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Neurocognitive Functions and Everyday Functions Change Together in Old Age

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Objective: Although neurocognitive functions are known to decline normatively with adult age, there is a common belief that everyday functions (e.g., paying bills, following medication instructions, making change, looking up telephone numbers in a phone book) are unaffected by these changes. ***Method:*** This hypothesis was examined by applying longitudinal growth models to data from a community-based sample of 698 adults (ages 65 to 94 years and living independently at baseline) who were repeatedly measured over five years on neurocognitive tests of executive reasoning, episodic memory, and perceptual speed, and on a number of tasks that adults should be reasonably expected to be able to perform in their day-to-day lives. ***Results:*** Individual differences in changes in neurocognitive performance were strongly correlated with individual differences in changes in performance on the everyday tasks. Alternatively, changes in self-reports of everyday functions were only weakly correlated with changes in performance on the neurocognitive tests and the everyday tasks. ***Conclusions:*** These results together suggest that normative neurocognitive aging has substantial consequences for the daily lives of older adults and that both researchers and clinicians should be cautious when interpreting self-reports of everyday functioning.

Keywords: cognitive aging, cognitive decline, everyday functioning, Activities of Daily Living

It is well-established that neurocognitive functioning declines with advancing adult age, even among healthy disease-free individuals (Raz & Lindenberger, 2010; Salthouse, 2004; Salthouse, 2010). However, there continues to be doubt that aging-related neurocognitive declines have appreciable consequences for everyday functioning. In fact, many consider the supposed independence of everyday functions from neurocognitive declines to be a paradox. For example, Park (1998, p. 61; also see Park & Gutchess, 2000) stated, "The global nature of the decline in speed of processing and working memory that occurs with age might lead one to expect that older adults would have substantial difficulties in managing the affairs of everyday life or maintaining a good level of performance on the job. However, there is considerable evidence (as well as our own personal observations) that older adults function well and that cognitive declines documented in the lab do not impact as negatively as one would expect on everyday domains of behavior." Salthouse (2004, p. 141) has similarly commented that a question frequently raised when evidence for aging-related neurocognitive decline is presented is "Why are the effects not more noticeable in everyday life?" Moreover, the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000, p. 148) directs that for a diagnosis of dementia to be warranted, cognitive deficits must result in a decline from previously higher levels of occupational or social functioning. This directive to exclude from dementia diagnosis adults who exhibit cognitive deficits absent of declines in occupational or social functioning implies a perspective that normative aging often results in cognitive declines without accompanying declines in everyday functions.

The perspective that everyday functioning is unrelated to neurocognitive aging largely derives from three complementary rationales (see, e.g., Park, 1998; Salthouse, 1990; Salthouse, 2004; Salthouse, 2010). First, it has been argued that everyday functions largely rely on knowledge and personality factors. It is well established that, while the efficiency of cognitive processing declines with adult age, stores of knowledge remain relatively stable, or even increase, with adult age (Tucker-Drob & Salthouse, 2008), as do aspects of personality, such as motivation, vigilance, and conscientiousness (Roberts, Walton, & Viechtbauer, 2006). Second, it has been argued that while neurocognitive functions might be necessary for the initial acquisition of competencies for everyday functions early in life, after these competencies are acquired they soon become automated and hence causally independent of neurocognitive functions. Third, it has been argued that while everyday tasks are indeed dependent on cognitive processing, the amount of cognitive processing necessary to succeed at the tasks is so minimal that everyday task performance will only be affected by the severe forms of cognitive deficits that are associated with dementia.

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These three rationales presuppose an independence between cognition and everyday functions that must be explained. The current study seeks to examine this presupposition by investigating the extent to which neurocognitive declines and everyday functions are interdependent in old age. The study makes use of five year longitudinal data from independently living older adults. Three neurocognitive functions (executive reasoning, episodic memory, and perceptual speed) were assessed using the sorts of conventional psychometric measures that have been suggested not to reflect real world demands (e.g., Sternberg, 1999). Following the approach of Allaire and Marsiske (1999), everyday functions were assessed using three previously developed measures that are highly ecologically valid in that they require participants to engage in the very same activities that they should be expected to engage in during their day-to-day lives. Examples of these activities include reading and understanding medication labels, preparing bills for payment, looking up telephone numbers, and making change. Many of the activities make use of tangible stimuli, such as actual medication bottles, a real telephone, real U.S. currency, a medical history form, and real cans of food.

Approaches to Testing Whether Neurocognitive Aging Relates to Everyday Functioning

There are at least three types of evidence potentially relevant to testing the independence versus interdependence of neurocognitive functions and everyday functions. First, one could examine the correlations between individual differences in cognition and everyday functions in older adults. In community-based cross-sectional samples of older adults a number of researchers (e.g., Diehl, Willis, & Schaie, 1995; Allaire & Marsiske, 1999; Allaire & Marsiske, 2002) have reported that such concurrent relations between performance on cognitive tests and objective tests of everyday functions range from approximately $r = .30$ to $r = .70$. However, while positive concurrent correlations could be indicative of an interdependence between cognition and everyday functions during late adulthood, they could also be reflective of an interdependence that existed earlier on in life (e.g., during skill acquisition), but no longer exists (e.g., as a result of automation). Examination of concurrent relations between cognitive functions and everyday functions is therefore only of limited value for resolving the question of interdependence.

Second, one could examine the extent to which everyday functions exhibit negative average age trends similar to those exhibited by neurocognitive functions. Using cross-sectional data, Allaire and Marsiske (1999), for example, reported that the correlation between age and everyday functions was −.23 in older adults ages 60 to 92 (compared to a correlation of −.26 between age and general cognitive ability in these same adults). Moreover, using 7-year longitudinal data, Willis (1996) reported that average levels of performance by healthy community-dwelling individuals on an objective measure of everyday functioning significantly declined from baseline to follow-up. However, while the finding that average levels of both cognition and everyday functions decline similarly with age could reflect an interdependency between changes in the two functions, it could also simply reflect the fact that many different functions, both psychological and physical, worsen with adult age. That is, similar average age trends in two variables do not necessarily indicate that the two variables change together for specific individuals. For example, that the proportions of gray hair and poor vision in a population increase with adult age does not necessarily mean that the individuals who go gray are also the same individuals who end up needing glasses. In fact, one could envision a circumstance in which the two subpopulations are entirely nonoverlapping, even while average age trends for the two prevalence rates in the aggregate population are identical. Examination of mean age trends is therefore only of limited value for resolving the question of interdependence.

Third, one could examine whether individual differences in rates of longitudinal changes in neurocognition correlate with individual differences in rates of longitudinal changes in everyday functions. Although there do not appear to be any previous examinations of this sort, such an examination would be a quite rigorous test of the interdependency hypothesis. Strong positive correlations between rates of changes in measures of the two constructs would indicate that individuals who change considerably in their neurocognitive functions tend to be the same individuals who change considerably in their everyday functions, whereas individuals who maintain their neurocognitive functions tend to be the same individuals who maintain their everyday functions. Because such longitudinal correlations involve individual differences in a process that is actually occurring in old age, this form of evidence is not subject to the criticism that the correlations may simply reflect a historical interdependence from earlier on in life. Correlations among longitudinal changes were therefore the focus of the current study.

Method

Participants

Data for the current study came from a sample of participants who served as the no-contact control group for a randomized cognitive training intervention known as ACTIVE (*Advanced Cognitive Training for Independent and Vital Elderly;* Tennstedt et al., 1999–2001). Human subjects research for ACTIVE was approved by the institutional review boards at the University of Alabama at Birmingham; Wayne State University, Detroit, Michigan; the Hebrew Rehabilitation Center for the Aged, Roslindale, Massachusetts; the Johns Hopkins University School of Medicine, Baltimore; Indiana University, Bloomington; Purdue University, Indianapolis, Indiana; Pennsylvania State University, University Park; the University of Florida, Gainesville; and the New England Research Institutes, Watertown, Massachusetts. Only data from the control group were analyzed because the current investigation was concerned with naturally occurring longitudinal changes and not with the effects of any experimenter-controlled intervention. These data are therefore equivalent to data from an observational longitudinal study of healthy, independently living adults. As in a typical observational longitudinal study of normal aging, there were a number of exclusion criteria. Excluded from participation were persons who, at baseline, (a) were less than 65 years of age; (b) scored less than 23 of 30 on the Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975); (c) reported needing extensive assistance with dressing, personal hygiene, or bathing; (d) had medical conditions (e.g., recent stroke, or current chemotherapy/radiation treatment) that would predispose them to functional decline or mortality in the near future; (e) reported that they had vision problems that caused them extreme difficulty reading ordinary newspaper print, or that they had stopped reading because of vision problems; (f) had substantial communication difficulties, based on interviewer ratings of the prospective participant's effectiveness of both making himself/herself understood and understanding the interviewer during an initial telephone screening interview; (g) had recent cognitive training; or (h) were planning to move out of the area or anticipated being away from the study site for an extended period of time in the upcoming year (Jobe et al., 2001; Tennstedt et al., 1999–2001).

The control subsample from which data were analyzed consisted of 698 independently living individuals ages 65 to 94 (mean age = 74, *SD* = 6) at baseline who were followed longitudinally for up to six occasions over five years. Basic participant characteristics are presented in the top portion of Table 1. Seventy-four percent of participants were female, and 27% of participants were black (71% were white). Participants had 13.4 years of education on average (*SD* = 2.7). Eliminating participants with MMSE scores less than 27 of 30 resulted in a similar pattern of results to those reported here, as did eliminating participants older than 75 years of age. This suggests that patterns reported below were not carried by lower functioning or very elderly adults.

Sample sizes at occasions 1 through 6 were 698, 639, 582, 551, 510, and 452. Compared to those dropping out, participants returning at the sixth occasion had an average age of 73.6 at baseline (compared to 74.9), an average educational attainment of 13.6 (compared to 13.0), had an average MMSE score of 27.5 at baseline (compared to 26.8), and were 78% female (compared to 66% female). Only the gender comparison was significant at $p <$ .01. This may, in part, reflect gender differences in longevity. Full information maximum likelihood (FIML) estimation was used to capitalize on all available data. FIML assumes that any systematic patterns of missingness were functions of the variables included in the models. This helps to avoid parameter bias that would result from only analyzing data from individuals who remained in the study for the entire 5-year period.

Performance-Based Measures of Everyday Functioning

Everyday functions were assessed using three previously validated performance-based tasks. These measures were scaled such that higher scores correspond with better performance. Means, standard deviations, and reliabilities of each of the measures of everyday functions are provided in the middle portion of Table 1.

The Everyday Problems Test (Willis & Marsiske, 1993) is a written free-response test in which participants are shown printed stimuli about which they must answer questions. Examples of stimuli include a recipe for sour milk biscuits, a telephone bill, a mail-in coupon for membership in an organization, a taxi fare pricing chart, and the nutritional information for cereal. Examples of questions include reporting the percent daily value for sodium in a serving of cereal, and reporting which ingredient is mixed with sour milk when making sour milk biscuits.

Observed Tasks of Daily Living (Diehl, Willis, & Schaie, 1995) are rule-based observer ratings of participants' success at solving

Table 1
Descriptive Statistics of Study Variables Prior to Creation of Composites

Variable	65- to 75-year-olds (n = 439) Mean (*SD*)	76- to 94-year-olds (n = 259) Mean (*SD*)	Complete sample (n = 698) Mean (*SD*)	Age correlation	Reliability estimate
		Participant characteristics			
Age	70.20 (2.98)	80.58 (3.96)	74.05 (6.05)		
Gender	75%	71%	74%	−.05	
Education	13.54 (2.64)	13.10 (2.80)	13.37 (2.70)	−.08	
MMSE	27.50 (1.95)	26.88 (2.02)	27.27 (2.00)	−.17*	
		Measures of everyday functioning			
Timed Instrumental Activities of Daily Living	.10 (.53)	−.24 (.73)	−.03 (.64)	−.32*	.64
Observed Tasks of Daily Living	18.31 (4.20)	15.82 (4.38)	17.38 (4.43)	−.30*	.75
Everyday Problem Solving	19.14 (5.46)	16.72 (6.04)	18.25 (5.79)	−.22*	.87
Self-reported difficulty with Instrumental Activities of Daily Living[a]	1.05 (1.97)	1.75 (2.93)	1.31 (2.39)	.13*	.76[b]
		Neurocognitive measures			
Word Series	10.26 (4.89)	7.56 (4.16)	9.26 (4.81)	−.33*	.84
Letter Series	10.62 (5.70)	7.79 (4.75)	9.57 (5.54)	−.31*	.86
Letter Sets	6.14 (2.90)	4.90 (2.57)	5.69 (2.85)	−.24*	.69
UFOV Task 2[a]	104.34 (100.45)	192.15 (144.13)	136.90 (125.82)	.38*	.69[c]
UFOV Task 3[a]	286.32 (125.43)	389.08 (122.36)	324.05 (133.75)	.41*	.73[c]
UFOV Task 4[a]	445.99 (72.65)	482.01 (41.48)	459.22 (65.34)	.30*	.48[c]
HVLT	27.08 (4.60)	23.21 (6.46)	25.68 (5.66)	−.40*	.73
AVLT	49.99 (9.56)	43.03 (11.12)	47.47 (10.68)	−.41*	.78

Note. All reliability estimates come from Ball et al. (2002) except where otherwise noted.
[a] Lower scores reflect better performance/higher functioning. [b] Estimate comes from Morris et al. (1997). [c] Estimate is a 12-week test-retest correlation.
* Age correlation is significant at $p < .01$.

everyday tasks from the domains of Medication Use, Telephone Use, and Financial Management. Tasks are hands-on, in that they require participants to make use of stimuli such as medication bottles, a telephone, U.S. currency, a checkbook ledger, a medical history form, and a utility bill. Examples of the tasks include determining which medication might cause drowsiness, indicating where on a medical history form a preexisting condition should be indicated, determining the charge for making a long distance call at a particular time of day, and preparing a utility bill payment for mailing.

Timed Instrumental Activities of Daily Living (Owsley, McGwin, Sloane, Stalvey, & Wells, 2001) is a task in which an examiner measures how quickly participants can perform five tasks: finding a telephone number in a phone book, making change, reading food can ingredients, finding items on a shelf, and reading directions on medicine containers.

Self-Reported Measure of Everyday Functioning

Self-reported difficulty with instrumental activities of daily living. In addition to being administered performance-based measures of everyday functioning, participants also reported on the subjective difficulty that they had with independently performing instrumental activities of daily living (Morris et al., 1997) from the following categories: meal preparation, ordinary housework, managing finance, managing medications, phone use, shopping, and transportation. For this self report, higher scores reflect more difficulty. The mean, standard deviation, and reliability estimate of this measure is reported in the middle portion of Table 1.

Measures of Neurocognition

Executive Reasoning, Episodic Memory, and Perceptual Speed abilities were measured with up to three tasks each. Unit-weighted composite scores were produced for the three abilities by summing z-transformed scores on each of their constituent tasks. The speed composite was then multiplied by -1, so that higher scores would correspond with better performance. Means, standard deviations, and reliabilities of each of the neurocognitive tasks are provided in the bottom portion of Table 1.

Executive Reasoning was measured with Word Series, (Gonda & Schaie, 1985), Letter Series (Thurstone & Thurstone, 1949), and Letter Sets (Ekstrom, French, Harman, & Derman, 1976). These tasks required participants to identify patterns in letter or word series problems. Scores reflect the total number of items correctly answered.

Perceptual Speed was measured with three tasks from the Useful Field-Of-View (UFOV) measure (Owsley, Ball, Sloane, Roenker, & Bruni, 1991). These tasks measured the shortest amount of time needed for participants to identify and localize information at 75% accuracy under varying levels of cognitive demand. UFOV tasks differ in levels of complexity from merely identifying objects that appear in a fixation box, to judging which configuration of objects appears in a fixation box while simultaneously localizing peripheral targets.

Episodic Memory was measured with both the Hopkins Verbal Learning Test (HVLT; Brandt, 1991) and the Auditory Verbal Learning Test (AVLT; Rey, 1941). The HVLT and The AVLT consisted of lists of 12 and 15 words, respectively that were repeated over a series of consecutive learning trials. The HVLT consisted of three learning trials, and the AVLT consisted of five learning trials. Words were auditorily presented with 2-second pauses between each word. After each trial, participants were given 2 minutes to write down all the words that they could remember. HVLT and AVLT scores reflected the total number of words correctly recalled across the three and five trials, respectively. Participants were not penalized for minor spelling errors, or singularization or pluralization of words.

Analyses

The analyses for the current project made use of a longitudinal growth modeling approach (McArdle & Nesselroade, 2003), which is a form of multilevel modeling specific to longitudinal repeated-measures data. The basic version of the longitudinal growth model is written as

$$Y_{t,w,n} = y_{0,w,n} + t \cdot y_{s,w,n} + e_{t,w,n}, \quad (1)$$

where $Y_{t,w,n}$ is the score of person n on outcome w at t years since the beginning of the study; $y_{0,w,n}$ is the *level* of performance on outcome w for person n at the beginning of the study; $y_{s,w,n}$ is the rate of longitudinal change in performance (or *slope*) on outcome w for person n, and $e_{t,w,n}$ is a residual for person n on outcome w at time t.[1] The residuals are assumed to each have means of zero and be uncorrelated. The levels and the slopes are allowed to have nonzero means and to intercorrelate.

When there is evidence for intercorrelations among the slopes, a factor model can be useful to account for these relations with just a few dimensions. Such a model can be written for levels and slopes separately as

$$y_{0,w,x,n} = \upsilon_{0,w,x} + \lambda_{0,w,x} \cdot F_{0,x,n} + u_{0,w,n}, \quad (2a)$$

$$y_{s,w,z,n} = \upsilon_{s,w,z} + \lambda_{s,w,z} \cdot F_{s,z,n} + u_{s,w,n}, \quad (2b)$$

where the subscript w denotes the outcome, the subscript x denotes the factor ($F_{0,x,n}$) on which the levels (y_0) load, and the subscript z denotes the factor ($F_{s,z,n}$) on which the slopes (y_s) load. The separate subscripts x and z allow for the possibility that the factor configuration of the levels and the factor configuration of the slopes may differ (see Tucker-Drob, in press). Of particular interest for the current project was the factor configuration of the slopes. Different factor configurations of slopes can be compared to one another to test whether individual differences in changes in everyday functions and individual differences in changes in neurocognitive functions fall along unrelated dimensions, related dimensions, or the same common dimension.

Results

All models were fit in *M*plus (Muthén & Muthén, 1998–2010). Alpha levels were set to .01. The top portion of Table 2 reports the correlations among baseline levels of performance (*levels*) on the

[1] t for baseline, 12-week follow-up, first annual, second annual, third annual, and fifth annual are therefore equal to 0, 0.23, 1.23, 2.23, 3.23, and 5.23, respectively.

Table 2
Correlation Matrices for Levels and Slopes of Everyday Functions and Neurocognitive Functions

Outcome	1	2	3	4	5	6
Baseline performance (levels)						
1. Everyday Problems Test	1.0					
2. Observed Tasks of Daily Living	.86*	1.0				
3. Timed Instrumental Activities of Daily Living	.70*	.75*	1.0			
4. Executive Reasoning	.77*	.71*	.59*	1.0		
5. Perceptual Speed	.58*	.63*	.58*	.64*	1.0	
6. Memory	.65*	.69*	.64*	.63*	.59*	1.0
Rates of longitudinal change (slopes)						
1. Everyday Problems Test	1.0					
2. Observed Tasks of Daily Living	.61*	1.0				
3. Timed Instrumental Activities of Daily Living	.27	.51*	1.0			
4. Executive Reasoning	.70*	.60*	.34*	1.0		
5. Perceptual Speed	.64*	.69*	.27	.95*	1.0	
6. Episodic Memory	.92*	.86*	.51*	.92*	.94*	1.0

* $p < .01$.

three everyday functioning outcomes and the three neurocognitive outcomes. It can be seen that baseline levels of the three everyday functioning outcomes are strongly related to one another, baseline levels of the three neurocognitive outcomes are strongly related to one another, and baseline levels of the everyday functioning outcomes are strongly related to baseline levels of the neurocognitive outcomes. These findings together indicate that individual differences in everyday functions and individual differences in neurocognitive functions are strongly related to one another at a given period of time. This is initial, although not sufficient, evidence for the proposal that everyday functioning is related to cognitive aging.

Do Neurocognitive Functions and Everyday Functions Change Together Over Time?

The bottom portion of Table 2 reports correlations among rates of change (*slopes*) in the three everyday functioning outcomes and the three neurocognitive outcomes. It can be seen that the rates of changes in everyday functioning tend to be moderately to strongly related to one another, the rates of changes in neurocognitive functions tend to be moderately to strongly related to one another, and the rates of changes in everyday functions tend to be moderately to strongly related to the rates of changes in neurocognitive functions.[2] While most of these correlations are significant at $p <$ .01, there are two correlations that are not statistically significant by this standard. The correlation between change in performance on the Everyday Problems Test and change in performance on the Timed Instrumental Activities of Daily Living is not significant, although its magnitude is positive and moderate, at $r = .27$. Similarly, the correlation between change in performance on the Timed Instrumental Activities of Daily Living and change in the Processing Speed composite is not significant, although its magnitude is positive and moderate, at $r = .27$. In total, 13 change intercorrelations were positive and statistically significant and two change intercorrelations were positive and nonsignificant. Generally speaking, this is strong evidence that neurocognitive functions and everyday functions indeed change together in adulthood. This appears to be the first clear demonstration to date of such a pattern of correlated longitudinal changes in neurocognitive functioning and everyday functioning among cognitively healthy adults.

Do Correlated Changes in Neurocognitive Functions and Everyday Functions Persist After Controlling for Key Covariates?

To determine the extent to which changes in neurocognitive functions and everyday functions correlate with one another as the results of their mutual relations to basic participant characteristics, the analyses reported above were repeated with the inclusion of age, gender, years of education, MMSE, and baseline level of performance as covariates. The standardized coefficients from multiple regressions of the levels and changes of the six key outcomes on the covariates are reported in Table 3. It can be seen that age was consistently negatively related to both levels and changes. This indicates that older individuals performed lower, on average, on tests of neurocognitive functions and tests of everyday functions at baseline, and that older individuals declined in their performance on these tests more quickly over the study period. Further, it can be seen that educational attainment and performance on the MMSE were both consistently related to baseline levels of performance on all six outcomes but not related to rates of change in any of the outcomes (cf. Tucker-Drob, Johnson, & Jones, 2009). Being a female was related to higher baseline scores on Observed Tasks of Daily Living, Timed Instrumental Activities of Daily Living, and the Memory Composite, but was unrelated to rates of change in any of the six outcomes. Baseline levels of performance on executive reasoning were predictive of steeper longitudinal declines in executive reasoning, but baseline levels of performance on episodic memory were predictive of slower longitudinal declines in episodic memory. All in all, with age as the sole exception, the covariates were far more consistently related to baseline levels of performance than they were to changes in performance over time.

[2] Cohen (1992) classifies correlations of .10, .30, and .50 as small, medium, and large effect sizes, respectively.

Table 3
Standardized Coefficients From Regressions of Levels and Changes in Neurocognitive Functions and Everyday Functions on Key Covariates

Outcome	Age	Female	Educ.	MMSE	Baseline performance (levels)
Everyday Problems Test level	−.15*	.02	.36*	.45*	
Observed Tasks of Daily Living Level	−.27*	.13*	.33*	.44*	
Timed Instrumental Activities of Daily Living level	−.35*	.19*	.17*	.30*	
Executive Reasoning level	−.25*	.03	.31*	.38*	
Perceptual Speed level	−.47*	.01	.13*	.26*	
Memory level	−.38*	.34*	.22*	.41*	
Everyday Problems Test change	−.29*	.11	−.09	−.23	−.03
Observed Tasks of Daily Living change	−.13	.07	−.21	.12	−.16
Timed Instrumental Activities of Daily Living change	−.38*	.02	.01	.12	−.38*
Executive Reasoning change	−.34*	.12	−.17	.01	.10
Perceptual Speed change	−.30*	−.08	.03	−.05	−.05
Episodic Memory change	−.26*	−.26	−.26	−.23	.47*

Note. Educ, years of education; MMSE, Mini Mental Status Exam.
* $p < .01$.

Correlations among the levels and among the rates of change after controlling for the covariates are reported in Table 4. Of greatest relevance are the correlations among the rates of change, which occupy the bottom portion of Table 4. It can be seen that these correlations are generally moderate-to-large in magnitude. As was the case with respect to the uncontrolled correlations reported in the bottom portion of Table 2, there are two correlations that are not statistically significant but nevertheless positive and moderate in magnitude. These are the correlation between change in performance on the Everyday Problems Test and change in performance on the Timed Instrumental Activities of Daily Living ($r = .24$), and the correlation between change in performance on the Timed Instrumental Activities of Daily Living and change in the Perceptual Speed composite ($r = .31$). All in all, even after controlling for covariates, there was strong evidence for coupled changes in the six measures examined, with 13 of 15 of the correlations among rates of change significantly greater than zero.

Does a Single Process Underlie Changes in Neurocognitive Functions and Everyday Functions?

To distinguish whether changes in neurocognitive functions and changes in everyday functions represent two closely related change processes, or alternatively a single common change process, confirmatory factor models were fit to the rates of changes in the six outcomes. All factor models made use of the covariates described in the previous section. The first, *task content* model, specified a factor representing changes in neurocognition, and a second factor representing changes in every-

Table 4
Correlation Matrices for Levels and Slopes of Everyday Functions and Neurocognitive Functions Controlling for Key Covariates

Outcome	1	2	3	4	5	6
Baseline performance (levels)						
1. Everyday Problems Test	1.0					
2. Observed Tasks of Daily Living	.75*	1.0				
3. Timed Instrumental Activities of Daily Living	.63*	.64*	1.0			
4. Executive Reasoning	.61*	.49*	.42*	1.0		
5. Perceptual Speed	.43*	.44*	.39*	.48*	1.0	
6. Memory	.48*	.44*	.40*	.43*	.35*	1.0
Rates of longitudinal change (slopes)						
1. Everyday Problems Test	1.0					
2. Observed Tasks of Daily Living	.65*	1.0				
3. Timed Instrumental Activities of Daily Living	.24	.53*	1.0			
4. Executive Reasoning	.70*	.60*	.37*	1.0		
5. Perceptual Speed	.65*	.72*	.31	1.0*	1.0	
6. Episodic Memory	1.0*	.94*	.57*	.94*	1.0*	1.0

* $p < .01$.

day functions. The second, *task demands* model, specified a factor representing changes in outcomes requiring accurate performance and a second factor representing changes in speeded outcomes. A single factor model was also fit, with all six slopes allowed to load on it. Results are presented in Table 5. It can be seen that for all models, the loadings of the individual changes on the factors were moderate to high. It can also be seen that the *task content* and the *task demands* models both resulted in factors that were correlated at close to 1. For both models, constraining these correlations to 1 did not result in statistically significant reductions in model fit [$\chi^2(1) = .88$, $p = .35$, for task content model; $\chi^2(1) = .99$, $p = .32$, for task demands model]. This suggests that a single factor was sufficient to capture the interrelations among the six changes. The fit indices for the three models were consistent with this conclusion, as they were all very similar, indicating that a single factor represented the correlational patterns in changes just as well as two factors. Finally, the scree plot from an exploratory factor analysis of the slope correlation matrix also provided limited evidence for the utility of a solution with more than one factor. These findings strongly conflict with propositions that everyday functions are unrelated to cognitive aging. Rather, changes in cognition and changes in capabilities to perform everyday functions appear to reflect very closely related change processes, if not a single underlying change process.

Are Functional Declines Noticeable in Everyday Life?

The above results indicate that everyday functions indeed decline along with neurocognitive decline as adults age. An outstanding question concerns whether these changes are noticed by the aging adults who experience them. To examine this issue, correlations between the levels and the changes of the neurocognitive variables and the performance-based measures of everyday functioning with the level and the change of *Self-Reported Difficulty with Instrumental Activities of Daily Living* were estimated. Note that this variable had a floor effect—many participants (55% at baseline and 31% at 5 year follow-up) reported no difficulty with everyday functions whatsoever. This floor effect is an interesting observation by itself, because it indicates that many older adults subjectively believe their everyday functions to be perfect (i.e., no difficulty with Instrumental Activities of Daily Living whatsoever). For statistical reasons, it was important to disattenuate any relations that may have been masked by the floor effect (Wang, Zhang, McArdle, & Salthouse, 2008). A longitudinal growth model with a censored regression link was therefore used to analyze data from the Self-Reported Difficulty with Instrumental Activities of Daily Living. Note that ignoring this floor effect resulted in even smaller magnitude correlations than those reported here.

Correlations between changes in this self-report and changes in the neurocognitive and everyday tasks analyzed earlier are presented in Table 6. It can be seen that the magnitudes of the correlations between this self report and the objective measures of everyday functions were very low. To illustrate, the median correlation between baseline levels of this self-report and baseline levels of objective measures of everyday functioning was only −.25, whereas the median intercorrelation among baseline levels of objective measures of everyday functioning was .64. Even more importantly, rates of change in this self report did not significantly correlate with rates of change in the objective measures of everyday functioning. In fact, the median correlation between rates of change in this self report and rates of change in objective measures of everyday functioning was −.03, whereas the median intercorrelation among rates of change in objective measures of everyday functioning was .53. From these results, it therefore appears that the effects of cognitive aging on everyday functioning are indeed not very noticeable to aging adults, and that this is because aging adults are poor at both appraising their capabilities to perform routine everyday tasks and at appraising changes in their capabilities to perform such tasks.

Table 5
Alternative Factor Models of the Longitudinal Changes in Everyday Functions and Neurocognitive Functions

	Task content		Task demands		
Outcome	Neurocognition	Everyday	Accuracy	Speed	Single factor
Everyday Problems Test change		.82	.80		.79
Observed Tasks of Daily Living change		.91	.88		.87
Timed Instrumental Activities of Daily Living change		.43		.53	.48
Executive Reasoning change	.82		.83		.83
Perceptual Speed change	.94			1.2	.87
memory change	.96		.92		.95
Correlation between factors	.91		.87		
Fit indices					
χ^2	2072.244		2070.159		2093.500
Degrees of Freedom	687		687		694
Root Mean Square Error of Approximation	.054		.054		.054
Comparative Fit Index	.933		.933		.932
Akaike Information Criterion	90099.970		90097.886		90107.226

Note. All factor loadings are standardized. All factor loadings and correlations are significant at $p < .01$. For all models, age, gender, years of education, Mini Mental Status Exam score, and baseline level of performance are included as covariates.

Table 6
Correlations Between Levels and Changes of Objectively Measured Functions and Self-Reports of Everyday Functions

Outcome	Self-report level	Self-report change
Everyday Problems Test level	−.14	
Observed Tasks of Daily Living level	−.14	
Timed Instrumental Activities of Daily Living level	−.31*	
Executive Reasoning level	−.12	
Perceptual Speed level	−.13	
Memory level	−.19*	
Everyday Problems Test change		.15
Observed Tasks of Daily Living change		−.03
Timed Instrumental Activities of Daily Living change		−.30
Executive Reasoning change		−.02
Perceptual Speed change		.02
Episodic Memory change		.04

Note. Age, gender, years of education, Mini Mental Status Exam score, and baseline level of performance are included as covariates.
* $p < .01$.

Discussion

This study examined longitudinal changes in neurocognitive functions and the capabilities to perform tasks that are typically encountered in older adults' daily lives. Results indicated that individual differences in changes in psychometric measures of cognition were moderately to highly correlated with individual differences in changes in ecologically valid measures of everyday functions. A factor model positing only one common dimension of change fit just as well as a factor model with two common change dimensions, one representing everyday change and one representing cognitive change. These findings suggest that neurocognitive functions and everyday functions not only change in tandem, they may actually be manifestations of a common underlying process.

This study further found that self reports of everyday functioning were unrelated to changes in performance on the measures of everyday functioning. This is concerning for both neuropsychological researchers and clinicians who rely on self-reports of everyday functioning when making evaluations, assessments, and diagnoses. The current results indicate that older adults are not accurate judges of their own levels of functioning, and that self-reported levels of functioning may not be trustworthy. Why might older adults be miscalibrated in this way? In social psychological research with younger adults, it is now well-established that individuals tend to overestimate their competences in many different life areas (Dunning, Heath, & Suls, 2004), and it is the least competent individuals who tend to have the most inflated self-evaluations (Kruger & Dunning, 1999). Kruger and Dunning (1999) have suggested that the effect stems largely from a lack of metacognitive skills among low functioning individuals to recognize that they are indeed low functioning. It is possible that this same mechanism underlies the inaccurate reports by older adults documented in the current article. A complementary possibility was suggested by Rabbitt and Abson (1990), based on their work with older adults. They wrote (p. 15) that older adults' self reports of functioning "may, to a surprising extent, reflect their acquiescence to a social consensus rather than their assessment of cognitive processes which they cannot inspect."

Outstanding Issues and Future Directions

Accommodation. For the current project, everyday functions were defined in terms of efficiency and accuracy of completing tasks that older adults are either very likely to encounter in their day to day lives or should reasonably be expected to perform to live independently. This is the same general approach that has been applied in previous research on everyday functions (e.g., Allaire & Marsiske, 1999). One outstanding issue concerns whether older adults *accommodate* for their neurocognitive declines, either by altogether avoiding the functions that they are no longer able to carry out or by making use of the assistance of other individuals or devices. This possibility has been referred to as "selective optimization with compensation," by Baltes and Baltes (1990). To evaluate this possibility, it will be necessary for future research to rely on systematic observation of older adults in their home environments.

Carrying out activities versus initiating activities. A related issue concerns whether changes in neurocognitive functions relate to the abilities to initiate important activities in everyday life. The current study only measured the ability to carry out activities that older adults should reasonably be expected to perform in order to live independently. It is possible that an adult who is capable of carrying out a specific activity may still fail to initiate that activity at the ideal time or in necessary situations, for instance, because of failures of prospective memory. An important direction for future research will be to measure *initiation* of everyday activities by older adults. Systematic observations of adults in their home environments may prove necessary in this regard.

The global causes of declines in neurocognitive functions and everyday functions. An additional area for future research will be to identify the global mechanisms that underlie aging-related functional declines. While conventional approaches to cognitive aging have focused on attempting to explain deficits in a single specific domain of functioning (e.g., memory), a number of researchers (e.g., Salthouse & Ferrer-Caja, 2003; Tucker-Drob, in press) have commented that the ultimate explanation for cognitive aging will need to take into account global mechanisms in addition to domain-specific ones. The current results are consistent with these perspectives. They suggest that whatever the causal factors of neurocognitive aging turn out to be, they are to a large extent common across multiple domains of neurocognitive functioning and everyday functioning. Factors that have been previously mentioned in the literature as potentially underlying general aging-related cognitive deficits include reduced dopamingeric functioning (Bäckman, Lindenberger, Li, & Nyberg, 2010), brain matter atrophy (Dennis & Cabeza, 2008; Raz et al., 2005), demyelination (Kovari et al., 2004), pleitropic genetic risk factors (Deater-Deckard & Mayr, 2005), and accumulation of environmental insults (McDonald, 2002), to name a few.

Conclusions

In conclusion, the paradox that older adults experience declines in neurocognitive functions but are just as able to perform everyday tasks as they ever were appears to be a fictitious one. The current results indicate that the reason that normative neurocognitive declines are not more noticeable in everyday life is that people are rather poor judges of their own levels of functioning. It was demonstrated that individual differences in the magnitudes of changes in neurocognitive functions correspond very closely with individual differences in the magnitudes of changes in capabilities to perform typically encountered everyday activities, but not to changes in self reports of everyday functioning. Results of factor analyses suggested that changes in cognition and changes in objectively measured everyday functions were so highly correlated that they could be specified to a fall along a common dimension of individual differences.

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