

How General Are the Effects of Trait Anxiety and Depressive Symptoms on Cognitive Functioning?

Timothy A. Salthouse
University of Virginia

A total of 3,781 healthy adults between 18 and 97 years of age completed trait anxiety and depressive symptoms inventories and also performed a battery of cognitive tests. Consistent with recent research on cognitive abilities, the cognitive variables could be organized into a hierarchical structure, with 5 first-order abilities and a single *g*-factor representing the variance common to the first-order abilities at the top of the hierarchy. Analyses were conducted to determine where in this hierarchy effects associated with trait anxiety and depressive symptoms were operating. The results indicated that trait anxiety and depressive symptoms had significant relations at the highest level in the hierarchy of cognitive abilities, but few relations of either characteristic were evident on the cognitive abilities, or on measures of working memory, after controlling influences at the *g*-factor level.

Keywords: cognitive abilities, mood effects, level of influence, hierarchical structure of cognitive ability

An extensive literature exists concerning the relations of anxiety and depression on cognitive functioning in both clinical and non-clinical samples (for recent reviews see Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari & Lonnqvist, 2008; Eysenck, Derakshan, Santos, & Calvo, 2007; Gotlib & Joormann, 2010). In some cases, the relations have been interpreted as evidence that individuals high in trait anxiety or with more depressive symptoms have a specific cognitive deficit, such as an impairment in goal-directed attention (Eysenck et al., 2007), in the recruitment of prefrontal attentional control (Bishop, 2009), or in the efficiency of inhibitory activity (Beaudreau & O'Hara, 2009). Although these particular interpretations may be valid, when only a single cognitive variable is examined, it is impossible to determine whether the influences are specific to that variable, or are more general and shared with other variables. In other words, a limitation of a univariate focus is that it ignores interrelations that exist among cognitive variables, and thus it can be misleading about the precise nature of the influence of the target variable on cognitive functioning.

There is now a broad consensus on a hierarchical structure of cognitive variables (e.g., Carroll, 1993; Gottfredson, 1998; Gustafsson, 1988; Jensen, 1998) with observed variables at the lowest level, various cognitive abilities at the next level, and progressively more abstract factors at successively higher levels. There is still dispute about the number of levels and the number and identities of factors at each level, but it is widely accepted that cognitive variables are positively correlated with one another, and

thus can be organized into a structure based on the strengths of their correlations with one another.

If a hierarchical structure is assumed to be a reasonable representation of the organization of cognitive variables, it can be used to investigate the level at which factors such as trait anxiety and depressive symptoms operate in the hierarchy. The level of observed variables is often of limited interest because single variables can be postulated to represent an unknown mixture of influences of the construct of primary interest as well as influences associated with the particular materials, the modality of the stimuli and of the response, and measurement error. Because constructs represent the variance that several variables have in common, they tend to have greater theoretical relevance, and possibly generalizability, than individual variables, and if the constructs are established to have convergent and discriminant validity, they can be inferred to represent distinct dimensions of individual differences. The highest level in the structure, often designated *g*, can be considered to reflect the broadest, or most general, level of cognitive functioning because it represents variance that the different ability constructs have in common.

Prior research (e.g., Salthouse, 2004, 2009; Salthouse & Davis, 2006; Salthouse & Ferrer-Caja, 2003) has found that age-related variation across the adult years has influences on the highest level in the hierarchy, which represents variance common to all abilities, and in addition has unique associations with vocabulary, memory, and speed abilities. This pattern indicates that there is a large negative age relation on the general factor, a strong positive influence on vocabulary, and smaller specific negative age-related influences on memory and speed abilities after considering age-related influences on the general factor. In contrast, no significant sex differences were evident on the highest level factor, but there was a male advantage on spatial visualization ability, and a female advantage on the verbal memory and speed abilities. Soubelet and Salthouse (2011a) recently carried out similar analyses with the

This article was published Online First October 24, 2011.

The project was supported by award R37AG024270 from the National Institute on Aging. The content is solely the responsibility of the author and does not necessarily represent the official views of the National Institute on Aging or the National Institutes of Health.

Correspondence concerning this article should be addressed to Timothy A. Salthouse, Department of Psychology, University of Virginia, Charlottesville, VA 22904-4400. E-mail: salthouse@virginia.edu

“Big 5” personality traits as predictors and found that only conscientiousness was not related to the highest level factor, with additional specific relations of openness on vocabulary, agreeableness on memory, and conscientiousness on speed.

The question examined in this report is where do the factors of trait anxiety and depressive symptoms operate in the hierarchical structure of cognitive abilities, and are these relations moderated by the age or sex of the individuals. Influences of trait anxiety and depressive symptoms were first examined on cognitive abilities considered separately, and then their influences were examined at different levels in the hierarchical structure, starting at the top to control the broadest influences before considering the possibility of more specific influences. In order to examine whether the relations with trait anxiety and depressive symptoms were specific to those variables, similar analyses were also conducted with two other individual difference variables: self-rated health and self-reported engagement in cognitive activities.

Two subsamples of individuals from the total sample also performed tasks hypothesized to represent different conceptualizations of working memory. These data were used to examine the possibility of unique influences of the predictors on cognitive variables not used in the creation of the ability structure. Influences of trait anxiety, depressive symptoms, self-rated health, and engagement in cognitive activities on the working memory constructs were examined after controlling influences through separate cognitive abilities, and then after controlling influences through the highest-level factor.

Method

Participants

Research participants were recruited from newspaper advertisements, flyers, and referrals from other participants between 2001 and 2009. The total sample of 3,781 adults consisted of 81% Caucasian, 9.5% African-American, and small percentages of various other groups. The participants ranged from 18 to 97 years of age, with 1,640 between 18 and 49, 1,447 between 50 and 69, and 694 between 70 and 97. The average years of education was 15.6 ($SD = 2.7$), and 58% of the participants had college degrees.

Because the dataset was assembled from 10 studies conducted between 2001 and 2009, which differed in the particular combination of cognitive tests and questionnaires administered, some participants had missing data for a few tests or questionnaires. As can be seen from the sample sizes in Table 1, the proportions of missing data ranged from less than .01 for vocabulary to .26 for trait anxiety. However, the missing information primarily occurred because of the assignment of an individual to a study, and thus there is no reason to expect that the scores are related to the level of other variables (i.e., the data can be assumed to be missing completely at random, cf. Schafer & Graham, 2002). A statistical package (Amos, Arbuckle, 2007) with a full information maximum likelihood estimation algorithm was used to accommodate missing data in the analyses.

Table 1
Sample Sizes, Means, Standard Deviations, and Correlations for Predictor and Cognitive Variables

	1	2	3	4	5	6	7	8	9	10
1. Age	X									
2. Sex (0 = male, 1 = female)	-.02	X								
3. Health	.23*	-.01	X							
4. Depressive symptoms	-.18*	.02	.20*	X						
5. Trait anxiety	-.26*	.05	.15*	.80*	X					
6. Cognitive activities	-.06*	-.02	-.05*	.02	-.04	X				
7. Matrix reasoning	-.53*	-.05*	-.21*	.00	.06	.04	X			
8. Shipley abstraction	-.43*	.04	-.23	-.05*	.01	.07*	.70*	X		
9. Letter sets	-.30*	.05*	-.20*	-.08*	-.03	.05*	.59*	.69*	X	
10. Spatial relations	-.36*	-.17*	-.20*	-.05*	-.01	.03	.68*	.58*	.52*	X
11. Paper folding	-.27*	-.08*	-.14*	-.01	.04	.02	.41*	.32*	.31*	.44*
12. Form boards	-.46*	-.16*	-.16*	.01	.04	.04	.61*	.53*	.42*	.65*
13. Word recall	-.46*	.16*	-.20*	.01	.07*	.04	.49*	.51*	.43*	.37*
14. Paired associates	-.41*	.10*	-.16*	.03	.09*	.01	.51*	.52*	.44*	.45*
15. Logical memory	-.26*	.12*	-.13*	-.03	.01	.04	.43*	.52*	.42*	.38*
16. Digit symbol	-.59*	.16*	-.30*	-.00	.08*	.07*	.55*	.58*	.49*	.41*
17. Pattern comparison	-.58*	.01	-.26*	.03	.11*	.05*	.49*	.46*	.35*	.41*
18. Letter comparison	-.50*	.06*	-.27*	.01	.08*	.13*	.46*	.52*	.41*	.34*
19. WAIS vocabulary	.08*	-.02	-.12*	-.12*	-.08*	.03	.38*	.49*	.44*	.40*
20. Picture vocabulary	.26*	-.11*	-.08*	-.16*	-.15*	.00	.24*	.35*	.34*	.36*
21. Synonym vocabulary	.30*	-.05*	-.06*	-.14*	-.12*	-.01	.20*	.33*	.31*	.27*
22. Antonym vocabulary	.21*	-.04	-.08*	-.12*	-.10*	.03	.25*	.36*	.34*	.29*
<i>N</i>	3,781	3,780	3,779	3,590	2,787	3,354	3,632	2,957	3,506	3,683
<i>M</i>	51.1	.65	1.9	11.5	35.6	38.2	7.7	13.1	11.0	8.7
<i>SD</i>	18.6	0.5	0.8	8.6	10.5	22.1	3.4	3.7	2.8	5.0

Note. Higher values of the health variable represent poorer self-ratings of health. WAIS refers to the Wechsler Adult Intelligence Scale.
* $p < .01$.

Tasks

The cognitive variables are described in other articles (e.g., Salthouse, 2009, 2010a; Salthouse, Pink & Tucker-Drob, 2008), and are listed in Tables 1 and 2. Cognitive abilities of inductive reasoning, spatial visualization, verbal episodic memory, and perceptual speed were assessed with three variables each, and vocabulary was assessed with four variables. Coefficient alpha reliabilities for the individual variables ranged from .72 to .90, and alternate forms and test-retest reliabilities ranged from .61 to .86 (Salthouse, 2010a).

Subsamples of participants also performed tasks designed to assess working memory. The tasks are described in Salthouse, Pink, and Tucker-Drob (2008) and involve simultaneous storage and processing with complex span tasks (i.e., remember letters while making arithmetic decisions, and remember spatial positions while making visual symmetry decisions), or continuous updating with running memory tasks (i.e., remember the last four letters or the last four positions in a list of unpredictable length).

Individual Difference Variables

Trait anxiety was assessed with the 20-item Spielberger Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), which had a coefficient alpha of .94 in this sample. Depressive symptoms were assessed with the Center for Epidemiological Studies–Depression (Radloff, 1977) 20-item scale, which had a coefficient alpha of .90 in this sample.

Health was assessed with the average of self-ratings of health status and of health-related activity limitations (both on a scale

from 1 to 5, with 1 representing “excellent” or “not at all” and 5 representing “poor” or “a great deal”). The coefficient alpha for the combined two-item scale was .67.

Engagement in cognitive activities was assessed with an activity inventory (Salthouse, Berish & Miles, 2002). The participants examined a list of 22 activities, and reported the number of hours per week engaged in each activity and if the number was greater than zero, it also rated the cognitive demands of the activity. Many of the activities had low-rated cognitive demands, and therefore the sum of the hours per week in the seven activities with the highest average rated cognitive demands (i.e., reading newspapers, using a computer, driving a car, reading nonfiction books, working on crossword puzzles, handling finances, and writing) was used as the measure of cognitive activity. Internal consistency for the cognitive activity score as assessed with the coefficient alpha was only .30, but this is not surprising because the same individuals would not necessarily be expected to be high on all activities.

Analysis Plan

The analyses consisted of several steps. An initial step involved checking for nonlinear relations of trait anxiety and depressive symptoms on the cognitive variables. The trait anxiety and depressive symptoms scores were first centered, and then quadratic and cubic terms created by multiplying the centered scores with one another. Next, the composite scores were created for each cognitive ability by averaging the z-scores for the variables representing each ability. (The formation of composite scores was justified because, as indicated in Table 2, the test scores all had moderately

11	12	13	14	15	16	17	18	19	20	21	22
X											
.33*											
.26*	X										
.25*	.34*	X									
.22*	.39*	.61*	X								
.30*	.29*	.56*	.53*	X							
.30*	.41*	.52*	.44*	.39*	X						
.24*	.45*	.43*	.39*	.30*	.64*	X					
.24*	.36*	.43*	.34*	.34*	.65*	.66*	X				
.18*	.24*	.30*	.38*	.45*	.22*	.16*	.21*	X			
.14*	.18*	.18*	.25*	.35*	.08*	.05*	.10*	.70*	X		
.16*	.09*	.14*	.22*	.30*	.05*	-.01	.08*	.72*	.69*	X	
	.13*	.18*	.24*	.31*	.10*	.05*	.14*	.67*	.63*	.76*	X
3,688	3,475	3,766	3,279	3,753	3,766	3,710	3,713	3,778	3,771	3,637	3,596
6.2	7.1	34.5	3.0	43.9	71.9	16.2	10.4	50.3	18.2	7.0	6.6
2.8	4.3	6.6	1.8	10.2	18.3	3.8	2.5	10.7	5.4	2.8	2.8

Table 2
Standardized Coefficients for the Hierarchical Model of Cognitive Abilities

Ability	Age group				Males	Females	Complex	
	All	18–49	50–69	70–97			Span	Updating
<i>g</i>								
Reasoning	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Space	.85	.85	.76	.74	.88	.88	.90	.84
Memory	.79	.78	.70	.67	.80	.80	.72	.81
Speed	.75	.62	.61	.72	.82	.70	.71	.68
Vocabulary	.46	.71	.74	.69	.41	.49	.28	.56
Reasoning								
Matrix reasoning	.85	.81	.77	.77	.87	.84	.87	.84
Shipley abstraction	.86	.83	.87	.84	.87	.85	.79	.85
Letter sets	.75	.73	.75	.73	.74	.75	.69	.78
Spatial visualization								
Spatial relations	.86	.89	.87	.79	.88	.83	.83	.87
Paper folding	.51	.52	.41	.36	.54	.48	.79	.80
Form boards	.76	.70	.69	.72	.78	.73	.75	.74
Episodic memory								
Word recall	.78	.73	.67	.78	.83	.74	.75	.77
Paired associates	.77	.74	.72	.72	.77	.77	.75	.77
Logical memory	.71	.72	.70	.72	.69	.71	.58	.72
Perceptual speed								
Digit symbol	.84	.73	.75	.80	.85	.84	.80	.85
Pattern comparison	.79	.70	.64	.77	.82	.76	.77	.79
Letter comparison	.80	.69	.75	.83	.81	.78	.77	.79
Vocabulary								
WAIS vocabulary	.85	.88	.88	.77	.81	.87	.81	.89
WJ picture vocabulary	.80	.83	.79	.67	.74	.82	.71	.82
Synonym vocabulary	.88	.88	.88	.81	.87	.88	.87	.81
Antonym vocabulary	.84	.83	.84	.77	.85	.83	.83	.56
CFI	.93	.94	.94	.94	.93	.94	.93	.92
RMSEA	.08	.04	.04	.04	.08	.08	.08	.09

Note. CFI refers to comparative fit index, and RMSEA refers to root mean square error of approximation. CFI values closer to 1.0, and RMSEA values closer to 0, represent a better fit (cf., Kline, 2010). WAIS = Wechsler Adult Intelligence Scale. WJ = Woodcock Johnson.

strong loadings on their respective ability factors.) In separate analyses for each cognitive ability, age- and sex-partialed residual composite scores were predicted from the linear, quadratic, and cubic trait anxiety and depressive symptoms terms.

The remaining analyses were conducted with structural equation models. Based on prior research, measurement models were used to form latent constructs for each cognitive ability and for a higher-order *g* factor. Influences of the predictor variables were initially examined on separate ability constructs, and then at different levels in a hierarchical model similar to that in Figure 1. Finally, influences of the predictors on the working memory constructs were examined before and after controlling influences shared with cognitive abilities and the highest-level *g* factor.

In order to minimize collinearity, all predictor variables (i.e., trait anxiety, depressive symptoms, health, and cognitive activity, as well as age and sex) were centered before multiplying them to form cross-product interaction terms. Each primary predictor variable was examined in separate analyses with age and sex as additional simultaneous predictors, which has the effect that the coefficients represent the relative influence of the predictors on each node in the structure after controlling for variability associated with age and sex. If the sex-by-predictor interaction was significant, coefficients for the predictor were reported for males and females. If the age-by-predictor interaction was significant, co-

efficients for the predictor were reported at three age ranges, ages 18 to 49, 50 to 69, and 70 to 97. Three-way interactions of age-by-sex-by-predictor interactions were also examined, but none was significant in any of the analyses, and thus they are not reported.

Although the largest effects on cognition are sometimes found among individuals with high levels of both anxiety and depressive symptoms (e.g., Beaudreau & O'Hara, 2009; Kizilbash, Vanderploeg & Curtiss, 2002), interactive effects of trait anxiety and depressive symptoms could not be meaningfully examined in the current project because of the very high correlation ($r = .80$) between the scores on the two scales.

Results

Sample sizes, means, and standard deviations for each variable, and correlations among the variables, are reported in Table 1 for the complete sample of participants. It can be seen that trait anxiety and depressive symptoms were strongly correlated with each other (i.e., $r = .80$), and that better self-rated health was associated with lower levels of depressive symptoms and trait anxiety. As expected, nearly all of the cognitive variables were positively correlated with one another.

An initial set of analyses examined linear and nonlinear relations of trait anxiety and depressive symptoms on cognitive ability

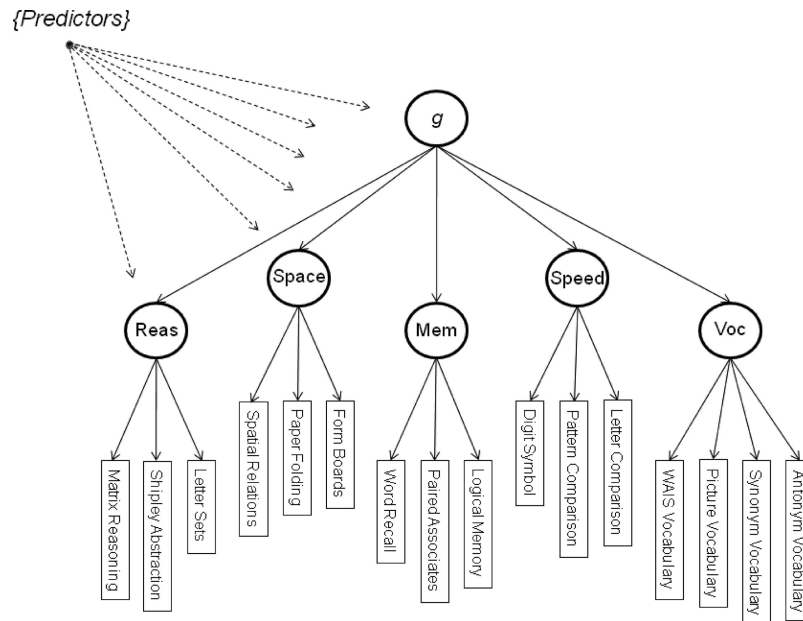


Figure 1. Schematic illustration of how the influences of trait anxiety, depressive symptoms, and other predictors are examined at different levels in a hierarchical structure of cognitive abilities.

composite scores formed by averaging the z -scores for variables representing each ability. All of the linear relations on the cognitive ability composite scores were significant for both trait anxiety and depressive symptoms, but none of the quadratic trends were significant for either predictor. The cubic trends were not significant with depressive symptoms, but they were significant with the trait anxiety predictor for the vocabulary, reasoning, and memory composite scores. Figures 2 and 3 portray the mean age- and sex-partialled residual composite cognitive ability scores for participants in each quartile of the distributions of depressive symptoms and trait anxiety. It can be seen that the relations between the

cognitive ability composite residuals and successive quartiles in the distribution of depressive symptoms scores were nearly monotonic (see Figure 2), but individuals in the second quartile of the trait anxiety distribution had the highest cognitive performance (see Figure 3). Because the inverted-U function relating trait anxiety to the cognitive abilities means that the relations may not be accurately captured by linear regressions, the analyses described below were repeated after deleting data from participants in the lowest quartile of trait anxiety scores to focus on the negative linear trends (cf. Figure 3). As expected, the linear relations of trait anxiety were stronger in these analyses, but the

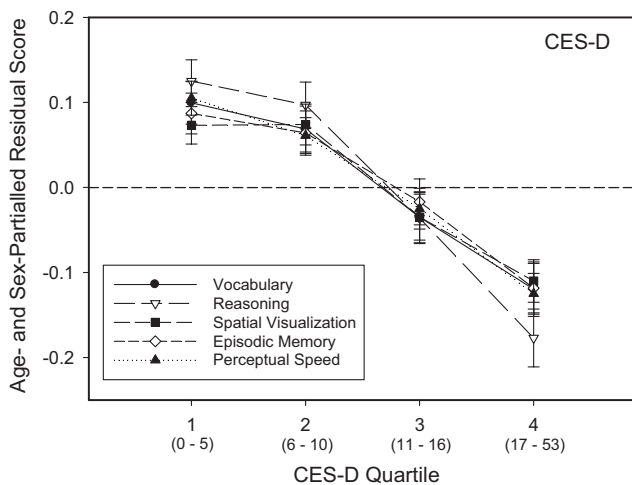


Figure 2. Means and standard errors of age- and sex-partialled residual cognitive ability composite scores as a function of successive quartiles in the distribution of scores on the depressive symptoms questionnaire.

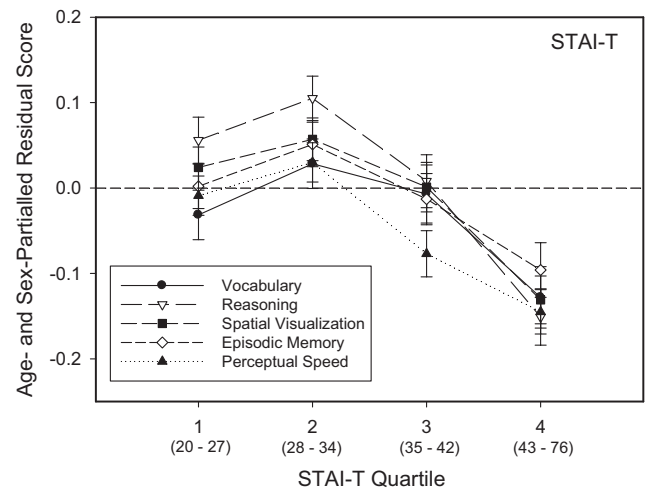


Figure 3. Means and standard errors of age- and sex-partialled residual cognitive ability composite scores as a function of successive quartiles in the distribution of scores on the trait anxiety questionnaire.

qualitative patterns were very similar to those reported with the complete sample. Analyses based on data only from participants in the lower two quartiles to examine the positive segment of the function in Figure 3 revealed small and nonsignificant relations of trait anxiety with the composite cognitive ability residuals, with correlations ranging from $-.01$ to $.03$.

Some correlations in Table 1 were significant between the trait anxiety, depressive symptoms, self-rated health and cognitive activity variables, and the individual cognitive variables. For example, higher levels of depressive symptoms and trait anxiety were associated with lower scores on vocabulary variables; higher levels of depressive symptoms were associated with lower scores on reasoning variables; and higher levels of trait anxiety were associated with higher scores on speed and memory variables. In addition, poorer self-rated health was associated with lower scores on most cognitive variables.

However, simple correlations are not easily interpreted unless influences of other variables are controlled. To illustrate, the simple correlation of depressive symptoms and word recall was only $.01$, but the partial correlation between these variables after controlling the variation in age and sex was $-.09$ ($p < .01$). Furthermore, as noted above, the levels at which the predictor variables operate cannot be determined when only single variables are examined.

A simple structure in which each observed cognitive variable was postulated to have a single influence from only one first-order ability factor had a modest fit (i.e., CFI = $.929$, RMSEA = $.080$; see Note in Table 2 for description of these fit indices). The fit could be improved by adding correlated residuals between variables involving similar methods (e.g., between the synonym and antonym vocabulary variables, and between the pattern comparison and letter comparison variables), and by allowing variables to load on multiple factors (e.g., Shipley abstraction and logical memory variables also loading on vocabulary ability). However, the simple structure provides a good representation of each ability, and has been robust in replications across independent samples

(e.g., Salthouse, Pink & Tucker-Drob, 2008), and therefore it was used in the current analyses.

Table 2 contains standardized coefficients for the measurement model relating the cognitive variables to the ability constructs, and the ability constructs to a higher-order g factor. Results are also reported from separate analyses for three age groups, for males and females, and in the two subsamples of participants with the working memory measures. It can be seen that the overall patterns were very similar in each analysis. There were a few differences, such as a weaker relation between g and vocabulary ability in the age-heterogeneous total sample, possibly because of the positive age trend with vocabulary measures (cf. Table 1). However, most of the differences across analyses were quite small, and thus the structures can be inferred to be qualitatively similar in each group.

Relations of the trait anxiety, depressive symptoms, self-rated health, and cognitive engagement predictors on each first-order ability were examined with age, sex, and their interactions as additional predictors. If the interaction was significant, separate analyses were conducted in three age groups, or in males and females. Results of these analyses are summarized in Table 3, where it can be seen that there were many significant influences on individual cognitive abilities, and also a few interactions. For example, females had greater negative relations between depressive symptoms and the speed and vocabulary abilities. Males had more positive relations of self-reported cognitive activity on all abilities except memory, as did adults over 50 years of age compared with younger adults.

Influences on the hierarchical structure were investigated next. Relations of the predictors and all interactions were initially examined on the highest level factor. Next, the influences of age, sex, and the predictor were examined separately on each ability construct after controlling their influences on the highest level factor. If any interactions were significant on the highest level factor, the analyses were repeated in each relevant group with the predictor and the control variable (i.e., age for the groups distinguished by

Table 3
Standardized Regression Coefficients (β) for Trait Anxiety, Depressive Symptoms, Self-Rated Health, and Self-Reported Activity Engagement on Separate Abilities

Predictor	Reas	Space	Mem	Speed	Voc
Trait anxiety	$-.12^*$	$-.12^*$	$-.06^*$	$-.08^*$	$-.07^*$
Depressive symptoms	$-.16^*$	$-.12^*$	$-.09^*$	$-.11^*$	$-.11^*$
Males	NA	NA	NA	$-.05$	$-.05$
Females	NA	NA	NA	$-.15^*$	$-.14^*$
Self-rated health	$-.15^*$	$-.12^*$	$-.11^*$	$-.18^*$	$-.16^*$
18–49	NA	NA	NA	$-.23^*$	NA
50–69	NA	NA	NA	$-.30^*$	NA
70–97	NA	NA	NA	$-.24^*$	NA
Cognitive activity	$.07^*$	$.02$	$.03$	$.07^*$	$.04$
Males	$.17^*$	$.10^*$	NA	$.13^*$	$.12^*$
Females	$.00$	$-.02$	NA	$.04$	$.00$
18–49	$-.06$	$-.10^*$	$-.10^*$	$.02$	$-.05$
50–69	$.15^*$	$.11^*$	$.12^*$	$.15^*$	$.09^*$
70–97	$.15^*$	$.13^*$	$.09$	$.16^*$	$.20^*$

Note. Reas refers to reasoning, Space refers to spatial visualization, Mem refers to episodic memory, Speed refers to perceptual speed, and Voc refers to vocabulary. NA indicates that the coefficient was not relevant because the predictor was not included in the analysis. Higher values of the health variable represent poorer self-ratings of health.

* $p < .01$.

Table 4
Standardized Regression Coefficients (β) for Trait Anxiety, Depressive Symptoms, Self-Rated Health, and Self-Reported Activity Engagement With the Model in Figure 1

Predictor	<i>g</i>	Reas	Space	Mem	Speed	Voc
Trait anxiety	-.11*	.01	-.02	.03	-.02	.05*
Depressive symptoms	-.15*	.02	.00	.02	-.04*	.03*
Males	-.08*	-.01	-.01	.02	.00	.04
Females	-.19*	.02	.00	.03	-.06*	.04
Self-rated health	-.16*	.07*	.03	.02	-.12*	-.00
Cognitive activity	.06*	.00	-.04*	-.02	.05*	-.02
Males	.15*	-.00	-.04	-.04	.05*	-.03
Females	.00	.01	-.04	-.00	.03	.00
18-49	-.08*	.04	-.04	-.04	.06	-.02
50-69	.16*	-.02	.01	.02	.06	-.02
70-97	.17*	-.07	-.01	-.02	.05	.09

Note. Reas refers to reasoning, Space refers to spatial visualization, Mem refers to episodic memory, Speed refers to perceptual speed, and Voc refers to vocabulary. Values below the main row contain coefficients for separate analyses on the groups in which there was an interaction of the predictor on the *g* factor in the primary analysis. Higher values of the health variable represent poorer self-ratings of health.

* $p < .01$.

sex, and sex for the groups distinguished by age) as simultaneous predictors. Results of these analyses are reported in Table 4. The most important result is that all predictors have their primary influence on the *g* factor, the highest level factor in the cognitive ability hierarchy. After controlling influences on the *g* factor, there were also small positive effects of both trait anxiety and depressive symptoms on vocabulary ability, and a negative effect of depressive symptoms on speed ability. Self-rated health had a small direct positive effect on reasoning ability, and a moderate negative relation on speed ability. Two small direct effects were evident with the cognitive activity predictor: a negative relation on space ability and a positive relation on speed ability.

There were also significant interactions of sex and depressive symptoms on the *g* factor, and on the speed and vocabulary factors, in the direction of stronger negative relations for females than for males. The interaction of age and health on speed was significant, but it was not systematic because there were moderate negative values at all ages. Both age and sex interacted with the level of

engagement in cognitive activities in their effects on *g*, in the direction of more positive relations for males, and for adults over age 50 compared with younger adults.

The final set of analyses examined influences of trait anxiety and depressive symptoms on the two working memory (WM) constructs. The correlations between the individual difference variables and the complex span variables are presented in Table 5, with Table 6 containing the same information for the subsample with the updating WM variables. The initial analyses with the WM constructs examined the relations of the cognitive abilities with the WM constructs, and the standardized coefficients for the relations of abilities and of *g* on the WM constructs are contained in the top panel of Table 7. Consistent with many other reports (e.g., Ackerman, Beier & Boyle, 2004; Blair, 2006; Salthouse et al., 2008), there were large relations of the WM constructs with reasoning and with *g*.

The bottom panel in Table 7 contains standardized regression coefficients for the relations of trait anxiety, depressive symptoms,

Table 5
Sample Sizes, Means, Standard Deviations, and Correlations for Predictor and Complex Span Working Memory Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Age	X									
2. Sex (0 = male, 1 = female)	.02	X								
3. Health	.10*	-.02	X							
4. Depressive symptoms	-.24*	.02	.19*	X						
5. Trait anxiety	-.28*	.04	.20*	.76*	X					
6. Cognitive activities	.03	-.06	.03	.03	-.05	X				
7. Operation Span, total	-.34*	-.02	-.15*	-.05	.01	-.06	X			
8. Operation Span, processing accuracy	-.21*	-.05	-.07	-.02	.01	.00	.30*	X		
9. Symmetry Span, total	-.53*	-.13*	-.09*	.05	-.01	.01	.52*	.26*	X	
10. Symmetry Span, processing accuracy	-.19*	-.07	-.11*	-.01	.00	.00	.23*	.30*	.32*	X
<i>N</i>	865	865	865	860	862	864	860	865	833	837
<i>M</i>	49.8	.66	1.7	8.5	35.0	37.8	52.2	.92	20.1	.91
<i>SD</i>	18.2	.47	.92	6.8	10.5	21.5	17.7	.07	9.2	.11

Note. Higher values of the health variable represent poorer self-ratings of health.

* $p < .01$.

Table 6
Sample Sizes, Means, Standard Deviations, and Correlations for Predictor and Updating Working Memory Variables

Variable	1	2	3	4	5	6	7	8
1. Age	X							
2. Sex (0 = male, 1 = female)	-.05	X						
3. Health	.06	-.06	X					
4. Depressive symptoms	-.23*	-.01	.29*	X				
5. Trait anxiety	-.25*	.00	.30*	.73*	X			
6. Cognitive activities	-.08	-.05	-.03	.07	-.02	X		
7. Running Memory Letters	-.28*	.03	-.17*	-.09*	-.03	.01	X	
8. Running Memory Position	-.38*	.04	-.13*	-.03	.02	.07	.61*	X
<i>N</i>	1008	1008	1007	1001	1000	984	1009	976
<i>M</i>	55.7	.66	2.1	8.6	35.2	38.1	39.2	36.9
<i>SD</i>	16.5	.47	.84	6.6	10.2	19.8	15.9	17.5

Note. Higher values of the health variable represent poorer self-ratings of health.

* $p < .01$.

self-rated health, and cognitive engagement on the WM constructs. Cognitive engagement was not related to the WM constructs, but higher levels of trait anxiety and depressive symptoms; poorer ratings of health were associated with lower levels of one or both WM constructs after controlling influences associated with age and sex. Importantly, however, these relations were much smaller and no longer significant after control of the influences shared with cognitive abilities, or the influences shared with *g*.

Discussion

Trait anxiety and depressive symptoms have significant relations with many cognitive variables, particularly when influ-

ences of age and sex are controlled, and when the relations are examined at the level of latent constructs representing cognitive abilities rather than the level of single variables (cf. Table 3 and Figures 2 and 3). Of particular importance, however, is that the analyses revealed that trait anxiety and depressive symptoms, as well as self-rated health and self-reported engagement in cognitively demanding activities, have their primary influence on *g*, corresponding to the variance common to the five abilities, rather than on specific abilities. Although individuals with higher levels of trait anxiety and depressive symptoms had lower levels of performance on several cognitive abilities and on different measures of working memory, these relations were

Table 7
Standardized Regression Coefficients (β) for Prediction of Working Memory Constructs

	<i>g</i>	Reas	Space	Mem	Speed	Voc
Complex span	NA	.65*	.31*	.14*	.13*	-.04
	.86*	NA	NA	NA	NA	NA
Updating	NA	.65*	.34*	.08	.04	-.04
	.84*	NA	NA	NA	NA	NA
Predicted variable	Complex span			Updating		
Trait anxiety						
After control of age and sex				-.17*		-.13*
After control of age, sex, and cognitive abilities				.00		-.04
After control of age, sex, and <i>g</i>				-.02		-.04
Depressive symptoms						
After control of age and sex				-.11*		-.08
After control of age, sex, and cognitive abilities				.02		-.02
After control of age, sex, and <i>g</i>				-.00		-.02
Self-rated health						
After control of age and sex				-.15*		-.08
After control of age, sex, and cognitive abilities				.06		.02
After control of age, sex, and <i>g</i>				.04		.02
Cognitive activity						
After control of age and sex				.05		-.02
After control of age, sex, and cognitive abilities				-.01		.01
After control of age, sex, and <i>g</i>				-.01		.00

Note. Reas refers to reasoning, Space refers to spatial visualization, Mem refers to episodic memory, Speed refers to perceptual speed, and Voc refers to vocabulary. Higher values of the health variable represent poorer self-ratings of health.

* $p < .01$.

largely eliminated after controlling influences on the higher-order g factor.

Perhaps because of the relatively high-functioning community sample, the effects of trait anxiety and depressive symptoms on cognitive functioning were rather small. It is nevertheless noteworthy that with the exception of somewhat lower levels of cognitive functioning among individuals with the lowest levels of trait anxiety, the trends in this sample were primarily linear, and therefore the relations can be presumed to operate throughout the entire range of the predictor variables. Whether similar results would be found in clinical samples cannot be determined from this research, but the current findings suggest that both broad as well as specific influences on cognitive functioning should be considered in research with clinical samples.

Although the patterns with trait anxiety and depressive symptoms were similar, comparison of Figures 2 and 3 reveals that only the trait anxiety variable had an inverted-U relation with cognitive functioning, in which the best performance was at intermediate levels of trait anxiety. These findings replicate earlier studies reporting an inverted-U relation with measures of anxiety (e.g., Bierman, Comijs, Jonker & Beekman, 2005; De Visser, et al., 2010), including one in which the same individuals exhibited linear relations with measures of depressive symptoms (e.g., Bierman et al., 2005).

A few interactions of the predictors on g were significant, as the influences of depressive symptoms were stronger in females, and the influences of cognitive activities were stronger in males. However, with the exception of more positive relations of cognitive activity engagement with g at older ages, the pattern of influences was generally similar across the entire adult age range. These findings imply that negative relations of trait anxiety and depressive symptoms on cognition are similar throughout adulthood, and are not more pronounced in the period of old age as sometimes suggested (e.g., Cohen, Eisdorfer, Vitaliano & Bloom, 1980; Deptula, Singh & Pomara, 1993; Hogan, 2003).

Because prior research has reported associations between anxiety and WM (e.g., Eysenck, Payne & Derakshan, 2005; Hayes, MacLeod & Hammond, 2009; Walkenhorst & Crowe, 2009), relations of trait anxiety and depressive symptoms were also examined with measures from two different methods of operationalizing WM. Both trait anxiety and depressive symptoms had significant relations on the WM constructs (cf. Table 7), but nearly all of the relations were shared with influences on other cognitive abilities. That is, none of the relations of trait anxiety or depressive symptoms on the WM constructs was significant after controlling the variance in the five cognitive abilities, or the variance in the highest level g construct. Although WM has been postulated to be central to other cognitive constructs, it is difficult to distinguish temporal or causal priority with data from a single point in time. Nevertheless, the reduction of the relations of trait anxiety, depressive symptoms, and self-rated health on WM after control of cognitive abilities, and particularly after control of g , suggests that the WM constructs have a narrower scope than these other cognitive abilities.

It is impossible to determine whether the specific effects of trait anxiety or depressive symptoms would be found on measures reflecting attention, inhibitory control, or various aspects of executive functioning because they were not included in the current analyses. However, it is instructive to consider research in which

specific effects associated with chronological age were examined in the context of age-related influences on the same five cognitive abilities included in this study. Across a number of studies, no direct or unique effects of age were found on measures of executive functioning, including inhibition (e.g., Salthouse, 2005, 2010b; Salthouse, Atkinson, & Berish, 2003), memory control (Salthouse, Siedlecki & Krueger, 2006), working memory (Salthouse, Atkinson & Berish, 2003; Salthouse, Pink & Tucker-Drob, 2008), divided attention (Salthouse, Atkinson & Berish, 2003; Salthouse & Miles, 2002), source memory (Siedlecki, Salthouse & Berish, 2005), or prospective memory (Salthouse, Berish & Siedlecki, 2004). Because nearly all of the measures had significant relations with age when considered in isolation, these results indicate that it is important to examine the relations of a predictor on the measures of cognitive functioning in the context of its relations on other cognitive measures in order to determine the level at which the influences operate.

As with all studies, this study has some limitations. For example, trait anxiety and depressive symptoms were assessed by the individual, and there is some evidence that self-reports are distorted by social desirability, and that the degree of distortion is greater at older ages (Soubelet & Salthouse, 2011b). Furthermore, although the sample was moderately large, the participants had relatively high average levels of education and cognitive functioning, and the relations between anxiety and depressive symptoms and cognition observed in this sample may not generalize to lower functioning and less educated individuals. Finally, because this was a community sample, relatively few individuals were likely to be in the clinical range for anxiety or depression. Nevertheless, the primarily linear relations between both trait anxiety and depressive symptoms and the cognitive ability variables apparent in Figures 2 and 3 indicate that the influences operate throughout almost the entire range of trait anxiety and depressive symptoms, and are not confined to individuals with the most extreme scores on these scales.

An important implication of the current results is that researchers should rule out broad or general influences on cognitive functioning before inferring the existence of effects of trait anxiety or depressive symptoms on specific cognitive processes. The analytical methods used in this report are not the only possible way of distinguishing between general and specific effects on cognitive functioning, and future research should be conducted to determine if other methods lead to similar outcomes. At least on the basis of the current results, however, it may be misleading to conclude that variables such as trait anxiety or level of depressive symptoms are uniquely associated with one particular cognitive process without considering the possibility that at least some of these relations are attributable to influences operating at broader, or more general, levels of cognitive functioning.

References

- Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2004). Working memory and intelligence: The same or different constructs? *Psychological Bulletin*, *131*, 30–60. doi:10.1037/0033-2909.131.1.30
- Arbuckle, J. L. (2007). AMOS (Version 7) [Computer program]. Chicago, IL: SPSS.
- Beaudreau, S. A., & O'Hara, R. (2009). The association of anxiety and depressive symptoms with cognitive performance in community-

- dwelling older adults. *Psychology and Aging*, *24*, 507–512. doi:10.1037/a0016035
- Bierman, E. J. M., Comijs, H. C., Jonker, C., & Beekman, A. T. F. (2005). Effects of anxiety versus depression on cognition in later life. *American Journal of Geriatric Psychiatry*, *13*, 686–693.
- Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature Neuroscience*, *12*, 92–98. doi:10.1038/nn.2242
- Blair, C. (2006). How similar are fluid cognition and general intelligence? A developmental neuroscience perspective on fluid cognition as an aspect of human cognitive ability. *Behavioral and Brain Sciences*, *29*, 109–160. doi:10.1017/S0140525X06009034
- Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. New York, NY: Cambridge University Press. doi:10.1017/CBO9780511571312
- Castaneda, A. E., Tuulio-Henriksson, A., Marttunen, M., Suvisaari, J., & Lonnqvist, J. (2008). A review on cognitive impairments in depressive and anxiety disorders with a focus on young adults. *Journal of Affective Disorders*, *106*, 1–27. doi:10.1016/j.jad.2007.06.006
- Cohen, D., Eisdorfer, C., Vitaliano, P. P., & Bloom, V. (1980). The relationship of age, anxiety, and serum immunoglobulins with crystallized and fluid intelligence. *Biological Psychiatry*, *15*, 699–709.
- Deptula, D., Singh, R., & Pomara, N. (1993). Aging, emotional states, and memory. *American Journal of Psychiatry*, *150*, 429–434.
- De Visser, L., van der Knaap, L. J., van de Loo, A. J. A. E., van der Weerd, C. M. M., Ohl, F., & van den Bos, R. (2010). Trait anxiety affects decision-making differently in healthy men and women: Towards gender-specific endophenotypes of anxiety. *Neuropsychologia*, *48*, 1598–1606. doi:10.1016/j.neuropsychologia.2010.01.027
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*, 336–353. doi:10.1037/1528-3542.7.2.336
- Eysenck, M. W., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuospatial processing, and working memory. *Cognition and Emotion*, *19*, 1214–1228. doi:10.1080/02699930500260245
- Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: Current status and future directions. *Annual Review of Clinical Psychology*, *6*, 285–312. doi:10.1146/annurev.clinpsy.121208.131305
- Gottfredson, L. S. (1998). The general intelligence factor. *Scientific American Presents*, *9*, 24–30.
- Gustafsson, J. E. (1988). Hierarchical models of individual differences in cognitive abilities. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 4, pp. 35–71). Hillsdale, NJ: Erlbaum Publishing.
- Hayes, S., MacLeod, C., & Hammond, G. (2009). Anxiety-linked task performance: Dissociating the influence of restricted working memory capacity and increased investment of effort. *Cognition and Emotion*, *23*, 753–781. doi:10.1080/02699930802131078
- Hogan, M. J. (2003). Divided attention in older but not younger adults is impaired by anxiety. *Experimental Aging Research*, *29*, 111–136. doi:10.1080/03610730303712
- Jensen, A. R. (1998). *The g factor*. Westport, CT: Praeger.
- Kizilbash, A. H., Vanderploeg, R. D., & Curtiss, G. (2002). The effects of depression and anxiety on memory performance. *Archives of Clinical Neuropsychology*, *17*, 57–67.
- Kline, R. B. (2010). *Principles and practice of structural equation modeling* (3rd ed.). New York, NY: Guilford Press.
- Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401. doi:10.1177/014662167700100306
- Salthouse, T. A. (2004). Localizing age-related individual differences in a hierarchical structure. *Intelligence*, *32*, 541–561. doi:10.1016/j.intell.2004.07.003
- Salthouse, T. A. (2005). Relations between cognitive abilities and measures of executive functioning. *Neuropsychology*, *19*, 532–545. doi:10.1037/0894-4105.19.4.532
- Salthouse, T. A. (2009). Decomposing age correlations on neuropsychological and cognitive variables. *Journal of the International Neuropsychological Society*, *15*, 650–661. doi:10.1017/S1355617709990385
- Salthouse, T. A. (2010a). Influence of age on practice effects in longitudinal neurocognitive change. *Neuropsychology*, *24*, 563–572. doi:10.1037/a0019026
- Salthouse, T. A. (2010b). Is flanker-based inhibition related to age? Identifying specific influences of individual differences on neurocognitive variables. *Brain and Cognition*, *73*, 51–61. doi:10.1016/j.bandc.2010.02.003
- Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology: General*, *132*, 566–594. doi:10.1037/0096-3445.132.4.566
- Salthouse, T. A., Berish, D. E., & Miles, J. D. (2002). The role of cognitive stimulation on the relations between age and cognitive functioning. *Psychology and Aging*, *17*, 548–557. doi:10.1037/0882-7974.17.4.548
- Salthouse, T. A., Berish, D. E., & Siedlecki, K. L. (2004). Construct validity and age sensitivity of prospective memory. *Memory & Cognition*, *32*, 1133–1148. doi:10.3758/BF03196887
- Salthouse, T. A., & Davis, H. P. (2006). Organization of cognitive abilities and neuropsychological variables across the lifespan. *Developmental Review*, *26*, 31–54. doi:10.1016/j.dr.2005.09.001
- Salthouse, T. A., & Ferrer-Caja, E. (2003). What needs to be explained to account for age-related effects on multiple cognitive variables? *Psychology and Aging*, *18*, 91–110. doi:10.1037/0882-7974.18.1.91
- Salthouse, T. A., & Miles, J. D. (2002). Aging and time-sharing aspects of executive control. *Memory & Cognition*, *30*, 572–582. doi:10.3758/BF03194958
- Salthouse, T. A., Pink, J. E., & Tucker-Drob, E. M. (2008). Contextual analysis of fluid intelligence. *Intelligence*, *36*, 464–486. doi:10.1016/j.intell.2007.10.003
- Salthouse, T. A., Siedlecki, K. L., & Krueger, L. E. (2006). An individual differences analysis of memory control. *Journal of Memory and Language*, *55*, 102–125. doi:10.1016/j.jml.2006.03.006
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, *7*, 147–177. doi:10.1037/1082-989X.7.2.147
- Siedlecki, K. L., Salthouse, T. A., & Berish, D. E. (2005). Is there anything special about the aging of source memory? *Psychology and Aging*, *20*, 19–32. doi:10.1037/0882-7974.20.1.19
- Soubelet, A., & Salthouse, T. A. (2011a). Personality-cognition relations across adulthood. *Developmental Psychology*, *47*, 303–310. doi:10.1037/a0021816
- Soubelet, A., & Salthouse, T. A. (2011b). Influence of social desirability on age differences in self-reports of mood and personality. *Journal of Personality*, *79*, 741–762.
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual of the state-trait anxiety inventory (Form Y)*. Palo Alto, CA: Consulting Psychologists Press.
- Walkenhorst, E., & Crowe, S. F. (2009). The effect of state worry and trait anxiety on working memory processes in a normal sample. *Anxiety, Stress & Coping*, *22*, 167–187. doi:10.1080/10615800801998914

Received November 22, 2010

Revision received July 29, 2011

Accepted August 19, 2011 ■