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Validation of the Frey and Detterman (2004) IQ prediction equations using the Reynolds Intellectual Assessment Scales

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Abstract

This study sought to assess the ability of the equations Frey and Detterman (2004) presented to assess IQ in the Reynolds Intellectual Assessment Scales (RIAS). The study confirmed Frey and Detterman's equation (2) best predicted IQ from recentered SAT scores. Nonetheless, both of the Frey and Detterman's equations did not match the optimal model found in the current data, namely that SAT Total or SAT Verbal, alone, best predicted IQ as measured by the RIAS. Implications from this study are much the same as those stated by Frey and Detterman, namely, that SAT appears to be a measure of general intelligence and is a useful tool in predicting cognitive functioning. Nonetheless, future research is needed with a wider range of IQ instruments to assess which SAT variables are the best predictors, and what weight each should be ascribed.

Keywords: Scholastic Aptitude Test (SAT); IQ prediction; Frey and Detterman; Reynolds Intellectual Assessment Scales

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1. Introduction

In 2004, Frey and Detterman reported that the Scholastic Aptitude Test (SAT) was, in large part, a measure of Spearman's (1904) *g*. Moreover, in the same article they developed two sets of regression equations to predict future IQ scores based on scores from the SAT (either the Total score, or a linear combination of the Math and Verbal sections). When such a regression model is developed in order to predict observations, it needs testing to assess its accuracy as a measure of quality—a process that requires observations obtained outside of the original sample (Camstra & Boomsma, 1992; Neter, Kutner, Nachtsheim, & Wasserman, 1996; Snee, 1977). Consequently, the purpose of this study is to assess the two regression equations given by Frey and Detterman.

The IQ score used for this study was the Composite Intelligence Index (CIX) from the Reynolds Intellectual Assessment Scales (RIAS; Reynolds & Kamphaus, 2003), a brief, individually-administered psychometric instrument that measures both general cognitive ability and general memory. There are six subtests given on the RIAS, four of which compose the CIX, with the others composing the Composite Memory Index. (For a listing of the subtests that make up the CIX, see Table 1.) The subtests that make up the CIX require both verbal and nonverbal reasoning. As it is a new instrument, few published studies are available in the professional literature, although the technical manual reports that the four subtests that make up the CIX all have moderate to high *g* loadings, ranging from .57 to .83 (Reynolds & Kamphaus, 2003, p. 98). In addition, the manual reports that the CIX highly correlates with the Wechsler Adult Intelligence Scale-Third Edition Full Scale IQ (.75; p. 107).

2. Method

Ninety-seven students from a general psychology class in a private, Midwestern university participated in this study. The participants were recruited from a general education component of the university, and represented a wide cross-section of academic majors. Their ages ranged from 18 to 23, approximately 75% of whom were female, and 94% of whom self-identified as Caucasian. They were administered the RIAS and their obtained CIX scores were used as the participants'

Table 1
RIAS subtests that make up the CIX score

Subtest	Name	Brief description
1	Guess What	Measures Vocabulary and Reasoning Skills; Participant is to guess the correct word from clues presented by examiner
2	Odd-Item Out	Measures general, nonverbal reasoning skills; Examinee must pick the one figure/drawing in a group that does not belong
3	Verbal Reasoning	Measures analytical reasoning; Examinee must complete orally presented sentences (1–2 words answers)
4	What's Missing	Measuring nonverbal reasoning; Examinee must determine missing component in a picture

Note. Taken from Reynolds and Kamphaus (2003). Reynolds Intellectual Assessment Scales. Lutz, FL: Psychological Assessment Resources, pp. 23–40.

Table 2
SAT ⇒ IQ studies

	Studies			
	Frey and Detterman (2004)		Current study	
	Eq. (1)	Eq. (2)	Eq. (1)	Eq. (2)
n	917	103	97	97
IQ	ASVAB	Raven's APM	RIAS Composite IQ	RIAS Composite IQ
$\bar{x}_{SAT}$	854	1372	1162	1162
$\bar{\sigma}_{SAT}$	226	119	131	131
$r_{SAT,IQ}$	.820	.483	.426*	.426
$r^*_{SAT,IQ}$	.857	.720	.583*	.583
R	.857	.554		
R^2	.734	.307		
$\hat{\beta}_{0_1}$	40.063			
$\hat{\beta}_1$ (SAT)	.126			
$\hat{\beta}_2$ (SAT^2)	−0.0000417			
$\hat{\beta}_{0_2}$		50.241		
$\hat{\beta}_1$ (SAT − M)		.095		
$\hat{\beta}_1$ (SAT − V)		−0.003		
SE_p	5.94	9.76		
$r_{IQ,\hat{IQ}}$	.481	.482	.337*	.301*
$r^2_{IQ,\hat{IQ}}$	.231	.232	.114	.091
$R^2 - r^2_{IQ,\hat{IQ}}$ (shrinkage)	.503	.075	.620	.216
SE_p (RIAS CIX)	13.320	11.859		

$r_{SAT,IQ}$: Uncorrected correlation between SAT and IQ.
$r^*_{SAT,IQ}$: Corrected correlation between SAT and IQ.
R: Multiple R for final model.
$\hat{\beta}_0$: Intercept; $\hat{\beta}_i (i = 1, \ldots, X)$: regression weights.
SE_p: Standard Error of Prediction.
* $p < .01$.

IQ score. In addition, SAT Verbal, SAT Math, and SAT Total scores were obtained from the transcript of each participant.[1]

Using the two equations Frey and Detterman (2004) provided to predict IQ scores from SAT scores (pp. 375–376), an IQ score was generated for each participant and correlated with their actual score, a coefficient called the *cross-validity coefficient* Osborne (2000) (see Table 2). For both equations, the correlation between the actual and predicted RIAS CIX scores was significant using an α of .01. When this coefficient is squared and subtracted from the original equation's R^2 values, it gives the amount of shrinkage. For the current study, Eq. (1) showed shrinkage of .620 and Eq. (2) showed shrinkage of .216. While the former is close to the value Frey and Detterman (2004) found (.503, p. 376), the latter is quite a bit larger than that found by Frey and Detterman (.075, p. 376). The standard error for predicting the RIAS CIX score using Eq. (1)

[1] Some participants in the project took the ACT. In these cases, the ACT scores were converted to the SAT metric via the tables in Dorans (1999).

Table 3
Subsequent regression equations

Model	$\hat{\beta}_0$ (SE)	$\hat{\beta}_1$ (SE)	$\hat{\beta}_2$ (SE)	R^2	adj R^2	C_p	AIC	SE_p	Tolerance	VIF
1	83.166 (6.027)	.012 (.010)	.035* (.011)	.184	.1730	.6757	371.286	6.6242	.712	1.404
2	94.177 (5.107)	.029* (.009)		.0915	.1009	9.8668	380.3647	6.959		
3	85.806 (5.629)	.042* (.009)		.1641	.1728	1.6484	372.2879	6.675		
4	82.901 (6.098)	.024* (.005)		.1726	.1813	0.6757	371.2859	6.641		

VIF: Variance Inflation Factor; C_p: Mallows' statistic; AIC: Akaike's Information Criterion.
SE_p: Standard Error of Prediction.
Model 1: SAT Math, SAT Verbal.
Model 2: SAT Math.
Model 3: SAT Verbal.
Model 4: SAT Total.
* $p < .01$.

was 13.320, and for Eq. (2) was 11.859. Overall, then, it appears that Eq. (2) predicted IQ better that Eq. (1), at least when measuring IQ by the RIAS.

As a subsequent analysis, regression equations were re-estimated using the current data. After checking for all linear regression assumptions, four different models were compared: (a) SAT Math + SAT Verbal; (b) SAT Math; (c) SAT Verbal; and (d) SAT Total[2] (see Table 3). From the table, it appears that using both SAT Math and SAT Verbal does not produce the optimal equation, as when both variables are included SAT Math loses significance as a predictor, although there was no indication of severe multicollinearity. Consequently, it appears that either using SAT Total or SAT Verbal (alone) as the predictor variable produces the best equation. As the *n* for this study is relatively small, cross-validation within the sample is not feasible.

3. Discussion

The purpose of this study was to assess the regression equations given by Frey and Detterman (2004). To that end, this study used IQ data gathered from the RIAS to evaluate the Detterman and Frey equations. This study found that for Eq. (1), there was substantial shrinkage, a result that Detterman and Frey also found in their own cross-validation. For Eq. (2), this study found that there was more shrinkage than that reported by Detterman and Frey, but that the degree of shrinkage was still much less than that found for Eq. (1). Likewise, this study also found the standard error of prediction was larger than that reported by Detterman and Frey for both equations, but was lower for Eq. (2).

As a subsequent analysis, this study found that, at least when using the RIAS CIX score as a measure of IQ, using SAT Verbal and SAT Math as predictors does not provide the optimal regression equation. Rather, using either SAT Total or SAT Verbal, alone, produced a better

[2] Of particular note was the fact that there was no curvilinear relationship between SAT and (RIAS) IQ, as Frey and Detterman (2004) noted existed between SAT and ASVAB scores (p. 374).

fitting model that explained as much of the variance in IQ as the combined SAT Verbal and SAT Math model.

Consequently, this study's findings lend support to Frey and Detterman (2004) in that their Eq. (2) is more appropriate than Eq. (1) for use with recentered SAT scores (i.e., scores obtained after 1985), but do not confirm that Eq. (2) is the optimum way to predict IQ from SAT scores. Even though the current participants had mean SAT scores more than 1.5 standard deviations above the national mean (i.e., their scores were from the high end of the IQ/SAT distribution), Eq. (2) did not optimally predict IQ scores derived from the RIAS—a finding that would have been predicted from Detterman and Frey's second study. Rather, it was a model that included just SAT Total (or perhaps SAT Verbal) that best predicted IQ scores. Part of the reason for this finding could be due to the fact that the CIX score is made up of both verbal and nonverbal subtests and the instrument Frey and Detterman (2004) used to measure IQ was strictly a nonverbal instrument, but more research, using both nonverbally- and verbally-loaded IQ scores, is needed to see if, indeed, this is the case.

Despite the difference in optimal prediction equations, this study provides support to the major findings of Frey and Detterman (2004):

> First, the SAT is an adequate measure of general intelligence, and second, it is a useful tool in predicting cognitive functioning when other estimates of intelligence are unavailable, too time-consuming, or too costly (p. 377).

Future research is definitely needed, though, with a wider array of IQ instruments to see which combination of SAT variables is needed to best predict IQ scores, and the exact weight they should be given.

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