Published in final edited form as:
Am J Geriatr Psychiatry. 2012 June ; 20(6): 514–523. doi:10.1097/JGP.0b013e318227f821.

The Memory Fitness Program: Cognitive Effects of a Healthy Aging Intervention

Karen J. Miller, Ph.D., **Prabha Siddarth, Ph.D.**, **Jean M. Gaines, Ph.D., R.N.**, **John M. Parrish, Ph.D.**, **Linda M. Ercoli, Ph.D.**, **Katherine Marx, M.P.H.**, **Judah Ronch, Ph.D.**, **Barbara Pilgram, M.A.**, **Kasey Burke, B.A.**, **Nancy Barczak, R.N., M.S.**, **Bridget Babcock, B.A.**, and **Gary W. Small, M.D.**

Division of Geriatric Psychiatry, Memory and Aging Research Center, Semel Institute for Neuroscience and Human Behavior, University of California, Los Angeles (KJM, PS, LME, GWS); The Erickson Foundation (JMG, JMP, KM, KB), Erickson Retirement Communities (JR, BP, NB, BB), and The Erickson School (JR), University of Maryland–Baltimore County, Baltimore

Abstract

Context—Age-related memory decline affects a large proportion of older adults. Cognitive training, physical exercise, and other lifestyle habits may help to minimize self-perception of memory loss and a decline in objective memory performance.

Objective—The purpose of this study was to determine whether a 6-week educational program on memory training, physical activity, stress reduction, and healthy diet led to improved memory performance in older adults.

Design—A convenience sample of 115 participants (mean age: 80.9 [SD: 6.0 years]) was recruited from two continuing care retirement communities. The intervention consisted of 60-minute classes held twice weekly with 15–20 participants per class. Testing of both objective and subjective cognitive performance occurred at baseline, preintervention, and postintervention. Objective cognitive measures evaluated changes in five domains: immediate verbal memory, delayed verbal memory, retention of verbal information, memory recognition, and verbal fluency. A standardized metamemory instrument assessed four domains of memory self-awareness: frequency and severity of forgetting, retrospective functioning, and mnemonics use.

Results—The intervention program resulted in significant improvements on objective measures of memory, including recognition of word pairs ($t_{[114]} = 3.62$, $p < 0.001$) and retention of verbal information from list learning ($t_{[114]} = 2.98$, $p < 0.01$). No improvement was found for verbal fluency. Regarding subjective memory measures, the retrospective functioning score increased

Send correspondence and reprint requests to Karen Miller, Ph.D., UCLA Center on Aging, PVUB, Suite 3119, 10945 Le Conte Ave, Los Angeles, CA 90095. kmiller@mednet.ucla.edu.

Author contributions: Miller, Siddarth, Parrish, Gaines, and Small had full access to the data in the study and take responsibility for the integrity of the data and the accuracy of the data analyses. Study concept and design: Miller, Siddarth, Gaines, Parrish, Ercoli, Ronch, Pilgram, and Small. Acquisition of data: Gaines, Parrish, Marx, Ronch, Pilgram, Burke, Barczak, and Babcock. Analysis and interpretation of data: Miller, Siddarth, Gaines, Parrish, and Small. Drafting of the manuscript: Miller, Siddarth, Gaines, and Parrish. Critical revision of the manuscript for important intellectual content: Miller, Siddarth, Gaines, Parrish, and Small. Financial disclosures: Dr. Small reports having served as a consultant and/or having received lecture and stock options in Dakim, Inc. Drs. Miller and Siddarth report having received grant support from Dakim, Inc.

significantly following the intervention ($t_{[114]} = 4.54$, $p < 0.0001$), indicating perception of a better memory.

Conclusions—These findings indicate that a 6-week healthy lifestyle program can improve both encoding and recalling of new verbal information, as well as self-perception of memory ability in older adults residing in continuing care retirement communities.

Keywords

Community setting; healthy lifestyle; memory training; older adult

---

Successful aging has been defined as maintaining both cognitive and physical health throughout life.[1] Age-related memory decline affects approximately 40% of older adults and is characterized by a self-perception of memory loss and a decline in objective memory performance. This memory decline has been termed age-associated memory impairment.[2] Although it may cause anxiety in some people, particularly those with a family history of dementia, it is generally stable and is not a risk factor for Alzheimer disease. By contrast, people with more severe forms of age-related cognitive decline, such as mild cognitive impairment, have an increased risk for developing dementia.[3]

Despite such declines with aging, memory demonstrates “plasticity,” or the potential for modification, and there are individual differences in plasticity.[4] Several lines of evidence indicate that learning and mental activity are associated with improved cognitive functioning and/or lower dementia risk. For example, people with advanced education and professional accomplishments tend to have greater density of neuronal connections in brain areas involved in complex reasoning.[5] Epidemiologic studies indicate that increased frequency of engaging in everyday mental or leisure activities (e.g., reading, watching the news, dancing, or playing board games) is associated with significantly reduced risk for developing dementia or cognitive decline,[6–8] although such human studies have not definitely proven a causal relationship between mental stimulation and lower dementia risk.

Clinical trials have shown that interventions of memory training techniques improve cognition in older adults. The memory techniques, often called “mnemonics,” involve the use of attentional strategies, verbal associations, visual imagery, and methods to organize and retrieve stored information.[9–12] Applying these strategies provides personally meaningful cues that can be used for recalling information later on.

Clinical trials on the effects of specific memory strategies, such as visualization and association, have been shown to improve memory, reasoning, and mental speed as measured by neuropsychological testing and everyday memory measures in younger and older adults.[10,12–18] Increased brain activity has been associated with learning specific techniques, like the Loci Mnemonics.[19] A meta-analysis of memory training in older adults showed that memory gains are large (0.73 effect size [ES]) compared with control (0.37) and placebo (0.38) conditions.[10] Benefits from memory training are robust and may last from 6 months to up to 5 years,[10–12] including a possible delay in driving cessation when completing speed of processing training.[20] However, it is also important to recognize that such factors as compliance with training and beliefs about one’s ability to enhance their memory (i.e.,

NIH-PA Author Manuscript

NIH-PA Author Manuscript

controllability or self-efficacy) contribute to an individual's abilities in successfully applying mnemonic techniques, and that it has been difficult to establish evidence to generalize the effects of training to everyday tasks.[21]

Memory training interventions involving mnemonic strategies generally benefit older adults with mild age-related cognitive complaints, but not those with severe cognitive impairments or dementia.[22,23] In fact, previous research on persons with dementia or mild cognitive impairment showed minimal gains[24] or even lower performance scores[25] following memory training. However, recent research suggests that training may improve memory in people with mild cognitive impairment, particularly in episodic memory (list recall and face–name association).

In addition to memory strategies, other components of effective memory training interventions in healthy older adults often include education about memory in general, pretraining (i.e., teaching the basic elements of memory training before teaching specific techniques), small group settings to encourage discussion, relatively brief sessions (≤2 hours), and use of home practice exercises assignments.[10,26] Thus, the most effective approaches to memory enhancement may involve a "multifactorial" approach.[10,27]

In a previous pilot study, our group found that a short-term memory training intervention resulted in improved verbal recall for older adults with normal cognition compared with baseline relative to a health education control condition.[15,16] In another study,[28] we also found that a 2-week healthy lifestyle intervention, including daily physical conditioning, healthy diet, and relaxation and memory training exercises, led to improved verbal fluency and significant changes in cerebral glucose metabolism measured by positron emission tomography scans during mental rest. These changes were localized to the left dorsolateral prefrontal cortex, a brain region that modulates working memory and verbal fluency. Other studies indicate that mental activity results in alterations in activity of other cortical brain regions modulating cognition.[29,30]

Despite the effectiveness of memory training interventions in clinical trials, few community-based programs exist, and their effects have not been systematically tested. The primary objective of this study was to examine the effects of a community-based memory training program developed from previous studies indicating the potential cognitive and brain health benefits from combining healthy lifestyle and memory training strategies.[28,31] In association with the Erickson Foundation, a foundation that engages in research as well as philanthropy, we assessed the effectiveness of this 6-week, 12-session community intervention, which focuses on improving memory functioning in older adults.

The memory improvement techniques included exercises for association and visual imagery,[10,11,13] as well as education about memory, pretraining (i.e., teaching the basic elements of memory training before teaching specific techniques), and assignment of home practice exercises. Sessions lasting 1 hour were taught in small groups of 15–20 participants. In conjunction with the focus on exercises to improve memory, the program included information on healthy nutrition, physical exercise, and stress reduction. All aspects of the memory training methods were scripted into a standardized curriculum that was used to teach the community-residing older adults. We hypothesized that those who attended the intervention program would experience improved objective and subjective memory abilities compared with control subjects who were placed on a waiting list and did not attend the program.

METHODS

Participants

A convenience sample of participants was recruited from two of Erickson's continuing care retirement communities. Candidate participants responded to advertisements at the facilities (e.g., recruitment flyers, scripted interviews on closed-circuit cable television stations, information packets presented at community reception desks). Those interested signed a contact sheet or called into a toll-free telephone line. Staff from the Erickson Foundation then called the interested individuals, reviewed the details of the study with the prospective participants, and scheduled an individual appointment for obtainment of informed consent and a baseline interview.

Inclusion criteria for participation were as follows: 1) at least 62 years old (criterion for entrance into an Erickson Community), 2) living at the independent level of care, and 3) expressing complaints about memory loss. Exclusion criteria were as follows: 1) having a physical condition rendering one incapable of physical exercise; 2) previous diagnosis of dementia (determined by their physicians and reported by the participant during the screening process); 3) use of medication for memory loss; 4) currently enrolled in another memory enhancement course; 5) unwilling to commit to a 6-week (12-session) course; 6) scoring 24 or lower on the Mini-Mental State Examination (MMSE);[32] and 7) failure to pass the age-based cutoff scores on three of the four memory tests administered at baseline. The program was approved by the institutional review board at the University of California, Los Angeles, and the Erickson Foundation's Research Advisory Team.

Measures and Study Design

Participants were prescreened using the MMSE, and those performing less than 24 were referred to their physicians for additional memory testing. If participants scored 24 or higher on the MMSE, additional tests were performed, including the Wechsler Memory Scale–III Verbal Paired Associates I and II (WMS–III, VPA),[33] and the Hopkins Verbal Learning Test–Revised (HVLT-R).[34–36] Participants who scored within normal limits (>16th percentile for same age peers) on 3 out of 4 of the memory tests (Verbal Paired Immediate Recall, Verbal Paired Delayed Recall, HVLT-R Immediate Recall, and HVLT-R Delayed Recall) were included in the study. Upon entry into the study, participants also received the Controlled Oral Word Association Test (COWAT).[37] In addition to the objective memory tests, participants completed a subjective assessment of memory functioning: the Memory Functioning Questionnaire (MFQ).[38] The MFQ is a 64-item scale used to identify the frequency and severity of forgetting, retrospective functioning, and mnemonics use. All questions are rated on a seven-point scale with anchors at each end (i.e., 1 for *always* to 7 for *never*). The maximum score for frequency of forgetting is 231, with higher scores indicating fewer forgetting incidents (sample item: "How often do recalling faces present a problem for you?"). The maximum score for severity of forgetting is 126, with higher scores indicating less serious forgetting (sample item: "When you actually forget in these situations, how serious of a problem do you consider your memory failure to be?"). The maximum score for retrospective functioning is 35, with higher scores indicating a better memory today than in the past (sample item: "How is your memory compared to the way it was one year ago?"). The maximum score for mnemonics use is 64, with higher scores indicating less use (sample item: "How often do you use an appointment book to remind yourself of things?").[38]

After testing, subjects were randomized into the treatment group (memory fitness curriculum) or the control group (wait-list). Demographic variables, including age, gender, marital status, ethnicity, highest level of education achieved, and annual income, were obtained. Current medical conditions were self-reported and measures of height and weight were taken.

Using a sequential study design, four cohorts were recruited for three classes of the memory fitness curriculum (see Figure 1). The wait-list cohort from one class became the intervention cohort in the next class. For example, Cohort 2 served as the wait-list comparison group for Cohort 1 before becoming the second cohort to receive the intervention. In this design, participants were tested up to three times: baseline, preintervention (defined as 7 weeks after baseline but before taking the memory class), and postintervention (defined as after taking the memory class). Cohort 4, for ethical considerations, was given the option of attending the class 2 months after the completion of the study but no posttesting was done.

Intervention

Twelve Erickson Retirement Community employees were selected as trainers for the memory fitness study. Trainers had academic backgrounds in exercise physiology, health promotion management, nursing, gerontology, social work, community health education, or psychology. The memory fitness instructors were responsible for scheduling of classes, determination of class size and composition, achieving program space requirements and room setup, detailing the nature and scope of responsibilities for both instructors and participants, attendance tracking, individual class curricula preparation, monitoring of class content, acquisition of handouts, and other relevant tasks (i.e., handling absences from class, reminders to attend). Each trainer was provided a copy of a comprehensive trainer's manual that was reviewed prior to the first class and each trainer received instructions on how to implement the course by the master instructor (i.e., by one of the authors of the memory fitness curriculum). They also received instructions to contact the project planners with questions related to the trainers' responsibilities and/or class curricula. An external evaluation of the training class was obtained at Site A during Class 2 for sessions 1, 3, 8, and 10 to assess the fidelity of the implementation of the memory fitness program. No discrepancies from protocol were noted during these sessions.

Drs. Gary Small and Karen Miller developed a scripted curriculum for trainers and a companion workbook for participants. Both resources are structured into 12 sessions focused on memory enhancement, stress reduction exercises, and information about nutrition and physical activity. The instructor's manual and student workbook are designed to complement the book *The Memory Prescription*,[31] which the participants also received as part of the course. Homework was assigned at the close of each class and reviewed during the next class. The memory enhancement aspect of the curriculum included pretraining, association, visual imagery, and linkage exercises (with a focus upon the "Look–Snap–Connect" method), the story method, chunking, remembering names and faces, everyday memory skills, and reviews of each of the presented memory mnemonic techniques.

Analysis

The baseline demographics (age, sex, education, and income) of the three cohorts were compared using χ^2 statistics for the categorical measures and analysis of variances for the continuous measures. The three cohorts were also compared on their attendance of the intervention sessions.

To evaluate the effects of the intervention, five cognitive domains—immediate memory (WMS–III, VPA I: total learning, and HVLT-R total learning), delayed memory (WMS–III, VPA II, delayed recall, and HVLT-R delayed recall), memory retention (WMS–III, VPA, and HVLT-R), memory recognition (WMS–III, VPA, and HVLT-R), and verbal fluency (COWAT, animals, fruits, or vegetables)—were assessed. The raw scores were used as the outcome measures. In addition, the four factor scores from the MFQ were used to evaluate changes in subjective memory following the intervention. We estimated general linear mixed models (as implemented in SAS PROC MIXED), with the cognitive scores as the dependent variables and time (baseline, preintervention, and postintervention) as the within-subject factor. Similar models were estimated for the MFQ factor scores as well. The general linear mixed model permits analysis of repeated measures with missing data, thus allowing us to use all of the participants' data, irrespective of whether the subject was evaluated at all three time points. For example, although Cohorts 2 and 3 underwent testing at three time points and Cohorts 1 and 4 were assessed only twice, a mixed model analysis was used because it allows the use of all the data to estimate the parameters. Post-hoc analyses were conducted to determine whether participants improved from baseline (t_0) to preintervention (t_1) testing as well as from pre- to postintervention (t_2) testing. All significance levels within a cognitive domain were Tukey adjusted to take into account multiple comparisons. Effect sizes for the changes (ES[$t_1 - \mathrm{t}_0$] and ES($t_2 - t_1$]) as well as 90% confidence intervals (CIs) for the effect sizes were calculated to examine whether the observed changes can be attributed to practice effects or intervention effects. If the CIs of the changes overlap, then the improvements seen pre- to postintervention are similar in magnitude to those seen from baseline to preintervention. Such similar improvements may be attributed to practice effects. However, if the CIs do not overlap, and more specifically if the upper bound of the ES($t_1 - t_0$) CI is less than the lower bound of the ES($t_2 - t_1$) CI, then the improvement seen from t_2 to t_1 can be attributed to the intervention.

RESULTS

Baseline appointments were made with a total of 135 residents from the two campuses: 72 (53.3%) from campus A and 63 (46.7%) from campus B. At baseline testing, 20 (14.8%) residents were determined to be ineligible and 115 (85.2%) residents were assigned to groups. From baseline to postintervention testing, 21 (18.3%) residents withdrew from the study. The sample of 115 participants had a mean age of 81.0 (SD: 6.0) years, with 91 women enrolled (Table 1). Ninety-eight percent of the participants were white; 68% reported having a college degree or higher. The mean score on the MMSE was 28.6 (SD: 1.3). The mean class attendance was 9.3 (SD: 2.9; range: 3–12) sessions out of 12. The three cohorts did not differ significantly in age, sex, education, income, or class attendance. In addition, there were no significant differences from the program completers and the dropouts in terms of demographic information (age, gender, race, educational level, MMSE scores). Table 2 presents the performance of the study participants on neuropsychological measures at each time point, in addition to their responses to the MFQ in regard to their subjective impressions of the impact of the planned intervention on their memory-related capacities. General linear mixed models revealed that participants improved from baseline to postintervention on several aspects of memory. More specifically, *immediate memory for verbal pairs* (WMS–III, VPAI) improved from baseline testing to preintervention testing ($t_{[114]} = 7.23$, $p < 0.0001$; ES[$-t_1 - t_0$] = 0.37) and from pre- to postintervention testing ($t_{[114]} = 6.56$, $p < 0.0001$; ES[$t_2 - t_1$] = 0.32). *Delayed memory for verbal pairs* (WMS–III, VPAII) also improved from both baseline testing to preintervention testing ($t_{[114]} = 3.06$, $p < 0.008$; ES[$t_1 - t_0$] = 0.19) and from pre- to postintervention testing ($t_{[114]} = 2.70$, $p < 0.02$; ES[$t_2 - t_1$] = 0.12). However, the 90% CIs for the changes ES($t_1 - t_0$) and ES($t_2 - t_1$) overlap for these two measures, indicating that similar improvements are observed from baseline to preintervention as from pre- to postintervention. Hence, these improvements may be attributed to practice effects. Regarding *recognition memory* for the word pairs (WMS–III, VPA), there was no significant change from baseline testing to preintervention testing (ES[$t_1 - t_0$] = 0.07). However, there was a significant improvement from pre- to postintervention testing ($t_{[114]} = 3.62$, $p < 0.001$; ES[$t_2 - t_1$] = 0.39). The 90% CIs for these two changes (ES[$t_1 - t_0$] = [−0.06, 0.20]; ES[$t_2 - t_1$] = [0.23, 0.55]) do not overlap. In particular, the upper bound of the CI for the $t_1 - t_0$ change is less than the lower bound of the $t_2 - t_1$ change, indicating that the observed postintervention change in recognition memory performance is attributable to the intervention. No statistically significant differences in retention memory (WMS–III, VPAII) were detected over time. As for *retention of list learning* (HVLT-R), there was no significant change from baseline testing to preintervention testing (ES[$t_1 - t_0$] = 0.02). However, a significant improvement from pre- to postintervention testing ($t_{[114]} = 2.98$, $p < 0.01$; ES[$t_2 - t_1$] = 0.34) was observed. The 90% CIs for these changes (ES[$t_1 - t_0$] = [−0.13, 0.17]; ES[$t_2 - t_1$] = [0.19, 0.49]) do not overlap, indicating that improvements are related to the intervention rather than to practice effects. There were no additional differences in immediate memory (i.e., total recall), delayed memory (i.e., delayed recall), or recognition for the list-learning task (HVLT-R). Finally, while verbal fluency (COWAT-Letter Fluency) improved from baseline to preintervention testing ($t_{[114]} = 2.61$, $p < 0.03$), no significant change from pre- to postintervention was noted. Among the four MFQ measures, only the retrospective functioning score increased significantly ($t_{[114]} = 4.54$, $p < 0.0001$) from pre- (14.09 [0.42]) to postintervention testing (16.43 [0.56]), with a higher score indicating a belief in having better memory.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

DISCUSSION

We found that a 6-week, 12-session healthy aging intervention led to improvement in both objective and subjective memory measures. These results are consistent with previous studies demonstrating memory enhancement in older adults.[10,12–17] However, the current results are unique in that they show that such interventions may be effective with residents of continuing care retirement communities, nearly 90% of whom are among the older-old (75+) or oldest-old (85+).

The participants improved on the objective memory tasks for word pairs (recognition) and a list of semantically related words (retention), suggesting that they improved their ability to learn and retain new verbal information. For example, participants improved in their ability to recall word pairs, at both immediate and delayed recalls. In addition, they were more likely to retain the information from the list-learning task. We believe that these improvements are likely to be associated with the techniques that are taught in the memory fitness program, including 1) the Look–Snap–Connect technique,[39] which provides a simple approach to combining attention, visualization, and association techniques, and 2) the Story Method, which builds on the Look–Snap–Connect method so that the participant makes up a story to facilitate encoding and retrieval of a list of unrelated words. In the aggregate, participants also demonstrated improved subjective memory (i.e., retrospective self-assessment of memory), suggesting that many of them believe their memory functioning benefited from the delivered intervention.

Previous studies indicate that research participants are more likely to improve on tasks that are specifically related to the techniques taught in a particular intervention.[10] However, recent investigations suggest that generally available strategies or a given person's idiosyncratic (i.e., self-generated) memory techniques can also be effective in improving memory performance.[14,40] Because the Look–Snap–Connect technique focuses on creating a blend of images for two words, and eventually a list of words into a story, this method may have facilitated the participants' ability to visualize and encode the list of words. Alternatively, it may be that the summation of strategies taught in the program improved overall memory functioning. In addition, self-awareness of improved memory, as measured by the subjective memory score, may encourage individuals to maintain healthy lifestyle choices, including the use of memory techniques on a daily basis.

The study is not without limitations. In particular, the homogenous settings resulted in a sample that was predominantly white and of a relatively high socioeconomic status. Furthermore, we did not measure intelligence quotient and mood functioning. Moreover, the use of multiple testing sessions (baseline, preintervention, and postintervention) may have resulted in a practice effect or a familiarization with neuropsychological testing. This effect has the potential to reduce or negate group differences. However, even with the possible presence of this effect, a statistically significant change from preintervention to postintervention persisted when measuring select aspects of memory. We acknowledge that an additional limitation of this study design is that it did not include a formal control condition (i.e., randomized controlled study). Finally, it is yet to be determined to what extent, if at all, demonstrated performance improvements on formal neuropsychological measures generalized to everyday life functioning.[21]

The current intervention differed from most other cognitive training courses, in that, in addition to cognitive training techniques, it included education on lifestyle factors that might influence cognitive decline, such as stress-reduction exercises, healthy diet rich in antioxidants, and regular physical exercise (e.g., daily walking or swimming). Thus, the current study expands upon recent evidence that the role of lifestyle and environmental factors can be neuroprotective against the development of Alzheimer disease and other forms of cognitive decline.[41] In our group's earlier study,[28] participants in the experimental group received a manual that detailed a 14-day program, consisting of memory mnemonics, mind-teasers, solving puzzles, mazes, and other specific strategies (e.g., Look–Snap–Connect). In addition to memory techniques, the healthy lifestyle program included daily cardiovascular exercises, diet and recipe recommendations, and relaxation strategies. Pre- and posttesting revealed that the intervention group demonstrated significant improvements on objective measures of verbal fluency. Concomitant positron emission tomography scanning revealed a 5% decrease in activity in the left dorsolateral prefrontal cortex, an area associated with working memory, semantic organization skills, anxiety, and verbal fluency, which was consistent with the emergence of greater cognitive efficiency in the intervention group than in the control group, which continued with its usual lifestyle habits.[28]

The memory fitness program was adapted from this previous program for use in a community setting. Rather than subjects following a manual on their own, instructors presented the material in class sessions over a longer time period (6 weeks versus 2 weeks). The curriculum content was reinforced through self-guided exercises, homework assignments, and reviews during class. These changes in the program, particularly teaching it twice weekly over 6 weeks, appeared to be well-received in this community setting. On average, participants attended 9 of the 12 sessions, and many demonstrated significant improvements in several cognitive measures. A potentially substantial advantage of this particular program is that it is relatively affordable to execute in terms of requisite expertise, time, effort, and money, given its reliance on a low-tech classroom format that is readily scalable for application with diverse adult populations.

The work presented here is exploratory and preliminary in many respects. To our knowledge, it is the first field trial of its type completed with the memory fitness curriculum in collaboration with older-old or oldest-old volunteers. Given this, we were especially eager to assess the feasibility of offering this curriculum to this at-risk, yet often motivated and underserved segment of our adult population. We recommend that investigators interested in contributing to this line of programmatic inquiry aim to amass a much larger, more diverse sample of older persons. With such a sample, and an adequate project budget at hand, future investigators can implement a randomized controlled trial with a more in-depth panel of metrics that better mitigate against threats to internal validity than the quasi-experimental design we were able to accomplish. Also, in such a context it may be feasible to pursue a multiple discriminant analysis built, at least in part, upon completion of general medical and psychiatric histories at baseline, and recurrent assessment of mood status, among other potentially contributing or confounding variables of interest to experts in brain–behavior relationships, and those practitioners striving to deliver evidence-based services on behalf of the cognitive health and wellness of older persons.

In summary, our results suggest that the memory fitness program is effective in improving memory performance and may generalize to a real-world setting. It is designed to be taught by practitioners in the community in a cost-effective classroom setting. As a community-based educational intervention, the program has the potential to meet the community's need for an affordable and sustainable memory program over time.

Acknowledgments

This study was supported by the Fran and Ray Stark Foundation Fund for Alzheimer's Disease Research, the Judith Olenick Elgart Fund for Research on Brain Aging, and the Parlow-Solomon Professorship. No company or foundation provided monetary support of any kind for this study.

References

1. Rowe JW, Kahn RL. Successful aging. Aging (Milano). 1998; 10:142–144. [PubMed: 9666196]
2. Crook TH, Larrabee GJ, Youngjohn JR. Diagnosis and assessment of age-associated memory impairment. Clin Neuropharmacol. 1990; 13(suppl 3):S81–S91. [PubMed: 2093420]
3. Petersen RC. Mild cognitive impairment as a diagnostic entity. J Intern Med. 2004; 256(3):183–194. [PubMed: 15324362]
4. Baltes, PB.; Willis, SL. Plasticity and enhancement of intellectual functioning in old age: Penn State's Adult Development and Enrichment Project (ADEPT), in Aging and Cognitive Processes. Craik, FIM.; Trehub, E., editors. New York: Plenum Press; 1982. p. 353-389.
5. Del Ser T, Hachinski V, Merskey H, et al. An autopsy-verified study of the effect of education on degenerative dementia. Brain. 1999; 122:2309–2319. [PubMed: 10581224]
6. Verghese J, Lipton RB, Katz MJ, et al. Leisure activities and the risk of dementia in the elderly. N Engl J Med. 2003; 348:2508–2516. [PubMed: 12815136]
7. Wilson RS, Bennett DA, Bienias JL, et al. Cognitive activity and incident AD in a population-based sample of older persons. Neurology. 2002; 59(12):1910–1914. [PubMed: 12499482]
8. Wilson RS, Bennett DA, Bienias JL, et al. Cognitive activity and cognitive decline in a biracial community population. Neurology. 2003; 61:812–816. [PubMed: 14504326]
9. Yesavage JA, Rose TL. Semantic elaboration and the method of loci: a new trip for older learners. Exp Aging Res. 1984; 10:155–159. [PubMed: 6519145]
10. Verhaeghen P, Marcoen A, Goossens L. Improving memory performance in the aged through mnemonic training: a meta-analytic study. Psychol Aging. 1992; 7:242–251. [PubMed: 1535198]
11. O'Hara R, Brooks JO, Friedman L, et al. Long-term effects of mnemonic training in community-dwelling older adults. J Psychiatr Res. 2007; 41:585–590. [PubMed: 16780878]
12. Willis SL, Tennstedt SL, Marsiske M, et al. ACTIVE study group: long-term effects of cognitive training on everyday functional outcomes in older adults. JAMA. 2006; 296:2805–2814. [PubMed: 17179457]
13. Ball K, Berch DB, Helmers KF, et al. Effects of cognitive training interventions with older adults. JAMA. 2002; 288:2271–2281. [PubMed: 12425704]
14. Cavallini E, Pagnin A, Vecchi T. Aging and everyday memory: the beneficial effect of memory training. Arch Gerontol Geriatr. 2003; 37(3):241–257. [PubMed: 14511850]
15. Ercoli, LM.; Crowe-Lear, T.; Siddarth, P., et al. The effects of memory enhancement training on verbal memory in healthy older adults. Paper presented at: American Association for Geriatric Psychiatry Annual Meeting; San Diego, CA. 2005.
16. Ercoli, L.; David, S.; Siddarth, P., et al. Memory enhancement training effects in healthy older adults compared to health education and wait list conditions. Abstracts from the 35th Annual Meeting of the International Neuropsychological Society; Portland, OR. 2007.

17. Valentijn SA, van Hooren SA, Bosma H, et al. The effect of two types of memory training on subjective and objective memory performance in healthy individuals aged 55 years and older: a randomized controlled trial. Patient Educ Couns. 2005; 57:106–114. [PubMed: 15797159]
18. Smith GE, Housen P, Yaffe K, et al. A cognitive training program based on principles of brain plasticity: results from the Improvement in Memory with Plasticity-based Adaptive Cognitive Training (IMPACT) study. J Am Geriatr Soc. 2009; 57(4):594–603. [PubMed: 19220558]
19. Nyberg L, Sandblom J, Jones S, et al. Neural correlates of training-related memory improvement in adulthood and aging. Proc Natl Acad Sci USA. 2003; 100(23):13728–13733. [PubMed: 14597711]
20. Edwards JD, Delahunt PB, Mahncke HW. Cognitive speed of processing training delays driving cessation. J Gerontol A Biol Sci Med Sci. 2009; 64(12):1262–1267. [PubMed: 19726665]
21. Owen AM, Hampshire A, Grahn JA, et al. Putting brain training to the test. Nature. 2010; 465(7299):775–778. [PubMed: 20407435]
22. Cahn-Weiner DA, Malloy PF, Rebok GW, et al. Results of a randomized placebo-controlled study of memory training for mildly impaired Alzheimer's disease patients. Appl Neuropsychol. 2003; 10(4):215–223. [PubMed: 14690802]
23. Bellezza, FS. Mnemonic-device instruction with adults, in Cognitive Strategy Research: Psychological Foundations. Pressley, M.; Levin, JR., editors. New York: Springer-Verlag; 1983. p. 51-73.
24. Yesavage JA. Degree of dementia and improvement with memory training. Clin Gerontol. 1982; 1:77–81.
25. Zarit SH, Zarit JM, Reever KE. Memory training for severe memory loss: effects on senile dementia patients and their families. Gerontologist. 1982; 4:373–377. [PubMed: 7129168]
26. Brooks JO, Friedman L, Pearman AM, et al. Mnemonic training in older adults: effects of age, length of training, and type of cognitive pretraining. Int Psychogeriatr. 1999; 11:75–84. [PubMed: 10189601]
27. Floyd M, Scogin F. Effects of memory training on the subjective memory functioning and mental health of older adults: a meta-analysis. Psychol Aging. 1997; 12:150–161. [PubMed: 9100276]
28. Small GW, Silverman DHS, Siddarth P, et al. Effects of a 14-day healthy longevity lifestyle program on cognitive and brain function. Am J Geriatr Psychiatry. 2006; 14:538–545. [PubMed: 16731723]
29. Haier RJ, Siegel BV Jr, MacLachlan A, et al. Regional glucose metabolic changes after learning a complex visuospatial/motor task: a positron emission tomographic study. Brain Res. 1992; 570:134–143. [PubMed: 1617405]
30. Chan AS, Cheung MC. Pre-activating the mesial temporal lobe facilitates learning. Neurosci Lett. 2007; 411:194–199. [PubMed: 17125924]
31. Small, GW.; Vorgan, G. The Memory Prescription. New York: Hyperion; 2004.
32. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975; 12:189–198. [PubMed: 1202204]
33. Wechsler, D. The Wechsler Adult Intelligence Scale, III Manual. San Antonio, TX: The Psychological Corporation; 1997.
34. Brandt J. The Hopkins Verbal Learning Test: development of a new memory test with six equivalent forms. Clin Neuropsychol. 1991; 5:125–142.
35. Shapiro AM, Benedict RHB, Schretlen D, et al. Construct and concurrent validity of the Hopkins Verbal Learning Test-Revised. Clin Neuropsychol. 1999; 13:348–358. [PubMed: 10726605]
36. Brandt, J.; Benedict, RHB. Professional Manual. Lutz, FL: Psychological Assessment Resources; 2001. Hopkins Verbal Learning Test-Revised.
37. Benton, A.; Hamsher, K.; Varney, RN., et al. Contribution to Neuropsychological Assessment: A Clinical Manual. New York: Oxford University Press; 1983.
38. Gilewski, MJ.; Zelinski, EM. Questionnaire assessment of memory complaints, in The Handbook for Clinical Memory Assessment of Older Adults. Poon, LW., editor. Washington, DC: American Psychological Association; 1986. p. 93-107.
39. Small, GW. The Memory Bible. New York: Hyperion; 2002.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

40. Derwinger A, Stigsdotter Neely A, Bäckman L. Design your own memory strategies! Self-generated strategy training versus mnemonic training in old age: an 8-month follow-up. Neuropsychol Rehabil. 2005; 15:37–54. [PubMed: 16353852]

41. Kramer AF, Bherer L, Colcombe SJ, et al. Environmental influences on cognitive and brain plasticity during aging. J Gerontol A Biol Sci Med Sci. 2004; 59:940–957.

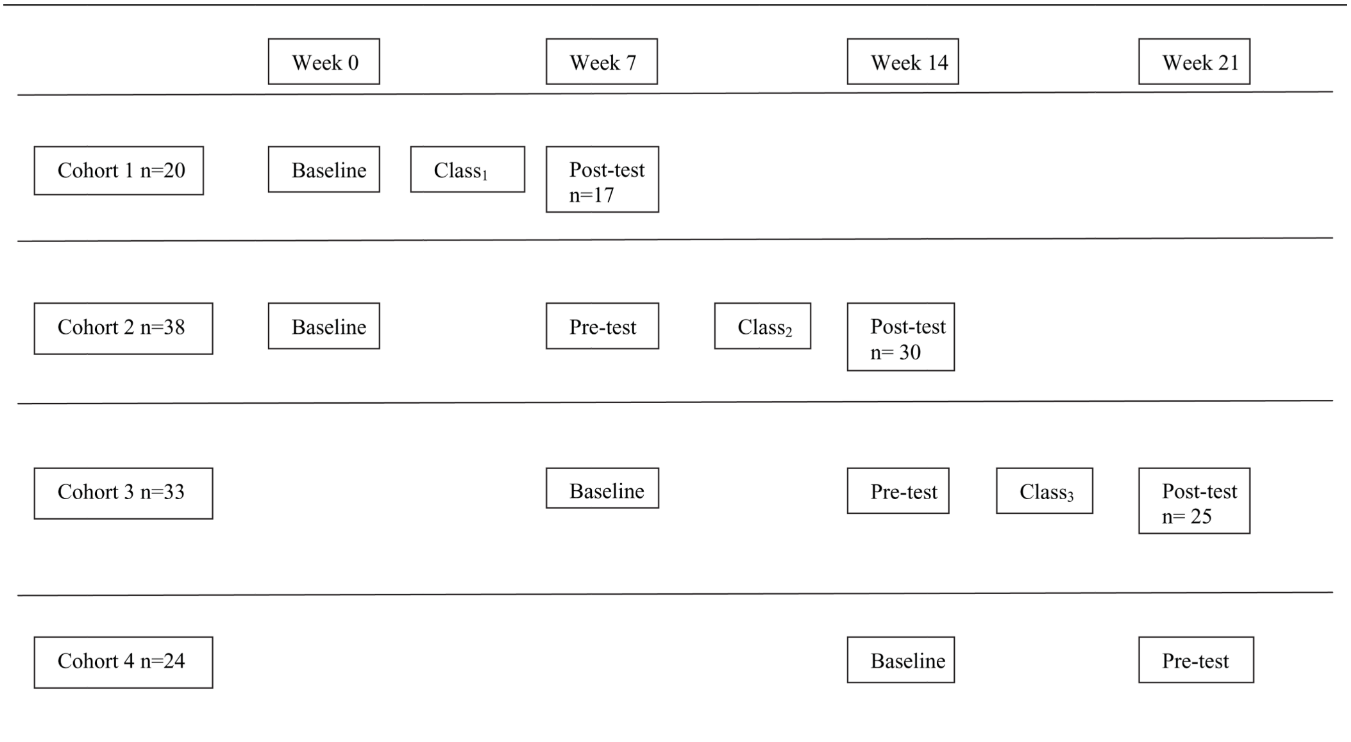

FIGURE 1.
Memory fitness study design. Pretest defined as 7 weeks after baseline but before taking the memory class. Posttest defined as after taking the memory class

NIH-PA Author Manuscript

NIH-PA Author Manuscript

TABLE 1

Demographic Characteristics of Participants

Characteristic[a]	**N = 115**
Age (years)	81.0 (6.0)
Female gender	79%
Race: white	98%
Education	
High school or lower	32%
Bachelor or associate degree	44%
Graduate or professional degree	24%
Mini-Mental State Examination	28.6 (1.3)

[a]Values are reported as mean (SD) for age, Mini-Mental State Examination; % for education, gender and race.

TABLE 2

Neuropsychological Test Scores of Participant

Characteristic[a]	**Baseline, t_0**	**Preintervention, t_1;ES[b] ($t_1 - t_0$)**	**Postintervention, t_2; ES[b] ($t_2 - t_1$)**	**Mixed models statistics: $t_1 - t_0$; $t_2 - t_1$**
Immediate memory				
WMS-III, verbal pairs, immediate total	15.2 (8.4)	18.3 (8.4); 0.37	20.9 (8.0); 0.32	$t_{[114]} = 7.23$, $p < 0.0001$; $t_{[114]} = 6.56$, $p < 0.0001$
HVLT-R total recall	24.7 (5.6)	24.4 (5.1); 0.06	24.9 (5.0); 0.10	$t_{[114]} = -0.67$, $p < 0.8$; $t_{[114]} = 1.02$, $p < 0.6$
Delayed memory				
WMS-III, verbal pairs, delayed total	4.9 (2.7)	5.4 (2.5); 0.19	5.7 (2.4); 0.12	$t_{[114]} = 3.06$, $p < 0.008$; $t_{[114]} = 2.70$, $p < 0.02$
HVLT-R delayed recall	6.5 (4.2)	6.5 (4.3); 0	7.0 (4.2); 0.12	$t_{[114]} = 0.02$, $p < 1$; $t_{[114]} = 1.21$, $p < 0.5$
Retention memory				
WMS-III, verbal pairs, retention score	84.0 (25.4)	85.6 (23.3); 0.07	85.9 (20.7); 0.01	$t_{[114]} = 0.86$, $p < 0.7$; $t_{[114]} = 0.22$, $p < 1$
HVLT-R retention score	63.2 (37.4)	64.0 (38.9); 0.02	77.3 (39.6); 0.34	$t_{[114]} = 0.13$, $p < 1$; $t_{[114]} = 2.98$, $p < 0.01$
Recognition memory				
WMS-III, verbal pairs recognition accuracy	91.3 (10.3)	92.0 (9.9); 0.07	95.2 (6.2); 0.39	$t_{[114]} = 1.22$, $p < 0.4$; $t_{[114]} = 3.62$, $p < 0.001$
HVLT-R recognition discrimination index	10.3 (1.8)	10.3 (1.8); 0	9.8 (2.4); 0.24	$t_{[114]} = 0.58$, $p < 0.8$; $t_{[114]} = -1.93$, $p < 0.1$
Verbal fluency				
Animals	16.3 (5.2)	15.9 (5.6); 0.07	15.9 (4.7); 0	$t_{[114]} = -0.92$, $p < 0.6$; $t_{[114]} = 0.08$, $p < 1$
Letter total	39.2 (11.7)	40.5 (11.9); 0.11	41.1 (11.1); 0.05	$t_{[114]} = 2.61$, $p < 0.03$; $t_{[114]} = 1.47$, $p < 0.3$
Fruits/vegetables	16.1 (4.0)	15.6 (4.2); 0.12	16.4 (4.4); 0.19	$t_{[114]} = -1.24$, $p < 0.4$; $t_{[114]} = 1.42$, $p < 0.3$
MFQ				
MFQ: frequency of forgetting	89.8 (14.5)	90.4 (15.5); 0.04	88.9 (18.0); 0.09	$t_{[114]} = 0.26$, $p < 0.8$; $t_{[114]} = -0.90$, $p < 0.4$
MFQ: severity of forgetting	74.1 (21.4)	74.4 (20.3); 0.01	73.6 (21.2); 0.04	$t_{[114]} = 0.24$, $p < 0.8$; $t_{[114]} = -0.56$, $p < 0.6$
MFQ: retrospective functioning	14.3 (4.9)	14.1 (4.2); 0.04	16.4 (5.1); 0.49	$t_{[114]} = -0.50$, $p < 0.6$; $t_{[114]} = 4.54$, $p < 0.0001$
MFQ: mnemonics use	21.9 (6.9)	20.4 (8.1); 0.20	19.7 (7.1); 0.09	$t_{[114]} = -1.40$, $p < 0.2$; $t_{[114]} = -0.79$, $p < 0.4$

Notes: ES = Effect size.

[a]Values are reported as mean (SD).