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The Effects of an Engaged Lifestyle on Cognitive Vitality: A Field Experiment

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Abstract

Experimental studies on cognitive training have suggested that the effects of experience are narrow in augmenting or maintaining cognitive abilities, while correlational studies report a wide range of benefits of an engaged lifestyle, including increased longevity, resistance to dementia, and enhanced cognitive flexibility. The latter class of evidence is ambiguous because it is possible that it is simply the case that those with relatively better cognitive vitality seek out and maintain a wider range of activities. We report data from a field experiment in which older adults were randomly assigned to participate in a program intended to operationalize an engaged lifestyle, built on a team-based competition in ill-defined problem solving. Relative to controls, experimental participants showed positive change in a composite measure of fluid ability from pretest to posttest. This study, thus, provides experimental evidence for the proposition that engagement, in the absence of specific ability training, can mitigate age-related cognitive declines in fluid ability.

Keywords

cognitive aging; engagement; use it or lose it; mental exercise; cognitive intervention

An engaged lifestyle during adulthood has been shown to be correlated with a variety of benefits, including enhanced longevity (Konlaan, Theobald, & Bygren, 2002), reduced risk of dementia (Verghese et al., 2003), enhanced cognitive resilience in the face of brain pathology (Wilson et al., 2000), and enhanced mental flexibility (Schooler & Mulatu, 2001; Schooler, Mulatu, & Oates, 1999). The explanation for such relationships is far from clear. One possibility is that engagement in an array of stimulating activities has self-enhancing effects on mind and body (the "mental-exercise" hypothesis; Salthouse, 2006), but if this were true, it is difficult to imagine what mechanisms would mediate the effects of activity on vitality so broadly conceived.

To be sure, both the experimental literature on training (Ball, 2002; Willis et al., 2006) and the correlational literature on expertise (Horn & Masunaga, 2006; Kramer & Willis, 2002;

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Morrow, Altieri, & Leirer, 1992) suggest that the effects of experience are very narrow in shaping behavior. Similarly, data from cognitive neuroscience also suggest that experience is highly specific in sculpting neural networks (Draganski et al., 2004; Maguire et al., 2003). Both the behavioral and neuroscience literature show that without continued exercise of the practiced abilities, effects fade over time even though some benefit is retained (Ball et al., 2002; Draganski et al., 2004); periodic booster training can help to maintain the training effects (Ball et al., 2002).

Given such clear findings of specificity from the training literature, expertise literature, and the neuroscience literature, one might be tempted to (sadly) conclude that the most likely explanation for the wide-ranging effects of engagement is selection: it is the most biologically and cognitively vital among us who seek out an active lifestyle. However, it remains a plausible hypothesis that a lifestyle rich in activity and novel experiences might promote intellectual growth. For engagement to have such broad causal effects, one possible account is that it does so by exercising multiple facets of cognition. According to Schooler's (Schooler & Mulatu, 2001; Schooler, Mulatu, & Oates, 1999, 2004) engagement hypothesis, the operative mechanism that promotes mental flexibility is “substantive complexity,” the embeddedness in a context that demands habitual self-direction to solve ill-defined problems. In our view, the reason that substantive complexity is a viable candidate for broadly enhancing cognition is that an investment in such a context requires one to be ever nimble in tackling problems with whatever one has in one's repertoire, inevitably requiring the exercise of multiple abilities in different combinations and in different contexts. Substantively complex environments entail a personal investment in achieving selected goals so that mental exercise is built into the fabric of everyday life, thereby sustaining the repertoire of skills.

Not only is the theoretical explanation of engagement at issue, but also the empirical basis. In a very careful review of the literature to assess the validity of the mental-exercise hypothesis, Salthouse (2006) recently concluded that there is to date little or no compelling evidence for the “use it or lose it” hypothesis that experience can alter the trajectories of cognition through the adulthood life span. Rather, to the extent that stimulating contexts or predispositions that might encourage one to seek out stimulation have been shown to predict cognition, there is little evidence that effects accumulate over the life span to reduce age declines, as would be predicted by the mental-exercise hypothesis. Salthouse argues that the largely correlational literature is far from definitive, and notes that to effectively test the mental-exercise hypothesis, what is required is an experiment in which there is random assignment to experimental and control groups, and careful control in the treatment conditions to assure differences in mental exercise. This is, of course, difficult to achieve inasmuch as one is asking research participants for a somewhat dramatic change in lifestyle over an extended period of time. Schooler (2007) has countered that Salthouse's criterion for evidence may be too stringent, and that to the extent that mental exercise can enhance cognition in adulthood, it may keep older adults above a functional floor (i.e., “losing it” in an absolute sense) for a longer period of time. This debate is not likely to be settled anytime soon (Salthouse, 2007).

The particular issue driving the research described in this paper was whether we could find stronger evidence for a causal connection between engagement and change in cognition by doing an experiment. We describe findings from a field experiment in which the cognitive intervention was based on Schooler's notion (Schooler & Mulatu, 2001; Schooler et al., 1999, 2004) of a “substantively complex” environment. As such, this constitutes a multimodal intervention in which participants are asked to change their lifestyle (for some, somewhat radically) along a number of dimensions (e.g., demands for self-direction, social activities built around intellectual goals, ritualized practice of brainteasers, choice of novel activity, public recognition for success), so that the goal was not to isolate a single operative mechanism, but rather to test the causal hypothesis about an engagement-cognition link more definitively than can be done with (even longitudinal) correlational designs.

There have been other recent examples of multimodal experimental approaches designed to assess the effects of stimulation on cognitive vitality. Experience Corps (Fried et al., 2004) is an ongoing project in which low-SES older adults are placed into the Baltimore schools to provide support to teachers and administrators. Participants are trained to do particular jobs in the schools (e.g., reading with children, calling homes to check on absent students), so that typically inactive elders increase their activity level in ways that are meaningful, thus capitalizing on generativity motives of adulthood. They have found differential improvement in executive function and memory among Experience Corps participants relative to wait-list controls (Carlson et al., in press). In the Toronto Cognitive Rehabilitation study (Craik et al., 2007; Levine et al., 2007; Stuss et al., 2007) the experimental group participated in a training program with three modules focusing on (a) memory skills, involving training in internal and external memory strategies, (b) goal-management training, focusing on self-regulation of everyday activities, and (c) psychosocial training, focusing on building confidence in cognitive abilities. Tranter and Koustaal (2008) presented older adults with novel perceptual-motor and cognitive activities that required creativity and problem-solving (e.g., creative drawing, logic puzzles, math activities, musical activity, origami) and demonstrated differential improvement in fluid ability relative to a no-contact control. Collectively, then, there is a rich and vibrant literature emerging to assess the causal hypothesis and to define models of engagement that have potential to constitute a form of mental exercise.

Our attempt to address the question of whether mental stimulation impacts cognitive vitality has involved translational research in which we operationalized an “engaged lifestyle” in terms of an existing program. The rationale for this choice rests in part on the *structural lag* argument (Riley & Riley, 2000) that social structures that afford meaningful roles for older adults are lagging behind the rapid changes in demographics toward an older society. Essentially, “old age” is historically young. Normative patterns of social roles typically afford opportunities for education in youth; and for work, in midlife. Later adulthood, by contrast, is often defined by “retirement,” a status without a role, in which the expectation is typically that there are more extended opportunities for leisure, even though there are few social structures that afford this in a way that is stimulating.

In light of data in neuroscience and in skill training, one implication of this argument is that to the extent that cultural norms have reduced opportunities for intellectually stimulating activities in old age, we may be perpetuating a context that would be expected to exacerbate senescence-related declines in cognition (see Schooler et al., 2004). Therefore, this program was designed to be a community-based program that takes advantage of existing social structures, so as to afford opportunities for making the program accessible (Sternberg et al., 2006). As translational research, it serves the dual purpose of addressing theoretically meaningful questions about life-span development, as well as insinuating cultural change that has the long-term potential to promote age-integration.

As a cognitive intervention, our program, called Senior Odyssey, has several key features: (1) regular and frequent exposure to ill-defined problems (Schooler et al., 1999; Schooler & Mulatu, 2001), (2) a collaborative context, because with age, cognition may be more tightly related to socioemotional goals (e.g., Isaacowitz, Charles, & Carstensen, 2000), (3) competition, since it provides an inherent reward structure for the development of effective solutions for ill-defined problems (cf. Schooler et al., 1999), and (4) an emphasis on creativity under the assumption that creative activities are inherently engaging, absorbing, rewarding, and engender a mindful approach to experience (Csikszentmihalyi, 1996; Levy & Langer, 1999; Sternberg & Lubart, 1996). The idea is that this is a context that invites the exercise of multiple abilities.

The Senior Odyssey was modeled in part on the Odyssey of the Mind program (OOTM; www.odysseyofthemind.org) developed as an enrichment activity for children and young adults (age-graded divisions ranging from primary grades through university level). OOTM teams are formed in the fall and work together through the winter to prepare for local and regional tournaments in the spring, with successful teams progressing to an international tournament in early summer. There are two components for the spring tournaments. Teams prepare a solution to a selected "long-term problem," and also practice working as a group to solve novel "spontaneous problems."

A new set of long-term problems is developed each year and teams work together through the season on design, implementation, and effective presentation. Long-term problems are drawn from four broad areas: literature, science and technology, civil engineering, and history. For example, teams build a structure of balsa wood within certain parameters designed so as to maximize the weight it will bear (civil engineering); create and present an original performance that reinterprets a certain classical work (literature); create and present a musical performance that presents alternative interpretations for some historical event (history); design a transport that will achieve a certain goal within certain limits (science/technology). Thus, a goal is presented that may be effectively achieved in an infinite number of ways by people of widely varying abilities. Indeed, most OOTM problems can be solved by both third graders and by college students. Individuals at different life stages bring different skills to bear, and the nature of the solutions will vary by division, but the important point is that all age groups can solve the problem in some way. The flip side is that there is no perfect solution, so that any solution is, by its nature, subject to revision. Solutions are presented in the context of a short performance, with points awarded not only for innovation in the solution but also for "style." In the implementation, a plan must be developed and work must be apportioned and coordinated (divergent thinking, prospective memory); sets, costumes, and structures must be built (spatial processing); a short script must be written (language processing) and learned for performance (memory). Thus, working toward the presentation of a solution to a long-term problem engages many basic cognitive skills in a creative and collaborative context.

In contrast to the generate-test-revise process engendered by long-term problems, spontaneous problems encourage the fluent generation of, as the name implies, spontaneous ideas ("thinking on your feet"). They may be verbal (e.g., "name a type of water," with more points awarded for creative responses like "water lily" or "water color," in contrast to common responses like "tap water"), hands-on (e.g., given a mailing label, six straws, a piece of paper, and a rubber band, protect a light bulb so that it can be tossed without breaking), or a combination of the two. These activities encourage speeded processing in a collaborative context so that participants typically have to consider and build on what others in the group have done (memory).

Thus, inherent in this program is not only the exercise of basic cognitive processes, but also decision-making, creativity, evaluation of ideas, and competition, arguably a substantively complex environment that offers rewards for participation and effective solutions. As an established program, OOTM occurs within a well-structured social system so that roles and expectations are well-defined and transmitted across generations of participants.

The process for development of the program and outcomes from pilot data are described elsewhere (Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007), as is a qualitative analysis of commentary from participants about personal impact (Parisi, Greene, Morrow, & Stine-

Morrow, 2007). The current report describes the effects of the program on cognitive and dispositional change over two cycles of the program.

METHOD

Participants

Participants (N=181) were older adults recruited from the community and local retirement communities through newspaper advertisements, flyers posted in local community centers and shops, and contacts from our existing participant pool. These participants were recruited across two seasons. Preliminary analyses showed that season did not interact with any of our effects, so data are collapsed for ease of presentation. Participants were randomly assigned to an experimental group who participated in the Odyssey program (n=107) or to a control group who did not (n=74)[1]. After group assignment, 20 participants from the experimental group (19%) and 11 participants from the control group (15%) elected to discontinue participation and did not complete the posttest. For the control group, there were no reliable differences between those who completed the study and those who did not in age, educational level, vocabulary, or speed. Among the experimental participants, there were no differences in age, educational level, or vocabulary between those who completed and those who did not. However, those who returned for posttest scored somewhat higher on speed (mean scores on the Letter and Pattern Comparison tasks) at pretest than those who did not (M_{COMP} = 11.5, se=.3; M_{DISC} = 9.9, se=.6), t(103) = 2.43, p=.02, suggesting that the intervention may have selected for those with initially better speed of processing.

Our experimental design was compromised somewhat by a practical consideration. Once we had secured agreements with the retirement communities, we found it difficult to implement the random assignment, so these participants (n=21) were assigned to the experimental group. As we show, the retention rate was no different for this subgroup, and the treatment effects did not differ when these participants were removed from the analysis; we have, therefore, included these data in the analyses we report.

Collectively, there were 87 participants in the experimental group and 63 participants in the control group for whom we had data at pretest and posttest so that we could evaluate change as a function of participation in the intervention. At pretest, these experimental participants did not significantly differ from control participants in age (M_E = 73.0 yrs, range: 59–93; M_C = 72.0 yrs, range: 58–91), t(148) = .80, years of formal education (M_E = 16.3, se=.4; M_C = 16.0, se=.3), t(148) = .65, Extended Range Vocabulary (M_E = 15.3, se=.5; M_C = 14.5, se=.6), t(146) = 1.07, or speed, (M_E = 11.5, se=.3; M_C = 11.9, se=.4), t(146) = .98. Thus, even though there may have been differential selection in the two groups, those for whom change was compared across the length of the intervention were initially similar.

Measures and Procedure

Participants were individually administered a battery of cognitive and psychosocial instruments prior to and after the program, a lag of seven to eight months. When possible, alternative forms were used. Dimensions of cognitive ability included:

[1]Our original recruitment goal was 54 participants in each group per season (6 participants per team × 9 teams). Recruitment and pretesting needed to be completed within a very tight timeframe in the late summer and early Fall so as to stay in synch with the Odyssey of the Mind program. When we did not meet our recruitment goal in time to start the program, we randomly assigned participants with the restriction that the experimental group was filled (so as to be able to create the full number of teams). Participants were allowed to pair with one other person in the random assignment; existing pairs were proportionately assigned to the experimental and control groups. There are slight variations in the degrees of freedom for inferential statistics due to occasional missing test scores that occurred because of experimenter error or participants not following instructions.

(1) Processing speed: Letter and Pattern Comparison tasks (Salthouse & Babcock, 1991); $\alpha = .814$.

(2) Working memory: Letter-Number Sequencing (Wechsler, 1997).

(3) Inductive reasoning: Letter Sets and Figure Classification (Ekstrom et al., 1976) and Everyday Problem Solving (Willis & Marsiske, 1993); $\alpha = .691$.

(4) Visual-spatial processing: Card Rotation and Hidden Patterns (Ekstrom et al., 1976); $\alpha = .706$.

(5) Divergent thinking (fluency): Word Association, Ornamentation, and Opposites (Ekstrom et al., 1976), FAS (Benton & Hamsher, 1978), and Alternate Uses (Reese et al., 2001); $\alpha = .755$.

We created a composite measure of these five constructs as a measure of fluid ability; $\alpha = .825$. All of the cognitive measures were paper-and-pencil tests, except the letter-number sequence, word association, and the FAS, for which oral responses were required (and recorded by the experimenter).

Three measures of dispositions plausibly reflective of habitual cognitive engagement were also included. Mindfulness (Bodner & Langer, 2001) is a tendency to be alert to novel distinctions in present experience. Need for Cognition (Cacioppo & Petty, 1982; Cacioppo, Petty, Feinstein, & Jarvis, 1996) is a tendency to seek information and to reflect on experience to make sense of events. A composite measure of Memory Self-Efficacy, derived from the Change and Capacity scales of the Metamemory in Adulthood (MIA) questionnaire (Dixon, Hultsch, & Hertzog, 1988), assesses beliefs that effective memory performance can derive from appropriate allocation of effort. (An examination of how dispositional and activity engagement relate to cognition is reported elsewhere (Parisi, Stine-Morrow, Noh, & Morrow, submitted).)

Following pretest, participants who were assigned to the experimental group were formed into Senior Odyssey teams of five to seven people, based on the individual choice of the long-term problem at pretest, as well as the need to accommodate scheduling constraints. While there were 20 weekly meetings scheduled for each group, there were breaks in the schedule (e.g., holidays, weather), but generally teams interacted in the context of formal and informal meetings from October through March. A common set of spontaneous problems was developed for each formal meeting that (based on a task analysis) cycled through problems exercising one or more of the targeted abilities (i.e., speed, working memory, reasoning, visuospatial processing, divergent thinking), through particular problem types (e.g., alternative uses, rebuses, odd-one-out), and through problems varying in difficulty. The 20 team meetings were led by the coach using a common set of PowerPoint presentations that displayed these problems. Coaches worked to keep sessions as fast-paced as possible and to use different strategies of eliciting solutions (e.g., free response, turn-taking, competition among teams or triads). Meetings early in the season were primarily devoted to spontaneous problems, but as the tournament approached, the emphasis shifted to developing and implementing solutions for the long-term problem. At the end of each season, a tournament was held in the community, the first at a community center and the second at an elementary school, where one of the local school teams performed for the seniors during the lunch period. In other words, this was also a social occasion, which family and friend attended to watch the performances.

Note that at no point in the season were participants provided explicit strategy instruction. Rather, participants were confronted with a variety of convergent and divergent problems and encouraged to take risks in suggesting solutions and to piggyback on one another's ideas, as they readied themselves for the tournament.

RESULTS AND DISCUSSION

Retention

Of the 87 participants in the experimental group who were retained until the posttest, 64 participants (74%; 14 out of 21, or 67%, for the retirement communities) completed the program and worked with their teams to prepare for the tournament performances (a couple of participants could not make the actual tournament because of family obligations or illness, but were there “in spirit”). The remaining 23 dropped sometime during the program (but returned for the posttest). Those who dropped prior to completion were on average slightly younger (M_D=70.0, range: 59–86; M_R=74.2, range: 59–93), $t(85)=2.16$, $p<.05$, and scored slightly higher on the pretest measures of speed (M_D=12.6, se=.4; M_R=11.0, se=.3), $t(85)=3.04$, $p<.01$, than those who were retained until the end of the program, but did not differ in educational level, $t(85)=.15$, or vocabulary, $t(83)=.62$. Of the 23 who dropped, almost half (n=11) left within the first two weeks of the program, with the most typical reasons given that the program was more time-consuming than they had expected, or it was not the type of activity they expected. The remaining participants dropped between weeks 3 and 9.

Of the 64 participants who were retained as members of the Odyssey team, attendance at the weekly meetings was highly variable (range: 6–20 sessions). On average, participants came to about three-quarters of the formal meetings (M=15.5, se=.4). The number of sessions attended could be predicted by certain pretest variables. Those who had higher initial levels of self-efficacy, r=.26, speed, r=.27, and inductive reasoning, r=.25, $p<.05$ for all, and an overall higher fluid composite, r=.31, $p<.01$, attended more of the sessions. So assuming a commitment to the program was made, there was some evidence that the initially more able may have been more drawn to the meetings (or able to coordinate the resources to make the meetings).

Effects of Engagement on Cognition

Mean raw scores for the cognitive measures at pretest and posttest are presented in Table 1. Change from pretest to posttest was calculated for each measure in terms of standard deviation units at pretest [$(T2–T1)/SD_{T1}$]. Composites for speed, reasoning, visual-spatial processing, divergent thinking were created as the mean standard unit change.[2] Working memory was measured by performance on a single task (letter-number sequencing). Intercorrelations among cognitive constructs (mean z-scores at pretest) and change scores are presented in Table 2. Group differences in change were tested with intent-to-treat analyses, so that pretest and posttest scores of the experimental group participants were included regardless of whether they completed the program. Figure 1 presents these findings. As shown in this figure, all differences were in the predicted direction, with the experimental group showing differential positive change relative to the control group. Using one-tailed tests, the difference in change was reliable for speed, $t(146)=1.81$, $p=.036$, inductive reasoning, $t(146)=1.83$, $p=.034$, and divergent thinking, $t(147)=1.88$, $p=.031$, but not for working memory, $t(146)=1.01$, $p=.136$, or visual-spatial processing, $t(144)=.60$, $p=.275$. Importantly, the overall composite of these variables, which might be taken as a measure of fluid ability, showed differential positive change among those who participated in the cognitive intervention, $t(149)=3.11$, $p=.001$.[3] This was a small, but reliable, effect.

[2]Given that we took advantage of standard instruments from the literature for which construct validity has been demonstrated elsewhere, we did not try to verify the factorial structure of our cognitive battery for this small sample. We note that the Cronbach alphas for each construct are acceptable.

[3]These findings were the same when the participants from the retirement communities were removed from the analysis. There were reliable differences in change between the experimental and control groups for speed, $t(135)=1.89$, $p=.030$, inductive reasoning, $t(136)=2.39$, $p=.009$, divergent thinking, $t(135)=2.07$, $p=.020$, and the composite of fluid ability, $t(136)=3.38$, $p<.001$, but not for working memory, $t(134)=1.13$, $p=.130$, or visual-spatial processing, $t(134)=.70$, $p=.241$.

We note that there was little evidence of correlated change among ability constructs (see the lower right corner of Table 2), with a possible exception being divergent thinking and inductive reasoning, both of which are linked to problem solving. This would be troublesome for an account in which engagement is assumed to affect an underlying fluid ability that is manifested in the individual constructs, but less so for an account in which it is assumed that engagement offers opportunities to improvise in exercising component skills on an ad hoc basis. According to the latter (skill-based) account, different individuals may exercise different facets of fluid ability, so that there may be selective improvement in component abilities (and little correlated change). Given the inherent unreliability of change scores, however, we do not draw any conclusions on this issue based on this small pilot, and leave the question open for future research.

The extent of participation was somewhat predictive of change in performance. For the experimental group, the number of sessions attended was predictive of an increase in the fluid composite, $r=.20$, $p=.03$. Number of sessions specifically predicted change in visual-spatial processing, $r=.32$, $p=.002$; none of the other correlations with change reached significance.

In contrast to training studies, which have shown fairly specific effects of experience, engagement in an intellectually stimulating environment (as modeled by the Odyssey program) showed change in multiple facets of cognition -- in the absence of explicit ability training.

Effects of Engagement on Cognition and Predispositional Engagement

We examined whether the program had any effects on predispositions that might influence how one engages experience on an everyday basis. It did not. Relative to the control group, the experimental group did not show differential positive change in self-efficacy, $t(133) = -1.59$, mindfulness, $t(128)=.81$, or need for cognition, $t(130)=.68$, suggesting that the program did not have broad effects in engendering confidence in one's cognitive ability, or in enhancing a predisposition toward approaching and engaging novelty. However, there was evidence within the experimental group that change in such predispositional engagement may have been modestly related to change in cognitive abilities: change in both mindfulness, $r=.19$, $p=.036$, and need for cognition, $r=.22$, $p=.03$, were predictive of change in the fluid composite; change in self-efficacy, $r=.08$, was not.

CONCLUSIONS

To this point, the literature on plasticity of cognitive function in adulthood has predominantly focused on a training approach in which high levels of experimental control have been used to isolate mechanisms of change in particular abilities. These findings have been clear in demonstrating plasticity in the ability targeted for training, with very little transfer. We found very small but reliable effects of immersion in a substantively complex environment on speed, inductive reasoning, and divergent thinking (fluency). Our tentative account of the possibly broad-based effects of engagement is that engagement engenders self-direction in the achievement of personally meaningful goals that are recognized and supported by a community. Such a context invites the exercise of individual abilities in service to these larger goals. As such, an engaged lifestyle sustains cognitive vitality by inviting sustained practice of multiple abilities over time. We found preliminary evidence for this in an experimental design in which older adults immersed in a program of creative problem solving showed small levels of improvement, relative to a wait-list control, in speed of processing, inductive reasoning, and divergent thinking (verbal and ideational fluency) in the absence of explicit training.

What are the underlying mechanisms? In one sense, our effects may be construed as just experience-specific effects, quite analogous to what is found in the training literature. The difference, however, is that in this case, skills were implicitly practiced in the context of multifaceted activities that were largely self-regulated (Stine-Morrow, 2007). We found some evidence for this in a “dose-response” effect of greater change in the fluid composite among those who were more thoroughly engaged through participation in formal meetings. In these data, we found some evidence that there is potential for a “Matthew effect” in such self-regulatory self-enhancement: those with initially higher levels of self-efficacy and fluid ability attended Odyssey meetings more regularly, which in turn was related to cognitive growth (though we note that self-efficacy was not directly related to change in cognitive scores). Longitudinal data with larger samples are needed to test this idea more systematically.

We did not find any evidence of differential change in need for cognition, mindfulness, or memory self-efficacy among those in the intervention, so this model of a substantively complex environment did not appear to enhance predispositional engagement (see Parisi et al. (submitted) for a discussion of differential effects of activity engagement and predispositional engagement on cognition). However, we did find a modest correlation between change in the fluid composite and change in both mindfulness and need for cognition over a seven- to eight-month period. We certainly cannot specify the causal link here, but a change in cognitive capacity does seem to go hand-in-hand with a predisposition toward engaging experience with a more nuanced eye.

The Senior Odyssey project is translational research, which is conducted in the context of existing social structures. To conduct this research, we registered as members of Odyssey of the Mind, so that participants were working in the same cycle and with the same sorts of problems as the children and younger adult participants in the international program. Relative to other models of training research in the literature, our manipulation as a cognitive intervention is no doubt as sloppy as life itself. Participants met in groups, some of which became the best of friends, some of which – did not. Some participants missed meetings; others gathered on their own outside of our group meetings to prepare for the tournament. Participants had a lot of latitude to choose activities of interest to them, and to ignore activities that were not. Nevertheless, adults turned loose in such an environment appeared to show at least some benefit.

The advantage to this approach to cognitive intervention research is that if the program does prove to be beneficial, it is already in place. This is turnkey science that you can take off the shelf and use. There is no need to work through the logistics of application, with worries about losing fidelity of the intervention in field: this is just about as messy as it can get. Consumers have the opportunity to enroll in the very program that will have been tested in the research. The season after this project was completed, one of our teams registered on their own so that they could compete in the Illinois state tournament. In recent years, there have been senior teams from other states who have participated in the World Finals Odyssey of the Mind competition. These few examples suggest that this is a program that will be attractive to some older adults, and offers an opportunity for age-integration.

There are certainly weaknesses that need to be addressed. There was differential drop-out in the experimental group. This is perhaps not surprising, given the time demands of the program. Intent-to-treat analyses enabled us to assess the effects of the program even with partial adherence. Differential rates of drop-out between the experimental and control groups, nevertheless, leave the findings vulnerable to the interpretation that those with less capacity for plasticity were more likely to withdraw. Thus, the relationship between meeting attendance and change in fluid ability may be interpreted as either a “dose-response” effect, or as evidence for treatment-related withdrawal.

Another potential weakness is the wait-list control group, which only allowed us to control for retest effects and instrument differences in the use of alternate forms. The lack of a placebo control makes our findings vulnerable to the interpretation of expectancy effects: the Odyssey group knew they were in the experimental group and might have expected to increase their performance; the control knew they were not. This is an important design element that needs to be incorporated into future research. The specificity of effects in the cognitive training literature (Ball et al., 2002) implies that expectancy may not produce broad effects on cognitive performance, suggesting that ability-specific training may be one avenue to solving the problem of the morally defensible placebo control.

Finally, we acknowledge that we have not met Salthouse's challenge for assessing mental-exercise hypothesis, in that to date we have no long-term follow-up of participants. The engagement hypothesis, as articulated here, would predict that abilities would not be maintained in the absence of further engagement. However, assuming effects of reciprocal influences of self-direction and intellectual functioning (e.g., Schooler et al., 2004), we would expect that when afforded the opportunity for similar activities, participants in the experimental group would be disproportionately likely to seek out substantively complex environments that would in turn engender the exercise of mental abilities.

Even though Odyssey is perhaps a good exemplar of a program embodying the principles of substantive complexity, it is not unique in offering avenues for engagement, as conceptualized here. We adopted Odyssey as an operational model of a substantively complex environment, in part, because of the advantages noted earlier of piggybacking onto a well-established program. This was a multimodal intervention that offers promise for improving cognitive abilities in the absence of specific training (see also Carlson et al. (in press), and Tranter and Koustaal (2008)). Such research suggests that immersion in complex work (e.g., balancing demands of multiple tasks), leisure (e.g., book clubs, hosting dinner parties), or volunteer activities (e.g., providing assistance in schools) demanding self-direction holds potential for cognitive self-enhancement. Further research is needed to explore specific mechanisms of action.

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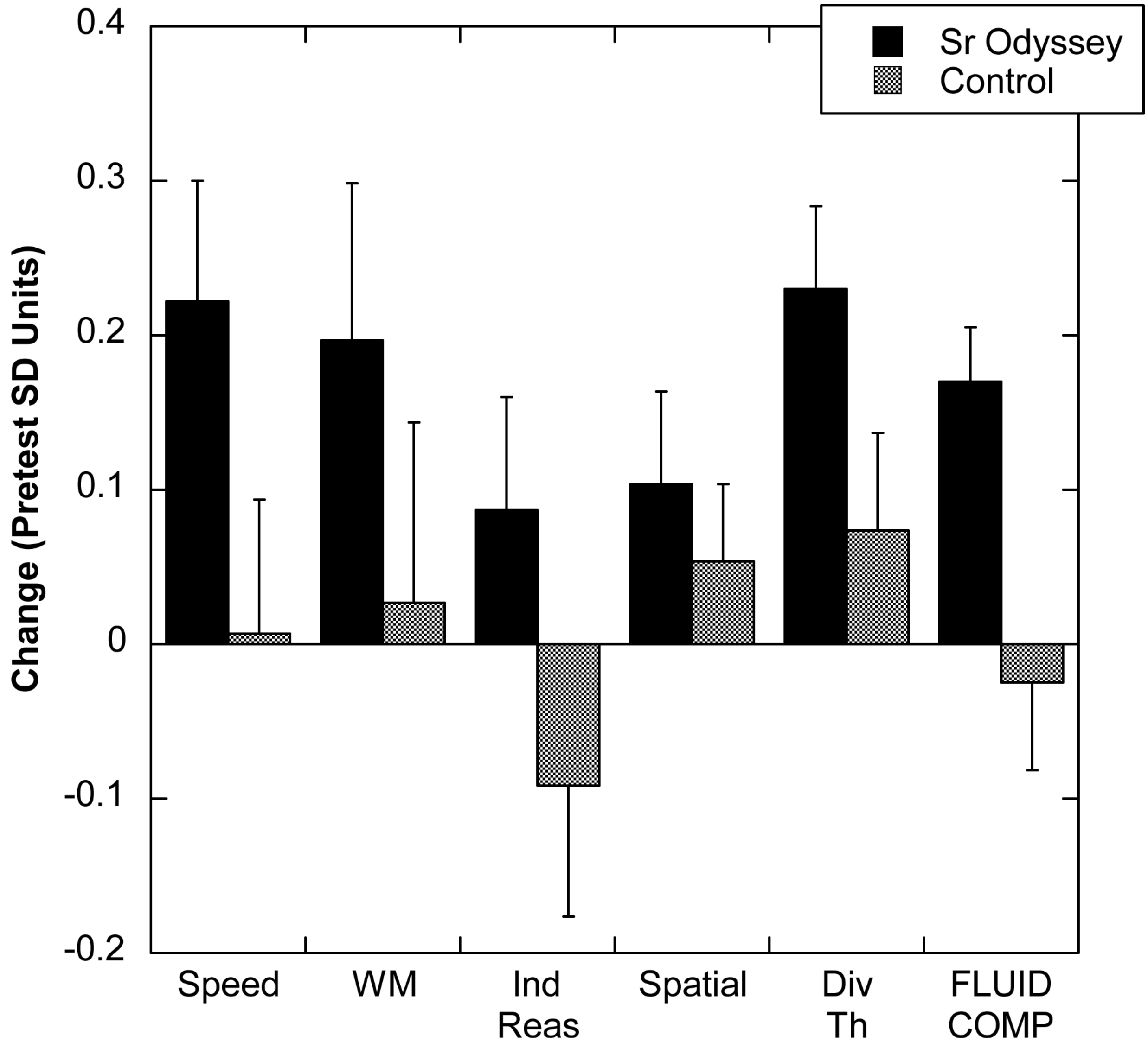

Figure 1.
Change from pretest to posttest for the experimental (Senior Odyssey) and control groups (error bars reflect standard errors in change).

Table 1

Mean raw scores on cognitive tasks for Control and Experimental Groups at pretest and posttest, and mean change scores expressed in standard units.

Cognitive Tasks	Control Group				Experimental Group				Change			
	Pretest		Posttest		Pretest		Posttest		Control		Experimental	
	Mean	se	Mean	se	Mean	se	Mean	se	Mean	se	Mean	se
Processing Speed												
Letter Comparison	8.6	0.4	9.0	0.4	8.1	0.2	9.4	0.3	0.14	0.11	0.48	0.09
Pattern Comparison	15.2	0.5	14.8	0.6	14.8	0.4	14.6	0.5	−0.12	0.10	−0.04	0.11
Working Memory												
Letter Number Sequence	10.2	0.3	10.3	0.4	9.7	0.3	10.2	0.3	0.03	0.12	0.20	0.10
Inductive Reasoning												
Letter Sets	7.1	0.4	6.9	0.4	6.6	0.3	7.3	0.3	−0.06	0.10	0.20	0.08
Figure Classification	35.4	1.9	27.5	1.6	33.9	1.5	25.2	1.7	−0.57	0.10	−0.63	0.10
Everyday Problem Solving	16.1	0.4	17.5	0.5	15.9	0.3	18.1	0.4	0.46	0.12	0.70	0.11
Visual-Spatial Processing												
Card Rotation	33.3	2.0	32.6	2.0	30.4	1.7	29.2	1.9	−0.05	0.09	−0.07	0.08
Hidden Patterns	61.1	4.0	65.7	4.1	58.1	3.0	67.0	3.1	0.15	0.09	0.29	0.09
Divergent Thinking												
Word Association Fluency	7.9	0.3	7.6	0.4	7.7	0.3	7.5	0.3	−0.11	0.09	−0.07	0.10
Ornamentation	16.1	0.7	15.5	0.7	14.9	0.7	15.8	0.6	−0.11	0.13	0.15	0.10
Opposites	13.3	0.6	15.7	0.7	14.7	0.5	16.3	0.6	0.51	0.12	0.34	0.10
FAS	41.3	1.4	41.0	1.6	42.6	1.5	45.5	1.8	−0.02	0.08	0.23	0.09
Alternate Uses	12.1	0.4	12.8	0.6	11.7	0.5	13.9	0.5	0.18	0.12	0.54	0.11

Table 2

Intercorrelations among cognitive constructs at pretest and change in cognitive constructs from pretest to posttest. (Values above the diagonal are based on the whole sample; values below, on the experimental group alone).

	Age	Speed T1	WM T1	Ind Reas T1	Spatial T1	Div Th T1	Fluid T1	Speed Ch	WM Ch	Ind Reas Ch	Spatial Ch	Div Th Ch	Fluid Ch
Age		−.463**	−.350**	−.493**	−.408**	−.169*	−.504**	−.110	.116	.077	−.073	−.176*	.006
Speed T1	−.398**		.465**	.609**	.619**	.515**	.831**	−.160	.056	−.038	.038	.131	−.047
WM T1	−.373**	.445**		.512**	.422**	.345**	.740**	.088	−.403**	.032	.030	.233**	−.060
Ind Reas T1	−.509**	.557**	.518**		.698**	.470**	.855**	.214**	.018	−.387**	.043	.087	−.027
Spatial T1	−.394**	.635**	.471**	.730**		.318**	.806**	.134	.117	−.170*	−.200*	.077	−.076
Div Th T1	−.225*	.560**	.420**	.482**	.455**		.656**	.095	.109	−.065	.036	−.020	.096
Fluid T1	−.497**	.802**	.762**	.841**	.840**	.717**		.099	−.042	−.161	−.017	.146	−.026
Speed Ch	−.192	−.148	.186	.282**	.198	.147	.172		.042	−.099	.134	.087	.536**
WM Ch	.145	.028	−.469**	−.025	.025	.079	−.109	.006		.084	−.191*	−.036	.576**
Ind Reas Ch	.012	.093	.018	−.334**	−.051	−.072	−.094	−.128	.116		.049	.165*	.570**
Spatial Ch	−.070	.070	.116	.130	−.156	.024	.051	.180	−.161	.008		.068	.321**
Div Th Ch	−.203	.188	.294**	−.010	.036	−.101	.114	−.002	−.129	.226*	.140		.430**
Fluid Ch	−.077	.056	−.034	.018	.039	.050	.033	.494**	.543**	.509**	.396**	.371**	

* $p<.05$

** $p<.01$