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ABSTRACT

The organization of cognitive factors in a sample of older adults was investigated by a joint factor analysis of the subtests from the Woodcock-Johnson Psychoeducational Battery-Revised (WJ-R) and the Detroit Tests of Learning Aptitude-Adult (DTLA-A). Two extensive batteries were administered, following R. W. Woodcock's recommendation that in order for factors to be identified, a sufficient number of markers for each factor must be present. Subjects for the study were 41 adults ranging in age from 55 to 76 years. Altogether, 9 sets of exploratory and confirmatory factor analyses on 29 variables were conducted. The results provide evidence for nine latent factors based on the theory of fluid and crystallized intelligence (Gf-Gc) theory of intelligence of J. L. Horn and R. B. Cattell (1966). Theoretical and practical implications of the findings are discussed. (Contains 8 tables and 21 references.) (Author/SLD)

JOINT FACTOR ANALYSIS OF THE WOODCOCK-JOHNSON PSYCHOEDUCATIONAL BATTERY-REVISED AND THE DETROIT TESTS OF LEARNING APTITUDE-ADULT

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Abstract

A number of recent studies have focused on verifying the factorial structure of human cognitive abilities hypothesized by Horn and Cattell in their Gf-Gc theory. While the stability of factors in populations from young childhood to middle adulthood has been well documented, little data have been gathered in for older adults. The organization of cognitive factors in a sample of older adults was investigated by a joint factor analysis of the subtests from the Woodcock-Johnson Psychoeducational Battery-Revised (WJ-R) and the Detroit Tests of Learning Aptitude-Adult (DTLA-A). Two extensive batteries were administered, following Woodcock's recommendation that in order for factors to be identified, a sufficient number of markers for each factor must be present. Subjects for the study were 41 adults ranging in age from 55 to 76 years. Altogether. nine sets of exploratory and confirmatory factor analyses on 29 variables were conducted. The results provide evidence for nine latent factors based on Horn and Cattell's Gf-Gc theory of intelligence. Theoretical and practical implications of the findings are discussed.

A number of recent investigations (Carroll, 1993; Woodcock, 1993) into the structure of human cognitive abilities have focused on the basic work of Horn and Cattell (1966) called Gf-Gc theory. In 1981, Carroll and Horn theorized that 80% of intellectual ability could be measured and predicted in terms of some 30 basic processes. They further suggested that most of the variation represented in primary processes could be organized into eight or nine second-order abilities. To date, nine broad abilities have consistently been identified and replicated in the work of Carroll & Horn (1981) and Woodcock (1990). The nine abilities are listed in Table 1.

Table 1
Nine Gf-Gc Broad Abilities

Name	Symbol	Description
Short-Term Memory	Gsm	Ability to hold information in immediate awareness and use it within a few seconds
Quantitative Knowledge	Gq	Ability to comprehend quantitative concepts and relationships
Visual Processing	Gv	Ability to analyze and synthesize visual stimuli
Fluid Reasoning	Gf	Ability to reason, form concepts, solve, often with novel information
Comprehension-Knowledge	Gc	Breadth and depth of knowledge
Auditory Processing	Ga	Ability to analyze and synthesize auditory stimuli
Long-Term Retrieval	Glr	Ability to store information and retrieve it later through association
Processing Speed	Gs	Ability to rapidly perform automatic cognitive tasks, often under pressure to maintain concentration
Correct Decision Speed	CDS	Ability to quickly provide correct answers to a variety of moderately difficult problems in comprehension and reasoning

Encouraged by analyses of data sets using principal factoring followed by hierarchical orthogonalization of factors with the Schmid-Leiman technique, Carroll (1993) postulated a three-level hierarchical structure of intelligence closely associated with the theories proposed earlier by Cattell and Horn (1978) and Gustafsson (1984). The top stratum is occupied by one general ability, g. The second stratum is occupied by a number of small broad abilities similar to those of Gf-Gc theory (fluid intelligence, crystallized intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval or production ability, broad cognitive speediness, and broad processing speed). At the lowest stratum are a large number of narrow, more specialized abilities similar to those identified by Thurstone (1938). The lowest level abilities are grouped under different second-stratum abilities. For example, under Gc (crystallized intelligence) are found abilities related to language, verbal comprehension, vocabulary, and basic knowledge learned through instruction. Each of the second-stratum abilities have different correlations with g (those measuring higher order processing (e.g. Gf), correlate highest with g, while those measuring lower level processing (e.g. Gv), correlate lowest with g. Factor analyses of all 37 WJ-R cognitive and achievement tests by J.B. Carroll (Woodcock, 1990) identified two new factors resembling [orthogra]phic ability and language ability (comprised of reading and writing measures). To date, however, these factors have not been adequately replicated and [integrated] into Gf-Gc theory. Additional exploratory analyses of the WJ-R cognitive and achievement tests was encouraged to explore these language or orthographic (Go) dimensions.

Gf-Gc theory stands as a valid criterion against which to evaluate instruments used in the assessment of intelligence. Recently, McGhee (1993) investigated the factor structure of the Detroit Tests of Learning Aptitude-3 (DTLA-3; Hammill, 1991), the Differential Ability Scales (DAS; Elliott, 1990) and the Woodcock-Johnson Tests of Cognitive Ability-Revised (WJ-R; Woodcock & Johnson, 1989) utilizing the Gf-Gc model. The results supported an eight-factor model comprised of Gf, Gc, Glr, Gv, Ga, and Gs; Short-Term (Gsm) Memory was replaced by Short-Term Auditory (Gsma) and Short-Term Visual (Gsmv) Memory. The Gq factor was not investigated. These findings were later replicated by McGhee & Lieberman (1993).

The stability of Gf-Gc factors from kindergarten to middle adulthood is well documented (McGrew, Werder, & Woodcock, 1990). However, there is less evidence of this factorial invariance in the older adult population. Indeed, the WJ-R Technical Manual cautions against overinterpretation of the Gf-Gc model in the Older Adult sample due to weaker confirmatory fit statistics and relatively small sample sizes. McGrew, et al (1993) also suggest that the loadings of some factorially complex tests change as a function of age. Thus it is desirable to explore additional model variations at the older age range.

A recent entry into the domain of adult intelligence assessment is the Detroit Tests of Learning Aptitude-Adult (DTLA-A, Hammill & Bryant, 1991). In many ways similar to the DTLA-3, the DTLA-A is a battery of 12 subtests that measure different mental abilities. The battery is designed for use with persons ages 16 through 79 (one of the few batteries that overlaps with the standardization sample of the WJ-R). The DTLA-A Examiner's Manual (Hammill & Bryant, 1991) reports the results of a factor analysis using the Promax rotation method on the entire standardization sample. This procedure generated four factors with eigenvalues greater than 1. The four factors were labeled Sequential Memory for Words, General Visual Intelligence, Conceptual Abstract Reasoning, and Residual (Difficult to Interpret). The amount of variance these factors account for is not cited in the manual. One characteristic of factor analytic studies that make the results more meaningful according to Woodcock (1990) is, "a sufficient number (generally three or more) of reasonably clean measures, or markers, for each of the factors present so that the factor can be identified clearly". Because the DTLA-A does not provide a sufficient number of markers to analyze adequately it's factorial composition across the standardization sample, it may well be underfactored. That is, factors that are present in the battery are not differentiated or perhaps have not been detected. The DTLA-A must be studied in conjunction with other measures; otherwise, inappropriate conclusions may be drawn about the factorial structure of the battery and about the construct validity of the individual subtests. Presently, data available from the DTLA-A provides little information that is new about the presence of latent factors in the older adult population.

Method

Subjects

Subjects in this study were 41 persons residing in Southwest Georgia of whom 19 were Caucasian female, 17 were Caucasian male, 3 were African-American female, and 2 were African-American male. The subjects ranged in age from 55 years to 76 years (M = 65 years, SD = 5.6 years).

Procedure

Fifteen subtests from the WJ-R (Standard and Supplemental batteries), two reading tests from the WJ-R Tests of Achievement (Word Identification and Passage Comprehension), and 12 subtests from the DTLA-A were administered to each subject in counterbalanced order (within and across batteries).

Data Analysis

Means, standard deviations and correlations were computed for each of the 29 variables. The data were subsequently analyzed using exploratory and confirmatory factor analyses. The principal axes factoring procedure (R squared in the diagonals with iterations) followed by orthogonal rotations of the factors was used to investigate various factor solutions. Structural equation procedures (LISREL) (Joreskog & Sorbom, 1989) were used to determine the degree to which the data support the proposed model. Multiple indices of model-data fit were used in this study; the chi-square fit statistic divided by degrees of freedom, the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), and root mean square residual (RMSR).

RESULTS

Means and variances for the WJ-R and DTLA-A subtests were within the average range. Most subtests displayed some range restriction (WJ-R median SD 11.5; DTLA-A median SD 13.4) indicating that this older adult sample is less variable than the general population. Two-factor and six-factor exploratory analyses of the DTLA-A (to investigate the theoretical models presented by Hammill and Bryant) are presented first followed by a series of joint exploratory analyses (eight, nine, and ten factor solutions) of the WJ-R and DTLA-A (to investigate Gf-Gc theory). This is followed by a two and six factor confirmatory analyses of the DTLA-A and a nine-factor and ten-factor confirmatory analyses of the WJ-R and DTLA-A.

Table 2 presents the factor pattern matrix for the two-factor exploratory orthogonal solution.

Table 2
Equamax Two-factor Solution for the DTLA-A Subtests

Test	Factor 1	Factor 2
Form Assembly	.61	-
Word Sequences	.56	-
Sentence Imitation	.55	-
Design Sequences	.55	-
Story Sequences	.54	-
Design Reproduction	-	.65
Reversed Letters	-	.50
Word Opposites	-	.49
Math Problems	-	.47
Quantitative Relations	-	.47
Basic Information	-	.39
Symbolic Relations	.48	-

Note. Loadings lower than .300 have been excluded from the table.

A review of Table 2 indicates that none of the two-factor theoretical interpretation models delineated by Hammill and Bryant for the DTLA-A are described by this two factor solution. Indeed, predictions for the Cattell and Horn Fluid/Crystallized model are particularly poor, with only 7 of 12 subtests loading as expected (58% of agreement). The Associative/Cognitive, Simultaneous/Successive and Verbal/Performance models had somewhat better fits with 8 of 12 subtests loading as [illegible] (67% of agreement). The large amount of specific variance remaining (79%) is a reflection that underfactoring has taken place. There are other latent [illegible] the data set unaccounted for, suggesting the need for exploring more complex models. These findings are consistent with those of Stone (1992) and McGrew, et al. (1990); highly restricted models based on two-factor frameworks do not provide a very credible representation of human abilities.

The factor loadings presented in **Table 3** are the results obtained from the exploratory analysis of the DTLA-A using a six-factor solution (Gf-Gc labels have been assigned to assist interpretation). The dramatic increase in explained total variance (73.7%) of this solution over the two-factor solution clearly indicates the complexity of human cognition. Five Gf-Gc factors (Gq, Gc, Gv, Gsma, Gsmv) are well defined in the pool of 12 DTLA-A subtests. These five factors are defined by high positive loadings from two to three DTLA-A subtests. The sixth factor is difficult to interpret, accounting for less than 5% of total variance. Of particular interest is evidence of clearly definable Short-Term Auditory Memory (Gsma) and Short-Term Visual Memory (Gsmv) factors replicating previous findings by McGhee (1993).

Table 3
Equamax Six-factor Solution for the DTLA-A Subtests

Test	Gsma	Gsmv	Gq	Gc	Gv	?
Word Sequences	.86	-	-	-	-	-
Sentence Imitation	.84	-	-	-	-	.42
Design Reproduction	-	.95	-	-	-	-
Reversed Letters	-	.89	-	-	-	.36
Math Problems	-	-	.95	-	-	-
Quantitative Relations	-	-	.82	-	-	-
Word Opposites	-	-	-	.90	-	-
Basic Information	-	-	-	.82	-	-
Story Sequences	-	-	-	-	.82	-
Form Assembly	-	-	-	-	.61	.37
Design Sequences	-	-	-	-	.56	-
Symbolic Relations	-	-	.36	-	.46	-

Note.-Loadings lower than .300 have been excluded from the table.

The results from the eight-factor exploratory analysis of the WJ-R and DTLA-A are presented in Table 4. Gf-Gc labels have been added to assist in interpretation of factors. High loadings on each of these eight factors (two to six subtests for each factor) provide strong empirical support of the presence of many Gf-Gc factors, including Gsma and Gsmv. Subtests measuring quantitative ability (Gq) and processing speed (Gs) load on the same factor as do measures of comprehension-knowledge (Gc) and reading ability (Go). Note in Table 4, that Cross Out, Visual Closure, Concept Formation, Picture Recognition, Reading Comprehension, and Word Identification in the WJ-R and Design Sequences and Story Sequences in the DTLA-A are classified as mixed subtests: significant loadings on multiple factors. This eight-factor solution accounted for 78% of the total variance.

Table 4
Equamax Eight-factor Solution for the WJ-R and DTLA-A Subtests

Test	Gq/Gs	Gc/Go	Gsma	Glr	Ga	Gsmv	Gf	Gv
Math Problems	.78	-	-	-	-	-	-	-
Quantitative Relations	.74	-	-	-	-	-	-	-
Visual Matching	.72	-	-	-	-	-	-	-
Cross Out	.68	-	-	-	.40	-	-	-
Picture Vocabulary	-	.95	-	-	-	-	-	-
Oral Vocabulary	-	.92	-	-	-	-	-	-
Word Opposites	-	.86	-	-	-	-	-	-
Basic Information	-	.82	-	-	-	-	-	-
Word Identification	-	.69	-	-	.36	-	-	-
Passage Comprehension	-	.60	.36	-	-	-	-	-
Memory for Words	-	-	.88	-	-	-	-	-
Word Sequences	-	-	.87	-	-	-	-	-
Sentence Imitation	-	-	.83	-	-	-	-	-
Memory for Sentences	-	-	.78	-	-	-	-	-
Visual-Auditory Learn	-	-	-	.91	-	-	-	-
Memory for Names	-	-	-	.89	-	-	-	-
Design Sequences	-	-	-	.77	-	-	-	.34
Sound Blending	-	-	-	-	.92	-	-	-
Incomplete Words	-	-	-	-	.76	-	-	-
Design Reproduction	-	-	-	-	-	.97	-	-
Reversed Letters	-	-	-	-	-	.77	-	-
Analysis/Synthesis	-	-	-	-	-	-	.81	-
Concept Formation	.35	-	-	-	-	-	.79	-
Symbolic Relations	-	-	-	-	-	-	.75	-
Spatial Relations	-	-	-	-	-	-	-	.85
Form Assembly	-	-	-	-	-	-	-	.76
Visual Closure	-	-	-	-	.34	-	-	.60
Story Sequences	-	-	-	-	-	-	.39	.54
Picture Recognition	-	.41	-	.39	-	-	-	.41

Note.-Loadings lower than .300 have been excluded from the table.

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The results in Table 5 are based on a nine-factor exploratory analysis of the WJ-R and DTLA-A subtests. The findings are similar to those reported by McGhee (1993); nine discrete Gf-Gc factors emerged including separate short-term auditory and memory factors. This solution explains 81% of the total variance. Quantitative Reasoning (Gq) and Processing Speed (Gs) measures have separated into distinct factors. In contrast, Comprehension-Knowledge (Gc) and Reading (Go) have not separated into distinct factors, offering no confirmation of a separate Orthographic factor as postulated by others (Carroll, 1993; Woodcock, The Picture Recognition subtest in the WJ-R is factorially complex. This finding is consistent with results obtained by McGhee (1993) as were the multiple for Story Sequences and Design Sequences in the DTLA-A. The multiple loadings for the Visual Closure subtest in the WJ-R is atypical and might be explained by the influence of numbers used in it's format.

Note the multiple loadings of the Word Identification subtest (Gc, Ga) and Passage Comprehension subtest (Gc, Gsma, Gf, and Gs). The loadings on Gc are not surprising in light of recent multiple regression analyses with the WJ-R by McGrew (1993); comprehension-knowledge and auditory processing abilities are highly associated with both types of reading achievement across the age span. Furthermore, McGrew's analysis demonstrates a moderate relationship between short-term memory and reading comprehension in older adults. Moderate to small correlations were found between fluid reasoning abilities and reading comprehension as well as processing speed abilities and both types of reading across the age span.

Table 5

Equamax Nine-factor Solution for the WJ-R and DTLA-A Subtests

Test	Gq	Gc	Gsma	Glr	Ga	Gsmv	Gf	Gv	Gs
Quantitative Relations	.91	-	-	-	-	-	-	-	-
Math Problems	.83	-	-	-	-	-	-	-	-
Picture Vocabulary	-	.92	-	-	-	-	-	-	-
Oral Vocabulary	-	.89	-	-	-	-	-	-	-
Word Opposites	-	.85	-	-	-	-	-	-	-
Basic Information	-	.83	-	-	-	-	-	-	-
Word Identification	-	.69	-	-	.35	-	-	-	-
Passage Comprehension	-	.54	.33	-	-	-	.37	-	.39
Memory for Words	-	-	.90	-	-	-	-	-	-
Word Sequences	-	-	.88	-	-	-	-	-	-
Sentence Imitation	-	-	.82	-	-	-	-	-	-
Memory for Sentences	-	-	.77	-	-	-	-	-	-
Visual-Auditory Learn	-	-	-	.89	-	-	-	-	-
Memory for Names	-	-	-	.89	-	-	-	-	-
Design Sequences	-	-	-	.78	-	-	-	.34	-
Sound Blending	-	-	-	-	.91	-	-	-	-
Incomplete Words	-	-	-	-	.78	-	-	-	-
Design Reproduction	-	-	-	-	-	.96	-	-	-
Reversed Letters	-	-	-	-	-	.79	-	-	-
Analysis/Synthesis	-	-	-	-	-	-	.79	-	-
Concept Formation	.35	-	-	-	-	-	.78	-	-
Symbolic Relations	-	-	-	-	-	-	.77	-	-
Spatial Relations	-	-	-	-	-	-	-	.86	-
Form Assembly	-	-	-	-	-	-	-	.75	-
Visual Closure	-	-	-	-	.31	-	-	.58	-
Story Sequences	-	-	-	.31	-	-	.37	.55	-
Cross Out	-	-	-	-	-	-	-	-	.85
Visual Matching	.35	-	-	-	-	-	-	-	.78
Picture Recognition	-	.39	-	.37	-	-	-	.39	-

Note.-Loadings lower than .300 have been excluded from the table.

The ten-factor exploratory analysis of the WJ-R and DTLA-A resulted in the same Gf-Gc factors that emerged in the nine-factor analysis, with the tenth factor related to simultaneous processing (Spatial Relations, Ricture Recognition, Story Sequences, Visual Closure, Oral Vocabulary). However, this tenth factor is weakly defined accounting for only 5% of the total variance. This solution, with 82% of total variance explained, shows no appreciable clarity above the nine-factor solution.

Two and six-factor confirmatory analyses were completed only for DTLA-A subtests, as confirmation of the exploratory analyses cited earlier in the study. It was possible to make a direct comparison between these two models by contrasting chi-square differences and changes in degrees of freedom. The nine-factor and ten-factor confirmatory analyses included subtests from both the WJ-R and DTLA-A and were also attempts at confirmation of earlier cited exploratory analyses.

As shown in Table 6, two models have been contrasted using the DTLA-A subtests: Model 1A: Two factors (Fluid and Crystallized) as classified by Hammill & Bryant (1991) - 4 Fluid subtests and 8 Crystallized subtests. Model 1B: Six factors (Gsma, Gv, Gc, Gf, Gq, and Gsmv). The five factors found in the exploratory analyses, with Symbolic Relations as a singleton sixth factor.

Table 6

Confirmatory Factor Analysis:

Goodness-of-fit Indices for Two Contrasting Models

Model	Chi square	df	GFI	AGFI	RMSR	X /df
Two factor (1A)	175.24	53	.67	.51	.22	3.30
Six factor (1B)	35.04	39	.88	.76	.09	0.90

These results indicate significant improvement in model fit of the six-factor model over the two-factor model (chi-square significance test $p < .001$). Hammill & Bryant's dichotomous classification system using Cattell's Gf-Gc model (1963) provides a very poor fit to the data. Indeed, suggesting this dichotomous classification system in face of numerous important changes in the Gf-Gc theory over the past ten years may leave practitioners confused when attempting to compare results between the DTLA-A and other intelligence batteries which utilize current Gf-Gc Theory. Furthermore, given that results of the two-factor exploratory analyses accounts for only 20% of total variance in the data set, none of the dual classification systems presented by Hammill and Bryant would yield satisfactory model-fits if confirmatory factor analyses were conducted for each. It is not until the fit of the data to more complicated models of intellectual functioning are that goodness-of-fit statistics improve to acceptable levels.

Table 7 shows factor loadings for the nine-factor Gf-Gc model proposed by McGhee (1993) and supported by the exploratory analyses cited earlier. The resulting primary factor loadings were moderate to high and positive. The goodness-of-fit chi square was significant and rejects the hypothesis that this model accounted for the data, (X [333] = 656, p<.01). The GFI was .59 and the AGFI was .47 (also below established criteria to accept the model). However, other goodness-of-fit indices (X /df ratio = 1.97 and RMSR = .094) suggested an acceptable fit to the data. The secondary factor loadings for Story Sequences on Glr and Gc are in the low range while a high loading was maintained on the Gv factor, suggesting this subtest is best interpreted as a measure of visual processing. Results also indicate that certain Gf-Gc abilities are related significantly to basic reading skills and reading comprehension (basic reading skills with Gc and Ga abilities; reading comprehension with Gc, Gsma, and Gf abilities). These findings are consistent with those reported by McGrew (1993).

Table 7
Confirmatory Factor Analysis Results of WJ-R and DTLA-A
Nine-factor Gf-Gc Model

	LISREL maximum likelihood estimates								
Test	Gq	Gc	Gsma	Glr	Ga	Gsmv	Gf	Gv	Gs
Quantitative Relations	.92	-	-	-	-	-	-	-	-
Math Problems	.86	-	-	-	-	-	-	-	-
Picture Vocabulary	-	.98	-	-	-	-	-	-	-
Oral Vocabulary	-	.96	-	-	-	-	-	-	-
Word Opposites	-	.85	-	-	-	-	-	-	-
Basic Information	-	.84	-	-	-	-	-	-	-
Word Identification	-	.74	-	-	.38	-	-	-	-
Passage Comprehension	-	.56	.30	-	-	-	.30	-	.39
Memory for Words	-	-	.91	-	-	-	-	-	-
Word Sequences	-	-	.90	-	-	-	-	-	-
Sentence Imitation	-	-	.83	-	-	-	-	-	-
Memory for Sentences	-	-	.73	-	-	-	-	-	-
Visual-Auditory Learn	-	-	-	.90	-	-	-	-	-
Memory for Names	-	-	-	.95	-	-	-	-	-
Design Sequences	-	-	-	.75	-	-	-	.28	-
Sound Blending	-	-	-	-	.84	-	-	-	-
Incomplete Words	-	-	-	-	.90	-	-	-	-
Design Reproduction	-	-	-	-	-	1.55*	-	-	-
Reversed Letters	-	-	-	-	-	.49	-	-	-
Analysis/Synthesis	-	-	-	-	-	-	.78	-	-
Concept Formation	-	-	-	-	-	-	.97	-	-
Symbolic Relations	-	-	-	-	-	-	.73	-	-
Spatial Relations	-	-	-	-	-	-	-	.90	-
Form Assembly	-	-	-	-	-	-	-	.83	-
Visual Closure	-	-	-	-	-	-	-	.66	-
Story Sequences	-	.20	-	.17	-	-	-	.57	-
Cross Out	-	-	-	-	-	-	-	-	1.12*
Visual Matching	-	-	-	-	-	-	-	-	.81
Picture Recognition	-	-	-	.28	-	-	-	.43	-

*"Heywood case"; a communality has converged on a value greater than 1.0

The last confirmatory analysis investigates the hypothesis of an orthographic dimension (Go) of human ability, separate from Gc, defined by measures of reading and writing. Therefore, Word Identification and Passage Comprehension were designated to load exclusively on Go. Woodcock's (1990) findings of secondary loadings for Memory for Sentences on Gc and McGhee's (1993) findings of secondary loadings for Picture Recognition on Glr and Gv and Design Sequences on Glr and Gv were also designated in the model. The LISREL estimates for this ten-factor model are presented in Table 8. The resulting primary factor loadings were moderate to high and positive. The goodness-of-fit chi square was significant, (X [329] = 646.86, p<.01). The GFI was .59 and the AGFI was .46 (below established criteria). The X /df ratio was 1.97 and RMSR = .094; similar to findings from the nine-factor model. The secondary factor loadings for Picture Recognition and Design Sequences were moderately high and confirm that these tests are factorially complex (mixed measures). Although fit statistics between the nine and ten-factor models are roughly equivalent, the nine-factor model is preferred since it is more parsimonious; fewer factors accounting for similar amounts of covariance. However, to quote Loehlin (1987), "Few, if any, users of chi- square tests or standard error estimates with maximum likelihood estimation are in a position to fully justify the probability values they report. . ., the statistical tests and probability values. . . are reported in a mainly descriptive spirit, to help orient the reader among the various models we present." Therefore, to the extent that the underlying assumptions hold, we conclude that a nine-factor model of intelligence similar to Gf-Gc theory provides the best explanation of human cognition in our sample.

Table 8
Confirmatory Factor Analysis Results of WJ-R and DTLA-A
Ten-factor Gf-Gc Model

Test	LISREL maximum likelihood estimates									
	Gq	Gc	Gsma	Glr	Ga	Gsmv	Gf	Gv	Gs	Go
Quantitative Relations	.89	-	-	-	-	-	-	-	-	-
Math Problems	.89	-	-	-	-	-	-	-	-	-
Picture Vocabulary	-	.99	-	-	-	-	-	-	-	-
Oral Vocabulary	-	.96	-	-	-	-	-	-	-	-
Word Opposites	-	.85	-	-	-	-	-	-	-	-
Basic Information	-	.83	-	-	-	-	-	-	-	-
Word Identification	-	-	-	-	-	-	-	-	-	.74
Passage Comprehension	-	-	-	-	-	-	-	-	-	.79
Memory for Words	-	-	.91	-	-	-	-	-	-	-
Word Sequences	-	-	.91	-	-	-	-	-	-	-
Sentence Imitation	-	-	.82	-	-	-	-	-	-	-
Memory for Sentences	-	.24	.74	-	-	-	-	-	-	-
Visual-Auditory Learn	-	-	-	.91	-	-	-	-	-	-
Memory for Names	-	-	-	.93	-	-	-	-	-	-
Design Sequences	-	-	-	.75	-	-	-	.27	-	-
Sound Blending	-	-	-	-	.79	-	-	-	-	-
Incomplete Words	-	-	-	-	.96	-	-	-	-	-
Design Reproduction	-	-	-	-	-	1.43*	-	-	-	-
Reversed Letters	-	-	-	-	-	.53	-	-	-	-
Analysis/Synthesis	-	-	-	-	-	-	.77	-	-	-
Concept Formation	-	-	-	-	-	-	.99	-	-	-
Symbolic Relations	-	-	-	-	-	-	.71	-	-	-
Spatial Relations	-	-	-	-	-	-	-	.88	-	-
Form Assembly	-	-	-	-	-	-	-	.85	-	-
Visual Closure	-	-	-	-	-	-	-	.64	-	-
Story Sequences	-	-	-	-	-	-	-	.70	-	-
Cross Out	-	-	-	-	-	-	-	-	1.11*	-
Visual Matching	-	-	-	-	-	-	-	-	.82	-
Picture Recognition	-	-	-	.27	-	-	-	.44	-	-

*"Heywood case"; a communality has converged on a value greater than 1.0

DISCUSSION

Results of the exploratory and confirmatory factor analyses support the presence of nine latent factors similar to Gf-Gc theory in the older adult population. These findings have implications for assessment of cognitive functioning and theories of intelligence. Cronbach and Snow (1977), Brody (1985), and McDermott et al (1990) have argued against subtest analysis (there is limited data to support the notion that multiple intelligence constructs have predictive validity that surpasses that of a general factor). Identifying the underlying constructs of intelligence (or an intelligence test) may or may not result in improved Aptitude-Treatment Interactions (ATI). With improved psychometric instruments at their command, future investigators may reveal the answer. However, the present study has relevance to the development of intelligence tests and assessment of cognitive functioning, particularly if one's preference is in obtaining and utilizing a broad index score. Woodcock (1990) provides data regarding the factorial composition of the WJ-R, K-ABC, SB-IV, WISC-R, and WAIS-R using Gf-Gc theory. Although a broad score can be obtained from each battery, these global scores vary immensely as a function of the different weighted mix of cognitive abilities measured. For example, on the K-ABC, measures of Visual Processing (Gv) contribute 44% to the broad score while 80% of the WISC-R broad score is comprised of measures from only two factors; Comprehension-Knowledge (Gc) and Visual Processing (Gv). Since individuals in the normal population demonstrate statistically significant intracognitive variation, clinicians must recognize that results of a broad based score are a direct reflection of the factorial composition of the administered test and that another test battery can, and often do, yield different results. Thus, individuals with normal, yet statistically significant, intracognitive variation may be penalized on certain batteries if their relative weakness is one of the excessively measured constructs. Woodcock (1990) acknowledges the great responsibility placed on clinicians to investigate what constructs the tests they use measure, and to what extent underlying factors contribute to the overall result. Only through such exploration can proper interpretation of results and subsequent predictions take place.

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