Strategy Use Mediates the Relationship Between Control Beliefs and Memory Performance for Middle-Aged and Older Adults

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We examined whether the relationship between control beliefs and memory performance varied for young, middle-aged, and older adults and whether strategy use mediated this relationship. Participants were 335 adults, ages 21 to 83, who had been recruited from local probability samples. We used structural equation modeling to test the predicted model and compare it by age group (young, middle-aged, and older adults). As expected, control beliefs were related to memory performance on a word list recall task for middle-aged and older adults, but not for younger adults. An analysis of indirect effects revealed that strategy use partially mediated this relationship. Specifically, middle-aged and older adults who perceived greater control over cognitive functioning were more likely to categorize the words and had better recall performance.

Past work has shown that control beliefs, especially beliefs specific to the cognitive domain, are related to better performance on a wide variety of cognitive tasks, including memory performance (Hertzog, Dixon, & Hultsch, 1990; Lachman, 1986, 1991). Although research has consistently shown that there is a relationship between control beliefs and cognitive performance, especially in later life, research is sparse on the mechanisms or mediational factors linking beliefs and cognitive performance (Miller & Lachman, 1999). Lachman and colleagues (Miller & Lachman, 2000) have described a conceptual model, which describes the relationship between control beliefs and performance as well as potential mediators. Control beliefs are postulated to affect future performance through behavioral (e.g., strategy use), physiological (e.g., anxiety, stress), motivational (e.g., effort), or affective (e.g., depression) mediators.

Based on cognitive social learning theory (Bandura, 1997) and the social breakdown syndrome (Kuypers & Bengston, 1973), the model illustrates the relationship between beliefs about control and age-related declines in memory. Age-related losses in memory can lead to a lowered sense of control, including lack of confidence in abilities, feeling that one cannot do anything about declining performance, and attributions to aging and poor ability (Elliott & Lachman, 1989). Both actual as well as perceived declines in cognitive functioning can contribute to a low sense of control. This lowered sense of control may affect motivation, resulting in low levels of effort, persistence, and strategy use as well as greater anxiety and stress when one is faced with memory challenges. This process is cyclical in that lowered effort and increased stress can result in further cognitive decline. Thus, the sense of control is considered to be an antecedent and consequence of age-related losses in memory (Lachman, Ziff, & Spiro, 1994; Miller & Lachman, 1999, 2000). The present study was guided by this model and focused on strategy use as a possible mediator between control beliefs and cognitive performance. Past work has shown that the sense of control and strategy use are amenable to intervention in older adults (Lachman, 1991).

Thus, the model specifies modifiable factors involved in memory aging. In addition, the model is also useful for examining conceptual links between beliefs and behavior. Consistent with the conceptual model just described, a low sense of control over memory could be detrimental to memory performance by distracting attention from the task, decreasing motivation to engage and perform, or minimizing efforts to utilize effective strategies (Bandura, 1989, 1997). Research has shown that older adults typically are more likely than younger adults to believe that their memory is poor, that it has gotten worse over time, and that it will continue to deteriorate (Gilewski, Zelinski, & Schaie, 1990; Hultsch, Hertzog, Dixon, & Small, 1998; Lachman, Bandura, Weaver, & Elliott, 1995). Older adults are also less likely than the young to believe that they have control over their memory or that there is anything they can do to improve their memory (Dixon & Hultsch, 1983; Lachman, 1991). There is also evidence that concerns about memory emerge in middle age (Aldwin, 1990; Willis & Schaie, 1999). Thus, we expected that middle-aged and older adults in the present study would have a lower sense of control and that the relationship between control and performance would be stronger for middle-aged and older adults than for young adults. Although age-related declines in memory performance and cognitive-specific control beliefs have been well documented, much of the research examining the relationship between control beliefs and memory has been limited to older adults, so that variations by age have not often been examined. Thus, in addition to examining strategy use as a potential mediator between beliefs and performance, we also examined whether this relationship varied by age group. If control beliefs are found to relate to memory performance differentially for the young and old, this could shed some light on the psychosocial processes involved in memory aging.

Although work directly linking control beliefs to strategy use is limited, several studies have provided some evidence for this relationship. For example, Hertzog, McGuire, and Lineweaver (1998) found that those with greater perceived control over memory functioning reported greater use of optimal strategies...
in a recall task. In another study, those with higher control beliefs benefited more from performance experience in that they were able to make effective adjustments in the selection of segment lengths in order to maximize recall during an online memory-processing task (Riggs, Lachman, & Wingfield, 1997).

The use of effective strategies is clearly linked to better memory performance (Bäckman, Small, & Wahlin, 2001). Although some studies have shown only small or no age differences in strategy use (Blatt-Eisengart & Lachman, 2004), other research has shown that older adults may not always use a specific strategy as effectively as younger adults or they may be less likely to choose the most effective strategy when a variety of strategies are available (e.g., Dunlosky & Hertzog, 1998; Rogers, Hertzog, & Fisk, 2000; Verhaeghen & Marcoen, 1996). For example, when given the opportunity to control the input of stimuli (segment length) in a memory experiment, elderly individuals did not effectively take advantage of this opportunity (Stine, Lachman, & Wingfield, 1993). Even when older adults do use strategies effectively, this does not typically account for age differences in memory performance (Dunlosky & Hertzog). This may reflect age differences in attributions for performance. For example, Blatt-Eisengart and Lachman (2004) found that older adults were less likely than young adults to attribute their memory performance on a categorizable list to strategy use, which is an internal controllable factor. In contrast, all age groups were equally likely to attribute performance to ability, an internal stable factor. These beliefs about the sources of memory performance could lead to less effective strategy use among older adults. Interestingly, strategy use was related to better performance for all age groups, but older adults were less aware of the connection. Even if strategy use cannot account for age differences in performance, it is important to understand what motivates individuals, particularly older adults, to use effective strategies. Perhaps the presence or absence of age differences in strategy use is related to individual differences in control beliefs. Those who believe they have control over their memory should be more likely to engage in strategic recall behaviors, although it is not clear if this is the case for all age groups. Thus, we were also interested in examining whether the relationship between control beliefs and strategy use varied by age group.

Goals of the Present Study

In summary, our goals in the present study were to examine whether the relationship between control beliefs and memory performance varied for young, middle-aged, and older adults and whether strategy use mediated this relationship across age groups. We assessed control beliefs by using a domain-specific measure of control, as relationships found between control beliefs and behavior are typically stronger with domain-specific measures, particularly for older adults (Lachman, 1986, 1991; Lachman & Weaver, 1998). We used recall of a categorizable word list as a measure of memory performance, given that it is conducive to strategy use and age-related differences in performance have been consistently found in episodic memory tasks (Bäckman et al., 2001). We used structural equation models to test the hypothesized relations (see Figure 1). We included age and education as background variables, given that both age and education are related to control beliefs and memory. Those who have higher education levels typically believe they have greater control over outcomes (Lachman & Weaver; Mirowsky, 1995). Moreover, research shows that age differences in control beliefs are reduced when education is included in the model (Mirowsky). Given that younger adults are less likely than older adults to have concerns about their memory and that previous work has shown that relationships between domain-specific beliefs and behaviors are weaker for younger than for older adults (Lachman, 1986), we expected that control beliefs specific to the cognitive domain would be related to performance for middle-aged and older adults but not for younger adults. Thus, for middle-aged and older adults, we expected that higher control in the cognitive domain would be related to better memory performance. We also expected that control would be related to strategy use for middle-aged and older adults, but not younger adults, as younger adults should be more likely to use strategies regardless of their beliefs. We predicted that strategy use would mediate the relationship between control beliefs and memory performance for middle-aged and older adults, but not for younger adults. Finally, we hypothesized that strategy use would be related to memory performance for all participants, regardless of age.

Methods

Participants

Participants included in the present study were 335 adults ranging in age from 21 to 83 years. Eighty-six percent were Caucasian, 9% African-American, 2% Asian-American, and 3% other or unknown ethnicity or race. We divided participants into three age groups. There were 103 young adults ranging in age from 21 to 39 years \((M = 32.0, SD = 5.3)\), 117 middle-aged adults ranging in age from 40 to 59 years \((M = 48.1, SD = 5.4)\), and 115 older adults ranging in age from 60 to 83 years \((M = 69.3, SD = 5.8)\). We drew participants from two different studies (Study 1, Study 2) and combined their data for analysis in the present study.

Participants from both studies were volunteers initially recruited from a random sampling of individuals living in the Greater Boston metropolitan area by use of address lists stratified by age and gender. We contacted persons on the list by letter and telephone, and we excluded them from
participating in either study if they had a stroke in the past 5 years, had a serious head injury, had Parkinson’s disease, did not have full use of both hands, or reported being in poor health compared with others their same age (we excluded 18 individuals in Study 1 and 15 in Study 2). We also excluded individuals if they had less than a high school education or were not native English speakers (unless they spoke English fluently before the age of 10 years; we excluded 50 people in Study 1 and 52 in Study 2). In addition, we excluded participants from Study 2 if they made two or more errors on a modified version of the Short Portable Mental Status Questionnaire (Pfeiffer, 1975; we deleted two items because we could not verify a correct response over the telephone). Participants were paid $25.

Study 1 participants were 149 adults (67 men, 82 women) ranging in age from 21 to 80 years. Study 2 participants were 195 adults (93 men, 102 women) ranging in age from 21 to 83 years. There were 9 participants whom we did not include in the present study because some data were missing on key variables; this resulted in a total of 335 participants (147 from Study 1 and 188 from Study 2). The samples were comparable in sex and race or ethnicity distributions. The study included Caucasians (89% in Study 1 and 82% in Study 2), African Americans (8% in Study 1 and 11% in Study 2), and Asian Americans (2% in Study 1 and 3% in Study 2). In Study 1, 55% of the participants were women; in Study 2, 51% of the participants were women. We conducted t tests to compare the means between Studies 1 and 2 for age, education, and health. There were no significant differences between the samples on age (Study 1, M = 50.03, SD = 16.11; Study 2, M = 50.72, SD = 16.16), education (Study 1, M = 15.44, SD = 2.32; Study 2, M = 15.84, SD = 2.45), or self-reported health (Study 1, M = 4.01, SD = 0.95; Study 2, M = 4.08, SD = 0.95).

**Measures**

**Education.**—We measured education on a 12-point scale with 1 = some grade school; 2 = junior high–eighth grade; 3 = some high school; 4 = Graduate Equivalency Diploma; 5 = graduated from high school; 6 = 1–2 years of college, no degree; 7 = 3 years of college, no degree; 8 = 2-year college degree; 9 = 4-year college degree; 10 = some graduate school; 11 = master’s degree; and 12 = doctoral level degree. We converted this variable to years of education (1 and 2 = less than high school and not used in the study; 3 = 10 years, 4 = 11, 5 = 12, 6 = 13, 7 = 15, 8 = 14, 9 = 16, 10 = 17, 11 = 18, and 12 = 20). The correlation between the two education variables was r(333) = .98, p < .001.

**Word list recall and strategy use.**—We used lists of categorizable nouns developed by Hertzog and colleagues (1990) to assess memory performance. Each list contained six words from five taxonomic categories, which we developed by using norms from Howard (1980). We randomized the order of words, with the condition that words from the same category not appear adjacent to one another, and list order was counterbalanced. We presented words in two columns on a computer screen in the same random order for all participants. When the words disappeared from the computer screen, participants wrote as many of the words as they could remember on the paper provided. In Study 1, there were three consecutive trials for each word list; participants studied the words for 1 min and had unlimited time for recall during each trial. In Study 2, there was only one trial for each word list; participants studied the words for 3 min and had unlimited time for recall. We used only the recall scores from the first trial of each study. Because the amount of study time varied across studies, we standardized recall scores within each study.

Although both studies had experimental manipulations, there was no effect of condition on recall at the first trial in Study 1, and in Study 2, the manipulation did not occur until Trial 2 (see Procedures section). We scored recall data by using Version 2.0 of the Scoring Options for Recall Tests (Elme & Payne, 1999). We computed two aspects of memory for each trial. List recall refers to the total number of words correctly recalled out of 30. We computed the adjusted ratio of clustering (ARC) to measure strategy use or the extent to which participants categorized the words at recall (Roeken, Thompson, & Brown, 1971). Strategy use scores range from 0 to 1 and higher scores reflect a greater degree of categorization or clustering. We also standardized strategy use within each study for comparability across studies.

**Control beliefs.**—We measured control beliefs with the Personality in Intellectual Contexts Inventory (PIC), a domain-specific measure of cognitive control beliefs (Lachman, 1986; Lachman, Baltes, Nesselroade, & Willis, 1982). We averaged three scales from the PIC (internal, chance, and powerful others) to create a composite measure of control beliefs in intellectual contexts (standardized r = .86). Participants read each statement and indicated the extent to which they agreed or disagreed with each statement on a 6-point Likert-type scale (1 = strongly agree to 6 = strongly disagree), with higher scores indicative of higher control. In both studies, the PIC was administered by means of a questionnaire sent to participants about 1 week prior to the testing session and was returned to the experimenter at the testing session.

**Procedures**

The subjects for the present study were part of two large studies that were conducted for multiple related research questions about control beliefs, memory, and aging. Some of the study procedures differed, but the measures were nearly identical, except as already above. Study 1 was a study on the relationship between aging stereotypes, and beliefs about memory, and memory performance (see Andreoletti & Lachman, 2003). In this study, subjects were randomly assigned to one of three conditions. The conditions varied in the messages given about the memory task. However, the manipulation did not have a significant effect, and there were no condition differences after the first or second trials for word recall [F(2, 140) = 0.25, p = .78] or ARC [F(2, 140) = 0.95, p = .39]; thus, we used only the first trial memory scores in this study.

Study 2 was also conducted to examine the relationship between memory beliefs and performance and the relationship with strategy use. In this study (see Andreoletti, Veratti, & Lachman, in press; Lachman, Andreoletti & Pearman, in press), we used the first memory trial, which was taken after random assignment and before any manipulation. Thus, the assessments across studies were largely comparable even
though the studies had slightly different goals and small procedural variations.

RESULTS

Descriptive Statistics

We conducted \( t \) tests to compare the means between Study 1 and Study 2 on all variables. We found no significant differences on digit symbol substitution (Study 1, \( M = 58.36, SD = 13.26 \); Study 2, \( M = 58.24, SD = 13.35 \)) or forward digit span (Study 1, \( M = 7.28, SD = 1.30 \); Study 2, \( M = 7.07, SD = 1.31 \)). We found significant differences on some measures, as the Study 1 participants scored higher (\( p < .001 \)) on the ARC measure of categorization (Study 1, \( M = 0.64, SD = 0.29 \); Study 2, \( M = 0.51, SD = 0.37 \)). Study 2 participants scored significantly higher on word list recall (\( p < .001 \); Study 1, \( M = 13.23, SD = 4.16 \); Study 2, \( M = 18.48, SD = 4.99 \)); backward digit span (\( p = .04 \); Study 1, \( M = 5.54, SD = 1.40 \); Study 2, \( M = 5.20, SD = 1.56 \)); Shipley vocabulary (\( p = .003 \); Study 1, \( M = 17.83, SD = 2.10 \); Study 2, \( M = 18.44, SD = 1.67 \)); and the PIC personal control composite (\( p = .006 \); Study 1, \( M = 4.92, SD = 0.63 \); Study 2, \( M = 5.09, SD = 0.51 \)).

Given that the samples were drawn from the same parent pool and there were only minor differences between the samples, we combined the data from the two studies. Means and standard deviations for all variables are presented separately by age group in Table 1. Consistent with past research (Bäckman et al., 2001), middle-aged and older adults scored lower on the digit symbol substitution (Wechsler, 1981), \( F(2, 332) = 101.35, p < .001 \), and had better Shipley vocabulary scores than did the young adults, \( F(2, 331) = 3.41, p < .05 \). There was also a significant age difference in number of years of education, \( F(2, 332) = 3.46, p < .05 \), such that older adults had fewer years of education than did young and middle-aged adults. There were no age group differences for forward and backward digit span or for self-rated overall health compared with other individuals of the same age on a 5-point scale (1 = excellent, 2 = good, 3 = average, 4 = fair, 5 = poor), all \( F \)s < 2, \( ns \).

Correlations among variables by age group are presented in Table 2. It is noteworthy, as predicted, that control beliefs are significantly related to strategy use and list recall for middle-aged and older adults, but not for the young. Moreover, strategy use is related to recall for all age groups. It is also of interest that education is related to control beliefs for middle-aged and older adults, whereas education is related to strategy use only for the young adults.

Data-Analysis Plan

We used maximum likelihood estimation, using Amos 5.0 (Arbuckle, 2003; Arbuckle & Wothke, 1999), to estimate a path model predicting recall from strategy use and control beliefs. Given the age ranges within each age group and the fact that age and education have been related to control beliefs and memory performance in past research (Albert et al., 1995; Bäckman et al., 2001; Lachman & Weaver, 1998; Mirowsky, 1995), we included age and education in all models and allowed them to covary. We expected that age and education would be related to recall performance. We also expected education to predict strategy use and control beliefs. We did not include the path from age to strategy use in the model, given that previous research has not always found age differences in categorization (Hertzog, Dunlosky, & Robinson, et al., 2003), and age was not related to strategy use, \( r(333) = .03, p = .65 \), in the present sample. All variables in the model were observed variables, and we used listwise deletion to handle missing data (2.6% missing data).

Preliminary Path Analysis

To increase power for testing our path model by each age group, we combined participants from Studies 1 and 2. However, before combining the samples, we conducted a preliminary path analysis to test whether the predicted model was a good fit for each study. Thus, we performed a multiple-group analysis with all paths constrained to be equal across the two studies and compared the fit of the constrained model with the fit of interim models in which we individually freed up each path. This allowed us to compare the similarity of each

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Table 1. Means and Standard Deviations for Background and Study Variables by Age Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Young ((N = 103))</th>
<th>Middle Aged ((N = 117))</th>
<th>Older ((N = 115))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age*</td>
<td>31.95 ± 5.30</td>
<td>48.13 ± 5.41</td>
<td>69.28 ± 5.84</td>
</tr>
<tr>
<td>Education*</td>
<td>15.95 ± 2.05</td>
<td>15.87 ± 2.47</td>
<td>15.19 ± 2.57</td>
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<tr>
<td>Vocabulary*</td>
<td>17.84 ± 1.88</td>
<td>18.14 ± 2.17</td>
<td>18.51 ± 1.54</td>
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<tr>
<td>DSS*</td>
<td>67.83 ± 9.81</td>
<td>60.17 ± 10.25</td>
<td>47.83 ± 11.33</td>
</tr>
<tr>
<td>BDS</td>
<td>7.22 ± 1.35</td>
<td>7.20 ± 1.36</td>
<td>7.08 ± 1.22</td>
</tr>
<tr>
<td>Health</td>
<td>5.47 ± 1.60</td>
<td>5.35 ± 1.46</td>
<td>5.25 ± 1.46</td>
</tr>
<tr>
<td>Strategy use</td>
<td>0.90 ± 0.08</td>
<td>0.07 ± 0.06</td>
<td>0.96 ± 0.07</td>
</tr>
<tr>
<td>Control beliefs</td>
<td>5.09 ± 0.47</td>
<td>5.03 ± 0.66</td>
<td>4.95 ± 0.54</td>
</tr>
<tr>
<td>Recall*</td>
<td>0.33 ± 0.18</td>
<td>0.18 ± 0.92</td>
<td>0.49 ± 0.99</td>
</tr>
</tbody>
</table>

Notes: DSS = digit symbol substitution; BDS = forward digit span; BDS = backward digit span. *Significant age group differences, \( p < .05 \).

Table 2. Zero-Order Correlations for Study Variables by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Age</th>
<th>Education</th>
<th>Control beliefs</th>
<th>Strategy Use</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young ((n = 103))</td>
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<td>Age</td>
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<tr>
<td>Education</td>
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<tr>
<td>Control beliefs</td>
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<td>.19</td>
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<td></td>
<td></td>
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<tr>
<td>Strategy use</td>
<td>.17</td>
<td>.31**</td>
<td>—.04</td>
<td></td>
<td>—</td>
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<tr>
<td>Recall</td>
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<td>.13</td>
<td>.44***</td>
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<td>Middle ((n = 117))</td>
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<td>Age</td>
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<td>Education</td>
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<td>Strategy use</td>
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<td>Recall</td>
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<td>.29***</td>
<td>.30***</td>
<td>.45***</td>
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<tr>
<td>Old ((n = 115))</td>
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<td>Age</td>
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<tr>
<td>Education</td>
<td>—.23*</td>
<td>—.17</td>
<td>.29***</td>
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<tr>
<td>Control beliefs</td>
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<td>.33***</td>
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<tr>
<td>Strategy use</td>
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<td>.38***</td>
<td>.53***</td>
<td>.48**</td>
<td>—</td>
</tr>
<tr>
<td>Recall</td>
<td>—.51**</td>
<td>.38***</td>
<td>.53***</td>
<td>.48**</td>
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*\(p < .05\); **\(p < .01\); ***\(p < .001\).
individual path across studies. The constrained model was a good fit, $\chi^2 = 18.75, df = 10, p = .04$, Goodness of Fit Index (GFI) = 0.98, Comparative Fit Index (CFI) = 0.96, root mean square error of approximation (RMSEA) = 0.05. The only model that was a significantly better fit than the constrained model was a model that allowed the path from strategy use to recall to vary across studies, $\chi^2 = 2.97, df = 9, p = .97, \Delta \chi^2 = 15.79, p < .01, CFI = 1.00, GFI = 1.00, RMSEA < 0.01$. The only difference was the strength of the relationship between strategy use and recall (likely a result of the differential study time allotment in the two studies), but not the direction (for Study 1, $\beta = 0.15, p < .05$; for Study 2, $\beta = 0.48, p < .001$). In each study, all paths were significant except for the path from age to control beliefs; therefore, we did not include this path in subsequent analyses. Note that for the overall sample the age to control beliefs was significant, $r = -0.12, p = .03$. However, when education is controlled for, the age difference is reduced ($r = -0.09, p = .11$), as Mirowsky (1995) has found.

Control Beliefs and Performance

To determine whether the relationships among control beliefs, strategy use, and recall varied across age groups, we performed a multiple-group analysis testing path models that varied in the number of constraints. A model that constrained all paths to be equal across all age groups was a relatively good fit, $\chi^2 = 34.37, df = 20, p = .02, CFI = 0.92, GFI = 0.96, RMSEA = 0.047$, and served as a baseline comparison. As already noted, examination of correlations within each age group revealed that control beliefs were related to strategy use and recall only for middle-aged and older adults, whereas education was related to strategy use only for young adults (see Table 2). Thus, we tested an alternative model that allowed the paths from control beliefs to strategy use, control beliefs to recall performance, and education to strategy use to vary across age groups, while all other paths were constrained to be equal. This alternative model was a significantly better fit than the fully constrained baseline model, $\chi^2 = 14.07, df = 14, p = .44, \Delta \chi^2 = 20.30, p < .01, CFI = 1.00, GFI = 0.98, RMSEA < 0.01$ (see Figure 1; also see the end notes at the end of this article).

Standardized path coefficients for this alternative model are presented in Table 3. As we predicted, strategy use was related to recall for all age groups and control beliefs were related to strategy use for middle-aged and older adults, but not for younger adults. In the final model, control beliefs were directly related to recall performance for older adults only. Education was positively related to strategy use for young adults only and positively related to control beliefs and memory performance for all age groups. Education was not significantly related to age for the middle-aged adults. Education and age were positively related for the young adults and negatively related for the older adults. As we expected, age was negatively related to memory performance.

Strategy Use as a Mediator

In order to examine whether strategy use mediated the relationship between control beliefs and memory performance, we examined the significance of the indirect effects by using the Sobel test (Baron & Kenny, 1986; Preacher & Leonardelli, 1999). The Sobel test was significant for middle-aged ($z = 2.47, p < .05$, indirect $\beta = 0.09$) and older adults ($z = 3.11, p < .01$, indirect $\beta = 0.12$), but not for young adults ($z = -1.05, ns$). These results reveal a reduction in the magnitude of the relationship between control and recall and that the indirect effect of control beliefs on recall is significantly different from zero for middle-aged and older adults. However, for older adults, the path from control beliefs to recall ($\beta = .32, p < .001$) is still significant with strategy use in the model. These results provide evidence that the effects of control beliefs on recall are mediated for middle-aged adults and partially mediated for older adults by strategy use.

As suggested by Miller and Lachman (1999), when background factors are taken into consideration, the nature of the relationship between control beliefs and performance may change. Therefore, we also examined the indirect effects of education on recall and strategy use. The indirect effects of education on recall were significant only for younger and older adults. Sobel tests revealed that strategy use partially mediated the effect of education on recall for younger adults ($z = 3.05, p < .01$, indirect $\beta = .13$), whereas control beliefs partially mediated this effect for older adults ($z = 3.37, p < .001$, indirect $\beta = .15$). Sobel tests also revealed that control beliefs partially mediated the effect of education on strategy use for middle-aged ($z = 2.32, p < .05$, indirect $\beta = .06$) and for older adults ($z = 2.84, p < .01$, indirect $\beta = .09$), but not for younger adults. For middle-aged and older adults, those with higher education had higher control beliefs and were more likely to use the categorization strategy, but education was not related to control beliefs for the younger adults.

**DISCUSSION**

Although the relationship between control beliefs and cognitive performance has been well documented, researchers have only begun to examine the mechanisms that could account for this relationship (Hertzog et al., 2003; Miller & Lachman,
Lachman and colleagues (Miller & Lachman, 1999) have postulated that strategy use may mediate the relationship between beliefs and cognitive performance; however, few studies have directly tested this assertion. The results of the present study provide evidence that strategy use does mediate the relationship between control beliefs and memory performance for middle-aged and older adults, as predicted, although it does not fully account for the relationship, at least for older adults. More specifically, our results revealed that strategy use partially mediates the relationship between control and performance, for older adults. Interventions targeting strategy use, directly or indirectly through the sense of control, may be one avenue for enhancing memory in middle and later adulthood.

As we hypothesized, control beliefs specific to the cognitive domain were significantly related to memory performance for middle-aged and older adults, but not for younger adults. Although there was a small but significant correlation of age and control beliefs in the expected inverse direction for the overall sample (r = -0.12, p < .05), for young adults the control beliefs were not related to strategy use or recall performance. This finding is consistent with the idea that beliefs play a more important role in areas in which performance is threatened or variable as a result of factors such as aging (Bandura, 1997; Lachman, 1991). As younger adults are typically less concerned about their memory ability, control beliefs may not be associated with their memory performance. In contrast, for middle-aged and older adults, who are more likely to be concerned about their memory performance, their perceptions of control are important for strategy use and memory performance. For middle-aged adults, we found the relationship between control beliefs and recall to operate indirectly through strategy use. However, for older adults, the relationship between control and memory was only partially mediated by strategy use. It will be important in future work to consider what other factors such as anxiety or stress may also contribute to the relationship between control beliefs and recall among older adults (Miller & Lachman, 1999).

Our findings are somewhat consistent with a recent study by Hertzog and colleagues (2003), which showed that the use of effective strategies mediated the effects of control beliefs on a paired associate recall task. However, these researchers found that strategies completely mediated the effect and that this was true for all age groups. In contrast, we found no mediation for younger adults, partial mediation for older adults, and full mediation only for the middle-aged adults. One possible explanation for the difference in our findings is that Hertzog and colleagues used retrospective strategy reports obtained after recall, whereas we used an objective measure of strategy use. Perhaps young adults with a greater sense of control would be more likely to have knowledge of and report effective strategies; however, it is not clear whether younger adults with greater control actually used more effective strategies than did young adults with less control during the memory task. Another difference between studies is that Hertzog and colleagues used paired associates recall rather than categorizable lists. Given that there is a wider range of possible effective strategies for paired associates than for lists, it is possible that control beliefs would play a role for the young and not just for middle-aged and older adults. Thus, the use of the ARC as the only indicator of strategy use could account for differences between the two studies. Moreover, it is important to note that the ARC is a measure of clustering, not necessarily strategy use per se (Bjorklund, Schneider, Cassel, & Ashley, 1994). It is possible that participants used the categories as a retrieval cue rather than as an organizational strategy. The examination of only one strategy is a limitation of the present study, and future work should consider other measures of strategy use in relation to control beliefs. Although the ARC was assessed on the first memory recall trial in both studies, the use of clustering may vary differentially by age across trials (Witte, Freund, & Brown-Whistler, 1993). Therefore, in future studies it would be interesting to examine age differences in the relationship between control beliefs and strategy use over multiple trials.

In conclusion, our results demonstrated that strategy use is one factor that can account for the relationship between control beliefs and memory performance in middle-aged and older adults. Although our model fit the data well, it is important to note that the relationship between beliefs and performance could involve other factors besides strategy use. There are other potential mediators that could be involved in this relationship. It is likely that various behavioral (e.g., physical exercise), affective (e.g., anxiety, mood, depression), physiological (e.g., arousal, stress), and motivational (effort, persistence) mechanisms are at work simultaneously (Miller & Lachman, 1999). Thus, future research should examine the interplay of multiple mediators that may be involved in this relationship. The more we understand the mechanisms underlying the influence of control beliefs on performance, the better able we will be to understand the psychosocial factors related to age-related memory decline. Moreover, the results suggest that interventions that target conceptions of control over memory could be effective for improving strategy use and enhancing memory in middle and later adulthood.

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END NOTES
We also tested interim models in which we individually freed up the paths from control to strategy, control to memory performance, and education to strategy use while all other paths were constrained to be equal across age groups. For control to strategy ($\Delta \chi^2 = 8.34, p < .05$) and control to memory ($\Delta \chi^2 = 6.43, p < .05$), there was a significant improvement in fit when the path was unconstrained. There was no significant improvement for the path from control to memory performance, and education to strategy alone. However, the best fit was found when all three paths were left unconstrained, so this is the model we reported.