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Incremental Criterion Validity of the WJ-III COG Clinical Clusters: Marginal Predictive Effects Beyond the General Factor

Ryan J. McGill

Texas Woman's University

Author notes

Ryan J. McGill, Department of Psychology and Philosophy, Texas Woman's University, P.O. Box 425470, CFO 702, Denton, TX 76204. E-Mail: rmcgill@twu.edu

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Correspondence concerning this article should be addressed to Ryan J. McGill, Department of Psychology and Philosophy, Texas Woman's University, P.O. Box 425470, CFO 702, Denton, TX 76204. E-Mail: rmcgill@twu.edu

Abstract

The current study examined the incremental validity of the clinical clusters from the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III COG) for predicting scores on the Woodcock-Johnson III Tests of Achievement (WJ-III ACH). All participants were children and adolescents (*N* = 4,722) drawn from the nationally representative WJ-III standardization sample. Hierarchical multiple regression analyses were used to assess for cluster-level effects after controlling for the variance accounted for by the General Intellectual Ability composite score. Consistent with previous studies, the GIA accounted for clinically significant portions of WJ-III ACH score variance in all of the regression models with R^2 values ranging from .33 to .63. The clinical cluster scores collectively accounted for small to moderate incremental effects with no meaningful effects observed for individual indicators. Potential implications of these results for empirically supported interpretation of the WJ-III COG are discussed.

Keywords: WJ-III COG, Incremental Validity, General Factor, Narrow Abilities

Incremental Validity of the WJ-III COG Clinical Clusters: Marginal Predictive Effects Beyond the General Factor

The Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III COG; Woodcock, McGrew, & Mather, 2001c) is a comprehensive assessment battery designed to measure general intelligence as well as broad and specific cognitive abilities. Although principally designed to measure abilities related to the Cattell-Horn-Carroll (CHC) model of intelligence, the WJ-III COG also provides users with six additional cognitive and neuropsychological clinical clusters. These clusters include measures of Phonemic Awareness, Working Memory, Broad Attention, Cognitive Fluency, Executive Processes, and Delayed Recall. The clinical clusters were designed to provide clinicians with additional measures of cognitive/neuropsychological processing abilities useful for specific diagnostic purposes (Mather & Woodcock, 2001). Additionally, many of the abilities sampled by the clinical clusters correspond with several of the “narrow” stratum I abilities in the CHC model. Narrow abilities are potentially more useful in diagnostic assessment due to the fact that they influence performance on a smaller subset of tasks, resulting in less construct irrelevant variance (Schneider, 2013).

Despite the intuitive appeal of the clinical clusters, they were supported by far fewer sources of validity evidence than the CHC-related cognitive clusters in the technical manual (Floyd et al., 2006). As a result of this limitation, subsequent reviewers (e.g., Schrank, Miller, Wendling, & Woodcock, 2010; Strauss, Sherman, & Spreen, 2006) have encouraged users to avoid interpretation of these measures until additional evidence is provided regarding their clinical utility. Unfortunately psychometric research on the WJ-III COG has focused almost exclusively on extending CHC theory through demonstrating relationships between the CHC-related clusters and subtests and external cognitive-achievement measures. As a result, the efficacy of the clinical clusters has yet to be established.

Since predicting achievement is a primary use of intelligence tests (Brown, Reynolds, & Whitaker, 1999), examining relationships between cognitive variables (e.g., cluster scores) and external measures of achievement are an important component of establishing the external validity of a cognitive measure. Since the publication of the WJ-III COG, moderate to strong relationships have been found between specific clinical clusters and standardized measures of reading (Evans, Floyd, McGrew, & Leforgee, 2001), mathematics (Floyd, Evans, & McGrew, 2003) and writing skills (Floyd, McGrew, & Evans, 2008) by investigators using simultaneous multiple regression. However the potential effects of the general factor were not controlled for in these studies, a significant limitation given recent exploratory factor analyses (Dombrowski, 2013; Dombrowski & Watkins, 2013; Floyd, Bergeron, Hamilton, & Parra, 2010) that have found that many of the subtests that comprise the clinical clusters contain large amounts of common variance attributable to *g*. These findings are not surprising given the fact that each of the clinical clusters, with the exception of Delayed Recall, contains at least one subtest that is used to derive the full-scale General Intellectual Ability (GIA) composite.

Examination of the incremental predictive validity provided by the clinical clusters after controlling for the effects of variance already accounted for by the GIA are potentially important for establishing the diagnostic efficiency of the clinical cluster scores. No incremental validity analysis was reported in the WJ-III COG technical manual (McGrew, Schrank, & Woodcock, 2007) however, zero-order correlations between the GIA and the clinical clusters ranged from .38 to .74 for the school-age sample, indicating moderate to strong relationships between these measures.

Currently, there are no examinations of the incremental validity of the WJ-III COG clinical clusters. To address this gap in the literature, the present study examined the predictive validity of the WJ-III COG clinical cluster scores in accounting for Woodcock-Johnson III Tests of Achievement (WJ-III ACH; Woodcock, McGrew, & Mather, 2001b) score variance beyond that already accounted for by the GIA. The current study is an extension of previous research and will potentially provide practitioners with additional information regarding correct interpretation of the WJ-III COG, and its forthcoming revision, in clinical/school-based practice. It should be noted that the WJ-IV COG will feature several composites associated with the clinical measures from the previous edition (e.g., short-term working memory, cognitive efficiency, perceptual speed). If the clinical clusters are to be included as part of strategies that emphasize primary interpretation of the WJ-III COG at the cluster level than they must demonstrate meaningful predictive validity beyond the GIA.

Method

Participants

Participants were drawn from the nationally representative Woodcock-Johnson III (WJ-III; Woodcock, McGrew, & Mather, 2001a) standardization sample. The sample for the current study included children and adolescents ages 6-0 to 18-11 ($N = 4{,}722$) who were administered relevant portions of both the WJ-III COG and the WJ-III ACH. Additional demographic data for the study sample is presented in Table 1. Participants ranged in grade from kindergarten to grade 12 with males comprising a larger portion of the sample ($n = 2{,}382$, 50.4%). The mean age of the sample was 11.48 ($SD = 3.51$).

Measurement Instruments

Woodcock-Johnson III Tests of Cognitive Abilities. The WJ-III COG is a multidimensional test of general intelligence for ages 2 to 90 years, comprised of 20 subtests, 12 of which contribute to the measurement of seven CHC clusters and six additional clinical cluster scores. The GIA composite is derived from a linear combination of weighted subtest measures. The norming sample (N = 8,818) is stratified according to region, community type, sex, and race, and is nationally representative based upon 2000 U.S. census estimates. Extensive normative and psychometric data can be found in the WJ-III technical manuals (McGrew, Schrank, & Woodcock, 2007; McGrew & Woodcock, 2001). Average internal consistency estimates for the included ages in this study ranged from .88 to .96 for the cluster scores. The average internal consistency estimate for the GIA was .97. Validity evidence was provided in several forms in the technical manual and independent reviews are available (Cizek, 2003; Sandoval, 2003).

Woodcock-Johnson III Tests of Achievement. The WJ III-ACH is a comprehensive academic assessment battery designed to measure five academic domains: Reading, Written Language, Mathematics, Oral Language, and Academic Knowledge. The WJ-III ACH is comprised of 22 subtests that combine to provide 17 clusters and a total achievement composite score. Average internal consistency estimates for the included ages in this study ranged from .82 to .96 for the cluster scores that were assessed. Additional technical information for the WJ-III ACH can be found in the WJ-III technical manuals (McGrew, Schrank, & Woodcock, 2007; McGrew & Woodcock, 2001).

Data Analysis

Hierarchical multiple regression analyses were conducted to assess the proportions of WJ-III ACH cluster score variance accounted for by the observed GIA and clinical cluster scores. The GIA was entered into the first block, and the clinical cluster scores were entered jointly into the second block of the SPSS version 21 linear regression analysis. Clinical cluster effects were also assessed individually by entering each cluster alone into the second block of the regression equation. WJ-III ACH analyses included the Broad Reading, Basic Reading Skills, Reading Comprehension, Broad Mathematics, Math Reasoning, Math Calculation Skills, Broad Written Language, Basic Writing Skills, Written Expression, and Oral Expression cluster scores as criterion variables. The change in the WJ-III ACH achievement variance predicted by the clinical cluster scores in the second block of the regression model provided an estimate of the incremental prediction beyond the GIA in the first block of the model. As in previous incremental validity investigations (e.g., Glutting, Watkins, Konold, & McDermott, 2006) interpretation was limited to the resulting R^2 statistic, as an effect size estimator due to the expectation of collinearity amongst the predictor variables. Guidelines for interpreting R^2 as an effect size are found in Cohen (1988); they are “small,” .01; “medium,” .09; and “large,” .25.

Missing Data Analysis. Due to the standardization procedures described in the technical manual, missing data values ranged from 14.7% (Broad Reading) to 93.6% (Delayed Recall). Little’s test for Missing Completely at Random (MCAR) was statistically significant across the sample χ^2 (2,178) = 3431.31, $p < .001$, indicating that the MCAR hypothesis may not be tenable. Consistent with strategies employed in previous validity studies using this same dataset (e.g., Taub & McGrew, 2014), hierarchical multiple regression analyses was conducted after replacing missing data with values estimated using the expected-maximization algorithm (Schafer & Graham, 2002) in the missing values subprogram of SPSS version 21.

Results

The means, standard deviations, skewness, and kurtosis statistics for all of the WJ-III cognitive and achievement variables are listed in Table 2. The mean (99.37 to 101.38) and standard deviation ranges (14.34 to 16.44) for the cognitive and achievement variables generally reflect values that would be expected for normally distributed standard score variables. Additionally, inspection of the residual plots of the data indicated that the regression models utilized in this study met the assumptions for linearity and homoscedasticity of residuals.

Table 3 presents the results from hierarchical multiple regression analyses for the WJ-III ACH achievement scores. The GIA accounted for statistically significant ($p < .05$) portions of each of the WJ-III ACH composite scores. Across the 10 regression models the GIA accounted for 33.5% (Math Calculation Skills) to 63.9% (Reading Comprehension; *Mdn* = 53.2%) of the dependent variable variance. The R^2 values that corresponded to those variance increments all indicate large effects using Cohen's (1988) interpretive guidelines.

The clinical clusters entered jointly into the second block of the regression equations accounted for 3.3% (Basic Reading Skills) to 17.6% (Oral Expression; *Mdn* = 4.9%) of incremental achievement variance. The R^2 values that corresponded to those variance increments indicated small to moderate effects. Although ANOVA-based tests of significance suggest that the clinical clusters contributed statistically significant ($p < .05$) portions of incremental achievement variance beyond the effects of the GIA, effect size estimates were considerably more conservative as indicated by the fact that none of the R^2 values associated with individual measures exceeded the critical levels for meaningful effects. The unique contributions of the WJ-III COG cluster scores in predicting each of the 10 WJ-III ACH measures were as follows:

Phonemic Awareness (0%-3.1%), Working Memory (0%-2.8%), Broad Attention (0.1%-6.4%), Executive Processes (0%-6.3%), Cognitive Fluency (0%-2.7%), and Delayed Recall (0%-8.8%).

Discussion

Due to recent advances in neuropsychological and cognitive psychology (e.g., CHC), our understanding of the nature and structure of intelligence has evolved. Accordingly, contemporary intelligence tests such as the WJ-III COG have been designed to reflect these changes and now provide users with a multitude of interpretive options. Despite the illusion of orthogonality, all cognitive indicators contain some degree of common variance that is attributable to the general factor (Canivex, 2013). The purpose of this study was to provide information about the predictive validity of the WJ-III COG clinical clusters after accounting for these effects. To this author's knowledge, this is the first investigation to do so.

Results indicated that the GIA accounted for statistically and clinically significant portions of WJ-II ACH score variance across all of the regression models. Incremental prediction of the six clinical clusters combined was also statistically significant for all of the achievement scores. The effect sizes for Reading Comprehension, Math Calculation Skills, and Oral Expression was in the moderate range whereas all remaining effect sizes for the clinical clusters combined were trivial. The unique contribution of individual cluster scores was consistently small to negligible.

Though the current study's results indicated that the clinical clusters combined accounted for moderate portions of additional achievement variance beyond the GIA in several of the prediction models, none of the individual clusters in those models accounted for meaningful effects when examined in isolation. Although similar cluster or factor level effects have been noted in incremental validity investigations using clinical samples (e.g., Nelson & Canivez, 2012; Nelson, Canivez, & Watkins, 2013), those findings were buttressed by the concomitant observation of small to moderate predictive effects associated with the full scale IQ score in many of the prediction models. In the present study, the GIA consistently accounted for large effects (Average $R^2 = .53$). As a result, primary interpretation at the cluster level was not supported.

Though previous investigations (e.g., Evans et al., 2001; Floyd, Evans, McGrew, 2003; Floyd, McGrew, Evans, 2008) examining cognitive-achievement relationships with WJ-III COG variables found significant predictive effects for many of the clinical clusters, these studies failed to account for the fact that the clinical clusters all contain non-trivial amounts of second-order variance that is attributable to *g*. Findings from the present study suggest that the previously documented significant predictive relationships between the clinical clusters and individual achievement measures may have been an artifact of the predictive power of the *g* variance contained within those cognitive measures. These findings are consistent with recent investigations (Dombrowski, 2014a; 2014b) that utilized an exploratory bifactor measurement model (Reise, 2012) to examine the latent structure of the WJ-III COG across the lifespan. Both of these studies found that after accounting for *g* variance in the WJ-III COG subtest measures there was little unique variance accounted for by the lower-order factors. According to Watkins and Beaujean (2013), the inability of lower order factors to contribute beyond shared variance with the general factor suggests that contemporary cognitive measures such as the WJ-III COG may be overfactored (e.g., Frazier & Younstrom, 2007).

Collinearity between the GIA and the six clinical clusters was observed in all of the regression models in the present study consistent with previous incremental validity investigations (e.g., Glutting et al., 2006) due to the linear combination of subtest scores to produce cluster scores as well as the GIA. According to Canivez (2013), this redundancy is precisely the problem that practitioners must confront when simultaneously interpreting full scale and cluster level scores on intelligence tests such as the WJ-III COG. Furthermore, it should be noted that collinearity does not invalidate the use of hierarchical multiple regression analysis to detect improvements in R^2 such as those provided by the clinical cluster scores beyond the GIA (Dana & Dawes, 2007; Schneider, 2008). Additionally, collinearity is not an issue in predictive studies that are limited to interpreting the R^2 statistic (Cohen, Cohen, West, & Aiken, 2003).

Limitations

This study is not without limitations that should be considered when interpreting the results. First, it is important to remember that this study was designed to be predictive in nature, which limits the explanatory inferences that can be drawn from the data. Whereas this necessarily limits the generalizability of the findings, it is worth noting that the present study utilized a large, nationally stratified, standardization sample that has been utilized consistently in the technical literature to validate WJ-III COG interpretive strategies. Nevertheless, additional research examining the generalizability of these findings to clinical samples is needed. Finally, the current analyses did not take into consideration potential developmental trends in the relative importance of specific cognitive variables (e.g., Executive Processes). Future research is needed to examine the stability of these results across the lifespan.

Implications for Practice

Several implications for practice can be drawn from the current study. First, clinicians who fail to account for the effects of the GIA when interpreting the clinical indicators on the WJ-III COG may overestimate predictive relationships between these indicators and achievement variables that are largely attributable to the variance associated with the GIA. Despite this implication, these results provide greater support for secondary interpretation of WJ-III COG cluster scores than a previous study conducted by McGill and Busse (2014) that was limited to examining the incremental predictive effects of the WJ-III COG CHC clusters; although those devoting additional clinical attention to interpreting at the cluster level must be mindful of the fact that none of the clusters individually accounted for meaningful portions of achievement beyond the GIA. Interestingly the variance coefficients for the Cognitive Fluency and Working Memory clusters ranged from 0.0% to 2.8%, indicating that effects associated with constructs most often linked to achievement deficits in the literature (e.g., Johnson et al., 2010) was mostly small. Additional research is needed to determine whether these findings are an artifact of the way those abilities are measured on the WJ-III COG.

The failure of the clinical measures to emerge consistently from the shadow of the GIA may explain why the WJ-IV test authors elected not to retain some of the measures (e.g., Executive Processes). Though it should be noted that elements of the clinical measures were incorporated into several of the retained clusters in order to increase the cognitive complexity of the measures (McGrew, Schrank, & Mather, 2014). Additional research with the soon to be published WJ-IV COG will be important in determining whether the cognitive cluster scores provide useful clinical information beyond the GIA. In the meantime, clinicians who continue to utilize the WJ-III COG are advised to focus the greatest interpretive weight on the GIA because it consistently accounted for the largest amount of variance across achievement indicators on the WJ-III ACH. Therefore, clinicians who forego interpreting the GIA in favor of the cluster scores may risk over-interpretation of the measurement instrument.

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Table 1

Demographic Information for the Study Sample (N = 4,722)

Variable	*n*	Percent of Sample	Percent of U.S. Population
Sex			
Male	2382	50.4	51.2
Female	2340	49.6	48.8
Race			
Caucasian American	3702	78.4	78.5
African American	684	14.5	16.1
American Indian	95	2.0	1.3
Asian American	241	5.1	4.1
Hispanic/Latino/Chicano			
Yes	567	12.0	18.7
No	4155	88.0	81.3
Census Region			
Northeast	1133	24.0	17.8
Midwest	978	20.7	22.3
South	1487	31.5	35.9
West	1124	23.8	24.0
Community Size			
Large City	2800	59.3	68.3
Suburban	1025	21.7	10.7
Rural	897	19.0	21.0
Type of School			
Public	4099	86.8	86.5
Private	571	12.1	11.3
Home	52	1.1	2.2
Foreign Born			
No	4486	95.0	94.3
Yes	236	5.0	5.7
Father's Education			
Less than High School	527	11.7	13.3
High School	1507	33.5	31.8
More than High School	2465	54.8	54.9
Not Available	223		
Mother's Education			
Less than High School	432	9.6	10.9
High School	1485	33.0	29.5
More than High School	2583	57.4	59.6
Not Available	222		

Table 2

Univariate Descriptive Statistics for WJ-III Cognitive-Achievement Variables

Variables	*N*	*M*	*SD*	Skewness	Kurtosis
GIA	2130	100.36	14.94	-0.12	0.39
Phonemic Awareness	3605	99.24	16.44	-0.13	0.60
Working Memory	2500	100.38	15.63	-0.15	0.64
Broad Attention	2095	99.67	15.83	-0.16	0.56
Cognitive Fluency	2330	100.53	15.49	0.09	0.41
Executive Processes	2289	100.12	14.34	-0.30	0.62
Delayed Recall	304	99.37	15.46	-0.09	0.59
Basic Reading Skills	4028	100.94	15.00	-0.35	0.57
Reading Comprehension	3217	101.15	15.53	-0.37	1.12
Math Calculation Skills	3961	100.19	15.63	-0.25	0.70
Math Reasoning	3647	100.31	15.82	-0.11	0.40
Written Expression	3890	101.13	15.10	-0.32	0.90
Oral Expression	3183	100.06	15.30	-0.11	0.43
Listening Comprehension	3831	100.00	16.08	-0.27	0.46
Broad Reading	3845	101.38	15.26	-0.36	0.99
Broad Mathematics	3954	100.76	15.70	-0.20	0.68
Broad Written Language	3877	100.51	15.44	-0.41	1.07

Note. GIA = General Intellectual Ability Composite. Obtained values rounded to the nearest hundredth.

Table 3

Incremental Contribution of Observed Woodcock-Johnson III Tests of Cognitive Abilities Clinical Cluster Scores in Predicting Woodcock-Johnson III Tests of Achievement Cluster Scores Beyond the GIA.

	Broad Reading		Basic Reading Skills	
Predictor	Variance (%)	Increment[a] (%)	Variance (%)	Increment[a] (%)
GIA	62.7	62.7*	53.3	53.3*
Clinical Clusters (*df* = 6)[b]	67.4	4.7*	56.3	3.3*
Phonemic Awareness		0.0		0.0
Working Memory		0.2*		0.4*
Broad Attention		1.1*		0.2*
Executive Processes		0.1*		1.5*
Cognitive Fluency		0.9*		0.2*
Delayed Recall		0.8*		0.3*

	Reading Comprehension		Broad Mathematics	
Predictor	Variance (%)	Increment[a] (%)	Variance (%)	Increment[a] (%)
GIA	63.9	63.9*	52.1	52.1*
Clinical Clusters (*df* = 6)[b]	75.3	11.4*	58.1	6.1*
Phonemic Awareness		0.0		3.1*
Working Memory		0.0*		1.2*
Broad Attention		0.1*		2.1*
Executive Processes		1.1*		1.2*
Cognitive Fluency		0.0*		0.0
Delayed Recall		8.8*		2.0*

	Math Calculation Skills		Math Reasoning	
Predictor	Variance (%)	Increment[a] (%)	Variance (%)	Increment[a] (%)
GIA	33.5	33.5*	60.3	60.3*
Clinical Clusters (*df* = 6)[b]	44.6	11.1*	64.4	4.1*
Phonemic Awareness		3.1*		2.5*
Working Memory		2.2*		0.3*
Broad Attention		6.4*		0.1*
Executive Processes		3.6*		0.1*
Cognitive Fluency		1.4*		0.6*
Delayed Recall		3.5*		0.6*

Predictor	Broad Written Language		Basic Writing Skills	
	Variance (%)	Increment[a] (%)	Variance (%)	Increment[a] (%)
GIA	53.0	53.0*	48.0	48.0*
Clinical Clusters (*df* = 6)[b]	57.3	4.4*	51.9	3.9*
Phonemic Awareness		0.1*		0.6*
Working Memory		0.7*		0.4*
Broad Attention		2.5*		1.2*
Executive Processes		0.1*		0.0
Cognitive Fluency		1.3*		0.1*
Delayed Recall		0.6*		0.0

Predictor	Written Expression		Oral Expression	
	Variance (%)	Increment[a] (%)	Variance (%)	Increment[a] (%)
GIA	48.9	48.9*	54.7	54.7*
Clinical Clusters (*df* = 6)[b]	53.8	5.0*	72.3	17.6*
Phonemic Awareness		0.0		0.1*
Working Memory		0.7*		2.8*
Broad Attention		2.6*		5.1*
Executive Processes		0.3*		6.3*
Cognitive Fluency		2.7*		0.1*
Delayed Recall		1.4*		7.1*

Note. GIA = General Intellectual Ability. All percentages are coefficients rounded to nearest tenth, may not equate due to rounding errors.
[a]Represents proportion of variance accounted for by variables at their point of entry in to regression equation. R^2 values multiplied by 100.
[b]Degrees of freedom reflects controlling for the effects of the GIA.
*$p < .05$.