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PREDICTIVE AND CONSTRUCT VALIDITY OF THE DEVELOPING COGNITIVE ABILITIES TEST: RELATIONS WITH THE IOWA TESTS OF BASIC SKILLS

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This study investigated the predictive and construct validity of the Developing Cognitive Abilities Test in a heterogeneous sample of 863 sixth grade students. Level H of the DCAT was administered during the student's sixth grade year and selected subtests of the Iowa Tests of Basic Skills were administered eight months later during their seventh grade year. Results showed that correlations between the DCAT and Iowa Tests of Basic Skills ranged from .50 (DCAT Spatial-ITBS Language Usage) to .74 (DCAT Total-ITBS Mathematics Problem Solving) with a median $r = .635$. Correlations also supported the construct (convergent) validity of the DCAT when compared to the ITBS with the DCAT Verbal subtest correlating significantly higher with the ITBS Vocabulary, Reading, and Language Usage than either the DCAT Quantitative or Spatial subtests which are not as verbally oriented. The DCAT Quantitative subtest was associated with the ITBS Mathematics Problem Solving to a greater extent than either the DCAT Verbal or Spatial subtests. © 2000 John Wiley & Sons, Inc.

Construction of the Developing Cognitive Abilities Test (DCAT; Beggs & Mouw, 1980) reflected a hierarchy of cognitive development presented by Bloom (1956) within three content areas (Verbal, Quantitative, and Spatial). The DCAT was revised and restandardized in 1989 with items continuing to reflect Bloom's taxonomy with Basic Cognitive Abilities tapping Knowledge and Comprehension, Application Abilities tapping Application, and Critical Thinking Abilities measuring Analysis and Synthesis within each of the three content areas (Verbal, Quantitative, and Spatial) (Wick, 1990). Designed to assess the cognitive abilities of children in grades 1 through 12, each level (C/D through L) of the DCAT is comprised of 27 items for each Content Area for a total of 81 test items. There are nine items for each Thinking Skills area within each Content Area.

The DCAT is part of the Comprehensive Assessment Program that also includes the National Achievement Test and the School Attitude Measure. All three measures were co-normed and nationally standardized from 1988–1989 using a stratified, multistage probability sample with 92,397 students. The DCAT "provides continuous measurement of student growth from grades 1 through 12" and is purported to be useful in educational decision making and student evaluation (Wick, 1990, p. 1). Other uses of the DCAT include simultaneous use with achievement batteries and attitude measures in order to develop profiles and identify discrepancies, strengths, and weaknesses that could be used in determining areas for intervention (Wick, 1990). The DCAT is also used as a screening measure for identifying potentially gifted students in an objective manner (Wick, 1990). Perhaps the most important distinguishing characteristic of the DCAT is the link between specific items and Bloom's cognitive taxonomy.

Internal consistency (KR-20) coefficients for each grade, level, content area, and thinking skills area are presented in the Technical Manual and are acceptable, ranging from .70 to .96. Most of the internal consistency estimates were in the mid .80s (Wick, 1990). As expected, internal consistency estimates were highest for the DCAT Total score, a global composite score, ranging from .88 (Grade 1, Level C/D) to .96 (Grade 4, Level F).

Construct (convergent) validity studies, although few, have shown the DCAT to have significant positive relationships with other ability measures such as the Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Slosson Intelligence Test (SIT) (Karnes & Lee, 1984; Karnes,

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Whorton, Curie, & Cantrall, 1986) but not with the Stanford Binet Intelligence Scale Form LM (Karnes et al., 1986). Although significant correlations were found between the DCAT and the WISC-R and SIT, they were low ($< .35$) and accounted for less than 12% shared variance. These low correlations may well have been the result of restricted range as the samples used in these studies were comprised of gifted students, a more homogeneous group than typically used in validity studies.

Farley and Elmore (1992) found the three subtests of the DCAT predicted performance on the Iowa Silent Reading Test (ISRT) in a sample of 165 underachieving first-year college students. The DCAT Total score was not investigated. The DCAT Verbal subtest was a better predictor of ISRT performance than the DCAT Quantitative or Spatial subtests. The correlations were generally low with only one correlation greater than .40 (DCAT Verbal-ISRT Vocabulary, $r = .49$). Perhaps due to restricted range, the DCAT subtests separately accounted for less than 12% of the achievement variability. However, multiple regression analyses indicated that both the DCAT Verbal and Spatial subtests added significant contribution to prediction of various types of reading comprehension. Henry and Bardo (1987) found significant relationships between the DCAT and the Achievement Series Test (Achievement Series Technical Manual, 1979) in a heterogeneous sample of 7007 students in 4th through 12th grades who were part of the DCAT standardization sample. Correlations were moderate to high in magnitude and provided better estimates of the true relations than previous published studies due to examination of "normal" youths. Correlations between the DCAT Verbal subtest and Achievement Series Reading and Language subtests were higher than correlations between the DCAT Verbal subtest and the Achievement Series Mathematics subtest. Correlations between the DCAT Quantitative subtest and Achievement Series Mathematics subtest were higher than correlations between the DCAT Quantitative subtest and Achievement Series Reading and Language subtests, providing evidence of the DCAT's construct (convergent) validity. Henry and Bardo (1990) also found the DCAT subtests and Total score moderately predicted later performance on the Medical College Admissions Test (MCAT) in a sample of 122 nontraditional premedical students. The DCAT Total score was the single best predictor of MCAT Biology, Physics, Science Problems, and Quantitative scores based on stepwise regression analyses. Khanna and Leitner (1992) reported that the DCAT moderately predicted freshman college GPA and at levels comparable to ACT scores. Khanna and Sheehan (1992) provided support for the construct validity of the DCAT and its use in the assessment and identification of gifted students. They found students scoring high on the Comprehensive Tests of Basic Skills (CTBS) also performed better in Application and Critical Thinking items of the DCAT than students scoring low on the CTBS.

To date, the only published studies investigating the concurrent validity of the DCAT with other measures of cognitive abilities are poorly designed with respect to the samples used. Published studies of the predictive validity of the DCAT have examined students outside the intended range of use of the DCAT. As Fox (1985) and Aylward (1992) noted, research on the validity of the DCAT, a potentially useful cognitive ability measure, is badly needed. The present study investigated the psychometric properties of the DCAT in relation to its prediction of future performance on selected subtests from the Iowa Tests of Basic Skills (ITBS). The ITBS is a frequently used measure of academic achievement in many school districts throughout the United States. If the DCAT is to be used in determining discrepancies in achievement or be useful in educational decision making, it should demonstrate adequate predictive validity. Given the moderate to high validity coefficients obtained by Henry and Bardo (1987) with the Achievement Series tests, the DCAT Total score and subtest scores were expected to have moderate to high correlations with subtests from the ITBS. Investigation of the construct validity of the DCAT was examined through convergent validity in the present study. Given the verbal nature of the ITBS Vocabulary, Reading, and Language Usage subtests, the DCAT Verbal subtest should correlate higher with these ITBS subtests than the DCAT Quantitative or Spatial subtests. Likewise, the DCAT Quantitative subtest should correlate higher with the ITBS

Mathematics Problem Solving subtest than should the DCAT Verbal or Spatial subtests. The DCAT Spatial subtest is not as theoretically related to the academic achievement areas of the ITBS and was hypothesized to have lower correlations with the ITBS subtests.

Method

Participants

Participants in this study were obtained from 1521 sixth grade students in a major southwest metropolitan area public school system. Of these, 177 (12%) were identified by the district as limited English proficient (LEP) and were thus dropped from the study. An additional 481 students were not present during administration of one or more DCAT or ITBS subtests and were missing such data. These students were also eliminated from the study.

Demographic information on the 863 students with complete DCAT *and* ITBS data indicated that 449 (52%) were female and 414 (48%) were male. Racial/ethnic characteristics were as follows: Caucasian 566 (65.6%), African American 77 (8.9%), Hispanic 170 (19.7%), Native American 28 (3.2%), and Asian American 22 (2.5%). Of the total sample, 778 (90.2%) students' primary home language was English, 62 (7.2%) students' primary home language was Spanish, and the remaining 23 (2.6%) students' primary home languages were some type of Asian or Native American language. Students in special education were not specifically excluded from administration of the DCAT or ITBS but data on special education participation was not available and thus unknown in this sample. There were 244 (28.3%) participants enrolled in the Free or Reduced Lunch program while the remaining 619 (71.7%) did not participate or were not eligible.

Instruments

The Developing Cognitive Abilities Test (DCAT; Wick, Beggs, & Mouw, 1989) is a group administered measure of mental abilities for students in grades 1 through 12 (Level C/D through Level L) which includes Verbal, Quantitative, and Spatial subtests which combine to provide a Total score. Internal consistency estimates are generally acceptable, ranging from .70 to .96, with the majority in the mid .80s (Wick, 1990). A review of the original DCAT by Fox (1985) indicated that reliability data were fairly high but that validity research was greatly needed. Aylward's (1992) review of the current edition of the DCAT was positive indicating it was well designed, psychometrically sound, and provided a broad range of assessment requiring recall, recognition, application, transformation, and integration skills. Aylward also noted the lack of validity data in the DCAT Manual.

The Iowa Tests of Basic Skills (ITBS; Hieronymus, Hoover, Cantor, Frisbie, Dunbar, Lewis, & Lindquist, 1990) is a very popular group administered test of academic achievement comprised of Vocabulary, Reading, Language Usage, Work Study, and Mathematics subtests. Test–retest stability coefficients over a one year time interval were mostly in the .70 to .90 range and internal consistency and alternate forms reliability coefficients were in the .80s and .90s (Gregory, 1996). Reviews by Lane (1992) and Raju (1992) were very positive, noting sound measurement practices, high technical standards (i.e., internal consistency and alternate forms reliability), and good content validity.

Procedure

Students were administered Level H the DCAT in March of 1993 by their sixth grade classroom teachers as part of the school district's gifted education screening and evaluation process. Test answer forms were sent to the test publisher for scoring and results were sent back to the school district on a data disk. The DCAT data set obtained by the school district included raw scores and percentile ranks. Selected subtests (Vocabulary, Reading, Language Usage, Mathematics Problem Solving) from the ITBS were administered in October of 1993 during the students' seventh grade

year as part of the State mandated academic achievement testing program. This provided a natural opportunity to investigate the short term predictive validity of the DCAT. ITBS results were also provided to the district on data disks. The ITBS data set included raw scores, grade equivalent scores, percentile ranks, and normal curve equivalent scores. DCAT and ITBS data sets were merged using the common student identification number for analyses. All data analyses utilized raw score data due to the absence of standard scores for the DCAT.

Pearson product–moment correlation coefficients were calculated between the DCAT (Total, Verbal, Quantitative, Spatial, Basic Cognitive, Application, and Critical Thinking) raw scores and ITBS (Vocabulary, Reading, Language Usage, and Mathematics Problem Solving) raw scores to estimate the predictive validity of the DCAT. To investigate the construct validity of the DCAT, dependent *t* tests for the differences between correlation coefficients (Hotelling, 1940; Guilford & Fruchter, 1978) were used to determine if there were significant differences between the various validity coefficients. To control for family-wide error rates in the predictive validity and construct validity analyses, Bonferroni correction was used resulting in α levels of .002 (.05/28), and .006 (.05/8), respectively.

Results and Discussion

Predictive Validity

Raw score means, standard deviations, and observed ranges are presented in Table 1. Pearson product–moment correlations and r^2s are presented in Table 2. The present data show the DCAT to be a significant predictor of future performance on the ITBS. All correlations between the DCAT (Total, Content Areas, Thinking Skills Areas) and ITBS (Vocabulary, Reading, Language Usage, Mathematics Problem Solving) were significant, $p < .0001$ and in the moderate to high range. Correlations ranged from .50 (DCAT Spatial-ITBS Language Usage) to .74 (DCAT Total-ITBS Mathematics Problem Solving) with a median $r = .635$. Predictive validity coefficients were highest overall for the DCAT Total score, a global composite, which accounted for approximately 50% of the achievement variability. These results are similar to the results obtained by Henry and Bardo (1987) in their study of the DCAT standardization sample. It appears that when a heterogeneous sample is studied, correlations between the DCAT and achievement tests are moderate to high in magnitude.

Table 1
Raw Score Means and Standard Deviations for DCAT and ITBS (n = *863)*

	M	*SD*	Range
Developing Cognitive Abilities Test (DCAT)			
Total	45.86	11.30	17–78
Content Areas			
Verbal	18.79	4.50	5–27
Quantitative	11.06	4.24	1–25
Spatial	16.01	4.84	3–27
Thinking Skills Areas			
Basic Cognitive	16.11	4.33	5–27
Application	16.19	4.12	3–26
Critical Thinking	13.56	4.35	1–27
Iowa Tests of Basic Skills			
Vocabulary	23.38	6.55	4–40
Reading	28.83	9.92	5–55
Language Usage	26.97	7.25	8–42
Mathematics Problem Solving	15.45	5.63	1–30

Table 2
DCAT Predictive Validity Coefficients and r^2's ($n = 863$)

	ITBS-V	ITBS-R	ITBS-LU	ITBS-MPS
Developing Cognitive Abilities Test (DCAT)				
Total	.73 (.53)	.72 (.52)	.69 (.48)	.74 (.55)
Content Areas				
Verbal	.71 (.50)	.68 (.46)	.66 (.44)	.60 (.36)
Quantitative	.58 (.34)	.60 (.36)	.56 (.31)	.73 (.53)
Spatial	.54 (.29)	.52 (.27)	.50 (.25)	.55 (.29)
Thinking Skills Areas				
Basic Cognitive	.64 (.41)	.63 (.40)	.62 (.38)	.65 (.42)
Application	.67 (.45)	.61 (.37)	.61 (.37)	.66 (.44)
Critical Thinking	.63 (.40)	.65 (.42)	.61 (.37)	.65 (.42)

Note. ITBS = Iowa Tests of Basic Skills, V = Vocabulary, R = Reading, LU = Language Usage, MPS = Mathematics Problem Solving. r^2's presented in parentheses. Basic Cognitive Abilities include knowledge and comprehension, Application Abilities include application, and Critical Thinking Abilities include analysis and synthesis skills from Bloom's taxonomy (Bloom, 1956; Wick, 1990). All correlations significant $p < .0001$.

Construct Validity

Construct validity of the DCAT was examined through convergent validity where subtests of the DCAT and ITBS measuring similar constructs should have higher correlations than subtests measuring different constructs. The correlation between the DCAT Verbal subtest and ITBS Vocabulary subtest ($r = .71$) was significantly higher than the DCAT Quantitative subtest and ITBS Vocabulary subtest, $r = .58$, $t(860) = 5.17$, $p < .00001$; and significantly higher than the correlation between the DCAT Spatial subtest and ITBS Vocabulary subtest, $r = .54$, $t(860) = 6.61$, $p < .00001$. The correlation between the DCAT Verbal subtest and ITBS Reading subtest, $r = .68$, was significantly higher than the DCAT Quantitative subtest and ITBS Reading subtest, $r = .60$, $t(860) = 3.04$, $p < .002$; and significantly higher than the DCAT Spatial subtest and ITBS Reading subtest correlation, $r = .52$, $t(860) = 5.92$, $p < .00001$. The correlation between the DCAT Verbal subtest and ITBS Language usage subtest, $r = .66$, was significantly higher than the DCAT Quantitative subtest and ITBS Language Usage subtest correlation, $r = .56$, $t(860) = 3.67$, $p < .0003$; and significantly higher than the DCAT Spatial subtest and ITBS Language Usage subtest correlation, $r = .50$, $t(860) = 5.74$, $p < .00001$. Finally, the correlation between the DCAT Quantitative subtest and ITBS Mathematics Problem Solving subtest, $r = .73$, was significantly higher than the DCAT Verbal subtest and ITBS Mathematics Problem Solving subtest correlation, $r = .60$, $t(860) = 5.38$, $p < .00001$; and significantly higher than the correlation between the DCAT Spatial subtest and ITBS Mathematics Problem Solving subtest, $r = .55$, $t(860) = 7.29$, $p < .00001$.

These results show that the DCAT Verbal subtest was associated with the verbally oriented ITBS subtests (Vocabulary, Reading, and Language Usage) to a greater extent than either the DCAT Quantitative or Spatial subtests that are not as verbally oriented. Likewise, results showed that the DCAT Quantitative subtest was associated with the quantitatively oriented ITBS subtest (Mathematics Problem Solving) to a greater extent than either the DCAT Verbal or Spatial subtests. The lowest correlations obtained were between the DCAT Spatial subtest and the four ITBS subtests, although they were significant. This was not an unexpected result as these subtests are not as theoretically related. The Verbal and Quantitative subtests of the DCAT and the subtests of the ITBS are most certainly *crystallized* (G_c) abilities whereas the Spatial subtest could be considered a type of *fluid* (G_f) ability (Cattell, 1971; Gustafsson, 1988) or *visualization* (G_v) ability (Carrol, 1993; Gustafsson, 1988; Horn, 1985). DCAT Spatial items are a mixture of tasks requiring recognition and reasoning of objects' size,

shape, symmetry, and pattern; identification of objects changes in location or position; and mental rotation, folding, or identifying divisions of objects; and mechanical principles. As such, these items are associated with a broad array of major spatial factors (Lohman, 1988) that may very well overlap and be related to both G_f *and* G_v (Horn) in what may be referred to as G_{fv} (Snow & Lohman, 1984).

Interestingly, the correlations among the DCAT Thinking Skills areas (Basic Cognitive, Application, and Critical Thinking) and ITBS subtests were relatively similar, ranging from .59 to .65. These correlations were not significantly different. This is likely because of the fact that each thinking skills area is comprised of an equal number of verbal, quantitative, and spatial items.

The present study provided ample evidence of the short term predictive and construct validity of the DCAT (Level H) with a heterogeneous sample of sixth grade students. Additional validity studies are needed to see if these findings replicate. Additional research should investigate psychometric characteristics of the DCAT with different populations, such as ethnic minorities and students with limited English proficiency (LEP). Specifically, studies of differential predictive validity should be conducted to help determine the presence or absence of predictive validity bias. If future studies replicate the present findings the DCAT may become a more frequently used group measure of cognitive abilities.

Limitations of the present study include examining the predictive validity of only one level of the DCAT (Level H). Thus, results may not generalize to other age groups or levels of the DCAT. Also, the time delay for administering the ITBS was approximately 8 months. Longer duration of time between DCAT and ITBS testing should be the topic of future research to examine the influence of time on the predictive utility of the DCAT. Finally, these data were obtained from one metropolitan school district in the southwest and although the sample was diverse with respect to race/ethnicity, gender, home language, and income, it was not selected to representative of the larger national population. Future studies should attempt to utilize more representative samples in order to generalize to the larger population. These findings, however, are certainly encouraging.

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