

Cognitive Predictors of Reading and Math Achievement Among Gifted Referrals

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This study investigated the predictive power of the Wechsler Intelligence Scale for Children—Fourth Edition (WISC–IV) Full Scale IQ (FSIQ), the General Ability Index (GAI), and the WISC–IV index score composites on subsequent reading and math standardized test scores among high-achieving students. The sample consisted of 84 elementary-age students who received an individual cognitive assessment with the WISC–IV in the previous year as part of the application process for gifted and talented programming through their schools. Although there were no significant differences among the mean WISC–IV index scores, 77% of the individual students evidenced statistically significant WISC–IV index score variability. Thus, intraindividual test score variability appears to be the norm among high-achieving students. In spite of this variability, regression analyses indicated that the FSIQ predicted reading comprehension and mathematics achievement better than, or as well as, the GAI or individual scores for verbal comprehension and perceptual reasoning. None of the cognitive variables correlated significantly with achievement scores for Word Reading or Pseudoword Decoding scores, but the FSIQ, GAI, Verbal Comprehension, and Perceptual Reasoning scores predicted reading comprehension. Limitations and directions for future research are discussed.

Keywords: gifted identification, GAI, WISC–IV, FSIQ

The current federal definition for gifted students is based largely on the 1972 [Marland Report to Congress](#). Almost 40 years later, this definition remains essentially unchanged. According to the definition, gifted students are students who demonstrate high ability in areas such as intellectual, creative, or artistic endeavors or in specific academic domains, and who require services and activities not typically offered by the school to fully cultivate those capacities.

Although many state and local definitions are consistent with the federal definition, the methods for identifying gifted students vary and are at the discretion of state departments of education or local education authorities. Although methods of identification vary, an assessment of

some form is often a core component of the process. In its position paper *The Role of Assessment in the Identification of Gifted Students*, the National Association for Gifted Children (NAGC, 2008) highlights a number of best assessment practices for the identification of gifted children. Among its recommendations are the use of defensible measurement practices that match the gifted program's definition, purpose, and objective.

Standardized intelligence tests are among the categories of assessment in the [NAGC \(2008\)](#) report. Cognitive tests are frequently a component of evaluations for gifted programs ([Volker & Smerbeck, 2009](#); [Winner, 2000](#)), and the Wechsler Intelligence Scale for Children—Fourth Edition (WISC–IV; [Wechsler, 2003a](#)) is the most commonly used individualized intelligence test for this purpose ([Rimm, Gilman, & Silverman, 2008](#); [Sparrow, Pfeiffer, & Newman, 2005](#); [Volker & Smerbeck, 2009](#)).

Despite a relatively long-standing federal definition and agreement on the most popular individualized cognitive measure, debate remains about which score(s) from the WISC–IV

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is/are best suited for identifying intellectually gifted students. Contributing to this debate are changes made from the Wechsler Intelligence Scale for Children—Third Edition (WISC-III; Wechsler, 1991) to the WISC-IV. One now interprets the four index scores, Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI), but not Verbal and Performance IQ. Additional subtests measuring working memory and processing speed were also added to the core battery.

Following these changes, researchers have found that the performance of gifted students on the WISC-IV often results in significant variability among the index scores (NAGC, 2010; Rimm et al., 2008; Wechsler, 2003b). In particular, scores for working memory and processing speed are frequently lower than those for verbal comprehension and perceptual reasoning. For instance, Rimm et al. (2008) presented the mean WISC-IV scores for 103 students from the Gifted Development Center in Denver, Colorado. The mean scores were VCI = 131.7, PRI = 126.4, WMI = 117.7, and PSI = 104.3 (Rimm et al., 2008). Likewise, the sample of gifted students in the *WISC-IV Technical and Interpretive Manual* (Wechsler, 2003b) had a difference of approximately 14 points between the VCI and PSI. These findings with the WISC-IV have led experts to question whether a Full Scale IQ (FSIQ) that includes specific composites and additional subtests for working memory and processing speed is the most appropriate score for gifted students (NAGC, 2010; Rimm et al., 2008; Sparrow et al., 2005).

Various alternatives to the FSIQ for identifying gifted children have been proposed. A common suggestion is the General Ability Index (GAI; Flanagan & Kaufman, 2009; NAGC, 2010; Rimm et al., 2008; Volker & Smerbeck, 2009). Prifitera, Weiss, and Saklofske (1998) suggested the GAI composite for use with the WISC-III. On the WISC-IV, the GAI is derived from a combination of the VCI and PRI scores. Because WMI and PSI scores are not included, the GAI represents a measure of cognitive ability that minimizes the impact of working memory and processing speed. Procedures for calculating the GAI and normative tables are provided in *WISC-IV Technical Report 4* (Rai-ford, Weiss, Rolfhus, & Coalson, 2005). Other recommendations for gifted identification are

the VCI or the PRI composites used individually (NAGC, 2010; Rimm et al., 2008; Sparrow et al., 2005; Volker & Smerbeck, 2009).

A number of arguments have been made in support of these recommendations. One argument is that the WISC is essentially a two-factor test among gifted students, with factors resembling the VCI and PRI composites (Sparrow et al., 2005; Watkins, Greenawalt, & Marcell, 2002). Watkins et al. (2002) identified a two-factor solution with a sample of gifted students, but the measure they analyzed was the WISC-III, not the WISC-IV. The WISC-III core subtests included subtests measuring primarily verbal comprehension and perceptual organization, but only one working memory and one processing speed subtest. It may be that the two factors that emerged were similar to verbal comprehension and perceptual organization because most of the subtests analyzed measured those constructs. These findings led Watkins et al. to recommend the GAI instead of the FSIQ for the identification of gifted students with the WISC-III. As noted previously, however, the WISC-IV is very different from the WISC-III. In fact, only five of the WISC-IV 10 core subtests were core subtests on the WISC-III. Furthermore, preliminary evidence with the core subtests of the WISC-IV suggests that the WISC-IV is a four-factor test among gifted students (Rowe, Dandridge, Pawlusch, & Thompson, 2011).

Another argument in favor of the GAI or the VCI or PRI individually is that when substantial variability exists among the index scores, the FSIQ represents merely an average of disparate abilities (Flanagan & Kaufman, 2009). Although this argument makes sense, Watkins, Glutting, and Lei (2007) found that the FSIQ predicted reading and math scores equally well between students with significant index score variability and those without significant variability. The students from the Watkins et al. study were not necessarily gifted, but the findings support the idea that the FSIQ is a valid predictor of academic achievement, even in the presence of index score variability.

A final argument for the GAI or the VCI or PRI individually is that these tasks consist primarily of reasoning or verbal tasks, and those are the tasks at which gifted students typically excel (NAGC, 2010; Rimm et al., 2008; Volker & Smerbeck, 2009). However, if the goal of

administering a cognitive test is to identify the students who are most likely to be successful in advanced academic programs, then the purpose of the assessment is prediction of achievement.

With these issues in mind, Rowe, Kingsley, and Thompson (2010) compared the predictive ability of the GAI versus the FSIQ among high-achieving students. The students in the Rowe et al. sample were referred for a cognitive assessment as part of the application for advanced academic programming in their schools, and all evidenced index score differences of at least 23 points. Rowe et al. found that even among students with substantial index score differences, the FSIQ score was a better predictor of subsequent achievement than the GAI. When Rowe et al. examined the predictive power of the individual index scores, they found that working memory scores were the strongest predictor, and it was the presence of working memory scores in the FSIQ that made it the better predictor.

Beyond the Rowe et al. (2010) study, there is little empirical research about the prediction of academic achievement among gifted students with the WISC-IV. The goal of the current study was to extend the findings of Rowe et al. by considering the predictive power of WISC-IV scores on achievement for students with less variability among their index scores. All students in the Rowe et al. study had a difference among their index scores that was greater than 22 points. However, the question remains as to whether or not the FSIQ is a valid predictor of achievement for students who demonstrate less score variability.

Method

Participants

The participants were 84 elementary-age students who received an individual, cognitive assessment at a university training clinic as part of the application for gifted and talented programming in their schools. The clinic routinely conducts cognitive assessments as part of the gifted and talented programming application for local schools.

The students in the Rowe et al. (2010) study were selected if the pattern of their WISC-IV scores met the criteria outlined by Flanagan and Kaufman (2009) for interpretation of the GAI.

Flanagan and Kaufman recommend interpreting the GAI if a student evidences a difference of at least 23 points between the lowest and highest index scores but no substantial difference (<23 points) between the VCI and PRI. For the current study, students were selected for participation if their WISC-IV scores did not meet Flanagan and Kaufman's criteria for the GAI.

The students ranged in age from 7 to 14 years old at the time of achievement testing. The mean age was 9 years 5 months. There were 45 boys (54%) and 39 (46%) girls. Parents were asked to complete a questionnaire about their child's race or ethnicity and home language, as well as parents' educational attainment and occupation. The sample included 39 White students (46%), 38 Asian students (45%), and four (5%) students of Hispanic ethnicity (two parents marked other, and one parent did not respond). A large number of parents (46%) indicated that a language in addition to or other than English was spoken at home. The most frequent was Korean (13%) followed by Telugu (8%), Chinese (6%), and Tamil (6%). The average level of parental education was 18 years. The most common occupations (30%) related to computers and engineering.

The sample, then, was diverse and well educated, but these demographics are generally consistent with those of the surrounding area. For example, the racial and ethnic composition of the local magnet high school is 46% Asian, 44% White, and 2% Hispanic. In the surrounding county, 38% of residents speak a language other than or in addition to English (Fairfax County, Virginia, government, n.d.) and 78% of adults have attended some college.

Instruments

The WISC-IV is an individually administered instrument for the assessment of children's cognitive ability or abilities (Wechsler, 2003a). The *WISC-IV Technical Manual* (Wechsler, 2003b) provides considerable information supporting the reliability and validity of the measure. For example, the internal consistency of the FSIQ score was .97 with the normative data. The internal consistency values for the VCI, PRI, WMI, and PSI scores were .94, .92, .92, and .88, respectively. The confirmatory factor analyses supported a four-factor model for the WISC-IV; high correlations with other

cognitive tests further supported the validity of the measure (Wechsler, 2003b).

The FSIQ and index scores were calculated in the standard manner, as outlined in the *WISC-IV Administration and Scoring Manual* (Wechsler, 2003a). The GAI was obtained using the instructions and tables provided in *WISC-IV Technical Report 4* (Raiford et al., 2005).

Students' academic achievement was measured with the Wechsler Individual Achievement Test—Second Edition (WIAT-II; Wechsler, 2001), an individually administered test of achievement. The nine WIAT-II subtests combine to yield four composite scores. To limit the time for study participants, we decided to administer an abbreviated achievement battery consisting of the reading and math subtests. We selected these composites because of their status as key academic areas. The reading tasks were Word Reading, Reading Comprehension, and Pseudoword Decoding, and the math subtests were Numerical Operations and Math Reasoning. The *WIAT-II Examiner's Manual* (Wechsler, 2001) gives information supporting the reliability and validity of the measure. For reading and math, the average split-half reliability values were .98 and .95, respectively. The WIAT-II also correlated highly with other achievement tests.

Procedure

At the cognitive evaluation, parents were offered the option of signing a consent form for possible inclusion in future research. We contacted consenting parents from the previous year whose children's scores did not meet criteria for the GAI. Both the cognitive and achievement testing took place at the university training clinic. The time between the cognitive and achievement tests ranged from 4 to 12 months. Graduate students in school and clinical psychology with graduate-level training in assessment administered the tests.

Analyses

We began the analyses with basic descriptive information and correlations among the variables. We followed these with a series of regression analyses to determine whether the FSIQ and the GAI predicted reading and math achievement. Because a number of participants spoke a language in addition to English, we also

examined the interaction of the FSIQ and the GAI with language for reading. For the interaction, we created a dichotomous variable for language (speaks another language/does not speak another language). Following the initial regressions, we conducted a set of hierarchical regression analyses with the four WISC-IV index scores as predictors. The advantage of hierarchical regression is that it allows researchers to control for shared variance among variables. Hierarchical regression, then, allows one to consider the unique contribution of scores for different abilities. We sought a sample of 84 students for sufficient statistical power (Cohen, 1992). Given our sample size, we did not consider the interaction of the four index scores by language. The analyses were run using SPSS 18.

Results

The descriptive statistics for the WISC-IV and achievement scores are presented in Table 1. As shown in Table 1, the means for the PRI, FSIQ, GAI, and reading and math achievement were in the superior range, and the means for the VCI, WMI, and PSI were in the high average range. None of the variables were substantially skewed or kurtotic.

There were no significant mean differences among the index scores, but many of the individual students in our sample evidenced statistically significant variability among their index scores. The mean difference between the lowest and highest index scores was 17.88 points. According to the criteria in the *WISC-IV Administration and Scoring Manual* (Wechsler, 2003a), a difference of greater than 13.20 points is significant at the .05 for all index score comparisons. In our sample, 77% of students had a difference of at least 14 points between their lowest and highest index scores.

The correlations among the variables are in Table 2. As indicated, the correlations for both the GAI and the FSIQ scores with overall reading and math scores were significant. Among the index scores, the VCI and PRI were significantly correlated with overall scores in reading, and the PRI, WMI, and PSI were correlated with math scores. It is not surprising that the correlation between the GAI and FSIQ was high (.92). A further observation about the correlations is that many of the values for cognitive

Table 1
Descriptive Statistics for WISC-IV and WIAT-II Composites

Composite	Mean	SD	Skew	Kurtosis
WISC VCI	118.20	11.93	-.19	-.19
WISC PRI	120.18	9.92	-.34	.42
WISC WMI	117.45	9.74	.16	-.35
WISC PSI	115.57	11.41	.06	.03
WISC FSIQ	123.32	9.96	-.29	.38
WISC GAI	122.38	10.99	-.12	.40
WIAT Reading	119.58	9.87	-.29	-.49
WIAT Math	129.7	16.29	.19	-.76

Note. WISC-IV = Wechsler Intelligence Scale for Children—Fourth Edition; WIAT-II = Wechsler Individual Achievement Test—Second Edition; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full Scale IQ; GAI = General Ability Index.

and achievement variables were not as high as one might expect.

One reason for the lower correlations between cognitive and overall reading scores could be that the relationships are different depending on the reading task. To explore this, we analyzed the correlations between the cognitive variables and the three reading tasks separately. As shown in Table 2, there were no significant correlations between cognitive scores and Word Reading or Pseudoword Decoding. However, the correlations between Reading Comprehension and the GAI, FSIQ, VCI, PRI, and PSI were all significant. On the basis of these findings, all subsequent analyses for reading were conducted with Reading Comprehension scores only. The relationships among cognitive vari-

ables and the math subtests were relatively similar, so we used the Mathematics composite score as the dependent variable.

Before conducting the analyses with Reading Comprehension, we examined the descriptive information and basic assumptions for this variable. In doing so, we detected an outlying case. In regression, an outlier is a case with a large standardized residual, meaning that the regression equation does a poor job of predicting the value for that case. In this case, the standardized residual was greater than -3 , and the outlying Reading Comprehension score was not consistent with other cognitive, reading, or math scores for this participant. Therefore, we did not include this case in the analyses for reading.

Table 2
Correlations Among Composite Scores

Variable	VCI	PRI	WMI	PSI	GAI	FSIQ	Math	Read
VCI	1.00							
PRI	.44**	1.00						
WMI	.38**	.37**	1.00					
PSI	.39**	.41**	.26*	1.00				
GAI	.87**	.82**	.43**	.46**	1.00			
FSIQ	.81**	.78**	.63**	.69**	.92**	1.00		
Math	.12	.39**	.43**	.23*	.28**	.37**	1.00	
Read	.24*	.23*	.20	.02	.29*	.24*	.05	1.00
WR	.15	.07	.20	-.06	.14	.11		
RC	.37**	.37**	.09	.30**	.43**	.41**		
PD	.01	.06	.15	-.19	.05	-.00		

Note. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; GAI = General Ability Index; FSIQ = Full Scale IQ; Math = WIAT-II Math composite score; Reading = WIAT-II Reading composite score; WR = WIAT-II Word Reading; RC = WIAT-II Reading Comprehension; PD = WIAT-II Pseudoword Decoding.

* $p < .05$. ** $p < .01$.

The regression equations revealed that the FSIQ score significantly predicted Reading Comprehension, $\beta = .41$, $t(81) = 4.08$, $p < .01$, and Mathematics, $\beta = .37$, $t(82) = 3.63$, $p < .01$, scores. The GAI also predicted Reading Comprehension, $\beta = .43$, $t(81) = 4.30$, $p < .01$, and Mathematics, $\beta = .28$, $t(82) = 2.67$, $p < .01$, scores. The interactions with language were not significant for either the FSIQ, $\beta = -.13$, $t(80) = -1.23$, $p = .22$, or the GAI, $\beta = -.11$, $t(80) = -1.12$, $p = .27$, and Reading Comprehension. Thus, the GAI was the better predictor of scores in reading (.43), but it was only marginally better than the FSIQ (.41). The FSIQ predicted Mathematics scores (.37) better than the GAI (.28). We elected to present standardized regression coefficients because they are easy to interpret as the correlation between the predictor and the outcome.

The results of the hierarchical regressions are found in Table 3 (Reading Comprehension) and Table 4 (Mathematics). We entered the predictors in the order of VCI, PRI, WMI, and PSI to determine whether scores for working memory and processing speed contributed to the prediction over and above the VCI and PRI. The VCI and PRI both significantly predicted Reading Comprehension, and they remained significant predictors in Step 4 with all four index scores in

Table 4
Hierarchical Regression of Math Achievement Scores on WISC-IV Index Scores

Step		β	R^2	ΔR^2
1	VCI	.12	.02	.02
2	VCI	-.06		
	PRI	.41**	.15	.13**
3	VCI	-.16		
	PRI	.32**		
	WMI	.38**	.27	.12**
4	VCI	-.18		
	PRI	.30*		
	WMI	.37**		
	PSI	.08	.27	.01

Note. WISC-IV = Wechsler Intelligence Scale for Children—Fourth Edition; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index.

* $p < .05$. ** $p < .01$.

the equation. For Mathematics, both the PRI and WMI predicted unique variance, even with the other index scores in the equation. As indicated by the R^2 and ΔR^2 values in , the WMI added significant additional variance, over and above that of the PRI.

Discussion

Current Findings

The mean scores for this high-achieving sample were lower than the commonly cited criterion (e.g., Winner, 2000) of 2 standard deviations above the mean for intellectually gifted students. However, the FSIQ score mean for the current sample was 123.3, and the FSIQ score for the gifted sample in the *WISC-IV Technical Manual* (Wechsler, 2003b) was 123.5. Thus, although our sample did not necessarily consist entirely of students selected for gifted programming, their mean scores were higher than average and were in line with scores from other samples of cognitively gifted students.

Another observation about the scores is that because participants were selected only if their scores did not meet criteria for the GAI (Flanagan & Kaufman, 2009), they evidenced less variability than those in the Rowe et al. (2010)

Table 3
Hierarchical Regression of Reading Comprehension Scores on WISC-IV Index Scores

Step		β	R^2	ΔR^2
1	VCI	.37**	.14	.14**
2	VCI	.26*		
	PRI	.25*	.19	.05*
3	VCI	.30*		
	PRI	.29*		
	WMI	-.13	.20	.01
4	VCI	.27*		
	PRI	.25*		
	WMI	-.14		
	PSI	.13	.22	.02

Note. WISC-IV = Wechsler Intelligence Scale for Children—Fourth Edition; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index.

* $p < .05$. ** $p < .01$.

study, in which the minimum difference was 23 points. Furthermore, the mean scores did not fit the typical pattern of higher VCI and PRI scores with lower scores for working memory and processing speed. Even though no pattern of score differences predominated, statistically significant differences among the index scores were still common (77% of the sample). Score variability that is statistically significant does not necessarily mean that the differences are rare or meaningful, but it does indicate that they are not likely the result of chance. Because we excluded students whose scores met [Flanagan and Kaufman's \(2009\)](#) criteria for interpreting the GAI, this finding suggests that at least moderate variability in scores is the norm among high-achieving students.

The finding of index score variability is consistent with other samples of high-achieving students ([Lohman, Gambrell, & Lakin, 2008](#); [NAGC, 2010](#); [Rimm et al., 2008](#); [Winner, 2000](#)). Reasons suggested for these differences include regression to the mean as well as differences in actual abilities. Furthermore, the inclusion of additional tasks measuring working memory and processing speed on the WISC-IV is thought to have increased the differences ([NAGC, 2010](#); [Rimm et al., 2008](#); [Sparrow et al., 2005](#)). The common finding of significant differences among index scores highlights the issue of whether or not the WISC-IV FSIQ score is a valid predictor for high-achieving students.

The FSIQ and the GAI both significantly predicted Reading Comprehension and Mathematics scores. For Reading Comprehension, the standardized regression coefficient for the GAI (.43) and the FSIQ (.41) were functionally equivalent. For Mathematics, however, the regression coefficient for the FSIQ (.37) was substantially higher than that for the GAI (.28). In both this sample and the sample from [Rowe et al. \(2010\)](#), the FSIQ was the better predictor of math.

The first paragraph of the [NAGC \(2010\)](#) position statement *Use of the WISC-IV for Gifted Identification* states, "the Full Scale IQ score of the WISC-IV often does not represent a child's intellectual abilities as well as the General Ability Index." The current results, however, along with those of [Rowe et al. \(2010\)](#) offer empirical support for use of the FSIQ as a predictor of reading and math performance among high-

achieving students. This conclusion is consistent with the NAGC recommendation for the use of sound, defensible measurement practices and the commonly accepted professional standards for validity ([American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1999](#)). In fact, those standards point to regression analyses as the most effective in specifying the prediction of test performance on an outcome variable such as achievement test scores.

From a broader perspective, the finding that the FSIQ is a predictor of achievement with high-achieving students is congruent with those of [Watkins et al. \(2007\)](#). That study found that the FSIQ significantly predicted reading and math scores even among students with significant index score variability or scatter.

As was the case in the [Rowe et al. \(2010\)](#) study, the WMI had the highest association with math scores. The strong relationship between working memory and math scores is the reason that the FSIQ was a better predictor for math. The literature on math disabilities has documented the relationship between lower working memory scores and math difficulties (e.g., [Swanson & Jerman, 2006](#)), so it is not surprising that working memory scores also predicted math performance among high-achieving students.

Although the PSI was significantly correlated with both Reading Comprehension and Mathematics scores, the results from Step 4 of the hierarchical regression analyses indicated that scores for processing speed added no unique variance to the prediction of achievement. It should be noted that had we entered the variables in a different order (i.e., with PSI scores first), the regression coefficients would remain the same in Step 4 because hierarchical regression controls for the shared variance. Thus, the relationship between scores for processing speed and achievement is due to variance the PSI shares with other cognitive ability scores and not the unique variance of the PSI. The finding that processing speed does not uniquely predict math and reading achievement scores is also consistent with the findings of [Rowe et al. \(2010\)](#). One reason could be [Kaufman's \(1992\)](#) assertion that gifted students are not necessarily good at speeded tasks. They may have a reflective cognitive style ([Kaufman, 1992](#)), and they

may be more careful and check their work, which would impair performance on timed tasks (NAGC, 2010). Another factor could be that the Coding subtest has relatively high demands for fine motor control (Kaufman, 1992), and many of our participants were given the WISC-IV in second grade. It may be that processing speed is more related to early reading skills or that processing speed becomes more predictive of academic outcomes among high-achieving students as they develop more consistent fine motor control. Future research should examine these ideas.

A surprising finding was the lower correlations among cognitive variables and reading scores. One likely reason for the lower correlations is the restricted range of scores that results from a sample of high-achieving students. Formulas exist for the correction of correlations due to restricted range. However, as Kline (2010) notes, correcting scores to reflect an unrestricted population implies that the researcher wishes to generalize to a population with unrestricted scores. Because our results are intended to apply to high-achieving students, correcting the scores would not be meaningful.

Another hypothesis for the finding with reading scores was that language was a factor, as many students in our sample spoke a language in addition to or other than English at home. However, the interactions with language were not significant. It may be that we were not accounting for language correctly. For instance, we did not distinguish between students who learned English as a second language and those who learned two languages simultaneously. This represents an area for future research.

A more accurate picture of the relationship with reading emerged by conducting analyses with reading subtest scores separately. None of the cognitive scores were associated with Word Reading or Pseudoword Decoding scores. Given that Word Reading and Pseudoword Decoding assess fundamental reading skills, however, inclusion of these measures seemed warranted. Gresham and Vellutino (2010) reported low correlations between IQ scores and early reading skills (e.g., nonsense word decoding, a parallel to Pseudoword Decoding, and word reading) among normal readers, but they did find associations between measures of verbal abilities and reading comprehension. These re-

sults are consistent with our current findings among high-achieving students.

A possible reason for the lack of a relationship between Word Reading and Pseudoword Decoding scores and those for individual cognitive abilities in the present study could be the age of our participants. They were, on average, 9 months older than the participants in the Rowe et al. (2010) study, and 90% were in at least third grade when they took the achievement tests. By that point, high-achieving students have likely mastered early decoding and word reading skills. Thus, there may have been a ceiling effect for these scores.

At the same time, working memory scores were not associated with any reading scores. These findings for working memory were somewhat surprising given the larger association between working memory and reading in the Rowe et al. (2010) study. Moreover, numerous studies have highlighted the link between low working memory scores and reading disabilities (e.g., Swanson, Zheng, & Jerman, 2009). It may be that working memory is more critical for early readers, but less critical for later readers and reading comprehension skills.

In general, the nature of reading skills and the required abilities change throughout development. For instance, Evans, Floyd, McGrew, and Leforgee (2002) examined the relationships among cognitive variables and reading tasks during childhood and adolescence with a large sample of normative data. They found that crystallized (Gc) abilities were associated with reading comprehension and basic reading scores throughout childhood and adolescence. Evans et al. also found a relationship between measures of processing speed and reading skills for early readers, but this relationship disappeared as children got older. Hence, it is likely that the association between cognitive abilities and reading achievement changes over time for high-achieving students as well. This is an additional topic for future research.

Limitations

This study is not without limitations. One limitation relates to our sample. The students who participated came from educated parents with professional occupations, and a large number of students (45%) were Asian. Moreover, many speak an additional language in their

homes. Although these demographics are representative of students in local gifted educational programs, they are not representative of all gifted students. This potentially limits the degree to which the findings generalize to other groups of high-achieving students. Future research should include larger, more representative samples. A larger number of participants and more precise information about additional languages would allow researchers to consider the impact of language on the prediction of achievement among high-achieving students. A larger sample would also allow researchers to consider the impact of age on the prediction of reading achievement.

A further limitation is the research goal. Although cognitive scores are frequently a component of the evaluation for gifted programs, multimodal assessment that includes different types of information from different sources represents best practices. None of our variables accounted for all of the variance in achievement scores, but we cannot speak to other sources of information that are predictive of success in advanced academic programs. In addition, there are many domains of giftedness, but our results apply primarily to students who are applying to programs for intellectually or academically gifted students.

Conclusions and Recommendations

Although limitations exist, this research does provide further clarification about cognitive abilities and their prediction of math and reading performance among high-achieving students. Although we selected students with less index score variability than those in the Rowe et al. (2010) study, the majority of students in the current study did have moderate index score differences. In spite of this variability, the WISC-IV FSIQ predicted reading and math performance.

The findings are particularly salient for school psychologists, as they are usually the experts in data-based decision making, psychometrics, and assessment in school settings. Moreover, school psychologists are in a position to make recommendations to parents and their colleagues in education on the basis of the empirical literature. Although these results are preliminary, the results of this study, combined with those of Rowe et al. (2010), imply that for

students applying to advanced academic programs, scores for working memory should not be overlooked if the program will include math. At the same time, the current results, together with the findings of Rowe et al., suggest that scores for processing speed can be overlooked when other cognitive scores are available.

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