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Aging and Memory for Self-Performed Tasks: Effects of Task Difficulty and Time Pressure

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An increase in task difficulty or time pressure during the performance of cognitive tasks decreased the ability of older adults to recall the tasks. In Experiments 1 and 2, adult age differences in recall of cognitive tasks were smaller for easier than for more difficult tasks, and, in Experiment 3, adult age differences were smaller for recall of cognitive tasks without time pressure than for recall of cognitive tasks with time pressure. During difficult or time-pressured cognitive tasks, older adults may become anxious about their performance, and they may have trouble inhibiting negative self-evaluative thoughts about their performance. Older adults may thus devote less attention to aspects of the cognitive tasks that would be beneficial for task recall.

MEMORY for self-performed activities decreases with age during adulthood (e.g., Earles, 1996; Kausler, 1994). This age-related decrease has meaningful implications for the lives of older adults. Memory for activities, such as feeding the dog, returning a borrowed item, or paying the bills, is essential for everyday functioning. Thus, it is not surprising that older adults express concern about any perceived loss in activity memory (Cavanaugh, Grady, & Perlmutter, 1983).

In most studies of age differences in memory for self-performed activities, younger and older adults have been asked to recall very simple actions, referred to as self-performed tasks or SPTs, that are described by simple action phrases containing a single noun and a single verb, such as *break stick* and *wave hand* (see, e.g., Earles & Kersten, 2002; Nyberg, Nilsson, & Backman, 1992). Younger adults recall more of these simple action phrases than do older adults, but both age groups remember the phrases better if they perform the action than if they do not perform the action (e.g., Earles, 1996).

Another method for studying age differences in memory for actions is to ask younger and older adults to recall more complex cognitive tasks, such as the subscales of the Weschler Adult Intelligence Scale (WAIS). In this research, participants perform a series of cognitive tasks and are then asked to recall the tasks rather than the individual items from each task. Cognitive tasks are more complex than simple action phrases and contain many features (e.g., task length, difficulty, and complexity) that can be manipulated. There is strong evidence for adult age differences in memory for this type of performed cognitive task. For example, in the study by Earles and Kersten (1999), the correlation between age and immediate recall of a series of cognitive tasks was –.38 (age range = 20–85 years). Large age differences in memory for cognitive tasks have also been found in extreme age groups designs (e.g., Earles, 1996; Earles & Coon, 1994; Earles & Kersten, 1998). The magnitude of the age differences, however, has varied for memory for different activities (Earles & Kersten, 1998; Kausler, 1994), and the causes of this variation are unclear (Kausler, 1994).

Earles and Kersten (1998) proposed that cognitive task difficulty is one important mediator of the relation between age and activity memory. There are two hypotheses concerning the effects of task difficulty on memory for a cognitive task. One hypothesis is that an increase in the difficulty of a cognitive task could potentially make the task easier to remember. Kausler and Hakami (1983) proposed that an increase in task difficulty increases the effort that a participant uses to perform the task, and this increase in effort leads to a stronger memory trace for the task. Because this strong memory trace is proposed to be generated by performance itself rather than by any self-initiated memory strategy, older adults could possibly be expected to benefit more than younger adults from an increase in task difficulty. In fact, Kausler and Hakami (1983) did find evidence for a smaller age difference in memory for difficult tasks than in memory for easier tasks.

Support for the hypothesis that an increase in task difficulty should decrease age differences in activity memory is, however, limited to this single study. An alternative hypothesis is that, rather than decreasing adult age differences in activity memory, an increase in cognitive task difficulty could actually increase the age differences. One potential mechanism that could produce an increase in age differences in activity memory with an increase in cognitive task difficulty is an increase in anxiety, accompanied by an increase in self-evaluative thoughts about performance. In other words, difficult activities may tax the limited processing resources of older adults by diverting attention to negative self-evaluative thoughts and away from features of the task that promote successful encoding of the task.

Carstensen's (1995) socioemotional selectivity theory provides an additional mechanism that could produce an increase in age differences in activity memory with increases in cognitive task difficulty. This theory suggests that, as people get older, they place greater emphasis on regulating emotion. Thus, older adults may direct fewer cognitive resources to the processing of information that has negative content (Charles, Mather, & Carstensen, 2003).

Charles and colleagues (2003) found that age differences in recall of negative images were greater than age differences in recall of positive images. Younger adults recalled approximately the same number of positive as negative images. Older adults, in contrast, recalled more positive than negative images. The authors hypothesized that the older adults did not process the negative images as well as the positive images because they were more interested than younger adults in regulating their emotions. Thus, older adults may be expected to process easy tasks better than difficult tasks because they place more emphasis on emotional regulation, and difficult tasks may be more likely to evoke negative emotions.

Earles and Kersten (1998) provided evidence in support of the hypothesis that increasing cognitive task difficulty increases age differences in the ability to recall a cognitive task. In the study by Earles and Kersten (1998), participants were asked to perform and later recall a series of cognitive tasks. Following performance of each task, participants were asked to rate the difficulty of the task. Older adults, but not younger adults, were more likely to recall cognitive tasks that they had previously rated as easier than cognitive tasks that they had previously rated as more difficult. Earles and Kersten (1998) proposed that an increase in anxiety could be responsible for the decrease in recall of more difficult activities by older adults.

Many studies have demonstrated that people who are anxious often perform more poorly on cognitive tasks than do people who are not anxious, especially if the cognitive tasks are difficult (Eysenck, 1982). Eysenck (1979) suggested that increased anxiety impairs cognitive performance by increasing task-irrelevant processing. This task-irrelevant processing utilizes resources in working memory, so that there is less working memory capacity available for the processing of information that is relevant to the current task. Thus, if a task requires more working memory capacity than is available, anxiety will cause a decrease in performance. For example, Mueller (1979) found that an increase in anxiety resulted in impaired memory performance because of a decrease in elaboration. In contrast, anxiety would not be expected to decrease performance on easy tasks that did not tax working memory resources (Eysenck & Calvo, 1992).

One way that anxiety has been manipulated is by adding time pressure to a task. Coy (1997) found evidence that increasing anxiety by increasing time pressure can increase task-irrelevant thoughts. Participants who received instructions that stressed time pressure and task importance did not perform as well on a digit span task or on a Stroop task as did participants who did not receive these instructions. Participants who received instructions stressing time pressure also reported feeling more anxious than participants who did not, and they reported more task-irrelevant thoughts. Thus, increasing anxiety by increasing time pressure and stressing task importance may lead to task-irrelevant thoughts, and these thoughts may utilize working memory resources that would then not be available for task performance.

Tohill and Holyoak (2000) also used time pressure to induce anxiety and found evidence to support the hypothesis that increased anxiety leads to reductions in working memory capacity. Participants who were given a speeded test prior to the experiment performed worse on those aspects of an analogical reasoning test that depend heavily on working memory capacity than did participants who were not given the speeded test.

Increasing anxiety by increasing time pressure may have an even larger negative effect on the memory performance of older than of younger adults. In Earles and Kersten (1998), following performance of each of a series of cognitive tasks, participants were asked if they felt time pressure on the task. Older adults, but not younger adults, were less likely to recall cognitive tasks during which they previously felt time pressure than cognitive tasks during which they felt less time pressure.

For older adults, the negative effects of anxiety on memory performance may be more pronounced than they are for younger adults because, compared with younger adults, older adults already have reduced working memory capacity (e.g., Park et al., 1996; Salthouse & Babcock, 1991), and there is much evidence that older adults have reduced inhibitory function (e.g., Earles, Connor, Frieske, Park, & Smith, 1997; Hasher, Stoltzfus, Zacks, & Rypma, 1991). If increased task difficulty or time pressure causes participants to have negative self-evaluative thoughts, older adults would be expected to have more difficulty inhibiting these thoughts than would younger adults. Thus, the already reduced working memory capacity of older adults would be expected to be further reduced by increasing task difficulty or time pressure. An increase in task difficulty or in time pressure should, therefore, lead to more dramatic decreases in memory performance for older than for younger adults.

The present research was designed to test the prediction that increases in time pressure and activity difficulty produce increases in age differences in activity memory. In particular, we predicted that age differences in activity memory are larger when the to-be-remembered activities are difficult than when they are easy, and we also expected age differences to be larger when time pressure was increased. We designed Experiment 1 to replicate the finding of Earles and Kersten (1998) that age differences in activity memory are larger for difficult than for easy cognitive tasks. In Experiment 1, we collected rankings of task difficulty from participants after the recall task. Thus, it is possible that participants' rankings of task difficulty could have been influenced by their ability to recall the tasks. In Experiment 2, we experimentally manipulated task difficulty by creating a set of easy and difficult activities. Finally, in Experiment 3, we manipulated time pressure. Participants performed some cognitive tasks with time pressure and other cognitive tasks without time pressure. We expected time pressure to cause an increase in age differences in activity memory.

Thus, we designed the present series of experiments to examine the influences of task difficulty and time pressure on adult age differences in activity memory. We hypothesized that an increase in task difficulty or time pressure would impair the ability of older adults to remember the activities.

Experiment 1

Methods

Participants

Twenty-four undergraduate students aged 19–22 years ($M = 20.21$, $SD = .83$) received course credit in an introductory psychology course for their participation. Twenty-four community-dwelling older adults aged 63–84 ($M = 72.92$, $SD = 6.04$) were recruited from a university lifelong learning program and received $10 for their participation. The younger sample consisted of 7 men and 17 women, and the older sample consisted of 11 men and 13 women. Thus both samples contained more women than men. The older adults were well educated (years of education $M = 15.71$, $SD = 2.35$). Both younger and older adults rated their health as good on a scale of 1 (*poor*) to 5 (*excellent*). Younger adults had a mean health rating of 4.08 ($SD = .72$), and older adults had a mean health rating of 4.04 ($SD = 1.00$), $t(46) < 1$. The Mill Hill vocabulary test (Raven, 1965) was administered to all participants. The older adults ($M = 20.33$, $SD = 6.86$) scored significantly higher than the younger adults ($M = 15.71$, $SD = 4.04$) on this test, with $t(46) = 2.85$, $p = .007$.

Materials

Participants performed 16 paper-and-pencil cognitive tasks. We took care to give participants cognitive tasks with directions that were simple to understand. Thus, none of the tasks were so difficult that participants could not follow the directions. Descriptions of these tasks are in Table 1. There were two versions of each task, each containing different items. Half of the participants received each version. We created these two versions to ensure that the results reflected the structure of the task rather than the specific items on the task. There were two presentation orders, and half of the participants in each age group received each order.

Procedure

Participants were told that they had 2 min to perform each of the 16 cognitive tasks. After performing each task, participants answered three questions about the task: "How well do you think you did on the task that you just performed?" (1 = very poorly to 7 = very well), "How difficult was the task that you just performed?" (1 = very difficult to 7 = very easy), and "How did you feel during the task that you just performed?" (1 = very anxious to 7 = very calm).

Following performance of the last cognitive task, participants were given a free recall test in which they were asked to write descriptions of the tasks. They were given as much time as they needed to complete the recall test. The 16 cognitive tasks were then returned to the participants, and they were asked to rank the tasks from the most difficult to the easiest (1 = the most difficult task to 16 = the easiest task). Participants then completed a brief demographics questionnaire.

Results

We ranked the 16 cognitive tasks from easiest to most difficult on the basis of the task rankings by the participants. We conducted a median split in order to divide the tasks into an easy set and a difficult set of tasks. The easy tasks were connect the dots, letter comparison, symbol-digit substitution, forward-digit span, multiplication, free recall of words, geography, and stem completion. The difficult tasks were series completion, anagrams, definitions, remote associations, word fluency, analogies, paired associate memory, and word search.

We compared the average number of items completed on the easy tasks with the average number of items completed on the difficult tasks, for both younger and older adults. For the easy tasks, the older adults completed an average of 29.97 ($SD = 5.68$) items, and the younger adults completed an average of 38.20 ($SD = 5.68$) items. For the difficult tasks, the older adults completed an average of 9.36 ($SD = 1.94$) items, and the younger adults completed an average of 11.88 ($SD = 1.84$) items. Both younger adults, $t(23) = 35.94$, $p < .001$, and older adults, $t(23) = 21.94$, $p < .001$, completed significantly more items on the easy tasks than on the difficult tasks, suggesting that the easy tasks were indeed easier to complete than the difficult tasks.

We thought that controlling the amount of time that each task was processed was more important than controlling the actual number of items completed. As can be seen by the data just presented, however, controlling the time to perform the task did result in the completion of more items by the younger adults than by the older adults. When we used the number of items completed as the dependent variable, there was a significant interaction between age and difficulty: $F(1, 46) = 23.27$, $MSE = 8.25$, $p < .001$. Thus, the age difference in the number of items completed was even greater for the easy tasks than for the difficult tasks. If the number of items completed was the major contributor to memory for the activities, then the age difference in recall should have been larger for the easy than for the difficult tasks. Instead, we predicted that the age difference would be larger for the difficult than for the easy tasks.

We compared the questionnaire ratings for the easier tasks with those for the more difficult tasks. On Question 1, participants rated how well they had performed on each task on a scale of 1 (very poorly) to 7 (very well). Participants reported doing significantly more poorly on the difficult tasks ($M = 3.51$, $SD = .76$) than on the easy tasks ($M = 4.81$, $SD = .73$), $t(47) = 14.03$, $p < .001$. On Question 2, participants rated how difficult each task was on a scale of 1 (very difficult) to 7 (very easy). Participants rated the difficult tasks ($M = 3.61$, $SD = .62$) as being more difficult than the easy tasks ($M = 4.94$, $SD = .74$), $t(47) = 16.01$, $p < .001$. On Question 3, participants rated anxiety on a scale of 1 (*very anxious*) to 7 (*very calm*). The participants reported being significantly calmer and less anxious during performance of the easy tasks ($M = 4.83$, $SD = .93$) than during performance of the more difficult tasks ($M = 4.23$, $SD = .93$), $t(47) = 7.05$, $p < .001$.

Raters gave participants credit for remembering a cognitive task if the task could be identified from its description. We used two independent raters, but because of the simple nature of the instructions for the tasks, these raters had only seven disagreements about whether or not a participant recalled a particular task (out of 768 possible decisions). These seven disagreements were settled by J. Earles. We conducted a 2 (age group) × 2 (task difficulty) analysis of variance (ANOVA). We set the alpha level at $\alpha = .05$ for this and all other analyses. We provide eta squared as an estimate of effect size for each analysis. As we expected, the younger adults recalled significantly more of the cognitive tasks than did the older adults, $F(1, 46) = 27.95$, $MSE = 2.33$, $\eta^2 = .38$, $p < .001$, and easier tasks were recalled significantly better than more difficult tasks, $F(1, 46) = 8.54$, $MSE = 2.47$, $\eta^2 = .16$, $p = .005$.

As we also predicted, there was a significant interaction of Age × Task Difficulty, $F(1, 46) = 6.42$, $MSE = 2.47$, $\eta^2 = .12$, $p = .015$. As can be seen in Figure 1, the age difference in activity memory was much larger for difficult than for easy tasks. The younger adults, on one hand, recalled approximately the same number of easy tasks ($M = 5.63$, $SD = 1.21$) and difficult tasks ($M = 5.50$, $SD = 1.47$), $t(23) < 1$. Older adults, on the other hand, recalled significantly more of the easy tasks ($M = 4.79$, $SD = 1.77$) than of the difficult tasks ($M = 3.04$, $SD = 1.68$), $t(23) = 3.44$, $p = .002$.

Table 1. Descriptions of the Cognitive Tasks

Task	Description	Experiments
Anagrams	Participants unscrambled strings of letters to make words (e.g., *rtee*).	1, 2, and 3
Analogies	Participants saw a pair of words and were asked to generate an analogous pair given the first word in the pair (e.g., *box square*; *ball* __).	1, 2, and 3
Antonyms	Participants were given a word and chose, out of five words, the word that meant the opposite of the presented word.	3
Arithmetic	Participants solved simple arithmetic problems.	2
Boxes	Participants completed each of a series of three-sided boxes with a line.	2
Circle *e*s	Participants circled all the *e*s in each word in a list.	2
Definitions	Participants generated words that were defined.	1, 2, and 3
Digit copying	Participants copied digits from one box to another.	2
Dot connection	Participants received a page containing circles with numbers. Their task was to draw lines connecting the circles in numerical order.	1
Figure rotation	Participants looked at a model line figure and circled the same figure in a rotated orientation.	2 and 3
Forward-digit span	Participants listened to a string of numbers and were asked to repeat the numbers in the order in which they were heard.	1
Free recall	Participants recalled a list of nouns.	1
Geography	Participants answered multiple-choice questions about geography.	1
Letter and number transformation	Participants were given numbers and letters along with a cue to add one or two to that number or letter (e.g., R ++ = __).	3
Letter comparison	In this task, designed by Salthouse and Babcock (1991), participants received pairs of letter strings and were asked to decide if they were the same or different.	1 and 2
Letter series completion	Participants provided the next letter in the series of letters.	3
Line marking	Participants crossed a series of lines to form a "+."	2 and 3
Matrices	This task was based on the Raven's Progressive Matrices Task.	2

Table 1. Descriptions of the Cognitive Tasks (*Continued)*

Task	Description	Experiments
Multiplication	Participants solved a series of multiplication problems.	1 and 3
Number string completion	Participants saw a series of numbers with one number missing, and they filled in the missing number.	3
Paired associates	Participants received five pairs of words and were then given the first word in each pair and asked to recall the second word.	1
Pattern comparison	In this task, designed by Salthouse and Babcock (1991), participants received pairs of line drawings and were asked to decide if they were the same or different.	2
Reasoning	Participants read logic statements and answered a question about whether or not a relationship was true or false based on the provided information.	2
Remote association	Participants were given three words and were asked to generate a fourth word that was related to the other three (e.g., *envy*, *golf*, *beans*, __).	1, 2, and 3
Sentence comprehension	Participants read sentences and answered a question about each one.	2
Series completion	Participants saw a series of items and were asked to provide the next item in the series (e.g., 15, 22, 31, 42, __).	1 and 2
Stem completion	Participants completed word stems with the first word that came to mind.	1 and 3
Symbol-digit substitution	Participants received a key in which digits were paired with symbols. They were given rows of symbols and were asked to write the digit that corresponded to each symbol.	1 and 3
Synonyms	Participants were given a word and asked to choose a synonym for the word from among five choices.	3
Word fluency	Participants wrote down as many words as they could that began with a specific letter.	1 and 3
Word search	Participants saw a block of letters and were asked to locate words within the block.	1 and 3

Discussion

An increase in difficulty decreased older adults' ability to recall the self-performed cognitive tasks. In Experiment 1, we determined task difficulty from rankings provided by the participants following the recall test. It was thus possible that participants allowed their ability to recall a task to influence their ranking of the difficulty of that task. We thus designed a second experiment in which eight easy and eight difficult tasks were created a priori. Another potential problem in Experiment 1 was that the questions that participants answered following performance of each task could potentially have influenced their ability to recall the task. Earles and Kersten (1998) tested and found no evidence for this hypothesis. Nevertheless, we eliminated these questions in Experiment 2.

We expected that the results of Experiment 2 would be similar to those of Experiment 1. We expected an increase in task difficulty to be detrimental to the memory performance of older adults. Thus, we expected the age differences in recall to be smaller in memory for the easy than for the difficult cognitive tasks.

Experiment 2

Methods

Participants

Participants were 14 undergraduate students between the ages of 18 and 22 years ($M = 19.46$, $SD = 2.16$) who received course credit in a psychology course for participation and 14 community-dwelling older adult volunteers between the ages of 60 and 84 ($M = 70.00$, $SD = 7.31$) who were recruited from a university lifelong learning program. The younger sample consisted of 5 men and 9 women, and the older sample consisted of 3 men and 11 women. Thus both samples were composed mostly of women. The older adults were well educated, with an average of 14.64 ($SD = 3.25$) years of education. Older adults ($M = 24.43$, $SD = 3.92$) performed significantly better on the Mill Hill vocabulary test than did younger adults ($M = 14.93$, $SD = 4.71$), $t(26) = 5.80$, $p < .001$. There was no significant age difference in health ratings, with both younger ($M = 4.21$, $SD = .43$) and older adults ($M = 3.86$, $SD = .86$) rating their health as good on a scale of 1 (poor) to 5 (excellent), with $t(26) = 1.39$, $p = .177$.

Materials

We selected eight easy and eight difficult paper-and-pencil cognitive tasks. We adapted these tasks from Experiment 1, Earles (1996), Earles and Coon (1994), and Earles and Kersten (1998, 1999). The easy tasks were line marking, digit copying, sentence comprehension, arithmetic, circle *e*s, boxes, pattern comparison, and letter comparison. The difficult tasks were series completion, figure rotation, analogies, remote association, anagrams, reasoning, definitions, and matrices. A description of the tasks is provided in Table 1. We created four random task orders, and we randomly assigned each participant to receive one of the four orders.

Procedure

As in Experiment 1, participants received 2 min in which to perform each of the 16 cognitive tasks, and they were told of the 2-min time limit. Unlike in Experiment 1, participants did not fill out a questionnaire following each task. Following the last cognitive task, participants completed a demographics questionnaire. They were then asked to write descriptions of the cognitive tasks and were given as much time as they wanted to recall them. As in Experiment 1, following the recall test, the 16 tasks were returned to the participants, and they were asked to rank them from easiest to most difficult (1 = easiest and 16 = most difficult).

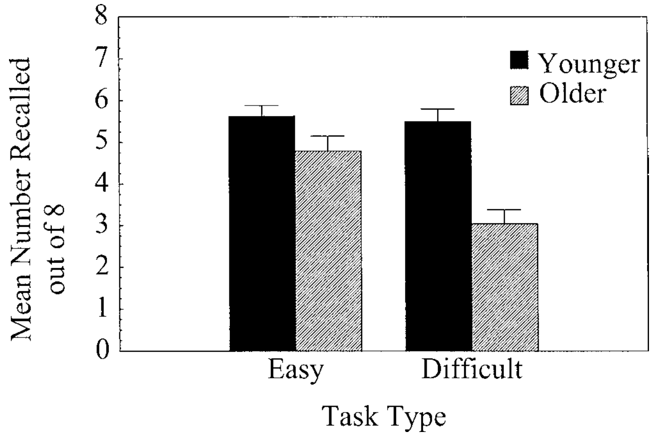

Figure 1. Mean number of easy and difficult tasks recalled by younger and older adults in Experiment 1. Bars represent standard errors.

Results

Participants ranked the difficult tasks as being significantly more difficult than the easy tasks, $t(27) = 21.42$, $p < .001$. The average ranking for the difficult tasks was 11.74 ($SD = .80$), and the average ranking for the easy tasks was 5.27 ($SD = .80$).

As in Experiment 1, participants received credit for remembering a task if the task could be identified from its description. A 2 (age group) × 2 (task difficulty) ANOVA revealed a significant interaction of age and difficulty, with $F(1, 26) = 7.50$, $MSE = .77$, $\eta^2 = .22$, $p = .011$. As can be seen in Figure 2, older adults recalled significantly more of the easy tasks ($M = 3.93$, $SD = 1.14$) than of the difficult tasks ($M = 2.00$, $SD = 1.30$), with $t(13) = 5.21$, $p < .001$. Unlike in Experiment 1, the younger adults also recalled significantly more of the easy tasks ($M = 5.64$, $SD = 1.45$) than of the difficult tasks ($M = 5.00$, $SD = 1.18$), with $t(13) = 2.22$, $p = .045$. The difference was, however, much larger for the older than for the younger adults. Thus, although younger adults recalled significantly more of both the easy tasks, $t(26) = 3.38$, $p = .002$, and the difficult tasks, $t(26) = 6.40$, $p < .001$, than did the older adults, the age difference in recall of the easy tasks was smaller than the age difference in recall of the difficult tasks.

Discussion

As in Experiment 1, in Experiment 2 an increase in task difficulty increased age differences in recall because the increase in task difficulty was detrimental to the recall performance of older adults. One possible explanation for this finding is that task difficulty increased the performance anxiety of older adults and led older adults to have negative

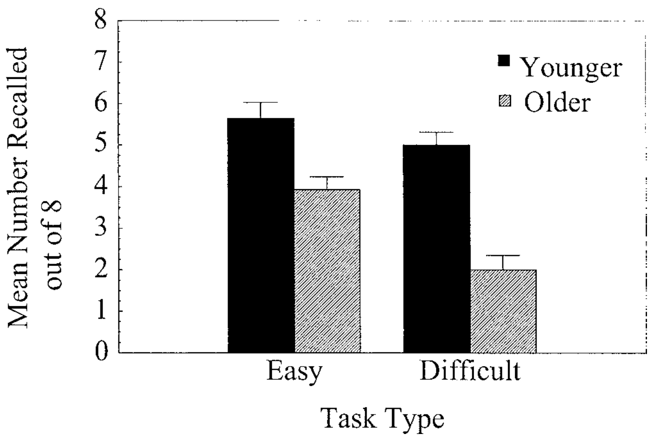

Figure 2. Mean number of easy and difficult tasks recalled by younger and older adults in Experiment 2. Bars represent standard errors.

self-evaluative thoughts about their performance. The processing of these self-evaluative thoughts could result in poorer memory for difficult tasks because this processing uses resources that could otherwise be used for encoding the tasks. For example, Coy (1997) found evidence that the processing of task-irrelevant thoughts that accompanies an increase in anxiety utilizes working memory resources.

Another potential explanation is provided by Carstensen's socioemotional selectivity theory (Carstensen, 1995). This theory predicts that older adults would not place emphasis on difficult tasks because they are interested in regulating their emotional state.

Because the tasks differed in ways other than in difficulty, it is possible that the more difficult tasks differed from the easier tasks in some way that made them more difficult to remember. For example, the difficult tasks could have been more complex and therefore more difficult to describe. This seems unlikely, however, because even the difficult tasks had simple instructions that were easy to understand.

Another feature of cognitive tasks that could produce effects similar to those produced by task difficulty is time pressure. Time pressure has been used as a potential way to increase anxiety (Coy, 1997; Tohill & Holyoak, 2000). The advantage of manipulating time pressure rather than task difficulty is that the structure of the tasks can remain the same in the time-pressure and no-time-pressure conditions. In other words, a single task can be performed either with or without time pressure. Thus in Experiment 3, participants performed tasks either with time pressure or without time pressure. We expected that the memory performance of older adults, but not younger adults, would be negatively influenced by the addition of time pressure during the performance of the cognitive tasks.

Experiment 3

Methods

Participants

Participants were 18 undergraduate students between the ages of 18 and 22 ($M = 19.28$, $SD = 1.60$) who received course credit for their participation and 18 community-dwelling older adult volunteers between the ages of 62 and 87 years ($M = 69.28$, $SD = 7.80$) who were recruited from a university lifelong learning program. The younger sample consisted of 6 men and 12 women, and the older sample consisted of 4 men and 14 women. Thus there were more women than men in both samples. The older adults were well educated (years of education $M = 16.61$, $SD = 1.97$). Older adults ($M = 22.44$, $SD = 3.01$) performed significantly better on the Mill Hill vocabulary test than did younger adults ($M = 15.17$, $SD = 3.96$), with $t(34) = 6.21$, $p < .001$. There was no significant difference in self-reported health ratings for younger adults ($M = 3.94$, $SD = .87$) and older adults ($M = 3.31$, $SD = 1.09$), $t(34) = 1.69$, $p > .05$.

Procedure

As in Experiments 1 and 2, participants performed 16 paper-and-pencil cognitive tasks for 2 min each. A description of these tasks is provided in Table 1. There were two random orders of task presentation, and each order was presented to half of the participants in each age group.

For each participant, half of the cognitive tasks were performed with time pressure, and half were performed without time pressure. In the time-pressure condition, participants were told to work as quickly as possible on the task. They were given verbal warnings by the experimenter when 60 s remained and again when 30 s remained. In addition, a small (2 cm $\times$ 5 cm) digital timer was placed in front of the participant and counted down from 2 min. The timer beeped at the end of this time period. In the no-time-pressure condition, the experimenter timed the task on a stopwatch and told the participant at the end of 2 min that it was time to move on to the next task. The order of presentation of the two conditions was random with the constraint that no more than two tasks in a row were presented in the same condition. Each cognitive task was performed with time pressure for half of the participants and without time pressure for the other half of the participants. Thus, task type and time pressure were not confounded.

As in Experiment 1, participants were asked to answer three questions following each task. "How difficult was this task?" on a scale of 1 (easy) to 5 (difficult), "How well do you think you did on this task?" on a scale of 1 (very well) to 5 (badly), and "How did you feel during the task that you just performed?" on a scale of 1 (very anxious) to 5 (very calm). Following performance of the last cognitive task, participants were given a vocabulary test. They were then given a recall test in which they were given as much time as they needed to write down descriptions of the 16 tasks.

Results

We first conducted analyses on the ratings that participants gave for each task. Participants rated the time-pressure tasks ($M = 3.05$, $SD = .59$) as being significantly more difficult than the no-time-pressure tasks ($M = 2.36$, $SD = .53$), with $t(35) = 6.56$, $p < .05$. Participants thought that they performed significantly better on the no-time-pressure tasks ($M = 2.62$, $SD = .50$) than on the time-pressure tasks ($M = 3.31$, $SD = .52$), $t(35) = 7.56$, $p < .05$, and participants felt significantly more anxious during the time-pressure tasks ($M = 2.85$, $SD = .50$) than during the no-time-pressure tasks ($M = 3.34$, $SD = .60$), $t(35) = 5.96$, $p < .05$.

As in Experiments 1 and 2, a participant was given credit for remembering a task if the task could be identified by the description. We conducted a 2 (age group) × 2 (time pressure) ANOVA. There was a significant main effect of age, $F(1, 34) = 8.15$, $MSE = 3.45$, $\eta^2 = .19$, $p < .001$. In addition, participants recalled significantly more of the no-time-pressure tasks than of the time-pressure tasks, $F(1, 34) = 7.26$, $MSE = 1.61$, $\eta^2 = .18$, $p = .011$.

As we expected, however, there was a significant interaction of Age × Time Pressure, $F(1, 34) = 6.29$, $MSE = 1.61$, $\eta^2 = .16$, $p = .017$. As can be seen in Figure 3, the age difference was larger in memory for the time-pressure tasks than in memory for the no-time-pressure tasks because time pressure during a cognitive task hindered the ability of older adults to later recall the task. For younger adults, there was no significant effect of time pressure on recall, $t(17) = .136$, $p > .05$ (time pressure $M = 5.11$, $SD = 1.75$; no time pressure $M = 5.17$, $SD = 1.98$). Older adults, on the other hand, recalled significantly more of the no-time-pressure tasks ($M = 4.67$, $SD = 1.37$) than of the time-pressure tasks ($M = 3.11$, $SD = 1.13$), $t(17) = 3.56$, $p = .002$.

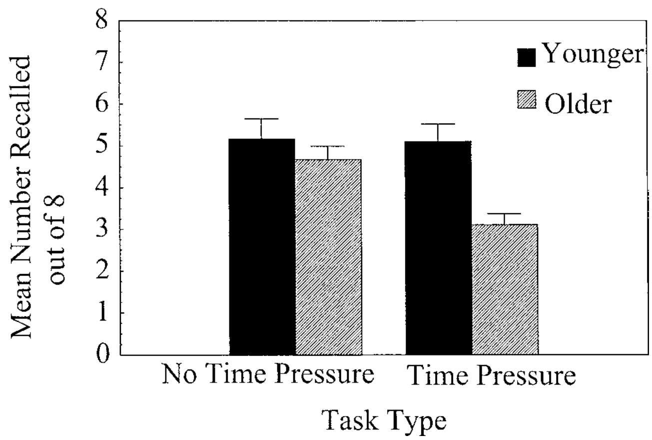

Figure 3. Mean number of tasks with and without time pressure recalled by younger and older adults in Experiment 3. Bars represent standard errors.

Discussion

As we predicted, an increase in time pressure on the cognitive tasks decreased the ability of older adults to later recall the tasks. This result is consistent with the results of Earles and Kersten (1998), in which older adults were found to have more difficulty recalling tasks on which they reported feeling time pressure than tasks on which they did not report feeling pressured for time. One possible explanation for this effect is that increasing time pressure increased anxiety, and this increase in anxiety caused older adults to attend to self-evaluative thoughts instead of to aspects of the tasks that would have been beneficial for recall. An alternative explanation is that the time-pressure tasks made the older adults feel uncomfortable, so they allocated fewer processing resources to the tasks on which they felt time pressure, as would be postulated by the socioemotional selectivity theory.

Another potential explanation for the finding that time pressure was detrimental to older adults' memory for cognitive tasks is that participants were distracted by the small timer and by the reminders from the experimenter. These components of the task were necessary for us to create a sense of time pressure while controlling for the amount of time that participants spent working on each task. If participants were more distracted in the time-pressure condition, then their actual performance on the tasks would most likely be worse than their performance on tasks without time pressure.

Thus, in order to test the hypothesis that distraction, and not time pressure, caused the present results, we computed performance scores for each participant on each task. Then, for each task, we compared performance under the time-pressure condition with performance under the no-time-pressure condition. We found no significant differences in actual task performance for younger adults or for older adults (all ps $> .05$). We then converted task performance scores to z scores, and we computed an overall composite score for tasks performed with time pressure and an overall composite score for tasks performed without time pressure. As with the single tasks, we found no significant effect of condition for younger adults, $t(16) < 1$, or for older adults, $t(16) = 1.31$, $p = .210$. It seems likely, therefore, that time pressure, and not distraction, caused older adults to have more difficulty remembering the cognitive tasks that were performed in the time-pressure condition.

General Discussion

An increase in task difficulty or time pressure reduced the ability of older adults to remember cognitive tasks. Thus, age differences in activity memory were larger for difficult than for easy tasks, and they were larger for tasks on which participants felt time pressure than for tasks in which time pressure was reduced. We hypothesized that one possible mechanism responsible for this effect was that an increase in task difficulty may have increased anxiety and caused participants to have negative self-evaluative thoughts about their performance. Self-evaluative thoughts associated with performance anxiety, especially on tasks for which older adults do not feel like they are performing well, may not be inhibited, and may thus interfere with the ability of older adults to encode the task. Although we did not measure self-evaluative thoughts in the current studies, Coy (1997) did find evidence for an increase in task-irrelevant thoughts with increased arousal. Older adults would be expected to have more difficulty inhibiting these self-evaluative thoughts than would younger adults.

Self-reports of anxiety completed after the performance of each cognitive task suggested that participants did feel more anxious during difficult than during easy tasks and that participants did feel more anxious when there was time pressure. These self-reports, however, were based on a single question, and participants may have thought that difficulty should be related to anxiety and answered the self-report questions according to these expectations. The use of other measures of anxiety, such as physiological measures, could help to clarify the relations among age, anxiety, and memory performance.

Eysenck's working memory restriction theory suggests that anxiety interferes with working memory because it causes people to have task-irrelevant thoughts. This interference with working memory causes a decrease in cognitive function (Eysenck, 1979; Eysenck & Calvo, 1992). This theory predicts that the effects of anxiety should be largest when working memory is already restricted. For example, MacLeod and Donnellan (1993) found that a memory load increased the negative effects of anxiety on cognitive performance. Thus, an increase in anxiety would be expected to be more problematic for older than for younger adults, because older adults have reduced working memory capacity compared with that of younger adults.

Other research has examined the effects of task instructions that could increase anxiety on age differences in cognitive performance. As people get older, they tend to worry about potential decreases in cognitive ability. Rahhal, Hasher, and Colcombe (2001) compared age differences in memory for newly learned trivia under conditions that stressed the memory component of the test and under conditions that did not emphasize the memory component of the test. Older adults did not recall as many items when they were told that their memory was being tested. The authors suggested that a decrease in confidence with increased age might cause a decrease in memory performance. They suggested that features of the testing situation, such as the instructions given to participants, can influence that size of age differences in performance on a task.

The present results provide further evidence that features of the testing situation can increase age differences in cognitive performance. Most laboratory cognitive tasks, such as tests of working memory, are difficult. If the difficulty of the task causes older adults to have self-evaluative thoughts about performance, then these thoughts could potentially interfere with task performance, just as in the present studies task difficulty and time pressure reduced the memory performance of older adults. To further evaluate the hypothesis that anxiety is indeed responsible for the increase in age differences in activity memory that accompanies an increase in task difficulty or time pressure, we need to conduct further research in which other measures of anxiety are used.

Alternatively, older adults may remember easier tasks better than difficult tasks because they place emphasis on things that they do well. If older adults place more emphasis on positive than on negative information, this could affect their memory for the information, such that they remember positive information better than negative information.

According to Carstensen's (1995) socioemotional selectivity theory, older adults might not focus on negative self-evaluation during difficult tasks. Instead they might place less emphasis on the negative aspects of the task. Charles and colleagues (2003), however, found that older adults actually chose to spend more time viewing negative images than positive images. In the current study, older adults may have placed more emphasis on tasks that they found to be less stressful. Thus, older adults may have had selective memory for the easier tasks because they found the experience of completing these tasks to be more pleasant. This increased emphasis on emotional regulation with increased age could result in poorer memory for difficult tasks or tasks with time pressure.

It is also possible that the performance of difficult tasks taxes the processing resources of older adults. The performance of a difficult task may require most of an older adult's available processing resources, and thus an older adult may not have the necessary resources available for forming a strong memory trace of the performed task.

The present research contributes to our understanding of adult age differences in memory for self-performed tasks. We found both increases in task difficulty and time pressure to decrease older adults' ability to recall cognitive tasks. We hypothesized that older participants may feel anxious while performing difficult tasks or tasks with time pressure, which may potentially cause them to focus cognitive resources on self-evaluative thoughts, leaving fewer cognitive resources for the formation of a strong memory trace. Future studies should be conducted in which additional measures of anxiety are used in order for researchers to further examine this hypothesized relation between anxiety and age differences in memory performance.

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