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The Role of Cognitive Stimulation on the Relations Between Age and Cognitive Functioning

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To make a convincing argument that cognitive stimulation moderates age trends in cognition there must be (a) a negative relation between age and level of cognitive stimulation, (b) a positive relation between level of cognitive stimulation and level of cognitive functioning, and (c) evidence of an interaction between age and cognitive stimulation in the prediction of cognitive functioning. These conditions were investigated in a study in which 204 adults between 20 and 91 years of age completed an activity inventory and performed a variety of cognitive tasks. Only the 1st condition received empirical support, and, thus, the results of this study provide little evidence for the hypothesis that cognitive stimulation preserves or enhances cognitive functioning that would otherwise decline.

There is considerable interest, and often acceptance, of the "use it or lose it" adage with respect to the effects of aging on cognitive functioning. This view holds that age-related effects on measures of cognitive performance can be moderated by individuals' lifestyles, and particularly by the amount of cognitive stimulation individuals receive in their daily lives. Hultsch, Hertzog, Small, and Dixon (1999) stated the hypothesis as follows: "Individuals who engage in activities that make significant loads on their cognitive skills will show greater maintenance or improvement of their abilities than individuals who are exposed to less complex environments with minimal cognitive loads" (p. 246).

Many articles and books oriented toward the general public appear to consider the use it or lose it hypothesis firmly established, as is evident in the following quotations.

> By far the best way of actually improving memory and all other mental performances is to use them—by continued activity and learning and by "enrichment of the environment." Mental deterioration would occur at any age if we had only a chair and a television set. (Comfort, 1976, p. 135)

> To a large extent, problems with memory and thinking are just the same as problems with our physical body. If we don't use a faculty, we will lose it. The myths of aging tend to make us expect intellectual decline. Actually, if we use our minds frequently and in novel ways, many of the attributes of intelligence, such as wisdom, actually can improve with age. (Fries, 1989, pp. 105–106)

> Much of what was once attributed to a loss of intelligence is now being recognized as the result of the way old people are often treated. . . . Study after scientific study has shown that people who stay active and intellectually challenged not only maintain their mental alertness but also live longer. (Dychtwald, 1990, p. 40)

> The best defense against age-related cognitive decline is practice. Practice prevents disuse from occurring (pp. 69–70). All of us tend to use certain skills or abilities less as we grow older. As a result, these skills decline (pp. 99–100). The take-home message when it comes to the brain? Your brain: use it or lose it. (Restak, 1997, p. 246)

> Maintenance of cognitive ability requires the continued use of the mind, continued engagement in complex cognitive activity. (Rowe & Kahn, 1998, p. 50)

When the use it or lose it hypothesis has been put to the test, however, the results have not been very supportive. Much of the relevant research literature has been reviewed by Salthouse (1991), where it was concluded that the pattern of age differences was similar across variables presumed to be unfamiliar and those presumed to be familiar or ecologically valid, across different amounts of practice or experience, and in subgroups distinguished by type of experience. One subgroup that has attracted special interest is college professors, because of the (perhaps delusional) assumption that their professional lives are high in cognitive stimulation. A report by Shimamura, Berry, Mangels, Rusting, and Jurica (1995) is often cited as finding smaller age differences among professors than among adults from other occupational groups, but closer examination of those results reveals a complex pattern. In some variables, such as reaction time, paired associate memory, and errors in a self-ordered pointing task of working memory, the professors exhibited a typical age difference. The major "exception" to age differences in that study was in a measure of prose recall, but other studies have also reported relatively small age differences on that type of measure, particularly among individuals with high levels of cognitive ability (e.g., Meyer &

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Rice, 1989). Furthermore, research by Sward (1945) and by Christensen (1994) and colleagues (Christensen & Henderson, 1991; Christensen, Henderson, Griffiths, & Levings, 1997) has been consistent in reporting age-related declines in cognitive variables among college professors that are similar to those reported with other types of samples.

Another approach to investigating effects of long-term cognitive stimulation has focused on the role of experience and expertise in adults of all ages (e.g., Masunaga & Horn, 2001; Meinz, 2000; Meinz & Salthouse, 1998; Salthouse, Babcock, Mitchell, Skovronek, & Palmon, 1990). The rationale is that age comparisons in highly experienced or expert individuals are likely to be informative about the effects of a lifetime spent in active pursuit of cognitive stimulation. However, effects of experience or expertise have been found to be very specific to functioning in the particular domain that has been practiced, and there has been little evidence of transfer to other types of cognitive functioning. Expertise research therefore provides little basis for concluding that general cognitive stimulation will have broad effects across many different types of cognitive variables.

Regular engagement in mentally stimulating activities such as crossword puzzles is also frequently assumed to maintain or enhance cognitive abilities that would otherwise decline. However, Hambrick, Salthouse, and Meinz (1999) recently investigated this hypothesis in a series of four studies, and they failed to find any indication that the age trends in measures of cognitive functioning were moderated by the time per week spent working on crossword puzzles.

Among the research sometimes considered as supporting the cognitive stimulation perspective are studies investigating effects of short-term practice or training on measures of cognitive functioning. Although benefits of short-term practice or training have been demonstrated in adults of all ages (e.g., Baltes & Lindenberger, 1988; Schaie & Willis, 1986), the results may not be directly relevant to the effect of long-term cognitive stimulation on the relations between age and cognitive functioning. That is, merely because the level of certain types of cognitive performance can be enhanced with experimentally controlled short-term cognitive stimulation does not necessarily mean that the same processes would operate in the same manner with naturally occurring cognitive stimulation over a much longer period of time, or that any effects would generalize to untrained abilities.

The ideal method to investigate the role of cognitive stimulation in age differences in cognitive functioning would be an experimental intervention with random assignment of individuals to different cognitive activity levels and broad assessments of cognitive ability over an extended period of time. Although results from intervention studies with animals have revealed that exposure to complex environments is associated with neural growth even among older animals (e.g., Black, Greenough, Anderson, & Isaacs, 1987; Greenough, Cohen, & Juraska, 1999), a random-assignment intervention design is obviously impractical with humans.

The next best alternative might be to follow the same individuals over a period of many years with repeated inventories of the activities being performed and to conduct an objective assessment of the cognitive demands of those activities at every measurement occasion. This method is not optimal because there could be a selection bias with respect to the type of activities in which individuals choose to engage, and unless there is moderate variation over time in the nature or frequency of the activities, it may be difficult to detect a relationship between changes in activity level and changes in cognitive functioning. Furthermore, because very little is currently known about the relation between cognitive stimulation and cognitive functioning, it is not clear (a) whether one should expect simple correlations between changes in the measures of cognitive stimulation and cognitive functioning or (b) whether change in cognitive stimulation should precede any change in cognitive functioning, and if so, then (c) whether there is a critical interval that must elapse, or a threshold level that must be exceeded, before effects are evident in cognitive functioning. A study of this type also poses several methodological problems in that a longitudinal study must continue long enough for substantial age-related changes to occur in the least active group, and it is not yet clear how to quantify the frequency of daily activities or to assess their cognitive demands.

It is this lack of consensus with respect to how to measure use or level of cognitive stimulation that stands as one of the major challenges confronting all attempts to investigate the cognitive stimulation hypothesis. Although it may not be possible at the current time to assess cognitive stimulation directly, two indirect approaches can be used to estimate the amount of cognitive stimulation an individual receives. These consist of (a) self-reports of frequency of engagement in different types of activities and (b) inferences based on responses to personality questionnaires about dispositions to seek cognitive stimulation.

The assessment of self-reported activities typically involves the presentation of a list of activities, with individuals asked to estimate the number of hours in an average week they are engaged in each. The sum of the hours across all of the activities is then used as the index of individuals' activity level. A number of studies have reported a positive relation between various measures of cognitive ability and level of activity (e.g., see a review in Hultsch et al., 1999). Although results of this type are sometimes interpreted as implicating cognitive stimulation as a determinant of level of cognitive functioning, a positive correlation by itself is ambiguous because of uncertainties about the causal direction. That is, (a) activity could enhance cognitive functioning, (b) some other factor such as health status could affect both activity level and cognitive functioning, or (c) only the most cognitively capable people might be able to engage in certain activities. Salthouse (1991) phrased this latter possibility as follows: "High levels of cognitive functioning may be a prerequisite for certain kinds of experiences, in which case the correlation would reflect the effects of cognition on experience, rather than the effects of experience on cognition" (p. 154). In fact, evidence of reciprocal or bidirectional relations between cognitive stimulation and cognitive performance has recently been reported by Schooler and colleagues (Schooler & Mulatu, 2001; Schooler, Mulatu, & Oates, 1999), and Hultsch et al. (1999) demonstrated good fit to the data for a model with an influence from a measure of self-reported involvement in activities classified as requiring novel information processing to measures of verbal and memory abilities, as well as for a model with an influence in the opposite direction.

Most of the studies that have reported an influence of activity on cognitive functioning have emphasized an "engaged lifestyle" construct, which includes a broad variety of activities and not merely those that might be cognitively stimulating. (For further discussion, see the exchange on the assessment of engaged lifestyle between Pushkar et al., 1999, and Hertzog, Hultsch, & Dixon, 1999.) A few reports have distinguished different types of activities according to hypothesized cognitive demands (e.g., Arbuckle, Gold, Andres, Schwartzman, & Chaikelson, 1992; Christensen & Mackinnon, 1993; Gold et al., 1995; Hultsch et al., 1999), and Arbuckle et al. (1992), Gold et al. (1995), and Schooler and Mulatu (2001) had other people rate the intellectual demands of the activities. However, the actual demands of most activities are unknown, and it is possible that they could vary as a function of the situation or the individual. Consider the activity of watching television. The viewer could be completely passive with little or no cognitive stimulation. Alternatively, he or she could be analyzing the styles of the actors, searching for specific events in the background, or anticipating what comes next. It is also possible that the cognitive demands of the same activity could change with age, as the level of physical or cognitive ability changes. For example, what might have been a simple task with few cognitive challenges may become very demanding when a different approach must be used to accomplish the same goal.

In the current study, an attempt was made to obtain more precise estimates of the cognitive involvement in different activities by asking the participants to rate the cognitive demands of each activity in which they engage. In this manner, it is possible not only to investigate the relations of age and cognitive functioning to the number of hours engaged in different activities, as was done by earlier researchers, but it is also possible to investigate the relations of those variables to the average rating of cognitive demands and to an index of cognitive stimulation based on the sum across activities of the product of hours and rated cognitive demand.

The second indirect approach to evaluating cognitive stimulation relies on questionnaires designed to assess individuals' predispositions to engage in cognitively stimulating activities. One such questionnaire was used in this study. The Need for Cognition scale (Cacioppo, Petty, Feinstein, & Jarvis, 1996) was designed to assess "stable individual differences in people's tendency to engage in and enjoy effortful cognitive activity" (p. 198). According to Cacioppo et al. (1996), "Individuals high in need for cognition tend to have active, exploring minds, and, through their senses and intellect, they reach and draw out information from their environment" (p. 245).

Several studies have reported small negative correlations between age and the Need for Cognition scale and small positive correlations between the scale and various cognitive measures (see review in Cacioppo et al., 1996). Results from a recent study by Blanchard-Fields, Hertzog, Stein, and Pak (2001) are fairly typical. Blanchard-Fields et al. (2001) administered the Need for Cognition scale to 219 adults between 23 and 86 years of age, along with a variety of other questionnaires and cognitive tasks. The Need for Cognition score correlated −.05 with age, .24 with education, .27 with vocabulary, and .23 with a measure designed to assess working memory (i.e., operation span).

To summarize, three major questions were addressed in this report. The first question is, What happens with increased age to the frequency of engaging in various activities, to the perceived cognitive demands of those activities, and to self-reported desire for intellectual stimulation? That is, Is there evidence that increased age is associated with lower levels of cognitive stimulation as implied by the use it or lose it perspective? The second question is, What is the relation between measures of cognitive stimulation and measures of cognitive functioning? This issue is important because cognitive stimulation cannot be expected to moderate or mediate age differences in cognitive functioning if it has weak or nonexistent relations to measures of cognitive performance. The third major question to be investigated concerns the effects of cognitive stimulation on the age trends in measures of cognitive functioning. That is, Is there evidence that people who constantly seek out cognitive challenges and keep mentally active maintain or enhance their cognitive abilities?

The analyses to be reported are based on cross-sectional data, and, thus, it is difficult to specify the exact causes of any age-related differences that might be observed. However, moderate to large relations between age and many measures of cognitive performance are frequently reported in cross-sectional comparisons, and thus it is meaningful to attempt to identify moderators of those relations. Of particular interest in the current context is whether the negative relations between age and measures of cognitive functioning are smaller for people who report higher levels of cognitive stimulation in their daily lives or who report stronger tendencies to seek out cognitive stimulation. A finding that the age trends in cognitive functioning vary according to level of cognitive stimulation would be consistent with view that engagement in mental activity contributes to the maintenance or improvement of cognitive functioning.

Method

Participants

The sample consisted of 204 participants ranging from 20 to 91 years of age. Characteristics of the sample divided into three age groups are summarized in Table 1. Five participants did not complete the activity inventory as instructed, and thus some of the analyses are based on data from only 199 participants. In general, the participants were highly educated, averaging 16 years of formal education, and healthy, with an average rating of 2.1 on a scale ranging from 1 (*excellent*) to 5 (*poor*). The average scores on two standardized cognitive measures were substantially above the age-adjusted mean values (i.e., $M = 10$ and $SD = 3$) derived from a nationally representative normative sample. Of the 204 participants, only 14, all of whom were under the age of 35, reported that they currently attended either undergraduate, graduate, or professional school.

Procedure

Participants were recruited through flyers, newspaper advertisements, and referrals from other participants. Three 2-hr sessions were conducted in the laboratory, during which a variety of cognitive tests was administered. Most of the cognitive variables used in the analyses reported here were based on tests from standardized cognitive test batteries. For example, spatial ability was assessed with (a) the Block Design test from the Wechsler Adult Intelligence Scale—Third Edition (WAIS–III; Wechsler, 1997a), in which examinees assembled blocks to match a design; (b) the Spatial Relations test from the Differential Aptitude Test battery (Bennett, Seashore, & Wesman, 1997), in which the examinee determined the correspondence between assembled and unassembled three-dimensional objects; and (c) the Paper Folding test from the Educational Testing Service Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1976), which required the examinee to identify the pattern

Table 1
Means and Standard Deviations of Characteristics of the Sample

	Age range					
	20–39		40–59		60–91	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*
N	52		84		68	
Age	27.9	5.7	49.5	5.9	70.0	7.4
Female (%)	75		70		53	
Years of education	15.5	2.7	16.2	2.3	16.1	2.5
Health rating	1.9	0.8	1.9	0.9	2.5	0.8
Activity limitation	1.2	0.9	1.1	0.8	1.5	0.9
CES-D Score	11.9	9.5	9.2	7.5	9.8	7.6
Average scaled score	12.4	3.7	12.7	2.4	12.4	2.6
Need for Cognition scale	11.1	14.0	9.6	12.8	6.8	11.8

Note. Health rating on a scale ranging from 1 (*excellent*) to 5 (*poor*). Activity limitation on a scale ranging from 1 (*very little*) to 5 (*very much*). The Center for Epidemiological Studies—Depression scale (CES–D; Radloff, 1977) is a self-report depression scale. Average scaled score is the average of the age-adjusted scores for the Wechsler Adult Intelligence Scale—Third Edition (Wechsler, 1997a) Block Design and Vocabulary subtests.

of holes that would result from a sequence of folds of a piece of paper followed by a hole punch through the folded paper. Reasoning was assessed with (a) the Analysis–Synthesis test from the Woodcock–Johnson Cognitive Ability battery (Woodcock & Johnson, 1990), in which examinees must use logical rules to determine relations among elements; (b) the Raven's Advanced Progressive Matrices test (Raven, 1962), in which the examinee selects the best completion of a missing cell in a matrix of geometric patterns; and (c) a letter series completion test described by Noll and Horn (1998). Episodic memory was assessed with (a) the sum of idea units recalled across three stories in the Logical Memory test from the Wechsler Memory Scale—Third Edition (Wechsler, 1997b), (b) the sum of words recalled across four repetitions of the same word list in the Word List test from the Wechsler Memory Scale—Third Edition, and (c) the number of word pairs recalled in a locally developed paired associates test involving two lists of six different word pairs. Two vocabulary tests were also administered, that from the WAIS–III involving the examinee providing definitions of the target words and the Picture Vocabulary test from the Woodcock–Johnson Cognitive Ability test in which the examinee names pictures.

The participants were also asked to complete several questionnaires at home, including the Activity Inventory and the Need for Cognition (18-item version). In addition, all participants reported the number of years of education they had completed, rated their health and the degree to which their activities were limited by health factors, and completed the Center for Epidemiological Studies—Depression scale (CES–D; Radloff, 1977). The protocol was slightly modified after the first 54 participants, and, thus, one of the cognitive composites described below, Cog2, is based on only 150 participants.

The activity inventory consisted of a list of 22 activities (see Table 2) that were assumed to involve a range of cognitive demands. For each activity, the participants were asked to report the number of hours they were engaged in the activity in a typical week and to rate the cognitive demands of the activity. The specific instructions read, "rate how cognitively demanding you feel the activity is on a 5-point scale where 1 = absolutely no cognitive demands (e.g., sleeping), 3 = moderate cognitive demands (e.g., reading a newspaper), and 5 = high cognitive demands (e.g., completing a tax form)." In addition to the 22 listed activities, the participants were also allowed to report this information for any other activity they performed at least 2 hr per week. The cognitive demand ratings were only computed from the participants who reported that they performed the activity in a typical week.

An additional 17 adults (mean age = 27) completed the activity inventory twice with a 1-week interval between the two administrations. Retest correlations were .80 for the total hours per week, .73 for the average rated cognitive demands, and .58 for the cognitive stimulation index computed by summing the product of the hours per week and the rated cognitive demand. Although the reliability of the cognitive stimulation index was lower than desired, this was largely attributable to low retest consistency for a few activities, such as nonfiction reading and housework. The median retest correlation across the 22 activities for the product of hours by rated cognitive demands was .77.

Results

To examine the relationships between the indices of cognitive stimulation and cognitive performance, we combined the cognitive variables into four composites by averaging *z* scores for the relevant variables. The selection of variables to form the composites was based on a confirmatory factor analysis reported in Salthouse and Ferrer-Caja (in press), in which variables from the first two composites were highly correlated with one another, variables from the third composite loaded on a different factor, and variables from the fourth composite loaded on still another factor. The first two composites are treated separately because all 204 participants performed the tasks used in the first composite, but only 150 participants performed the tasks used in the second composite. (Correlations between variables within each composite were all greater than .54, with medians ranging from .59 to .73.) The first composite, Cog1, was based on the WAIS–III Block Design (Wechsler, 1997a) and Woodcock–Johnson Analysis–Synthesis (Woodcock & Johnson, 1990) variables. The second, Cog2, was based on Raven's Advanced Progressive Matrices (Raven, 1962), Letter Series (Noll & Horn, 1998), Spatial Relations (Bennett et al., 1997), and Paper Folding (Ekstrom et al., 1976) variables. The third, Cog3, was based on story memory (Wechsler, 1997b), word list recall (Wechsler, 1997b), and paired associates recall (locally developed) variables. Finally, the fourth composite, Cog4, was based on the WAIS–III Vocabulary (Wechsler, 1997a) and Woodcock–Johnson Picture Vocabulary (Woodcock & Johnson, 1990) variables. The first two composites can be considered to reflect fluid intelligence, the third episodic memory, and the fourth crystallized intelligence. Correlations among these composites, and between the composites and age, are reported in Table 3.

Internal consistency of the Need for Cognition scale was evaluated with coefficient alpha. The coefficient alpha was .90, which indicates that the items had moderately high correlations with one another, and thus it can be concluded that the items reflect a coherent construct.

Table 2 contains summary statistics on the individual activities from the Activity Questionnaire, where it can be seen that several of the activities had significant correlations between age and reported frequency. Specifically, relative to the younger participants, older participants reported spending fewer hours using a computer, supervising activities of others, socializing with friends, teaching or attending classes, writing, and engaging in musical or other artistic activities. However, older participants reported

Table 2
Means, Standard Deviations, and Correlations of Frequency and Rated Cognitive (Cog) Demands of Different Activities

Activity	*M*	*SD*	*N*	Age	Sex	Educ	Cog1	Cog4	NdCog
TV									
hr	11.2	9.7	199	.29*	−.12	−.11	−.22*	−.03	−.02
cog. level	2.1	1.0	190	.20*	.04	−.15	−.32*	−.23*	−.13
Computer									
hr	10.3	11.5	199	−.22*	−.14	.23*	.31*	.26*	.28*
cog. level	3.3	1.0	171	.18	−.13	.13	−.05	.26*	.10
Supervising									
hr	9.6	20.4	199	−.26*	.17	.00	.13	.01	.06
cog. level	3.5	1.1	99	−.25	.07	−.01	−.09	−.11	.04
Social									
hr	8.1	8.5	199	−.37*	.07	−.26*	.06	−.25*	−.03
cog. level	2.6	0.8	196	.01	.06	−.08	−.14	−.07	.07
Driving									
hr	7.6	6.0	199	−.09	.01	−.17	−.07	−.13	−.09
cog. level	2.9	1.1	186	.16	−.03	−.04	−.14	.03	−.16
Meals									
hr	6.5	5.6	199	−.09	.27*	−.19*	−.05	−.11	−.04
cog. level	2.6	1.0	188	−.05	.09	−.24*	−.21*	−.26*	−.16
Housework									
hr	5.9	5.7	199	−.01	.27*	−.17	−.10	−.14	−.01
cog. level	2.0	1.0	198	−.10	.13	−.26*	−.22*	−.36*	−.12
News									
hr	5.8	4.6	199	.32*	−.05	.02	−.21*	−.03	.09
cog. level	3.0	0.7	193	.15	.00	.04	−.07	.06	.07
Novels									
hr	4.6	5.0	199	.06	.14	−.13	−.20*	−.06	−.02
cog. level	3.2	0.9	154	−.10	−.03	.07	.19	.19	.18
Nonfiction									
hr	4.4	4.1	199	.02	−.07	.16	.01	.04	.23*
cog. level	3.7	0.9	184	.02	−.14	.25*	.20*	.40*	.23*
Classes									
hr	4.0	8.4	199	−.32*	.04	−.04	.12	−.02	.11
cog. level	4.0	1.1	115	−.25*	−.10	.13	.22	.11	.23
Shopping									
hr	3.0	2.6	199	.00	.22*	−.25*	−.23*	−.27*	−.04
cog. level	2.4	0.9	199	−.01	.06	−.07	−.09	−.12	−.11
Writing									
hr	2.8	5.0	199	−.20*	.05	−.03	−.01	−.08	.22*
cog. level	3.6	1.1	162	−.05	−.00	.15	.08	.17	.16
Gardening									
hr	2.2	3.3	199	.27*	−.06	.06	−.08	.12	.02
cog. level	2.1	0.9	114	.16	−.17	−.06	−.17	.02	−.03
Hobbies									
hr	2.2	3.5	199	−.02	.05	−.04	−.16	−.14	.08
cog. level	2.8	1.0	118	.04	−.11	.15	−.05	.03	.17
Volunteering									
hr	2.1	4.4	199	.13	.10	−.06	−.03	.09	.07
cog. level	2.8	1.0	126	.02	−.01	.14	.19	.35*	.04
Music									
hr	2.1	4.6	199	−.23*	.08	−.07	.10	−.02	.13
cog. level	3.2	1.2	111	−.08	−.03	.07	.13	.24	.14
Meetings									
hr	2.1	3.1	199	−.11	−.01	.02	.02	−.07	.16
cog. level	3.3	1.0	138	−.20	−.00	.09	.26*	.07	.10
Finances									
hr	1.6	1.3	199	−.02	.02	−.07	−.14	−.17	.03
cog. level	3.6	1.1	176	.09	.03	.00	−.13	−.08	−.03
Puzzles									
hr	1.4	2.6	199	.17	.12	.02	−.03	.08	.01
cog. level	3.7	1.3	86	−.02	−.12	.21	.36*	.45*	.13
Bridge									
hr	1.2	2.8	199	.04	.07	−.20*	−.14	−.20*	−.17
cog. level	3.1	1.3	82	.21	−.13	.14	.09	.33*	.07

Table 2 (*continued*)

Activity	*M*	*SD*	*N*	Age	Sex	Educ	Cog1	Cog4	NdCog
Chess									
hr	0.8	2.1	199	−.14	.02	−.13	−.01	−.15	.14
cog. level	3.9	1.3	60	−.41*	−.11	.01	.30	.23	.23
Total hr per week	99.4	44.8	199	−.24*	.15	−.14	.01	−.09	.18
Average cog. level	3.0	0.5	199	−.08	−.03	.03	.02	.09	.10
Cognitive stimulation	308.7	170.1	199	−.27*	.11	−.11	.01	−.09	.19*

Note. Sex is coded 0 for males and 1 for females. Educ is the number of years of formal education completed. Cog1 and Cog4 are composites defined in Table 3. NdCog is the Need for Cognition scale; hr = hour; cog. level = cognitive level.
* $p < .01$.

spending more hours watching television, reading newspapers or magazines, and gardening than did younger participants.

In terms of rated cognitive demands, increased age was associated with higher rated cognitive demands for watching television and with lower rated cognitive demands for teaching or attending classes and playing chess. Some of these age trends may be because of a shift in the nature of activity at different ages. For example, classes taken by middle-aged and older adults may be less academic than those taken by younger adults.

For all of the activities, there was a small positive correlation between the number of hours the participant reported that he or she engaged in the activity each week and its rated cognitive demands. The correlations, computed only for the individuals who reported at least some hours per week of participation in the activity, ranged from .011 (for reading novels) to .310 (for gardening), with a median of .184. Although these correlations could reflect a positive self-presentation bias, it could also be the case that people who devote more time to the activity are actually more cognitively involved in the activity.

It is conceivable that with increased age people tend to reduce the frequency with which they engage in the most cognitively demanding activities. This possibility was investigated by computing a correlation, across the 22 activities in Table 2, between the mean cognitive demand of the activity and the correlation between age and number of hours per week devoted to that activity. This correlation was −.41 ($p = .06$), which indicates that there was a trend for older adults relative to young adults to devote fewer hours to activities rated higher in cognitive demands.

An index of weekly cognitive stimulation was created for each participant by multiplying the rated cognitive demand by the hours spent per week engaged in each activity, and then summing these products across all activities. To illustrate, consider an individual who reported 15 hr per week watching television at a rated cognitive demand of 2, 5 hr per week reading nonfiction at a rated cognitive demand of 4, and 5 hr per week using a computer at a rated cognitive demand of 3. The cognitive stimulation index for this individual would therefore be $(15 \times 2) + (5 \times 4) + (5 \times 3) = 65$.

The cognitive stimulation index was not significantly related to sex ($r = .11$, with males coded as 0 and females as 1), education ($r = -.11$), self-reported health ($r = .01$), health-related activity limitations ($r = -.03$), or depression score ($r = .11$). However, there was a significant negative correlation ($r = -.27$) between age and the cognitive stimulation index, which indicates that increased age was associated with lower levels of self-reported cognitively stimulating activity.

Examination of the entries in the bottom of Table 2 reveals that several variables, including age, had nearly the same magnitude of correlation with the total number of hours of activity per week as with the cognitive stimulation index based on the product of hours and rated cognitive demand of the activity. Furthermore, correlations of the variables with the average rated cognitive demand were all quite small. This pattern of results suggests that most of the relation between age and the cognitive stimulation index is carried by the relation between age and number of hours engaged in the activities, and not by the rated cognitive demands of the activities.

Table 3
Correlations Among Cognitive (Cog) Composites

Composite	1	2	3	4	5
1. Cog1	—				
2. Cog2	.87*	—			
3. Cog3	.63*	.71*	—		
4. Cog4	.51*	.47*	.43*	—	
5. Age	−.41*	−.52*	−.55*	.19*	—

Note. Cog1 is the average of *z* scores for Block Design (Wechsler, 1997a) and Analysis–Synthesis (Woodcock & Johnson, 1990); Cog2 is the average of *z* scores for Raven's Advanced Progressive Matrices (Raven, 1962), Letter Series (Noll & Horn, 1998), Spatial Relations (Bennett et al., 1997), and Paper Folding (Ekstrom et al., 1976); Cog3 is the average of *z* scores for Logical Memory (Wechsler, 1997b), Free Recall (Wechsler, 1997b), and paired associates (locally developed). Cog4 is the average of *z* scores for Vocabulary (Wechsler, 1997a) and Picture Vocabulary (Woodcock & Johnson, 1990).
* $p < .01$.

Mediation and Moderation

A series of hierarchical regression analyses was conducted to examine the age-related variance in the four cognitive composites before and after controlling for both the Need for Cognition scale and the cognitive stimulation index. Regression analyses were also used to determine the interactions of age and those factors by examining the cross-product term after partialling the main effects of age and either Need for Cognition or cognitive stimulation. The results of these analyses are summarized in Table 4, where it can

Table 4
Proportion of Age-Related Variance in Four Cognitive (Cog) Composites

Variable	Cog1	Cog2	Cog3	Cog4
Age alone	.165*	.267*	.298*	.035*
Age after				
Need for cognition	.138*	.218*	.270*	.049*
Cognitive stimulation	.209*	.274*	.297*	.022
Need for cognition & cognitive stimulation	.186*	.242*	.279*	.030
Interaction of age and				
Need for cognition	.008	.005	.002	.006
Cognitive stimulation	.001	.003	.007	.060*

Note. Cog1, Cog2, Cog3, and Cog4 are cognitive composites defined as described in Table 3. Age is in years.
* $p < .01$.

be seen that there was very little change in the relations of age to the cognitive composites after control of the Need for Cognition scale, cognitive stimulation, or both. Control of the Need for Cognition score was associated with a slight decrease in the age relations on the Cog1, Cog2, and Cog3 composites, but control of the cognitive stimulation index was associated with a slight increase in the age relations on the first two of these variables. These results could indicate that age differences in the Need for Cognition scale partially mediate age differences in cognitive functioning. However, because the opposite pattern was found for the cognitive stimulation index, the same type of argument implies that age differences in cognitive stimulation may serve to suppress age differences in cognitive functioning, in that the relations between age and cognitive functioning were larger when the level of cognitive stimulation was controlled. Very similar results were apparent when the analyses were repeated after excluding the data from the 14 students, and, thus, the pattern cannot be attributed to the influence of students who might be expected to have higher levels of cognitive stimulation and need for cognition than other adults.

Only one interaction between age and the cognitive stimulation index was significant and that was on the Cog4 composite based on measures of vocabulary. This interaction is attributable to a near-zero correlation between age and vocabulary knowledge for people below the median on the cognitive stimulation index (r = .02) but to a moderately positive correlation for people above the median level of cognitive stimulation (r = .30).

One way of portraying the interrelationships among the major variables is in the form of a path diagram such as that in Figure 1. Figure 1 summarizes the results of several simultaneous multiple regression analyses, and it illustrates relations among variables when the influences of other variables, such as education and sex, are taken into consideration. It should be noted that because relations are portrayed among all possible variables, the path diagram corresponds to a saturated model, and, thus, fit statistics are not meaningful. Numbers adjacent to the paths are standardized regression coefficients, and the four values adjacent to the paths to

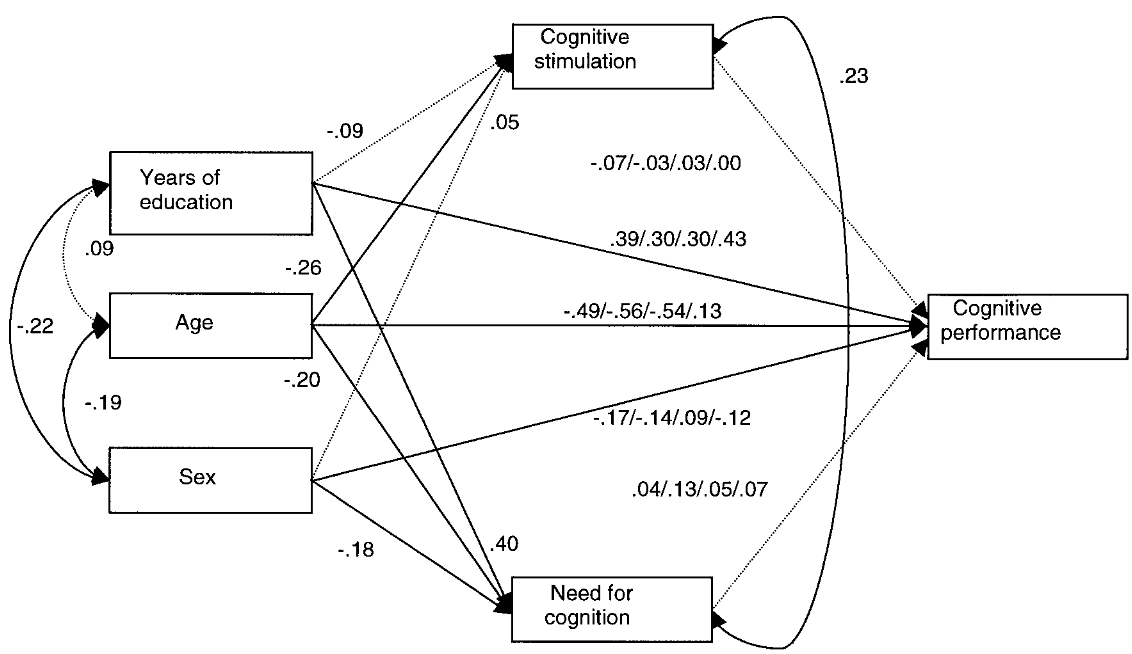

Figure 1. Path diagram portraying relations among major variables. Numbers adjacent to the arrows are standardized regression coefficients. Dotted lines represent paths with coefficients that were not significantly different from zero. Cog1/Cog2/Cog3/Cog4: Cog1: Cognitive performance = Analysis–Synthesis, Block Design; Cog2: Cognitive performance = Raven's Advanced Progressive Matrices, Letter Series, Spatial Relations, Paper Folding (N = 150); Cog3: Cognitive performance = Logical Memory, Free Recall, Paired Associates; Cog4: Cognitive performance = Vocabulary, Picture Vocabulary.

the box labeled cognitive performance correspond to the coefficients for the four different cognitive composites. The most important results apparent in these analyses are that although increased age was associated with lower levels of cognitive stimulation (−.26) and lower scores on the Need for Cognition scale (−.20), neither the cognitive stimulation index nor the Need for Cognition score was significantly related to any of the cognitive composites. Furthermore, comparison of the age correlations in Table 3 with the coefficients for the age-cognition paths in the figure indicates that there was no evidence that the relations of age to the cognitive composites were attenuated by controlling effects on either the cognitive stimulation index or the Need for Cognition scale.

Although the regression results summarized in Table 4 indicate that only one of the eight possible interactions of age and cognitive stimulation or need for cognition on the cognitive composites was significant, an additional examination of possible age differences in the role of cognitive stimulation on cognitive functioning was carried out by repeating the path analyses for participants under and over the age of 50. That is, the path analysis model represented in Figure 1 was applied to the data of the 95 participants between 20 and 49 years of age and to the data of the 109 participants between 50 and 91 years of age. Of particular interest was the effect of constraining the relations of cognitive stimulation and need for cognition on the cognitive composites to be equal in the two age groups. For none of the cognitive composites was there a significant reduction in fit [i.e., $\Delta\chi^2(1) < 3.46$] compared to a model in which all of the relations could vary in the two age groups. There is, therefore, no indication in these results that the relations of cognitive stimulation or need for cognition to the measures of cognitive functioning were different for adults under or over the age of 50.

Discussion

The results of this study are unequivocal in the failure to find evidence that cognitively stimulating activity either mediates or moderates age-related cognitive declines. That is, the results summarized in Table 4 and Figure 1 indicate that there was little or no attenuation of the age-related effects on four different composite measures of cognitive functioning after statistical control of an index of cognitive stimulation or of a measure of one’s tendency to seek cognitive stimulation. Thus, there is no evidence that low levels of cognitive stimulation mediate age-related declines in cognitive functioning in this sample. Moderating effects of cognitively stimulating activity on the age–cognition relations would have been manifested in interactions of age and either the cognitive stimulation index or the Need for Cognition scale, but only one of eight possible interactions was statistically significant. The significant interaction is consistent with the idea that people with higher levels of cognitive stimulation have larger age-related increases in word knowledge. However, there was no evidence that age-related decreases in fluid intellectual and episodic memory abilities were smaller for people with higher levels of cognitive stimulation or with stronger dispositions to seek cognitive stimulation. Furthermore, the cognitive stimulation perspective leads to an expectation of larger effects of cognitive stimulation at older ages, and yet a comparison of the strength of relations between cognitive stimulation or need for cognition and the cognitive composites in adults under and over the age of 50 failed to reveal significant differences.

Although the results of this study seem unambiguous, questions can nevertheless be raised about how they are best interpreted. Some of these questions are based on concerns about the use of self-reports, the nature of the activity assessment, characteristics of the sample, and the focus on current level of cognitive stimulation as opposed to average or cumulative stimulation.

The validity of self-reports can always be challenged, and those used in this study are no exception. For example, if the cognitive stimulation index and the Need for Cognition scale truly reflect a common construct, then one might have expected them to be moderately correlated with one another. However, the correlation was relatively small (i.e., .19 in Table 2 and .23 after controlling for the influence of other variables in Figure 1), and, thus, the validity of one or both measures may be suspect. Although this study follows a long tradition of reliance on self-reports to assess frequency of activities or personality dispositions, the information obtained from these methods could clearly be incomplete, inaccurate, or distorted. One possible means of obtaining information about the validity of the self-reports of cognitive stimulation is to collect ratings of activity frequency and cognitive demands from other observers, such as spouses, other relatives, or close friends, but that was not done in the current study.

It is also possible that the activity inventory may have failed to include a number of activities with substantial cognitive demands. Only 22 activities were included in the inventory, and thus it is obviously not exhaustive. Because the participants were allowed to add any activity that they performed at least 2 hr per week, the responses in the “other” category were also examined. The most frequently mentioned added activities were various types of exercise and sleeping. Neither of these activities appears very high in cognitive demands, and thus it is unlikely that their omission would have altered the results. Idiosyncratic activities with high cognitive demands could have been performed by some individuals such that the cognitive stimulation index underestimated their overall level of cognitive stimulation. However, it should be noted that relatively little additional time was unaccounted for by the listed activities because the average number of hours per week reported for the 22 activities was 99, which corresponds to about 14 hr a day.

A third possible reason for the failure to find support for either a mediating or a moderating role of cognitively stimulating activity on the relations between age and cognitive functioning is that the sample was healthy, highly educated, and functioning at a high cognitive level according to national norms. That is, variations in cognitive stimulation may only be important for cognitive performance among relatively low functioning samples. In fact, the positive correlations between mental activity and measures of cognitive functioning reported by Arbuckle et al. (1992), Christensen and Mackinnon (1993), and Gold et al. (1995) all involved participants with low levels of education. To explore this possibility in the current study, we divided the sample into two groups at the median of the average of the age-adjusted scaled scores for the Block Design and Vocabulary variables. Because the median was 13, which is one standard deviation above the mean based on the national norms, the two groups should probably be considered as representing very high and moderately high functioning adults. In the 94 individuals above the median, none of the correlations between either the cognitive stimulation index or the Need for Cognition scale and any of the cognitive composites was significantly different from zero. There were also no significant correlations between the cognitive stimulation index and any of the cognitive composites for the 105 individuals below the median on the average scaled score. However, three of the four correlations between Need for Cognition and a cognitive composite score were significant for the individuals with average scaled scores below the sample median. The significant correlations were with Cog1 ($r = .33$), Cog2 ($r = .48$), and Cog3 ($r = .34$), representing fluid, fluid, and episodic memory abilities, respectively. These results therefore suggest that the relations between certain types of cognitive stimulation measures and cognitive functioning may be more pronounced among individuals with relatively lower levels of cognitive performance.

However, if sample characteristics are responsible for the weak effects of cognitive stimulation on cognitive functioning in the current study then it raises questions about the role of cognitive stimulation in cognitive decline. That is, if the absence of main effects of cognitive stimulation or interactions of age and cognitive stimulation is to be explained by the high levels of cognitive stimulation and of cognitive functioning in the sample, then it seems unreasonable to attempt to explain the presence of negative relations between age and cognitive functioning in the same sample in terms of low levels of cognitive stimulation. Not only were there strong negative correlations between age and the Cog1, Cog2, and Cog3 composites in the complete sample (cf. Table 3), but they were also evident in the highest functioning individuals with average scaled scores above the sample median (i.e., $r = -.60$ for Cog1, $r = -.70$ for Cog2, and $r = -.68$ for Cog3). It is quite possible that cognitive stimulation plays a role in the relations between age and performance in various cognitive tests among lower functioning adults, but the results of this study suggest that it has little or no impact among high-functioning adults.

Another possible interpretation of the failure to find evidence for a role of cognitive stimulation on the relations between age and cognitive functioning is that it is not one's current level of cognitive stimulation that is important, but rather either the average or the cumulative amount over one's entire life. This hypothesis is difficult to evaluate without detailed longitudinal information, but to the extent that the current level of reported cognitive stimulation is lower than the average or cumulative level of stimulation across one's life, then positive, rather than negative, relations between age and cognitive stimulation might be expected. Moreover, if increased age is associated with higher rather than lower average or cumulative levels of cognitive stimulation, then it would not be meaningful to attempt to explain age-related cognitive declines in terms of reduced levels of cognitive stimulation.

As noted in the introduction, this study is far from ideal as a means of investigating the impact of cognitive stimulation on the age trends in cognitive functioning, and thus only tentative conclusions are possible from the results of this study. However, it is important to emphasize that a similar tenuousness applies to virtually all studies concerned with this issue, and hence it may be premature to reach a definitive conclusion about the validity of the use it or lose it perspective. More rigorous evaluation of the cognitive stimulation hypothesis will require postulation of detailed mechanisms for how cognitive stimulation might affect cognitive functioning, explicating the time course and possible nonlinear relations between changes in cognitive stimulation and changes in cognitive functioning, and describing how and why the level of cognitive stimulation changes with increasing age. Nevertheless, we would still recommend that people act as though there is a positive relationship between cognitive stimulation and cognitive functioning because engaging in cognitively stimulating activities appears to do no harm, it is often enjoyable for its own sake, and future research may eventually establish that it does have a beneficial effect in preventing or remediating age-related cognitive decline.

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