and probability of recall, in line with previous investigations of how aging influences the ability to selectively remember information according to its value (Castel, 2007; Castel et al., 2002). Furthermore, when the value dictated that information should not be remembered (i.e., negative value information), both the younger and the older adults exhibited good control by recalling only positive information. This good control of recollection on the part of older adults is somewhat surprising in light of findings from the process dissociation procedure (Hay & Jacoby, 1999) and from the item-method directed-forgetting paradigm (Zacks et al., 1996) showing age-related impairments in controlled encoding and retrieval. In contrast to the directed-forgetting results, the present findings show that older adults can control memory processes in a somewhat similar context. One major difference may be that the selectivity paradigm provides a guided form of *directed remembering* that helps participants to utilize strategic control (Castel, 2007). In addition, the explicit presentation of value information may be especially motivating to older adults, and this factor may contribute to their heightened control. It is interesting to note that in the recognition test following recall in Experiment 2, although the younger adults were better able to recognize the positive words than were the older adults, the older adults did comparatively well on negative words, suggesting that they did encode these negative words. The findings from the recognition memory tasks that followed the free recall suggest that both younger and older adults still maintain some representation of low-value (or even negative value) words in long-term memory. This observation argues against the possibility that both groups simply ignored low-value words. However, the best-recognized words were high-value words, and there were small or negligible age differences for the later recognition of these words. Overall, these findings show that both younger and older adults use value information to guide memory processes, but it is likely that value is represented or retained in a different manner for the two groups (see Castel, 2007).

Whereas the free recall and recognition tests for the words themselves showed relatively good performance in the older group, especially for higher valued words, the cued recall tests for value information showed generally lower performance in the older group, relative to their younger counterparts. In Experiment 1, it seemed that recall of range information was intact in the older adults but that, when range information was called for explicitly in Experiment 2, the older group's recall performance was lower than that of the young group, except in the case of high-value words. This pattern of results gives some support to the notion that older adults encode information in a more general, less contextually specific form than younger adults do (Craik, 2002; Craik & Simon, 1980); that is, there is a greater reliance on gist-based memory in old age (Brainerd & Reyna, 2001; Koutstaal & Schacter, 1997; Tun et al., 1998). Nonetheless, the good performance of the older group in the cued recall of high-value range information does show that the older adults successfully selected these items, both at encoding and at retrieval, for special treatment. This result suggests that older adults use a coarser *grain size* when encoding and retrieving information (Goldsmith, Koriat, & Weinberg-Eliezer, 2002), although the degree to which the present results may be more a reflection of declining abilities than a reflection of differences in strategic choice remains debatable.

What do the findings tell us about age-related differences in the control of encoding operations? It seems, overall, that some aspects of control remain relatively unimpaired by aging, whereas other aspects show significant decline. The substantial age-related decrement in the ability to remember specific word–value pairings is in line with the associative deficit hypothesis of aging put forward by Naveh-Benjamin (2000). However, older adults showed good recall and recognition of high-value words, demonstrating that they both encoded them well and could utilize the efficient encoding at the time of retrieval. Also, the strong correlations between word value and recall in free recall tests provide further evidence for selectivity. Importantly, older adults exhibited good control in terms of not recalling negative value words, as well as good recall of range information for high-value words. The overall pattern of results is in line with a shift toward the encoding and retrieval of general gist-like information with advancing age and with the idea that whereas specific information may be difficult to recollect explicitly at older ages, the information may still be used to selectively encode and retrieve the more general and higher value aspects of remembered events.

AUTHOR NOTE

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