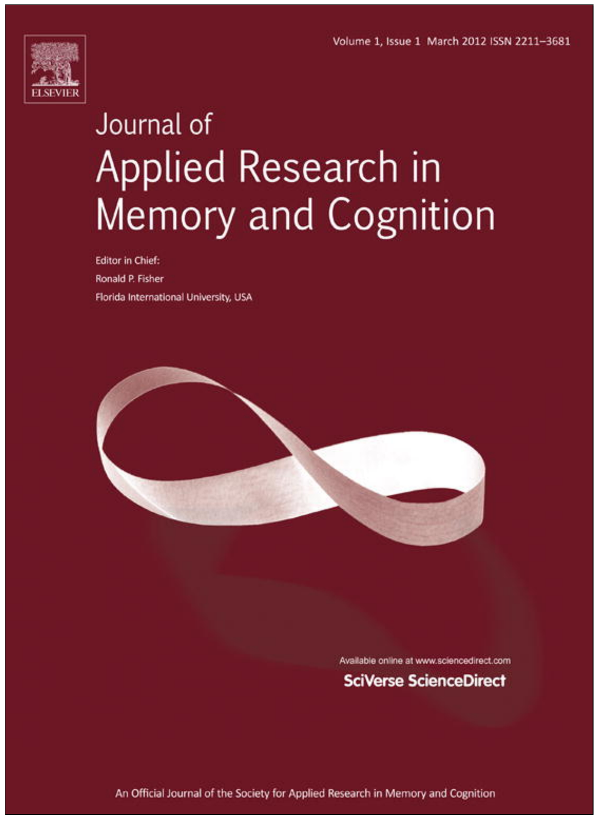
Volume 1, Issue 1 March 2012 ISSN 2211-3681
ELSEVIER
Journal of
Applied Research in
Memory and Cognition
Editor in Chief:
Ronald P. Fisher
Florida International University, USA
Available online at www.sciencedirect.com
SciVerse ScienceDirect
An Official Journal of the Society for Applied Research in Memory and Cognition

Journal of Applied Research in Memory and Cognition 1 (2012) 45–50

Contents lists available at SciVerse ScienceDirect

Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

Memory training interventions: What has been forgotten?☆

Mark A. McDaniel*, Julie M. Bugg

Washington University, St. Louis, MO 63130-4899, United States

ARTICLE INFO

Article history:
Received 16 August 2011
Received in revised form
21 November 2011
Accepted 22 November 2011
Available online 8 December 2011

Keywords:
Memory training
Memory interventions
For older adults

ABSTRACT

Memory training for older adults often produces gains that are limited to the particular memory tasks encountered during training. We suggest that memory training programs may be misguided by an implicit "generalist" assumption—memory training on a couple of memory tasks will have a positive benefit on memory ability in general. One approach to increase memory-training benefits is to target training for the everyday memory tasks for which older adults struggle. Examples include training retrieval strategies, prospective memory strategies, and strategies for learning and remembering names. Another approach is to design training to foster transfer. Possible elements to improve transfer are increasing the variation that is experienced during the course of training at the level of stimuli and tasks, incorporating "homework" that guides the older adult to become attuned to situations in which the strategies can be applied, and providing older adults with a better understanding of how memory works. Finally, incorporating aerobic exercise into memory training programs may potentiate the acquisition and maintenance of the trained cognitive strategies.

By way of introduction, in this initial *JARMAC* target article, we were given the charge of writing an opinion-sprinkled commentary on whether memory training interventions might have value for older adults' everyday memory functioning. This is not a comprehensive and scholarly review; it is our viewpoint and biases communicated in a somewhat conversational voice on the reasons for why some approaches to memory training might not fare well in transfer to everyday memory functioning, and on what ideas might have currency for a second generation of memory training interventions. Some of these points may have been made elsewhere, and some may provoke disagreement. The hope is to galvanize a conversation among the applied (and basic) research community that might better illuminate the points of convergence and of contention and possibly stimulate progress in this important area.

There is no question that memory training benefits the elderly (for meta-analysis, see Verhaeghen, Marcoen, & Goosens, 1992). As an example, consider the advanced cognitive training for independent and vital elderly (ACTIVE) trial, a multi-site, randomized single-blind study involving 2832 participants. Findings from this trial indicate that engagement in memory training (instruction in organizational, associative and visualization strategies for remembering verbal material) produces immediate and significant gains in performance on the memory tasks encountered during training (Ball et al., 2002; see also the trial conducted by West, Bagwell, & Dark-Freudeman, 2008), as well as gains in strategy use for word-list learning that appear to be maintained for at least five years (Gross & Rebok, 2011). Indeed, recent reviews are fairly clear in establishing that benefits, in general, are observed for the particular memory tasks that are trained (Hertzog, Kramer, Wilson, & Lindenberger, 2009).

What is debatable is the meaningfulness of these benefits for older adults' memory function. To the extent that older adults are faced with precisely these memory tasks in their everyday lives, then the benefits may be considered meaningful. But, older adults' memory complaints do not typically center on tasks psychologists have developed to assess memory in the laboratory. They are more varied and complex, as we describe below. Because there is little evidence showing that memory training produces transfer, that is, leads to benefits on memory tasks or everyday memory challenges that have not been encountered during training (for an exception, see Jennings, Webster, Kleykamp, & Dagenbach, 2005), the meaningfulness of the benefits that are reaped from memory training programs remains in question. Below we discuss an underlying theoretical assumption that appears to guide many memory training programs, an assumption which we believe to be flawed. We then suggest alternative assumptions to guide memory training with an eye toward those that are most likely to make memory training meaningful by producing transfer.

1. The generalist assumption

A theoretical assumption, which is primarily implicit, seems to be that one needs only to train some memory strategies in order to produce relatively comprehensive positive outcomes for older

☆ Preparation of this article was supported in part by NIA Grant R01AG034581.
* Corresponding author. Tel.: +1 314 935 8030.
E-mail address: mmcdanie@artsci.wustl.edu (M.A. McDaniel).

2211-3681/$ – see front matter © 2011 Society for Applied Research in Memory and Cognition. Published by Elsevier Inc. All rights reserved.
doi:10.1016/j.jarmac.2011.11.002

adults' memory. As long as the older adult is practicing how to remember information, perhaps with a handy strategy that is provided in the training, memory will improve. This has been dubbed informally as the "generalist" position (Einstein & McDaniel, 2004). The idea is that memory training on a couple of memory tasks or strategies will have a positive effect on all memory abilities. This idea has been adopted in the popular media, and is reinforced with interviews from academics: "Memorizing long series of numbers can . . . fortify your long-term memory" (Brain Trainer, 2011, p. 135). In this section, we consider the merit of the generalist assumption from several perspectives. First, though, it is worth noting that the assumption touches on a fundamental issue in the transfer literature, which is the degree to which transfer is limited and fairly specific or is general and cuts across a range of tasks and content (Singley & Anderson, 1989). This issue has been hotly debated in the psychological literature for over 100 years, with little resolution (Barnett & Ceci, 2002). Still, we believe that a number of observations disfavor optimism for a generalist approach to memory training.

Perhaps the historically most influential orientation from which the generalist assumption naturally emerges is the faculty view of mind, the idea that the mind is composed of a collection of general faculties. These faculties were assumed to be improved through their exertion, and by so doing would produce better performance on a broad range of tasks that demand a particular faculty. It is beyond the scope of the article to review the domains in which this view has permeated (see Singley & Anderson, 1989, for how this view has been "circulated with regularity over the years"; p. 6). However, it is worth noting that prominent educational psychologists in the early 20th century endorsed the doctrine that education should train (exercise) general faculties like memory, with the content of the training being relatively unimportant. In pursuit of this objective, a common educational practice would have been to require students to memorize poems, with the idea that doing so would create a better memory. As those of you who experienced this kind of instruction in your grammar schools know, though you gained some competence in reciting particular poems, it is likely that your memory in general did not improve. The "faculty" approach to education has of course fallen out of favor, primarily because educators and theorists raised strong doubts that training faculties was a successful educational approach. That approach, however, appears to be a core assumption (at least implicitly in one guise or another) of attempts to provide older adults with memory training.

A second observation is that elite memory performers practice memory tasks regularly, often concentrating on particular strategies to achieve impressive feats of memory. Accordingly, from the perspective of the generalist position, these individuals, of all people, ought to demonstrate improved general memory ability. Yet, both objective laboratory results and personal experiences related by these memory "experts" indicate that the benefits of memory training are limited to the tasks and strategies that are practiced. For instance, the memorist Rajan, after thousands of hours of practicing a strategy for encoding strings of digits, performed at a vastly superior level on tests of digit span but was no better than college students (on initial testing) at remembering strings of familiar symbols (Ericsson, Delaney, Weaver, & Mahadevan, 2004) or other kinds of material (Thompson, Cowan, & Frieman, 1993).

Similarly, Ben Pridemore, a former world memory champion and one-time world record holder for the shortest time taken to memorize the order of a deck of cards (just over 20 s), readily admits that he is not so good at remembering face–name associations and is just as bad as any of us at remembering where he put his keys. Moreover, when he wants to remember a list of things to do or to get at the grocery, he does not use his fantastic memory strategies; instead he writes it down (personal communication, July 18, 2011). Thus, despite long hours of memory training and practice, the evidence shows that these memorists' memories have not generally improved, nor do they necessarily exploit their hard-earned strategies for everyday tasks.

A third observation rests on results from studies that have examined general memory abilities of older college professors. By the nature of their jobs, these individuals have continually engaged in intellectual activity through their lifetimes, including practice at remembering lectures, talks, and research findings. According to a generalist position these professors should score well on a broad range of memory tests. But Shimamura, Berry, Mangels, Rusting, and Jurica (1995) reported a somewhat different pattern. For a prose recall task the older professors did exhibit no age-related decline (whereas the non-university older adults did). The prose recall memory task is arguably similar to the kind of memory demands commonly faced by professors—integration of new knowledge into existing knowledge structures (at least, this was the argument made by the authors of the study). In sharp contrast, for paired associate (and working) memory tasks, the older professors showed similar age-related decline as non-university older adults. This state of affairs (including the considerations mentioned in preceding paragraphs) undercuts the assumption that providing older adults with memory training is an effective way to improve their memory in general, and we reiterate that though memory training may transfer to similar tasks, the limits of the generalizability can be striking. Consider that in one study, an older adult group given training on a particular memory strategy useful for the training content (an interactive imagery strategy applied to lists of concrete words) showed no improvement when the contents of the to-be-learned lists changed (to action phrases or abstract words; Neely & Backman, 1995). Given the above considerations, it should not be especially surprising that memory training programs have not enhanced memory/cognition in general.

A more specific rendering of the generalist position is the possibility that memory (or cognitive) training will improve the neurobiological functioning of brain systems that subserve memory/cognition and thereby forestall or attenuate age-related neural decline. With improved neurobiological functioning, the expectation is that memory and cognitive processes should overall be enhanced. It remains possible that for the aging brain, memory/cognitive training could stimulate neurobiological improvements. Though little evidence with humans is available at present, a number of ongoing projects are examining this assertion. Preliminary results hint that training with tasks or strategies that are linked to specific neural systems/processes and that challenge those processes may enhance the functioning of those neural systems (e.g., Mahncke et al., 2006; Mozolic, Hayasaka, & Laurienti, 2010) or promote transfer to tasks that engage the same neural systems (Dahlin, Neely, Larsson, Backman, & Nyberg, 2008); however, at present this approach is long on promise and short on conclusive evidence (Lustig, Shah, Seidler, & Reuter-Lorenz, 2009).

We pause to note that undoubtedly some will protest that our characterization that memory training approaches have dovetailed with the generalist (faculty) approach has missed the point of the memory training research (at least several initial reviewers thought so) or mischaracterized the theoretical underpinnings of the enterprise. Perhaps so, if indeed the objective of previous memory training programs was to examine whether older adults could be trained to use and retain particular memory strategies. The training programs have clearly shown this outcome, with that outcome possibly informing theoretical issues regarding cognitive consequences of aging (e.g., see Baltes & Kliegl, 1992). But, as noted at the outset this objective misses the central applied reasons for providing and engaging (older adults) in memory training. Those of us interested in applied cognition and memory surely expect that memory training is being developed to assist older adults to fare better in their everyday memory challenges, and perhaps cognitive activities in general. Given that objective, we think it is important to recognize that adopting the approach of training older adults to perform a convenient laboratory memory task, with the hope that older adults improve their memory functioning, smacks of the generalist position (and its attendant limitations).

An alternative theoretical underpinning for training a particular memory strategy (or several strategies) could be that those older adults who have been taught an effective organizational, or imaginal, or semantically-based strategy will be able to adapt and generalize that strategy to the range of memory challenges that they face outside of the laboratory. We return to this idea below. The key point here is that too often there has been little explicit development of the theoretical assumptions and presumed mechanisms of transfer that underlie the memory training protocol investigated. Encouraging researchers to be explicit about what they assume is being learned in training and how this training (and what is learned) overlaps or does not overlap with the demands of everyday tasks where improvement is desired, might hasten progress in understanding and identifying the kinds of training that will and will not effectively promote improvements to the everyday memory challenges faced by older adults.

2. Are training programs targeting the right memory challenges?

If memory training does not produce general improvements in memory, positive outcomes of training then rest largely on the utility of the strategies being trained. Older adult memory training programs appeal to the basic memory literature for identifying candidate memory strategies to train. Older adults are trained on the method of loci (Baltes & Kliegl, 1992), organizational strategies for word lists, associative and imagery strategies for paired associate tasks, and strategies for text recall (Ball et al., 2002; West et al., 2008). On the one hand, that approach is not unreasonable, as it focuses on memory strategies that have been vetted in the laboratory, including some that were useful over 2000 years ago when recording information was laborious and expensive. For example, the method of loci was developed by Greeks to assist them in memorizing speeches, and in modern psychology textbooks the method of loci is typically illustrated in the context of remembering a grocery list. The method is similar in its structure to strategies used by at least some memorists. Older adults clearly can substantially improve the number of unrelated words they can remember with training on the method of loci (Baltes & Kliegl). In a similar vein, older adults can learn an organizational strategy for remembering a word list, which might also be useful in remembering a shopping list (West et al.), and they can learn to use mediational techniques to remember pairs of unrelated words.

On the other hand, although these strategies work well with laboratory materials and in laboratory contexts, whether these strategies assist older adults with their everyday memory needs is not clear for at least two reasons. First, often the memory strategies trained with laboratory materials are matched for a particular type of laboratory material and are relatively useless for other (even laboratory) material (see e.g., McDaniel & Kearney, 1984), thereby severely limiting their possible generalizability. For instance, having an older adult learn a taxonomic organizational strategy for remembering a list of words is not much use for remembering foreign language vocabulary in her continuing education class. We suggest that memory training might be more successful if trained strategies were bundled or formulated at a more abstract level, one that would translate across a range of target material. Arguably, there is some support for this suggestion. In the recent Improvement in Memory with Plasticity-based Adaptive Cognitive Training (IMPACT), training was oriented toward improving central sensory system functioning, and in particular the speed and accuracy with which participants processed auditory information (Smith et al., 2009). Training exercises ranged from discriminating confusable syllables to identifying details from a story that was presented in the auditory modality. Compared to an active control group, the trained group showed significant gains on numerous, untrained memory and attention measures from neuropsychological batteries, indicative of broad transfer.

As an alternative example, training might focus on a general approach of semantically enriching target material, using specific strategies (organization, story-elaboration, creating relations among items) as illustrations, rather than immutable target strategies (cf. Dunlosky, Bailey, & Hertzog, 2011). In concert, training would sample a range of materials, and encourage older adults toward idiosyncratic development of semantic enrichment strategies. Drawing from the problem solving and transfer literature, the more abstract rendering of the strategy, as well as the practice in instantiating the strategy to new materials, should enable more robust generalization of the training to individual memory challenges. Still, a surprising (at least to us) recent result suggests that the training of laboratory memory strategies (e.g., word list learning) seems to have positive outcomes on everyday cognitive functioning (Gross & Rebok, 2011), though it is unclear why. One speculation would be that when older adults improve their memory strategies to accomplish a memorization task, it underscores the value of cognitive strategies and thereby stimulates more strategic approaches to their everyday activities (medication management, telephone use, and checkbook balancing). This would be fantastic if it were a robust effect, and clearly more work is needed.

A second reason that the usual memory strategies might not provide much benefit for older adults is that in their daily lives they do not need these strategies (even if transferred to everyday material). Power point presentations obviate the need to memorize speeches, paper and pencil provide reliable means for remembering grocery lists, and most older adults are not aspiring to become memory champions. When the first author gives workshops to older adult groups on aging and memory, informing them that they can remember more information if they apply the kinds of strategies just mentioned, invariably an older adult will remark that these strategies are interesting but not useful to them; it is easier to simply write down the information they want to retain (e.g., grocery lists). Thus, another shortcoming of memory training, at least as conceptualized in many interventions, is that the particular memory strategies that are trained may not be well aligned with the memory challenges that older adults are concerned about and are in most need of assistance.

3. Train strategies attuned to the memory issues of concern to older adults

We suggest that to increase the benefits of memory training for older adults, continuing efforts are needed to identify the everyday tasks and contexts for which older adults struggle *and* for which older adults want to improve. Based on comments that audiences volunteer at our community talks, and paralleling the laboratory research (e.g., Craik, 1986), one struggle for older adults is retrieving (or activating) information from long-term memory. The common complaint from these adults is that sometimes they cannot recover details about information or experiences that they encounter in their daily lives (movies, current events, political figures, and so on). This information is not necessarily important at the time it is encountered, so that one would not be trying to strategically commit this information to memory (e.g., using trained encoding techniques). Even if the information were deemed important at initial encounter, many might not strategically recruit a potent encoding strategy. Thus, for older adults, training retrieval strategies may be at least as important, if not more so, than training encoding strategies. Happily, basic and applied memory work has identified retrieval strategies, and some of our own SARMAC members have helped develop an integrated retrieval-enhancement technique, the *Cognitive Interview*. The Cognitive Interview is effective at enhancing retrieval of a range of content (see Fisher & Quigley, 1992; McCauley & Fisher, 1995), unlike the relatively content-specific strategies (e.g., word list learning) typically trained, and importantly, the cognitive interview increases older adults' free recall of complex verbal information (narratives) after a 3-week delay (Dornburg & McDaniel, 2006; see also Mello & Fisher, 1996, for effects of the cognitive interview with older adults). Accordingly, training older adults to apply the techniques of the cognitive interview to improve retrieval of needed information may enhance the applicability and success of memory training programs.

Another ready example of an everyday memory task that challenges older adults is prospective memory. Prospective memory refers to memory tasks in which one has to remember to perform an intended action at some point in the future. With just minimal reflection, it is apparent that prospective memory is richly embedded in everyday tasks—from managing household activities (remembering to pay bills) to coordinating social relations (remembering to prepare for and attend a potluck luncheon with friends) to regulating health related needs (remembering to take medication). Prospective memory is likely to be especially important for older adults (e.g., consider the prevalence of medications that older adults take, Park & Kidder, 1996), and surveys have suggested that a majority of older adults' memory failures and complaints are prospective in nature (McDaniel & Einstein, 2007). Yet, memory training interventions for older adults have so far not included prospective memory training (e.g., ACTIVE, Ball et al., 2002; Everyday Memory Clinic Project, Bagwell & West, 2008; the Senior Odyssey Project, Stine-Morrow, Parisi, Morrow, & Park, 2008; IMPACT study, Zelinski, Yaffe, Smith, Ruff, & Kennison, 2008).

The basic prospective memory literature has identified effective strategies that are excellent candidates for training (see Einstein & McDaniel, 2004; Liu & Park, 2004), and we believe that including prospective memory in training interventions could have a significant impact on improving prospective memory in everyday tasks that older adults care about. (Parenthetically, external devices can of course be quite useful, but they may not appeal to all individuals, be convenient for all prospective memory tasks, or be affordable for some as high-tech pillboxes can cost $218 and up, plus $16 a month; "Manage Mediations," 2011.) For instance, in our presentations to older-adult groups we describe an imagery strategy to help remember to collect an umbrella brought to lunch (when the day has turned sunny, it is easy to forget the umbrella). In later encounters with some of these older adults, they are pleased to tell us that they now never forget their umbrella. Of course, these are just anecdotes. One study demonstrated that a spaced retrieval technique (which is also useful for everyday retrospective memory tasks, such as name learning) improved prospective remembering of a particular intention in older adults with dementia (Camp, Foss, Stevens, & O'Hanlon, 1996). As implemented in Camp et al., a caretaker would be responsible for administering the spaced retrieval, but for non-demented individuals, a self-initiated spaced retrieval strategy could be quite practical. To formally investigate the value of a prospective memory training regimen, we and our colleagues have included an 8-week prospective memory training component in our ongoing **Ex**ercise **a**nd **C**ognitive **T**raining (EXACT) trial (which we describe in greater detail below).

A final brief example of an everyday memory challenge that is well documented for older adults and that older adults express concern about is learning and remembering people's names (see Cohen & Burke, 1993). Mediational strategies for paired associate learning with an explicit focus on face-name learning have been included in at least one memory training intervention (West et al., 2008). The training produced significant improvements on recall of names (when shown the faces) for lists of 12–24 face (pictures)–name pairings. Unfortunately, whether the older adults transferred these strategies to everyday name learning is unknown, and gathering these outcomes is important for future work. Generally, we suggest that memory training for older adults will be quite useful if the training were oriented to training strategies that target everyday, functional memory tasks.

4. Train for transfer

A key aspect of memory training that warrants significantly more attention, is focusing training so that it fosters transfer of the instructed strategies to the individual memory challenges faced by the older adult. At present, the hope seems to be that older adults will acquire the trained strategies, recognize the everyday situations in which the trained strategies could be applied, and then map and adapt the trained strategies to the real-world situation. Let us consider for a moment the plausibility of this idea. One of the alarms being sounded about educational training is that young-adult students are not able to transfer what they have learned in school to job contexts. Classic research in cognitive psychology reinforces the observation that transfer of solution strategies is relatively poor, even when the transfer problem is given minutes after an analogous solution has been demonstrated to subjects (e.g., Gick & Holyoak, 1980). Why then should we expect that older adults, adults with declining cognitive function, would spontaneously transfer laboratory-trained memory strategies to everyday memory challenges? Though not impossible (see Lustig & Flegal, 2008, for evidence that training an encoding strategy in a laboratory task affected everyday memory performance), assuming that spontaneous transfer is not the norm, we suggest that a different approach is needed, and that classic research on memory and on skill learning may hold some answers.

For example, retention of acquired strategies can be facilitated by spacing the training of each strategy (or task) across the duration of training rather than massing training sessions in a short time-period (see Dempster, 1990). By increasing variation in the instances experienced during training, transfer can be increased (Bjork, 1994; Gick & Holyoak, 1983; Homa & Vosburgh, 1976; Posner & Keele, 1968). At the level of individual strategies or tasks, this would involve applying such strategies or tasks to varying stimuli across the course of training to avoid development of stimulus-specific procedures that prove brittle in transfer (see e.g., Healy, Wohldmann, Parker, & Bourne, 2005). At the level of multiple strategies or tasks, training on each should be interleaved with training of the others, thereby increasing the likelihood of transfer (e.g., Kerr & Booth, 1978; Shea & Morgan, 1979). In our ongoing EXACT trial, we have incorporated each of these principles in an effort to train cognitive control processes that are relevant to prospective memory, task-coordination (attention), and avoiding interference in retrospective memory. Over the course of 8 weeks, participants engage in three training sessions per week, with one session per week devoted to each of the modules just highlighted (e.g., retrospective memory). Importantly, within each module, participants encounter diverse stimuli from one week to the next. For example, in the domain of prospective memory, sessions range from asking participants to judge famous faces while trying to remember to press a particular key when they encounter a person wearing glasses, to engaging in a virtual driving task while trying to remember to press a key if they ever see a particular roadside object, to playing an active anagramming game using letter tiles while trying to remember to give the trainer a message at a certain time.

Although we are unaware of empirical support for the next suggestion, to explicitly foster transfer we believe that training should incorporate "homework" that guides the older adult to become attuned to situations to which the strategies can be applied and to practice the strategy in those situations. As an example, in our EXACT trial, following each training module (e.g., avoiding interference in retrospective memory), older adult participants are asked to envisage a real-world situation in which they might encounter interference in memory during the upcoming week, and develop a strategy for resolving this interference. A trainer provides feedback and helps guide them in identifying situation-strategy links. In their next memory training session, a week later, they report on the usefulness of their strategy and discuss other applications to daily life.

Another component that might enhance the effectiveness of memory training but that is not commonly incorporated into memory training programs is to provide older adults with an overview of how memory works (but see West et al., 2008), perhaps focusing on general techniques for committing information to memory (elaboration, organization) and for retrieving information from memory. This would provide older adults with the conceptual underpinnings of the trained strategies, thereby theoretically allowing older adults to transfer and adapt trained strategies, and perhaps even develop idiosyncratic strategies, to meet the challenges they encounter (e.g., interference; lack of retrieval cues; failure to monitor for environmental cues in prospective memory) during everyday remembering.

Finally, although we offered several examples of "memory" challenges (or tasks) above, another assumption guiding effective memory training must be that many real-world memory tasks do not necessarily reflect a single cognitive process (i.e., memory) akin to that isolated in laboratory tasks. Rather, everyday memory challenges almost certainly rely on a combination of attentional, memory, and cognitive (i.e., executive) control skills (e.g., task-management) and processes (Craik & Bialystok, 2006). As an example, remembering an individual's name following a conversation in a noisy room requires that one selectively attend to the name when communicated, at least briefly engage in the process of committing that name to memory while simultaneously attending to the ongoing conversation, and subsequently use an effective retrieval strategy to search for and select the correct name among the many names learned in that context. Accordingly, to enhance transfer to real-world tasks, we suggest that memory training include training across this range of component processes. Indeed, our aim of training participants to avoid interference in retrospective memory, to implement prospective memory strategies *and* to learn to effectively engage attention for task-coordination in the EXACT trial reflects our view that everyday tasks are not process-pure.

Extending the above theme, one potentially fruitful approach to supporting transfer may be to orient training more toward processes than strategies. As a concrete example, much work has suggested that older adults' memory decline is associated with increasing reliance on familiarity, rather than recollective processes (see McDaniel, Einstein, & Jacoby, 2008, for review). Accordingly, training might target recruitment of recollective processes to support memory performances, rather than defaulting to familiarity (see Jennings & Jacoby, 2003, for a successful illustration of this approach). Theoretically, recollective processes should be useful on a range of memory tasks, including everyday memory tasks, so that trained reliance on recollection might be expected to transfer to memory tasks that are not obviously similar to the training context. Initial work along these lines has been promising (Jennings et al., 2005), but more is needed.

5. Incorporate exercise training

In contrast to the limited transfer effects observed in response to memory training, aerobic exercise training has been shown to produce benefits to a range of "non-trained" tasks, including memory and cognitive control. In a seminal study, Kramer et al. (1999) demonstrated that engagement in a 6-month aerobic exercise (i.e., walking) intervention significantly enhanced performance on a range of cognitive control tasks (e.g., task-switching; interference resolution), a benefit that was not observed for a group who engaged in toning/stretching for an equivalent period. More recently, the benefits of aerobic exercise engagement have been shown to extend to the memory domain (Erickson et al., 2011). A provocative possibility that we are investigating in the EXACT trial is that the initiation of aerobic exercise training prior to cognitive (including memory) training may be an especially important feature for obtaining more robust transfer effects in cognitive training interventions (cf. Fabre, Chamari, Mucci, Masse-Biron, & Prefaut, 2002). This hypothesis is based in part on the neural benefits associated with aerobic exercise engagement, including increased prefrontal lobe volumes (Colcombe et al., 2003, 2006) and enhanced hippocampal/medial temporal lobe integrity (e.g., Bugg & Head, 2011; Erickson et al., 2011; Pereira et al., 2007; van Praag, 2008). Our theoretical assumption is that aerobic exercise may potentiate the functioning of prefrontal and hippocampal/medial temporal systems (among others) that subserve a range of cognitive processes (e.g., memory, attention, cognitive control), thereby boosting the likelihood that these systems can adequately acquire, retain and execute effortful strategies and perhaps better utilize them in coping with novel future inputs (i.e., transfer).

6. Conclusion

A wide range of memory training interventions exist both in the cognitive literature and on store shelves boxed in packages that purport to boost memory function. The promise of these interventions is enormous. Equally enormous is the challenge for researchers to develop empirically supported memory-training programs that lead to meaningful benefits. We suggest this goal can be achieved when training is developed with a comprehensive consideration of the theoretical assumptions underlying the training approach, the everyday mnemonic concerns and challenges faced by older adults, and the transferability of trained strategies to everyday target tasks.

References

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. *The Journal of the American Medical Association*, *288*, 2271–2281.

Baltes, P. B., & Kliegl, R. (1992). Further testing of limits of cognitive plasticity: Negative age differences in a mnemonic skill are robust. *Developmental Psychology*, *28*, 121–125.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin*, *128*, 612–637.

Bugg, J. M., & Head, D. (2011). Exercise moderates age-related atrophy of the medial temporal lobe. *Neurobiology of Aging*, *32*, 506–514.

Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe, & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185–205). Cambridge, MA: MIT Press.

Brain Trainer: 07. (2011, December). *Men's Health*, 135.

Camp, C. J., Foss, J. W., Stevens, A. B., & O'Hanlon, A. M. (1996). Improving prospective memory task performance in persons with Alzheimer's disease. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 351–367). Mahwah, NJ: Erlbaum.

Cohen, G., & Burke, D. M. (1993). Memory for proper names. *Memory*, *1*, 249–263.

Colcombe, S. J., Erickson, K. I., Raz, N., Webb, A. G., Cohen, N. J., McAuley, E., et al. (2003). Aerobic fitness reduces brain tissue loss in aging humans. *Journals of Gerontology*, *58A*, 176–180.

Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., et al. (2006). Aerobic exercise training increases brain volume in aging humans. *Journals of Gerontology*, *61A*, 1166–1170.

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. Klix, & H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performances* (pp. 409–422). North Holland, Amsterdam: Elsevier.

Craik, F. I. M., & Bialystok, E. (2006). Planning and task management in older adults: Cooking breakfast. *Memory & Cognition*, *34*, 1236–2124.

Dahlin, E., Neely, A. S., Larsson, A., Backman, L., & Nyberg, L. (2008). Transfer of learning after updating training mediated by the striatum. *Science*, *320*, 1510–1512.

Dempster, F. N. (1990). The spacing effect: A case study in the failure to apply the results of psychological research. *American Psychologist*, *43*, 627–634.

Dornburg, C. C., & McDaniel, M. A. (2006). The cognitive interview enhances long-term free recall of older adults. *Psychology and Aging*, *21*, 196–200.

Dunlosky, J., Bailey, H., & Hertzog, C. (2011). Memory enhancement strategies: What works best for obtaining memory goals? In P. E. Hartman-Stein, & A. La Rue (Eds.), *Enhancing cognitive fitness in adults: A guide to the use and development of community-based programs* (pp. 3–23). Springer Science.

Einstein, G. O., & McDaniel, M. A. (2004). *Memory fitness: A guide for successful aging*. Haven, CT: Yale University Press.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., et al. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.1015950108

Ericsson, K. A., Delaney, P. F., Weaver, G., & Mahadevan, R. (2004). Uncovering the structure of a memorist's superior basic memory capacity. *Cognitive Psychology*, *49*, 191–237.

Fabre, C., Chamari, K., Mucci, P., Masse-Biron, J., & Prefaut, C. (2002). Improvement of cognitive function by mental and/or individualized aerobic training in healthy elderly subjects. *International Journal of Sports Medicine*, *23*, 415–421.

Fisher, R. P., & Quigley, K. L. (1992). Applying cognitive theory in public health investigations: Enhancing food recall with the cognitive interview. In J. M. Tanur (Ed.), *Questions about questions: Inquiries into the cognitive basis of surveys* (pp. 154–169). New York: Russell Sage Foundation.

Gick, M. L., & Holyoak, K. (1980). Analogical problem solving. *Cognitive Psychology*, *12*, 306–355.

Gick, M. L., & Holyoak, K. (1983). Schema induction and analogical transfer. *Cognitive Psychology*, *15*, 1–38.

Gross, A. L., & Rebok, G. W. (2011). Memory training and strategy use in older adults: Results from the ACTIVE study. *Psychology and Aging*, *26*, 503–517.

Healy, A. F., Wohldmann, E. L., Parker, J. T., & Bourne, L. E. (2005). Skill training, retention, and transfer: The effects of a concurrent secondary task. *Memory & Cognition*, *33*, 1457–1471.

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2009). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest*, *9*, 1–65.

Homa, D., & Vosburgh, R. (1976). Category breadth and the abstraction of prototypical information. *Journal of Experimental Psychology: Human Learning and Memory*, *2*, 322–330.

Jennings, J. M., & Jacoby, L. L. (2003). Improving memory in older adults: Training recollection. *Neuropsychological Rehabilitation*, *13*, 417–440.

Jennings, J. M., Webster, L. M., Kleykamp, B. A., & Dagenbach, D. (2005). Recollection training and transfer effects in older adults: Successful use of a repetition-lag procedure. *Aging, Neuropsychology, and Cognition*, *12*, 278–298.

Kerr, R., & Booth, B. (1978). Specific and varied practice of motor skill. *Perceptual and Motor Skills*, *46*, 395–401.

Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., et al. (1999). Aging, fitness, and neurocognitive function. *Nature*, *400*, 418–419.

Liu, L. L., & Park, D. C. (2004). Aging and medical adherence: The use of automatic processes to achieve effortful retrieval. *Psychology and Aging*, *19*, 318–325.

Lustig, C., & Flegal, K. E. (2008). Targeting latent function: Encouraging effective encoding for successful memory training and transfer. *Psychology and Aging*, *23*, 754–764.

Lustig, C., Shah, P., Seidler, R., & Reuter-Lorenz, P. A. (2009). Aging, training, and the brain: A review and future directions. *Neuropsychology Review*, *19*, 504–522.

Mahncke, H. W., Connor, B. B., Appelman, J., Ahsanuddin, O. N., Hardy, J. L., Wood, R. A., et al. (2006). Memory enhancement in healthy older adults using a brain plasticity-based training program: A randomized, controlled study. *Proceedings of the National Academy of Sciences*, *103*, 12523–12528.

Managing medications. (2011, June). *Money*, 92.

McCauley, M. R., & Fisher, R. P. (1995). Facilitating children's recall with the revised cognitive interview. *Journal of Applied Psychology*, *80*, 510–516.

McDaniel, M. A., & Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Thousand Oaks, CA: Sage Publications.

McDaniel, M. A., Einstein, G. O., & Jacoby, L. L. (2008). New considerations in aging and memory: The glass may be half full. In F. Craik, & T. Salthouse (Eds.), *The handbook of aging and cognition* (3rd ed., pp. 251–310). New York, NY: Psychology Press.

McDaniel, M. A., & Kearney, E. M. (1984). Optimal learning strategies and their spontaneous use: The importance of task appropriate processing. *Memory & Cognition*, *12*, 361–373.

Mello, E. W., & Fisher, R. P. (1996). Enhancing older adult eyewitness memory with the cognitive interview. *Applied Cognitive Psychology*, *10*, 403–417.

Mozolic, J. L., Hayasaka, S., & Laurienti, P. J. (2010). A cognitive training intervention increases resting cerebral blood flow in healthy older adults. *Frontiers in Human Neuroscience*, *4* doi:10.3389/neuro.09.016.2010

Neely, A. S., & Backman, L. (1995). Effects of multifactorial memory training in old age: Generalizability across tasks and individuals. *Journal of Gerontology: Psychological Sciences*, *50B*, 134–140.

Park, D. C., & Kidder, D. (1996). Prospective memory and medication adherence. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 369–390). Mahwah, NJ: Erlbaum.

Pereira, A., Ribeiro, S., Wiest, M., Moore, L. C., Pantoja, J., Lin, S-C., et al. (2007). Processing of tactile information by the hippocampus. *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 18286–18291.

Posner, M. I., & Keele, S. W. (1968). On the genesis of abstract ideas. *Journal of Experimental Psychology*, *77*, 353–363.

Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skill*. Boston, MA: Harvard University Press.

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor-skill. *Journal of Experimental Psychology: Human Learning and Memory*, *5*, 179–187.

Shimamura, A. P., Berry, J. M., Mangels, J. A., Rusting, C. L., & Jurica, P. J. (1995). Memory and cognitive abilities in university professors: Evidence for successful aging. *Psychological Science*, *6*, 271–277.

Smith, G. E., Housen, P., Yaffe, K., Ruff, R., Kennison, R. F., Mahncke, H. W., et al. (2009). A cognitive training program based on principles of brain plasticity: Results from the improvement in memory with plasticity-based adaptive cognitive training (IMPACT) study. *Journal of the American Geriatrics Society*, *57*, 594–603.

Stine-Morrow, E. A. L., Parisi, J. M., Morrow, D. G., & Park, D. C. (2008). The effects of an engaged lifestyle on cognitive vitality: A field experiment. *Psychology and Aging*, *23*, 778–786.

Thompson, C. P., Cowan, T. M., & Frieman, J. (1993). *Memory search by a memorist*. Hillsdale. NJ: Erlbaum.

van Praag, H. (2008). Neurogenesis and exercise: Past and future directions. *Neuromolecular Medicine*, *10*, 128–140.

Verhaeghen, P., Marcoen, A., & Goosens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging*, *7*, 242–251.

West, R. L., Bagwell, D. K., & Dark-Freudeman, A. (2008). Self-efficacy and memory aging: The impact of a memory intervention based on self-efficacy. *Aging, Neuropsychology, & Cognition*, *15*, 302–329.

Zelinski, E. M., Yaffe, K., Smith, G. E., Ruff, R., & Kennison, R. F. (2008). The IMPACT study: A randomized controlled trial of a brain plasticity-based training program for age-related cognitive decline. *Journal of the American Geriatrics Society*, *56*, S199.