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ACT and general cognitive ability

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Abstract

Research on the SAT has shown a substantial correlation with measures of *g* such as the Armed Services Vocational Aptitude Battery (ASVAB). Another widely administered test for college admission is the American College Test (ACT). Using the National Longitudinal Survey of Youth 1979, measures of *g* were derived from the ASVAB and correlated with ACT scores for 1075 participants. The resulting correlation was .77. The ACT also shows significant correlations with the SAT and several standard IQ tests. A more recent sample ($N=149$) consisting of ACT scores and the Raven's APM shows a correlation of .61 between Raven's-derived IQ scores and Composite ACT scores. It appears that ACT scores can be used to accurately predict IQ in the general population.

Keywords: ACT; General cognitive ability; SAT; Advanced progressive matrices; ASVAB

A primary concern of college-bound adolescents is performance on a college admissions test. One of the most widely used tests is the American College Test (ACT). The ACT is accepted by colleges throughout the United States and is administered to over 1 million students annually. Designed in 1959 as an alternative to the SAT, the ACT purports to closely parallel high school curriculum and to measure the preparedness of the test-taker for more advanced education. According to the ACT web site: "The ACT is curriculum-based. The ACT is not an aptitude or an IQ test" (Facts about the ACT). Frey and Detterman (2004) showed that the SAT was correlated with measures of general intelligence .82 (.87 when corrected for nonlinearity). In addition, a correlation of .92 was found between SAT I Verbal + Math and ACT composite scores in a sample of 103,525 students, and ACT Math correlated .89 with SAT I Math (Dorans, Lyu, Pommerich, & Houston, 1997). Given the similarity between the SAT and the ACT it is not unreasonable to expect that the ACT would show similar correlations with general intelligence, despite claims to the contrary. However, to the best of our knowledge, the relationship between the ACT and general intelligence has never been investigated in a large sample.

The ACT is composed of four sections measuring Mathematics, English, Reading, and Science, with a composite score that is the average of the four subtest scores. The score range for each subtest is 1–36 with a 2003 average of 20.8. Composite and subtest scores have varied little in the past decade, though changes to the ACT were implemented in 2005 in the form of an optional writing test (Facts about the ACT).

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Much research has focused on the usefulness of the ACT for predicting success in college. Stumpf and Stanley (2002) found that ACT scores show a .70 correlation with college graduation rates. In addition, ACT scores have been shown to correlate with college GPA from .54 to .63, and the ACT math subtest correlates with math GPA from .48 to .64 (Koretz & Berends, 2001; Pettijohn, 1995; Sibert & Ayers, 1989; Snowman, Leitner, Snyder, & Lockhart, 1980). Composite ACT scores are generally better at predicting college GPA than is high school GPA, especially at high levels of ability (Noble & Sawyer, 2002). In data gathered at St. Norbert College, ACT composite scores correlated with final college GPA about .50, and the correlation between ACT composite scores and high school GPA was found to be about .55. (St. Norbert College, 2002).

In general, tests of academic achievement correlate with IQ scores about .50 (Brody, 1997; Petrill & Wilkerson, 2000). Several studies have explored the relationship between IQ and ACT scores specifically (Lewis & Johnson, 1985; Steinberg, Segel, & Levine, 1967). These studies used relatively small samples and found moderate to high correlations between verbal, performance, and full scale IQ and English, Mathematics, and Composite ACT scores. In addition, the ACT composite scores show gender effects, with males scoring significantly higher than females (Mau & Lynn, 2001). This does not mean that the ACT is a biased test. Dragsow (1987) used Item Response Theory to analyze a sample of over 8000 individual scores on the ACT Mathematics and English subtests and found no gender or race bias.

The psychometric similarities between measures of academic achievement and measures of IQ are great. Coyle (2006) correlated scores on the SAT and ACT with performance on three highly *g*-loaded cognitive measures (college GPA, the Wonderlic Personnel Test and a word recall task). The *g*, or general, factor is a common element among all tests of mental ability, the first shared factor that is extracted through factor analysis. Coyle performed a factor analysis that showed high *g*-loading for raw ACT and SAT scores, and the raw scores were significantly predictive of scores on measures of cognitive ability. Coyle also calculated change scores on the SAT and ACT (all subjects had taken the exams twice). Change scores did not correlate with *g*, indicating that a change in score on a test of academic achievement does not represent a change in *g*. Rather, change scores may represent change in a group factor, such as memory or spatial ability. This is consistent with research that shows that for tests of cognitive ability test–retest change scores are not related to *g* (Jensen, 1998, pp. 314–316).

There is also considerable research on the relationship between IQ, academic achievement, and heritability. It is well-established that the genetic influence on IQ is significant. As an individual ages, there is evidence that the heritability of IQ increases, so that environment accounts for less individual variance (Plomin, 1986). Twin studies show that levels of heritability for academic achievement are only slightly lower than levels of heritability for IQ. For example, in a sample of 91 adult male twin pairs, Lichtenstein and Pederson (1997) found that the heritability of educational attainment was .42. In a sample of 132 dizygotic twin pairs and 146 monozygotic twin pairs, aged 6–12, Thompson, Detterman, and Plomin (1991) found the genetic contribution to academic achievement was about .30, while the shared family environment effect was .60. Academic achievement appears to follow the same pattern of heritability, with heritability increasing with age (see review in Petrill & Wilkerson, 2000).

In a study of the Queensland Core Skills Test (QCST), Wainwright, Wright, Geffen, Luciano, and Martin (2005) investigated genetic and environmental contributions to performance. The QCST is a test of academic achievement given to students in the 12th year of schooling. It includes writing, multiple choice, and short response, and is designed to test reasoning and the ability to integrate information. 326 dizygotic twin pairs and 256 monozygotic twin pairs ranging from 15 to 22 years were administered the QCST and the Multidimensional Aptitude Battery (MAD), a measure of IQ. The adjusted heritability on the QCST was found to be .64. A correlation of .81 was found between MAD Verbal IQ and QCST scores and .57 between MAD Math IQ and QCST scores. The authors also found that the genetic influences responsible for the heritability of IQ overlapped almost completely with those responsible for the heritability of academic achievement. This is similar to the findings of Thompson et al. (1991), who also found that genetic influences can best explain the covariance between cognitive ability and achievement. According to Wainwright et al. (2005), this finding makes intuitive sense. Tests of academic achievement in many respects measure what a student has been exposed to and assimilated during his or her education. Many widely-used IQ tests include subtests (such as Vocabulary) that depend on knowledge an individual has been exposed to through culture. Indeed, in many cases Verbal IQ correlates more highly with measures of academic achievement than Performance IQ (Thompson et al., 1991; Wainwright et al., 2005).

As discussed in Frey and Detterman (2004), the ability to predict IQ from widely used tests such as the SAT and ACT can increase the accuracy of estimates of pre-morbid functioning in clinical populations. Clinicians currently use a number of demographic variables and current performance on psychological measures to predict pre-morbid functioning in individuals who sustain, for example, an injury causing brain damage (Baade & Schoenberg, 2004). While demographic variables alone can be useful in prediction, the addition of tests of current functioning increases prediction substantially (Axelrod, Vanderploeg, & Schinka, 1999). However, premorbid ACT scores may provide a more efficient and more accurate means of estimation. Because a large number of students have taken the ACT, the potential impact of a more accurate estimate of IQ is great.

In a review of existing research, Baade and Schoenberg (2004) looked at 15 studies of academic achievement and IQ. Their review finds a high correlation between a variety of achievement tests (including the ACT) and scores on the WAIS or WISC. The authors suggest the use of the predicted-difference algorithm to calculate IQ from test scores, but caution that at the time of the review no large scale research had looked at the relationship between many of the measures of academic achievement and IQ. The validity of the predicted-difference method described in the article depends on a high correlation between IQ scores and measures of academic achievement, and confirmation of the relationship is critical.

The growing field of cognitive epidemiology would also benefit from a widely-used test of cognitive abilities. By exploring the link between differences in general intelligence and illness and injury rates, investigators can account for group differences in health outcomes. With a fuller understanding of the causes of disparate health outcomes, more appropriate preventative measures can be developed and implemented (Gottfredson, 2004; Gottfredson & Deary, 2004). A test as widely used as the ACT would surely be an asset to this research. Beyond the idea of group differences, knowledge of an individual's level of cognitive functioning can aid health workers in identifying those individuals who may need additional assistance understanding the "job" of managing their healthcare (Lubinski & Humphreys, 1997).

Use of ACT as a measure of intelligence has implications for other research as well. Researchers that use undergraduate populations will gain a valuable tool, as ACT scores could be used as an estimate of IQ when administration of traditional IQ tests is impractical. As noted, ACT scores have already been used as an estimate of IQ in some research. The conclusions of these papers depend on the relationship between ACT and cognitive ability. A transformation equation will provide an accurate estimate of IQ that preserves traditional scaling for comparison across studies. By examining the relationship between ACT and cognitive ability in a large sample we hope to develop an equation to quickly predict cognitive ability from ACT.

1. Study 1

1.1. Method

1.1.1. Sample

The current study utilized the National Longitudinal Survey of Youth 1979 (NLSY79) data set, available from the Center for Human Resource Research at The Ohio State University (www.chrr.ohio-state.edu). The National Longitudinal Surveys are directed by the Bureau of Labor Statistics of the U.S. Department of Labor. They were originally developed to collect labor market and labor force data, but the content of the questions cover a variety of subjects.

The NLSY79 is a sample of 12,686 individuals living in the United States in 1979. Participants were 14–22 year-old in 1979. They were interviewed annually from 1979 to 1994 and continue to be interviewed every other year. The sample was designed to be nationally representative, with 24% African–American respondents, 15% Hispanic respondents, 41% Caucasian respondents (National Longitudinal Surveys).

1.1.2. Procedures

Variables used for analysis included the ACT Verbal and Math subtests, the Armed Services Vocational Aptitude Battery (ASVAB), the Scholastic Aptitude Test (SAT), and six standard intelligence tests.

The ASVAB is administered to new recruits by the US military to determine eligibility and trainability. The Department of Defense selected the nationally representative NLSY79 sample to update the ASVAB norms. At the request of the Department of Defense, the ASVAB was administered to 11,914 NLSY79 participants (94% of the total sample) in 1980. Participants were born between 1957 and 1964 (Miller, 2004).

A measure of *g* was derived from the 10 ASVAB subtests using principal factor analysis. Ree and Carretta (1994) found a three-factor hierarchical model best represents the ASVAB, with 63.8% of common variance accounted for by the first factor *g*. Kass, Mitchell,

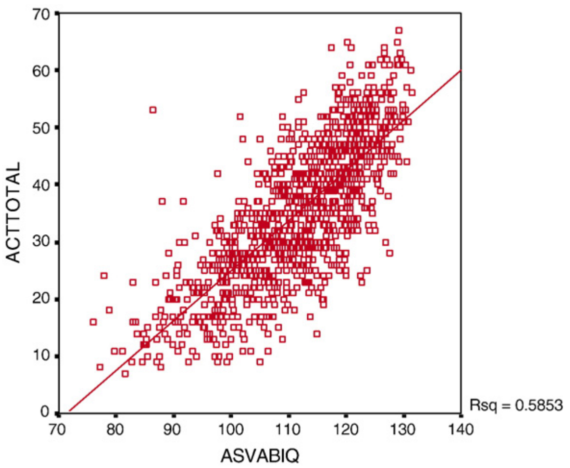

Fig. 1. Scatter plot of the relationship between total (Math+Verbal) ACT score and ASVAB IQ.

Grafton, and Wing (1983) factor analyzed a sample of 98,689 ASVAB scores from Army applicants. They found few meaningful differences in factor loadings across race/ethnic group or gender. Ree and Carretta (1995) analyzed ASVAB scores from a portion of the NLSY79 sample. For all gender groups and racial/ethnic groups *g* accounted for the most variance, and the researchers concluded that predictiveness should be consistent across groups.

A total of 11,914 subjects had available ASVAB scores, and all 10 subtests showed loading on *g*. Explained variance ranged from .687 for Coding Speed to .896 for Word Knowledge. The equation $IQ=(z*15)+100$ was used to transform the first factor onto an IQ scale.

ACT, SAT, and standard intelligence test data were gathered from high school and transcript surveys for those respondents over 17 years of age. Three rounds of data were collected in 1980, 1981, and 1983 (Miller, 2004).

The IQ scores derived from the ASVAB were correlated with the ACT scores for the 1075 respondents who had scores on the ASVAB, ACT verbal, and ACT math. One participant was discarded because both ACT math and verbal scores were not within the allowed range of ACT scores. Simple correlations were examined between ACT, SAT, ASVAB factor scores and the six standard intelligence tests.

1.2. Results

1075 subjects had scores on all ASVAB subtests and scores on the Verbal and Math portions of the ACT. A significant correlation was found between total (Math+Verbal) ACT score and ASVAB IQ ($r=.77$, $p<.001$). A scatter plot of this relationship revealed an *r*-squared of .5853 (Fig. 1). A squared component of the total ACT score added a significant but small amount of prediction and was not included in the regression ($r=.77$, $p<.001$).

Total ACT showed significant correlations ($p<.01$) with all of the standard intelligence tests, ranging from .55 to .81 (Table 1). The ACT and all standard intelligence tests show significant correlations ($p<.01$) with the first factor of the ASVAB. The highest correlation with the ASVAB factor score was the Coop School and College Test ($r=.83$, $p<.01$), followed by the California Test ($r=.78$, $p<.01$) and the ACT

Table 1
Correlations between ACT and tests of mental ability

Test		1	2	3	4	5	6	7	8	Total *N*
1. California test	*r*	–	.757**	.769	.878**	.582**	.888**	.794**	.777**	599
	N		12	6	7	25	19	64	358	
2. Otis–Lennon			–	.864**	.525	.738**	.605	.719**	.756**	1,191
				27	11	85	5	97	572	
3. Lorge–Thorndike				–	.377	.545**	.485*	.545**	.560**	691
					12	64	17	32	295	
4. Henmon–Nelson					–	−.532	.858**	.713**	.690**	201
						7	19	29	166	
5. Differential aptitude						–	.770**	.783**	.751**	569
							28	110	600	
6. Coop school and college							–	.814**	.825**	164
								33	162	
7. ACT Total								–	.767**	1,123
									1075	
8. ASVAB									–	11,914

*$p>.05$ **$p>.01$.

Table 2
Correlations between SAT, ACT, and ASVAB

	SAT Math SAT Math section	SAT Verb SAT Verbal section	ACT Math ACT Math section	ACT Verb ACT Verbal section	ASVAB IQ	ACT total	SAT total
SAT Math							
Pearson correlation	1	.748	.860	.723	.782	.857	.935
SAT Verbal							
Pearson correlation		1	.646	.738	.747	.729	.935
ACT Math							
Pearson correlation			1	.673	.743	.944	.827
ACT Verbal							
Pearson correlation				1	.647	.878	.797
ASVAB IQ							
Pearson correlation					1	.767	.817
ACT total							
Pearson correlation						1	.868
SAT total							
Pearson correlation							1

All correlations are significant at the 0.01 level (2-tailed).

(r=.77, p<.01). Total ACT and total SAT correlate .87 (Table 2).

From the regression of total ACT on the transformed first factor of the ASVAB, the following equation was developed:

$$X'_{IQ} = (.685^{*}\text{ACTTOTAL}) + 87.760 \quad (1)$$

This equation has a standard error of prediction of 7.11. This standard error illustrates that using ACT for prediction is somewhat less accurate than using SAT scores, but is more accurate than traditional methods of IQ estimation (Frey & Detterman, 2004).

A double jack knife procedure was used to determine the reliability of prediction. The 1075 subjects with ACT and ASVAB scores were randomly split into two roughly equal groups. A regression equation was developed for each group and used to predict IQ in the other half of the sample. The predicted IQ for each sample was correlated with the transformed ASVAB factor scores for the same sample. IQ predicted from the regression equation developed on the first set of data correlated .75 (p<.01) with IQ extracted from the ASVAB on the second set. IQ predicted from the regression equation developed on the second set of data correlated .78 (p<.01) with IQ extracted from the ASVAB on the first set.

Though the NLSY79 only provided Math and Verbal subtest scores, past ACT research suggests even better prediction using a Composite ACT score. Further research with a more recent sample could provide a more precise equation, particularly given changes in the ACT.

2. Study 2

2.1. Method

2.1.1. Participants

Participants were recruited through the psychology subject pool at a private university. Valid ACT scores were obtained for 72 male and 77 female participants through the university records office.

2.1.2. Procedures

Participants completed the Raven's Advanced Progressive Matrices (1962 Revision) in untimed sessions. ACT scores were acquired from the Case Western Reserve University Office of Undergraduate Studies with the written consent of the participants.

Raven's scores were transformed onto an IQ scale using Table APM36 of the Raven's APM Manual (p. APM 102, Raven, Raven, & Court, 1998). A significant difference was found for the ACT Math, ACT Composite, and Raven's scores between males and females, with males scoring slightly higher than females. All differences were significant at the p<.001 level. The difference between male and female participants is likely due to selection bias at the university the sample was drawn from. It did not affect further analyses. The number of participants identified as a particular ethnic or racial group did not allow for meaningful analysis of between-group differences.

2.2. Results

Raven's APM scores on an IQ scale and Composite ACT scores showed a simple correlation of r=.61,

Table 3
Comparison of mean ACT scores

	Study 1		Study 2		National scores	
English	Mean	SD	Mean	SD	Mean	SD
	17.57	5.51	27.9	4.06	20.4	5.9
Math	Mean	SD	Mean	SD	Mean	SD
	17.51	7.99	28.3	3.87	20.7	5.0
Composite	–		Mean	SD	Mean	SD
			28.2	3.24	20.9	4.8

$p<.001$. Math ACT scores correlated with IQ at $r=.56$, $p<.001$, and English ACT showed a correlation of $r=.43$, $p<.001$.

The current sample shows a restriction of range (Table 3). The ACT has no targeted population standard deviation, but a correction for restriction of range was performed using the 2005 average scores and standard deviations for all students taking the ACT (1,186,251 individuals). Composite ACT showed a corrected correlation of $r=.75$, Math ACT showed a corrected correlation of $r=.65$, and English ACT showed a corrected correlation of $r=.57$.

As in Study 1, a jack knife procedure was used to test for reliability of prediction. The dataset was randomly split and a regression equation was developed for each half using ACT comprehensive scores. The Raven's derived IQ scores were correlated with IQ scores predicted from the regression equation developed on the other half of the data. IQ predicted from the equation developed on half one correlated .53, $p<.01$ with Raven's IQ on half two. IQ predicted from the equation developed on half two correlated .67, $p<.01$ with Raven's IQ on half one.

2.2.1. Cross validation

In order to validate our equations across data sets we applied the regression equation developed on each dataset to the other. The equation created using Study 1 data was used to predict IQ in the Study 2 dataset. IQs predicted from the first equation correlated significantly with the Raven's IQ ($r=.61$, $p<.01$). Study 1 IQ predicted from the Study 2 equation correlated with ASVAB IQ ($r=.77$, $p<.01$).

2.3. Discussion

The analyses presented above demonstrate a significant relationship between measures of cognitive ability and ACT scores. Based upon correlations with conventional intelligence tests and the first factor of the ASVAB, it appears that that ACT is a measure of general intelligence. Indeed, based on the correlations among the tests in Study 1, the ACT is indistinguishable from other tests that are identified as intelligence tests. In addition, the ACT shows a high correlation with the SAT, itself considered to be a measure of intelligence (Frey & Detterman, 2004). The jackknife analysis confirms the stability of these results.

In an analysis of three test batteries, Johnson, Bouchard, Krueger, McGue, and Gottesman (2004) found that the *g* factors extracted from each test are essentially identical. The three batteries were composed of over 42 subtests, tapping a variety of mental abilities. They concluded that a common component of mental ability, *g*, is consistently tapped by even very distinct tests of mental ability. This conclusion was also supported by Roznowski (1987) in a sample of over 20,000 individuals. In this study males and females were given sets of tests that were selected to be gender-biased. For example, female tests included etiquette, foods, and home economics. Male tests included mechanics, military, and fishing. Scores on these narrow tests were highly correlated with measures of general intelligence and were highly predictive of general intelligence. We suspect that a factor analysis of all four subtests of the ACT would yield a common factor that is highly correlated with the first factor of other tests of mental ability. In addition, evidence that the ACT is an IQ test is shown though equivalency of prediction. The ASVAB is known to be a measure of crystallized intelligence, while the Raven's is well established as a measure of fluid intelligence (Roberts et al., 2000). That both types of tests are so closely related to the ACT is evidence that the ACT is an acceptable measure of general intelligence.

The more recent sample obtained in Study 2, while showing restriction of range, also shows significant correlation between a measure of cognitive ability and ACT scores. In particular, use of a Composite ACT score as a rough estimate of IQ can prove useful when other testing methods are unavailable or not practical. This application will prove especially useful to those researchers working in fields that utilize large sample sizes drawn from the general population, and those that work with college students, many of whom will have ACT scores on file. Clinicians will find ACT scores a reliable estimate of premorbid intelligence in individuals where no conventional measure of premorbid IQ is available. ACT scores show high correlations with conventional IQ measures and are more quickly and easily obtained and converted than demographic data and measures of current functioning.

As discussed in the opening of this article, ACT, Inc. claims that the ACT is not an IQ test, but rather measures the preparedness of the test-taker for advanced education. Given the results of the current study, this statement is misleading. Colleges that use scores on the ACT and SAT for admission decisions are basing admissions partially on intelligence test results. Whether this is acceptable or efficient practice is beyond the scope of this article, but we argue that the testing companies have a responsibility to the public to accurately describe what these widely-used tests measure.

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