

Criterion-Related Validity of the Matrix Analogies Test Among High Achieving Adolescents

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ABSTRACT

The concurrent and predictive validity of the Matrix Analogies Test (MAT) was examined in a sample of 231 students who sought admission into a high school, international baccalaureate program. Significant correlations were evidenced between the MAT and the Verbal and Nonverbal section of the Otis-Lennon School Ability Test, reflecting a moderate degree of similarity between these instruments. Additionally, the MAT was found to be a significant predictor of Stanford Achievement Test Reading and Mathematics. A significant improvement in predictive power was found for the MAT, over and above the Otis-Lennon, in the prediction of mathematics achievement but not for reading achievement. Implications for practitioners and directions for future research are also provided.

Introduction

The International Baccalaureate Diploma Programme is a preuniversity course of studies, for secondary students between the ages of 16 and 19 years. The I.B. Diploma is a comprehensive, two year curriculum that allows students to fulfill requirements of various national education systems. The program involves the final two years of secondary school and is offered in English, French and Spanish. Since its founding in the mid-1960s, the program has grown to more than 400 schools in 59 countries (International Baccalaureate, 1992). In the United States, it is not unusual to find one high school within a school district designated as offering the Diploma option with enrollment open to students from high schools across the district. In some settings admission may be on an open enrollment basis, at others, various levels of screening are used to identify candidates for the program.

One of the screening components most likely to be of benefit in selecting students for an international curriculum would be a nonverbal test of intelligence which minimizes the need for receptive or expressive language in its administration and completion. One measure particularly suited for this task is the Matrix Analogies Test - Short Form (MAT; Naglieri, 1985). This test is a highly g-loaded, nonverbal measure of intellectual ability. The nonverbal nature of the MAT makes it particularly well suited for use with students from multicultural or international backgrounds.

The MAT was standardized on a nationally representative sample of students ages five through seventeen years of age. Participants in the standardization sample included representative numbers of males, females, Black, White, and Hispanic students across all levels of socioeconomic status. Significant correlations between the MAT and other tests of intelligence and academic achievement have been reported for students without handicaps (Naglieri & Bardos, 1989), and for students with learning disabilities (Bardos & Prewett, 1991; Prewett, Bardos, & Naglieri, 1988), and mental retardation (Prewett, Bardos, & Naglieri, 1989).

Similarly, the MAT has been found to correlate significantly with individual tests of intelligence in younger, gifted populations (Schneider & Gervais, 1991), and although the MAT requires no reading, it has consistently been found to correlate significantly with reading achievement in regular education (Naglieri, 1996), and above-average elementary age students (Haddad & Bardos, 1990). These results have not yet been extended however to an older, high achieving population.

The purpose of the present study was, therefore, to examine the criterion-related validity of the MAT in a sample of high-achieving adolescents. Specifically, both the concurrent validity of the MAT (comparing the test with scores from a similar group measure of intelligence), as well as the test's predictive validity (comparing the MAT with reading and mathematics achievement) will be examined.

Method

Participants

All students who sought admission into the international baccalaureate program, over a 4-year period, at an urban high school in western Pennsylvania were included as participants. This selection criteria identified 231 students who were enrolled in the eighth grade at the time of their application. Males comprised 47.7% and females 52.3% of the participants. Ethnic identity, as reported by parents on school records, was 96% White, 1% Asian-American, 1% Hispanic, and 2% Black. All students identified English as their primary home language.

Instruments

The Matrix Analogies Test - Short Form (MAT; Naglieri, 1985) is an individually or group administered test of intelligence. The test consists of 34 nonverbal, matrix type questions and requires no reading or verbal responses. The standardization sample (N = 4,668) was stratified on the bases of age, gender, ethnic background, geographic region and community size according to the 1980 U.S. Census. Reliability coefficients are adequate (median Cronbach alpha = .83), and significant correlations between the MAT and tests of academic achievement have been previously reported (Bardos & Prewett, 1991; Haddad & Juliano, 1991; Prewett & Farhney, 1994).

Additionally, a second ability measure, the Otis-Lennon School Ability Test (6th ed.) was administered to all students. The Otis-Lennon assesses verbal and nonverbal ability and includes items which measure verbal comprehension, verbal reasoning, figural reasoning, and quantitative reasoning. Reliability coefficients reported in the technical manual are satisfactory (.87 to .93), and correlations between the Otis-Lennon and the Stanford and Metropolitan Achievement Tests are also strong (Otis & Lennon, 1993).

Finally, students completed the reading and mathematics sections of the Stanford Achievement Test (8th ed.). The Stanford Achievement Test is a nationally normed instrument which can be administered in individual or group formats. Reading achievement on the Stanford includes reading vocabulary and reading comprehension sections while mathematics achievement includes concepts of numbers, mathematics computation and mathematics application (SAT-8; 1990). The technical adequacy of the Stanford is well documented (SAT-8; 1990), and the test is used by many states as part of their mandated achievement programs.

Procedure

All three tests were administered to students in a group format with groups averaging approximately 10 students per administration setting. All tests were administered by a state certified school psychologist following standardized directions.

Results

Descriptive Statistics

Table 1 presents descriptive statistics for the total sample for each of the three admissions tests. All scores are presented as standard scores. As would be expected in a high achieving sample, means for all three tests were approximately one standard deviation above average. Similarly, standard deviations for all measures were reduced slightly given the restricted range of the homogeneous sample. A follow-up t-test revealed non-significant gender differences on the MAT ($t = -.46, p > .01$) with males having only a slightly higher MAT score (114.01) than females (113.25).

Concurrent and Predictive Validity

Significant correlations were evidenced between the MAT and the Otis-Lennon Verbal ($r = .45$) and Nonverbal ($r = .53$) sections, reflecting a moderate degree of overlap between the two instruments. Although both the MAT and the Otis-Lennon Nonverbal section contain items which require the successful solving of analogies and matrixes, the moderate correlation between the two measures indicates that somewhat unique constructs are being measured and suggests that a stepwise regression approach be utilized in the prediction of academic achievement. Table 2 provides the entire correlation matrix for the MAT, Otis-Lennon and Stanford Achievement tests.

Although both the Otis-Lennon (Verbal and Nonverbal sections) and the MAT evidenced strong correlations with math and reading achievement, the rationale for selecting a stepwise method was to examine the predictive power of the MAT **over and above** what could explained from a more verbally-loaded measure of group intelligence. Subsequently, the first stepwise analysis examined the forecasting power of the MAT and the Otis-Lennon in predicting Stanford Reading Achievement. The first variable entered into the equation was the Otis-Lennon Verbal score ($R^2 = .43, P < .001$), followed by the Otis-Lennon Nonverbal score ($R^2 = .45, P < .01$), indicating a statistically significant improvement in the forecasting of reading achievement. The subsequent attempt to add the MAT score to the equation was found to not add a significant improvement to the regression model.

Table 1 Means, Standard Deviations, and Ranges of the Matrix Analogies Test, Otis-Lennon Verbal and Nonverbal Test, and Stanford Reading and Mathematics Achievement Test for the Total Sample

Test	Mean	SD	Minimum	Maximum
Matrix Analogies Test	113.60	13.81	70	138
Otis Lennon Verbal	116.03	12.71	77	138
Otis Lennon Nonverbal	115.75	13.38	70	138
Stanford Total Reading	119.44	14.30	76	138
Stanford Total Math	117.10	14.11	77	138

Table 2 Intercorrelations among the Matrix Analogies Test, Otis-Lennon, School Ability Test and Stanford Achievement Test for High Achieving Adolescents

	OL-NON	OL-VER	OL-TOT	READ	MATH
MAT	.53	.45	.55	.37	.49
OL-NON		.63	.89	.54	.69
OL-VER			.89	.66	.66
OL-TOT				.65	.75
READ					.67

Note. MAT = Matrix Analogies Test ;
 OL-NON = Otis-Lennon Nonverbal ;
 OL-VER = Otis-Lennon Verbal ;
 OL-TOT = Otis-Lennon Total ;
 READ = Stanford Reading Achievement ;
 MATH = Stanford Mathematics Achievement.

Table 3 Stepwise Regression of the Matrix Analogies Test, and Otis-Lennon Verbal and Nonverbal Test, Predicting Stanford Total Reading Achievement

Variable	R ²	B	SE B	Beta	t	Sig t
OTISVERB	.43	.59	.07	.53	8.12	.0000
OTISNONV	.45	.19	.07	.18	2.58	.0104
MAT	.46	.04	.06	.04	.68	.4981
(Constant)		25.87	6.91		3.74	.0002

Note. MAT = Matrix Analogies Test ;
 OTISNONV = Otis-Lennon Nonverbal ;
 OTISVERB = Otis-Lennon Verbal.

Table 4 Stepwise Regression of the Matrix Analogies Test, and Otis-Lennon Verbal and Nonverbal Test, Predicting Stanford Total Mathematics Achievement

Variable	R ²	B	SE B	Beta	t	Sig t
OTISNONV	.47	.42	.07	.40	6.51	.0000
OTISVERB	.55	.39	.06	.35	6.02	.0000
MAT	.56	.12	.05	.12	2.28	.0236
(Constant)		9.13	6.51		1.40	.1622

Note. MAT = Matrix Analogies Test ;
 OTISNONV = Otis-Lennon Nonverbal ;
 OTISVERB = Otis-Lennon Verbal.

The next analysis similarly examined the ability of the MAT and the Otis-Lennon to predict Stanford Mathematics Achievement. In this instance, The first variable entered into the equation was the Otis-Lennon Nonverbal score ($R^2 = .47$, $P < .001$), followed by the Otis-Lennon Verbal score ($R^2 = .55$, $P < .01$), again reflecting a statistically significant improvement in the forecasting of mathematics achievement. Unlike reading however, the subsequent addition of the MAT score to this equation did add a significant improvement to the prediction of mathematics achievement ($R^2 = .56$, $P < .05$). Tables 3 and 4 present the results of the stepwise regression results for both reading and mathematics achievement.

Discussion

These findings support Schneider & Gervais' (1991) contention that the MAT has utility in the screening of high achieving students. The nonverbal format of the MAT, combined with the fact that the measure requires no reading makes it particularly suited for students from diverse ethnic and linguistic backgrounds. The concurrent validity of the MAT was demonstrated by the significant correlations with both the Otis-Lennon Verbal and Nonverbal composites. However, given the moderate degree of overlap between the two instruments, it appears that the tests are measuring intellectual skills from somewhat different perspectives. While the approximately 20% overlap (shared variance) between the MAT and the Otis-Lennon Verbal section was not unexpected given the nonverbal quality of the MAT, it was expected that a stronger correlation would be evidenced with the Otis-Lennon Nonverbal section. Unlike the Otis-Lennon Nonverbal section, the MAT does not require reading for success and in this regard may be a more culture-free measure of nonverbal skills. However both measures do contain items involving analogies and matrices even though their degree of shared variance was less than 30%. Previous research has shown somewhat higher correlations between the MAT and other measures of intelligence (e.g. MAT and Stanford-Binet IV composite correlation of .73, Prewett & Farhney, 1994; MAT WISC-R Full Scale correlation of .75, Naglieri & Wisniewski, 1988).

It is important to note that the MAT and Otis-Lennon Nonverbal means were quite comparable and appeared to accurately reflect the intellectual characteristics of the high achieving population from which they were drawn. Similarly, the nonsignificant difference between male and female MAT scores suggests that the test remains free of gender bias in this population.

The predictive validity of the MAT was also shown in this population for both reading and mathematics achievement. Strong correlations between the MAT and Stanford Reading and Mathematics Achievement were demonstrated however, an improvement in predictive power when using the MAT in combination with the

Verbal and Nonverbal sections of the Otis-Lennon was found for mathematics achievement but not for reading achievement. In both instances, regression analyses found the Otis-Lennon Verbal and Nonverbal sections to provide separate, significant, contributions to the prediction of academic achievement; with regards to reading achievement the Otis-Lennon Verbal section loaded first, with mathematics achievement the Nonverbal section loaded first. This finding supports the contention that in the identification of high achieving students, verbal and nonverbal abilities should be considered separately (Schneider & Gervais, 1991).

As would be expected in the prediction of reading achievement, it appears that a verbally loaded screening test like the Otis-Lennon Verbal composite will offer the single greatest utility. In the present study the addition of the Otis-Lennon Nonverbal composite added only a slight improvement in this prediction, while the subsequent addition of MAT scores to this prediction equation did not contribute a significant improvement in forecasting power. Certainly reading is a linguistic process however future research should examine how the MAT relates the various components of reading achievement. In this regard, it may prove to be the case that given the analytical content of the test, the MAT is less related to basic reading skills such as word recognition and sight word vocabulary but more strongly related to higher level components such as phoneme awareness and reading comprehension.

With regards to mathematics achievement however, the MAT was found to add significant predictive power over and above that explained by the Otis-Lennon Verbal and Nonverbal indices. A post-hoc analysis indicated that this trend was true for the Concepts of Numbers and Mathematics Application sections of the Stanford Achievement Test but not for the Mathematics Computation section. In both instances the addition of MAT scores was found to contribute significant additional predictive power, over and above what was provided by the Otis-Lennon Verbal and Nonverbal sections. This finding is most likely due to the higher level, conceptual requirements of the Concepts of Numbers and Mathematics Application subtests. Mathematics Computation, in contrast, is more likely to require rote memory strategies for success, a skill not typically measured by highly g-loaded, nonverbal measures of intellectual ability such as the MAT.

Future research should continue to examine the predictive power of the MAT, on a longer-term basis, to determine whether accurate academic forecasts can be made over a four or five year basis. Additionally, the predictive power of the MAT (and other psychoeducational instruments) in determining success on International Baccalaureate Diploma Examinations has yet to be examined in a systematic, empirical manner. The nonverbal nature of the MAT will allow for this research to be conducted in the United States as well as the international educational community.

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