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DIFFERENTIAL ABILITY SCALES–II PREDICTION OF READING PERFORMANCE: GLOBAL SCORES ARE NOT ENOUGH

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This study investigated the effects of broad cognitive abilities derived from the Cattell–Horn–Carroll (CHC) taxonomy, together with the effect of the general factor (g), on Wechsler Individual Achievement Test, Second Edition (WIAT-II) reading achievement. Structural equation modeling (SEM) and commonality analyses were applied to the Differential Ability Scales, Second Edition (DAS-II) standardization and clinical sample data. All seven DAS-II CHC broad cognitive abilities were shown to have significant effects on one or more WIAT-II reading domains with different patterns found across typical, poor reader, and reading specific learning disability (SLD) groups. In the SEM analyses, the general factor g had only indirect effects on reading achievement variance. In the commonality analyses, after the effects of the seven CHC factors had been accounted for, the six-factor commonality—which could be considered an alternative measure of global intelligence—accounted for only 1%–2% of reading measure variance. For children who are having difficulties with reading skill acquisition, the data suggest that primary emphasis on g will result in a major loss of DAS-II predictive validity. Results emphasize the importance of having a comprehensive cognitive assessment with the DAS-II in the evaluation of reading competency and disability. Links between CHC broad ability factors and neuropsychological constructs may provide a promising foundation for developing specific cognitive, academic, and behavioral interventions for children with reading SLD. © 2010 Wiley Periodicals, Inc.

Designed to optimize clinical assessment of children's cognitive abilities, the recently revised Differential Ability Scales, Second Edition (DAS-II; Elliott, 2007a) has improved, and made explicit, its alignment with Cattell–Horn–Carroll (CHC) theory (McGrew & Wendling, 2010). The DAS-II basic factor structure has been carefully evaluated and validated in the standardization sample (Elliott, 2007b). It measures seven CHC broad ability factors, with three Verbal (VE; *Gc*), Nonverbal Reasoning (NR; *Gf*), and Spatial Ability (SP; *Gv*) Core clusters, and four Diagnostic clusters. The Core clusters, each based on two subtests, yield a higher-order measure of the general factor with General Conceptual Ability (GCA) serving as its nomothetic proxy. In addition to the Core battery, the DAS-II contains Diagnostic subtests to assess additional CHC abilities, including Working Memory (*Gsm*-MW) and Processing Speed (*Gs*-PS) clusters and subtests that assess memory span (*Gsm*-MS), phonological processing (*Ga*-PC), and visual-verbal memory (*Glr*-M6; referred to in CHC theory as long-term storage and retrieval).

The Core battery of the original DAS, based on the same structure, has been validated through independent exploratory and confirmatory factor analyses (EFAs and CFAs; Daleo et al., 1999;

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Dunham, McIntosh, & Gridley, 2002; Keith, 1990; McGhee, 1993), and has demonstrated a comparable factor structure in samples of children with disabilities (Dumont, Cruse, Price, & Whelley, 1996; Elliott, 2001; Gibney, McIntosh, Dean, & Dunham, 2002; Hughes & McIntosh, 2002; Kercher & Sandoval, 1991; McIntosh & Gridley, 1993; Shapiro, Buckhalt, & Herod, 1995) and of those with cultural, racial, or linguistic differences (DiCerbo & Barona, 2000; Keith, Quirk, Schartzer, & Elliott, 1999; Riccio, Ross, Boan, Jemison, & Houston, 1997). The DAS factor structure also has been validated according to CHC theory, confirming the placement of subtests in their respective clusters (Sanders, McIntosh, Dunham, Rothlisberg, & Finch, 2007).

General Factor versus Profiles

There is considerable evidence from the CFAs conducted on DAS-II standardization data that CHC-based models account for observed relationships in the data far better than a single general factor solution, often referred to as "*g*" (Elliott, 2007b). For example, at ages 6 through 12 years, 11 months, 14 subtests were included in the CFAs reported by Elliott. Five models were evaluated: a one-factor model (g), a two-factor Verbal-Nonverbal model, a three-factor *Gc-Gf-Gv* model, a six-factor model which specified additional factors of *Gsm*, *Gs*, and *Ga*, and a seven-factor model, which added an additional factor of *Glr*. Every model with more than one factor fitted the standardization data better than the single-factor *g* model, with the seven-factor model better than all others (Elliott, 2007b, p. 161). The analyses demonstrated that the DAS-II measures a range of cognitive abilities and that the general factor *g* is not sufficient to explain the relationships between the subtests and clusters (Elliott, 2007b, pp. 153–162).

This robust finding of a multifactorial model should not be surprising, given that the DAS-II was designed to allow profile analysis to identify cognitive strengths and weaknesses for developing targeted interventions (Elliott, 2007b); however, some researchers have called for interpretation only at the level of the GCA score in the original DAS, saying that such a large proportion of the standardization sample has significant intra-individual differences that they should not be interpreted (Kahana, Youngstrom, & Glutting, 2002). The presence of significant DAS-II intra-individual differences, however, indicates simply that they should be studied to determine whether and how they serve to illuminate processes underlying reading achievement, as we have done elsewhere with mathematics (Hale, Fiorello, Dumont, et al., 2008).

The question of whether to interpret a cognitive test *level* (e.g., IQ) or *pattern* (e.g., factors, subtests) of performance is one of the most controversial in clinical assessment, a question that essentially stems from philosophical differences in orientation, with heirs to Spearman (1927) focusing on level of performance or global IQ interpretation (see, e.g., Canivez & Watkins, 1998; Glutting, McDermott, Konold, Snelbaker, & Watkins, 1998; Gottfredson, 1997; Jensen, 1998) and heirs to Thurstone (1938) focusing on the importance of patterns of performance, or analyzing cognitive strengths and weaknesses (see, e.g., Carroll, 1997; Dumont, Willis, & Sattler, 2001; Elliott, 2001; Fiorello et al., 2007; Flanagan, Ortiz, & Alfonso, 2007; Horn & McArdle, 2007; Kaufman, 1994).

In an effort to demonstrate the importance of global scores in comparison with lower-level broad factors, some authors (e.g., Glutting,Watkins, Konold, & McDermott, 2006; Watkins, Glutting, & Lei, 2007) have performed regression analyses using multicollinear data sets. Multicollinearity occurs "when one independent variable is a near linear combination of other independent variables. Multicollinearity can result in misleading and sometimes bizarre results" (Keith, 2006, p. 199). Again, Pedhazur (1997, p. 295) states, "Collinearity may have devastating effects on regression statistics to the extent of rendering them useless, if not highly misleading." Ignoring such admonitions and instead exploiting multicollinearity among predictors, the statistical techniques by Glutting and colleagues (2006) have led to such inaccurate conclusions (see Fiorello et al., 2007; Hale, Fiorello, Kavanagh, Hoeppner, & Gaither, 2001; Hale, Fiorello, Kavanagh, Hodnack, & Aloe, 2007; Hale, Fiorello, Dumont et al., 2008; Hale, Fiorello, Miller, et al., 2008; Hale & Morley, 2009).

In contrast to the assertions of Glutting and colleagues (2006), recent DAS-II (Hale, Fiorello, Dumont, et al., 2008) and Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Hale, Fiorello, Miller, et al., 2008) studies support idiographic interpretation of specific cognitive abilities in the prediction of academic achievement. Also using the Wechsler scales, Flanagan, McGrew, and Ortiz (2000) note that a CHC approach is preferred over the traditional interpretation for predicting reading achievement. Additionally, Vanderwood, McGrew, Flanagan, & Keith (2001) have shown that specific cognitive abilities provide a better fitting model in predicting reading achievement scores than does general cognitive ability. These studies suggest that CHC factors predict reading achievement more accurately than do general ability composite scores across ages and samples, and reflect the dynamic nature of reading development during childhood.

Cognitive Processes Involved in Reading

Reading is a complex task, demanding a wide variety of cognitive and neuropsychological processes (Ramus, 2004). Unlike spoken language, which develops naturally in all neurologically intact children, reading is a relatively artificial activity that depends on mobilizing a variety of brain areas to learn (Wolf, 2007). Children must develop phonemic awareness, the knowledge that words are made up of sounds, and then learn to associate those sounds with print (Richards & Berninger, 2008; Shaywitz, 2003). Over time and with systematic instruction, word reading becomes increasingly automatized until fluency is achieved, freeing cognitive resources for more sophisticated comprehension and appreciation of text (see Hale & Fiorello, 2004; Wolf, 2007). As words are read, children must also simultaneously access lexical–semantic meaning to comprehend passages (Stojanovik & Riddell, 2008). As a result, reading instruction across the early grades not only must target basic skills, but must develop a wide range of processes to foster phonemic awareness, phonics, fluency, vocabulary, and comprehension (National Institute of Child Health and Human Development, 2000).

An ongoing research synthesis by McGrew and Wendling (2010) summarizes research on the CHC factors that contribute to basic reading and reading comprehension across three age groups from 6 to 19. Across all ages, the bulk of the research literature finds the broad abilities of *Ga*, *Gs*, *Gc*, and *Gsm* contributing to basic reading achievement when *g* is not included in the analysis. With *g* included, between two and four of the broad factors remain as contributors, depending on age. Factors contributing to reading comprehension reveal few differences from basic reading for ages 6 to 8—once again, *Gc*, *Ga*, *Gs*, and *Gsm* are consistent predictors when *g* is excluded. For ages 9 to 19, *Gc* and *Gsm* are consistently found as strong predictors when *g* is not included in the analysis, and the effect of *Gc* continues to be robust even in the presence of the conglomerate *g* factor.

The importance of *Gc* in predicting reading should not be surprising, given that it is typically measured using auditory–verbal skills (Carroll, 1993) and prior learning-acquired knowledge (Fiorello, Hale, & Synder, 2006), with language development clearly essential for acquisition of reading competency (Richards & Berninger, 2008). *Ga* is another CHC factor that has a critical role to play in reading development. Peter Bryant and his coworkers (Bryant & Bradley, 1985; Goswami & Bryant, 1990) conducted the research that established a key connection between phonological processing (auditory processing–phonemic coding or *Ga*-PC in CHC theory) and reading and spelling acquisition in children. This was followed by a veritable explosion of research confirming these findings (e.g., Snow, Burns & Griffin 1998; Uhry, 1999). Subsequent studies have confirmed *Ga*-PC to be related to superior temporal lobe functioning (e.g., Temple et al., 2001), with activation changes found suggesting neuropsychological response to reading intervention (Simos et al., 2002). Although *Gv* processes are not often associated with competent reading, knowledge of the visual-orthographic representations of letters and words depends in part on *Gv* (Richards et al., 2006). Orthographic representations have been consistently related to the visual extrastriate cortex in functional magnetic resonance imaging (fMRI) studies, with deficits a robust meta-analytic finding in children with reading disability (e.g., Maisog, Einbinder, Flowers, Turkeltaub, & Eden, 2008). Additionally, combining phonemes with graphemes (i.e., the alphabetic principle) appears to be associated with the visual-symbolic associative learning likely tapped by some *Gs* and *Glr* measures (Fiorello, Hale, Snyder, Forrest, & Teodori, 2008; Hale, Fiorello, Miller, et al., 2008). In addition to these basic skills, processing speed (*Gs*) and working memory (*Gsm*-WM) underlie development of reading automaticity/fluency and comprehension, respectively (Gathercole, Alloway, Willis, & Adams, 2006; Wolf, 2007). These skills interact with comprehension-knowledge and language development (*Gc*) to foster reading comprehension (Cutting & Scarborough, 2006). Fluid reasoning (*Gf*) processes are needed to interpret complex text structures and inferential reading comprehension in older children (Bryan & Hale, 2001; Goldberg, 2001). As *Gf* is nearly isomorphic with *g* (e.g., McGrew, 2005) and is highly related to executive function (Decker, Hill, & Dean, 2007), the influence of *g* in many CHC studies may reflect this complex interrelationship.

Given the complexity of cognitive and neuropsychological factors that have been identified as important to reading achievement, this study was undertaken to determine DAS-II predictors of reading in typical children and in those with reading difficulties and disability. Such information is useful in directing practitioners to those measures necessary to conduct appropriate profile analysis for both diagnostic purposes and to inform intervention. This article presents a number of analyses designed to identify CHC factors (and empirically derived factor relationships) that predict reading decoding and reading comprehension achievement test scores for typical children, with results compared to those of poor readers and children with specific reading disability.

Method

Participants

Four samples, all linked to the collection of standardization data for the DAS-II (Elliott, 2007a), were used for the analyses. Samples A and B, used for structural equation modeling (SEM) analyses, covered children in the age range of 7 years, 0 months to 12 years, 11 months (7:0–12:11). Only children who had DAS-II subtest scores and Wechsler Individual Achievement Test, Second Edition (WIAT-II) Word Reading (WR) and Pseudoword Decoding (PD) subtest scores available were used in the two samples.

Sample A: Typical. A total of 1,166 children (age 7:0–12:11) were selected from the DAS-II standardization sample, described in depth in the DAS-II *Introductory and Technical Handbook* (Elliott, 2007b, pp. 102–113). The DAS-II standardization sample was representative of the U.S. population according to the October 2002 census for race, ethnicity, parent education level, and geographic region. Thirty-four children were excluded because of missing data. Note here that this full sample was not given the WIAT-II Reading Comprehension (RC) subtest, which is why we needed Sample C.

Sample B: Poor Readers. A total of 230 children (age 7:0–12:11) with WIAT-II WR standard scores (*SS*) less than 85 were identified. Children were drawn from the following sources:

- 140 children in the DAS-II standardization sample;
- 62 children not included in the final DAS-II standardization sample; and
- 28 children from the Reading Disorder ($n = 3$), Reading and Written Expression Disorder ($n = 5$), Mathematics Disorder ($n = 11$), Attention Deficit/Hyperactivity Disorder (ADHD; $n = 6$), and ADHD with Learning Disorder ($n = 3$; samples described in detail by Elliott, 2007b, p. 184 *ff*).

Samples C and D from the DAS-II/WIAT-II Linking Sample also had WIAT-II RC subtest data ($n = 371$). Because of smaller sample size, the commonality analyses using Samples C and D were conducted on the full school-age range (6:0–17:11).

Sample C: Typical. This DAS-II/WIAT-II Linking Sample of 371 children (age 6:0–17:11) who took all DAS-II and WIAT-II subtests (see Elliott, 2007b, pp. 171–172 for detailed description).

Sample D: Reading specific learning disability. This clinical validity sample included a total of 151 children (age 7:0–15:0) with classifications of Reading Disorder ($n = 51$), Reading and Written Expression Disorder ($n = 44$), and ADHD with Learning Disorder ($n = 56$). All children had been previously identified as having a specific learning disability (SLD) by multidisciplinary teams before the DAS-II and WIAT-II were administered to them (see Elliott, 2007b, pp. 261–262). Additionally, they were identified for the purposes of this article as having a specific learning disorder in Reading using the Concordance-Discordance Model (C-DM) of learning disability determination (Hale & Fiorello, 2004, pp. 181–182; Hale, Fiorello, Miller, et al., 2008). This model ensures that any child identified with SLD meets both Individuals with Disabilities Education Act (IDEA, 2004) SLD statutory and regulatory requirements (Hale, Flanagan, & Naglieri, 2008). The C-DM decision sequence used for each child was as follows:

1. From the DAS-II core clusters (VEerbal Ability [*Gc*], Nonverbal Reasoning Ability [*Gf*], and SP [*Gv*]), select the highest cluster score for the cognitive strength.
2. Pick one or more other cognitive scores from among the DAS-II measures of *Gc, Gf, Gv, Gsm*-WM, *Gs, Glr, or Ga* that are significantly lower ($p < .05$) than the selected high score. This establishes a *discordance* between the cognitive strength and the cognitive weakness.
3. Identify WIAT-II reading subtest(s) (WR, PD, or RC) that are significantly below the cognitive strength ($p < .05$). This establishes a *discordance* between the cognitive strength and the academic weakness.
4. Finally, establish a *concordance* between the cognitive weakness(es) and the academic weakness—the academic weakness may be lower, but should not be significantly higher than the cognitive weakness.

Instrumentation

The DAS-II (Elliott, 2007a) is an individual test of cognitive ability. The School-Age Battery (age 7-0–17-11) includes six Core and eight Diagnostic subtests. Subtests also yield Cluster scores, generally derived from pairs of subtests. For the standardization sample (age 6:0–12:11), CFA identified seven factors that are clearly consistent with CHC theory. The clusters and subtests that represent these seven CHC Broad Abilities are listed in Table 1. Full details of the factor analyses are provided by Elliott (2007b, pp. 153–162). The subtests have good IRT-based reliabilities (see Table 1), and considerable evidence of internal and external validity (see Elliott, 2007b). The Cluster and GCA scores are reported as *SS* (mean [M] = 100, standard deviation [SD] = 15), whereas subtests are in a T-score metric ($M = 50$; $SD = 10$).

The WIAT-II (Psychological Corporation, 2001) is an individual test of academic achievement. It was standardized on 2,950 students (age 4–19), and the normative sample closely represented the

Table 1
Clusters and Subtests of the DAS-II School-Age Battery with CHC Broad Abilities and Internal Reliabilities for Ages 6:0–12:11

Cluster	CHC Broad Ability	Cluster Reliability	Subtest	Subtest Reliability
Core Clusters:				
Verbal	*Gc*	.88	Word Definitions	.82
			Verbal Similarities	.80
Nonverbal Reasoning	*Gf*	.92	Matrices	.86
			Sequential and Quantitative Reasoning	.92
Spatial	*Gv*	.94	Pattern Construction	.96
			Recall of Designs	.85
Diagnostic Clusters:				
Working Memory	*Gsm*	.94	Recall of Digits, Backward	.90
			Recall of Sequential Order	.92
Processing Speed	*Gs*	.90	Speed of Information Processing	.92
			Rapid Naming	.80
[Visual-Verbal Memory]*	*Glr*		Recall of Objects, Immediate	.84
[Auditory Processing]*	*Ga*		Phonological Processing	.87

*These are descriptions of processes measured by these subtests. Being single subtests, they are not characterized as clusters.

October 1998 census on race, ethnicity, geographic region, and parent education level. The Reading subtests are WR (a test of reading decoding), PD (a test of phonological decoding knowledge using nonsense words), and RC (measuring understanding of short sentences or passages). Scores are reported as *SS*. WR (average split-half reliability .97), PD (average split-half reliability .97), and RC (average split-half reliability .95) are reliable and have adequate content-, construct-, and criterion-related validity (Psychological Corporation, 2001).

Procedure

The data sets for the DAS-II Standardization Sample, the DAS-II/WIAT-II Linking Sample, and the Clinical Validity Samples (Elliott, 2007b) were obtained from Harcourt Assessment and uploaded to SPSS 15.0 and Amos 17.0 (Arbuckle, 2008). Descriptive data and correlational analyses were performed separately for each of the four samples. SEM analyses were conducted for Samples A and B. Multiple regression analyses using commonality equations were performed on Samples C and D using the WIAT-II WR, PD, and RC subtests as dependent variables in separate regression equations and the seven DAS-II factors (VE, NR, SP, WM, PS, VVM, and AP) as predictors.

SEM Analyses

Figure 1 presents the initial CHC-based measurement and structural model for Samples A and B. The model is hierarchical in nature representing the DAS-II structure in practice, with just three paths leading from the *g* factor[1] to the first-order factors of VE, NR, and SP. The lower left side

[1] We chose to focus on this model rather than the "full *g*" model that would fully reflect CHC theory because we were primarily interested in addressing the question "Which DAS-II measures of broad CHC abilities have significant paths to reading decoding?" The "full *g*" model would, of course, specify paths from *g* to every broad factor.

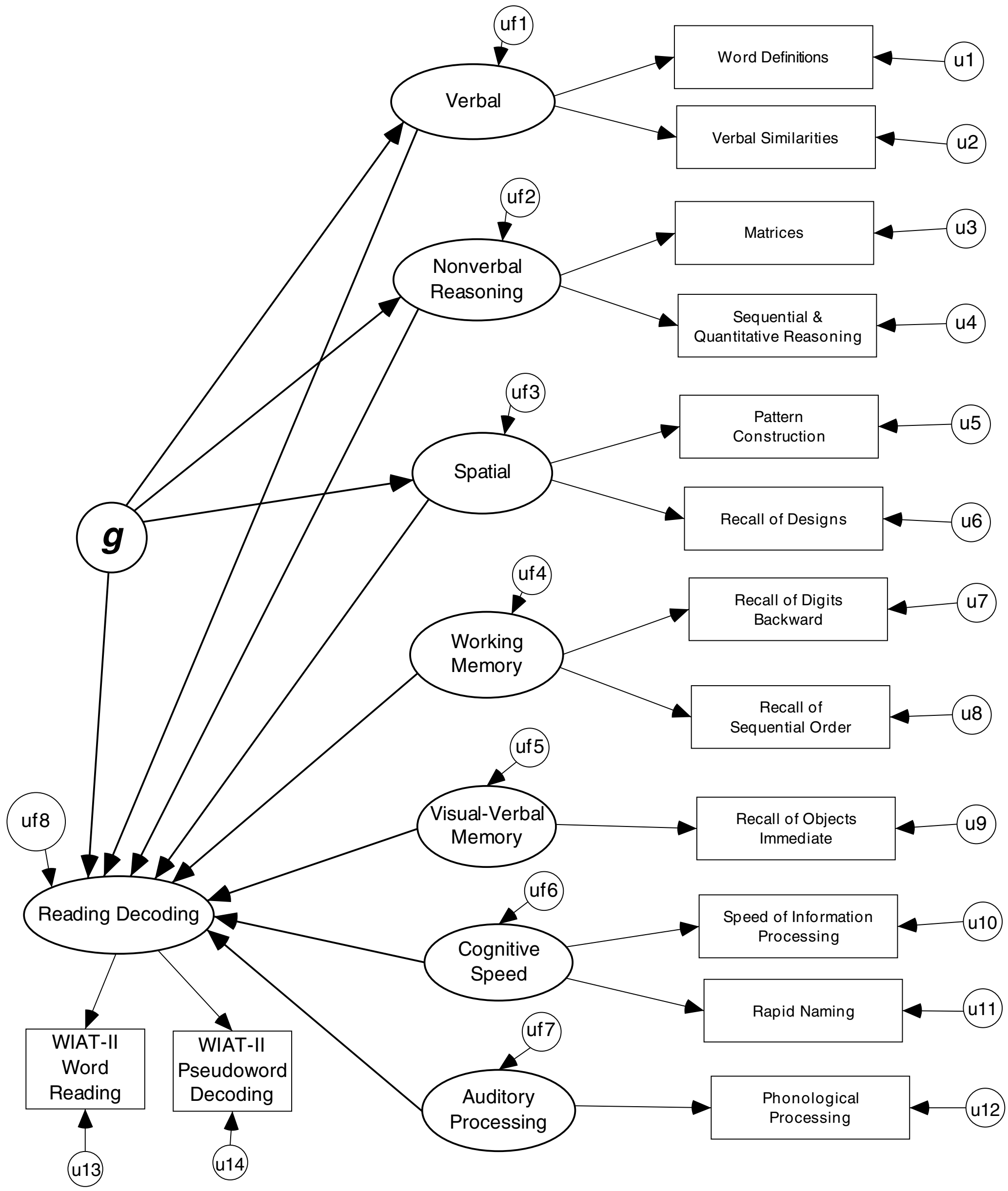

FIGURE 1. Initial model for SEM analysis.

of Figure 1 shows a further ellipse representing the factor of Reading Decoding, defined by two measured variables—WIAT-II WR and PD.

The initial structural model shows paths leading from the seven CHC broad cognitive ability factors and from the second-order *g* factor to the Reading Decoding factor (eight paths in all). The SEM analyses were exploratory rather than confirmatory, and their purpose was to determine which of these cognitive ability factors displayed significant effects on reading decoding in each sample. We used a similar methodology to that reported by Floyd, Keith, Taub, & McGrew (2007) and Taub, Keith, Floyd, & McGrew (2008) who examined the effects of general and broad abilities as measured by the Woodcock–Johnson III Tests of Cognitive Abilities (WJ III COG; Woodcock, McGrew, & Mather, 2001) on mathematics achievement, but did not split the samples into Calibration and Validity subsamples. The initial analysis for both Sample A and Sample B specified a model that included the direct effect of *g* together with all seven broad cognitive ability factors on the Reading Decoding factor. After a model was estimated, the highest negative path was removed and the revised model re-estimated. This was continued until all negative paths were eliminated. After the negative paths had been removed, nonsignificant paths ($p \geq .05$) were removed. Modification indices were examined to see whether any deleted structural paths should be reinstated. Thus the final models were those containing only significant positive structural paths from cognitive factors to the achievement factor.

Commonality Analyses

Commonality analysis (see Hale, Fiorello, Miller et al., 2008; Pedhazur, 1997) offers an advantage over SEM and other regression techniques in that the unique and shared variance among collinear predictors of reading measures can be examined to aid interpretation. The use of commonality analysis has been challenged by Schneider (2008), who argues that commonalities can be subsumed under *g* and that no firm statistical standards have been developed for their interpretation. On the contrary, we find nothing in these arguments that are either statistically or clinically compelling enough to dissuade us from using commonality analysis to examine DAS-II predictors of academic achievement. The interpretation of commonalities in this article is based on CHC and neuropsychological research (e.g., Hale & Fiorello, 2004; Hale, Fiorello, Miller, et al., 2008), and could be further enhanced by future functional imaging research.

Commonality equations were written using standard variance partitioning procedures described by Pedhazur (1997). This technique allows for the examination of the proportion of dependent variable variance (i.e., WR, PD, and RC achievement scores) that is accounted for by unique and shared predictor variance (e.g., DAS-II factor scores). To conduct the commonality analysis, equations were entered into an SPSS syntax file by using compute commands. For each dependent variable, force-entry multiple regression equations were computed with all possible predictor combinations to acquire the required R^2 components for the commonality computations. These R^2 values were entered into a new data file with each being a new variable. The compute statements were applied to this new data file to acquire the unique and shared variance components for each factor predictor. Given the substantial computations needed, zero-order correlations with reading measures, and number of variance components examined, only the DAS-II Core factors, and WM, PS, and AP, were included in commonality analyses. In addition, only commonalities exceeding .01 are reported, as these indicate appreciable amounts of interpretable dependent variable variance.

RESULTS

Descriptive analyses for study variables are shown for each group in Tables 2 and 3. As expected, DAS-II and WIAT-II *M* values were approximately 100 for the typical groups (Samples A and C). The samples of poor readers (Sample B) and of those with an SLD in Reading (Sample D) had scores significantly lower than those of the typical groups on all DAS-II and WIAT-II variables.

SEM Analyses

The final model for Sample A is shown in Figure 2. This figure indicates that four CHC factors have significant structural paths to Reading Decoding: Verbal (*Gc*), Nonverbal Reasoning (*Gf*), WM (*Gsm*-WM), and AP (*Ga*). Goodness of fit of the model to the data was evaluated using the root

Table 2
Descriptive Statistics for Sample A (Typical Children) and Sample B (Poor Readers

	Sample A: Typical ($N = 1166$)		Sample B: Poor Readers ($N = 230$)			
	M	*SD*	*M*	*SD*	*t*	*p*
DAS-II Clusters						
Verbal	100.27	14.99	89.81	13.40	10.60	<.001
Nonverbal Reasoning	100.14	14.79	89.57	10.94	12.56	<.001
Spatial	99.80	14.45	92.38	11.71	8.43	<.001
Working Memory	99.44	14.88	89.03	12.11	11.44	<.001
Processing Speed	100.74	15.11	93.97	14.31	7.60	<.001
DAS-II Subtests*						
Recall of Objects – Immediate	98.8	16.67	92.07	16.93	5.52	<.001
Phonological Processing	101.56	13.85	92.00	12.38	10.49	<.001
WIAT-II Subtests						
Word Reading	100.95	15.44	79.02	5.37	38.18	<.001
Pseudoword Decoding	101.36	15.27	83.29	8.37	25.44	<.001

*t-score means for subtests were converted to standard scores for comparison purposes.

Table 3
Descriptive Statistics for Sample C (Typical Children) and Sample D (SLD in Reading)

	Sample C: Typical ($N = 191$)		Sample D: SLD in Reading ($N = 151$)			
	M	*SD*	*M*	*SD*	*t*	*p*
DAS-II Clusters						
Verbal	101.83	13.96	92.95	12.53	6.19	<.001
Nonverbal Reasoning	100.80	12.95	91.99	12.56	6.35	<.001
Spatial	99.14	12.38	92.81	13.21	4.52	<.001
Working Memory	101.12	13.40	89.83	12.01	8.20	<.001
Processing Speed	102.05	14.34	89.18	13.96	8.36	<.001
DAS-II Subtests*						
Recall of Objects – Immediate	98.32	15.92	90.52	17.79	4.22	<.001
Phonological Processing	102.73	13.05	92.52	11.73	7.60	<.001
WIAT-II Subtests						
Word Reading	103.99	14.31	81.03	13.51	15.20	<.001
Pseudoword Decoding	104.65	13.34	85.53	11.88	14.00	<.001
Reading Comprehension	105.81	12.26	82.86	16.23	14.42	<.001

*T-score means for subtests were converted to standard scores for comparison purposes.

mean square of approximation (RMSEA = .158) and the standardized root mean square residual (SRMR = .2873). This represents poor fit to the data, largely because four paths from *g* to the factors of *Gsm, Glr, Gs,* and *Ga* had not been specified.[2]

[2] This finding was confirmed by an analysis of the complete "full *g*" CHC model, which yielded RMSEA = .053 and SRMR = .052, indicating good fit of the complete CHC model to the data.

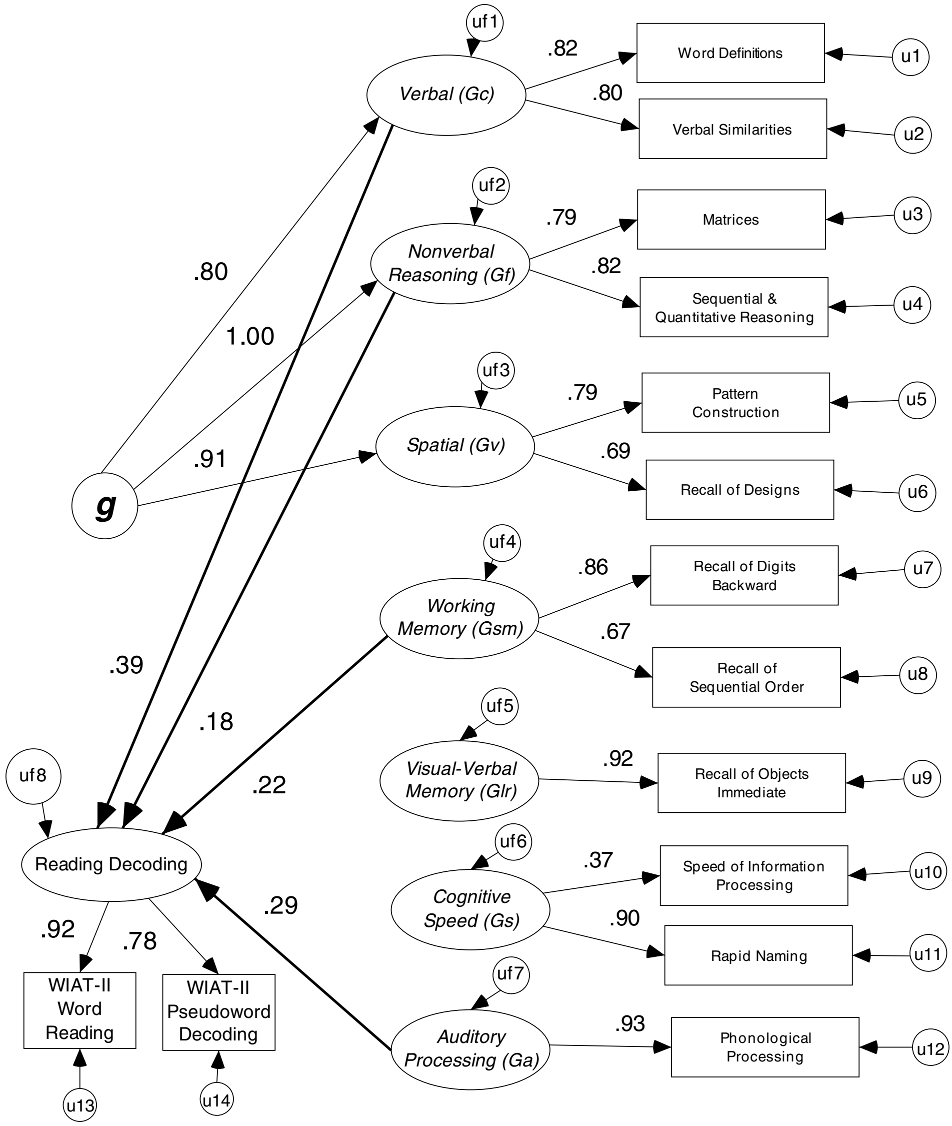

FIGURE 2. Final SEM model for Sample A, showing four CHC broad factors having significant effects on reading decoding.

Table 4 shows the standardized path coefficients for Samples A and B. Taking the path coefficient of .29 for Sample A as an example, the interpretation of the path coefficient is that if AP were to increase by 1 *SD*, Reading Decoding would increase by 0.29 *SD*s.

A major finding is that, for the typical group (Sample A), the general second-order factor, *g*, had a large but *indirect* standardized effect (.485) on the Reading Decoding factor. In other words, the effect of *g* is mediated through the three first-order factors that measure it in the DAS-II (VE, NR, and SA). The results indicate that *g* had a direct effect on these three broad first-order CHC factors, which in turn had a direct effect on the dependent variable of Reading Decoding. The poor readers

Table 4
Standardized Indirect Effects of g (in parentheses) and Standardized Direct Effects of Significant CHC Broad Cognitive Abilities on Reading Decoding for Ages 7–12

Standardized Effects	Sample A: Typical	Sample B: Poor Readers
From *g*	(.49)	(.21)
From VE (*Gc*)	.39	—
From NR (*Gf*)	.18	—
From WM (*Gsm*)	.22	—
From AP (*Ga*)	.29	.59
From SP (*Gv*)	—	.26
From VVM (*Glr*)	—	.30
From PS (*Gs*)	—	.22

showed a similar but more moderate standardized indirect effect of .211 for *g* on Reading Decoding.[3] Note that the standardized indirect effects interpretation is similar to the path coefficients: For typical children, when *g* increases by 1 *SD,* Reading Decoding increases by 0.485 *SD*s.

An interesting finding is that AP had a significant large effect on Reading Decoding both for typical readers and for poor readers, although its effect is greater among poor readers. Apart from this common significant effect, no other effects were significant for both samples. Each sample had three separate significant CHC factors that produced significant direct effects on Reading Decoding. For the typical sample, the VE (*Gc*) factor had a large effect, with moderate direct effects for NR (*Gf*) and WM (*Gsm*). For the sample of poor readers, the SP (*Gv*) and VVM (*Glr*) factors had large effects, with a moderate effect found for PS (*Gs*), thereby demonstrating that the children with reading problems have different cognitive predictor–reading achievement relationships than adequate readers.

Commonality Analyses

WR. Table 5 shows the results of the commonality analysis for WIAT-II WR. Combined, the DAS-II predictors accounted for 43% of typical WR variance, and 46% of WR variance in the SLD group. A major difference between the samples is in the percentage of unique variance. For the typical sample, 5.8% of WR variance was unique to the six DAS-II factors whereas, for the reading SLD group, there was substantial unique variance (14%) suggesting some factor specificity for interpretation, with NR, SP, and Phonological Processing (PP) playing important roles. In contrast, the percentage of WR variance accounted for by the shared variance among all six predictors gives us an estimate of the contribution of alternative conceptualization of general intelligence (*g*), and this amounts to only 2.5% for the typical group (and 1.4% for the reading SLD sample). An examination of squared zero-order correlations revealed that the four strongest DAS-II predictors of WR variance were, for the typical group, VE (31%), PP (28%), WM (27%), and SP (24%) whereas, for the reading SLD group, the four strongest predictors were SP (28%), PP (28%), NR (26%), and WM (16%). The largest commonality for the typical group (.061) was the commonality among VE/NR/SP/WM/PP factors. For the reading SLD group, the NR/SP/WM/PP commonality was the largest (.025), with the five-way VE/NR/SP/WM/PP commonality (.023) also important, which suggests that these variables share variance in WR prediction.

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[3] Standardized coefficient effect sizes between .05 and .10 are considered to be small; effect sizes between .11 and .25 are considered to be moderate, and those greater than .25 can be considered to be large effects (cf. Keith, 2006; Pedhazur, 1997).

Table 5
DAS-II Factor Predictors of WIAT-II WR Performance

	DAS-II Factor/CHC Classification					
	VE/*Gc*	NR/*Gf*	SP/*Gv*	WM/*Gsm*	PS/*Gs*	PP/*Ga*
DAS-II/WIAT-II WR – Sample C: Typical ($R^2_{\text{Total}} = .425$)						
U_{VE}	.024					
U_{NR}		.000				
U_{SP}			.018			
U_{WM}				.013		
U_{PS}					.003	
U_{PP}						.000
$C_{VE/PP}$	.051					.051
$C_{WM/PP}$				.024		.024
$C_{VE/NR/SP}$	.010	.010	.010			
$C_{VE/WM/PP}$	.021			.021		.021
$C_{VE/NR/SP/WM}$	.014	.014	.014	.014		
$C_{VE/NR/SP/PP}$	.017	.017	.017			.017
$C_{VE/NR/WM/PP}$	.024	.024		.024		.024
$C_{NR/SP/WM/PP}$		.010	.010	.010		.010
$C_{VE/NR/SP/WM/PP}$	.061	.061	.061	.061		.061
$C_{ALL(g)}$	.025	.025	.025	.025	.025	.025
Unique	.024	.000	.018	.013	.003	.000
Shared	.289	.202	.219	.253	.070	.284
Total	.313	.202	.237	.266	.073	.284
DAS-II/WIAT-II WR – Sample D: SLD in Reading ($R^2_{\text{Total}} = .457$)						
U_{VE}	.004					
U_{NR}		.021				
U_{SP}			.034			
U_{WM}				.001		
U_{PS}					.013	
U_{PP}						.067
$C_{NR/SP}$		.020	.020			
$C_{NR/PP}$		.010				.010
$C_{SP/PP}$			.026			.026
$C_{VE/NR/SP}$	.010	.010	.010			
$C_{VE/NR/PP}$	.012	.012				.012
$C_{NR/SP/WM}$		.016	.016	.016		
$C_{NR/SP/PP}$		.019	.019			.019
$C_{VE/NR/SP/PP}$	.018	.018	.018			.018
$C_{NR/SP/WM/PP}$		.025	.025	.025		.025
$C_{VE/NR/SP/WM/PP}$	.023	.023	.023	.023		.023
$C_{NR/SP/WM/PS/PP}$		.013	.013	.013	.013	.013
$C_{ALL(g)}$	.014	.014	.014	.014	.014	.014
Unique	.004	.021	.034	.001	.013	.067
Shared	.120	.238	.247	.162	.080	.211
Total	.124	.259	.281	.163	.093	.278

Note. Except for C_{ALL}, Commonalities <.01 omitted. U: Unique Variances; C: Commonalities (shared variances); Gc: Crystallized Ability; Gf: Fluid Reasoning; Gv: Visuospatial Ability; Gsm: Short-Term Memory; Gs: Cognitive Processing Speed; Ga: Auditory Processing.

Table 6
DAS-II Factor Predictors of WIAT-II PD Performance

	DAS-II Factor/CHC Classification					
	VE/*Gc*	NR/*Gf*	SP/*Gv*	WM/*Gsm*	PS/*Gs*	PP/*Ga*
	DAS-II/WIAT-II PD – Sample C: Typical ($R^2_{Total} = .338$)					
U_{VE}	.002					
U_{NR}		.002				
U_{SP}			.001			
U_{WM}				.008		
U_{PS}					.000	
U_{PP}						.054
$C_{VE/PP}$	.014					.014
$C_{SP/PP}$			.010			.010
$C_{WM/PP}$				.020		.020
$C_{NR/SP/PP}$		.010	.010			.010
$C_{NR/WM/PP}$		.012		.012		.012
$C_{VE/NR/SP/PP}$	.017	.017	.017			.017
$C_{VE/NR/WM/PP}$	.023	.023		.023		.023
$C_{NR/SP/WM/PP}$		.015	.015	.015		.015
$C_{VE/NR/SP/WM/PP}$	.048	.048	.048	.048		.048
$C_{ALL(g)}$	.020	.020	.020	.020	.020	.020
Unique	.002	.002	.001	.008	.000	.054
Shared	.172	.192	.160	.190	.038	.238
Total	.174	.194	.161	.198	.038	.292
	DAS-II/WIAT-II PD – SLD in Reading ($R^2_{Total} = .301$)					
U_{VE}	.004					
U_{NR}		.001				
U_{SP}			.004			
U_{WM}				.003		
U_{PS}					.005	
U_{PP}						.153
$C_{VE/PP}$	.010					.010
$C_{SP/PP}$			.018			.018
$C_{NR/SP/WM/PP}$		.011	.011	.011		.011
$C_{VE/NR/SP/WM/PP}$	.013	.013	.013	.013		.013
$C_{ALL(g)}$	.007	.007	.007	.007	.007	.007
Unique	.004	.001	.004	.003	.005	.153
Shared	.056	.070	.096	.072	.034	.123
Total	.060	.071	.100	.075	.039	.276

Note. Except for C_{ALL}, Commonalities <.01 omitted. U: Unique Variances; C: Commonalities (shared variances); Gc: Crystallized Ability; Gf: Fluid Reasoning; Gv: Visuospatial Ability; Gsm: Short-Term Memory; Gs: Cognitive Processing Speed; Ga: Auditory Processing.

PD. Table 6 shows the results of the commonality analysis for WIAT-II PD. For the typical group, DAS-II predictors accounted for 34% of the PD variance whereas, for the Reading SLD group, DAS-II predictors accounted for 30% of WR variance. Although significant, these variance amounts are considerably lower than those obtained for WR, and most probably reflect the lower level of cognitive complexity required for PD performance. Unlike WR, both samples demonstrated a SP/PP commonality for PD, which could suggest that this in part measures the orthographic and/or the alphabetic principle requirements during word attack. A major difference between the samples is in the percentage of unique variance, most of which was composed of PP for both. For the typical sample, 6.7% of PD variance was unique to the six DAS-II factors whereas, for the reading SLD group, there was substantial unique variance (17%), once again suggesting factor specificity for interpretation in SLD populations. The percentage of PD variance accounted for by the shared variance among all six predictors, giving us an estimate of the contribution of alternative *g*, was only 2% for the typical group, and less than 1% (0.7%) for the reading SLD sample. The four strongest DAS-II predictors of PD variance were, for the typical group, PP (29%), WM (20%), NR (19%), and VE (17%). For the reading SLD group, the four strongest predictors were PP (28%), SP (10%), WM (8%), and NR (7%). The largest commonality for the typical group (.048) was again VE/NR/SP/WM/PP, but, for the reading SLD group, SP/PP was the largest commonality (.018), with the second highest being the same five-way VE/NR/SP/WM/PP commonality (.013). Interestingly, the WM/PP commonality present in typical children was absent in the SLD sample for both the WR and PD analyses.

RC. Table 7 shows the results of the commonality analysis for WIAT-II RC. For the typical group, DAS-II predictors accounted for considerably more RC variance in the typical (49%) as compared to the reading SLD group (30%), which could indicate the presence of RC SLD subtypes (Hale, Fiorello, Miller, et al., 2008). For unique variance, 11.4% of RC variance was unique to the six DAS-II factors for the typical sample, mostly consisting of VE, SP, and PS, yet only 8% unique variance was found for the reading SLD sample, which was mostly VE, NR, SP, and PP. Once again, the contribution of alternative *g* to reading comprehension was quite small. The percentage of RC variance accounted for by the shared variance among all six predictors ($C_{ALL(g)}$) amounted to 3% for the typical group and 0.7% for the reading SLD sample. The three strongest DAS-II predictors of RC variance were, for the typical group, VE (40%), NR (31%), WM (26%), and SP (24%) whereas, for the reading SLD group, the four strongest predictors were NR (28%), SP (17%), VE (14%), and PP (14%), suggesting possible poor automaticity in the SLD group. The VE/NR/SP/WM/PP commonality was again the largest for the typical group (.062). Similarly, for the reading SLD group, the VE/NR/SP/WM/PP commonality (.021) was the largest, with the next largest (.020) being VE/NR. Interestingly, many VE commonalities found in typical children were absent in children with reading SLD, whereas NP/SP and NR/SP/WM commonalities were present in the SLD group only.

Discussion

This study compared the relationships between DAS-II CHC-based predictors of WIAT-II reading for typical children and for those with reading difficulties and disabilities. Typical group *M* values were close to the expected value, with *M* values for children with reading difficulty and SLD consistently lower (*M* range: 89–93). There was no apparent "poor reader" or "reading SLD" profile established, however, which could suggest that they have comparable reading problems and/or the inadequacy of ability–achievement discrepancy in identifying SLD (e.g., Fletcher, Denton, & Francis, 2005). Cognitive and neuropsychological evidence, however, suggests that children fail to develop adequate reading skills for multiple reasons (see Fiorello et al., 2006) and that subtypes of children with reading difficulty and disability should be identified using empirical alternatives to the traditional discrepancy approach (Hale, Flanagan, & Naglieri, 2008). There are many different significant profiles in both SLD and reading difficulty samples, with many of these profiles diametrically opposed and explicitly distinct (see Elliott, 2005, pp. 414–419). When these within-group differences are eliminated by collapsing children into a generic heterogeneous group,

Table 7
DAS-II Factor Predictors of WIAT-II RC Performance

	DAS-II Factor/CHC Classification					
	VE/*Gc*	NR/*Gf*	SP/*Gv*	WM/*Gsm*	PS/*Gs*	PP/*Ga*
	DAS-II/WIAT-II RC – Sample C: Typical ($R^2_{\text{Total}} = .489$)					
U_{VE}	.089					
U_{NR}		.000				
U_{SP}			.010			
U_{WM}				.003		
U_{PS}					.012	
U_{PP}						.000
$C_{VE/NR}$	.024	.024				
$C_{VE/SP}$	.012		.012			
$C_{VE/PP}$	.013					.013
$C_{NR/PP}$		.010				.010
$C_{WM/PP}$				.012		.012
$C_{VE/NR/SP}$	.019	.019	.019			
$C_{VE/NR/WM}$	.014	.014		.014		
$C_{VE/NR/PP}$	.014	.014				.014
$C_{VE/WM/PP}$	.012			.012		.012
$C_{NR/WM/PP}$		.011		.011		.011
$C_{VE/NR/SP/WM}$	.026	.026	.026	.026		
$C_{VE/NR/SP/PP}$	.019	.019	.019			.019
$C_{VE/NR/WM/PP}$	.033	.033		.033		.033
$C_{VE/NR/SP/WM/PP}$	.062	.062	.062	.062		.062
$C_{ALL(g)}$	.031	.031	.031	.031	.031	.031
Unique	.089	.000	.010	.003	.012	.000
Shared	.308	.306	.226	.260	.066	.232
Total	.397	.306	.236	.263	.078	.232
	DAS-II/WIAT-II RC – Sample D: Reading LD ($R^2_{\text{Total}} = .297$)					
U_{VE}	.022					
U_{NR}		.018				
U_{SP}			.015			
U_{WM}				.003		
U_{PS}					.003	
U_{PP}						.018
$C_{VE/NR}$	.020	.020				
$C_{NR/SP}$		.013	.013			
$C_{VE/NR/SP}$	.011	.011	.011			
$C_{VE/NR/PP}$	.010	.010				.010
$C_{NR/SP/WM}$		.012	.012	.012		
$C_{VE/NR/SP/PP}$	.012	.012	.012			.012
$C_{NR/SP/WM/PP}$		.013	.013	.013		.013
$C_{VE/NR/SP/WM/PP}$	.021	.021	.021	.021		.021
$C_{ALL(g)}$	.007	.007	.007	.007	.007	.007
Unique	.022	.018	.015	.003	.003	.018
Shared	.118	.179	.151	.111	.040	.122
Total	.140	.197	.166	.114	.043	.140

Note. Except for C_{ALL}, Commonalities <.01 omitted. U: Unique Variances; C: Commonalities (shared variances); Gc: Crystallized Ability; Gf: Fluid Reasoning; Gv: Visuospatial Ability; Gsm: Short-Term Memory; Gs: Cognitive Processing Speed; Ga: Auditory Processing.

attenuated cognitive performance occurs, with similar *M* values the result. In addition, collapsing distinct profiles into a generic reading disability group also attenuates correlations, and therefore limits DAS-II predictive validity. Profile diagnostic distinctions cannot be made using a global *level*-of-performance approach for samples of children with reading SLDs that have multiple causes. Instead, the identification of subgroups with distinctive profiles requires an idiographic *pattern*-of-performance-interpretation approach grounded in cognitive and neuropsychological theory and empirical evidence (Fiorello et al., 2008; Hale, Fiorello, Dumont, et al., 2008).

Both SEM and commonality analyses confirmed the inadequacy of different measures of the general factor, *g*, as a sole cognitive ability predictor of reading achievement. This finding might seem counterintuitive because of the substantial zero-order correlations typically found between *g* and reading measures. The question arises, however, as to whether this is due to the direct general factor effect or to the combined effect of the cluster scores (VE, NR, SP) from which the GCA is derived. The SEM analyses showed that, although *g* was substantially related to ability in reading decoding, its effect was *indirect.* Thus its effect is mediated through the first-order factors which measure it, confirming the conclusion reported by Floyd and colleagues (2007) and Taub and colleagues (2008). The commonality analyses also demonstrated that the shared variance of all factors, which can be considered as an alternative estimate of the variance accounted for by general intelligence (alternative *g*; Fiorello et al., 2007), was quite limited in the prediction of reading. Results confirm that factor scores, or even subtest scores if substantiated with additional evidence (e.g., Cognitive Hypothesis Testing), explain significant amounts of variance over and above the variance explained by alternative *g*, which could have diagnostic and intervention implications (Hale, Fiorello, Miller, et al., 2008).

An interesting finding is that *every one* of the seven DAS-II CHC-based predictors had a significant path in one of the two SEM analyses. This finding suggests that the DAS-II and similar measures of CHC broad factors are essential for the assessment of children with reading difficulties, not only to understand the full range of cognitive processes that may underlie their learning difficulties, but also to guide systematic instruction. This would be supported by neuropsychological research that suggests that multiple brain structures and systems are needed for reading competence (e.g., Berninger & Richards, 2002; Fiorello et al., 2006; Hale, Fiorello, & Miller, et al., 2008) and that these systems can be aligned with CHC constructs (Fiorello et al., 2008) measured by the DAS-II (Hale, Fiorello, Dumont, et al., 2008).

As has been the case in our previous DAS-II study (Hale, Fiorello, Dumont, et al., 2008), and WISC-IV studies (Hale et al., 2001; 2007; Hale, Fiorello, Miller, et al., 2008), the present commonality results demonstrate that there is more DAS-II shared variance in the typical sample than in the reading SLD sample in the prediction of WIAT-II reading subtests, with unique variance estimates often the most salient and interpretable for the SLD population. In addition, total variance estimates tend to be higher for typical children than for children with SLD in reading, which could suggest that within-sample SLD variability may require interpretation at the subtest level (and below the factor/CHC level) for individual children (Hale, Fiorello, Dumont, et al., 2008; Hale, Fiorello, Miller, et al., 2008).

As is the case in our previous WISC-IV and DAS-II studies, this level of interpretation may be necessary because the subtests account for the most achievement variance, followed by factors and finally the global composite. The loss of reliable variance is substantial when global scores (such as the DAS-II GCA or the WISC-IV Full Scale IQ) are interpreted for children with SLD to the exclusion of factor and subtest scores (Hale et al., 2007; Hale, Fiorello, Dumont, et al., 2008; Hale, Fiorello, Miller, et al., 2008). In the current commonality analyses, DAS-II CHC-based predictors accounted for considerable portions of WIAT-II WR (42.5%), PD (33.8%), and RC (48.9%) variance in the typical population, similar to the results found in the Hale, Fiorello, Miller, et al. (2008) WISC-IV study. The DAS-II CHC factors were more effective than the WISC-IV factors in predicting WR

(45.7%) and PD (30.1%) achievement for children with reading SLD, but the WISC-IV accounted for more RC variance (37.8%) as compared to the DAS-II study (29.7%) for the reading SLD group. In addition to these differences in level of performance, it is important to note that different patterns of cognitive-achievement relationships emerged for the two measures, suggesting that they are not interchangeable instruments. For instance, the WISC-IV combines *Gf* and *Gv* skills into the Perceptual Reasoning Index (PRI), which is not as effective as looking at them separately (e.g., Keith, Fine, Taub, Reynolds, & Kranzler, 2006), and this may obscure important factor interrelationships found here for the DAS-II NR and SP predictors of reading.

DAS-II Predictors of WIAT-II WR and PD

The SEM analyses carried out on typical children resulted in four factors being identified as having significant effects on reading decoding (defined by WIAT-II WR and PD subtests). The four factors (with their CHC designations and path coefficients) were VE (*Gc*; .39), PP (*Ga*; .29), WM (*Gsm*; .22), and NR (*Gf*; .18). The poor reader analyses also resulted in four significant factors, including PP (*Ga*; .59), VVM (*Glr*; .30), SP (*Gv*; .26), and PS (*Gs*; .22). Note the different paths and variables predicting reading decoding for the two samples, suggesting that, like children with SLD (e.g., Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996), these low achieving children likely experience a developmental reading *deficit*—not a reading *delay* as Response to Intervention (RTI) proponents might argue (see Hale, Fiorello, Miller, et al., 2008, for discussion). As a result, a more intense instructional approach advocated by RTI proponents (e.g., Barnett et al., 2004) may not meet the individual instructional needs of these children with reading disability (e.g., Fiorello et al., 2006).

For the typical groups, both the SEM and commonality analyses show that VE, WM, and PP are important predictors, consistent with previous research suggesting that crystallized ability, lexical–semantic knowledge, receptive and expressive language, phonological processing, and working memory processes are important for word reading (Berninger & Richards, 2002; Evans, Floyd, McCrew, & Leforgee, 2002; Fiorello et al., 2006; Hale, Fiorello, Miller, et al., 2008; Richards et al., 2006; Shaywitz et al., 2003; Simos et al., 2005). The SEM and the commonality analyses showed that, for typical children, PP was a central predictor of reading decoding, a finding consistent in the literature (Vellutino, Fletcher, Snowling, & Scanlon, 2004), suggesting that the DAS-II PP is useful in reading SLD evaluations. Prior learning of words and word meaning, tapped by VE measures such as Word Definitions and Verbal Similarities, likely facilitates automatic reading of whole words, but WM results suggest that it is also important for retrieval of words from long-term memory and for deciphering phoneme–grapheme relationships during decoding of unfamiliar words (Fiorello et al., 2006).

Children must use WM in combination with PP for effective auditory discrimination, sequential processing, analysis, and synthesis to decode words and make connections with lexical–semantic knowledge (Berninger, Abbott, Billingsley, & Nagy, 2001; Fiorello et al., 2006; Semrud-Clikeman, Guy, & Griffin, 2000; Waber et al., 2001). WM, however, was found to be a significant predictor only in the typical group, and WM variance was lower for both the poor readers group and the SLD group. Although children with reading difficulties may attempt to guess at words based on configuration, which would account for the higher NR and SP results, they likely spend significant effort processing graphemes and mapping them onto phonemes during decoding (i.e., alphabetic principle), which overloads their working memory processes and undermines reading comprehension (e.g., Gathercole et al., 2006). Given the WM/PP commonality in typical children, and its absence in children with reading SLD, intervention efforts could be designed to build maintenance and manipulation of phonemes in WM; this design could build word attack and WR skills as a result.

For typical children, the NR factor was also identified as a significant predictor for reading decoding by the SEM analysis. In the commonality analyses for typical children, it was the fifth largest predictor for WR and the third largest for PD. Commonality analyses also showed that, for children with SLD in reading, NR was the third largest predictor of WR. Between 20% and 40% of children with reading disabilities (depending on the sample) have significantly low scores on the DAS NR cluster (Elliott, 2001, 2005). Although this is a measure of *Gf*, the subtests contributing to this cluster replicate to a large degree what is required in the act of reading—visual stimulus, verbal encoding, sequencing information, and hypothesis testing—to arrive at a correct response. One neuropsychological hypothesis is that the executive control systems related to frontal lobe and white matter integrity are central to complex mental processes and that this may provide a structural correlate for fluid reasoning (*Gf*) tasks (e.g., Decker et al., 2007). Similarly, it is clear that the corpus callosum has a major role in connecting the right and left cerebral hemispheres, and limitations in callosal transmission may be implicated in cases of poor visual-verbal integration (Elliott, 2007b, p. 15).

SP is likely a measure of right hemisphere processes that appear to be more relevant for children with SLD than for typical children when reading known words and pseudowords. The greater involvement of SP in SLD children has been interpreted to reflect compensatory whole-word reading (Weekes, Coltheart, & Gordon, 1997). It could also suggest poor word reading automaticity, because the right hemisphere processes novel information and is important for new learning (Hale & Fiorello, 2004). SP is also involved in two-way SP/PP and four-way NR/SP/WM/PP commonalities found for children with reading SLD. These interactions likely reflect the greater right hemisphere skills needed to address word attack, lexical–semantic knowledge, and working memory/retrieval deficiencies, processes that diminish as children respond to systematic reading instruction (Simos et al., 2002).

DAS-II Prediction of WIAT-II RC

To comprehend written passages, children need to be proficient in lower level processes required for word reading and pseudoword tasks, as well as lexical–semantic knowledge, working memory, and reading fluency (see Fiorello et al., 2006; Hale, Fiorello, Miller, et al., 2008). Not surprisingly, VE was a strong predictor of WIAT-II RC among the typical group because word knowledge and semantic and syntactic knowledge are important for reading comprehension and competency (Hale & Fiorello, 2004). This group also used some SP and PS skills when comprehending written text, suggesting possible automaticity in word retrieval necessary for fluent reading (e.g., Fiorello et al., 2006; Hale, Fiorello, Miller, et al., 2008; Stein, 2001; Wolf, Miller, & Donnelly, 2000).

VE was still a predictor of RC for children with SLD, but VE commonalities were largely absent and, instead, NR, SP, and PP remained important, consistent with earlier arguments that they use right hemisphere global-holistic and/or visualization skills to compensate for poor left hemisphere VE, WM, and PP skills (Hale & Fiorello, 2004). Typical students had several higher level commonalities absent in the SLD group, possibly because they use multiple skills to decipher meaning in more difficult passages to obtain higher scores, whereas children with SLD may only use more basic psychological processes to respond, and not attempt passages for which basic reading demands are too great (Hale, Fiorello, Miller, et al., 2008). Compared to WR and PD, WM accounted for considerably more RC variance in the SLD group, suggesting that improving executive/WM skills could aid reading comprehension (e.g., Semrud-Clikeman et al., 2000; Swanson & Ashebaker, 2000).

The two-way NR/SP commonality found for the SLD group but not the typical group suggests that for this group the combination of decoding the visual stimulus, and subsequent verbal encoding, sequencing information, and hypothesis testing contribute to these children's ability to decipher meaning in more difficult passages. We note that there was more DAS-II NR/SP variance than WISC-IV PRI variance in Hale, Fiorello, Miller, and colleagues (2008), which could suggest that combining *Gf* and *Gv* is not effective for predicting reading and (possibly) that the Sequential and Quantitative Reasoning subtest taps into sequential processing demands during reading comprehension. Finally, the considerably lower amount of RC variance explained by DAS-II predictors in the SLD group is worth noting. This variance could suggest the presence of different SLD reading comprehension subtypes (Fiorello et al., 2006; Hale, Fiorello, Miller, et al., 2008) and that collapsing this heterogenous population into a single group attenuates results (e.g., Semrud-Clikeman & Pliszka, 2005). As a result, there may be a need to interpret below the global or CHC factor score levels when evaluating reading comprehension deficits in children with reading SLD. Given the problems with profile analysis, however, it would be important to verify any hypotheses derived from subtest interpretation with additional measures to ensure concurrent validity of findings (e.g., Cognitive Hypothesis Testing Model; Hale & Fiorello, 2004).

Limitations

We did not follow the Floyd and colleagues (2007) and Taub and colleagues (2008) method of splitting Sample A into two subsamples (Calibration and Validity). Our SEM findings may therefore have slightly overidentified significant causal paths. Independent researchers interested in replicating this study may contact the first author for the covariance matrices for the total Sample A and for split Calibration and Validation subsamples. Note that Sample B is too small to allow a split-sample analysis. In the SEM analyses, the *g* factor reflected the way *g* is measured in the DAS-II, and is not fully consistent with CHC theory. If *g* had been defined by all seven CHC factors, it is possible that the results may have been different. In addition, given the high collinearity among DAS-II CHC factors and the GCA, an opposite model that makes little clinical sense could be developed, with "*g*" being the source of most of the variance. That would eliminate the clinically and theoretically useful information derived from DAS-II CHC factors.

The method used for identifying the SLD sample (Sample D) did not use the Bonferroni or other statistical corrections for multiple comparisons. This will have increased the sample size in comparison with that achieved using more stringent criteria. In our view, this is unlikely to have a major impact on the findings from the commonality analyses. Further research into the CD-M approach for SLD identification is desirable, however. A reviewer of this article has pointed out that the selection of samples of poor readers or SLD children inevitably yields different correlations between variables to those found in the general population. This effect leaves us with a situation in which there are no objective criteria to identify SLD in reading which will not have an impact on subsequent research into their characteristics. In addition, findings reveal that relationships are not just altered in a unified direction (e.g., more unique and less shared variance), but are different for typical and reading SLD groups. What we can say with confidence is that different variables have different effects on children's reading based on whether they read well or have reading disabilities, consistent with research indicating that children with reading disability have neuropsychological deficit(s) that require individualized interventions (e.g., Hale, Fiorello, Miller, et al., 2008), not learning delays that require more intensive ones (e.g., Barnett et al., 2004).

Final Conclusions

This multimethod, multisample study has demonstrated that a range of CHC broad ability factors account for substantial portions of reading variance for typical children and children with reading SLD. Although psychometric *g* is still a reality, as has been demonstrated elsewhere (e.g., Daniel, 2007), the true utility of the DAS-II is examining subcomponent *patterns* of performance that underlie and go beyond the global intelligence score (e.g., Hale, Fiorello, Dumont, et al., 2008). The second conclusion is that it is important to evaluate all seven DAS-II CHC broad abilities in children with reading difficulty, as all seven measures accounted for significant amounts of variance in reading scores in one or more samples. Moreover, the facts that different commonalities were found for typical and reading SLD samples and the largest commonality was often VE/NR/SP/WM/PP suggest the breadth of influence of these variable interactions. The third conclusion is that the general findings from our analyses do not and cannot apply to all children with reading difficulties. Although we attempted to define our samples carefully, we are aware that reading disability is a heterogeneous, not a unitary, condition, and collapsing disparate profiles into large heterogeneous groups attenuates results. Future subtype analyses of DAS-II CHC patterns of performance will likely yield a large number of profile types, which can be subsequently evaluated for concurrent, ecological, and treatment validity (Hale, Fiorello, Dumont, et al., 2008). This study suggests that we need a range of CHC measures of cognitive ability to give us adequate understanding of the cognitive processes that might be implicated in the causation of reading difficulties or that may be harnessed in any intervention. Although DAS-II CHC measures can help with intervention design, any reading strategies attempted should be monitored, evaluated, and recycled as necessary to ensure treatment integrity and efficacy.

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