

Exploring the Effects of an “Everyday” Activity Program on Executive Function and Memory in Older Adults: Experience Corps[®]

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Purpose: There is little empirical translation of multi-modal cognitive activity programs in “real-world” community-based settings. This study sought to demonstrate in a short-term pilot randomized trial that such an activity program improves components of cognition critical to independent function among sedentary older adults at greatest risk. **Design and Methods:** We randomized 149 older adults to Experience Corps[®] (EC) or a wait-list control arm. Participants randomized to EC trained in teams to help elementary school children with reading achievement, library support, and classroom behavior for 15 hr/week during an academic year. We compared baseline and follow-up assessments of memory, executive function (EF), and psychomotor speed at 4 to 8 months by intervention arm, adjusting for exposure duration. We observed a range of EF abilities at baseline and stratified analyses according to the presence of baseline impairment using established norms. **Results:** Overall, EC participants tended to show improvements in EF and memory

relative to matched controls ($ps < .10$). EC participants with impaired baseline EF showed the greatest improvements, between 44% and 51% in EF and memory at follow-up, compared to declines among impaired-EF controls ($ps < .05$). **Implications:** Short-term participation in this community-based program designed to increase cognitive and physical activity in a social, real-world setting may train memory and, particularly, executive functions important to functional independence. This community-based program represents one potentially effective model to bring high doses of sustainable cognitive exercise to the greatest proportion of older adults, particularly those sedentary individuals at elevated risk for health disparities.

Key Words: Cognitive activity, Executive dysfunction, Activity intervention, Health disparities, Community-Based

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In response to the health needs of a growing aging population, Healthy People 2010 (U.S. Department of Health and Human Services, 2000) has established goals over the next decade to increase the quality and years of healthy life and to further eliminate health disparities that appear to magnify with age. Although the last half-century has realized many improvements in health care, preventive medicine, and healthy behaviors important to increase years of life, the aggregate risk for cognitive and functional disability has also increased. Increased risk is not uniform among older adults. Persons with low education and low income are at elevated risk for cognitive and functional impairments (Stern, Albert, Tang, & Tsai, 1999; Tang et al., 2001; Zsembik & Peek, 2001), with inner city middle-aged African Americans at particular risk relative to suburban African Americans or

Whites of similar age (Miller, Wolinsky, Malmstrom, Andresen, & Miller, 2005). The combination of poor cognitive and functional health often results in dementia, a looming and costly public health target for prevention given its current irreversibility. In the United States, the prevalence of Alzheimer's disease is expected to rise fourfold, to 8.6 million, over the next 50 years (Brookmeyer, Johnson, Ziegler-Graham, & Arrighi, 2007). Effective interventions are critically needed to help slow declines in both cognitive and independent functioning and to bring prevention to the greatest proportion of the older population, particularly those at elevated risk for health disparities (Adler, 2003).

Epidemiologic, observational studies have suggested that leisure time cognitive, physical, and social activities help maintain cognitive and functional health (for reviews, see Fratiglioni, Paillard-Borg, & Winblad, 2004; Studenski et al., 2006). In the absence of formal cognitive activity intervention trials, experts have learned substantially from laboratory-based cognitive training studies and trials showing that older adults demonstrate immediate and reliable cognitive gains following brief exposure to targeted training (e.g., Ball et al., 2002; Willis & Schaie, 1986; for a review, see Rebok, Carlson, & Langbaum, 2007). However, these training effects are often highly task specific (e.g., word list memory) and show limited transfer to other tasks or to everyday functions (Kliegl, Smith, & Baltes, 1989), with the exception of promising findings from the ACTIVE trial (Willis et al., 2006). These findings provide important knowledge about next steps for developing novel training methods that have the potential to boost cognitive abilities broadly, perhaps by training to an array of tasks simultaneously (Floyd & Scogin, 1997; Verhaeghen, Marcoen, & Goossens, 1992). Such cognitive interventions could extend beyond memory to incorporate executive planning and organizational skills important to maintaining functional independence (Carlson et al., 1999; Grigsby, Kaye, Baxter, Shetterly, & Hamman, 1998) and that appear to be particularly vulnerable to decline at later ages (Carlson, Xue, Zhou, & Fried, in press). One can infer the optimal intervention through merging findings from observational activity and targeted laboratory trials. To date, little is known about the efficacy of community-based cognitive and physical exercise programs for improving a range of cognitive abilities (Studenski et al., 2006). Engaging in complex work and leisure environments has been associated with improved mental flexibility over the long term, particularly among older adults (Schooler & Mulatu, 1999). Complex environments impose cognitive challenges through the diversity of stimuli and the number of decisions required. As a result, people may exercise organizational, inhibitory, and working memory skills, all of which are encompassed by the term *executive function* (EF; Shallice, 1994).

The findings above collectively offer challenges and insights into potentially important features for novel, innovative approaches to cognitive intervention by taking activity out of the laboratory or gym and into one's daily life, thereby exercising EF skills. First, researchers have examined cognitive, physical, and social activity independently for effects on cognition; when combined, these may offer additive cognitive benefits. Second, experts have yet to design intervention programs that effectively influence a range of cognitive abilities beyond improving a trained target task; to address this, training interventions could target and train complex, real-world functions. Third, a major translational challenge is "incentivizing" sedentary individuals to adopt and maintain new behaviors. A "hook" or enticement is required that extends beyond the typical appeals to personal health promotion. Interventions that offer "real-life" meaning, and environments and tasks that can be applied in varied settings, may promote better adoption, interest, and adherence.

The Experience Corps[®] (EC) program offers one such model through a high-intensity, volunteer senior service in elementary school settings designed to address the issues above. It was created to provide a context within which older adults could become (a) motivated to be engaged through the opportunity to "give back" and make a difference in the success of the next generation; (b) cognitively active through reading with children and library service; (c) physically active through daily transit to and service in schools; and (d) introduced into new social networks, which include other team members, children, teachers, and staff in the school community. We now describe this new model and how it was designed to enhance physical, social, and cognitive activity simultaneously and, in doing so, to exercise memory and EF, in particular.

As outlined in Figure 1, EC program goals were to harness the social capital of a larger proportion of the older population through "health promotion" programs that offer generative opportunities to give meaning to one's life through the transfer of knowledge and wisdom to younger generations in one's own community (Erikson, 1959). This service could simultaneously provide an important vehicle for motivating and sustaining social, physical, and cognitive activity to promote long-term health benefits that may exceed those associated with interventions targeting any one dimension of activity (for a review, see Carlson, Seeman, & Fried, 2000). To be successful as a potential large-scale intervention, EC was designed to appeal to those sedentary individuals who typically do not volunteer. Core features of the EC program designed to yield high retention and high "doses" of preventive exposure included placing a critical mass of volunteers in trained teams of 10 or more in schools; having them fulfill meaningful roles to meet school needs in literary development, library support, behavioral conflict resolution, and parent

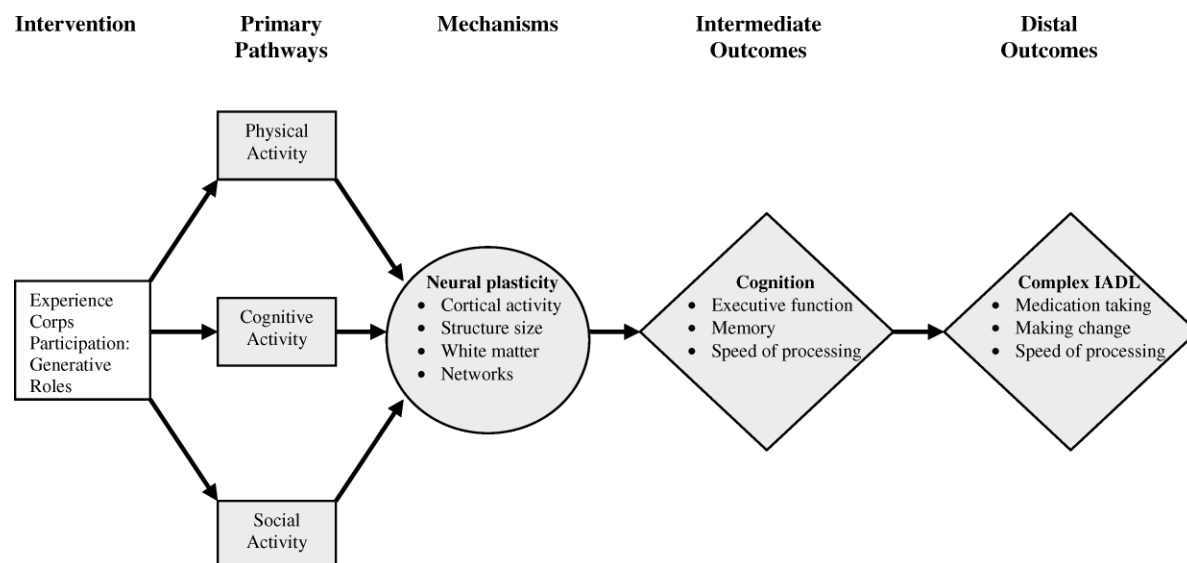


Figure 1. Hypothesized causal pathway of the Experience Corps: Baltimore program effects on cognitive health in older adults. IADL = instrumental activity of daily living.

outreach; requiring a commitment of 15 hr/week over an academic year; and providing an incentive reimbursement to offset volunteer expenses (e.g., transportation, meals). Seniors worked with children in kindergarten through third grade, an age range in which such support can be most beneficial to future academic success.

This multimodal EC activity program targeted memory and components of EF by exercising working memory skills through reading and comprehension exercises with children; library organization skills through use of the Dewey Decimal Classification system to help children locate and select age-appropriate books that they could enjoy; cooperative problem solving with team members, students, and teachers; and mental flexibility through regular shifts among these roles. We hypothesized that the summary effects of these roles would result in measurable gains in, or maintenance of, EF and memory.

We evaluated whether the EC program could increase activity levels in older at-risk individuals through a short-term pilot randomized trial of EC in Baltimore, Maryland (Fried et al., 2004). This “everyday” activity program increased physical activity and improved physical objective measures of function while also decreasing sedentary behaviors (e.g., lying down and watching TV; Fried et al., 2004), particularly among the most inactive at baseline (Tan, Xue, Li, Carlson, & Fried, 2006). Effects of the program on participating children and schools have been promising and are elaborated upon in a separate paper (Rebok et al., 2004).

Although the EC pilot randomized trial demonstrated short-term improvements in activity and physical function, the objectives of this study were to examine the EC program’s short-term impact on EF and memory. Researchers are now beginning to

test for the cognitive efficacy of such programs when placed in everyday settings (Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007). The EC study represents, to our knowledge, the first known short-term randomized controlled trial of an everyday activity intervention to boost cognitive health, and one that does so among those at greatest risk for health disparities in cognition. As summarized in Figure 1, we hypothesized that these intermediate improvements in cognition would lead to downstream benefits in the maintenance of instrumental activity of daily living function. In this study, we examined whether EC participation during an academic year had any short-term impact on intermediate cognitive outcomes. Participants in this short-term trial had sociodemographic characteristics that placed them at great risk for age-related cognitive impairment. It was important to evaluate whether this intervention had the potential to prevent or delay further declines in cognition in these at-risk individuals.

Methods

Intervention Design

The EC program was initially designed and implemented in the mid 1990s (Fried, Freedman, Endres, & Wasik, 1997) and core components substantially refined and developed in 1999, through program refinement and evaluation in a short-term pilot randomized controlled trial in Baltimore, Maryland (Fried et al., 2004; Glass et al., 2004; Rebok et al., 2004). In October 1999, we initiated this pre-post pilot trial in six Baltimore public schools, randomizing three schools to participate and three schools to wait-list and receive the EC program the following

year, and randomizing older volunteers to EC or to a wait-list control. The program was implemented in partnership with the Greater Homewood Community Corporation, a community development organization of 40 community groups in Baltimore City.

The primary cognitive intervention can be divided into two parts: (a) an intensive preparatory training course followed by (b) senior service over the ensuing academic year, which is described in greater detail elsewhere (Glass et al., 2004). Seniors trained collectively and interactively over a 32-hr, 2-week period to acclimate themselves to the school culture, learn to work as a team, and have the tools and training for three standardized intervention roles. The three roles were developed specifically for EC members in collaboration with experts in childhood literacy development and education: (a) Literacy support provided a comprehensive training for volunteers in reading stories to children, listening to children read, and helping children develop oral language skills. The training included a detailed manual, opportunities to model appropriate reading behavior, and guidelines for selecting appropriate books for young readers; (b) library support and management training, developed by one of the coauthors (SM), included familiarization with the Dewey Decimal Classification system, coordinating effective systems to catalog, and helping to maintain and open closed school libraries and to reshelve books; and (c) "I to I" messages and materials taught children conflict resolution skills inside and outside of the classroom.

Volunteers were trained in three successive groups of approximately 25 and then placed with teams in one of three local elementary schools closest to their residence. A full-time program coordinator was responsible for program startup in collaboration with teachers and principals and worked with each school's team of volunteers and the school staff to help solve problems, conduct weekly team meetings, and ensure intervention adherence to program goals, procedures, and protocols. Principals and teachers trained in working with EC volunteers, including understanding the roles volunteers were trained to perform and what volunteers were not allowed to do (e.g., not permitted to solely manage or oversee a class).

A number of approaches were developed to enhance recruitment and retention, such as the use of incentive stipends to reimburse expenses; team building, which promoted strong social networks; and feedback to the volunteers on their successes throughout and at the end of the school year.

Sample

From October to December 1999, recruitment efforts targeted community groups and churches in the neighborhoods around the chosen schools, senior events, job fairs, sidewalk recruitment, and a local AARP mailing list. Details of recruitment are pro-

vided elsewhere (Fried et al., 2004). Briefly, to be eligible, individuals had to be 60 years or older; be able to read; be willing to travel to the schools; be cognitively intact, with a Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) score ≥ 24 among those with more than 12 years of education, or, if the MMSE score was between 20 and 23 and education was 12 years or less, completion of the Trail Making Test (TMT) Parts A and B (Reitan, 1958) within the allotted time (Part A = 240 s and Part B = 360 s); be willing to commit 15 hr/week during the school year, and be able to pass a criminal background check required by the schools. Eligible individuals agreeing to participate were administered a 2-hr baseline evaluation of cognitive and physical functioning that included questionnaires assessing depressive symptoms, self-efficacy, activity, and health habits. Half were subsequently randomized to the intervention group and half to the control group.

In all, 149 eligible individuals agreed to participate and were randomized in three replicates of approximately 50 into one of three public elementary schools in eastern Baltimore, Maryland. Immediately following randomization 21 dropped out, leaving 70 in the intervention group and 58 in the control group. A greater number of those in the control than the intervention group may have dropped out upon learning that they were wait-listed for participation. Recruiting volunteers in replicates allowed schools to absorb and integrate seniors more effectively. Those randomized to the program underwent training and placement (see "Intervention Design"). All were asked to return for follow-up evaluation in June through early July 2000 following 4 (March entry), 6 (January entry), and 8 (November entry) months of exposure. A total of 62 of 70 intervention group members completed follow-up evaluations, as did 48 of 58 controls. Those who completed follow-up evaluations differed from those lost to follow-up in that they were more often younger, female, and Black (Fried et al., 2004). Participants randomized to intervention received a reimbursement for daily out-of-pocket expenses (lunch, travel) of \$150 per month. Controls received an honorarium of \$15 per evaluation and were placed on a wait-list for cross-over into the EC program the following year.

Evaluation

Tests included timed and untimed measures of EF, verbal and visuospatial memory, and psychomotor speed. The two EF tests included the TMT and the Rey-Osterrieth Complex Figure Test (CFT; Lezak, 1995). The TMT comprises two timed parts emphasizing speed and accuracy: Part A required one to use a pencil to connect the numbers 1 to 25 randomly arrayed on a standard-size page in an ascending sequence. This part served as the psychomotor speed and visual search control condition for

Part B. Part B required one to connect randomly arrayed letters A through L and numbers 1 through 13 in an ascending alphanumeric sequence. The Rey-Osterrieth CFT presented a detailed nonsensical figure at the top of a page and tested one's ability to copy the figure on the lower half of the page. Nonverbal memory was assessed as delayed recall of the CFT following a 15-min filled interval. Verbal learning and memory were assessed over three learning trials by reading to participants a list of 20 common words from the Iowa Established Populations for Epidemiologic Studies of the Elderly project (Cornoni-Huntley et al., 1993), immediately after which they verbally recalled as many words as possible in any order (maximum recall = 60 words). Following a 15-min filled interval, participants were asked to recall as many of the words as they could remember. Psychological function was assessed by using the Geriatric Depression Scale (Yesavage et al., 1982), the results of which were reported by Fried et al. (2004) and did not differ at baseline or follow-up by intervention status.

Statistical Analysis

We first examined descriptive characteristics at baseline by intervention status. We compared baseline and follow-up assessments of cognitive function in each group by using *t* tests and within-subjects repeated measures analysis of covariance, adjusting for age, education, and exposure duration (4, 6, and 8 months). Baseline demographic and health characteristics did not differ by exposure duration. Exposure duration was not associated with change in performance, and controlling for it did not alter the patterns of intervention effects observed. This finding may reflect the high doses of exposure associated with even the shortest period of exposure (15 hr/week over 4+ months = 500+ hr). We therefore removed exposure duration from the final models. In secondary analyses, we stratified by the presence of baseline impairment on a measure of EF, the TMT Part B. Performance on the TMT Part B declines more rapidly than memory with age (Carlson et al., in press) and is associated with functional independence (Carlson et al., 1999; Grigsby et al., 1998). We defined baseline impairment by performance in the poorest tertile (>203 s). This cutoff corresponded to a 1.5 *SD* cutoff on external norms (Ivnik et al., 1999; Lopez et al., 2003), indicative of cognitive impairment. We subdivided the intervention and control groups into those with baseline EF impairment and those without (unimpaired). Baseline impairment was equally represented across intervention (*n* = 22 of 70) and control (*n* = 16 of 58) groups. We compared intervention effects within EF impaired and unimpaired subgroups to determine whether those at greatest risk for EF deficits would show any short-term benefit.

Table 1. Demographic and Health Characteristics by Intervention Status

Variable	Intervention (<i>N</i> = 70)	Control (<i>N</i> = 58)
Age, <i>M</i> (<i>SD</i>)	70.1 (6.42)	68.4 (5.15)
Education (years), <i>M</i> (<i>SD</i>)	11.9 (2.54)	11.2 (2.66)
Baseline MMSE score, <i>M</i> (<i>SD</i>)	24.96 (3.45)	25.3 (2.60)
Annual income <\$15,000, %	65	82
Black, %	94	95
Female, %	83	93
Married, %	24	28
Number of health conditions	2.6 (1.7)	2.6 (1.3)
Persons with health conditions diagnosed by a physician, %		
Myocardial infarction	6	0
Angina	11	10
Congestive heart failure	8	5
High blood pressure	68	73
Diabetes	30	24
Stroke	5	0
Arthritis of knees/hip	43	40
Arthritis of hands	26	41
Cancer	9	5

Note: MMSE = Mini-Mental State Examination.

Results

Table 1 presents demographic, income, and health characteristics of the sample stratified by intervention status and illustrates the sample's socioeconomic diversity relative to most volunteer samples. The sample averaged 69 years of age and was primarily female (90%) and African American (95%), with most earning less than \$15,000 annually. Participants had obtained an average of 11.5 years of education, with 38% receiving less than a high school education. The mean MMSE score at baseline was 25.1. Approximately 28% obtained an MMSE score below 24, typically suggesting possible cognitive impairment (Crum, Anthony, Bassett, & Folstein, 1993), but successfully completed the TMT. Participants reported an average of 2.6 chronic diseases from among 16 surveyed, with frequencies for the more common diseases listed individually in Table 1. These characteristics did not differ by intervention group (*ps* > .05). Overall, this sample included disproportionately more African American older adults with low incomes and education than other volunteer samples.

Intervention Versus Control Groups

Table 2 presents age- and education-adjusted mean intervention and control group cognitive and physical function data at baseline and follow-up. There were no group differences in cognitive performance at baseline. On the TMT Part A, both groups showed comparable improvements at follow-up. On the TMT Part B, the intervention group showed a modest 8% improvement (1.3 s), whereas controls showed a 13% slowdown (−21.7 s). This group difference at follow-up was statistically

Table 2. Adjusted Mean Baseline and Follow-Up Performance

Cognitive Outcome	Intervention		Control	
	Baseline	Follow-Up	Baseline	Follow-Up
Trail Making Test				
Part A (s)	68.7	52.8	66.6	56.3 [†]
Part B (s)	174.3	160.7	169.6	191.3*
Word list memory				
Immediate recall	20.7	20.3	21.0	20.8
Delayed recall	5.6	6.1	6.3	6.3
Rey-Osterrieth				
Copy score	19.5	17.9	18.8	17.0
Delayed recall	11.0	12.0	11.4	10.3*

Notes: Analysis of variance was used to assess interactions.

*Cross-sectional group differences significant at $p \leq .05$.

[†]Main effect of time significant at $p \leq .05$.

significant ($p < .05$). Similarly, on the Rey-Osterrieth CFT Delayed Recall, the intervention group showed a 9% improvement (1 point) at follow-up, whereas controls showed a 10% decline (−1.1 point). This group difference at follow-up was also marginally significant ($p = .05$). In the analysis of covariance models, these two interactions were indicative of a treatment effect ($ps < .10$) but did not reach significance at $p < .05$, probably because of the small sample size and heterogeneity in treatment response.

Stratifying by Baseline Impairment in EF

To understand the source of heterogeneity in treatment response, we also examined intervention effects according to the presence of baseline EF impairment. As seen in Table 3, the EC subgroup with baseline EF impairment showed a clinically significant 42% (124.5 s) improvement on the TMT Part B relative to EF impaired controls. One cannot simply view this improvement as regression to the mean, as the corresponding EF impaired control subgroup showed only a 9% (23.4 s) improvement. The EF impaired intervention subgroup also showed an approximately 40% improvement in immediate and, in particular, delayed word list recall, whereas the corresponding EF impaired controls showed declines (−12%). We obtained a similar trend for memory on another untimed measure, the Rey-Osterrieth CFT Delayed Recall ($p = .07$). The EF impaired group exhibited consistent intervention-specific gains on all tests, with the exception of the TMT Part A. Those in the unimpaired intervention and control groups showed no appreciable changes between baseline and follow-up scores. Baseline performances in the unimpaired groups were between 9% and 60% better than those in the impaired group. These performances were average to above average according to established norms, suggesting

Table 3. Adjusted Mean Baseline and Follow-Up Performance Stratified by the Presence of Baseline Impairment in Executive Function Using the Trail Making Test, Part B

Variable	Intervention		Control	
	Baseline	Follow-Up	Baseline	Follow-Up
Trail Making Test				
Part A (s)				
Impaired	95.2	56.5	90.2	55.2
Normal	56.3	51.1	55.0	56.8
Part B (s)				
Impaired	297.5	173.0	260.4	237.0
Normal	118.7	154.7	127.5	170.4*
Word list memory				
Immediate recall				
Impaired	19.3	20.9	21.6	19.6
Normal	21.4	19.9	20.7	21.3*
Delayed recall				
Impaired	5.0	7.0	6.4	5.6
Normal	5.9	5.6	6.3	6.6*
Rey-Osterrieth				
Copy score				
Impaired	18.4	17.8	16.5	15.2
Normal	20.0	17.8	19.9	17.9
Delayed recall				
Impaired	9.1	12.8	10.6	8.0
Normal	12.0	11.5	11.8	11.2

Note: * $p < .05$.

that any changes at follow-up were due to regression to the mean, or practice. Practice effects often mask improvements in higher functioning individuals over brief periods. Such practice effects are typically less evident in lower functioning individuals, making the observed improvements in those at elevated risk for cognitive impairment all the more striking.

Discussion

This short-term pilot randomized controlled trial evaluating an everyday activity intervention that operated along multiple activity pathways and targeted a range of cognitive abilities related to functional independence yielded cognitive benefits among persons at greatest risk for health disparities. Short-term results of this pilot trial of EC demonstrate clinically meaningful, intervention-specific improvements in EF and memory among those with borderline to impaired EF at baseline. These findings are consistent with past cognitive intervention work showing that individuals with the most to lose have the most to gain from such training (Willis & Schaie, 1986). In addition, we observed intervention-specific cognitive improvements over a relatively brief period in a sociodemographically high-risk sample of older individuals. Specifically, participants were

predominantly African American, low income, and low in formal education and often presented with an MMSE score below 24, the score typically used to screen for cognitive impairment. Our promising short-term findings among individuals at risk for cognitive impairment suggest that this type of high-impact activity intervention may offer immediate benefit to those at highest risk and may be a successful approach to help ameliorate the life-long accumulation of risk factors that promote health disparities.

These initial findings further suggest that a “real-world” intervention can be successful by integrating the individual effects of increased cognitive, social, and physical activity into daily life, thus allowing for large daily doses of stimulating activity. The fact that such doses were well tolerated, and even exceeded, in individuals at elevated risk for major chronic diseases suggests that, with expansion of such community-based health promotion programs (Center for Healthy Aging Model Health Programs for Communities, 2006; Schneider, Altpeter, & Whitelaw, 2007), physicians may be able to offer their patients a greater array of options than games and crossword puzzles when asked to recommend efficacious sources of cognitive stimulation.

These promising findings in a small sample over two test occasions spanning a 4- to 8-month period are preliminary and beg the question as to the full potential effects of this intervention among those with higher baseline function. As with other interventions (Rapp, Brenes, & Marsh, 2002), maximal benefits following this generalized intervention may only be evident in higher functioning participants with more extended follow-up evaluating effects on mitigating rates of cognitive decline. In nondemented older adults, it is extremely difficult to move abilities over a 6-month study interval. For example, the well-powered ACTIVE trial observed modest treatment-related improvements in cognition over a 2-year interval. Furthermore, practice effects often mask improvements in higher functioning individuals over brief periods. In the short term, benefits among high-functioning adults may be better observed using sensitive, computerized tests of EF and intermediate biomarkers of brain plasticity, such as that observed following physical activity (Colcombe et al., 2004) and juggling training (Draganski et al., 2004). A next-level pilot study using functional neuroimaging in a subset of EC participants and matched controls is providing initial evidence of intervention-specific gains in EF and associated prefrontal regions over a 6-month interval (in preparation), similar to those observed for physical activity (Colcombe et al., 2004). Targeting EF represents a neurobiologically important goal, as this region appears to be particularly vulnerable to volume loss with age (Buckner, 2004; Raz, 2000). In the longer term, one can expect benefits to be evident in the mitigation of age-related cognitive and everyday functional declines.

This everyday cognitive activity intervention represents an effort to reconcile the sometimes equivocal findings in epidemiologic studies with those of controlled laboratory studies, in which little generalized benefit occurs within or across domains of ability (Kliegl et al., 1989; Oswald, Rupperecht, Gunzelmann, & Tritt, 1996; Willis & Schaie, 1986). Everyday activity interventions such as this appeal to an older adult's desire to remain socially engaged post-retirement and to give back and be generative, rather than appeal solely to personal health promotion motives. Numerous activity interventions have demonstrated that the latter approach is consistently associated with poor retention and adherence, perhaps because rewards are not immediate or substantial enough to warrant continued effort (Pate et al., 1995). Furthermore, these interventions are conducted primarily among persons of higher socioeconomic status and with greater access to resources. By comparison, the present context led to high retention (Fried et al., 2004) and adherence as well as large weekly doses of exposure over a prolonged period, in part because activity was an essential and habitual component of program participation. Another component of everyday activity interventions that may mediate their effectiveness is via exercising of broad abilities rather than specific skills, with the expectation that such an approach would be generalizable to independent function (see right side of Figure 1). This idea is consistent with earlier work observing long-term generalized intellectual benefits of environmentally complex work and leisure activities (Schooler & Mulatu, 1999).

It remains to be understood whether the desire to be generative and make valued contributions to society served only as the hook to spur older adults out of bed each morning and into consistently high doses of cognitive, social, and physical activity in the form of service (left side of Figure 1), or whether it represented an independent component contributing to the intervention's cognitive efficacy (Fried et al., 2004). In other words, cognitively stimulating activity that generates a valuable commodity by providing services of economic value, much as pre-retirement occupational activity, may confer benefits that exceed those of nongenerative activity (Morrow-Howell, Hinterlong, & Sherraden, 2001). As such, EC may have value both as a health promotion program to delay and compress morbidity in later years (Fries, 1980) and, simultaneously, as a powerful, low-cost educational program to harness the wisdom of an experienced generation. In addition, the idea that EC appeals to generative motives in later life may speak to the program's success in recruiting and retaining older adults (Kahn, 1994). Thus, this program and other community-based models like it (Schneider et al., 2007) have the potential to impact profoundly on the social capital, both young and old, in any neighborhood, with particular impact on those impoverished urban neighborhoods in critical need. The older give

back to the young, and the young give to the older through purpose. The long-term success and sustainability of evidence-based community programs such as EC require collaborative research—community partnerships. This collaboration of resources has occurred at the foundation (Erickson Foundation), state (U.S. Department of Education), Baltimore city, and community levels and has since expanded to include federal support through the provision of Americorps funding to support senior volunteer service.

Limitations

Numerous limitations of this short-term randomized trial warrant consideration. First, the sample was small and the study interval brief, limiting the power to observe intermediate cognitive changes in higher functioning participants relative to controls. A longer trial would allow us to further examine whether such intermediate improvements lead to downstream benefits in the maintenance of independent function, as hypothesized. Second, although the sample represented an important and often understudied segment of the aging adult population, we have yet to determine whether this program enhances or maintains cognition among more ethnically and socioeconomically diverse individuals. Finally, this study design did not allow us to definitively discern whether the effects of this intervention on cognition function were mediated primarily by cognitive or physical pathways, or whether benefits represent the synergy of increased activity in all domains. Understanding the mediating source may not be as critical as observing that a multiple-pathway approach set in the community is associated with high doses, good retention, and short-term effects spanning many abilities in persons most at risk.

Conclusion

Briefly, we observed that those cognitive abilities most impacted by aging were those abilities that benefited from a multidimensional activity intervention in a sociodemographically at-risk sample. Furthermore, we observed short-term benefits primarily among those at elevated risk for impairment in EF. This finding highlights an important study element intended to reach and retain those at elevated sociodemographic risk for cognitive and functional impairments through the use of a two-step cognitive screen. Here, we used the MMSE in conjunction with the TMT to more specifically assess executive skills necessary to function successfully in a school setting. This two-step screen allowed us to recruit many individuals with a high school education or less and MMSE scores of 20 to 23 who could nonetheless understand and complete this EF measure and perform effectively with elementary-age children. This group represents a segment of older adults who may benefit sub-

stantially from participating in this and other primary prevention programs but who may nonetheless be prematurely excluded, or who may not elect to volunteer at all. As a result, such screening helped us intervene upon an atypical volunteer sample representing a high-risk segment of the older adult population with low likelihood of accessing physical activity or other health promotion programs. One can extend to clinical settings the application of measures targeting EF important to independent function in order to identify those most at risk, and therefore those most in need of and likely to benefit from remediation strategies (e.g., EC) for EF and related instrumental activities of daily living.

Given the current and projected health care costs associated with managing functional disabilities (Brookmeyer et al., 2007), population-based strategies that can even modestly shift their onset and course by 6 months to 1 year have tremendous potential to reduce burden at the level of the individual, the family, and society. In order for such a public health strategy to have high impact, it would in particular need to be inclusive of those historically at greater risk for cognitive impairment—namely, those with poor access to health care and other resources. Evidence suggests that older adults in minority groups and with lower incomes are less likely to enroll in health promotion programs or interventions (van der Bij, Laurant, & Wensing, 2002). The consequences of these factors would be to increase health disparities into later ages, unless programs can explicitly attract these populations (Adler, 2003). The cognitive data presented here suggest that EC offers one such model by which to disseminate widely encompassing and broadly effective cognitive intervention programs to those at high risk for onset or progression of functional disability. They further suggest that these individuals have substantial cognitive resilience and plasticity following relatively brief exposure to an enriching environment, a finding that holds promise for the future design of community outreach and health promotion programs.

References

- Adler, N. E. (2003). Community preventive services: Do we know what we need to know to improve health and reduce disparities? *American Journal of Preventive Medicine*, 24(Suppl.), 10–11.
- 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*, 288, 2271–2281.
- Brookmeyer, R., Johnson, E., Ziegler-Graham, K., & Arrighi, H. M. (2007). Forecasting the global burden of Alzheimer's disease. *Alzheimer's and Dementia*, 3, 186–191.
- Buckner, R. L. (2004). Memory and executive function in aging and AD: Multiple factors that cause decline and reserve factors that compensate. *Neuron*, 44, 195–208.
- Carlson, M. C., Fried, L. P., Xue, Q. L., Bandeen-Roche, K., Zeger, S., & Brandt, J. (1999). Association between executive attention and physical functional performance in community-dwelling older women. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 54B, S262–S270.
- Carlson, M. C., Seeman, T., & Fried, L. P. (2000). Importance of generativity for healthy aging in older women. *Aging*, 12, 132–140.

- Carlson, M. C., Xue, Q. L., Zhou, J., & Fried, L. P. (In press). Executive decline and dysfunction precedes memory declines: The Women's Health and Aging Study II. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences*.
- Center for Healthy Aging Model Health Programs for Communities. (2006). *Using the evidence base to promote healthy aging: The Administration on Aging's Evidence-based Prevention Programs for the Elderly Initiative*. Retrieved January 1, 2007 from <http://www.healthyagingprograms.org/content.asp?sectionid=92&ElementID=306>
- Colcombe, S. J., Kramer, A. F., Erickson, K. I., Scalf, P., McAuley, E., Cohen, N. J., et al. (2004). Cardiovascular fitness, cortical plasticity, and aging. *Proceedings of the National Academy of Sciences, USA*, 10, 3316–3321.
- Cornoni-Huntley, J., Ostfeld, A. M., Taylor, J. O., Wallace, R. B., Blazer, D., Berkman, L. F., et al. (1993). Established Populations for Epidemiologic Studies of the Elderly: Study design and methodology. *Aging*, 5, 27–37.
- Crum, R. M., Anthony, J. C., Bassett, S. S., & Folstein, M. F. (1993). Population-based norms for the Mini-Mental State Examination by age and educational level. *Journal of the American Medical Association*, 269, 2386–2391.
- Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004, January 22). Changes in grey matter induced by training. *Nature*, 427, 311–312.
- Erikson, E. H. (1959). Identity and the life cycle. In *Psychological issues* (1st ed., pp. 161–171). New York: International Universities Press.
- Floyd, M., & Scogin, F. (1997). Effects of memory training on the subjective memory functioning and mental health of older adults: A meta-analysis. *Psychology and Aging*, 12, 150–161.
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12, 189–198.
- Fratiglioni, L., Paillard-Borg, S., & Winblad, B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurology*, 3, 343–353.
- Fried, L. P., Carlson, M. C., Freedman, M., Frick, K. D., Glass, T. A., Hill, J., et al. (2004). A social model for health promotion for an aging population: Initial evidence on the Experience Corps model. *Journal of Urban Health*, 81, 64–78.
- Fried, L. P., Freedman, M., Endres, T. E., & Wasik, B. (1997). Building communities that promote successful aging. *Western Journal of Medicine*, 167, 216–219.
- Fries, J. F. (1980). Aging, natural death, and the compression of morbidity. *New England Journal of Medicine*, 303, 130–135.
- Glass, T. A., Freedman, M., Carlson, M. C., Hill, J., Frick, K. D., Ialongo, N., et al. (2004). Experience Corps: Design of an intergenerational program to boost social capital and promote the health of an aging society. *Journal of Urban Health*, 81, 94–105.
- Grigsby, J., Kaye, K., Baxter, J., Shetterly, S. M., & Hamman, R. F. (1998). Executive cognitive abilities and functional status among community-dwelling older persons in the San Luis Valley Health and Aging Study. *Journal of the American Geriatrics Society*, 46, 590–596.
- Ivnik, R. J., Smith, G. E., Lucas, J. A., Petersen, R. C., Boeve, B. F., Kokmen, E., et al. (1999). Testing normal older people three or four times at 1- to 2-year intervals: Defining normal variance. *Neuropsychology*, 13, 121–127.
- Kahn, R. L. (1994). Opportunities, aspirations and goodness of fit. In M. W. Riley, R. L. Kahn, & A. Foner (Eds.), *Age and structural lag: Society's failure to provide meaningful opportunities in work, family and leisure* (pp. 37–53). New York: Wiley.
- Kliegl, R., Smith, J., & Baltes, P. B. (1989). Testing-the limits of adult age differences in cognitive plasticity of a mnemonic skill. *Developmental Psychology*, 25, 247–256.
- Lezak, M. (1995). *Neuropsychological assessment* (3rd ed.). New York: Oxford University Press.
- Lopez, O. L., Jagust, W. J., Dulberg, C., Becker, J. T., DeKosky, S. T., Fitzpatrick, A., et al. (2003). Risk factors for mild cognitive impairment in the Cardiovascular Health Study Cognition Study: Part 2. *Archives of Neurology*, 60, 1394–1399.
- Miller, D. K., Wolinsky, F. D., Malmstrom, T. K., Andresen, E. M., & Miller, J. P. (2005). Inner city, middle-aged African Americans have excess frank and subclinical disability. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 60A, 207–212.
- Morrow-Howell, N., Hinterlong, J., & Sherraden, M. (2001). *Productive aging: Concepts and challenges*. Baltimore: The Johns Hopkins University.
- Oswald, W. D., Rupperecht, R., Gunzelmann, T., & Tritt, K. (1996). The SIMA-project: Effects of 1 year cognitive and psychomotor training on cognitive abilities of the elderly. *Behavioural Brain Research*, 78, 67–72.
- Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical activity and public health: A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association*, 273, 402–407.
- Rapp, S., Brenes, G., & Marsh, A. P. (2002). Memory enhancement training for older adults with mild cognitive impairment: A preliminary study. *Aging and Mental Health*, 6, 5–11.
- Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of structural and functional findings. In F. I. M. Craik & T. A. Salthouse (Eds.), *Handbook of aging and cognition* (pp. 1–90). Hillsdale, NJ: Erlbaum.
- Rebok, G. W., Carlson, M. C., Glass, T. A., McGill, S., Hill, J., Wasik, B. A., et al. (2004). Short-term impact of Experience Corps participation on children and schools: Results from a pilot randomized trial. *Journal of Urban Health*, 81, 79–93.
- Rebok, G. W., Carlson, M. C., & Langbaum, J. B. (2007). Training and maintaining memory abilities in healthy older adults: Traditional and novel approaches. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62B(Special Issue 1), 53–61.
- Reitan, R. M. (1958). Validity of the Trail Making Test as an indicator of organic brain damage. *Perceptual and Motor Skills*, 8, 271–276.
- Schneider, E. C., Altpeter, M., & Whitelaw, N. (2007). An innovative approach for building health promotion program capacity: A generic volunteer training curriculum. *The Gerontologist*, 47, 398–403.
- Schooler, C., & Mulatu, M. S. (1999). The reciprocal effects of leisure time activities and intellectual functioning in older people: A longitudinal analysis. *Psychology and Aging*, 16, 466–482.
- Shallice, T. (1994). Multiple levels of control processes. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance XV* (pp. 395–420). Cambridge, MA: MIT Press.
- Stern, Y., Albert, S., Tang, M. X., & Tsai, W. Y. (1999). Rate of memory decline in Alzheimer's disease is related to education and occupation: Cognitive reserve? *Neurology*, 53, 1942–1947.
- Stine-Morrow, E. A., Parisi, J. M., Morrow, D. G., Greene, J., & Park, D. C. (2007). An engagement model of cognitive optimization through adulthood. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62B(Special Issue 1), 62–69.
- Studenski, S., Carlson, M. C., Fillit, H., Greenough, W. T., Kramer, A. F., & Rebok, G. W. (2006). From bedside to bench: Does mental and physical activity promote cognitive vitality in late life? *Science of Aging Knowledge Environment*, 6, pe21.
- Tan, E. J., Xue, Q. L., Li, T., Carlson, M. C., & Fried, L. P. (2006). Volunteering: A physical activity intervention for older adults—The Experience Corps program in Baltimore. *Journal of Urban Health*, 83, 954–969.
- Tang, M.-X., Cross, P., Andrews, H., Jacobs, D. M., Small, S., Bell, K., et al. (2001). Incidence of AD in African-Americans, Caribbean Hispanics, and Caucasians in northern Manhattan. *Neurology*, 56, 49–56.
- U.S. Department of Health and Human Services. (2000). *Healthy People 2010. With understanding and improving health and objectives for improving health* (Vol. 2, 2nd ed.). Washington DC: U.S. Government Printing Office.
- van der Bij, A. K., Laurant, M. G., & Wensing, M. (2002). Effectiveness of physical activity interventions for older adults: A review. *American Journal of Preventive Medicine*, 22, 120–133.
- 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.
- Willis, S. L., & Schaie, K. W. (1986). Training the elderly on the ability factors of spatial orientation and inductive reasoning. *Psychology and Aging*, 1, 239–247.
- Willis, S. L., Tennstedt, S. L., Marsiske, M., Ball, K., Elias, J., Koepke, K. M., et al. (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *Journal of the American Medical Association*, 296, 2805–2814.
- Yesavage, J. A., Brink, T. L., Rose, T. L., Lum, O., Huang, V., Adey, M., et al. (1982). Development and validation of a geriatric depression screening scale: A preliminary report. *Journal of Psychiatric Research*, 17, 37–49.
- Zsembik, B. A., & Peek, M. K. (2001). Race differences in cognitive functioning among older adults. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 56B, S266–S274.

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