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# Age Differences in the Effects of Experimenter-Instructed Versus Self-Generated Strategy Use

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## Abstract

**Background/Study Context—**Interactive imagery is superior to rote repetition as an encoding strategy for paired associate (PA) recall. Younger and older individuals often rate these strategies as equally effective before they gain experience using each strategy. The present study investigated how experimenter-supervised and participant-chosen strategy experience affected younger and older adults' knowledge about the effectiveness of these two strategies.

**Methods—**Ninety-nine younger (*M* = 19.0 years, *SD* = 1.4) and 90 older adults (*M* = 70.4 years, *SD* = 5.2) participated in the experiment. In learning a first PA list participants were either instructed to use imagery or repetition to study specific items (supervised) or could choose their own strategies (unsupervised). All participants were unsupervised on a second PA list to evaluate whether strategy experience affected strategy knowledge, strategy use, and PA recall.

**Results—**Both instruction groups learned about the superiority of imagery use through task experience, downgrading repetition ratings and upgrading imagery ratings on the second list. However, older adults showed less knowledge updating than did younger adults. Previously supervised younger adults increased their imagery use, improving PA recall; older adults maintained a higher level of repetition use.

**Conclusions—**Older adults update knowledge of the differential effectiveness of the rote and imagery strategies, but to a lesser degree than younger adults. Older adults manifest an inertial tendency to continue using the repetition strategy even though they have learned that it is inferior to interactive imagery.

### Keywords

Self-regulated learning; aging; strategy; knowledge; metacognition

Cognitive task performance is influenced by whether people identify and use the most effective strategy in a given task (Schunn & Reder, 2001; Siegler & Stern, 1998). Indeed, intelligence is often defined in part as involving fast and fluent adaptation to novel problem solving situations (Carroll, 1993; Sternberg & Gastel, 1989). In unfamiliar task environments, individuals often lack knowledge of cognitive strategies that are normatively most effective (Hertzog & Dunlosky, 2004). For instance, when first introduced to a paired-associate (PA) learning task, individuals initially rate interactive imagery as being only about as effective as simply repeating the words (Dunlosky & Hertzog, 2000; Hertzog &

Dunlosky, 2006; Hertzog, Price, & Dunlosky, 2008), even though imagery and other more elaborative mnemonics (e.g., sentence generation) are far superior to rote repetition (Bower, 1970; Bower & Winzenz, 1970; Robbins, Bray, Irvin, & Wise, 1974).

## Strategy Knowledge Updating in Paired-Associate Tasks

We have investigated whether instructed (or supervised) experience with these two strategies leads individuals to gain knowledge that interactive imagery is a superior basis for learning PA items (Dunlosky & Hertzog, 2000; Hertzog, Price et al., 2009). In particular, on an initial study trial, participants are instructed to use either interactive imagery or rote repetition to study a given item (e.g., TICK – SPOON), which is followed by a test of associative recall (i.e., TICK - ?). Afterwards, they complete a second study-test trial with strategy instructions, except new items are presented for study. Throughout the task, various metacognitive judgments (e.g., global predictions and postdictions, and item level judgments of learning; JOLs) and a strategy questionnaire are administered, which are used to measure knowledge participants gain about the differential effects of the strategies as they complete the task. Knowledge updating is revealed by an increased sensitivity of the metacognitive judgments and questionnaire ratings to the differential effects of the strategies across trials (see Hertzog et al., 2008 for a theoretical review of knowledge updating).

Questionnaire ratings of strategy effectiveness show major knowledge updating effects (in the present case, increasing for imagery and decreasing for repetition) even when JOLs remain relatively insensitive to differential strategy effectiveness (Bieman-Copland & Charness, 1994; Hertzog et al., 2008; Hertzog, Price et al., 2009). Furthermore, people who rate imagery as most effective are more likely to use imagery while studying PA items (Hertzog & Dunlosky, 2006), showing that people’s beliefs are related to actual strategic behaviors. Hertzog, Price et al. (2009) made the strategy used at study more easily accessible and salient at test by giving strategy-homogeneous blocks of cued recall tests (e.g., testing all imagery items in a block, followed by all repetition items). Blocked testing produced greater knowledge updating effects on predictions, postdictions, and imagery and rote strategy effectiveness ratings.

## Aging and Strategy Knowledge Updating

Several studies indicate that older adults are deficient in learning about strategy effectiveness from task experience (Bieman-Copland & Charness, 1994; Brigham & Pressley, 1988; Devolder & Pressley, 1992; Matvey, Dunlosky, Shaw, Parks, & Hertzog, 2002). Price, Hertzog, and Dunlosky (2008) used blocked testing to study age differences in knowledge updating. There were age differences in blocked testing benefits, with younger adults showing larger effects on predictions, postdictions, and changes in strategy effectiveness ratings across trials. However, older adults did show a benefit of blocked testing on questionnaire ratings of strategy effectiveness and an increase in imagery effectiveness ratings after task experience with and without blocked testing.

## Transfer of Knowledge Updating to Self-Chosen Strategies

An open question is whether the previously observed age differences in strategy knowledge updating have functional significance for strategic behavior. For example, the knowledge older adults do gain, albeit less in many cases than that obtained by younger adults, may still be sufficient to produce changes in their strategic behavior in a subsequent associative learning task.

A second issue is whether individuals learn more when provided experimenter-structured (i.e., supervised) task experience than when studying on their own. Underwood and Keppel

(1963) found that younger adults' recall of trigrams differed depending on whether they received encoding instructions or were unsupervised and allowed to encode items as they wished. More recently Baltes, Sowarka, and Kliegl (1989) found that unsupervised practice on intelligence tests produced performance gains of a comparable magnitude to gains produced by explicit ability training. Similarly, Derwinger, Neely, Persson, Hill, and Bäckman (2003) found older adult participants recalled four-digit numbers at similar levels whether they were given mnemonic training or were told to develop their own encoding and retrieval strategies. However, 8 months later older adults who had originally been in the unsupervised, self-generated strategy group outperformed those who had received mnemonic training, unless mnemonic participants were given cognitive support and allowed to record some of the strategy information on the computer (Derwinger, Neely, & Bäckman, 2005). Such findings suggest that task and stimuli characteristics may influence whether supervised training yields better performance than unsupervised task experience as well as how long the training benefits persist.

The cited studies combine with those in the training literature (e.g., Ball et al., 2002; Lustig & Flegal, 2008) to examine how multi-session training programs affect cognitive performance and whether the training benefits transfer to other domains. Nonetheless, by focusing solely on memory performance outcomes, these studies have left open the question of how supervised versus unsupervised training might influence whether participants learn which encoding strategies are more effective. Unsupervised discovery of strategic benefit through spontaneous strategy use is a hallmark of strategy development in children (e.g., Crowley, Shrager, & Siegler, 1997). Regarding aging, the critical question is whether younger and older adults are more likely to learn about the superiority of the imagery strategy when an experimenter explicitly tells them to use both imagery and rote strategies for studying items versus letting them decide on their own how they will encode and retrieve items. It is at this point unknown whether younger and older adult individuals would exhibit knowledge updating if they were not instructed to use specific strategies (imagery and rote) and were instead given the opportunity to select their own encoding strategies.

With the present experiment, we examined whether experimenter-instructed strategy experience (henceforth, supervised experience) would produce greater knowledge updating than participant-structured strategy experience (henceforth, unsupervised experience). Participants were randomly assigned to groups that either did or did not receive explicit instructions to use rote repetition and interactive imagery. Importantly, all participants were allowed to choose which strategies they would use to encode a second list of paired associates. Of interest was whether strategy use would differ in List 2 for those who were supervised versus unsupervised in List 1, as well as whether measures of knowledge updating would differ across supervised (vs. unsupervised) groups and age groups. A comparison of the supervised versus unsupervised group would establish whether supervised experience necessarily produces larger changes in strategic behavior, or whether unsupervised task experience is sufficient for this purpose.

# METHOD

## Design and Participants

The design was a 2 × 2 × 3 mixed factorial, with List (first vs. second study list), Age group (younger vs. older adults), and Supervision (supervised blocked, supervised random, and unsupervised)[1]. List was manipulated within-subjects and Supervision was a randomly assigned between-subjects factor.

Ninety-nine younger and 90 older adults participated in the experiment. Younger adults (*M* = 19.0 years, *SD* = 1.4) were students at The Georgia Institute of Technology who received course credit for participating. Older adults (*M* = 70.4 years, *SD* = 5.2) were community-dwelling adults recruited from the greater Atlanta metropolitan area who were able to come in to the laboratory to be tested. They received a nominal fee for their participation. Random assignment to groups resulted in 33 older and 31 younger adults in the blocked testing group, 27 older and 36 younger adults in the random testing group, and 30 older and 32 younger adults in the unsupervised group.

Table 1 reports the characteristics of the younger and older adults in the experimental groups – supervised (i.e., those in the random or blocked group) and unsupervised. Older adults had on average about 15 years of education, and reported themselves to be in very good health (about 3.8 on a 5 point scale). A multivariate GLM on the cognitive variables and self-rated health indicated that random assignment to groups was successful, given that there were no reliable multivariate effects of Supervision ($p > .10$) or the Supervision X Age interaction ($F < 1$). The analysis revealed reliable age differences on the four dependent measures, using a transformed Wilk's lambda test statistic, $F(4, 163) = 57.70$, $p < .001$, $\eta_p^2 = .59$. The pattern of results consisted of typical age differences in intellectual abilities and self-rated health.

## Materials

The personal encoding preferences (PEP) questionnaire (Hertzog & Dunlosky, 2004) was used to measure perceived associative encoding strategy effectiveness. It was given (a) before task exposure to measure participants' preexisting strategy knowledge and (b) after completion of the experimental task to assess gains in strategy knowledge.[2] The PEP defines various associative memory strategies (including imagery, rote repetition, and sentence generation). Participants rated the effectiveness of each strategy on a 10-point Likert-type scale.

One hundred twenty-four word pairs, consisting of relatively frequent, concrete nouns (e.g., TICK- SPOON) were used in this study. The word pairs were selected from the University of South Florida free-association norms to have no prior association (Nelson, McEvoy, & Schreiber, 1998). Four of these word pairs were used during practice; the remaining 120 pairs were randomly divided into two lists of 60 word pairs. The experimental task was programmed in Visual Basic (Visual Studio, Version 6.0, Microsoft Corporation, 1998) programming language and run on PC desktop computers. All responses were entered and recorded on the computer keyboards.

## Procedure

The experimental task consisted of two study-test trials. Participants completed a brief demographic questionnaire and the first PEP prior to receiving instructions for the PA experimental task.

**List 1 Study—**Prior to studying List 1, participants in the supervised (i.e., blocked and random) groups were told that they would be instructed to study half of the items with

[1]The initial design involved comparing knowledge updating for participants in two groups who were supervised in List 1 – those given random testing and blocked testing – to those who were unsupervised in both List 1 and List 2. Given our prior research (Hertzog et al., 2008; Hertzog, Price et al., 2009; Price et al., 2009) we hypothesized that participants exposed to blocked testing in List 1 would experience greater knowledge updating, which might then influence the choice of List 2 study strategies. However, preliminary analysis showed no reliable differences between random and blocked testing on the strategy effectiveness and PA recall measures. Hence participants in the supervised random and supervised blocked were combined into a single supervised group (on List 1) and compared to the unsupervised group for all reported analyses.

[2]Asking participants to complete the PEP before beginning the task may have affected the frequency with which individuals chose to use certain strategies within the task, but it was critical to collect participants' pre-existing and post-task views about the effectiveness of each strategy in order to assess knowledge updating. Providing participants with descriptions of strategies to facilitate accurate strategy reports is not outside the norm in metacognitive research (e.g., see Dunlosky & Hertzog, 2001).

imagery and half the items with rote repetition. Participants in the unsupervised group were simply told that they would be asked to study 60 concrete noun pairs. All participants were provided descriptions of the imagery, repetition, and sentence generation strategies and told they would be asked to provide strategy reports for each item.[3]

Younger adults were allotted 6 seconds and older adults 10 seconds to study each word pair to ensure older adults would not have floor recall performance for items studied with the normatively less effective rote repetition strategy. The presentation order for studying the items was randomized for each participant. However, for participants in the supervised groups the computer randomly assigned half of the items to receive instructions to use imagery and the other half to receive repetition instructions. Thus a strategy prompt (either “Imagery” or “Repetition”) appeared for 1 s, followed by the word pair for either 6 or 10 s, depending on age group, during which time the strategy prompt remained on the screen to ensure participants would not forget what the instructed strategy was. Because compliance to instructions is less than perfect (Hertzog, Price et al., 2009), participants were asked after studying each item to report which strategy, if any, they had *actually* used. Thus after the encoding time for each item ended, a screen containing a list of strategies appeared and participants typed a number corresponding with the strategy they used to encode that item.

Participants in the unsupervised group were presented with the 60 PA items in a random order, one at a time, without encoding strategy instructions, and asked to report which strategy they had used to study each item.

**List 1 Test—**After participants finished studying the 60 items in List 1, they received instructions for the PA recall task and attempted to recall 40 of the 60 studied items. Supervised participants were tested in two supervised groups that were modeled after Hertzog, Price et al. (2009): a random testing order and a blocked testing order. For both orders, the computer program selected at random 20 items that each participant had previously reported having been studied with imagery and 20 items that had been studied with rote repetition. In the random testing group, these 40 items were tested for cued recall in a random order. In the blocked testing group, participants received four homogeneous blocks of 10 items each, and a prompt prior to the onset of each block regarding which strategy (imagery or repetition) they had reportedly used to study that set of items. If participants in the blocked group were sufficiently noncompliant with instructed strategies to prevent the formation of homogeneous blocks, then the prompt informed participants that they had reported using a mixture of strategies to study the upcoming block of items. For unsupervised participants the computer program randomly selected 40 items for testing, ignoring which strategies had been reported for those items.

In all groups, cued recall was initiated by presenting the first word of each PA item (e.g., “TICK- ?”) and asking participants to type the word that was originally paired with the stimulus (e.g., “SPOON”). Participants had unlimited time to respond and omissions were not allowed. Responses were scored as correct if the first three letters matched the target response.

**List 2 Study—**For List 2, supervised participants were informed they would not receive encoding strategy prompts to use imagery or rote repetition as they had in List 1 and would

[3]Although our prior research (Dunlosky & Hertzog, 2000; Hertzog et al., 2008; Hertzog, Price et al., 2009; Price et al., 2008) has focused on whether individuals update their knowledge about the differential effectiveness of only two strategies – interactive imagery and rote repetition – we included a description of sentence generation given that this is a normatively effective strategy that individuals in both Supervision and age groups might choose to use. Providing a description ensured accurate strategy reports.

instead be allowed to choose any strategy they wished to study List 2 items. Otherwise, the study phase occurred as before.

**List 2 Test—**Participants in the supervised and unsupervised groups were tested on a subset of 40 of the 60 items they had studied. In all groups, 40 items were selected randomly for all participants, ignoring which strategies had been used to encode them. Other than these changes, the testing phase occurred as in List 1.

**Metacognitive judgments—**Predictions, postdictions, and JOLs were collected (see Hertzog et al., 2008, for a description and rationale). These measures are not as sensitive to knowledge updating effects as the questionnaire ratings (see Hertzog, Price, et al., 2009, for relevant data and a discussion). The insensitivity of JOLs to knowledge updating was also observed in this study. For this reason and for space constraints, we focus on questionnaire ratings and do not describe these metacognitive judgments further.[4]

# RESULTS

The primary issues of interest were whether (a) knowledge updating would be greater for participants who were supervised to use imagery or rote on List 1 than for unsupervised participants, and (b) whether older adults would show equivalent shifts to the use of interactive imagery after task experience. Because blocked testing did not produce any relevant interaction with supervision or age, we collapse on this factor in subsequent analyses. All reported analyses combine the two groups (blocked and random) that received supervision in List 1 for comparison with the unsupervised group.

## Strategy Effectiveness Ratings

To address the first issue, we focused on strategy effectiveness ratings from the PEP questionnaire. Participants' ratings for the within-subjects factor of Strategy Type (imagery, rote repetition, and sentence generation) were examined across Lists (i.e., before and after task experience). The sentence generation strategy was included in the analyses because it is a viable effective strategy that could be used in the unsupervised group, and because participants' perceptions about its effectiveness could change after either using it or using a less effective strategy like rote repetition.

The data yielded a robust knowledge updating effect, manifested in a Strategy X List interaction, $F(2, 173) = 58.32$, $p < .001$, $\eta_p^2 = .40$ (see Figure 1). After task experience, individuals downgraded their rote repetition ratings and upgraded ratings of imagery and sentence generation. The partial interaction contrasts testing list-changes in imagery or sentence ratings against rote repetition ratings were reliable in both cases ($p < .001$). There was also a reliable Age X Strategy interaction, $F(2, 173) = 5.56$, $p < .01$, $\eta_p^2 = .06$; older adults gave rote repetition relatively higher ratings. The robust Age X Strategy interaction for List 2 only, $F(2, 180) = 8.10$, $p < .001$, $\eta_p^2 = .08$, revealed that the difference in ratings existed after task experience. The partial interaction contrast comparing the two effective strategies against rote repetition was reliable, $F(1, 181) = 15.22$, $p < .05$, $\eta_p^2 = .08$.

Older adults showed a knowledge updating effect, but it was attenuated relative to the effect in younger adults. Knowledge updating was not influenced by whether participants were supervised during List 1, as indicated by a lack of a Supervision main effect ($F < 1$) or any group-associated interaction ($p > .15$). On average, participants in both the supervised and

[4]The data on predictions, postdictions, and JOLs can be obtained by contacting the first author.

unsupervised groups increased their imagery and sentence generation ratings and lowered their repetition ratings across trials to a similar extent.

The questionnaire data were consistent with an age-deficit in knowledge updating, as manifested in older adults showing a higher rating of rote repetition effectiveness, even after task experience in which rote repetition produced substantially lower levels of recall (see below). However, one can argue that the differences observed could simply reflect age differences in the use of the Likert rating scale, because older adults reduced their rote repetition ratings and increased their imagery ratings after task experience. An important question, then, was whether the age differences in strategy effectiveness ratings were associated with age differences in strategy use.

## Changes in Using Interactive Imagery and Sentence Generation After Task Experience

**Mean changes in strategy use—**We next evaluated whether individuals were more likely to use imagery to mediate new associations after task experience (see Table 2). As would be expected, participants in the supervised group started on List 1 with somewhat higher levels of usage of the two instructed strategies, although imagery use was the most frequently reported strategy in all groups. The principal hypothesis was that use of rote repetition would decrease after task experience; the question of interest was whether older adults would show a less dramatic shift away from using repetition to using interactive imagery.

We analyzed reported strategy use for the most frequently used strategies -- interactive imagery, rote repetition, and sentence generation -- as dependent variables in a 2 × 2 X (3 × 2) (Age X Supervision X Strategy type X List) GLM, with Strategy type and List as within-subjects factors. Our focus was on changes from List 1 to List 2 (the latter being the self-chosen strategy list for all groups). The results revealed reliable interactions involving Strategy X List, $F(2, 184) = 21.90$, $p < .001$, $\eta_p^2 = .19$, and Supervision X Strategy X List, $F(2, 184) = 15.92$, $p < .001$, $\eta_p^2 = .15$. In all these cases a contrast pitting rote repetition versus the two effective strategies (interactive imagery and sentence generation) fully accounted for the interactions – usage of imagery and sentence strategies did not differ over lists. Overall, use of rote repetition was reliably lower, relative to the effective strategies, on List 2 compared to List 1, (Repetition: List 1 *M* proportion = .31, *SE* = .01 and List 2 *M* proportion = .21, *SE* = .02; Effective: List 1 *M* combined proportion = .60, *SE* = .01 and List 2 *M* combined proportion = .69, *SE* = .02), $F(1, 185) = 36.09$, $p < .001$, $\eta_p^2 = .16$. Moreover, older adults (Repetition: List 1 *M* proportion = .30, *SE* = .00 and List 2 *M* proportion = .23, *SE* = .03; Effective: List 1 *M* combined proportion = .61, *SE* = .02 and List 2 *M* combined proportion = .65, *SE* = .03) showed less of a shift away from using rote repetition to the effective strategies than did younger adults, (Repetition: List 1 *M* proportion = .31, *SE* = .02 and List 2 *M* proportion = .18, *SE* = .03; Effective: List 1 *M* combined proportion = .60, *SE* = .02 and List 2 *M* combined proportion = .72, *SE* = .03), $F(1, 185) = 5.78$, $p < .05$, $\eta_p^2 = .03$. Judging from Table 2, the effect was primarily attributable to less reduction in use of rote repetition after supervised experience by older adults.

We also computed an effective strategy use variable by combining the proportions of interactive imagery, sentence generation, and other strategies (Hertzog, Dunlosky, & Robinson, 2009). Figure 2 shows the proportion of effective strategies for List 2, when both younger and older adults in both conditions were free to choose any strategy. The Age X List interaction was reliable, $F(1, 185) = 6.77$, $p < .01$, $\eta_p^2 = .04$. For List 1, the age groups were equivalent in effective strategy use, but on List 2 older adults were less likely to use effective strategies, $M_O = .70$ (*se* = .03) versus $M_Y = .77$ (*se* = .03).

The Supervision X List interaction, $F(1, 185) = 14.87$, $p < .001$, $\eta_p^2 = .07$, was entirely attributable to supervised participants catching up with unsupervised participants in effective strategy use when allowed to choose their own strategies for List 2 (marginal $M = .73$ in both groups). Thus, supervised experience had no additional influence on using effective mediational strategies.

**Stability of individual differences in effective strategy use over lists—**To evaluate stability of individual differences in strategy use across lists, we computed Pearson correlations of effective strategy use in each of the 2 × 2 (Supervision X Age) cells. For the unsupervised group, the correlations of individual differences in effective strategy use were high between List 1 and List 2: $r = .81$, $p < .01$, for younger adults, and $r = .77$, $p < .01$, for older adults, indicating stable individual differences in strategy selection when people could use any technique they wished on List 1. In contrast to the unsupervised group, younger adults who were transferred from supervised (List 1) to self-chosen (List 2) strategies showed little correlation of strategy use between lists, $r = .16$, $p > .20$. For the older adults, however, the correlation was reliable, $r = .43$, $p < .01$, indicating an intermediate level of stability of individual differences in effective strategy use despite transfer to a condition in which they could choose their own strategies.

In sum, older adults were more likely to use the rote repetition strategy after supervised List 1 task experience. They also showed greater stability of effective strategy use upon transfer from supervised to self-chosen strategies, relative to younger adults, probably reflecting a tendency for those who were most likely to use rote repetition under instructions to stick with that strategy after transfer.

### Performance Improvements Due to Strategy Shift

PA recall was analyzed in a 2 (Age) by 2 (Supervision) by 2 (List) analysis, with repeated measures on list. There was the expected reliable main effect of Age, $F(1, 185) = 51.13$, $p < .001$, $\eta_p^2 = .22$, with older adults doing worse in recall. This effect was qualified by both a significant Age X List interaction, $F(1, 185) = 4.77$, $p < .05$, $\eta_p^2 = .03$, and a significant Age X Supervision X List interaction, $F(1, 185) = 5.07$, $p < .05$, $\eta_p^2 = .03$.

Figure 3 plots the relevant means. Older adults' recall in the supervised group lagged behind the unsupervised group. More interesting, neither group of older adults showed appreciable performance improvement, with List 2 recall approximately equivalent to List 1 recall. In contrast, younger adults showed a 10 percentage point increase in recall performance when initially supervised (from 49% to 59% recall), although those in the unsupervised group improved less. These differential age-related outcomes were not merely due to different initial baseline performance on List 1. When List 2 data were analyzed separately, the Age X Supervision interaction was reliable, $F(1, 185) = 6.46$, $p < .05$, $\eta_p^2 = .03$.

Recall patterns covaried with the increase in effective strategy use for the supervised group. To further analyze whether the strategy shift was responsible for recall improvements in the young supervised group, we evaluated PA recall, conditional on the use of different strategies. Table 3 provides the relevant means. Little improvement arose in strategy-specific recall over lists in any group.[5] Hence, we conclude that the improvement for the

[5]The unusually high List 1 recall for the sentence strategy by older adults in the supervised condition was produced by 7 persons who occasionally used sentences instead of the instructed strategy to good effect. Note that the recall advantage for sentences dissipated on List 2 when more people used the sentence strategy when allowed to do so. The cause of the List 1 result is unclear; among other possibilities, it could reflect selective nonadherence by persons high in memory ability (an adaptive strategy shift) or a benefit of encoding distinctiveness.

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supervised group can be attributed to the increase in effective strategy use after supervised experience contrasting imagery with rote repetition.

We also ran a general linear model analysis on the 127 participants in the supervised condition, using total PA recall for List 2 as the dependent measure. We entered the difference in rote repetition strategy use from List 1 to List 2, and used it as a predictor, along with List 1 PA recall and Age. The effect of List 1 PA recall was potent, reflecting high stability of individual differences in memory, $F(1, 122) = 157.63$, $p < .001$, $\eta_p^2 = .56$, $b = 0.80$. Most important, individuals who had the greatest shift of strategies away from rote repetition use from List 1 had higher levels of List 2 recall, controlling on List 1 recall, $F(1, 122) = 23.36$, $p < .001$, $\eta_p^2 = .56$, $b = 0.43$. This effect confirms that recall improvements on List 2 (indirectly identified on the basis of including List 1 PA recall as a covariate) were associated with avoiding rote repetition by shifting to effective strategies. Furthermore, this effect interacts reliably with age, $F(1, 122) = 6.27$, $p < .01$, $\eta_p^2 = .05$, $b = -0.30$. Older adults had a reliably smaller effect of the shift away from rote repetition on their recall performance.

## Discussion

This study demonstrated that older adults do not learn as completely as younger adults about the relative disadvantage of rote repetition as a strategy for associative learning after supervised experience. As in our earlier work (Price et al., 2008), both older adults' and younger adults' pre-experimental ratings of rote repetition are overly optimistic, given its inferiority to interactive imagery. Although older adults show increased differentiation between rote repetition and imagery effectiveness ratings after task experience, this improved strategy knowledge effect is reliably smaller for them than it is for younger adults. Furthermore, this difference apparently has consequences for strategy use and recall on a second PA list. Younger adults show small improvements on List 2 recall, whereas older adults do not. These improvements appear to be due to younger adults' increased use of effective strategies, particularly interactive imagery, after supervised experience with imagery and rote repetition. Young individuals in the supervised group were more likely to increase their proportion of imagery strategy use when allowed to do so. Some of this shift appeared to be caused by the supervised strategy experience, not merely a release from instructional constraints, given the greater imagery use on List 2 after supervised versus unsupervised experience.

Admittedly, these learning-to-learn effects (Hultsch, 1974) were small in the present experiment. One possible explanation for the small effect is that there was already a high level of interactive imagery use in the unsupervised group, prior to task experience. We required that people report their strategies to us in order to be able to evaluate compliance with instructions and to tailor tests to provide adequate experience at recall with each strategy. However, to do so required us to describe each strategy to the participants. This, plus the questionnaire ratings, may have encouraged a level of imagery use that was higher than would normally be the case (Dunlosky & Hertzog, 2001). Reported imagery use in this experiment was higher than in Dunlosky and Hertzog (2001) and Hertzog, Dunlosky, and Robinson (2009), where retrospective reports were used to get a better estimate of spontaneous strategy use. Moreover, the latter study did produce small but reliable learning-to-learn effects following unsupervised learning and retrospective strategy reports on the first list. It is likely, then, the modest increases observed here would have been larger had they been assessed relative to a spontaneous-use baseline.

It would be interesting to pursue this question in the context of understanding learning-to-learn effects in adulthood. The present data suggest that, when they are observed, they could be a function of increased strategy use due to updating of knowledge about strategy effectiveness. This conclusion also seems consistent with list differences in Hertzog, Dunlosky, & Robinson (2009), but a direct experimental test of the hypothesis is needed.

Supervised strategy experience had no appreciable effect on the magnitude of knowledge updating. These results suggest that merely informing people about the existence of strategies may lead to unsupervised experimentation with the different strategies (e.g., Crowley et al., 1997) that leads to knowledge updating. However, such an effect may be limited to the present stimuli and task demands, because repetition would be a typical fall-back strategy when an alternative mediational strategy fails. Addressing when and whether simple task practice leads to changes in strategic behavior and strategy knowledge updating is an interesting topic for future research.

In the unsupervised group, there was little shift in strategy use, whereas the shift was dramatic in the supervised group, which led to slightly higher effective strategy use. However, people in the unsupervised group did exhibit high levels of effective strategy use and knowledge. To a limited degree, supervised experience benefitted younger adults more than older adults. When choosing strategies on List 2 after supervised experience, older adults were more likely to stick with their previously preferred strategy, including rote repetition. Younger adults were more likely to increase effective strategy use after supervised experience, probably a consequence of downgrading perceived effectiveness of rote as well as upgrading perceived effectiveness of imagery.

An interesting question is why older adults would show less strategy shift after supervised experience of the differences in rote repetition and interactive imagery. Our preferred explanation is that older adults maintain their use of rote repetition to a greater degree than younger adults, showing an inertial tendency to stick with the simpler rote repetition strategy despite knowledge that it is less effective than interactive imagery. However, we cannot specify at present the underlying cause of this inertial tendency. It could represent an avoidance of the imagery strategy, perhaps due to low self-efficacy about ability to implement it effectively, or it could represent a failure to inhibit a strategic approach one has previously been required to use, despite the knowledge that it is less effective.[6] Further research would be needed to investigate competing explanations for this effect.

Other experimental conditions might augment effects of supervised strategy experience on effective strategy use. Consider the self-efficacy account of the reduced strategy shift after supervised learning. West, Dark-Freudeman, and Bagwell (2009) recently showed that self-efficacy training, combined with a goal-setting manipulation, led to better performance improvements for older adults than in a control group. Perhaps self-efficacy training in the older adults would encourage greater shift towards the use of the imagery strategy after supervised strategy experience, which is arguably more effortful and challenging than rote repetition. Given that individuals in the unsupervised strategy group showed updating of knowledge about imagery effectiveness, setting higher performance goals could also encourage more strategy shift on the second list in the unsupervised group.

Older adults apparently manifest a mild inertial tendency (see Hertzog, 2008) to stick with a strategy they can use without great effort, even though they know after task experience that it is less effective for them. In the present study, this tendency also produced less learning-to-learn after supervised strategy experience. These age differences therefore remind us that knowing and doing are two different things.

[6]We thank an anonymous reviewer for suggesting this alternative hypothesis.

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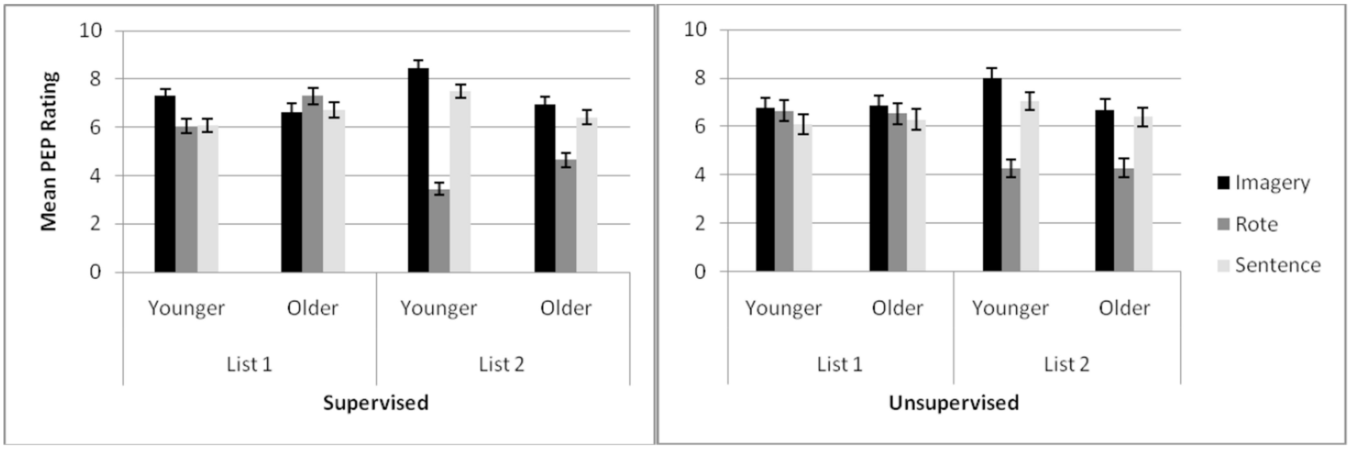


**Figure 1.**
Mean strategy effectiveness (PEP) ratings for interactive imagery, rote repetition, and sentence generation in List 1 and List 2 for young and older adults in the Supervised and Unsupervised conditions. Higher ratings indicate higher degree of perceived effectiveness of a given strategy. Error bars are standard errors of the mean.

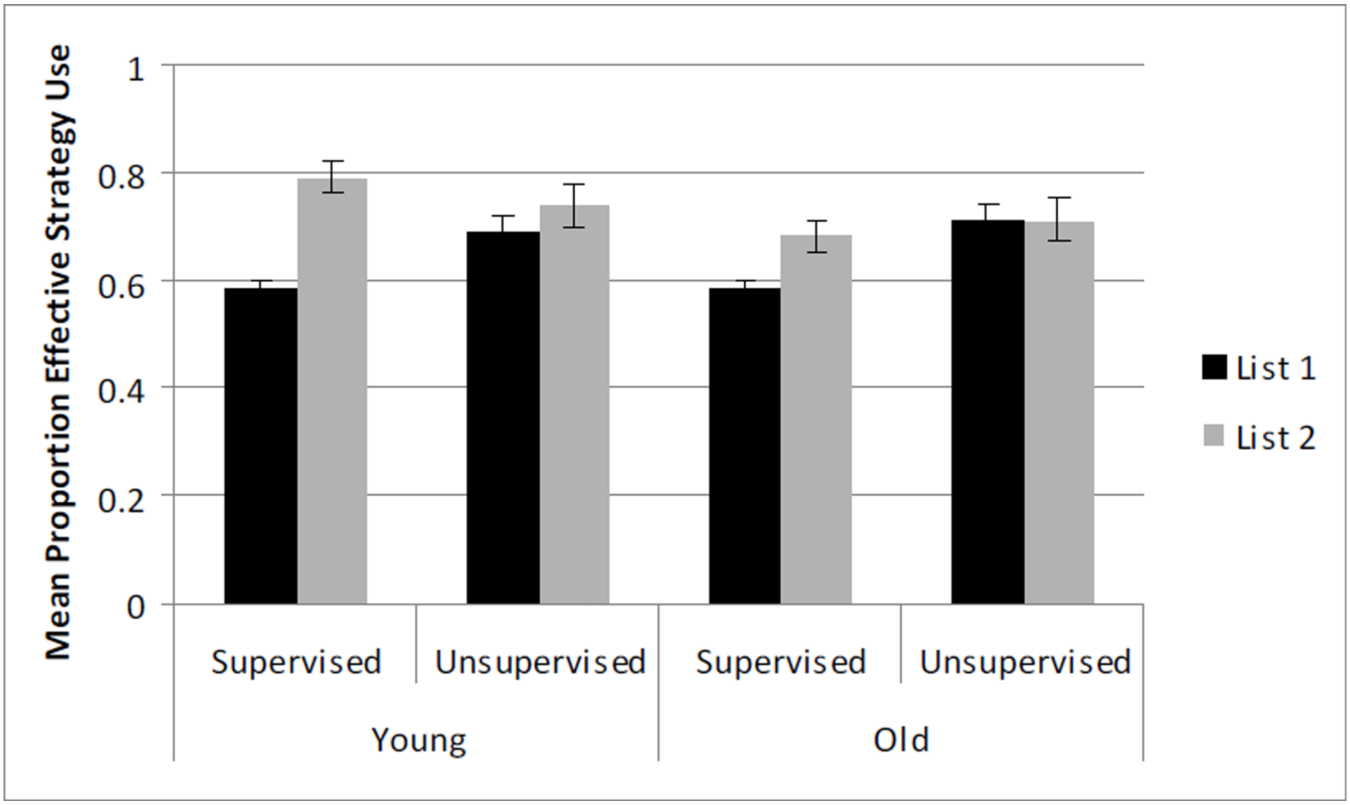


**Figure 2.**
Mean proportion effective strategy use reported by younger and older adults for supervised and unsupervised strategy use across lists. Error bars are standard errors of the mean.

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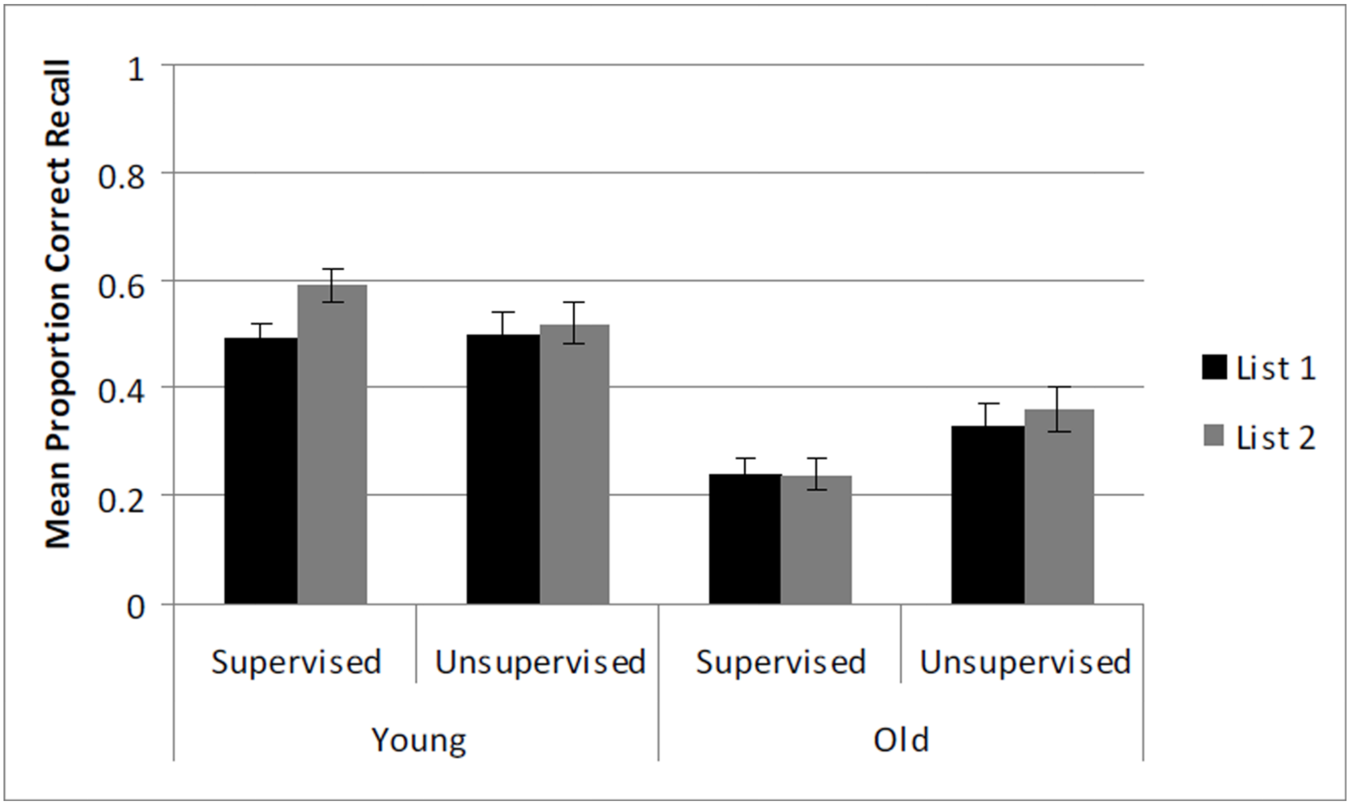


**Figure 3.**
Young and older adults' mean proportion correct recall performance for supervised and unsupervised strategy use across lists. Error bars are standard errors of the mean.

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**Table 1**

Participant Characteristics as a Function of Age Group and Supervision

| Measure | Supervised *M (SD)* | Unsupervised *M (SD)* |
|---|---|---|
| | Young | |
| Percent Female | 48 | 46 |
| Age | 19.03 (1.31) | 19.00 (1.46) |
| Education | 12.97 (1.39) | 12.94 (1.39) |
| Health * | 4.09 (0.69) | 4.06 (0.91) |
| AVT | 16.97 (4.45) | 17.72 (4.71) |
| Pattern Comparison ** | 42.55 (6.75) | 42.31 (6.21) |
| Letter Comparison ** | 24.03 (4.21) | 25.78 (4.89) |
| | Old | |
| Percent Female | 52 | 54 |
| Age | 70.62 (5.17) | 70.00 (5.13) |
| Education ** | 15.38 (2.73) | 14.93 (3.22) |
| Health | 3.82 (0.77) | 3.81 (0.83) |
| AVT * | 19.47 (7.72) | 21.45 (8.85) |
| Pattern Comparison | 27.59 (5.94) | 29.83 (6.93) |
| Letter Comparison | 16.52 (3.58) | 18.34 (4.41) |

*Note*. Entries are means (standard deviations). Abbreviations: Percent Female = the percentage of individuals within each group that were female; Education = mean number of years of education completed; Health = Self-rated health where 1 is 'Poor' and 5 is 'Excellent'; AVT = Advanced Vocabulary Test score out of 36 possible; Pattern Comparison = mean number correct on Pattern Comparison Test out of 60 possible; Letter Comparison = mean number correct on Letter Comparison Test out of 42 possible;

* = a reliable difference between age groups, $p < .05$,

** = a reliable difference between age groups, $p < .001$.

## Table 2

Proportions of Items that Participants Reported Studying by a Given Strategy

**Supervised**

| | List 1 Strategy | | | | | List 2 Strategy | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Imagery** | **Rote** | **Sentence** | **Other** | **None** | **Imagery** | **Rote** | **Sentence** | **Other** | **None** |
| **Age Group** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** |
| Young | .52 (.02) | .40 (.02) | .05 (.02) | .02 (.01) | .02 (.01) | .60 (.04) | .17 (.03) | .16 (.02) | .03 (.01) | .04 (.01) |
| Old | .53 (.03) | .39 (.02) | .04 (.02) | .01 (.01) | .03 (.01) | .53 (.04) | .27 (.03) | .12 (.02) | .03 (.02) | .05 (.02) |

**Unsupervised**

| | List 1 Strategy | | | | | List 2 Strategy | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Imagery** | **Rote** | **Sentence** | **Other** | **None** | **Imagery** | **Rote** | **Sentence** | **Other** | **None** |
| **Age Group** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** |
| Young | .41 (.03) | .23 (.03) | .22 (.03) | .05 (.02) | .08 (.01) | .48 (.05) | .19 (.04) | .21 (.03) | .06 (.02) | .06 (.02) |
| Old | .47 (.04) | .21 (.03) | .18 (.03) | .06 (.02) | .08 (.01) | .48 (.05) | .18 (.04) | .17 (.03) | .06 (.02) | .11 (.02) |

*Note*. Entries are means (standard errors). Abbreviations: Imagery = the mean proportion of items that participants reported studying with interactive imagery; Rote = the mean proportion of items that participants reported studying with rote repetition; Sentence = the mean proportion of items that participants reported studying with sentence generation; Other = the mean proportion of items that participants reported studying with a strategy other than imagery, rote, or sentence generation; None = the mean proportion of items that participants reported studying without producing a strategy or after attempting to produce a strategy, but running out of time before being able to do so.

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## Table 3

Mean Recall Performance as a Function of Which Strategy Was Used to Encode Items

**Supervised**

| | List 1 Recall | | | List 2 Recall | | |
|---|---|---|---|---|---|---|
| | **Imagery** | **Rote** | **Sentence** | **Imagery** | **Rote** | **Sentence** |
| **Age Group** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** |
| Young | .65 (.06) | .34 (.08) | .56 (.09) | .62 (.06) | .49 (.08) | .58 (.08) |
| Old | .33 (.08) | .28 (.12) | .73 (.13) | .34 (.09) | .17 (.12) | .39 (.11) |

**Unsupervised**

| | List 1 Recall | | | List 2 Recall | | |
|---|---|---|---|---|---|---|
| | **Imagery** | **Rote** | **Sentence** | **Imagery** | **Rote** | **Sentence** |
| **Age Group** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** | ***M (SE)*** |
| Young | .62 (.05) | .41 (.07) | .57 (.08) | .66 (.05) | .27 (.07) | .60 (.07) |
| Old | .53 (.08) | .25 (.11) | .36 (.13) | .54 (.08) | .18 (.11) | .41 (.11) |

*Note*. Entries are means (standard errors). Abbreviations: Imagery = the mean proportion of items that participants correctly recalled for items studied with interactive imagery; Rote = the mean proportion of items that participants correctly recalled for items studied with rote repetition; Sentence = the mean proportion of items that participants correctly recalled for items studied sentence generation.