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ABSTRACT

The relationships between examinee background characteristics and performance on the Graduate Record Examinations (GRE) General Test were appraised by a structural equation modeling analysis. The initial characteristics of 3,145 examinees (i.e., sex, ethnicity, parental education, geographic region, and age) had modest relationships with their test performance. Of these, parental education had the most consistent and strongest association. Sex also had an appreciable association, but it was limited to the quantitative score. College-related characteristics (e.g., college major and the institution's public vs. private control, Carnegie classification, selectivity, and Ph.D. productivity) and undergraduate grade point average (GPA) generally had stronger and more pervasive relationships with test performance than did the examinees' initial characteristics, not only by mediating the associations of the examinees' initial characteristics with test performance but also by making independent contributions in their own right. The associations were especially strong for school quality (e.g., a composite of public vs. private control, selectivity, and Ph.D. productivity), college major, and undergraduate GPA. Five tables and three figures illustrate the analysis. (Contains 38 references.) (Author/SLD)

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RESEARCH

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Lawrence J. Stricker
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Donald A. Rock



March 1993

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ETS Research Report 92-80

Educational Testing Service, Princeton, New Jersey

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March 1993

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Educational Testing Service, Princeton, N.J. 08541

The Graduate Record Examinations Board and Educational Testing Service are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

Abstract

The relationships between examinee background characteristics and performance on the GRE General Test were appraised by a structural equation modeling analysis. The examinees' initial characteristics (sex, ethnicity, parental education, geographic region, and age) had modest relationships with their test performance. Of these, parental education had the most consistent and strongest association. Sex also had an appreciable association, but it was limited to the quantitative score. College-related characteristics (college major and the institution's public vs. private control, Carnegie classification, selectivity, and Ph.D. productivity) and undergraduate grade-point average (GPA) generally had stronger and more pervasive relationships with test performance than did the examinees' initial characteristics, not only mediating the associations of the examinees' initial characteristics with test performance but also making independent contributions in their own right. The associations were especially strong for school quality (a composite of public vs. private control, selectivity, and Ph.D. productivity), college major, and undergraduate GPA.

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## Introduction

A variety of examinee background characteristics are known to be associated with performance on the GRE General Test (Conrad, Trismen, & Miller, 1977), as routine summaries of test data demonstrate (e.g., Wah & Robinson, 1990). A few of the more salient characteristics--sex, ethnicity, and age--have been the subject of research (Clark, 1984; Hartle, Baratz, & Clark, 1983; Rock, Werts, & Grandy, 1982; Stricker, 1982, 1984; Stricker & Rock, 1987; Swinton, 1987). However, other potentially important characteristics, such as socioeconomic status (see the review by Loehlin, Lindzey, & Spuhler, 1975), have largely been ignored. Furthermore, it is difficult to gauge, on the basis of existing data, the relative importance of even sex, ethnicity, and age, for they have been studied in isolation, investigations typically focusing on a single characteristic. In the General Test examinee population, these characteristics are not only interrelated but also have different patterns of associations with a variety of pertinent variables, some of which may be "causes" of others (Holland & Thayer, 1983). This confounding is not easily disentangled. For example, male and female examinees differ in college major (e.g., Wah & Robinson, 1990). Sex, by virtue of the socialization process, may affect choice of majors (e.g., see the review by Fox, Tobin, & Brody, 1975), and the educational experiences associated with the major, in turn, may affect test performance (e.g., Astin, 1968). In this hypothetical situation, the link between sex and test performance is indirect, mediated by college major.

Although their results must be interpreted cautiously because of these problems, two recent studies suggest these several examinee characteristics are independently associated with performance on the General Test. One investigation found that ethnicity, age, father's education, mother's education, college major, overall grade-point average (GPA) in the last two years of college, and GPA in college major had significant regression weights in predicting all three scores on the test--verbal, quantitative, and analytical; sex had significant weights in predicting the quantitative and analytical scores only; and English proficiency had significant weights in predicting the verbal and analytical scores only (Powers, 1985). A second study found that age, college major, type of college (i.e., public vs. private), size of college, and years since college graduation each had noticeable effects on the results when used to make stepwise adjustments, by the standardization method, in both the verbal and quantitative scores for different ethnic groups, and sex had a noticeable effect on the results for the quantitative score only (Holland & Thayer, 1983). (The General Test in the study did not include an analytical score.)

In contrast to the limited information about the comparative importance of different background characteristics in performance on the General Test or other college- or graduate-level admissions tests, a great deal is known about the role of background characteristics in performance on ability and achievement tests at the elementary and secondary school levels (see the reviews by Bridge, Judd, & Moock, 1979; Jencks, 1972). A schematic "input-output" model (Werts, 1968) of the relationships between students' characteristics and test performance in this work appears in Figure 1. This model indicates that students' own initial characteristics (e.g., sex, socioeconomic status) are not only directly associated with test performance but indirectly associated with test performance through the mediation of school characteristics (e.g., school quality, amount of schooling). The most pertinent conclusions from this research are that students' sex and

socioeconomic status, along with the amount and quality of their schooling, have at least modest associations with test performance.

One input-output study is especially relevant because it not only included many pertinent characteristics of examinees but also was based on young adults, similar in age to General Test examinees (Griliches & Mason, 1973). This investigation estimated, among other things, the relationships of background characteristics with performance on the Armed Forces Qualification Test (Uhlaner, 1952) for a national sample of employed male veterans 21 to 34 years old. The variables examined were the examinees' initial characteristics (ethnicity, father's education, father's occupation, type of childhood community [e.g., city, suburb], and geographical region of childhood residence) and school characteristics (amount of schooling before military service). Ethnicity, amount of schooling, and geographical region had larger direct associations with test performance than did father's education, father's occupation, or type of community. (The associations for the last variable were not significant.) The indirect associations were not reported.

The aim of this study was to assess the comparative importance of a comprehensive set of background characteristics in examinees' performance on the General Test, using analytical methods designed to disentangle the confounding among the various characteristics.

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Insert Figure 1 about here

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## Method

### Samples and Test Form

The total sample consisted of the 3,145 examinees who (a) took Form 3JGR3 of the General Test at the October 1989 administration; (b) had complete data for the test scores and background variables; (c) were college seniors or recent graduates (i.e., graduated in 1989); (d) reported that English was their best language; (e) were United States citizens or permanent residents; and (f) had no test irregularities. The total sample was randomly divided into two subsamples: Sample 1 ($N$=1,573) and Sample 2 ($N$=1,572).

This test administration was chosen because of its recency and large size (67,494 examinees, divided among four different test forms); this test form was selected because it had been administered to the largest number of examinees who met the requirements for inclusion in the study sample.

Restricting the sample to college seniors and recent graduates was necessary to ensure that variables concerning the examinees' college career had the same meaning for everyone. For example, college grades in the 1960s may not be comparable to current grades because of grade inflation (e.g., Bejar & Blew, 1981), and the association of 1960s grades with current test performance is attenuated by the passage of time. This restriction, while facilitating the evaluation of other background variables, precludes an adequate appraisal of the importance of age. (Age is included in the study,

but primarily because of its possible value in clarifying the associations of other variables.)

Limiting the sample to citizens and permanent residents was essential to obtain information about ethnicity and permanent residence in the United States, because data on these variables are not available for other examinees.

The characteristics of the samples are summarized in Tables 1 and 2. The two subsamples were very similar. For the total sample, slightly more than half of the examinees were women (56%), most were White (89%), and they typically resided in the South (34%). Their mean age was 23, both of their parents had a mean of 15 years of education, and their mean General Test scores were 531 for verbal, 591 for quantitative, and 598 for analytical. The examinees were graduates of 709 undergraduate institutions.

These examinees were similar to the 1989-90 test-taking population in sex (53% women) and ethnicity (85% White) but differed in their General Test performance (Educational Testing Service, 1992). The population's mean scores were 487 for verbal, 557 for quantitative, and 534 for analytical. These mean differences largely reflect the comparative youth of the study sample, given the relationship between age and test performance (Holland & Thayer, 1983; Powers, 1985).

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Insert Tables 1 and 2 about here

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## Variables

Background characteristics. The examinee background characteristics are listed below. Most were derived from data on the registration form, including the Background Information Questions and test records. The remaining characteristics were derived by matching undergraduate institution (reported on the registration form) with data for the institution from other sources: type of control--1984-85 (i.e., public, private; Center for Statistics, 1986), Carnegie classification--1987 (categorization by level of degree offered and comprehensiveness of mission; Carnegie Foundation for the Advancement of Teaching, 1987), Ph.D. productivity ratio (proportion of 1946-76 baccalaureates receiving Ph.D.s in 1951-80 in all fields; Fuller, 1986), and college selectivity (estimated mean total SAT scores for 1973 entering freshmen; Astin & Henson, 1977). The background characteristics fall into three groups:

1. Examinees' initial characteristics

   a. Female sex (female = 1, male = 0)

   b. Asian ethnicity (Asian = 1, all others = 0)

   c. Black-Hispanic-Other ethnicity (Black, Hispanic, American Indian, or Other = 1, all others = 0)[1]

d. Father's education--years (grade school or less = 4; some high school = 10; high school diploma or equivalent = 12; some college or associate's degree = 14; bachelor's degree = 16; some graduate or professional school, or graduate or professional degree = 18)

e. Mother's education--years (coded the same as father's education)

f. Northeastern resident (Northeastern = 1, all others = 0)[2]

g. Northcentral resident (Northcentral = 1, all others = 0)

h. Western resident (Western = 1, all others = 0)

i. Age--years

2. College-related characteristics

a. Physical science major (physical science = 1, all others = 0)[3]

b. Research university (Research Universities I or II = 1, all others = 0)[4]

c. Public institution (public = 1, all others = 0)

d. College selectivity

e. Ph.D. productivity ratio (highest ratio = 1, all others = 0)[5]

3. College-related performance

a. Undergraduate GPA--overall (A = 4.2, A- = 3.7, B = 3.2, B- = 2.7, C = 2.2, C- = 1.7, D = 1.0)

General Test scores. The General Test scores (in scaled-score form) were verbal, quantitative, and analytical.

## Analysis

Product-moment correlations were computed between the background characteristics and General Test scores for each sample. A structural equation modeling analysis was carried out in Sample 1, using the EQS computer program--maximum-likelihood version (Bentler, 1985), and the model was modified as necessary.[6] The analysis was then repeated in Sample 2 with the modified model. The analysis was done separately for the three General Test scores to evaluate differences in their patterns of relationships. Correlation matrices were used because of the comparative ease of interpreting their results. The goodness of fit of the structural equation models was assessed by the average off-diagonal absolute standardized residual and the Bentler-Bonett nonnormed fit index (Bentler & Bonett, 1980; Tucker & Lewis, 1973).

The standardized path coefficients for the background characteristics, reflecting each variable's direct, indirect, and total associations after

controlling for potentially confounding background characteristics, were evaluated for both their statistical and practical significance. A coefficient was considered to be significant if its absolute value was .10 or more and, in the case of a direct or indirect coefficient, its associated t value was 2 or greater (a t value is not available for a total coefficient). The former criterion was based on the analogous convention of regarding a correlation coefficient of .10 as representing a "small" effect size from the standpoint of practical significance (Cohen, 1988).

The hypothesized model about the structural relationships among the background characteristics and the test scores being evaluated by the analyses appears in Figure 2. This model is an elaboration and extension of the general input-output model of influence on test performance discussed earlier.

The model hypothesizes that the examinees' own initial characteristics (e.g., sex), college-related characteristics (e.g., college major), and college-related performance (e.g., undergraduate GPA) are directly associated with test scores. In addition, this model hypothesizes that the examinees' initial characteristics and college-related characteristics are indirectly associated with test scores through the mediation of intervening variables. Examinees' initial characteristics are mediated by college-related characteristics and college-related performance. And college-related performance is mediated by college-related characteristics.

This model also hypothesizes that two sets of variables represent factors: father's education and mother's education define a Parental Education factor; and public institution, college selectivity, and Ph.D. productivity ratio define an Institutional Quality factor. The definition of the latter was guided by a previous factor analysis of institutional data that identified a "Quality/Affluence" factor (Chapman, 1979). According to the model, the other variables are observed variables, subject to measurement error.

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Insert Figure 2 about here

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## Results and Discussion

### Intercorrelations

The intercorrelations of the variables in the two samples appear in Tables 3 and 4, along with the means and standard deviations. The internal-consistency reliability of the General Test, for the total sample, was .90 for the verbal score, .92 for the quantitative score, and .84 for the analytical score; the reliability of each score was estimated from the subscores for its two separately timed sections (Angoff, 1953).

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Insert Tables 3 and 4 about here

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Analysis of Initial Model

The goodness of fit of the initial model in Sample 1 was unacceptable. The average absolute off-diagonal standardized residuals were .019 in the verbal score analysis, .020 in the quantitative score analysis, and .019 in the analytical score analysis; the corresponding Bentler-Bonett nonnormed fit indexes were .468, .514, and .454.

Based on an inspection of the standardized residual matrices, a change was made in the model, concerning research university and two of the variables that define the Institutional Quality factor--public institution and college selectivity. Correlated measurement errors were permitted between research university, on the one hand, and public institution and college selectivity, on the other. This change was consistent with the common time period that research university (1987) shared with public institution (1984-85) and college selectivity (1973). (The remaining Institutional Quality variable, Ph.D. productivity ratio, was based largely on an earlier period, 1946-1976.)

Analysis of Modified Model

The goodness of fit of the modified model in Sample 2 was acceptable. The average off-diagonal absolute standardized residuals were .017 in the verbal score analysis, .018 in the quantitative score analysis, and .017 in the analytical score analysis; the corresponding Bentler-Bonett nonnormed fit indexes were .883, .896, and .882. The direct, indirect, and total standardized path coefficients in the three analyses appear in Table 5.

Parental education and institutional quality factors. In the three analyses, the standardized loadings on the Parental Education factor were .82 for father's education and .73 to .74 for mother's education; the loadings on the Institutional Quality factor were .86 to .88 for college selectivity, .62 to .64 for Ph.D. productivity ratio, and -.44 to -.45 for public institution. These results indicate that both factors were well defined.

In each analysis, the measurement errors for research university correlated .33 with the errors for public institution and .25 with the errors for college selectivity. These results indicate the presence of method variance, presumably stemming from the common time period shared by the variables.

College-related characteristics. In each analysis, the examinees' initial characteristics had limited direct associations with the college-related characteristics: physical science major, Institutional Quality, and research university. (No indirect associations are possible for these variables.)

Female sex had an appreciable association (-.34) and Asian-American ethnicity a moderate association (.12) with physical science major; the associations were minimal for the other characteristics (Black-Hispanic-Other ethnicity, Parental Education, age, Northeastern resident, Northcentral resident, and Western resident). These results indicate that men and, to a lesser extent, Asian examinees chose physical science majors.

Two characteristics, Northeastern resident (.41) and Parental Education (.32 to .33), had appreciable associations with Institutional Quality; three characteristics, Western resident (.18), Northcentral resident (.13), and age (-.13) had moderate associations with it; and the other characteristics had minimal associations. These results indicate that examinees who lived outside the South, had better educated parents, and, to a lesser degree, were younger attended higher quality colleges.

All the examinee characteristics had minimal associations with research university, indicating that these variables were not linked to whether examinees attended research universities.

Undergraduate GPA. All the examinees' initial characteristics had minimal direct, indirect, and total associations with undergraduate GPA, with one exception: a moderate total association (.10) for Western resident. All the college-related characteristics (physical science major, Institutional Quality, and research university) also had minimal direct associations. (Indirect associations are not possible for these variables.) These results indicate that the examinees' own characteristics as well as characteristics related to the colleges they attended were generally unconnected to the college grades earned.

Verbal scores. Four of the examinees' initial characteristics--Parental Education (.10), age (.10), Northeastern resident (-.10), and Northcentral Resident (-.10)--had moderate direct associations with the General Test verbal score; the other characteristics had minimal associations. Two of these four characteristics, Northeastern resident (.17) and Parental Education (.16), also had a moderate indirect association, as did Western resident (.11); the other characteristics had minimal associations. Only Parental Education had a moderate total association (.26); the associations were minimal for the other characteristics.

One college-related characteristic, Institutional Quality, had an appreciable direct association (.38) with the verbal score; the other characteristics had minimal associations. All these characteristics had minimal indirect associations. And only Institutional Quality had an appreciable total association (.40); the associations were minimal for the other characteristics.

Undergraduate GPA had an appreciable direct association (.36) with the verbal score. (An indirect association for undergraduate GPA is not possible.)

These results indicate that examinees with better educated parents obtained higher verbal scores. This link for parental education was partly indirect, mediated by the quality of the colleges examinees attended. More important than parental education were the quality of the college and the grades earned there. Examinees who attended high-quality colleges earned higher verbal scores, regardless of their parents' education. And examinees who earned good grades in college also got higher verbal scores.

Quantitative score. Two of the examinees' initial characteristics had moderate direct associations with the General Test quantitative score: female

sex (-.19) and Parental Education (.11); the other characteristics had minimal associations. The same two variables also had moderate indirect associations--female sex (-.12) and Parental Education (.14)--as did Northcentral resident (.13); the other characteristics had minimal associations. One of these characteristics, female sex, had an appreciable total association (-.31), and two of the others had moderate associations--Parental Education (.25) and age (-.16); the associations were minimal for the other characteristics.

All the college-related characteristics had appreciable or moderate direct associations with the quantitative score: physical science major (.35), Institutional Quality (.28), and research university (.14). All these characteristics had minimal indirect associations but appreciable or moderate total associations: physical science major (.37), Institutional Quality (.29), and research university (.13).

Undergraduate GPA had a moderate direct association (.27) with the quantitative score. (An indirect association for undergraduate GPA is not possible.)

These results indicate that examinees who were men, had well-educated parents, and, to a lesser degree, were younger earned higher quantitative scores. The connection for parental education was partly mediated by the quality of the college attended; the association for sex was partly mediated by the college major selected. Equally or more important than the examinees' sex, age, and parental education were the students' college major, the quality of the college attended, whether it was a research university, and their grades there. Regardless of their sex or parental education, examinees who had physical science majors and attended high-quality colleges got higher quantitative scores. Examinees who earned good grades in college and, to a lesser extent, attended a research university also got higher quantitative scores.

Analytical score. One examinee initial characteristic had a moderate direct association with the General Test analytical score: age (-.12); the other characteristics had minimal associations. Two characteristics had moderate indirect associations--Parental Education (.13) and Northeastern resident (.13); the other characteristics had minimal associations. And three characteristics had moderate total associations--Parental Education (.21), age (-.18), and Black-Hispanic-Other ethnicity (-.12); the associations were minimal for other characteristics.

All the college-related characteristics had moderate direct associations with the analytical score--Institutional Quality (.28), physical science major (.17), and research university (.11); all had minimal indirect associations. And all had moderate total associations--Institutional Quality (.30), physical science major (.19), and research university (.10).

Undergraduate GPA had a moderate direct association (.26) with the analytical score. (An indirect association for undergraduate GPA is not possible.)

These results indicate that examinees who had well-educated parents, were younger, and, to a lesser degree, did not have Black, Hispanic, American

Indian, or Other ethnicity earned higher analytical scores. The association for parental education was wholly mediated by the quality of the college attended. College quality, whether the school was a research university, the major taken, and the college grades earned were equally or more important than the examinees' age, ethnicity, and parental education. Regardless of their parents' education, examinees attending high-quality colleges earned better analytical scores. And examinees who earned higher grades in college, majored in physical science, and, to a lesser extent, attended research universities also got better analytical scores.

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Insert Table 5 about here

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## Conclusions

### Initial Characteristics

A major finding of this study is the generally modest level of the relationships between the examinees' initial characteristics (sex, ethnicity, parental education, and age) and their performance on the General Test. Among these variables, it is striking that parental education generally had the most consistent and strongest associations. (Sex had an appreciable association, but it was restricted to the quantitative score.) Although parental education was a latent variable and the other characteristics were observed variables in this analysis, the stronger associations for parental education cannot be attributed to its greater reliability, for the other variables, concerning objective demographic information, are presumably highly reliable.

The weak associations displayed for age may underestimate the importance of this characteristic, given the restriction in range of age in this study, resulting from limiting the sample to college seniors and recent graduates. In view of the relatively restricted variability of age, it is remarkable that any interpretable associations were observed.

The negligible relationships for ethnicity partly reflect the small proportion of minority examinees in the study (10% in Sample 2), which limits the correlations of the dichotomous dummy variables for ethnicity with other variables. For example, in Sample 2, the maximum correlation was .44 for Asian ethnicity, which had an .04/.96 dichotomy; for Black-Hispanic-Other ethnicity, with an .06/.94 dichotomy, the maximum correlation was .50. Nonetheless, these correlations and the path coefficients based on them reflect the importance of ethnicity in this sample and its corresponding population (Cohen & Cohen, 1983).

### Intervening Variables

An equally important finding concerns the role played by the intervening variables in this study: college-related characteristics and college-related performance. These variables not only served as intermediaries but also made an independent contribution to the relationship with General Test performance.

First, these variables partly mediated the associations for the two strongest initial characteristics of the examinees: parental education and sex. Parental education was mediated by institutional quality, as higher status students attended the better--and more expensive--colleges. And sex was mediated by major, as women avoided the physical science curriculum. This result underscores the importance of socioeconomic status and sex in choosing colleges and college majors, and in the ultimate implications of these choices for achievement (e.g., Fox et al., 1979; Karabel & Astin, 1975).

Second, the intervening variables generally had stronger and more consistent relationships with performance on the test than did the examinees' initial characteristics. The associations for school quality, major, and college grades equaled or exceeded those for even parental education and age. The more pervasive and stronger connections of these variables with test performance is consistent with the purpose of the General Test to assess "developed abilities" that reflect students' experience in college and elsewhere, not innate intelligence (Conrad et al., 1977). Hence, this outcome supports the test's construct validity.

Correspondence with Previous Findings

The present results are broadly congruent with previous findings. The relationships of sex, socioeconomic status, and school quality with test performance have been well established in research at the grade school and high school levels (see the reviews by Bridge et al., 1979; Jencks, 1972). The associations of socioeconomic status and school characteristics, as well as geographical region, with test performance were also observed in the study of male veterans (Griliches & Mason, 1973). But contrary to the present results, socioeconomic status in that study had appreciably weaker associations than ethnicity, a variable with minimal relationships in the present investigation. Differences in variability do not appear to be the explanation for the divergent results. The variability of father's education was similar in both studies (the standard deviations were 3.2 in the previous study and 2.9 in Sample 2), and the variability in ethnicity was smaller in the earlier investigation than in the present one (96% White vs. 90% White in Sample 2).

The same general relationships of sex, socioeconomic status, undergraduate GPA, and college major with General Test performance were also found in earlier multivariate studies (Holland & Thayer, 1983; Powers, 1985). The main inconsistency was the associations of ethnicity with all the General Test scores in one of these studies (Powers, 1985) in contrast to the absence of a relationship in the present investigation. But the associations in the previous study were moderate or minimal. (The largest standardized regression coefficients of the ethnicity dummy variables with each test score were -.14 for Black ethnicity with the verbal score, -.12 for Black ethnicity with the quantitative score, and .15 for White ethnicity with the analytical score; these coefficients were computed for the present report.) And similar relationships of sex and college major with General Test performance were observed in a previous investigation that controlled for examinees' performance on the Scholastic Aptitude Test (SAT; Donlon, 1984), an admissions test somewhat similar to the General Test, that they took before entering college (Angoff & Johnson, 1988).

Revisions in the Model

Although the hypothesized model was confirmed as a whole, after minor modifications involving the Institutional Quality factor, changes are clearly needed in some aspects of the model. Contrary to expectations, the examinees' initial characteristics were not linked, directly or indirectly, with research university or undergraduate GPA, though both variables were, indeed, linked with other variables, notably, the General Test scores. Furthermore, ethnicity was generally not linked, directly or indirectly, with the intervening variables (physical science major, Institutional Quality, research university, undergraduate GPA) or the test scores. And age and the college-related characteristics (physical science major, Institutional Quality, research university) had no indirect links with test scores, though all had direct links with them. Further research on this topic may benefit from a more simplified model that reflects these findings. Such a model is shown in Figure 3.

The complete absence of any connections between the examinees' initial characteristics and both research university and undergraduate GPA is intriguing. The relationships of research university and undergraduate GPA to other variables make it clear that the two are reliable enough to be predicted. Some obvious predictors were either unavailable or not included in the study, such as college admissions test scores and motivational variables for undergraduate GPA and aspirations for research university.

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Insert Figure 3 about here

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Research Implications

The strong showing for parental education points to the need for research into the links between socioeconomic status and General Test performance. As a starting point, the same kinds of studies of test bias and differential item performance that have been carried out for sex, ethnicity, and age are called for. It is notable that a study of differential item functioning on the SAT found no items that performed differently for subgroups of examinees defined by father's education (Kulick & Dorans, 1983).

Additional research concerning socioeconomic status and similar proxy variables in this study, such as sex and ethnicity, need to go beyond these social categories and delineate the underlying psychologically relevant processes that produce the observed associations with the intervening variables and test performance.

Notes

[1]Black, Hispanic (i.e., Mexican American, Puerto Rican, and other Hispanic), American Indian, and "Other" examinees were pooled to increase the number of examinees and permit a dummy variable for these combined ethnic groups to be included in the analysis. Even when pooled, these groups account for only 6% of the total sample. The four groups have roughly similar patterns of General Test scores (Educational Testing Service, 1988).

A dummy variable for White ethnicity (White = 1, all others = 0) was not included because of its collinearity with the two other variables for ethnicity: Asian ethnicity, and Black-Hispanic-Other ethnicity.

[2]State of residence was categorized by region, using the U.S. Bureau of the Census (1972) classification scheme.

[3]Because of the complexities of interpreting results for several dummy variables for the same endogenous characteristic, a single dummy variable for major was chosen: physical science major. Physical science was selected over the other groups of majors (humanities, social sciences, and biological sciences) because its pattern of General Test scores was most disparate (Educational Testing Service, 1988) and it accounted for a substantial proportion of the examinees (25% of the total sample). Physical science consists of the following subgroups of majors in the BIQ: architecture and environmental design; chemistry; computer and information sciences; earth, atmospheric, and marine sciences; engineering; mathematical sciences; and physics and astronomy.

[4]Because of the complexities of interpreting results for several dummy variables for the same endogenous characteristic, a single dummy variable for the Carnegie classification was chosen: research university. This combination of the Research Universities I and Research Universities II categories represents the highest levels in the Carnegie classification scheme and accounts for a substantial proportion of the examinees (44% in the total sample). The other categories for institutions in this study are Doctorate-Granting Universities, Comprehensive Universities and Colleges, Liberal Arts Colleges, and Professional Schools and Other Specialized Institutions.

[5]Data are available only for the 87 institutions with the highest productivity ratios.

[6]The use of dichotomous endogenous variables in an EQS analysis produces underestimates of the associated standard errors. Standard errors are of limited interpretive value in this study because of the large samples involved.

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Table 1

Characteristics of the Samples: Percentages for Categorical Variables

| Variable | Subsample 1 | Subsample 2 |
|---|---|---|
| Sex | | |
| Female | 56.1 | 56.4 |
| Male | 43.9 | 43.6 |
| Ethnicity | | |
| White | 88.6 | 89.6 |
| Asian-American | 5.0 | 4.3 |
| Black | 2.9 | 2.4 |
| Hispanic | | |
| American Indian and Other | | |
| Permanent Residence | | |
| Northeast | 18.2 | 21.6 |
| Northcentral | 27.4 | 26.1 |
| South | 34.5 | 32.8 |
| West | 19.8 | 19.5 |
| Undergraduate Major | | |
| Humanities | 18.6 | 19.9 |
| Social Sciences | 38.4 | 38.9 |
| Life Sciences | 18.2 | 16.7 |
| Physical Sciences | 24.9 | 24.5 |
| Carnegie Classification of Undergraduate Institutions[a] | | |
| Liberal Arts Colleges | 13.9 | 15.6 |
| Comprehensive Universities and Colleges | 26.9 | 24.1 |
| Professional Schools and other Specialized Institutions | 1.2 | .9 |
| Doctorate Granting Universities | 14.8 | 14.2 |
| Research Doctorate | 43.2 | 44.5 |

Table 1 (Continued)

| Variable | Subsample 1 | Subsample 2 |
|---|---|---|
| Control of Undergraduate Institution[b] | | |
| Public | 61.9 | 61.5 |
| Private | 38.1 | 38.5 |
| Ph.D. Productivity Ratio of Undergraduate Institution[c] | | |
| High[d] | 12.1 | 11.8 |
| Low | 87.9 | 89.2 |

Note. Percentages for variables do not total 100.0 because of rounding errors.

[a]Carnegie Foundation for the Advancement of Teaching (1987).

[b]Center for Statistics (1986).

[c]Proportion of bacalaureates receiving Ph.D.s in all fields (Fuller, 1986).

[d]One of the 87 institutions with the highest ratios.

Table 2

Characteristics of the Samples: Means and Standard Deviations for Continuous Variables

| Variable | Subsample 1 | | Subsample 2 | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Age--Years | 23.0 | 4.1 | 23.1 | 4.2 |
| Parental Education--Years | | | | |
| Father | 15.4 | 3.1 | 15.5 | 2.9 |
| Mother | 14.8 | 2.7 | 14.8 | 2.7 |
| Undergraduate GPA | 3.4 | .5 | 3.4 | .5 |
| Selectivity of Undergraduate Institution[a] | 1051.7 | 129.7 | 1050.7 | 124.2 |
| General Test | | | | |
| Verbal Score | 529.6 | 109.6 | 532.6 | 107.0 |
| Quantitative Score | 591.5 | 124.8 | 591.3 | 124.3 |
| Analytical Score | 595.1 | 117.2 | 600.2 | 114.6 |

[a]Estimated mean total Scholastic Aptitude Test score for entering freshmen (Astin & Henson, 1977).

Table 3

Intercorrelations of Variables in Sample 1

| Variable | Mean | S.D. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Female Sex | .56 | .50 | | | | | | | | | | | | | | | | | | |
| (2) Asian Ethnicity | .05 | .22 | -.02 | | | | | | | | | | | | | | | | | |
| (3) Black-Hispanic-Other Ethnicity | .06 | .25 | -.04 | -.06 | | | | | | | | | | | | | | | | |
| (4) Father's Education | 15.45 | 3.06 | .00 | .05 | -.21 | | | | | | | | | | | | | | | |
| (5) Mother's Education | 14.79 | 2.70 | .04 | .02 | -.12 | .59 | | | | | | | | | | | | | | |
| (6) Northeastern Resident | .18 | .39 | .01 | .01 | -.07 | .06 | .06 | | | | | | | | | | | | | |
| (7) Northcentral Resident | .27 | .45 | -.04 | -.06 | -.09 | -.05 | -.02 | -.29 | | | | | | | | | | | | |
| (8) Western Resident | .20 | .40 | -.01 | .16 | .0[illegible] | .02 | .01 | -.24 | -.31 | | | | | | | | | | | |
| (9) Age | 23.01 | 4.13 | .00 | -.01 | .02 | -.20 | -.17 | -.06 | -.05 | .06 | | | | | | | | | | |
| (10) Physical Science Major | .25 | .43 | -.33 | .10 | .05 | .02 | -.02 | .04 | -.04 | -.02 | -.05 | | | | | | | | | |
| (11) Research University | .43 | .50 | -.05 | .12 | -.01 | .06 | .08 | -.04 | -.01 | .09 | -.06 | .09 | | | | | | | | |
| (12) Public Institution | .62 | .49 | .01 | -.04 | .01 | -.12 | -.12 | -.20 | -.01 | .11 | .13 | -.02 | .33 | | | | | | | |
| (13) College Selectivity | 1051.68 | 129.71 | -.07 | .17 | -.07 | .24 | .25 | .25 | .01 | .05 | -.17 | .13 | .30 | -.40 | | | | | | |
| (14) Ph.D. Productivity | .12 | .33 | -.08 | .16 | .03 | .14 | .19 | .09 | -.04 | .12 | -.09 | .06 | .03 | -.36 | .55 | | | | | |
| (15) Undergraduate GPA | 34.26 | 5.23 | -.03 | -.04 | -.16 | .05 | .08 | .01 | .10 | .00 | -.02 | .04 | .02 | -.05 | .07 | .03 | | | | |
| (16) General Test Verbal Score | 529.56 | 109.59 | -.11 | .01 | -.13 | .24 | .22 | .09 | -.01 | .07 | -.04 | .08 | .14 | -.20 | .44 | .28 | .39 | | | |
| (17) General Test Quantitative Score | 591.50 | 124.83 | -.36 | .13 | -.10 | .20 | .16 | .05 | .06 | .07 | -.17 | .48 | .26 | -.12 | .43 | .23 | .32 | .55 | | |
| (18) General Test Analytical Score | 595.10 | 117.16 | -.10 | .00 | -.14 | .22 | .21 | .04 | .07 | .04 | -.18 | .24 | .22 | -.12 | .36 | .19 | .32 | .62 | .73 | |

Table 4

Intercorrelations of Variables in Sample 2

| Variable | Mean | S.D. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Female Sex | .56 | .50 | | | | | | | | | | | | | | | | | | |
| (2) Asian Ethnicity | .04 | .20 | -.06 | | | | | | | | | | | | | | | | | |
| (3) Black-Hispanic-Other Ethnicity | .06 | .24 | .00 | -.05 | | | | | | | | | | | | | | | | |
| (4) Father's Education | 15.49 | 2.93 | -.05 | .05 | -.08 | | | | | | | | | | | | | | | |
| (5) Mother's Education | 14.78 | 2.68 | .00 | .05 | -.05 | .60 | | | | | | | | | | | | | | |
| (6) Northeastern Resident | .22 | .41 | -.02 | .00 | -.06 | .01 | .02 | | | | | | | | | | | | | |
| (7) Northcentral Resident | .26 | .44 | .02 | -.08 | -.08 | -.02 | .00 | -.31 | | | | | | | | | | | | |
| (8) Western Resident | .20 | .40 | -.02 | .20 | .10 | .06 | .03 | -.26 | -.29 | | | | | | | | | | | |
| (9) Age | 23.13 | 4.17 | .01 | -.07 | .00 | -.22 | -.19 | -.06 | -.03 | .03 | | | | | | | | | | |
| (10) Physical Science Major | .24 | .43 | -.35 | .16 | -.05 | .09 | .04 | .03 | -.04 | .04 | -.10 | | | | | | | | | |
| (11) Research University | .45 | .50 | -.07 | .12 | .03 | .09 | .07 | -.04 | -.02 | .15 | -.07 | .11 | | | | | | | | |
| (12) Public Institution | .62 | .49 | .00 | .05 | .05 | -.12 | -.15 | -.26 | .03 | .13 | .17 | -.01 | .34 | | | | | | | |
| (13) College Selectivity | 1050.73 | 124.18 | -.08 | .12 | -.09 | .29 | .26 | .29 | -.02 | .06 | -.22 | .15 | .33 | -.36 | | | | | | |
| (14) Ph.D. Productivity | .12 | .32 | -.05 | .03 | -.02 | .14 | .14 | .19 | -.10 | .07 | -.11 | .09 | .04 | -.35 | .56 | | | | | |
| (15) Undergraduate GPA | 34.32 | 5.37 | .04 | .00 | -.06 | .06 | .10 | -.01 | .06 | .06 | -.04 | .06 | -.02 | -.05 | .08 | .06 | | | | |
| (16) General Test Verbal Score | 532.55 | 106.96 | -.08 | .00 | -.10 | .20 | .21 | .07 | -.05 | .05 | -.03 | .07 | .08 | -.17 | .36 | .27 | .39 | | | |
| (17) General Test Quantitative Score | 591.34 | 124.31 | -.33 | .13 | -.10 | .26 | .22 | .07 | -.01 | .05 | -.23 | .50 | .22 | -.10 | .42 | .24 | .32 | .52 | | |
| (18) General Test Analytical Score | 600.20 | 114.56 | -.10 | .04 | -.14 | .22 | .22 | .05 | .04 | .01 | -.24 | .26 | .15 | -.15 | .36 | .23 | .31 | .60 | .72 | |

Table 5

Standardized Path Coefficients in Analyses of General Test Verbal, Quantitative, and Analytical Scores for Sample 2

| | Physical Science Major | | Institutional[a] Quality | | Research University | | Undergraduate Grade-Point Average | | | General Test Verbal Score | | | General Test Quantitative Score | | | General Test Analytical Score | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Direct | Total | Direct | Total | Direct | Total | Direct | Indirect | Total | Direct | Indirect | Total | Direct | Indirect | Total | Direct | Indirect | Total |
| Female Sex | -.34 | -.34 | | | | | | | | | | | -.19 | -.12 | -.31 | | | |
| Asian Ethnicity | .12 | .12 | | | | | | | | | | | | | | | | |
| Black-Hispanic-Other Ethnicity | | | | | | | | | | | | | | | | | | -.12 |
| Parental Education | | | .33 | .33 | | | | | | .10 | .16 | .26 | .11 | .14 | .25 | | .13 | .21 |
| Northeastern Resident | | | .41 | .41 | | | | | | -.10 | .17 | | | .13 | | | .13 | |
| Northcentral Resident | | | .13 | .13 | | | | | | -.10 | | | | | | | | |
| Western Resident | | | .18 | .18 | | | | | .10 | | .11 | | | | | | | |
| Age | | | .13 | -.13 | | | | | | .10 | | | | | -.16 | -.12 | | -.18 |
| Physical Science Major | -- | -- | -- | -- | -- | -- | | -- | | | | | .35 | | .37 | .17 | | .19 |
| Institutional Quality | -- | -- | -- | -- | -- | -- | | -- | | .38 | | .40 | .28 | | .29 | .28 | | .30 |
| Research University | -- | -- | -- | -- | -- | -- | | -- | | | | | .14 | | .13 | .11 | | .11 |
| Undergraduate GPA | -- | -- | -- | -- | -- | -- | -- | -- | -- | .36 | -- | .36 | .27 | -- | .27 | .26 | -- | .26 |

Note. Only path coefficients of ± .10 or greater are listed; all direct and indirect path coefficients listed have t values of 2 or more.

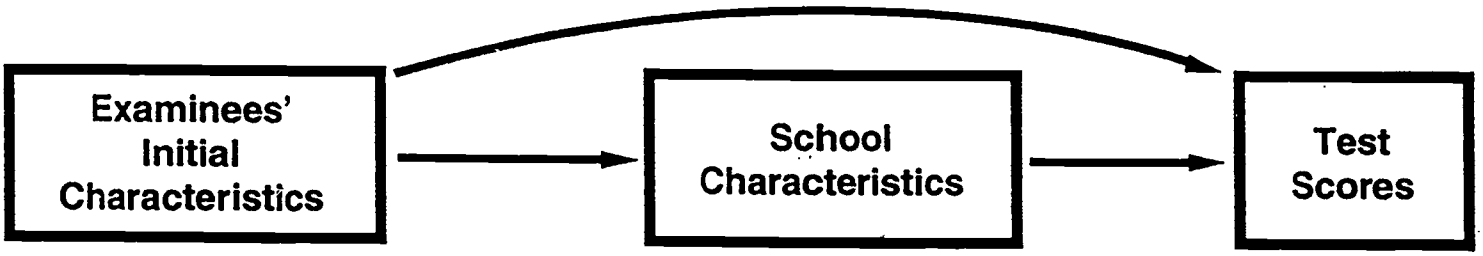
[a]The direct and total path coefficients in the quantitative score analyses are .32 for parental education and .14 for Northeastern resident.

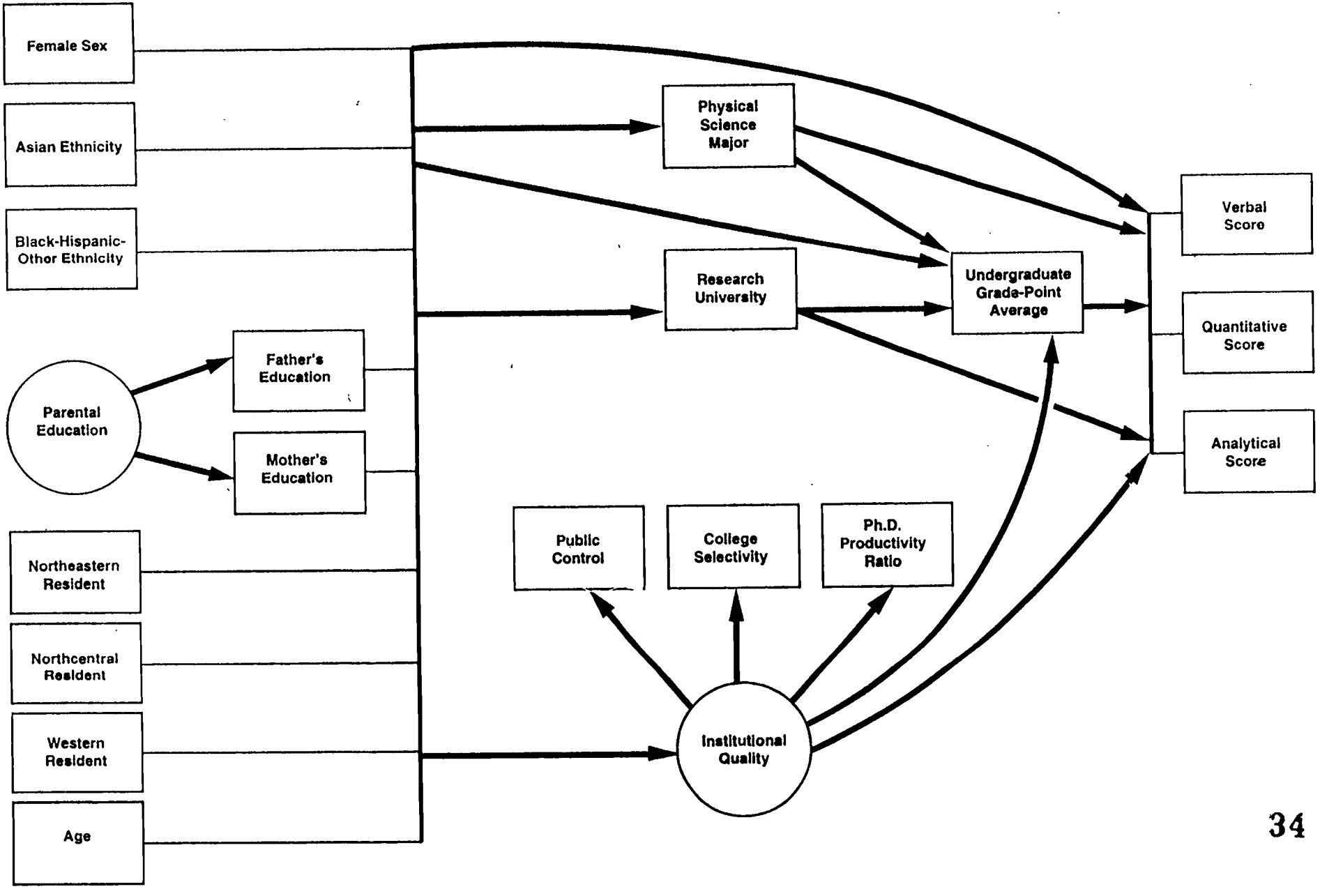
## Figure Captions

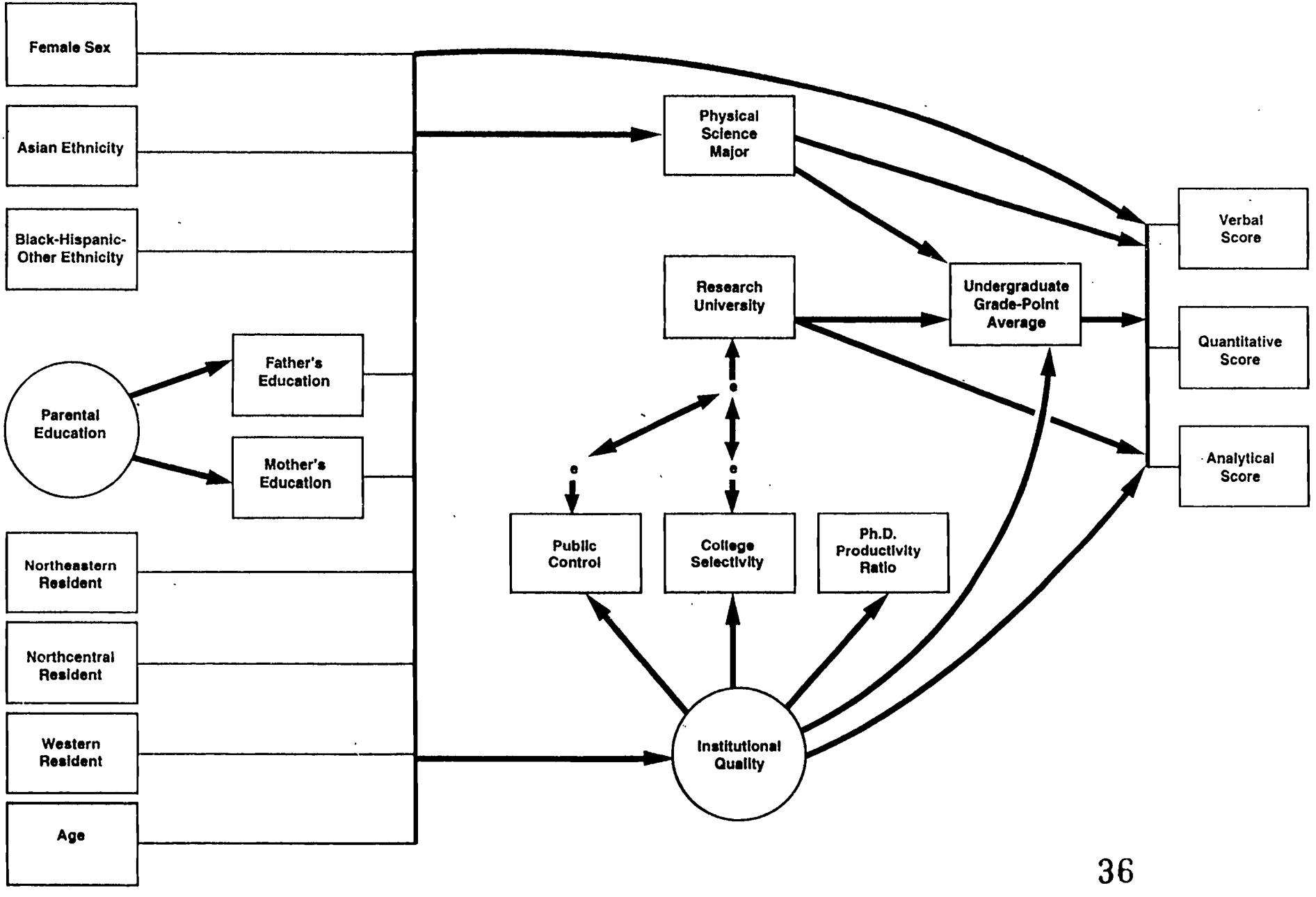
Figure 1. Schematic model of relationships between examinee background characteristics and test performance.

Figure 2. Hypothesized model of relationship between examinee background characteristics and General Test performance.

Figure 3. Simplified model of relationships between examinee background characteristics and General Test performance.


Examinees' Initial Characteristics
School Characteristics
Test Scores


Female Sex
Asian Ethnicity
Black-Hispanic-Other Ethnicity
Parental Education
Father's Education
Mother's Education
Northeastern Resident
Northcentral Resident
Western Resident
Age
Physical Science Major
Research University
Undergraduate Grade-Point Average
Public Control
College Selectivity
Ph.D. Productivity Ratio
Institutional Quality
Verbal Score
Quantitative Score
Analytical Score



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