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Shared and Unique Influences on Age-Related Cognitive Change

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Objective: Decompose cognitive change into influences unique to particular cognitive domains, and influences shared across different cognitive domains. ***Method:*** A total of 2,546 adults between 18 and 95 years of age performed a battery of 12 cognitive tests on 2 occasions separated by an average of 3 years. An estimate of general cognitive functioning based on the first principal factor was regressed from the observed cognitive scores to derive an estimate of specific influences on each measure, and this value was subtracted from the observed score to provide an estimate of general influences on the measure. Longitudinal change was assessed by the (T2 − T1) difference between scores on the 2 occasions. ***Results:*** Although increased age was associated with specific influences on speed in cross-sectional comparisons, and in memory change in longitudinal comparisons among older adults, most of the relations between age and cognitive functioning in both cross-sectional and longitudinal comparisons were manifested as general influences shared with other cognitive measures. ***Conclusions:*** Differences in cognitive functioning associated with aging are often attributed to domain-specific effects, but results from this and other recent studies suggest that large proportions of the age differences are associated with general influences shared across different types of cognitive measures.

Keywords: cognitive aging, memory decline, longitudinal change

Because a wide variety of cognitive measures have been found to be related to adult age, an important theoretical question is whether these effects are attributable to many specific influences, a few general influences, or a combination of specific and general influences. The question can be confusing because the terms general and specific have somewhat different meanings among researchers working at different levels of analysis. For example, when the primary focus is on a particular task, specific relations are often inferred to exist when the age-related effects are larger in measures of some hypothesized components than in others. In contrast, when the focus is on different types of cognitive measures, specific relations are inferred when the age-related effects on measures from certain tests are statistically independent of the effects on measures from other tests. Both levels of analysis can be informative, but the goal in the current study was to distinguish shared and unique influences on age-related cognitive change, and thus the focus was on the latter, macro, rather than the former, micro, perspective (cf. Salthouse, 2000).

Most of the research investigating general (or shared) and specific (or unique) age-related influences has relied on cross-sectional data. For example, one method used to investigate general influences on age-cognition relations has been based on structural models of the organization of cognitive measures, with the models differing in how general influences are represented. Some models have postulated a single common factor (e.g., Lindenberger & Baltes, 1994; Lindenberger, Mayr, & Kliegl, 1993; McArdle & Prescott, 1992; Salthouse, 1993, 1998, 2001a; Schroeder & Salthouse, 2004; Verhaeghen & Salthouse, 1997), others have specified a hierarchical structure in which successive levels in the hierarchy correspond to progressively more shared or general variance (e.g., Salthouse, 1998, 2001a, 2004, 2009; Salthouse & Davis, 2006; Salthouse & Ferrer-Caja, 2003), and still others have involved a bifactor structure in which a general factor is specified to be orthogonal to factors representing cognitive abilities (e.g., Hildebrandt, Wilhelm, Schmiedek, Herzmann, & Sommer, 2011; Salthouse & Ferrer-Caja, 2003; Schmiedek & Li, 2004). With each type of model, strong relations of age have been found on the portion of the structure representing general influences, which implies that at least some of the age-related differences on individual target measures are shared with other measures.

Another method that has been used to investigate general and specific age-related influences involves examining age-related effects on target cognitive measures before and after controlling an estimate of general influences derived from other cognitive measures. Substantial reductions of the cross-sectional age relations after controlling the variability in other measures have been found across a wide range of cognitive measures (e.g., see Table 3 in Salthouse, 2001b), including measures from the Wechsler Adult Intelligence Scale IV and the Wechsler Memory Scale IV batteries (Salthouse, 2009). In the case of the Wechsler measures, the median age correlation was −.44 when the measures were considered alone, but only .02 after controlling an estimate of general cognitive functioning. Parallel analyses on data from the Virginia Cognitive Aging Project also revealed a median age correlation of −.44 when the measures were considered alone, but a median correlation of only .03 after controlling an estimate of general influences.

Results from these and other analytical procedures imply that large proportions of the cross-sectional age-related differences on

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cognitive measures are general, in the sense that they are shared with other measures, and are not unique to particular cognitive measures. The purpose of the current project was to employ a variant of the statistical control method to distinguish general and specific influences in longitudinal changes in cognitive functioning in healthy adults across a wide age range.

The logic of the current approach is portrayed in Figure 1. The primary assumption is that scores on cognitive tests are determined both by general influences shared with other cognitive measures, and by influences specific to individual measures. Because the first principal factor (PF1) in a principal axis factor analysis represents variance shared across different cognitive measures, the PF1 based on a variety of measures, excluding those representing the target cognitive ability, was used to obtain an estimate of general influences for each ability domain. For example, measures of speed, reasoning, and spatial visualization, but not memory, were used to derive a measure of general cognitive functioning for the analyses of memory measures. Specific influences were estimated by regressing the PF1 from the observed measure to create a residual that represents unique aspects of that measure, independent of what is shared with other measures. An estimate of general influences on the measure was then derived by subtracting the specific estimate from the observed score. The same procedure was followed on each of two occasions to allow specific and general estimates to be derived for longitudinal comparisons. The primary interest in the study was on change in cognitive functioning, as represented by the difference between measures on the first (T1) and second (T2) occasions, but cross-sectional age relations on the first occasion (T1) scores were also examined.

Nonlinear relations between age and measures of cognitive functioning have frequently been reported (e.g., Borella, Meneghetti, Ronconi, & De Beni, 2014; Salthouse, 1998, 2004; Salthouse & Davis, 2006; Swagerman et al., 2016; Verhaeghen & Salthouse, 1997), but reasons for the nonlinear trends are not yet understood. An advantage of partitioning the observed score into several components, such as estimates of general and specific influences, is that the nonlinear trends can be examined on each component to determine whether the patterns in the observed scores are attributable to effects on one component, or to a mixture of different trends in the two components. Both linear and quadratic age relations were therefore investigated on the observed measures, and on the specific and general estimates, in the T1 scores and in the T2 − T1 differences.

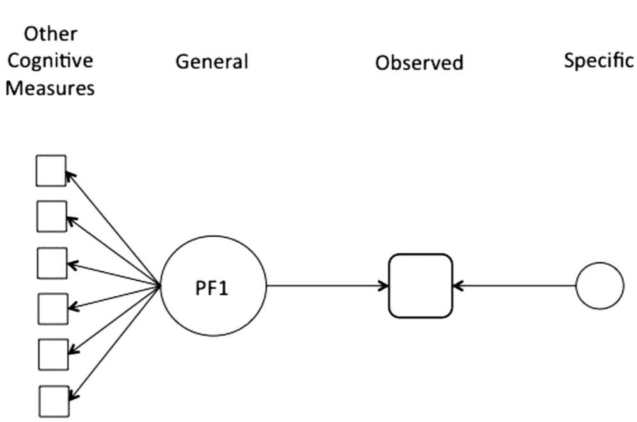

Figure 1. Illustration of hypothesized composition of general (left) and specific (right) influences on observed scores.

The data for the current project were based on the Virginia Cognitive Aging Project (VCAP), an ongoing longitudinal study in which participants perform 12 tests designed to represent four distinct cognitive abilities (i.e., memory, speed, reasoning, and spatial visualization) related to the efficiency or effectiveness of processing at time of assessment (Salthouse, 2014a). Measures of vocabulary knowledge were also obtained, but they were excluded from the current analyses because they have different age trends, and can be considered to represent an achievement rather than an ability.

A unique feature of VCAP is that on each longitudinal occasion participants reported to the laboratory for three sessions separated by about one week. About half of the participants performed alternate versions of the tests on the second and third sessions of the first occasion, with the remaining participants performing different tests on those sessions (e.g., Salthouse, 2013). All participants performed alternate versions of the tests on the three sessions of the second occasion. The primary analyses were based on the most extensive Session 1 data, but data from Sessions 2 and 3 were also analyzed to serve as a within-subjects replication involving different versions of the tests. That is, because the data from Sessions 2 and 3 were used to conduct separate principal factor analyses and derive general and specific estimates, the results are valuable in indicating whether the findings would be similar when the participants repeated the procedures with different versions of the tests.

Based on the research cited above, negative linear and quadratic relations of age were expected on the cross-sectional means, with larger age-related effects on estimates of general than specific influences. Because negative relations between cognitive change and age have been reported in a number of studies (e.g., Bielak, Anstey, Christensen, & Windsor, 2012; Caselli et al., 2009; Ferrer, Salthouse, Stewart, & Schwartz, 2004; Finkel, Pedersen, Plomin, & McClearn, 1998; Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003; McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Ronnlund & Nilsson, 2006; Ronnlund, Nyberg, Bäckman, & Nilsson, 2005; Schaie, 2005; Schaie & Hertzog, 1983; Singh-Manoux et al., 2012; van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2008; van Dijk, Van Gerven, Van Boxtel, Van der Elst, & Jolles, 2008; Zelinski & Burnight, 1997), those results were also expected to be replicated. A recent study (Salthouse, 2016) involving different analytical procedures (i.e., latent growth curve models of change across three longitudinal occasions) with a subset of the participants involved in the current study found very small age relations on estimates of specific influences on cognitive change, and thus those results were expected to be replicated and extended in the two-occasion difference score analyses in the current study. However, because there has apparently been no prior research on components of nonlinear trends, there were no specific hypotheses about the composition of quadratic age trends in terms of general and specific influences.

Method

Participants

VCAP participants were recruited by advertisements and referrals from other participants. Characteristics of the participants with data on at least two occasions are summarized in Table 1. As noted in earlier reports (e.g., Salthouse, 2014b), older participants who

Table 1
Demographic Characteristics of Participants in the Sample

Variable	20s	30s	40s	50s	60s	70s	80s	Age *r*
Number								
Session 1	276	223	436	660	512	324	115	NA
Sessions 2 & 3	140	89	192	354	283	170	67	NA
Age								
Session 1	22.8 (3.4)	34.7 (2.9)	45.1 (2.9)	54.4 (2.8)	64.2 (2.8)	74.1 (2.8)	83.6 (3.5)	NA
Sessions 2 & 3	23.1 (3.4)	34.8 (3.0)	45.0 (2.9)	54.7 (2.8)	64.1 (2.8)	74.2 (2.9)	83.4 (3.3)	NA
Prop. female								
Session 1	.61	.74	.71	.72	.65	.59	.47	−.06*
Sessions 2 & 3	.59	.70	.73	.72	.64	.61	.43	−.05
Health								
Session 1	2.0 (.9)	2.2 (.8)	2.1 (.9)	2.2 (.9)	2.1 (.9)	2.3 (.9)	2.5 (.9)	.10*
Sessions 2 & 3	2.1 (.9)	2.4 (.8)	2.2 (.8)	2.2 (.9)	2.2 (.9)	2.4 (.9)	2.6 (.8)	.09*
Education								
Session 1	14.2 (2.0)	15.6 (2.5)	15.4 (2.6)	15.9 (2.6)	16.5 (2.6)	16.0 (2.8)	16.2 (3.3)	.20*
Sessions 2 & 3	14.4 (2.0)	15.7 (2.6)	15.7 (2.6)	15.8 (2.6)	16.4 (2.7)	16.1 (2.8)	16.1 (3.0)	.17*
Estimated IQ								
Session 1	107.9 (12.6)	107.5 (15.6)	110.3 (14.7)	111.6 (14.6)	113.4 (12.9)	110.5 (13.5)	106.8 (13.2)	.06*
Sessions 2 & 3	108.2 (11.9)	108.6 (14.8)	110.2 (14.2)	111.2 (14.5)	112.3 (12.2)	112.3 (12.2)	107.4 (13.8)	.06
T1 MMSE								
Session 1	28.6 (1.7)	28.3 (1.8)	28.5 (1.8)	28.5 (1.3)	28.7 (1.6)	28.3 (1.7)	27.6 (2.0)	−.06
Sessions 2 & 3	28.6 (1.8)	28.3 (1.8)	28.7 (1.7)	28.4 (1.8)	28.6 (1.7)	28.3 (1.6)	27.5 (2.1)	−.08*
T1–T2 interval								
Session 1	3.1 (2.0)	3.1 (2.0)	3.3 (1.9)	3.0 (1.6)	2.8 (1.5)	2.7 (1.3)	2.5 (1.1)	−.10*
Sessions 2 & 3	2.8 (1.5)	2.8 (1.4)	2.8 (1.3)	2.9 (1.4)	2.7 (1.3)	2.6 (.9)	2.5 (.8)	−.06

Note. Participants with data on Sessions 2 and 3 were a subset of those with data on Session 1.
* $p < .01$.

returned for a second occasion had higher initial levels of performance than participants who did not return. There were 2,546 participants with data on Session 1, and of these, 1,296 also completed parallel versions of the tests on the second and third sessions on both occasions.

Self-rated health was on a scale from 1 = *excellent* to 5 = *poor*, estimated IQ was based on a regression equation relating age-adjusted scores on VCAP tests to WAIS IV full-scale IQ (see Salthouse, 2014c), and the MMSE (Folstein, Folstein, & McHugh, 1975) is a test used as an initial screen for dementia. Inspection of the entries in Table 1 reveals that, compared with young participants, older participants in the sample had slightly lower self-rated health, and shorter intervals between occasions, but more years of education. Furthermore, the subset of participants with data on Sessions 2 and 3 were very similar to the total sample in each characteristic.

Measures

Cognitive functioning was assessed with 12 cognitive tests previously established to be reliable, and valid as reflected in loadings on relevant abilities in factor analyses (e.g., Salthouse, 2014a; Salthouse, Pink, & Tucker-Drob, 2008). Memory was assessed with the word recall test (i.e., Wechsler, 1997b), based on the number of words recalled across Trials 1 to 4 of the same 12-word list, with the paired associates test (i.e., Salthouse, Fristoe, & Rhee, 1996) based on the number of response terms recalled when presented with the relevant stimulus term across six word pairs, and with the logical memory test (i.e., Wechsler, 1997b), based on the number of idea units recalled across one presentation of one story and two presentations of another story. Speed was assessed with the Digit Symbol test (i.e., Wechsler, 1997a), which consisted of using a code table to write symbols below digits, with the Pattern Comparison test (i.e., Salthouse & Babcock, 1991) which consisted of classifying pairs of line patterns as same or different, and with the Letter Comparison test (i.e., Salthouse & Babcock, 1991) which consisted of classifying pairs of sets of letters as same or different. In each of the speed tests performance was measured in terms of the number of correct responses produced within a specified time. Reasoning was assessed with the Matrix Reasoning test (i.e., Raven, 1962), involving the determination of which pattern best completes the missing cell in a matrix, the Shipley Abstraction test (i.e., Zachary, 1986) in which the examinee determines the words or numbers that best complete a sequence, and the Letter Sets test (i.e., Ekstrom, French, Harman, & Dermen, 1976) in which the task was to identify which of five groups of letters is different from the others. Spatial Visualization (Space) was assessed with the Spatial Relations test (i.e., Bennett, Seashore, & Wesman, 1997) in which the examinee determines the correspondence between a two-dimensional (2D) figure and alternative three-dimensional (3D) figures, the Paper Folding test (i.e., Ekstrom et al., 1976) in which the examinee determines the pattern of holes that would result from a sequence of folds and a punch through the folded paper, and the Form Boards test (i.e., Ekstrom et al., 1976) in which the examinee determines which combinations of shapes are needed to fill a larger shape.

Analysis Plan

The measures from each test were converted to *z*-scores based on the means and standard deviations of the scores on the first session of the first occasion. Because composite scores have greater generalizability and reliability than individual measures, most of the analyses were based on composite scores created by averaging the *z*-scores of three measures representing each ability domain.

A first principal factor (PF1) was created for each ability at each occasion based on the nine measures representing the other three cognitive abilities. The PF1 was regressed from the composite score for the target ability to derive a residual representing domain-specific influences, and this specific estimate was then subtracted from the observed composite score to obtain an estimate of general influences on the ability.

Cross-sectional data were based on the mean composite scores at the first (T1) occasion, and longitudinal change was assessed with the difference (T2 − T1) between the relevant values on the first (T1) and second (T2) occasions. Linear age relations were examined with the mean-centered age at the first occasion, and quadratic age relations were investigated with the square of the mean-centered age when both linear and quadratic age terms were considered in the same regression analyses.

Because the sample size was relatively large, a .01 significance level was used in all statistical comparisons.

Results

Means (and standard errors) for the composite scores on the first and second occasions are portrayed in Figure 2 as a function of age decade. The longitudinal data are represented by the solid lines connecting scores on the two occasions, and although not explicitly portrayed in the figure, cross-sectional relations correspond to the first occasion scores across successive decades.

The first occasion scores in each ability domain were lower with increased age, indicating negative cross-sectional age trends. For adults younger than about 50 or 60 years of age, the scores on the second occasion were higher than those on the first occasion, corresponding to positive longitudinal change. However, adults at older ages had lower second occasion scores than first occasion scores, indicating negative longitudinal change.

Table 2 contains standardized coefficients for the linear and quadratic (age^2) relations of age on the T1 values (cross-sectional) and on the T2 − T1 differences (longitudinal) for the observed measures, and for the estimates of specific and general influences. Inspection of the entries indicates that the linear age relations in the cross-sectional data were significant on all observed scores, and that the quadratic age relations were significant in every ability domain except space. Separate analyses in participants under and over the median age revealed that the quadratic trends were attributable to more negative age relations at older ages. Both linear and quadratic cross-sectional age relations were significant on the general estimates in all ability domains, but only with speed were there also large negative age relations on the specific estimates.

The linear relations with age on the observed T2 − T1 difference scores were significant in each ability domain, but the quadratic age relation on change was significant only with memory. The pronounced negative slopes in adults in the 70's and 80's in the top left panel in Figure 2 indicate that this nonlinear trend

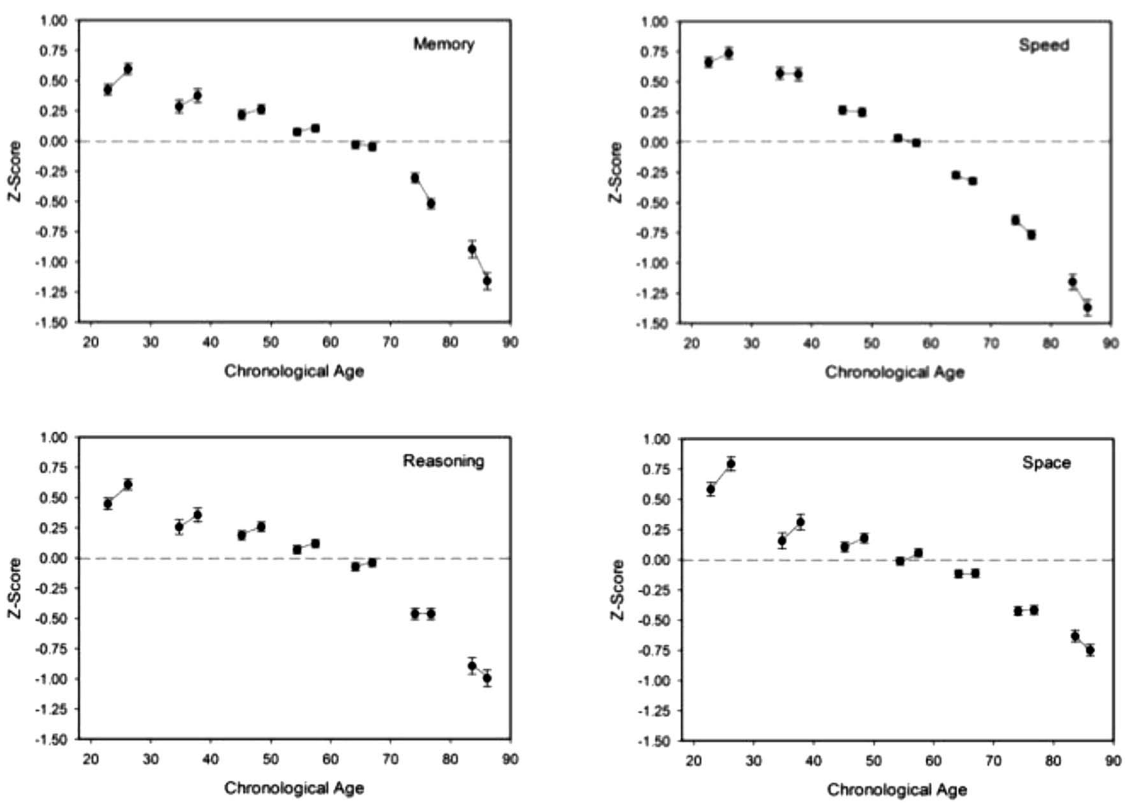

Figure 2. Means (and standard errors) of scores at the first (T1) and second (T2) occasions in T1 z-score units.

Table 2
Standardized Regression Coefficients Relating Cross-Sectional Means (T1) and Longitudinal Change (T2 − T1 Difference) to Linear (Age) and Quadratic (Age²) Age Terms in Observed Measures and Specific and General Estimates of Cognitive Functioning

	Observed		Specific		General	
Age Decade	Age	Age²	Age	Age²	Age	Age²
T1 means						
Memory						
Session 1	−.365*	−.131*	−.021	−.042	−.508*	−.079*
Session 2	−.413*	−.087*	−.084*	−.020	−.548*	−.097*
Session 3	−.405*	−.106*	−.042	−.030	−.557*	−.110*
Speed						
Session 1	−.592*	−.137*	−.422*	−.100*	−.417*	−.065*
Session 2	−.604*	−.110*	−.432*	−.086*	−.434*	−.063*
Session 3	−.626*	−.115*	−.446*	−.070*	−.458*	−.100*
Reasoning						
Session 1	−.392*	−.134*	.066*	−.078*	−.546*	−.089*
Session 2	−.387*	−.118*	.120*	−.059	−.600*	−.092*
Session 3	−.422*	−.124*	.048	−.059	−.578*	−.113*
Space						
Session 1	−.355*	−.017	.030	.156*	−.533*	−.129*
Session 2	−.397*	−.010	−.048	.080*	−.557*	−.121*
Session 3	−.341*	−.039	.029	.056	−.572*	−.126*
T2 − T1 differences						
Memory						
Session 1	−.218*	−.058*	−.118*	−.071*	−.281*	−.012
Session 2	−.235*	−.087*	−.134*	−.098*	−.188*	.009
Session 3	−.250*	−.090*	−.130*	−.104*	−.286*	.006
Speed						
Session 1	−.131*	−.013	−.060	−.011	−.218*	−.024
Session 2	−.130*	.000	.026	.006	−.288*	−.030
Session 3	−.125*	.015	.044	.040	−.316*	−.056
Reasoning						
Session 1	−.123*	−.012	.059	.044	−.249*	−.042
Session 2	−.127*	−.008	−.033	−.006	−.182*	−.020
Session 3	−.096*	.006	.052	.079	−.266*	−.070
Space						
Session 1	−.165*	.007	−.018	−.008	−.274*	−.030
Session 2	−.127*	−.008	.027	.092*	−.371*	−.098*
Session 3	−.096*	.006	−.007	−.005	−.345*	−.041

* $p < .01$.

corresponded to an acceleration of negative memory change in the oldest participants.

Linear age relations were significant on the general estimates of T2 − T1 change in each ability. However, only with memory were the linear and quadratic age relations significant on the specific estimates of change.

Means (and standard errors) of the specific and general estimates in each ability domain at T1 and T2 are portrayed in Figure 3. Consistent with the results in the second and third columns in Table 2, sizable negative age relations were apparent on the general estimates in the cross-sectional (T1) and longitudinal (i.e., slope from T1 to T2) data. However, with the exception of speed in the cross-sectional data and memory change in the longitudinal data, there was little relation of age on the specific estimates.

The remaining entries in Table 2 are based on the data from the subset of the total sample (cf. Table 1) who performed alternative versions of the tests on Sessions 2 and 3. It can be seen that the pattern of linear and quadratic age relations on specific and general estimates in these analyses was comparable with that based on the Session 1 data. Although these results are derived from a subset of the participants who also contributed to the Session 1 results, and thus are not independent, the similar pattern of results is nevertheless noteworthy because the tests involved different items and were administered on different sessions.

Longitudinal change was also examined with two-occasion latent change models (i.e., Ferrer & McArdle, 2010), in which the measures from the three tests representing each ability served as indicators of latent variables corresponding to the level (defined by measures at both occasions), and change (defined by measures only at the second occasion). The pattern of results with the latent change models was very similar to that with the difference scores, with significant quadratic age relations only on the specific estimates with memory.

Discussion

The patterns with the observed scores in Figure 2, and the results in the first column of Table 2, indicate that in all four ability domains increased age was associated with more negative T1 (cross-sectional) means, and more negative T2 − T1 (longitudinal) differences. The longitudinal change was positive rather than negative for adults under about 60 years of age, likely because of greater beneficial effects of prior test experience at younger ages (e.g., Salthouse, 2013, 2014b).

A substantial quadratic age trend was apparent in the cross-sectional data for the memory, speed, and reasoning composite scores, corresponding to more negative age relations at older ages. However, with the exception of memory, in which there was significant acceleration of decline at older ages, the age relations on the observed longitudinal difference scores were primarily linear.

Because the oldest age group differed from the other age groups in a number of respects (e.g., proportion of females, amount of education, and interval between occasions), it is possible that the nonlinear age trends were attributable to a somewhat unusual sample of adults over 80 years of age. In order to investigate this possibility, the analyses were repeated after excluding participants 80 years of age and older. The pattern of age relations in this restricted sample was very similar to that in the total sample, which implies that the quadratic age trends were not due to the inclusion of atypical adults over 80.

The analyses of general and specific estimates were based on the assumption that observed scores reflect a mixture of general (shared) and specific (unique) influences, and that an estimate of specific influences can be obtained by partialing the first principal factor based on other cognitive measures from the observed score. This estimate of specific influences was then subtracted from the observed score to derive an estimate of general influences.

The results in Table 2 and Figure 3 indicate that the cross-sectional age relations in each ability domain were primarily on the general estimates. However, there were also significant age relations on the specific estimates for speed, which may reflect sensitivity of age to factors specifically affecting measures of speed, such as integrity of white matter tracts responsible for efficient communication across brain regions associated with different functions (e.g., Kerchner et al., 2012; Lu et al., 2011; Nilsson, Thomas, O'Brien, & Gallagher, 2014; Penke et al., 2010). The

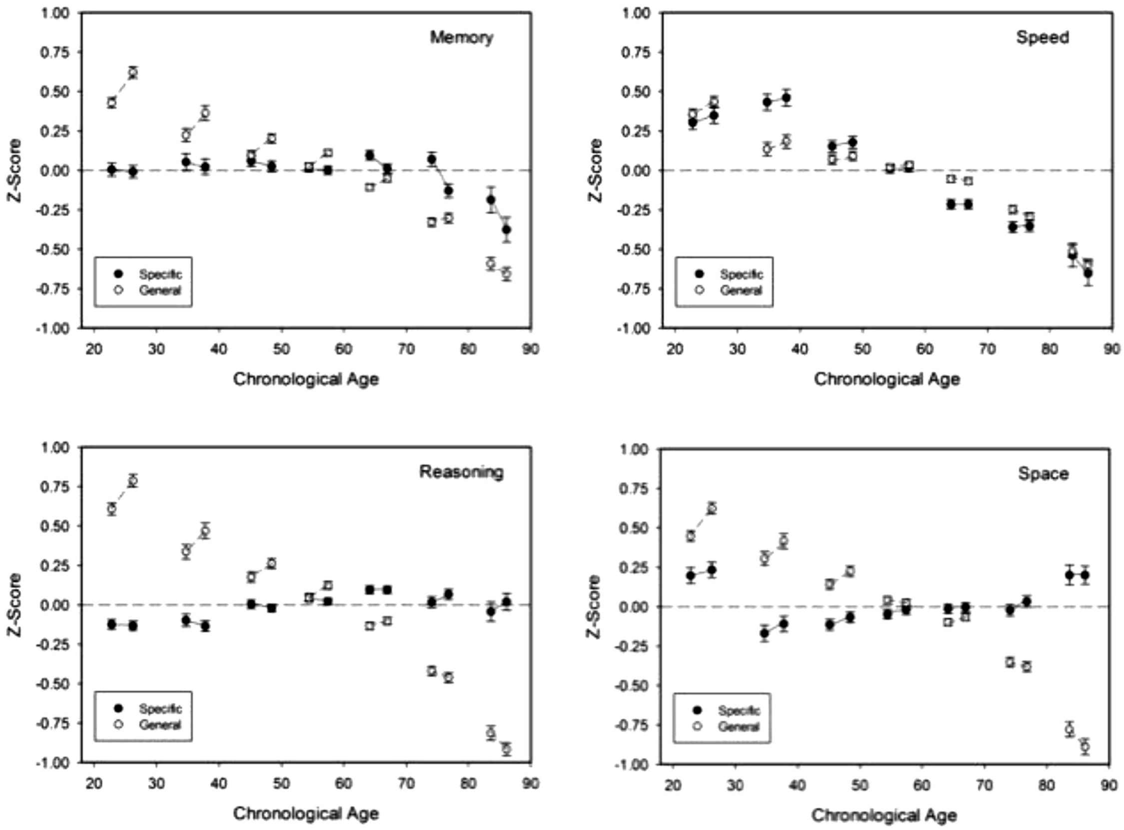

Figure 3. Means (and standard errors) of estimates of specific and general influences on the first (T1) and second (T2) occasions in T1 z-score units.

existence of both shared and unique age-related influences may help explain why speed measures are particularly sensitive to age (e.g., Salthouse, 1996).

Although smaller in magnitude than in the observed scores, the quadratic age trends were significant in the general estimates in each ability. These results suggest that the more negative age relations at older ages in the cross-sectional data are at least partially attributable to general influences.

The results in Figure 3, and the entries in the second and third columns of the bottom panel of Table 2, indicate that the age relations on longitudinal change were primarily on the estimates of general influences. A notable exception to this pattern is memory in which there were significant quadratic age relations both on the observed change, and on the estimates of specific influences. These results, together with those in the top left panel in Figure 3, suggest that the composition of memory change varied with age. That is, at younger ages memory change was primarily associated with general influences, but specific influences on memory were also evident in adults in their 70's and 80's. The late-life specific changes in memory may reflect the beginnings of dementia-related pathology in which memory loss is one of the initial symptoms (e.g., Bäckman, Small, & Fratiglioni, 2001; Bilgel et al., 2014; Blacker et al., 2007).

Results from the current project extend earlier findings regarding general (shared) and specific (unique) influences on age-cognition relations to measures of longitudinal change in addition to the previously documented cross-sectional differences. Moreover, the findings that a similar pattern was apparent in separate analyses of data in Sessions 2 and 3, and with analyses of latent change, suggest that the results are robust.

Converging evidence is now available from several different analytical procedures that large proportions of both cross-sectional and longitudinal relations of age on cognitive measures are shared, and are not unique to particular measures. In addition to the cross-sectional studies discussed in the introduction, numerous longitudinal studies have reported significant correlations among changes in different cognitive measures (see review in Tucker-Drob et al., 2014), which has led to conclusions that large proportions of the age-related changes in cognitive measures are shared, and are not unique to particular domains.

In light of the results of this and other recent studies, three categories of explanation can be postulated to be needed to account for age-related influences in cognition in healthy adults. One set of explanations should specify what is responsible for the negative relation between age and the general or shared influences that affect many different types of cognitive measures in both between-person and within-person comparisons. The findings reported here, together with those from other studies, suggest that general influences are associated with a substantial proportion of the age-related differences and changes across a broad range of cognitive measures. A second category of explanation should indicate what is responsible for specific or unique deficits that are statistically independent of general influences. In the current study, specific influences were evident in measures of speed in the cross-sectional comparisons, and in measures of memory change at older ages in the longitudinal comparisons. Finally, explanations are also needed to account for how age-related influences are manifested in particular cognitive tasks.

Many contemporary researchers have focused exclusively on the third category of explanation, but in so doing they may be neglecting age-related influences that are both larger in magnitude, and broader in impact. To illustrate, Healey and Kahana (2016) recently proposed an elegant model describing differential age sensitivity across four hypothesized components in a free-recall task similar to that used as one of the indicators of memory ability in the current study. Large age differences were apparent in the free recall measure in the current study, as a regression analysis revealed that age was associated with 12.8% of the variance in the free recall score. However, large age differences were also evident in the other cognitive measures, and after controlling the variance in these measures, age was associated with only 1% of the variance in the free recall measure. Results such as these indicate that explanations of the differential magnitude of measures within a particular task need to be supplemented with explanations of age-related influences that are shared across cognitive measures from different types of cognitive tasks.

Although the focus in the current study was on healthy aging, a potentially productive application of distinguishing shared and unique influences is with clinical samples. For example, in some clinical conditions the differences in particular cognitive measures might be primarily attributable to general influences shared across different types of cognitive measures, as was the case with the cross-sectional age comparisons of the memory, reasoning, and space measures in this study. However, in other clinical conditions the differences might involve a combination of general and specific influences, as was the case in the memory change among older adults in this study. Accurate description of the nature of the differences is an important first step in explaining why those differences occur.

Several limitations of the current study can be identified. First, the assumption of additive general and specific influences on measures of cognitive functioning is crude, and may not be correct. Second, the estimates of general influences were based on a limited set of cognitive measures, and the estimates could be different with a broader selection of measures. Third, the average longitudinal interval was less than three years, and influences on change might shift with longer intervals. Fourth, as with most longitudinal studies there was a certain amount of missing data. Although this could affect generalizability, it is not likely to affect the estimates of general and specific influences. And fifth, the sample consisted of healthy high-functioning adults, and it is possible that the composition of change differs in individuals with MCI or dementia.

Despite these limitations, the results of this study provide strong support for three conclusions. First, shared or general influences exert a large contribution on longitudinal changes in cognitive functioning, and not just on cross-sectional differences. Second, the cross-sectional age-cognition relations were more negative at older ages, and these nonlinear relations were primarily attributable to general or shared influences. And third, most of the relations of age on longitudinal change were linear, with the exception of memory in which nonlinear trends were associated with the emergence of specific influences on change at older ages.

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Correction to John et al. (2016)

In the article "The Effectiveness and Unique Contribution of Neuropsychological Tests and the δ Latent Phenotype in the Differential Diagnosis of Dementia in the Uniform Data Set," by Samantha E. John, Ashita S. Gurnani, Cara Bussell, Jessica L. Saurman, Jason W. Griffin, and Brandon E. Gavett (*Neuropsychology*, 2016, Vol. 30, No. 8, pp. 946–960. http://dx.doi.org/10.1037/neu0000315), the first sentence in the note to Table 6 should read "Odds ratios (*OR*) greater than 1 mean that better scores on a test are associated with greater odds of the first diagnosis shown in the Comparison column, whereas *OR* less than 1 mean that better scores on a test are associated with lower odds of the first diagnosis shown in that column." Also, the first sentence in the note to Table 7 should read "Odds ratios (*OR*) greater than 1 mean that higher δ scores (less severe dementia) are associated with greater odds of the first diagnosis shown in the Comparison column, whereas *OR* less than 1 mean that higher δ scores (less severe dementia) are associated with lower odds of the first diagnosis shown in that column."

http://dx.doi.org/10.1037/neu0000339