General Lifestyle Activities as a Predictor of Current Cognition and Cognitive Change in Older Adults: A Cross-Sectional and Longitudinal Examination

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General lifestyle activities were examined as a predictor of current cognition and cognitive change over a 6-year interval in older adults. Participants were drawn from a population-based longitudinal study, and they completed the Adelaide Activities Profile and a battery of tests measuring cognition and sensory functioning. Hierarchical regression analyses revealed that, after sensory functioning was controlled for, activity was a significant predictor of current levels of speed, picture naming, incidental recall, and verbal fluency, and of cognitive change in speed, picture naming, and incidental recall. Commonality analyses demonstrated that activity accounted for a notable amount of the total variance in cognition, and that there was prominent overlap in shared variance between activity and age, and between sensory functioning and age. These findings suggest that engaging in general lifestyle activities may help to promote successful cognitive aging.

The cognitive reserve hypothesis suggests that there is a developmental plasticity with regard to cognition, whereby the cognitive functioning of older adults can be altered within a limited range by environmental factors (Baltes, Reese, & Lipsitt, 1980; Woodruff-Pak, 1993). One such environmental factor that has received a large amount of research interest is an engaged lifestyle. It has been proposed that older adults who lead a more active lifestyle can promote their cognitive functioning within the limits of their reserve capacity (Scarmeas & Stern, 2003).

The majority of research in this area has focused on the effect that engaging in physical, mental, or social activity has on the cognitive functioning of older adults. Physical activity, as measured by exercise participation or physiologically by aerobic capacity, has been shown to benefit the cognitive functioning of older adults (Pignatti, Rozzini & Trabucchi, 2002; Schuit, Feskens, Launer, & Kromhout, 2001). Leading a cognitively intense lifestyle, such as work or leisure time spent reading or playing bridge, has also been shown as a good predictor of cognitive functioning in old age (Pushkar Gold et al., 1995; Schooler & Mulatu, 2001). Similarly, occupational cognitive complexity has been shown to influence the intellectual functioning of older workers (Schooler, Mulatu, & Oates, 1999). In addition, social activity in the form of increased social networks and emotional support, as measured by the amount of time engaged in social situations, has also been linked to higher cognitive functioning (Seeman, Lusignolo, Albert, & Berkman, 2001). Further studies that have examined the combined effect of physical, mental, and social activities, using self-reports and informant reports of how often specific activities are engaged in, have also demonstrated that declines in activity with increasing age are reflected in declines in cognition in both a cross-sectional and longitudinal context (Christensen et al., 1996; Christensen & Mackinnon, 1993; Mackinnon, Christensen, Hofer, Korten, & Jorm, 2003). These findings are further supported by experimental research demonstrating that changes in activity level are directly related to changes in cognitive functioning in older adults, as has been demonstrated for cognitive activity (Willis & Schaie, 1986) and physical activity (Colcombe & Kramer, 2003).

Although the precise mechanisms of the relationships between an engaged lifestyle and successful cognitive aging are not clear, it has been suggested that physical activity may benefit the cognitive functioning of older adults by improving cerebral blood flow (Hall, Smith, & Keele, 2001). The cognitive benefit derived in older age from a cognitively and socially intense lifestyle is commonly explained within Schooler’s (1989) environmental complexity hypothesis. This suggests that the enriched environment and cognitive complexity provided by a cognitively or socially intense lifestyle can create more dendritic branches and synaptic connections in the brain, as has been shown for animals (Greenough, McDonald, Parnisari, & Camel, 1986).

The direction of the causal relationship between activity engagement and cognitive functioning in older adults was recently debated by Hultsch, Hertzog, Small, and Dixon (1999), Pushkar and colleagues (1999), and Hertzog, Hultsch, and Dixon (1999). These researchers examined whether the relationship between activity and intellectual functioning may be better viewed in terms of how intellectual functioning influences activity engagement. However, subsequent longitudinal research suggests a reciprocal relationship between activity and intellectual functioning, whereby cognitive functioning promotes activity engagement and activity engagement simultaneously enhances cognitive functioning (Schooler et al., 1999; Schooler & Mulatu, 2001).

Currently research within this field is tempered by inconsistent findings in the literature. Although many researchers have provided support for the engagement hypothesis, many others have failed to detect a relationship between activity and cognitive functioning in older adults. For example, Aartsen, Smits, Tilburg, Knipscheer, and Deeg (2002) examined the effect of the amount of self-reported engagement in social, experiential, and developmental activities on immediate recall,
fluid intelligence, information processing, and scoring on the Mini-Mental State Examination, but they failed to detect a relationship. Similarly, Albert and colleagues (1995) found no relation between strenuous physical activity and cognitive functioning in a large sample of African Americans. It is plausible that a contributing factor to these inconsistent findings is the lack of a specific definition of what an active lifestyle is. Typically, an active lifestyle has been measured by informant ratings of activity engagement, physiological measures of cardiorespiratory fitness, or self-reported amount of engagement in specific types of activities (which is sometimes a factor of the amount of effort required in these activities and can be measured either currently or asked retrospectively in either a scale or time of participation format). This makes it difficult to compare the results of different research studies. Furthermore, vital activities that influence cognition may be overlooked. Researchers commonly assess activity levels by examining how often older adults engage in a restricted range of specific cognitive, physical, or social activities, thus providing an indication of how specific activities influence cognition. For instance, Mackinnon and associates (2003) examined six activities including reading a newspaper, engaging in physical activity, being involved in interests or hobbies, spending time sitting around without doing very much, spending time in planned activities, and having a daily nap. Measuring a restricted range of activities may underestimate the potential influence of activity because it creates small interindividual variation and may overlook many activities that older adults engage in. This is particularly important in the current society, in which a vast amount of everyday activities, beyond traditional reading and writing, are available to older adults, such as paid and volunteer work.

Another important issue is the use of both cross-sectional and longitudinal research designs. Longitudinal research is useful for examining how activity influences cognitive performance over time; however, because of financial and time constraints, many studies in the cognitive aging field utilize a cross-sectional methodology. The extent to which these two research designs differentially influence findings is not yet clear. Therefore, comparisons between cross-sectional and longitudinal findings could usefully clarify the utility of these designs.

A further issue is whether confounding variables are controlled for. In research, it is common for education and socioeconomic status to be statistically controlled for, with the rationale that these are factors known to influence cognition. However, a key mediator that is often disregarded is sensory functioning. Age-related changes in sensory functioning are thought to indicate age-based changes in the central nervous system, which are reflected in biological markers of aging such as vision and hearing. This is also known as the common-cause hypothesis (Baltes & Lindenberger, 1997; Hofer, Berg & Era, 2003). Changes in sensory functioning are particularly important in this field of research, as they influence both the capacity to engage in activities by limiting functional capacity to perform activities, and the cognitive functioning of older adults (Anstey & Smith, 1999; Spiriduso, 1995).

In the current study we sought to further examine the relationship between an engaged lifestyle and the cognitive functioning of older adults by addressing some of the aforementioned issues. First, we examined the effect of an engaged lifestyle on cognitive aging in terms of a generally active lifestyle, rather than the effect of separate and specific physical, mental, or social activities. The definition of a generally active lifestyle that we use here covers activities that many older adults have been demonstrated to regularly engage in, and it encompasses activities that are based in the physical, social, and mental domains. Using this broader definition of a generally active lifestyle means that findings from this research will be directly relevant to a broad range of older adults rather than an exclusive subset. It also allows for an examination of how engaging in a broad range of relatively simple activities integral to daily functioning can influence cognitive aging. Using a broader measure of activity, which encompasses measures of routine events such as shopping, doing housework, and caring for sick friends or relatives, as well as traditionally measured activities such as participating in volunteer work and going on outings, provides a more accurate reflection of the daily activity level of older adults. We used the Adelaide Activities Profile (AAP; Clark & Bond, 1995) as an index of general lifestyle activities. The AAP is valuable in examining the link between an active lifestyle and cognitive performance, because it is specifically designed to measure the type of activities engaged in by older adults and has been demonstrated to be reliable and valid for the measurement of activity level in community-dwelling older adults (Clark & Bond).

Second, in this study we examined the effect of a generally active lifestyle on both current cognitive functioning (cross-sectional) and on cognitive change over a 6-year interval (longitudinal). This allows for a comparison of the effect of current activity level on current cognitive functioning, and the effect of previous activity level on cognitive change over a 6-year interval.

Third, we examined the relationship between general activity and cognition after we controlled for the effects of sensory functioning, which is known to influence both activity level and cognitive functioning.

Specifically, our aims in the current study were to determine the following: (a) whether general lifestyle activities influence cognitive functioning after the influence of sensory functioning is controlled for, and (b) whether activity and sensory functioning account for age-related variance in current cognition and cognitive change. Our subsidiary aim was to examine the relative contributions of age, activity, and sensory functioning to the explained variance in cognition. We achieved these aims by examining the Australian Longitudinal Study on Ageing (ALSA) data set across two waves of data collected over a 6-year interval. ALSA is a population-based study that examines the psychological, medical, and demographic profile of older adults residing in South Australia.

**METHODS**

**Participants**

We drew participants for the current study from the ALSA. The initial sample consisted of 2,087 participants and was constructed by means of the South Australian Electoral Roll (see Andrews, Clark, & Luszcz, 2002, for a more detailed overview of the recruitment of participants). Currently, three main waves of psychological data collection have taken place. Additional cognitive measures central to this study were only introduced at the second and third wave of data collection. Therefore, we included only those participants who took part in
the second and third data-collection points in the present study. This enabled us to examine data over a 6-year interval from the second wave (Time 1) to the third wave (Time 2). We screened for dementia by using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). We removed participants with a score below the clinical cutoff from the sample.

This provided a subsample of 755 participants, 57.4% of whom were female. We evaluated the background characteristics of self-rated health and premorbid intelligence. Participants rated their general health on a 5-point scale from 1 (excellent) to 5 (poor). We assessed premorbid intelligence with the revised version of the National Adult Reading Test (NART-R; Blair & Spreen, 1989), which involved articulation of a list of words that violate the phoneme–grapheme rules. The mean age for participants at Time 1 was 77.44 (SD = 5.51), and at Time 2 it was 83.36 (SD = 5.48). Self-rated health at Time 1 had a mean rating of 3.28 (SD = 0.99), and at Time 2 it had a mean rating of 3.14 (SD = 1.05). At Time 1, NART-R (errors) had a mean score of 22.58 (SD = 7.63), and at Time 2 the mean score was 21.70 (SD = 8.43). A series of paired-sampled t tests revealed a significant change in health (t = 4.78, p < .001) and NART-R errors (t = 3.86, p < .001) over time. We found the small albeit significant change in NART-R scores to be somewhat surprising, given that it is purported as a measure of premorbid intelligence (Crawford, Deary, Starr, & Whalley, 2001). In addition, participants recorded the age at which they discontinued their education from 1 (never went to school) to 7 (18 years or over). The median age at which participants completed their schooling was a score of 3 (discontinued schooling at 14 years of age), which is equivalent to completion of primary schooling and midcompletion of secondary schooling.

A comparison between the current subsample of individuals and the noncontinuing participants on the main variables of interest to the study revealed that the current sample performed significantly higher on the cognitive outcome measures and engaged in significantly more activities, although the differences were moderate. There were no significant differences in self-rated health, education, or NART-R errors.

**Measures**

**Level of activity.**—We used the AAP (Clark & Bond, 1995) as a measure of general activity level. The AAP provides a wide-ranging profile of the lifestyle activities of older adults by measuring people’s behavior and physical capacity to carry out a number of daily tasks. The AAP consists of 21 questions that deal with how often a person completes certain activities integral to daily functioning within a typical 3-month period. Participants respond on a 4-point scale of 0 to 3 to indicate increasing frequency of activity. These response scales were tailored to individual activities based on the likely frequency of each activity in order to overcome possible polarized or skewed distributions. On the basis of a principal component analysis conducted by Clark and Bond, the AAP questions were grouped into four distinct categories: household maintenance (seven items, e.g., gardening, car maintenance), domestic chores (eight items, e.g., washing dishes, preparing a main meal), social activities (four items, e.g., participating in outdoor recreation or sports, participating at a club) and service to others (five items, e.g., caring for other family members, doing volunteer work). The principal component analysis demonstrated that the four factors accounted for 43.55% of the total variance. The scale construction process was calculated by comparing the individuals in the original sample with those in a validation sample, which demonstrated congruence between the four factors of .94 to .99. The reliability coefficients of the subscales were also shown to be good, ranging from .51 to .80. Hence, the AAP has been demonstrated to be reliable and valid for use in community-dwelling older adults as a measure of lifestyle activities. For the purposes of the current study, we standardized each subscale to a mean score of 50 with a standard deviation of 20, as recommended for research purposes by Clark and Bond.

**Sensory functioning.**—We used the biomarkers of auditory acuity and visual acuity as measures of sensory function. By measuring pure tone thresholds at 2000, 3000, and 4000 Hz in each ear, we assessed auditory acuity. We used a standard bracketing technique, and the final criterion was the average of the thresholds achieved in the left and right ear at each frequency, as measured in decibels. We measured corrected distance visual acuity for each eye with a Snellen chart at a distance of 3 m. We recorded the smallest line that a participant read successfully with the left or right eye, whereby at least half of the characters in the line were correctly read. The final score was the logarithm of the smallest line successfully read.

**Cognitive Outcome Measures**

**Speed of processing.**—We used the Digit Symbol Substitution test (DSST), a subtest of the Revised Wechsler Adult Intelligence Scale (Wechsler, 1981), as a measure of speed of processing. The DSST required participants to complete a series of 93 digit–symbol substitutions. The final score was the number of correctly substituted symbols completed within a 90-s period.

**Picture naming.**—We used an abbreviated version of the Boston Naming Test (BNT; Mack, Freed, Williams, & Henderson, 1992) as a measure of visual confrontation naming. The BNT comprises 15 line sketches of common objects. Participants were required to name the object illustrated in the drawing. The final score was the number of items named correctly without cues.

**Verbal fluency.**—We used the Excluded Letter Fluency Test (Crawford, Bryan, Luszcz, Obonsawin, & Stewart, 2000) and the Uses for Common Objects Test (Getzels & Jackson, 1962) as measures of verbal fluency. The Excluded Letter Fluency Task requires participants to articulate as many words as possible that do not contain a specified letter. Two 60-s trials were completed requiring participants to generate words not containing the letters e and a. The Uses for Common Objects Task requires individuals to construct novel uses for everyday objects. Two 90-s trials were completed requiring participants to generate as many novel and unique uses as they could for
Sensory functioning

Verbal fluency

Incidental recall

Cognitive outcome measures

Statistical Analyses

Procedure of the correct responses achieved across the two trials.

a bottle and a paperclip. The final score for each test was the sum of the correct responses achieved across the two trials.

Incidental recall.—We used two measures of incidental recall following the administration of the DSST and the BNT. After the Digit Symbol Substitution test, participants were asked to recall as many of the symbols as they could from the previous task. Following the BNT, participants were required to name any of the pictures that they could remember. The final score for each test was the correct number of items recalled.

Procedure

During each wave, data collection was conducted in two main phases. The initial phase comprised an interview in the participants’ own home, during which background information was obtained and questionnaires, such as the MMSE and the AAP, were completed. Approximately 2 weeks later, participants were invited to complete the second phase of data collection, which involved a clinical assessment interview, during which the neuropsychological measures of cognition were administered and the sensory functions were measured.

Statistical Analyses

We conducted hierarchical multiple regression analyses to examine the contribution of a generally active lifestyle to (a) current cognitive functioning using the Time 1 measures of cognitive performance (cross-sectional analyses), and (b) change in cognitive function over a 6-year interval (longitudinal analyses) using residualized change scores of cognitive performance. Following the regression analyses, we performed commonality analyses to provide a clearer understanding of the relative contributions of age, general lifestyle activities, and sensory functioning to the explained variance in cognition. During all analyses, we excluded missing data pairwise.

RESULTS

Prior to analysis, we examined the data set for outliers. We attenuated the influence of extreme univariate outliers, defined as a case with a standardized score in excess of 3.29, by assigning a raw score to those cases that were one unit above the next most extreme case, as recommended by Tabachnick and Fidell (2001). This successfully reduced the influence of outliers.

Descriptive and inferential statistics for the subscales of the AAP, the raw scores for measures of sensory functioning, and the raw scores for each cognitive outcome measure at Time 1 and Time 2 are presented in Table 1. We performed a series of paired sample t tests to determine changes in these measures with time. There were significant differences between the mean scores for each measure, indicating a decrease in engagement in activities and performance on tests of cognitive functioning across time, with the exception of social activity, which increased with time.

We created composite scores for variables with more than one measure to avoid overmodeling of the data in regression analyses. From the average of the standardized scores of each measure, we calculated these scores for sensory functioning, verbal fluency, incidental recall, and the AAP.

Prior to regression analyses, we conducted a series of Pearson product moment correlations between age, activity, sensory functioning, and cognitive outcome measures at Time 1 and Time 2. The correlation coefficients are presented in Table 2. In accordance with our expectations, age and activity were significantly correlated with each cognitive measure at Time 1 and at Time 2. Sensory functioning at each wave also showed a significant correlation with each cognitive measure at Time 1 and Time 2.

On the basis of these correlations, we performed a series of hierarchical multiple regression analyses to determine if activity continued to contribute to the variance in each cognitive function after we statistically controlled for the influence of...
sensory functioning in a cross-sectional and longitudinal context and if activity and sensory functioning reduced the contribution of age to nonsignificance. We present the regression analyses separately for the cross-sectional and longitudinal examinations; these analyses are followed by commonality analyses to partition the variance in each cognitive outcome measure.

Cross-Sectional Analyses

We carried out one three-step hierarchical model for each cognitive outcome measure. We devised the model to allow an examination of (a) whether current activity influences current cognition, beyond the influence attributable to current sensory functioning, by testing if activity was a predictor of cognitive functioning after we statistically controlled for the influence of sensory functioning; and (b) whether activity and sensory functioning account for age-related cognitive ability, by testing if age was a predictor of cognitive functioning after we controlled for the variance attributable to sensory functioning and activity. In the model, we entered sensory functioning at Step 1, followed by activity at Step 2 and age at Step 3. The results are presented in Table 3.

The regression models demonstrate that sensory functioning was a good predictor of current cognition, particularly for speed of processing. In relation to our first aim, current activity contributed significantly to the variance in all indicators of current cognition after we controlled for the influence of sensory functioning. Activity contributed a 4% increase in total variance explained for speed of processing, 3% for picture naming, 4% for incidental recall, and 5% for verbal fluency. In relation to our second aim, prior entry of activity and sensory functioning did not reduce the contribution of age to a non-significant amount, suggesting that additional variables are also responsible for age-related declines in cognitive functioning.

We then conducted a commonality analysis (Pedazhur, 1982) to partition the variance in each cognitive outcome measure that is unique and shared among the predictors of activity, sensory functioning, and age. The results are presented in Table 4. The unique variance attributable to each of the predictors was small. The amount of shared variance between age and activity and between age and sensory functioning was substantially larger than the shared variance between sensory functioning and activity. Age accounted for the largest amount of total variance in cognition. For speed of processing and picture naming, this was followed by sensory functioning and then activity, whereas this order was reversed for incidental recall and verbal fluency. Importantly, the total variance accounted for by activity was notable, ranging from 5% to 14%.

Longitudinal Analyses

We conducted longitudinal analyses by using a similar three-step hierarchical model as for the cross-sectional analyses. We entered sensory functioning at Step 1, followed by activity at Step 2 and age at Step 3. We entered sensory functioning as a residualized change score, which we derived from the actual value of sensory functioning at Time 2 minus the value predicted by the regression equation, using Time 1 as a predictor for each case, as recommended by Menard (1991). We did this to control for the influence of sensory functioning on activity and cognition at both time points. We also examined cognitive change by using a residualized change score of cognition as the outcome measure. We selected residualized scores of cognition over an absolute difference score because of the wide variance in age-related declines in cognition in older adults. The results are presented in Table 5.

The regression models demonstrate that sensory functioning only accounted for a moderate amount of variance in cognitive change scores for picture naming and verbal fluency and did not make a significant contribution to speed of processing or incidental recall. In relation to our first aim, activity contributed significantly to the variance in change scores for speed of processing, picture naming, and incidental recall, after we controlled for the influence of sensory functioning, but it made no significant contribution to change scores for verbal fluency. Activity contributed a 1% increase in total variance explained for speed of processing, 3% for picture naming, and 3% for incidental recall. In relation to our second aim, prior entry of age to the model did not reduce the contribution of sensory functioning to a non-significant amount, suggesting that additional variables are also responsible for age-related declines in cognitive functioning.

### Table 3. Hierarchical Multiple Regression Analysis for Cross-Sectional Analysis Predicting Current Cognition from Sensory Functioning, Activity, and Age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Speed of Processing ($n = 551$)</th>
<th>Picture Naming ($n = 566$)</th>
<th>Incidental Recall ($n = 549$)</th>
<th>Verbal Fluency ($n = 476$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory functioning</td>
<td>$\beta = .201$; $R^2 = .156$; $R^2$ Change = .038**</td>
<td>$\beta = .166$; $R^2 = .090$; $R^2$ Change = .026**</td>
<td>$\beta = .204$; $R^2 = .082$; $R^2$ Change = .040**</td>
<td>$\beta = .216$; $R^2 = .092$; $R^2$ Change = .045**</td>
</tr>
<tr>
<td>Activity</td>
<td>$\beta = .142$; $R^2 = .118$; $R^2$ Change = .015*</td>
<td>$\beta = .184$; $R^2 = .118$; $R^2$ Change = .015*</td>
<td>$\beta = .206$; $R^2 = .142$; $R^2$ Change = .015*</td>
<td>$\beta = .217$; $R^2 = .184$; $R^2$ Change = .026**</td>
</tr>
<tr>
<td>Age</td>
<td>$\beta = .184$; $R^2 = .118$; $R^2$ Change = .015*</td>
<td>$\beta = .184$; $R^2 = .118$; $R^2$ Change = .015*</td>
<td>$\beta = .206$; $R^2 = .142$; $R^2$ Change = .015*</td>
<td>$\beta = .217$; $R^2 = .184$; $R^2$ Change = .026**</td>
</tr>
</tbody>
</table>

Notes: This is a cross-sectional analysis that uses current cognition scores as dependent variables. Current cognition scores, sensory functioning, and activity are taken from Time 1. The beta weights are the actual weights at each step.

*p < .01; **p < .001.

### Table 4. Commonality Analysis for Cross-Sectional Analysis Using Current Cognition Scores as Dependent Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Speed of Processing ($n = 551$)</th>
<th>Picture Naming ($n = 566$)</th>
<th>Incidental Recall ($n = 549$)</th>
<th>Verbal Fluency ($n = 476$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique to age</td>
<td>$\beta = .072$</td>
<td>$\beta = .030$</td>
<td>$\beta = .015$</td>
<td>$\beta = .026$</td>
</tr>
<tr>
<td>Unique to sensory</td>
<td>$\beta = .020$</td>
<td>$\beta = .011$</td>
<td>$\beta = .007$</td>
<td>$\beta = .007$</td>
</tr>
<tr>
<td>Unique to activity</td>
<td>$\beta = .023$</td>
<td>$\beta = .017$</td>
<td>$\beta = .032$</td>
<td>$\beta = .034$</td>
</tr>
<tr>
<td>Shared between age and sensory</td>
<td>$\beta = .063$</td>
<td>$\beta = .033$</td>
<td>$\beta = .017$</td>
<td>$\beta = .023$</td>
</tr>
<tr>
<td>Shared between age and activity</td>
<td>$\beta = .015$</td>
<td>$\beta = .009$</td>
<td>$\beta = .092$</td>
<td>$\beta = .011$</td>
</tr>
<tr>
<td>Shared between sensory and activity</td>
<td>$\beta = .006$</td>
<td>$\beta = .004$</td>
<td>$\beta = .004$</td>
<td>$\beta = .004$</td>
</tr>
<tr>
<td>Shared between all predictors</td>
<td>$\beta = .029$</td>
<td>$\beta = .016$</td>
<td>$\beta = .014$</td>
<td>$\beta = .013$</td>
</tr>
<tr>
<td>Total effects for age</td>
<td>$\beta = .179$</td>
<td>$\beta = .088$</td>
<td>$\beta = .138$</td>
<td>$\beta = .073$</td>
</tr>
<tr>
<td>Total effects for sensory</td>
<td>$\beta = .118$</td>
<td>$\beta = .064$</td>
<td>$\beta = .042$</td>
<td>$\beta = .047$</td>
</tr>
<tr>
<td>Total effects for activity</td>
<td>$\beta = .073$</td>
<td>$\beta = .046$</td>
<td>$\beta = .142$</td>
<td>$\beta = .062$</td>
</tr>
</tbody>
</table>

Note: Activity and sensory scores are taken from Time 1.
activity and sensory functioning reduced the contribution of age to a nonsignificant amount for picture naming, whereas sensory functioning alone reduced the contribution of age to nonsignificance for verbal fluency. Age remained a significant, although moderate, predictor of speed of processing and incidental recall, after prior entry of sensory functioning and activity. This suggests that, in combination, sensory functioning and activity account for a large portion of the age-related variance in cognitive change for some cognitive measures.

We again conducted a commonality analysis to partition the variance in cognitive change that is unique and shared among the predictors of activity, sensory functioning, and age. The results are presented in Table 6. The unique variance accounted for by each of the predictors was marginal. Again, there were relatively large amounts of shared variance between age and activity, and between age and sensory functioning, in comparison with the shared variance between sensory functioning and activity. There was no consistency as to which predictor accounted for the largest amount of total variance in cognition. The total variance accounted for by all predictors was marginal.

DISCUSSION

In the present study we aimed to examine whether general lifestyle activities contribute to current cognition and cognitive change over a 6-year interval in a sample of older adults after we controlled for the influence of sensory functioning, and whether sensory functioning and activity accounted for age-related declines in current cognition and cognitive change. We extended the findings of previous research by (a) using an index of general lifestyle activity rather than a restricted list of specific activities, (b) using both a cross-sectional and longitudinal design, and (c) controlling for the influence of sensory functioning. In addition, we performed commonality analyses to provide new information concerning the unique and shared variance accounted for in cognition by age, activity, and sensory functioning.

Cross-sectional regression analyses revealed that current activity level accounted for a significant amount of variance in current levels of speed of processing, picture naming, incidental recall, and verbal fluency beyond the variance attributable to sensory functioning. These results suggest that a generally active lifestyle is associated with higher levels of current cognitive functioning in older adults. These findings are in accordance with previous cross-sectional studies (Christensen et al., 1996; Christensen & Mackinnon, 1993; Pignatti et al., 2002). Age continued to predict cognitive functioning after we controlled for activity and sensory functioning, suggesting that other factors also influence the age-related variance in cognition.

Longitudinal regression analyses revealed that general lifestyle activities were a significant predictor of change scores for speed of processing, picture naming, and incidental recall, but not for verbal fluency. This suggests that general lifestyle activities influence some domains of cognitive change in older adults, although the additional variance accounted for by activity was moderate. These findings are consistent with previous longitudinal research (Mackinnon et al., 2003). After we controlled for the variance attributable to activity and sensory functioning, age no longer made a significant contribution to change in picture naming, and sensory functioning accounted for all of the age-related variance in change in verbal fluency. In contrast, age continued to contribute a significant, although negligible, amount of variance in change in speed of processing and incidental recall. This suggests that sensory functioning and activity account for a worthy amount of the age-related variance in cognitive change.

The observation that activity was not a unique predictor of change in verbal fluency contradicts the cross-sectional findings, which showed activity to be a unique predictor of each cognitive outcome measure. Thus, although cross-sectional research is important for identifying relationships between variables, longitudinal research is imperative for disentangling how variables influence age-related changes in cognition.

Overall, these findings support the proposal that general lifestyle activities make a significant contribution to both current cognition and cognitive change in older adults. However, it
should be noted that a simultaneous reciprocal relationship between activity and intellectual functioning may also exist (Schooler et al., 1999; Schooler & Mulatu, 2001), such that although cognitive functioning is influenced by activity engagement, current activity engagement of the participants may simultaneously be influenced by prior intellectual functioning. However, examination of this possibility was beyond the scope of the present study.

We chose the definition and measurement of general lifestyle activity used herein to reflect a broad range of everyday activities in the physical, mental, and social domains, with the aim of generalizing findings to the majority of older adults and allowing an examination of how everyday activities can affect older adults’ cognitive functioning. The strength of the relationship identified between activity and cognitive aging was similar to the relationship found by Pushkar Gold and colleagues (1995), who also used an encompassing measure of activity in a longitudinal study. This suggests that broader measures of activity may more adequately identify the extent to which engaging in general lifestyle activities benefits older adults’ cognitive performance. However, Hultsch and associates (1999) also used a more encompassing activity measure and failed to provide convincing support for the influence of activity on cognitive functioning. An examination of the participant sample from the aforementioned studies reveals that both the study by Pushkar Gold and colleagues and the study by us examined a population-based sample of individuals with relatively low education and health ratings, whereas the individuals in the study by Hultsch and associates were healthier and more educated. It is therefore plausible that although a broader activity measure may be useful for detecting a relationship between activity and cognitive functioning, this relationship is greater in an average population-based sample than a healthier and educationally superior one. Further research is required to more fully examine this notion.

The commonality analyses revealed that the unique cognitive variance attributable to age, activity, and sensory functioning was moderate and that the largest portion of the total variance was related to shared variance between age and activity and between age and sensory functioning. This highlights the importance of including measures of sensory functioning when examining the relations between age, activity levels, and cognition. The total variance attributable to activity was noteworthy, which supports the proposal of activity as an important predictor of cognition.

The finding that sensory functioning was a good predictor of current cognition and a moderate predictor of cognitive change is consistent with previous research (Anstey & Smith, 1999; Baltes & Lindenberger, 1997). This finding adds further support to the growing body of literature that attributes a fundamental role to sensory functioning as a physiological predictor of cognitive development across the life span, and it again highlights the need to control for sensory functioning when examining cognitive performance in older adults.

The large change experienced in cognitive functioning with increasing age, as shown in the current study, is a common finding in the cognitive aging literature (eg. Collie, Shafiz-Antonacci, Maruff, Tyler, & Currie, 1999; Newson, Kemps, & Luszcz, 2003; Salthouse, 1996). Hence, it is important to identify the mechanisms by which cognitive skills can be preserved, or even enhanced, in older age so as to develop practical intervention strategies to combat age-related cognitive decline. However, not all predictors of cognitive decline are amenable to change. For example, older adults have minimal control over declines in sensory functioning and health. By contrast, they can readily modify their engagement in general lifestyle activities. Thus, encouraging older adults to lead active lifestyles offers a practicable strategy for promoting cognitive functioning and enabling independent living to an older age. Identifying techniques to enhance cognitive functioning in older adults is all the more important, given the demographic predictions of a burgeoning increase in the ratio of older to younger adults in the near future.

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