Published in final edited form as:

Neuropsychology. 2014 November ; 28(6): 819–828. doi:10.1037/neu0000096.

Ten-Year Longitudinal Trajectories of Older Adults' Basic and Everyday Cognitive Abilities

Anna Yam, M.S.¹, Alden Gross, Ph.D.², John Prindle, Ph.D.³, and Michael Marsiske, Ph.D.¹

¹Department of Clinical and Health Psychology, University of Florida

²Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Center on Aging and Health

³Max Planck Institute for Human Development

Abstract

Objective—To examine the longitudinal trajectories of everyday cognition and longitudinal associations with basic (i.e., laboratory and experimentally measured) cognitive abilities, including verbal memory, inductive reasoning, visual processing speed, and vocabulary.

Method—Participants were healthy older adults drawn from the no-treatment control group ($N = 698$) of the ACTIVE randomized trial, and were assessed at baseline and 1, 2, 3, 5, and 10 years later. Analyses were conducted using latent growth models.

Results—Modeling revealed an overall inverted “U” shape (quadratic) trajectory across cognitive domains. Among basic cognitive predictors, level and slope in reasoning demonstrated the closest association to level and slope of everyday cognition, and accounted for most of the individual differences in linear gain in everyday cognition.

Conclusions—Everyday cognition is not buffered against decline, and is most closely related to inductive reasoning in healthy older adults. To establish the clinical utility of everyday cognitive measures, future research should examine these associations in samples with more cognitive impairment.

Keywords

everyday cognition; longitudinal; memory; reasoning; processing speed

Older adults' functional outcomes, such as the ability to live independently, psychological well-being (Lawton, 1987; Willis, 1991), health care utilization, and institutionalization (Miller & Weissert, 2000; Wolinsky, et al., 1983, 2007; Wolinsky, Callahan, Fitzgerald, & Johnson, 1993), have been tied to their ability to perform instrumental activities of daily

Address Correspondence to: Anna Yam, M.S., Michael Marsiske, Ph.D., Department of Clinical and Health Psychology, PO Box 100165, 1225 Center Drive, Rm. 3150, Gainesville, FL 32610-0165, Phone: (352) 273-5097, ayam@phhp.ufl.edu or marsiske@phhp.ufl.edu.

Contact information for non-corresponding authors: Alden Gross, Ph.D., MHS, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Center on Aging and Health, Suite 2-700, 2024 E. Monument St., Baltimore, MD 21231, Phone: (443)-287-7196 (office), aldgross@jhsph.edu
John Prindle, Ph.D., Postdoctoral Research Fellow, Max Planck Institute for Human Development, Lentzeallee 94, 14195 Berlin, Germany, prindle@mpib-berlin.mpg.de

living (IADL, Lawton & Brody, 1969). IADL include meal preparation, telephone use, financial management, and other self- and home-maintenance tasks (Willis & Marsiske, 1991; Willis & Schaie, 1993). Successful IADL performance has physical, emotional, and cognitive components (Willis, 1996). For example, elders' ability to use public transportation might depend on their physical health (e.g., ambulation), as well as the cognitive capacity to remember a bus schedule. The cognitive aspect of IADL performance has been termed "everyday cognition" and conceptualized as the application of "basic" cognitive skills like reasoning, memory, and processing speed to solving IADL problems (Marsiske, & Margrett, 2006; Willis, 1996; Willis & Marsiske, 1991; Willis & Schaie, 1986). Numerous studies to date have used "everyday cognitive" measures (e.g., Everyday Problems Test, Willis & Marsiske, 1993) as performance-based means of assessing older adults' cognitive IADL competence (e.g., Allaire et al., 2009; Gross et al., 2011; see Yam & Marsiske, in press, for an analysis of correlated change in performance-based everyday cognition and self-reported IADL).

Everyday cognition is assessed objectively by asking older adults to perform everyday-type tasks, such as looking up a phone number in the phone book or reading a nutrition label (Owsley, Sloane, McGwin, & Ball, 2002). With regard to "basic" cognition, the term "basic" is used to reflect an underlying hierarchical model which suggests that acontextual, construct-pure measures assessed via laboratory and experimental techniques represent the cognitive constituents that are compiled to produce complex everyday performances (Cattell, 1987; Salthouse, 1990; Willis & Marsiske, 1991). Everyday cognition is thought to rely on multiple basic cognitive skills like reasoning, memory, and speed of processing (Marsiske & Margrett, 2006; Salthouse, 1990; Willis & Marsiske, 1991; Willis & Schaie, 1986), as well as crystallized and procedural knowledge stemming from prior experience performing IADL (Marsiske & Margrett, 2006).

Because crystallized and procedural knowledge is relatively preserved against age-related decline (Ackerman, 2008; Salthouse, 1990; Singer et al., 2003), some authors have speculated that everyday cognition might be "buffered" against the age related decline observed in basic abilities (Cornelius & Caspi, 1987; see also Marsiske & Willis, 1995). The underlying conceptual rationale for why everyday cognition might be relatively buffered against age-associated declines rests in the putatively greater relevance, familiarity (e.g., can of food) and enacted practice (Cornelius & Caspi, 1987) of everyday tasks. At the same time, to the extent that basic information processes are involved in everyday cognitive performance, the general understanding of aging in domains like attention, working memory, episodic memory, speed of processing, and executive functioning is one of normative decline in the later decades of life (Ghisletta & Lindenberger, 2004; Ghisletta, Rabbitt, Lunn, & Lindenberger, 2012; Park, Lautenschlager, Hedden, Davidson, Smith, & Smith, 2002; Rönnlund, Nyberg, Bäckman, & Nilsson, 2005; Schaie, 2012; Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003; Zimprich, Martin, Kliegel, Dellenbach, Rast, & Zeintl, 2008). Given the multidirectionality in the cognitive dimensions underlying everyday cognition (Baltes, 1987), it is not surprising that empirical support has been mixed with regard to the potential preservation of everyday cognitive skills against age-related decline.

In a meta-analysis of age differences in everyday cognition, Thornton and Dumke (2005) concluded that results from 28 cross-sectional studies they reviewed do not support theories of the preservation of everyday cognitive abilities. In terms of intraindividual change, however, Willis, Jay, Diehl, and Marsiske (1992) demonstrated that in the presence of overall mean decline with age, 62% of the sample exhibited stability or improvement in everyday cognitive abilities over a 7-year period. In the absence of studies comparing the longitudinal slopes of basic and everyday cognition, it is difficult to conclude whether everyday cognitive abilities are as vulnerable to decline as basic cognitive skills.

In line with the idea that everyday cognition is associated with basic cognitive abilities, mostly cross-sectional studies reported correlations ranging from 0.31 to 0.86 between basic and everyday cognitive skills (Allaire & Marsiske, 1999; Burton, Strauss, Hultsch, Hunter, 2006; Diehl et al., 1995; Thornton, Deria, Gelb, Shapiro, Hill, 2007; Weatherbee & Allaire, 2008; Wood et al., 2005; see Marsiske & Margrett, 2006 for a review). Controlling for demographic variables, basic cognitive predictors together explained between 18% and 55% of the variance in everyday cognition (e.g., Gross et al., 2011; Mitchell & Miller, 2008; Thornton et al., 2007; Wood et al., 2005). Overall, between-persons relationships between basic cognitive abilities and everyday cognition have received considerable attention (e.g., Allaire & Marsiske, 1999; Burton, Strauss, Hultsch, Hunter, 2006; Diehl et al., 1995; Thornton, Deria, Gelb, Shapiro, Hill, 2007; Weatherbee & Allaire, 2008; Wood et al., 2005), while relatively few studies have examined this relationship over time.

In one of the few longitudinal investigations, Willis et al. (1992) reported that baseline level of fluid intelligence uniquely explained 52% of total variance in a measure of everyday document literacy assessed seven years later. More recently, using data from the ACTIVE study, Gross et al. (2011) reported that baseline inductive reasoning was a significant unique predictor of baseline everyday cognition ($R^2=0.18$), while baseline memory was a significant predictor of 5-year longitudinal trajectory of everyday cognition ($R^2=0.06$). Also using ACTIVE data, Tucker-Drob (2011) reported significant bivariate associations between 5-year trajectories of basic abilities, and tasks assessing everyday cognitive skills (r s .31 to .94). Both Gross et al. (2011) and Tucker-Drob (2011) modeled only linear trajectories over time, while prior longitudinal work in aging suggests a trajectory of quadratic decline (i.e., inverse-U function) in cognitive abilities (Grady & Craik, 2000; Lindenberger & Ghisletta, 2009; MacDonald et al., 2011; Schaie, 1994; however see Salthouse, 2010). The present study aimed to extend the findings of Gross et al. (2011) and Tucker-Drob (2011) by describing the longitudinal trajectories of everyday cognitive and basic abilities over 10 years of assessment. Results are thought to contribute a fundamental understanding of normative 10-year change in these skills.

Unique contributions of the ACTIVE study include, (a) utilization of multiple distinct measures of everyday cognition; (b) inclusion of multiple cognitive factors as time-varying predictors of everyday cognitive growth; and (c) enrollment of a very large, diverse sample of older adults. Specific contributions of the current study include (a) availability of 10-year longitudinal data for basic and everyday cognition; and (b) more careful statistical adjustment for potential confounders of the basic-everyday cognition relationship than previous studies have allowed. Thus, specific aims of the current study were to (a)

characterize the 10-year longitudinal growth in a multivariate construct of everyday cognition; (b) to statistically compare longitudinal growth in everyday cognition to that observed in basic laboratory/experimental measures (thereby assessing whether everyday cognition is relatively buffered against age associated decline); and (c) evaluate complex multivariate models that simultaneously investigate how well correlated growth in multiple basic abilities, health, and sensory functioning predict everyday cognition. The fundamental question driving the current study was whether growth in basic cognition over ten years “travelled together” with growth in everyday cognition.

Methods

Participants

The current study sample was drawn from the Advanced Cognitive Training for the Independent and Vital Elderly (ACTIVE) study (Ball et al., 2002; Willis et al., 2006), a randomized controlled trial. The parent ACTIVE study examined effects of three types of cognitive training, for memory, reasoning, and speed, on cognition and function in adults aged 65 and older ($N = 2802$) (Jobe et al., 2001). In the present study, we used data from the no-contact control (i.e., untrained, retest-only) group ($n = 698$), assessed at baseline (1998–2011) and 1-, 2-, 3-, 5-, and 10- years later. Participants in this study were aged 65 and older, and were screened to be free at intake of substantial existing cognitive and functional impairment, medical conditions likely to lead to imminent functional decline or mortality (e.g. metastatic cancers) and severe sensory loss.

The present study sample at baseline had a mean age of 74 years (range 65–94, $SD = 6.05$), an average of 13 years of education (range 6–20, $SD = 2.71$), and an average Mini Mental State Exam (MMSE) score of 27 (range 23–30, $SD = 2.00$). Of these participants, 73% were female, 71% were White, 26% were African American, and 37% were married. Relative to the rest of the ACTIVE analytic sample at baseline (i.e. those randomized to intervention groups), the present study sample was .45 years older ($t(2800) = 2.15, p = .032, d = .09$), with no significant differences in years of education, MMSE scores, sex, race, or marital status.

The present study assessed data collected at baseline ($n = 698$) and 1 ($n = 582$), 2 ($n = 551$), 3 ($n = 511$), 5 ($n = 452$), and 10 ($n = 249$) years following the baseline occasion. Participants could exit and re-enter the study, so that individuals missing at a given wave could return at later ones.

Measures

Detailed summaries of each administered measure, including psychometric information, are provided in Jobe et al. (2001).

Demographic and health variables—Basic demographic information, including age, sex, race, and years of education, and the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) were collected at baseline. ACTIVE did not include a measure of socioeconomic status. At each study visit, participants also completed self-report measures of the 12-item Center for Epidemiological Studies Depression (CES-D; Radloff,

1977) and general health MOS 36-Item Short Form (SF-36; Ware & Sherbourne, 1992). Visual acuity was measured by performance on the Good-Lite LD-10 eye chart from a distance of 10 feet (Mangione et al. 1992).

Basic cognition—The ACTIVE study's cognitive battery was comprised mostly of age-sensitive measures of information processing and fluid intelligence (Horn & Cattell, 1967; Baltes et al., 1980). Four areas of cognitive ability were assessed within the battery. Inductive reasoning was assessed using the Letter Series (Thurstone & Thurstone, 1949), Word Series (Gonda & Schaie, 1985), and Letter Sets tasks (Ekstrom et al., 1976). These tasks assessed participants' ability to discern a pattern and choose the next letter or word in the set, or to pick out a pattern of letters that does not fit with the rest. Episodic verbal memory was assessed using the Hopkins Verbal Learning Test (HVLT; Brandt, 1991); Rey Auditory-Verbal Learning Test (AVLT; Rey, 1964); and the Rivermead Behavioral Memory Test, Paragraph Recall task (RBMT-PR; Wilson, Cockburn, Baddeley, 1985). These tasks assessed word list memory and prose memory. Visual processing speed was assessed via the Useful Field of View Test (UFOV; Ball, Owsley, Sloane, Roenker, & Bruni, 1993). These tasks became progressively more difficult and assessed the minimum presentation latency required to identify a central target and localize a peripheral target amidst clutter. Finally, vocabulary, from the Kit of Factor-Referenced Tests, Revised (Ekstrom, French, Harman, & Derman, 1976) was included as a measure of crystallized intelligence. The multiple measures of memory, reasoning and speed were combined into three unit-weighted composites, as described in Ball et al. (2002).

Everyday cognition—This domain was assessed with three measures: the Everyday Problems Test (EPT; Marsiske & Willis, 1995; Willis & Marsiske, 1993), the Observed Tasks of Daily Living (OTDL; Diehl, et al., 2005), and the Timed Instrumental Activities of Daily Living (TIADL; Owsley, Sloane, McGwin, & Ball 2002). For all everyday measures, participants were presented with common everyday stimuli (e.g., medication labels, transportation schedules, cake mix ingredients, phone book) and asked to answer questions (e.g., to calculate the number of days the supply of medication will last, find a phone number in the phone book). The dependent variables were the number of accurate responses. For the TIADL, the speed with which participants accurately responded to each item was also recorded; a final score was the average correct response time for all items (incorrect items received a time penalty). Time penalty was defined as 1 SD based on the data from all participants who had completed that item without error.

Data preparation

For reasoning, memory, speed, and everyday cognition, composite domain scores were computed by creating unit-weighted averages for each domain of the three measures each for reasoning, memory, and everyday cognition, and four measures for speed; see above (see Willis et al., 2006 for further details). ACTIVE administered parallel but nonequivalent forms for memory tests across visits, which introduced spurious form effects that we removed using an equipercentile equating procedure tailored for longitudinal analysis of within-person growth in the ACTIVE study (Gross et al., 2012).

Component variables at each occasion were Blom transformed (Blom, 1958) prior to analyses and standardized separately within each task, across occasions, producing normalized standard scores with $mean = 0$. The Blom transformation is a normalizing transformation that takes the inverse normal transformation of the relative rank of each value of an item distribution, yielding a z-score equivalent under the assumption that the underlying score is normally distributed. It results in a more normal distribution (Ball et al., 2002; Blom, 1958). All continuous variables were converted to have a mean of 50 and variance of 10 to facilitate interpretation of coefficients on a standardized metric. Finally, all variables except general health were scaled so that higher values reflect better performance.

Statistical Analyses and Results

Sample Attrition

To characterize the selectivity of longitudinal attrition and to examine the generalizability of results, study participants from the original baseline sample ($n = 698$) who were assessed at Year 10 ($n = 249$) were compared to those not assessed at this occasion ($n = 449$).

Participants assessed at Year 10 were younger at baseline (71.5 vs. 75.4 years, $t(696) = 8.61$, $p < .001$, $d = .70$), had more years of education (13.9 vs. 13.1 years, $t(696) = 3.53$, $p < .001$, $d = .28$), had higher MMSE scores (27.8 vs. 27, $t(693) = 5.75$, $p < .001$, $d = .45$), better vision (.32 vs. $-.08$, $t(549) = -4.95$, $p < .001$, $d = .42$), better self-reported general health (.27 vs. $-.07$, $t(694) = 4.63$, $p < .001$, $d = .37$) at baseline, and were more likely to be female (79.1% vs. 70.6%, $\chi(1)^2 = 5.98$, $p = .014$). There were no significant differences in race.

Stepwise logistic regressions were used to assess the impact of a number of factors on the likelihood that participants would be seen at each occasion. Models for each study visit contained the following independent variables as measured at baseline: age, sex, marital status, vision, years of education, general health, and reasoning ability. No predictors reached significance in years 1 and 2. In subsequent years, the models correctly classified 88.8% of cases at Year 3, 76.9% of cases at Year 5, and 70.5% of cases at Year 10. Table 1 illustrates the strength of each independent variable in predicting attrition status at each occasion. Older age was associated with greater probability of dropout at year 3. Older age, male sex, worse self-reported levels of general health, and higher inductive reasoning ability were each associated with increased probability of dropout at years, 5 and 10. Thus, significant predictors of attrition (age, sex, general health, and reasoning) were included in all longitudinal analyses (see below).

The 10-Year Trajectories of Time-Varying Variables

To describe the trajectory of 10-year growth in everyday cognition, as well as all cognitive and health-related predictors, simultaneous latent growth models were estimated for everyday cognition, reasoning, memory, speed, vocabulary, general health, and vision. We estimated intercept, linear, and quadratic parameters for each growth process. In every case, while both fixed linear and quadratic trends could be estimated and were required for optimal fit, only the intercept and linear slope had random variance, and were included in the regressions and correlations. Fixed baseline demographic predictors (age, sex, years of education) were included, and were correlated with all other intercept and slope predictors.

Table 2 shows the intercept and slope values for the cognitive variables of interest (everyday cognition, reasoning, memory, speed, and vocabulary). As illustrated in Table 2 (see also Figure 1), all cognitive variables except memory evidenced a positive linear trajectory, which likely captured retest effects. The largest linear gain was observed for speed, while memory evidenced linear decline. All cognitive variables demonstrated a negative quadratic (inverted U-shape) trajectory, indexing decline in cognition over time. The most pronounced quadratic slope was observed for speed.

To assess the possible impact of selective attrition, we examined the simple difference in everyday cognition level and slope between continuing and non-continuing participants. This difference was significant for both everyday cognition intercept ($b = 7.68$, $SE = 0.70$, $\beta = 0.41$, $p < .001$) and slope ($b = 0.25$, $SE = 0.08$, $\beta = 0.25$, $p = .003$). Subsequent interim models evaluated whether the inclusion of demographic (age, sex, general health) and reasoning intercept and slope attenuated the effect of attrition group differences. For the everyday cognition slope, after these variables were controlled, the unique effect of attrition was non-significant ($b = 0.15$, $SE = 0.09$, $\beta = 0.16$, $p = .095$). For the everyday cognition intercept, attrition group differences were attenuated but remained significant ($b = 1.247$, $SE = 0.50$, $\beta = 0.07$, $p = .012$). Thus, in addition to age, sex, general health, and reasoning, we included attrition status as a covariate in models.

Comparing Slopes of Cognitive Constructs

Figure 1 illustrates the longitudinal trajectories of everyday and basic cognitive variables (model estimated values conditioned on age, sex, general health, reasoning, and attrition status). Before examining predictors of level and slope in everyday cognition, we first compared the slope of everyday cognition to that of each basic cognitive ability. Parallel latent growth models using the fixed everyday cognition slope (expressed in T-score units of annualized growth; *linear* $\beta = 0.718$, $p < .001$; *quadratic* $\beta = -0.128$, $p < .001$) as the reference line, showed significant differences between the linear slope of everyday cognition and all other linear slopes. Memory (*slope difference estimate* = -1.41 , $p < .001$) and vocabulary (*slope difference estimate* = -0.43 , $p < .001$) evidenced flatter linear trajectories (attenuated linear gain), while reasoning (*slope difference estimate* = 0.25 , $p = .02$) and speed (*slope difference estimate* = 0.75 , $p < .001$) evidenced significantly more positive linear gain relative to everyday cognition. Turning to the quadratic slopes, and still using everyday cognition as the reference line, vocabulary (*slope difference estimate* = 0.08 , $p < .001$) and memory (*slope difference estimate* = 0.09 , $p < .001$) showed significantly flatter slopes, while speed (*slope difference estimate* = -0.09 , $p < .001$) showed a significantly larger negative quadratic trend. The quadratic slope of reasoning and everyday cognition did not differ (*slope difference estimate* = -0.01 , $p = .33$).

Predictors of Everyday Cognition

Table 3 shows the final model for the prediction of the everyday cognition intercept and slope¹. The model-estimated variance explained in the everyday cognition intercept was $r^2 = 0.85$, and in the everyday cognition slope was 0.96 . Model fit was excellent: $\chi^2(df = 903) = 1465.53$, $p < .001$; χ^2/df ratio = 1.623 ; NFI = 0.93 ; RFI = 0.92 ; IFI = 0.97 ; TLI = 0.97 ; CFI = 0.97 ; RMSEA = 0.03 . The table shows that older age and greater baseline levels of

reasoning, memory, speed, vocabulary, and vision were each uniquely associated with better initial everyday cognitive performance. Reasoning had the largest standardized effect size, followed by memory, vocabulary, and speed; vision and age had the smallest unique effect sizes. With regard to the prediction of everyday cognition slope, linear slope of reasoning was positively predictive, and explained most of the individual differences in the slope of everyday cognition¹.

Conditional correlations among the predictor growth parameters and demographic variables are shown in Table 4. The table shows positive associations among the cognitive intercepts, with the strongest relationship between baseline memory and reasoning ($r = 0.73$). Vision intercept was strongly and positively related to the cognitive intercepts ($r_s = 0.22\text{--}0.42$). Female sex was significantly associated with lower levels of all cognitive intercepts. Notably, there were strong associations between the slope of reasoning, and those of memory ($r = .80$) and speed ($r = .76$), suggesting considerable overlap in variance between these predictors, which might be interpreted as general cognitive growth (see Tucker-Drob, 2011). In the present model, reasoning appears to represent the predictive variance of basic abilities in everyday cognition.

Discussion

The present study examined the relationship between levels and slopes in basic cognitive abilities measured using laboratory-based tests (i.e., composites of psychometric/laboratory measures of inductive reasoning, verbal memory, visual processing speed, and vocabulary) and everyday cognitive performance measured using objective, performance-based tasks involving everyday stimuli. We examined 10-year trajectories in basic and everyday cognitive abilities, as well as time-varying associations between these variables. We characterized the 10-year longitudinal trajectory of everyday cognition in our sample of healthy, community-dwelling older adults, and examined the hypothesis that everyday cognitive skills are relatively preserved against age-related decline compared to basic abilities (Cornelius & Caspi, 1987; Denney, 1990). A particular strength of the current results is that all basic/everyday cognitive correlations were statistically adjusted for the

¹ Preparatory to conducting our conditional growth models, we first estimated a set of initial unconditional models. In these unconditional models, bivariate associations between the random variance in the everyday cognition linear slope and each other intercept, slope, or baseline demographic variable were examined. Improvement in everyday cognition was significantly ($p < .05$) associated with improvement in reasoning, $r = 0.93$; speed, $r = 0.74$; vision, $r = 0.39$; as well as with higher initial performance levels in speed, $r = 0.36$; everyday cognition, $r = 0.33$; reasoning, $r = 0.31$; and memory, $r = 0.25$. Furthermore, female sex and higher baseline age both predicted less everyday cognitive improvement ($r = -0.29$; and $r = -0.18$, respectively). As these bivariate associations illustrate, change in reasoning was most closely linked to change in everyday cognition, although there was clearly substantial multicollinearity among the cognitive change slopes.

In subsequent conditional models, no model would allow the simultaneous prediction of everyday cognition from multiple predictors (models did not converge and could not be identified because most of the reliable random variance in everyday cognitive rate of change had been explained). Thus, a series of univariate analyses in which only the growth parameters, intercept and slope, of a single independent variable were allowed to predict everyday cognition slope were considered. Each model was equivalently specified, except that two paths (predictor intercept to everyday cognition slope, predictor slope to everyday cognition slope) were added for a single predictor. Comparing these non-nested models via Akaike Information Criterion (AIC) (Akaike, 1974) and the Schwartz Bayesian Information Criterion (BIC) (Schwartz, 1978) suggested that the best fit was for reasoning. In order of best fit, predictors of everyday cognition were as follows: reasoning: AIC = 1750.62, BIC = 1772.15; memory: AIC = 1761.94, BIC = 1783.47; speed: AIC = 1763.68, BIC = 1785.22; vocabulary: AIC = 1797.20, BIC = 1818.73; general health: AIC = 1830.66, BIC = 1852.19; vision: AIC = 1830.44, BIC = 1851.98. After the reasoning slope was allowed to predict everyday cognition, no other slope predictor reached significance, and most models including a second slope could not be identified. Thus, in the final model, the reasoning slope and intercept were the sole predictors of the everyday cognition slope, and fully explained random variance in everyday cognition slope.

effects of attrition as well as multiple static and time-varying physical and sensory covariates.

Trajectories of Everyday and Basic Cognitive Abilities

Everyday cognition followed an inverted U-shape (quadratic) trajectory over 10 years, in a healthy older adult sample. Similar models also exhibited the most parsimonious fit to basic cognitive abilities of memory, reasoning, speed, and vocabulary. As Figure 1 shows, although the net trajectory over time is decline, breaking growth into linear and quadratic terms produced small linear improvements that were qualified by overarching quadratic declines. Although the current study did not specifically separate retest from maturational effects, these observed linear gains likely reflected retest, or practice effects, which are common in longitudinal cognitive research (Rabbitt, Diggle, Smith, Holland, & McInnes, 2001; Salthouse, 2010). In fact, when examining the differential effects of age and practice in longitudinal data, Rabbitt and colleagues (2001) found that practice effects increased over repeated testing. Since ACTIVE participants were assessed six times, a linear practice trend is theoretically plausible, and empirically supported by our models. The negative quadratic slope evidenced by all cognitive variables indexed decline in abilities over time.

To examine the hypothesis that everyday cognition might be buffered against decline relative to basic abilities, the 10-year longitudinal slopes between everyday cognition, reasoning, memory, speed, and vocabulary were compared. Relative to everyday cognition, the flat slope for vocabulary (less initial gain, and less precipitous decline), indexing stability over time, is consistent with the conceptualization of vocabulary as a measure of crystallized ability (e.g., Ghisletta, Rabbitt, Lunn, & Lindenberger, 2012; Singer et al., 2003). Memory was characterized by a lack of linear gain and a flatter, more precipitous trajectory of decline over time. Speed also evidenced more pronounced decline relative to everyday cognition. These findings are consistent with prior studies showing generally more pronounced age-related decline in memory and processing speed (e.g., Finkel, Reynolds, McArdle, & Pedersen, 2007; Park et al., 2002; Salthouse, 1996; Schaie, 1989). Finally, the longitudinal trajectory of reasoning was statistically similar to that of everyday cognition. Overall, these findings suggest that everyday cognitive abilities are better preserved against decline than memory and speed, but not reasoning and vocabulary.

The present work suggests that, after accounting for practice-related gain, everyday cognitive performance is sensitive to decline during a period in the life-course in which participants, on average, transitioned from young-old to old-old age (Marsiske & Willis, 1995; Schaie & Willis, 1986). Some have hypothesized that everyday cognitive skills should decline less than basic cognitive abilities in healthy older adults (Cornelius & Caspi, 1987). As illustrated in Figure 1, nearly all cognitive abilities evidenced accelerated (quadratic) decline. Thus, patterns observed in the present data suggest that as older adults reach their 80s, the familiarity of everyday cognitive tasks may not be sufficient to sustain performance of IADL in the face of cognitive losses.

Aimed at face-validity (i.e., using tasks that resemble those performed everyday life), the everyday cognitive measures used in this study required older adults to solve common daily problems. However, everyday problems assessed were not exactly those that are part of

every participant's life experience (e.g., a question about nutrition facts might refer to a product not used by a particular participant). It is possible that the trajectory of decline observed in this study might have been shallower had participants been tested on tasks directly drawn from their daily lives, but such an ipsative assessment approach would not be feasible in a large study like ACTIVE. Nonetheless, the current findings suggest that common everyday tasks, such as understanding new medication instructions, may present increasing levels of challenge in the later years of life.

Predictors of Level and Slope of Everyday Cognition

As shown in Table 3, higher baseline level of everyday cognition was associated with older age and higher levels of reasoning, memory, speed, vocabulary and visual acuity. Dropout status was a significant negative predictor of the slope in everyday cognition and positive linear slope in reasoning explained all of the individual differences in the positive linear slope of everyday cognition, suggesting that individual differences in everyday cognition are strongly related to those observed in inductive reasoning. This is consistent with the idea that inductive reasoning, or the ability to extract information from stimuli, work out patterns, and derive a solution based on available information, is particularly important for solving everyday problems (Willis & Schaie, 1986). Reasoning alone accounted for 85% of intercept and 96% of the slope variance in everyday cognition; however as the conditional bivariate relationships in Table 4 show, there is considerable overlap between reasoning, and memory, as well as reasoning and speed, suggesting that reasoning might be the most parsimonious basic cognitive predictor of everyday cognitive abilities. Indeed, Tucker-Drob (2011) reported that a common factor represented good fit to 5-year longitudinal data in ACTIVE, across basic and everyday cognitive domains.

Limitations

Several limitations merit attention. First, we had available a narrow set of basic cognitive predictors (i.e., inductive reasoning, verbal memory, visual processing speed, and vocabulary). The ACTIVE cognitive battery was comprised mostly of age-sensitive measures of information processing and fluid abilities (Horn & Cattell, 1967; Baltes et al., 1980). A more thorough neuropsychological battery could measure multiple aspects of executive functioning, as well as subdomains of memory and processing speed. Such an approach would facilitate a better understanding of the basic cognitive components of everyday cognition, and allow clinicians to better assess the clinical utility of everyday cognitive measures relative to more common, clinically-utilized cognitive measures (e.g., Hopkins Verbal Learning Test, Brandt & Benedict, 2001; Wechsler Adult Intelligence Scale, Wechsler, 2008; Delis-Kaplan Executive Function System, Delis, Kaplan, & Kramer, 2001). This was not feasible in this large epidemiologic randomized trial of older adults.

A second limitation is the selectivity of the research sample. The present sample was selected to be relatively healthy and free of cognitive decline at baseline. Despite this, the ACTIVE sample is broadly comparable with other longitudinal studies of aging in terms of age and sex (e.g., Dixon & de Frias, 2004; Rabbitt et al., 2004), and provided the opportunity to characterize the trajectory of growth in everyday cognitive skills in a relatively healthy, unimpaired sample. The current study found, for example, slight

performance disadvantages for women on many of the cognitive tasks studied; it is unclear whether this reflects, in part, the greater difficulty of recruiting men such that men are a more positively selected subset.

Another limitation is that we aimed to describe the unique contribution of each time-varying variable in predicting everyday cognition. However, after controlling for inductive reasoning, most of the reliable individual differences in the everyday cognition slope had been explained, so that additional predictors could not be added. To provide a lens on the unique association between each cognitive domain and everyday cognition, univariate analyses, as well as conditional bivariate relationships (Table 4), addressed the question of strength of association between everyday cognition and each basic cognitive ability. In general, all cognitive abilities were positively associated (i.e., “travelled together”) with everyday cognition over the ten-year period.

Finally, it should also be noted that the particular modeling approach used in the current study did not specifically isolate maturational from retest-related differences in growth of everyday cognition, nor could the causal status of predictors be evaluated given that the analyses in this paper examined only the associations among concurrent growth. Future research using alternative modeling framework (e.g., dual change score models, age basis models) might further decompose growth/differences into change scores and examine lead-lag associations, although preliminary analyses (not shown) conducted in the current sample found that the longitudinal sample in the later years of study, particularly at the oldest ages, when restricted only to the control (untrained) sample was not sufficient to permit estimation of these more complex models.

Future Directions

Future work should examine the association between basic and everyday cognitive abilities in more cognitively impaired samples of older adults. It will be informative to determine whether measures of everyday cognition might have utility in the assessment of the cognitive IADL capacity of clinical populations (e.g., older adults presenting with memory complaints). The incorporation of everyday cognitive measures into clinical assessment might improve efficiency, particularly in cases where everyday cognitive capacity, not differential diagnosis, is of primary clinical interest.

In summary, the present study augments the body of work aimed at characterizing older adults' everyday cognitive skills over time. We found that over 6 occasions of assessment spanning 10 years, reasoning alone was able to explain most of the individual differences in everyday cognition. Everyday cognition does not appear to be buffered from decline; however it appears to be better preserved than verbal memory and visual processing speed.

Acknowledgments

Ms. Yam was supported by a grant from the National Institute of Aging (T32 AG020499-07). ACTIVE is supported by grants from the National Institute on Aging and the National Institute of Nursing Research to Hebrew Senior Life (U01NR04507), Indiana University School of Medicine (U01NR04508), Johns Hopkins University (U01AG14260), New England Research Institutes (U01AG14282), Pennsylvania State University (U01AG14263), University of Alabama at Birmingham (U01AG14289), University of Florida (U01AG14276).

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Nursing Research, National Institute on Aging, or the National Institutes of Health. Representatives of the funding agency have been involved in the review of the manuscript but not directly involved in the collection, management, analysis or interpretation of the data. Dr. Marsiske has received research support from Posit Science, Inc., in the form of site licenses for cognitive training programs for a different research project.

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Figure 1. Model-estimated longitudinal trajectories of basic and everyday cognitive abilities. Results from the ACTIVE no-contact control group ($n = 698$). Data were collected at baseline and 1, 2, 3, 5, and 10 years post-baseline.

Table 1

Results of Logistic Regressions Determining Predictors of Attrition at Each Occasion of Longitudinal Assessment: Results from ACTIVE (n = 698)

Year	Predictor of Attrition	Odds ratio	95% Confidence Interval
3	Age	0.95	(0.92, 1.00)
5	Age	0.96	(0.93, 1.00)
	Sex (Female)	2.04	(1.28, 3.25)
	General Health (higher is worse)	1.43	(1.13, 1.80)
	Reasoning	1.38	(1.01, 1.07)
10	Age	0.89	(0.86, 0.93)
	Sex (Female)	1.68	(1.01, 2.63)
	General Health (higher is worse)	1.24	(1.00, 1.09)
	Reasoning	1.06	(1.04, 1.09)

Note. All predictors were significant at $p < .05$. The outcome was coded as 0 = not assessed, 1 = assessed.

Table 3

Predictors of Everyday Cognition Intercept and Slope

	Everyday Cognition Intercept				Everyday Cognition Slope			
	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Dropout by year 10	-0.52	0.45	-0.03	0.25	-0.16	0.09	-0.15	0.08
Education	0.34	0.22	0.04	0.12	0.00	0.04	0.01	0.93
Gender (Female)	-0.09	0.27	-0.01	0.72	0.03	0.04	-0.01	0.52
Age	0.43	0.20	0.05	0.03	0.06	0.04	0.13	0.11
Reasoning intercept	0.38	0.04	0.41	<.001	0.01	0.01	0.14	0.14
Memory intercept	0.26	0.04	0.27	<.001	-	-	-	-
Speed intercept	0.13	0.04	0.13	<.001	-	-	-	-
Vocabulary intercept	0.20	0.03	0.20	<.001	-	-	-	-
Health intercept	-0.00	0.02	-0.01	0.83	-	-	-	-
Vision intercept	0.12	0.03	0.10	<.001	-	-	-	-
Reasoning slope	1.21	0.55	0.07	0.03	0.98	0.11	0.97	<.001

Note. “-” = not estimated (see Footnote 1). *b* = raw values, β = standardized values.

Table 4

Conditional Bivariate Associations

	Present at A10	Age	Educa- tion	Sex (Female)	Memory Intercept	Reasoning Intercept	Speed Intercept	Voca- bulary Intercept	Vision Intercept	Health Intercept	Memory Slope	Reasoning Slope	Speed Slope	Voca- bulary Slope	Vision Slope	Health Slope
Present at year																
10	1.00															
Age	0.10	1.00														
Education	0.13	-0.22	1.00													
Sex (Female)	-0.31	-0.05	-0.08	1.00												
Memory Intercept	0.43	0.16	0.32	-0.47	1.00											
Reasoning Intercept	0.41	-0.02	0.40	-0.39	0.73	1.00										
Speed Intercept	0.44	-0.05	0.26	-0.55	0.65	0.69	1.00									
Vocabulary Intercept	0.17	-0.07	0.50	0.00	0.54	0.61	0.33	1.00								
Vision Intercept	0.25	0.00	0.11	-0.49	0.27	0.23	0.42	0.05	1.00							
Health Intercept	0.29	-0.11	0.26	-0.32	0.33	0.38	0.38	0.23	0.24	1.00						
Memory Slope	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	0.13	0.12	0.17	<i>a</i>	<i>a</i>	<i>a</i>	1.00					
Reasoning Slope	0.29	0.09	-0.13	-0.24	0.24	0.23	0.32	-0.05	0.10	0.18	0.80	1.00				
Speed Slope	0.27	-0.10	0.11	-0.29	0.40	0.36	0.36	0.12	0.16	0.24	0.43	0.76	1.00			
Vocabulary Slope	0.43	0.02	-0.06	-0.43	0.35	0.31	0.38	-0.01	0.37	0.30	<i>a</i>	0.58	0.32	1.00		
Vision Slope	0.11	0.20	0.12	-0.15	0.10	0.10	0.12	0.10	0.26	0.16	<i>a</i>	0.16	0.07	0.39	1.00	
Health Slope	0.24	-0.05	0.21	-0.30	0.18	0.23	0.25	0.04	0.12	0.26	<i>a</i>	0.05	0.14	0.23	-0.05	1.00

Note. Correlations greater than |0.08| are significantly different from zero, $p < .05$, and are shown in **boldface**;

a = not estimated/not identified parameter.

Each association is conditioned on all other measures in the matrix (i.e., attrition status, age, education, sex, as well as intercept and slope in memory, reasoning, speed, vocabulary, vision and health). Memory slope variance was constrained to zero due to negative variance estimates.