Do Self-Monitoring Interventions Improve Older Adult Learning?

Article *in* The Journals of Gerontology Series B Psychological Sciences and Social Sciences · July 2007
DOI: 10.1093/geronb/62.special_issue_1.70 · Source: PubMed

6 authors, including:

Elena Cavallini
University of Pavia

Christy Mcguire
University of Pittsburgh

Christopher Hertzog
Georgia Institute of Technology

Journals of Gerontology: SERIES B
2007, Vol. 62B (Special Issue I): 70–76

Cognitive Interventions and Aging

Do Self-Monitoring Interventions Improve Older Adult Learning?

John Dunlosky,[1] Elena Cavallini,[2] Heather Roth,[1] Christy L. McGuire,[3] Tomaso Vecchi,[2] and Christopher Hertzog[3]

[1]Kent State University, Ohio.
[2]University of Pavia, Italy.
[3]Georgia Institute of Technology, Atlanta.

We describe a self-monitoring approach for improving older adult learning that older adults can use in conjunction with more traditional mnemonic-based interventions. According to the self-monitoring approach, older adults can improve the effectiveness of learning by accurately monitoring their progress toward a learning goal and by using the output from such monitoring to allocate study time and to inform strategy selection. We review current evidence, which includes outcomes from two previously unpublished interventions, relevant to the efficacy of this approach. Both interventions demonstrated performance gains in memory performance after self-monitoring training, although these training gains did not exceed gains obtained through standard mnemonic training. Our discussion highlights both successes and failures of self-monitoring to enhance learning as well as challenges for future research.

EVER since antiquity, people have sought techniques to improve their memories for important events (Yates, 1997). This search has proved successful, providing mnemonics that can enhance learning of word lists, paired associates, number strings, and even text materials. Decades of research have shown that older adults can benefit substantially from mnemonic training (e.g., Ball et al., 2002; Kliegl, Smith, & Baltes, 1989; for reviews, see Dunlosky & Hertzog, 1998; Verhaeghen, Marcoen, & Goossens, 1992). Based on their meta-analysis, Verhaeghen and colleagues (1992) concluded that "mnemonic training in the elderly enhances performance reliably more than either mere retesting or placebo treatment" (p. 250). As important, these mnemonics can be used by people who demonstrate memory impairments (Hill, Bäckman, & Stigsdotter Neely, 2000).

In the present article, we present an approach based on self-monitoring and regulation that is meant to complement mnemonic training. Because we have described the self-monitoring approach to enhancing learning in detail elsewhere (Dunlosky, Hertzog, Kennedy, & Thiede, 2005), we only touch upon its essential features here and then move on to a critical review of prevailing evidence for its efficacy.

In contrast to mnemonic training, which aids memory by training people to use mnemonic strategies during study, the *self-monitoring approach* prescribes how people can regulate study across to-be-learned materials in a manner that enhances the efficiency of learning. As its name implies, a core component of this training approach involves the use of self-monitoring to make decisions about how to restudy. More specifically, after studying any to-be-learned items, a person monitors—or evaluates—his or her own memory for each item and, based on this monitoring, may decide whether it requires further study, and, if so, what strategy to use during study. Self-monitoring allows a learner to identify items that require further processing to learn. Even though the benefits of this approach may be intuitive, the extent to which self-monitoring improves learning depends on a number of more subtle principles.

First, people must be able to accurately monitor their learning. If a person cannot accurately evaluate which materials have not been learned well, using these evaluations to regulate study could accrue little benefit and may actually undermine effective learning (e.g., Thiede, 1999). A difficulty immediately arises in that people of all ages are often quite poor at accurately assessing how well they have learned newly studied materials, including paired associates (Koriat, 1997), sentences (Rawson, Dunlosky, & McDonald, 2002), and texts (Maki, 1998). Fortunately, at least for learning simple associates (e.g., chateau – castle), techniques have been discovered that consistently support high levels of monitoring accuracy. Nelson and Dunlosky (1991) reported that monitoring is highly accurate when it is informed by delayed self-tests. When a person first studies a paired associate (e.g., chateau – castle) and, after a delay, monitors memory by attempting to recall the target (in this case, castle) when viewing only the cue (i.e., chateau – ?), this monitoring is highly accurate. Because self-testing promotes high levels of monitoring accuracy for simple materials, scrutiny of the self-monitoring approach has focused almost entirely on the use of self-testing to improve older adults' learning of simple materials.

Second, for accurate monitoring to improve learning, individuals must use monitoring to allocate subsequent study in an appropriate manner. Even if a person was perfectly accurate at monitoring her on-going learning, if she did not use monitored outcomes to regulate study, its potential benefit would be lost. This principle may be self evident, but less obvious is exactly how individuals should use monitoring to regulate study. For instance, it may be best to restudy all items that one has judged as not yet having learned, such as when mastery is necessary and when much time is available for restudy. In other circumstances, it will be more efficient to study items judged as the easiest to learn, such as when a person has limited time for restudying (Thiede & Dunlosky, 1999). With respect to strategy selection during study, a person may identify items that he or she has not learned well and decide to use a different strategy in hopes of enhancing performance (Bahrick & Hall, 2005; Sahakyan, Delaney, & Kelley, 2004). Thus, monitoring can serve to inform people's decisions on whether to devote more time to individual items (Metcalfe & Kornell, 2005) and on which strategies to use during study (e.g., Butterfield, Peltzman, & Belmont, 1971; Matvey, Dunlosky, Shaw, Parks, & Hertzog, 2002).

A variety of factors influence how a person should use monitoring to obtain optimal regulation. These factors include the learner's goals, the time available for study, the overall difficulty of items, and the kinds of strategy that the learner can apply during study (e.g., Metcalfe & Kornell, 2005; Son & Metcalfe, 2000; for instances of suboptimal allocation, see Dunlosky & Thiede, 2004; Nelson & Leonesio, 1988). A formal model of optimal allocation of study time has been recently developed by Son and Sethi (2006). Their model is grounded in the fact that people learn different kinds of item at different rates. For instance, the learning curve for some items is concave downwards (initial study leads to a rapid rise in the learning curve, and subsequent study results in diminishing returns), whereas it may be logistic for other items (an S-shaped ogival function). Depending on the learning curve, optimality will require a different distribution of study time across items. For instance, for items with a concave learning curve, optimality requires that people allocate more study time to items that are least well learned (for details, see Son & Sethi, 2006). Thus, whether a learner regulates optimally depends in part on the learning curves for the to-be-learned material. Given that numerous factors (e.g., the strategies a learner employs) will likely influence the learning curve for any item, it may be difficult in many situations to determine if a learner is optimal. Nevertheless, it is also evident that even if adults do not regulate learning optimally, they do use monitoring to allocate study in a relatively adaptive manner. That is, older adults appear to allocate study time to items that they have not learned well and hold off on restudying items that they have already learned (e.g., Dunlosky & Connor, 1997; Dunlosky & Hertzog, 1997; Miles & Stine-Morrow, 2004), and older adults often choose normatively effective strategies during study (Hertzog & Dunlosky, 2004).

Third, the task environment must afford the use of self-regulatory skills. If people cannot allocate study time differentially across items during study, then they cannot use self-regulation skills. Similarly, even if people do have an opportunity to regulate their learning, self-monitoring may fail to enhance learning if not enough time is provided for them to allocate study time differentially across items to boost learning of the least well learned ones.

With these principles in mind, we review evidence relevant to the efficacy of self-monitoring interventions. Our main question is: Does the self-monitoring approach improve older adult learning? We first briefly discuss evidence from two published studies that demonstrate the efficacy of this approach, and then we describe more recent evidence from two unpublished studies. These new studies showcase some limitations of the self-monitoring approach and suggest directions for future research.

Research Relevant to the Self-Monitoring Approach for Improving Older Adult Learning

Murphy, Schmitt, Caruso, and Sanders (1987)

Murphy and associates (1987) explored the contribution of monitoring deficits to age-related differences in serial-order recall. Their task allowed participants to regulate learning. In particular, participants studied a list of pictures as long as wanted and asked to be tested when they were ready. During this recall-readiness task, an observer unobtrusively recorded whenever a participant "looked away from the stimuli or closed their eyes during study" (p. 333), which the researchers used to infer whether participants were self-testing during study.

On the most challenging lists (which exceeded each participant's memory span), serial recall was significantly greater for younger adults ($M = 87\%$ correct) than for older adults ($M = 58\%$). To isolate sources for this deficit, the researchers conducted analyses on study times and whether participants self-tested. Study times were longer for younger ($M = 83$ s) than older adults ($M = 56$ s). Why older adults terminated study prematurely was revealed by whether participants looked away (or closed their eyes) during study, which reflected attempts to self-test. Younger adults appeared to self-test—or monitor—their learning more than two times as often as did older adults. Thus, age differences in the use of monitoring skills—in this case, self-testing—may have contributed to the age-related deficit in serial recall (see also Murphy, Sanders, Gabriesheski, & Schmitt, 1981).

To test this hypothesis, Murphy and colleagues (1987) included another group of older adults who completed the same task, except that the researchers instructed them "to test themselves before signaling their readiness to recall . . . they were reminded that when in school, they probably didn't wait for an examination, but instead, tested themselves while studying to check their memory" (p. 333). These older adults tested themselves more than twice as often as the other groups described previously, and they also spent as much time studying the words ($M = 96$ s) as did younger adults. As important, their serial recall ($M = 85\%$ correct) was greater than that of the uninstructed older adults and nearly equivalent to the level of recall obtained by younger adults. These results demonstrate that older adults can benefit from instructions that encourage them to adopt accurate self-monitoring skills during study.

Dunlosky, Kubat-Silman, and Hertzog (2003)

Dunlosky and colleagues (2003) evaluated the efficacy of the self-monitoring approach using a standard intervention methodology. Participants received 4 hr of training (across two sessions), which included practice using the trained skills with lists of paired associates, with each pair printed on a separate index card. The strategy-control group was trained to use interactive imagery and sentence generation to associate words in each pair. The self-monitoring group was trained to monitor on-going learning and to apply this monitoring to regulate their learning. In particular, they received training on using the following activities: (a) self-test on each pair by covering the response and trying to recall it, (b) sort pairs into those they could recall versus those they could not, and (c) restudy those they could not recall. This self-monitoring group was also trained to use the mnemonic strategies (imagery and sentence generation) because we wanted to evaluate whether self-regulation would improve performance above and beyond gains enjoyed by strategy training alone. The study also included a waiting-list control group.

To evaluate the efficacy of training, Dunlosky and associates (2003) designed one task that afforded self-regulation in a manner that could be sensitive to effects of self-monitoring training. This task involved self-paced learning of 40 paired associates, followed by a test of paired-associate recall. Participants had up to 20 minutes for study, which was enough time to study the 40 items multiple times.

Paired-associate recall performance on the self-paced tasks increased significantly across the pretraining and posttraining tests for the self-regulation group and for the strategy-control group, whereas no improvement was evident for the control group. Training gains were significantly larger for the self-regulation group (effect size, $d = 0.72$) than for the strategy-control group ($d = 0.28$). Along with those of Murphy and associates (1987), these findings demonstrate the potential of training self-monitoring and regulation skills to enhance older adults' learning.

Evidence From Unpublished Research

The two intervention studies we discuss in this section have not yet been published, so we will describe them in more detail. Both share one attribute in common—a failure to find a significant training effect from a self-monitoring intervention that exceeded the training effects found for training mnemonic strategies alone. Publishing such results on interventions is critical for a variety of reasons, which include sidestepping file-drawer problems that can undermine the generalizability of meta-analyses (Bradley & Gupta, 1997) and providing insights into the possible limitations of an intervention. The latter is especially important for guiding future research, which we return to in the General Discussion.

McGuire (2001)

Participants and method.—For her dissertation, McGuire conducted an intervention quite similar to that used by Dunlosky and colleagues (2003). In all, 85 older adults (M age = 70.2 years, M years of education = 15) participated in one of the following groups: strategy only, monitoring only, combination, and no-contact control (for subsample sizes, see Table 1). McGuire recruited participants from the greater Atlanta area and randomly assigned them to groups.

The strategy-only group was taught to use sentence generation and interactive imagery to study paired associates. The monitoring-only group was taught how to use the self-testing technique. In particular, this group learned to evaluate their memory for word pairs by attempting to recall each target when given its cue. If the participant judged the word pair well learned, they could move on to a new one; however, McGuire instructed them that if they judged a word pair as not well learned, they should restudy the pair at a later time. Participants in the combination training group received training on how to use both strategies and self-testing.

Table 1. Mean (*SD*) Correct Recall on Paired-Associate Recall Task

Group	*n*	Pretraining	Posttraining	*d*[a]
Monitoring only	21	20.1 (16.6)	25.7 (15.0)	0.35
Strategy only	21	22.8 (14.4)	28.9 (16.0)	0.40
Combination	23	22.8 (13.8)	26.3 (13.9)	0.25
Control	20	15.1 (13.2)	18.7 (12.9)	0.28

Notes: *SD* = standard deviation.

Values are from McGuire (2001). Maximum score = 60.

[a]Effect size = pre–post difference divided by the average standard deviation across pretest and posttest performance.

The study used a standard intervention design, which involved pretraining tests, training, and then posttraining tests. For the pretraining and posttraining tests, participants completed the Personal Encoding Preferences form, which measures strategy preference for either relatively effective (e.g., imagery, sentence generation, semantic reference) or less effective (e.g., rote rehearsal, attentive reading) strategies. The Personal Encoding Preferences form is available in Hertzog and Dunlosky (2004). McGuire also administered a cued-recall task with 60 paired associates. For each pair (e.g., doctor – lobster), the cue was typed and underlined (i.e., doctor) on one side of an index card, and the target (i.e., lobster) was typed on the reverse side of the card. Participants had 20 minutes to study these word pairs and 10 minutes to recall them.

The training took place in two sessions in which participants received training on studying word pairs using the specific techniques relevant to their training group. McGuire (2001) conducted the strategy training and self-monitoring training similarly to Dunlosky and associates (2003), with the exception that, for the latter, participants evaluated their memory of each pair through self-testing and by explicitly predicting whether they would remember each pair. The participants had two trials to study each set of word pairs, and the sets gradually became more difficult (increasing in number) across sessions.

Results.—Table 1 includes mean recall performance for each group. To evaluate the efficacy of training, we conducted several 2 (pretraining recall vs posttraining recall) × 2 (training group vs control group) analyses of variance (ANOVAs), which compared recall performance of each of the training groups to that of the no-contact control group. The gains were larger in magnitude for the key training groups—monitoring and strategy—than for the control group, but the critical interaction (Training Group vs Control Group × Pretraining vs Posttraining Tests) for each of the three ANOVAs (one for each of the training groups) was not statistically significant for the monitoring group, $F(1, 38) = 0.59$, $MSE = 46.9$, $p > .10$, the strategy group, $F(1, 38) = 0.68$, $MSE = 56.8$, $p > .10$, or for the group receiving monitoring and strategy training, $F(1, 40) = 0.01$, $MSE = 25.7$, $p > .10$.

Table 2. Mean (*SD*) Scores on the Personal Encoding Preferences Questionnaire

Group	Pretraining	Posttraining
Monitoring only	2.55 (6.13)	11.67 (6.64)
Strategy only	3.62 (6.73)	11.28 (4.84)
Combination	5.73 (6.62)	8.55 (6.72)
Control	2.89 (7.07)	5.42 (5.40)

Notes: SD = standard deviation.

Values are from McGuire (2001). Higher values indicate preferences toward normatively more effective strategies.

Table 3. Mean (*SD*) Correct Recall on Paired-Associate Recall Task

Group	n	Pretraining	Posttraining	d[a]
Monitoring + strategy training	38	12.0 (8.9)	15.9 (10.2)	0.41
Strategy only	34	7.4 (6.1)	11.3 (7.7)	0.57
Control group	29	15.0 (8.7)	14.7 (9.0)	−0.03

Notes: SD = standard deviation.

Values are from Cavallini and colleagues (2005). Maximum score = 40.

[a]Effect size = pre–post difference divided by the average standard deviation across pretest and posttest performance.

Consider two issues about these outcomes. First, performance gains were slightly smaller for the combination group than for the other training groups. However, all three training groups used the same amount of training time, so the combination group received less training and practice on both strategies and self-monitoring, which may have contributed to their smaller gains. Second, and more important, performance gains were not significantly greater for the training groups than for the control group. A possible explanation is that McGuire (2001) did not have sufficient power to detect these effects. Nevertheless, training did yield significant gains in performance for the training groups, ts > 2.0, ps $< .05$, so we do not believe that insufficient power is the culprit; that is, the lack of differential training effects is instead likely attributable to other sources. One source is that the control group also demonstrated performance gains, which is atypical for tasks used in our intervention research (e.g., Dunlosky et al., 2003; and also Cavallini, Dunlosky, Bottiroli, Hertzog, & Vecchi, 2006, reported below) and may be partly attributable to the relatively low pretraining performance demonstrated by the control group. (We thank an anonymous reviewer for pointing out this possibility.) Note, however, even if the control group had a higher level of pretraining performance and showed no gain across tests, the training effects were still quite small when compared to outcomes from Dunlosky and colleagues (2003), who found that self-monitoring training supported substantial performance gains ($d = 0.72$). The smaller effect sizes found by McGuire (2001) may have resulted from a final source that involves a critical design issue—whether the criterion tasks promote self-testing. We return to this source in the General Discussion.

To evaluate participants' preference for various strategies, McGuire (2001) examined the scores for the Personal Encoding Preferences form (Table 2), which could range from –27 (least effective) to 27 (most effective). As is evident from inspecting Table 2, participants preferred to use effective strategies more after training as compared to before training, $F(1, 88) = 47.45$, $p < .001$. Also, the Preference Change × Group interaction was significant, $F(4, 88) = 2.91$, $p < .05$, with the monitoring-only ($M = 9.1$) and strategy-only ($M = 7.7$) groups showing a larger increase in preference for effective strategies as compared to the control group ($M = 2.5$). The combination group ($M = 2.8$) showed a similar mean increase to the control group.

Summary.—Training appropriately influenced participants' beliefs about what kinds of strategy were effective, but the training groups did not show statistically significant increases in recall performance as compared to the no-contact control group. The latter outcomes were partly due to the unexpected gains demonstrated by the control group, but they may also result from other subtle differences between the methods used in McGuire's dissertation and those used by Dunlosky and associates (2003), which we consider in the General Discussion.

Cavallini and Colleagues (2006)

Training older adults to use self-testing to improve their learning comprised a subset of this intervention research, which also attempted to promote transfer of classical mnemonics across various tasks. This larger program of research is ongoing and will be presented in its entirety elsewhere (Cavallini et al., 2006).

Participants and method.—In all, 101 older adults participated in one of three groups: self-monitoring group (M age = 68 years; $SD = 4.9$), strategy group (M age = 68 years; $SD = 6.3$), and a no-contact control group (M age = 66; $SD = 4.0$). (For subsample sizes, see Table 3.) The years of education were 11.3 ($SD = 3.6$) for the self-monitoring group, 10.7 ($SD = 3.6$) for the strategy group, and 14.0 ($SD = 2.5$) for the control group. Researchers recruited all participants from the University of the Third Age at Pavia.

As did Dunlosky and associates (2003), researchers trained the self-monitoring group to self-monitor and control their learning through self-testing and to use standard mnemonics (imagery and sentence generation) while studying paired associates. The strategy group received training on only these mnemonics. Both groups received two 2-hour training sessions that focused on learning paired associates. The training sessions were separated by 2 weeks. Participants practiced strategies by studying word pairs, which were each printed on one side of a separate index card. The lists of word pairs gradually increased across the two sessions (beginning with lists of 3 pairs in the first training session and growing to lists of 40 pairs in the second training session). After studying each list, participants recalled responses and discussed the strategies used during study.

The criterion tasks (both pretraining tests and posttraining tests) required studying 40 paired associates. Each pair was printed on one side of an index card. Participants had 20 minutes to study the pairs. They were told participants to notify the experimenter if they finished earlier than the 20-minute time limit. After studying was complete, the experimenter showed participants each stimulus word individually and asked them to write down the corresponding response. Participants had as much time as needed to perform the recall test.

Results.—For each participant, Cavellini and colleagues (2006) computed the proportion of correct recall on the pretraining test and on the posttraining test. Table 3 includes mean recall scores. As in McGuire (2001), to evaluate the effects of training we conducted several planned comparisons that consisted of a 2 (pretraining recall vs posttraining recall) × 2 (training group vs comparison group) ANOVA. First, as compared to the no-contact control group, training gains were larger for the self-monitoring group, $F(1, 65) = 7.45$, $MSE = 20.0$, $p = .008$, and for the strategy-only group, $F(1, 61) = 9.67$, $MSE = 14.2$, $p = .003$. The difference in performance gains between the self-monitoring group and the strategy-only group were not significant, $F(1, 70) < 1.0$, $MSE = 17.8$, $p > .10$, which demonstrates that training self-monitoring skills did not support greater improvements in associative learning than did training strategy use alone. One difficulty in interpreting this outcome is that pretraining performance was not matched for the two training groups. Accordingly, we selected a subset of participants who were approximately matched in pretraining performance for the self-monitoring group ($n = 20$, M pretraining recall $= 5.3$) and the strategy-only group ($n = 27$, $M = 4.9$), $t(45) = 0.34$, $p > .10$. Even when pretraining performance matched, posttraining performance did not significantly differ between the self-monitoring ($M = 10.5$) and strategy-only ($M = 9.4$) groups, $t(45) = 0.56$, $p > .10$. Thus, sampling differences across groups cannot explain why self-monitoring training did not produce greater training gains than did strategy training alone.

To further explore these outcomes, we computed the mean amount of time taken for self-paced study. Mean study times for the pretraining and posttraining tests (respectively) were 17.6 minutes and 19.1 minutes for the self-monitoring group, 16.0 minutes and 17.0 minutes for the strategy group, and 15.0 minutes and 15.2 minutes for the control group. A 2 × 3 ANOVA revealed that study times increased across tests, $F(1, 98) = 5.2$, $MSE = 7.9$, $p < .01$, and differed between groups, $F(2, 98) = 7.8$, $MSE = 23.1$, $p < .01$; the interaction was not significant, $F < 1.0$. To evaluate whether any differences between the training groups and the control group were responsible for the reliable training effects described above, we conducted the planned comparisons on recall covaried on study times from the posttraining tests. These analyses of covariance revealed significant training effects (i.e., significant Training vs Control Group × Pretest vs Posttest Interaction) for the self-monitoring group, $F(1, 64) = 5.5$, $MSE = 20.3$, $p < .01$, and for the strategy-only group, $F(1, 60) = 9.9$, $MSE = 14.4$, $p < .01$.

General Discussion

The self-monitoring approach offers some advantages not routinely available for more traditional mnemonic training. For instance, most mnemonic strategies are highly specific to the materials (e.g., method of loci for serial learning), which may constrain generalization and transfer to new learning contexts. In principle, learners can apply self-monitoring and regulation to any learning task, assuming of course that they have the option to use monitoring to regulate their learning. It is also rather intuitive and is easy to train, as demonstrated by Murphy and colleagues (1987), who found training effects when older adults were simply instructed to self-test without extensive training or practice using the techniques. Finally, given its generality and ease of use, individuals can adapt the self-monitoring approach to complement standard mnemonic training. It is not a replacement for mnemonics but a promising collaborator in the battle against age-related memory impairment.

In the present article, we described four studies relevant to evaluating the efficacy of the self-monitoring approach for improving older adult learning. Evidence from two published articles was positive. Evidence from the use of a related technique also showcases the power of self-monitoring. In particular, Camp and his colleagues have demonstrated that an intervention like those described here can help older adults with Alzheimer's disease learn new information (e.g., Camp, Foss, O'Hanolon, & Stevens, 1996; Camp & Stevens, 1990). Their intervention involves (a) presenting the to-be-learned information to the patient, (b) testing whether the patient can recall the information, and (c) regulating further study using spaced learning. Testing during the second step is analogous to self-testing that researchers have trained (or instructed) in the research described here, and, in both cases, the outcome of testing is used to regulate further study. A key difference between the self-monitoring approach and Camp's successful intervention is that the former encourages learners to accurately monitor and regulate learning, whereas in the latter, a trainer supports—and even takes over—monitoring and control processes. These independent lines of evidence demonstrate that the use of monitoring to regulate study can successfully enhance learning.

Based on more recent research described here, however, it is evident that further systematic, intervention-based research is needed to determine conditions that are necessary and sufficient for success. McGuire (2001) illustrated one condition; she found significant performance gains for the two training groups (albeit these gains were not significantly greater as compared to a control group) but did not demonstrate an added increase in gains for participants who were trained to use self-monitoring. The meager gains shown by this group are likely attributable to the sensitivity of the criterion task. In particular, people will benefit from mastering a given mnemonic as long as they are not already using the mnemonic. Even without the self-monitoring intervention, participants in McGuire's self-paced study task would likely have self-tested on the criterion tests because of how the materials had been presented. Namely, each paired associate was presented on an index card with the stimulus term on one side and the response on the other side. Thus, even during the initial tests prior to training, all participants were encouraged to self-test because they could examine only one side of the card at a time. To address this issue, future studies should explicitly measure spontaneous self-testing behavior during the criterion tests.

Cavallini and associates (2006) also found significant training effects, with performance gains being larger for the two training groups as compared to a control group; however, these gains were not larger for the self-monitoring plus strategy group than for the strategy-only group. This failure to find an added benefit for self-monitoring training was somewhat unexpected, because the criterion task was not expected to stimulate self-testing prior to training. Because identifying exactly which factors moderate the success of any intervention is a necessary endeavor, we offer some speculation about some factors that may have constrained the efficacy of self-monitoring training. First, the self-monitoring group received both strategy training and self-monitoring training so we could evaluate whether self-monitoring training could improve upon the training gains shown by strategy training alone. For these two training groups, the amount of training time was matched, so that the combined self-monitoring and strategy group received less training on both components. Thus, perhaps older adults require additional training to successfully coordinate the use of strategies and self-monitoring while regulating study. Second, as described previously, just as some older adults already use effective mnemonic strategies (e.g., Dunlosky & Hertzog, 1998) and hence would not benefit from mnemonic training, older adults who already self-tested during study would likely have shown only minor gains as result of this intervention. Given that Cavallini and colleagues' older adult participants were enrolled in classes at the University of the Third Age, perhaps many were already using this technique to study class materials.

Another moderating factor may have involved the sensitivity of the criterion tasks to the self-monitoring intervention. Currently, it is not evident how much study time a person needs to successfully self-monitor and to use this monitoring to learn the most difficult items. The criterion test must also be sensitive to the boosts in learning skill that arise from self-monitoring training as compared to no training. To better understand this issue, it is helpful to first consider the extremes. If very little time is available (e.g., just enough time to study each item once), then of course self-monitoring will not benefit posttraining performance. By contrast, if unlimited time is available, then posttraining criterion performance for all groups can be maximal. Thus, a total study time is required that allows those who are regulating their study with self-monitoring to demonstrate increased efficiency in their learning. This time would allow the self-monitoring group to study all items, self-monitor, and then have enough time to devote extra study to just the unlearned items. Participants who are not self-monitoring would presumably be less efficient, in that they would likely restudy most items again and hence waste time on those items that are already relatively well learned. Thus, we would expect that detecting the extra gains in posttraining performance garnered by self-monitoring training would show an inverted-U relationship to total study time allowed on the criterion test, with performance benefits being minimal with short total study time, rising as total study time passes some critical value, and then diminishing as total study time increases further. In the latter situation, however, we would also expect self-monitoring groups to be more efficient, in that they would obtain maximal levels of performance in less time and hence terminate study earlier than other training groups. We are currently pursuing these issues in our memory-training laboratory.

Summary

Consider a preliminary answer to the question of whether self-monitoring interventions improve older adults' learning. Our critique indicates that the answer to this question is "yes." The benefits demonstrated in multiple studies are undeniable, although the overall efficacy of the self-monitoring approach must be qualified in light of the outcomes from McGuire (2001) and Cavallini and associates (2006). A challenge for future research will be to discover factors that moderate the efficacy of this approach, so that standard recommendations about when to use (and not to use) self-monitoring will be available for adults of all ages who wish to enhance the efficiency of their learning.

Acknowledgments

This research was supported Grant R37 AG13148 from the National Institute on Aging, one of the National Institutes of Health.

Correspondence

Address correspondence to John Dunlosky, Department of Psychology, Kent State University, P.O. Box 5190, Kent, OH 44242-0001. E-mail: jdunlosk@kent.edu

References

Bahrick, H. P., & Hall, L. K. (2005). The importance of retrieval failures to long-term retention: A metacognitive explanation of the spacing effect. *Journal of Memory and Language, 52*, 566–577.

Ball, K., Berch, D. B., Helmers, K. F., Jobe, J. B., Leveck, M. D., Marsiske, M., et al. (2002). Effects of cognitive training interventions with older adults: A randomized controlled trial. *Journal of the American Medical Association, 18*, 2271–2281.

Bradley, M. T., & Gupta, R. D. (1997). Estimating the effect of the file drawer problem in meta-analysis. *Perceptual and Motor Skills, 85*, 719–722.

Butterfield, E. C., Peltzman, D. J., & Belmont, J. M. (1971). The effects of practice upon rehearsal in short-term memory. *Psychonomic Science, 23*, 275–276.

Camp, C. J., Foss, J. W., O'Hanlon, A. M., & Stevens, A. B. (1996). Memory interventions for persons with dementia. *Applied Cognitive Psychology, 10*, 193–210.

Camp, C. J., & Stevens, A. B. (1990). Spaced-retrieval: A memory intervention for dementia of the Alzheimer's type (DAT). *Clinical Gerontologist, 10*, 58–60.

Cavallini, E., Dunlosky, J., Bottiroli, S., Hertzog, C., & Vecchi, T. (2006). [Promoting transfer in interventions aimed at improving older adults' memory]. Unpublished raw data.

Dunlosky, J., & Connor, L. T. (1997). Age differences in the allocation of study time account for age differences in memory performance. *Memory & Cognition, 25*, 691–700.

Dunlosky, J., & Hertzog, C. (1997). Older and younger adults use a functionally identical algorithm to select items for restudy during multitrial learning. *Journal of Gerontology: Psychological Sciences, 52B*, P178–P186.

Dunlosky, J., & Hertzog, C. (1998). Aging and deficits in associative memory: What is the role of strategy production? *Psychology and Aging, 13*, 597–607.

Dunlosky, J., Hertzog, C., Kennedy, M. R. F., & Thiede, K. W. (2005). The self-monitoring approach for effective learning. *International Journal of Cognitive Technology, 10*, 4–11.

Dunlosky, J., Kubat-Silman, A. K., & Hertzog, C. (2003). Training monitoring skills improves older adults' self-paced associative learning. *Psychology and Aging, 18*, 340–345.

Dunlosky, J., & Thiede, K. W. (2004). Causes and constraints of the shift-to-easier-materials effect in the control of study. *Memory & Cognition, 32*, 779–788.

Hertzog, C., & Dunlosky, J. (2004). Aging, metacognition, and cognitive control. In B. Ross (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 215–251.) London, United Kingdom: Elsevier Academic Press.

Hill, R. D., Bäckman, L., & Stigsdotter Neely, A. (Eds.) (2000). *Cognitive rehabilitation in old age.* New York: Oxford University Press.

Kliegl, R., Smith, J., & Baltes, P. B. (1989). Testing-the-limits and the study of adult age differences in cognitive plasticity of a mnemonic skill. *Developmental Psychology, 25*, 247–256.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology, 126*, 349–370.

Maki, R. H. (1998). Test predictions over text material. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds), *Metacognition in educational theory and practice* (pp. 117–145). Hillsdale, NJ: Erlbaum.
Matvey, G., Dunlosky, J., Shaw, R. J., Parks, C., & Hertzog, C. (2002). Age-related equivalence and deficit in knowledge updating of cue effectiveness. *Psychology & Aging, 17*, 589–597.
McGuire, C. L. (2001). Memory monitoring intervention for healthy older adults. *Dissertation Abstracts International, 62B*, 1109.
Metcalfe, J., & Kornell, N. (2005). A region of proximal learning model of study time allocation. *Journal of Memory and Language, 52*, 463–477.
Miles, J. R., & Stine-Morrow, E. A. L. (2004). Adult age differences in self-regulated learning from reading sentences. *Psychology and Aging, 19*, 626–636.
Murphy, M. D., Sanders, R. E., Gabriesheski, A. S., & Schmitt, F. A. (1981). Metamemory in the aged. *Journal of Gerontology, 36*, 185–193.
Murphy, M. D., Schmitt, F. A., Caruso, M. J., & Sanders, R. E. (1987). Metamemory in older adults: The role of monitoring in serial recall. *Psychology & Aging, 2*, 331–339.
Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect." *Psychological Science, 2*, 267–270.
Nelson, T. O., & Leonesio, R. J. (1988). Allocation of self-paced study time and the "labor-in-vain effect." *Journal of Experimental Psychology, 14*, 676–686.
Rawson, K. A., Dunlosky, J., & McDonald, S. (2002). Influences of metamemory on performance predictions for text. *Quarterly Journal of Experimental Psychology, 55A*, 505–524.
Sahakyan, L., Delaney, P., & Kelley, C. M. (2004). Self-evaluation as a moderating factor of strategy change in directed forgetting benefits. *Psychonomic Bulletin & Review, 11*, 131–136.
Son, L. K., & Metcalfe, J. (2000). Metacognitive and control strategies in study-time allocation. *Journal of Experimental Psychology, 26*, 204–221.
Son, L. K., & Sethi, R. (2006). Metacognitive control and optimal learning. *Cognitive Science, 30*, 759–774.
Thiede, K. W. (1999). The importance of monitoring and self-regulation during multi-trial learning. *Psychonomic Bulletin & Review, 6*, 662–667.
Thiede, K. W., & Dunlosky, J. (1999). Toward a general model of self-regulated study: An analysis of selection of items for study and self-paced study time. *Journal of Experimental Psychology, 25*, 1024–1037.
Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging, 7*, 242–251.
Yates, F. A. (1997). *The art of memory*. London, United Kingdom: Pimlico.