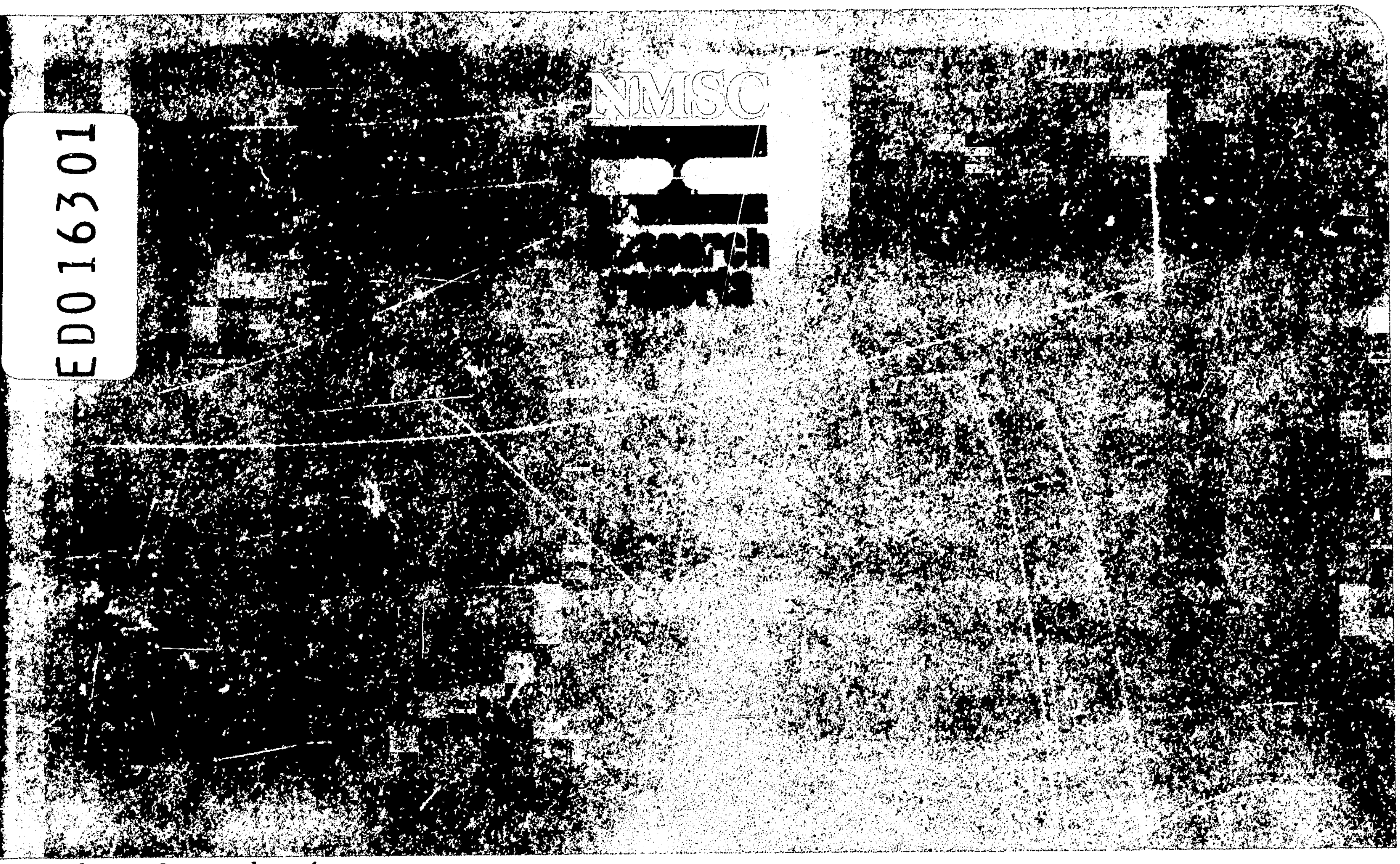
R E P O R T   R E S U M E S

ED 016 301 EA 001 126

THE STUDY OF COLLEGE ENVIRONMENTS USING PATH ANALYSIS.
BY- WERTS, CHARLES E.
NATIONAL MERIT SCHOLARSHIP CORP., EVANSTON, ILL.
REPORT NUMBER NMSC-RR-VOL-3-NO-4-1967 PUB DATE 67
EDRS PRICE MF-$0.25 HC-$1.80 43P.

DESCRIPTORS- *COLLEGE ENVIRONMENT, *CRITICAL PATH METHOD, *EDUCATIONAL OBJECTIVES, *GRADES (SCHOLASTIC), SELECTION, COLLEGE ADMISSION, ACADEMIC ABILITY, PARENTAL BACKGROUND, TEST RESULTS, *MATHEMATICAL MODELS, COLLEGE FRESHMEN, STATISTICAL ANALYSIS, EVANSTON,

THIS STUDY ATTEMPTS TO DEMONSTRATE THAT PATH ANALYSIS IS A VALUABLE TOOL FOR INTERPRETING CORRELATIONS IN A CAUSAL SENSE. PATH ANALYSIS IS APPLIED TO A NONEXPERIMENTAL, PANEL SURVEY IN AN EFFORT TO DETERMINE WHETHER THE MORE SELECTIVE OR LESS SELECTIVE COLLEGES HAD A DIFFERENTIAL IMPACT ON THE EDUCATIONAL PLANS OF THEIR STUDENTS. THE PROBLEM IS TO INTERPRET THREE CORRELATIONS--SELECTIVITY WITH CHANGES IN EDUCATIONAL PLANS, SELECTIVITY WITH COLLEGE GRADES, AND COLLEGE GRADES WITH CHANGES IN EDUCATIONAL PLANS. DATA FOR THE STUDY WERE OBTAINED FROM 127,125 ENTERING 1961 FRESHMEN IN 248 FOUR-YEAR COLLEGES AND UNIVERSITIES. THE GENERAL PROCEDURE WAS TO CONSTRUCT SIX EQUATIONS USING SEVEN VARIABLES--FATHER'S EDUCATION, NATIONAL MERIT SCHOLARSHIP TEST SCORE, HIGH SCHOOL GRADE AVERAGE, FRESHMAN EDUCATIONAL PLANS, SELECTIVITY OF COLLEGE ATTENDED, FRESHMAN YEAR COLLEGE GRADES, AND SOPHOMORE EDUCATIONAL PLANS. THE RESULTS SUGGEST THAT CHANGES IN EDUCATIONAL PLANS ARE A POSITIVE FUNCTION OF THE DEGREE TO WHICH A STUDENT'S ACADEMIC PERFORMANCE DIFFERS FROM THAT PREDICTED FROM HIS BACKGROUND AND THE COLLEGE HE ATTENDS AND THAT THE DIRECT INFLUENCE OF COLLEGE SELECTIVITY ON EDUCATIONAL PLANS APPEARS TO BE SMALL OR NONEXISTENT. IT IS CONCLUDED THAT IT IS EXTREMELY DIFFICULT TO PUT THEORIES ABOUT COLLEGE ENVIRONMENTS INTO TESTABLE FORM. (HW)



1967: volume 3, number 4

The Study of College Environments Using Path Analysis

Charles E. Werts

NATIONAL MERIT SCHOLARSHIP CORPORATION

Abstract

In the usual college studies, the investigator frequently has to interpret a matrix of intercorrelations between environmental variables, student experiences, and changes in student characteristics during college. If these correlations are to be used to determine how the college environment influences, or is influenced by, the students, a number of assumptions must be made about the variables under study. This interpretive problem can be handled by path analysis, a technique which specifies the logical consequences of the assumptions. To show how path analysis helps to render interpretations explicit, consistent, and more susceptible to rejection, a current research problem is studied in detail here.

The Study of College Environments Using Path Analysis[+]

Charles E. Werts

Thistlethwaite and Wheeler's (1966) well-designed paper on the effects of teacher and peer subcultures upon student aspirations deserves a careful examination because it illustrates the state of the art in studies of college environments. The current minimum standards (leaving much room for improvement; see Stanley, 1966a) for such studies include: pre-college measures of relevant, background variables (Astin, 1961, 1962); measures of the college environment; and measures of change (over time) in the student characteristics under study. After controlling for background variables--to deal with student input differences between colleges--Thistlethwaite and Wheeler found small but statistically significant correlations between changes in aspiration for graduate schooling and several college environment measures. A number of student experiences in college (grades, for example) also correlated significantly (after controls) with educational aspirations. Given these correlations between college environment variables, student experience variables, and changes in aspiration, what can be inferred about how the college environment influences student experiences and changes in aspiration? This interpretative question will be considered here, using for illustration one college environment variable ("selectivity,"

[+]The author is indebted to Alexander W. Astin, James A. Davis, Otis D. Duncan, Bruce K. Eckland, and Robert C. Nichols for advice and suggestions.

a measure of the ability level of the students at the college), one student experience variable (college grades), and changes in plans for advanced education (during the freshman year of college). We will show how the technique of path analysis can clarify the interpretation by making explicit the logical consequences of assumptions about the variables. Although our purpose is primarily didactic, a current research problem will be studied in detail in order to illustrate the method.

The problem is to interpret three correlations: "selectivity" (abbreviated SELECT) with changes in educational plans (SLOA),[1] "selectivity" with college grades (CG), and college grades with changes in educational plans. "Selectivity" refers specifically to the index devised by Astin (1965a) for the colleges in this study, and is the proportion of high ability students among entering freshmen at each college. For a sample of 105 colleges, Astin found that "selectivity" correlated .88 with mean Scholastic Aptitude Test (Verbal plus Math) scores of entering freshmen (College Entrance Examination Board, 1961). "Educational plans" refers to the academic degree the student expects to obtain, such as: less than a baccalaureate, baccalaureate, master's, or doctoral or professional degree (i.e. M.D., LL.B., D.D.S., B.D.). The choice of "selectivity," college grades, and changes in educational plans for analysis was dictated by a priori, theoretical considerations,

---

1. The abbreviation, SLOA, is used to indicate changes in educational plans, because freshman educational plans (FLOA) are controlled in every case where the meaning of SLOA is discussed. SLOA also refers to the actual measure of educational plans at the start of the sophomore year. It should be clear from the context whether the interpretation of SLOA (with FLOA controlled) or the measure itself is referred to. The letters, LOA, are a common abbreviation for "level of aspiration," of which educational plans are a subtype.

which will be discussed later. Unfortunately, since previously collected data were used, it was not possible to choose the most theoretically desirable combination of background factors. Available data included father's education (FaEd), high school grade average (HSG), and National Merit Scholarship Qualifying Test (NMSQT) (SRA, 1966) scores (obtained during the junior year of high school). It was deduced from Thistlethwaite and Wheeler's parallel study on a similar population that results would have been the same even if mother's educational level, number of freshman scholarship applications, family financial resources, and probable major field also had been controlled, since these factors would have contributed little variance to the prediction of aspiration changes beyond that accounted for by initial educational plans and NMSQT scores. Females were analyzed separately. Assuming that the factors influencing the college plans of high school students are similar to those influencing educational plans among college freshmen, Sewell and Armer's (1966) finding that neighborhood context adds little variance to prediction of college plans independently of sex, ability, and SES suggested negligible error in also failing to control for neighborhood context here. However, the absence of controls for peer group (Coleman, 1961) and high school context (Boyle, 1966), which have been known to independently influence educational aspirations, clearly indicates a defect in the present analysis.

Before proceeding, it is worthwhile to consider some problems in interpreting the correlations obtained in studies of college effects. Even though some of the relevant background characteristics are controlled, it may be necessary to make some assumptions about the temporal ordering of the remaining variables. For example, is "selectivity" of the college antecedent to both CG and SLOA? If so, this would mean that part of the correlation between CG and SLOA is spurious due to the common, antecedent factor, "selectivity." Although failure to control for relevant, antecedent variables can distort interpretation, one can make errors just as serious by overcontrolling, that is, by controlling variables which should not be. For example, if CG is an intervening variable between "selectivity" and SLOA (as will be argued later), controls for CG when interpreting the correlation of "selectivity" with SLOA may be misleading, if one assumes that the net association after controlling CG represents the influence of "selectivity" on SLOA, because one may be controlling for the very mechanism by which "selectivity" influences SLOA. The disappearance of a correlation under these circumstances is not evidence of a lack of relationship between "selectivity" and LOA, but instead is evidence of a mediated influence or the link (CG) that explains the relationship. In general, subsequent variables (i.e variables causally dependent on the variables under study) should not be controlled. If SLOA is dependent upon both CG and "selectivity" in the above case, controls for SLOA when studying the correlation of "selectivity" with CG would remove valid variance. Stanley (1966b) warned about controls for concurrent variables (referring specifically to correlated, simultaneously-measured variables that are neither cause nor effect of each other), such as equivalent test forms. The prescription is fairly clear in these cases: (a) control for relevant, antecedent variables, (b) do not control for concurrent or subsequent variables, (c) control for an intervening variable when you are attempting to describe the manner in which one variable mediates its influence on another, and (d) do not control for any variable unless controlling results in a clear-cut, theoretical gain, which usually means the elimination of plausible, alternate hypotheses. Methods of handling reciprocal variables, or variables that interact, are too complex for discussion here. The reader is referred to Wright (1960), Blalock (1961, pp. 55-57), and Wold and Jureen (1953, pp. 12-13). Careful consideration of the relationships between all variables studied is essential if reasoned--and hopefully reasonable--interpretations of the correl ions are to be made. To quote Eckland (1966):

> . . . without some kind of theoretical framework, without some logically derived set of expectations or hypotheses regarding the nature of the interrelationships between the variables being observed, it is impossible by any known means to make inferences regarding the "importance" of factors. When multiple and partial regressions, in general, are used to isolate the effects or unique contributions of any factor or set of factors, there must be a "causal" model which guides the inclusion or exclusion of variables in the regression equations. Without such guidelines, spurious correlations cannot logically be separated from "real" relationships.

To facilitate a systematic discussion and analysis, we formulated a series of simultaneous equations that have a one-to-one correspondence with our hypotheses about the nature of the relationships between each pair of variables. The rationale for this approach will not be reviewed; the reader is referred to the original sources (Boudon, 1965; Wright, 1934; Blalock, 1960, 1961, 1962, 1964; Duncan, 1966; and Simon, 1954). The word, "cause," frequently will be substituted for "due to," "influences," "produces," or "results in." To quote Blalock (1962): "We shall say that X is a direct cause of Y (written X→Y) if and only if we can produce a change in the mean value of Y by changing X, holding constant all other variables which have been explicitly introduced into the system and which are not causally dependent on Y (p. 183)."

Data Collection

In the fall of 1961, Astin (1965c) collected data on 127,125 students who, with few exceptions, included the entire freshman class entering each of 248 four-year colleges and universities. The sample of institutions was heterogeneous in size, type (e.g., coeducational, public, private, nondenominational, denominational), and quality indicators (e.g., Ph.D. productivity). Although neither the sample of institutions nor that of students was chosen to be representative of any particular population, the only significant bias appeared to lie in the exclusion of two-year institutions. At the time of registration, each freshman filled out a short information form, which included the following questions that were used in the present study:

1. Your high school average (circle one):

D	C	C+	B-	B	B+	A-	A	A+
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

2. Highest degree planned (circle one):

Less than BA or BS	BA BS	MA MS	PhD EdD	MD DDS	LLB BD	Other:________
(1)	(2)	(3)	(4)	(4)	(4)	(5)

3. Father's education (circle one):

Grammar school	Some high school	H. S. grad.	Some college	College degree	Post-grad degree
(1)	(2)	(3)	(4)	(5)	(6)

4. Circle one: Male Female

Follow-up data, which were part of a larger study of the intellectual and social environments of undergraduate institutions (Astin, 1965b), were obtained by mail survey in the summer of 1962. Approximately equal numbers of students at each institution were sent a 12 page questionnaire. In large institutions random sampling was used to select those to whom questionnaires would be sent, and in coeducational institutions equal numbers of males and females were selected. Of the approximately 60,000 questionnaires mailed, about 55 per cent were returned. The percentage of respondents per institution varied from 20 per cent to over 90 per cent, with higher rates for the more prestigious institutions. After questionnaires with large amounts of missing information had been discarded, a sample of 16,141 males and 14,417 females remained. The particular questions applicable to this study were:

1. What is the highest level of education you expect to complete? (circle one)

	(code)
Less than bachelor's degree	1
B.A. or B.S.	2
M.A. or M.S.	3
Ph.D. or Ed.D.	4
M.D. or D.D.S.	4
LL.B.	4
B.D.	4
Other (Circle and specify)_____	-

2. What is your average grade so far in college? (Circle one)

	(code)
A	7
A- or B+	6
B	5
B- or C+	4
C	3
C- or D+	2
D or less	1

The files of the National Merit Scholarship Corporation were searched, and National Merit Scholarship Qualifying Test (NMSQT) scores were retrieved for two thirds of the follow-up sample. The NMSQT is a test of educational development administered in the latter part of the junior year in high school as part of a national talent search. This analysis utilized the Composite Score, which is obtained by averaging the scale scores on the five subtests: English Usage, Mathematics Usage, Social Studies Reading, Natural Sciences Reading, and Word Usage. How those who do and those who do not take the NMSQT differ is unknown, since in some high schools the test is mandatory and in others it is administered only to outstanding students.

Although only changes in educational plans occurring during the freshman year of college were studied, this is the period when changes are most rapid and perhaps most meaningful. Wallace (1965) found that change is a function of previous academic achievement, socioeconomic ambition, and peer group attitudes. Astin (1965c, p. 112) indicated that the present results were not seriously vitiated by reporting error, since over a short time (six weeks) there was a test-retest correlation of .98 for father's educational level, .98 for size of high school class, and .91 for high school grade average.

Because it was desirable to use the NMSQT scores in the analysis, it became necessary to ascertain how much the correlations had been distorted by either nonresponse to the questionnaire or nonavailability of NMSQT scores. It was clear that students for whom NMSQT scores were available ($N \sim 20{,}000$) had higher high school grades (mean 5.6 for men, 6.1 for women) than those responding ($N \sim 30,000$, which included the $\sim 20,000$ with NMSQT scores) to the follow-up questionnaire (mean 5.1 for men, 5.8 for women), who, in turn, had higher high school grades (mean 4.7 for men, 5.5 for women) than the original freshman sample ($N = 127,125$, of whom the $\sim 30,000$ questionnaire respondents were a subsample). To estimate the effect of these biases, a number of inter-correlations were computed (using freshman data) for different groups: entering freshmen, all questionnaire respondents (a subsample of freshmen), and questionnaire respondents who had taken the NMSQT. The correlation of father's education (FaEd) with high school grade average (HSG) dropped from .09 for the original 76,015 males to .06 for the questionnaire respondents to .05 for the NMSQT takers. The correlation of HSG with freshman educational plans (FLOA) fell from .33 to .32 to .30 for the respective groups, and the correlation of FaEd with FLOA fell from .22 to .21 to .20. Although the biases produced slightly smaller correlations, the decrease tended to affect all relationships equally, so that the pattern of relationships and the deductions therefrom should not be affected seriously.

The correlations shown in Table 1 were computed on about 2,000 males and 2,000 females. They represent one eighth and one seventh random samples of the male and female respondents respectively. The correlations among FaEd, HSG, and FLOA in this subsample were within .01 of the same correlations on the total group of respondents of the same sex. As a preliminary measure, all correlations were screened to ensure reasonable linearity of regression and generally unimodal

Table 1

Correlation Matrix For a Sample of College Freshmen

Males (N = 2,000)

	FaEd	NMSQT	HSG	FLOA	SELECT	CG	SLOA	
FaEd	--	.202	.045	.205	.286	.053	.201	FaEd
NMSQT	.250	--	.514	.357	.518	.386	.286	NMSQT
HSG	.053	.468	--	.329	.420	.480	.320	HSG
FLOA	.122	.265	.230	--	.320	.244	.622	FLOA
SELECT	.321	.496	.233	.207	--	.126	.228	SELECT
CG	.060	.365	.525	.138	.033	--	.335	CG
SLOA	.105	.240	.240	.541	.168	.231	--	SLOA
	FaEd	NMSQT	HSG	FLOA	SELECT	CG	SLOA	

Females (N = 2,000)

Note.--All correlations were computed using a missing data correlation program. The correlations for males are above the diagonal, those for females below the diagonal.

distributions, with frequencies decreasing in either direction from the mode. All correlations were computed with a missing data correlational program, and these correlations were used in all additional computations.

<u>Construction of the Causal Framework</u>

The general procedure was to construct six equations using the seven variables under study, namely: (a) X_1 = Father's education (FaEd), (b) X_2 = National Merit Scholarship Test score (NMSQT), (c) X_3 = High school grade average (HSG), (d) X_4 = Freshman educational plans (FLOA), (e) X_5 = "Selectivity" of college attended, (f) X_6 = Freshman year college grades (CG), and (g) X_7 = Sophomore educational plans (SLOA). The dependent variable always is shown on the left side of the equation, and the independent variables on the right. The presence of an independent variable corresponds to the hypothesis that this variable is a cause of the dependent variable, and that variables not included do not affect this relationship. The justification for including or excluding a variable is solely logical, and hence corresponds to a theoretical premise. In discussing the meaning of each equation, the notation, $Y \leftarrow X$ (or, equivalently, $X \rightarrow Y$), is used, which simply indicates that X is an independent variable which appears on the right side of the equation, and that X is hypothesized to be one cause of the dependent variable, Y. In the following equations each variable will be measured in terms of deviation from its mean--otherwise an additional constant would be needed in the equations.

1. $X_2 = a_{21}X_1 + e_2$

The hypothesis here is that NMSQT (X_2) is caused by FaEd and residual (implicit) factors (e_2) not explicitly included in the causal scheme.

The correlation of FaEd with NMSQT undoubtedly summarizes the influence of both genetic and sociocultural processes.[2] In the sample of NMSQT takers, FaEd correlates more closely with the vocabulary portions than with the other subtests of the NMSQT, possibly because vocabulary is more affected by home background than is achievement in school subjects like mathematics,

---

2. O. D. Duncan notes that equation 1 is not too plausible, since both FaEd (X_1) and NMSQT scores (X_2) probably have substantial genetic components. If so, the father's genetic intelligence lies back of X_1 and X_2 in some complicated way which would render interpretation of a_{21} almost impossible. Personal communication, March 24, 1967.

reading, social studies, and the natural sciences. There is little reason, however, to believe that vocabulary is more "innate" than mathematical ability, despite the fact that verbal ability is the main factor in so-called "intelligence" tests. This investigator agrees with Coleman, et al. (1966, p. 293) that ability tests are broader and more gene measures of knowledge, while achievement tests are narrower measures directed to a restricted subject matter. From this viewpoint "intelligence" and "achievement" may be only concurrent, overlapping variables and therefore impossible to interpret in a causal manner. Because the NMSQT subtests clearly are also concurrent variables, a composite average of the subtest scores was used in order to avoid confounding the analysis.

2. $X_3 = a_{31}X_1 + a_{32}X_2 + e_3$

High school grade average (X_3) is caused by FaEd (X_1), NMSQT (X_2), and residual (implicit) factors (e_3). Studies by Nichols and Holland (1963) and Davidsen (1963) indicated that self-reported grades correspond highly ($r > .90$) to school-reported grades, which justifies their use here.

Although FaEd may be assumed to cause HSG for the same reasons that FaEd$\rightarrow$NMSQT, it is difficult to assert that NMSQT$\rightarrow$HSG since both are indicators of academic achievement, differing mainly in the method of measurement. HSG may be more affected by teachers' subjective judgments and consequently more affected by the student's relationship with teachers. NMSQT might be partialled out of HSG in order to study these factors (Lavin, 1965). This procedure would be hazardous with our data, since grades from various high schools are noncomparable because of differences in grading practices and in the academic ability of the student bodies. The main justification for NMSQT⟶HSG is that NMSQT is determined in the junior year, while HSG is not finalized until high school graduation. As a result, HSG includes academic performance in the senior year, and NMSQT⟶HSG merely states that past performance influences future performance.

The correlation of FaEd with HSG (.05 for both sexes) is smaller than that of FaEd with NMSQT (.20 for men, .25 for women), partly because high FaEd students attend more competitive schools and hence get lower grades than would be predicted from their test scores. (The correlation of FaEd with HSG when NMSQT is partialled out is small and negative.) The small correlations of FaEd with HSG and NMSQT suggest that among college students the ability differences between social class groups are small compared with the differences within social class groups. Compared with similar (moderate-sized) correlations among high school students, these small correlations apparently result from the fact that nearly all high FaEd students go to college, whereas at low FaEd levels only the higher ability students enter college.

3. $X_4 = a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + e_4$

Educational plans upon college entrance (FLOA) are caused by FaEd, NMSQT, HSG, and other, residual (implicit) factors (e_4).

The relationship, FaEd⟶FLOA, is now so well-documented that attention will be focused on NMSQT⟶FLOA and HSG⟶FLOA. Again we must defend the inclusion of these variables in the equation. While no definitive case can be made, the following considerations appear to be relevant: (a) Freshman educational plans were measured upon college entrance, which normally is three months, and frequently more, after high school graduation when HSG is finalized, and long after the NMSQT has been administered. (b) The elements of a cross-lag analysis were present in the design. Both HSG and FLOA were obtained from the student on entry to college, and their analogues, CG and SLOA, were obtained one year later. According to the theory (Campbell & Stanley, 1963) of cross-lag analysis, an "effect" (e.g., educational aspiration) should correlate higher with a prior "cause" (e.g., academic performance as measured by HSG) than with a subsequent "cause" (e.g., academic performance as measured by CG). If grades influence educational plans, the correlation of HSG with SLOA should be greater than the correlation of FLOA with CG. The finding that HSG correlates .32 with SLOA for men (.24 for women) and that FLOA correlates .24 with CG for men (.14 for women) supports this hypothesis. The evidence is not definitive, however, since one cannot be certain that HSG and CG are exactly comparable. Rozelle and Campbell (1967) have raised additional questions about the validity of cross-lag analysis. One value of having NMSQT and HSG as prior variables is that NMSQT scores may help to adjust HSG for differences between schools (in academic ability of student bodies and in grading practices) in perhaps the same way that a student may adjust his self-estimate according to the "selectivity" of his high school.

Equations 1, 2, and 3 fundamentally assume a causal ordering of variables: that is, FaEd, NMSQT, HSG, and FLOA, such that each variable may be influenced only by variables prior to it and, in turn, may influence only subsequent variables. Even if this causal ordering were correct, meaningful results also would depend on the nature of the data collected. In particular, we want the correlations between the four variables to represent the influences of one variable on another without major distortions from variables outside the causal model. In a sample of college students the correlations between these variables are markedly changed by college admission requirements. For example, the correlation of FaEd with NMSQT or with HSG is much lower among college freshmen than among high school students, and therefore radically underestimates the true influence of FaEd on NMSQT or on HSG. For this reason, equations 1, 2, and 3 will not be used to make causal interpretations.

4. $X_5 = a_{51}X_1 + a_{52}X_2 + a_{53}X_3 + a_{54}X_4 + e_5$

The "selectivity" of the college (X_5) is determined by the student's grades (HSG), test scores (NMSQT), family background (FaEd), and freshman educational plans (FLOA). "Selectivity" may be expected to correlate higher with NMSQT than with HSG because "selectivity" scores were derived from NMSQT data. The rationale for NMSQT→SELECT and HSG→SELECT is simply that, using both test scores and high school grades as screening devices, more selective colleges admit only the more academically able students.

Because the more selective schools generally are more expensive (Astin, 1965c), students from affluent backgrounds will be more likely to attend them, thus FaEd→SELECT. Furthermore, more highly-educated parents may have a predilection for the more prestigious institutions (they may have attended one themselves), and often may be willing to sacrifice to give their children the "best possible" start in life.

The hypothesis that FLOA→SELECT ($r = .32$) is included because the more selective colleges possibly may prefer students aspiring to the higher professions, and may structure their admissions policies and their curricula to attract them. These students also may feel that by attending a more selective, prestigious college their chances of eventually getting into graduate or professional school are increased.

5. $X_6 = a_{61}X_1 + a_{62}X_2 + a_{63}X_3 + a_{64}X_4 + a_{65}X_5 + e_6$

College grades (X_6) are influenced by the competitiveness of the college attended ("selectivity"), prior academic ability (HSG, NMSQT), freshman educational plans (FLOA), and family background (FaEd).

Again it is hypothesized that future performance depends upon past performance (NMSQT→CG, HSG→CG). Because on entry to college students frequently move away, psychologically and/or physically, from their families, the relationship, FaEd→CG, may be much weaker than FaEd→HSG. Since some students undoubtedly continue to be influenced by parents, however, FaEd→CG was not deleted.

The hypothesis, FLOA→CG, suggests that students who aspire to graduate or professional school (high FLOA) may study harder because they realize that good grades are requisite for graduate work. Finally, SELECT→CG is based on the supposition that colleges tend to have the same distribution of grades (Davis, 1966), a supposition consistent with our finding that "selectivity" correlates only .13 with CG for males (.03 for females). Therefore, the student attending a more selective college can be expected to get lower grades than he would have at a less selective college. In other words, Davis hypothesized that when antecedent variables are controlled the association of SELECT with CG will be negative.

6. $X_7 = a_{71}X_1 + a_{72}X_2 + a_{73}X_3 + a_{74}X_4 + a_{75}X_5 + a_{76}X_6 + e_7$

Sophomore educational plans (SLOA) are a function of all prior variables, including CG, "selectivity" of college, FLOA, HSG, NMSQT, and FaEd.

The core of the present study is the examination of changes in educational plans during college as a function of "selectivity" (SELECT→SLOA). The hypotheses, HSG→SLOA, NMSQT→SLOA, and FaEd→SLOA, correspond to controls for background variables. Since variance due to initial level of aspiration is partialled out, FLOA→SLOA in effect means that changes in educational plans are being studied.

The literature contains at least two different hypotheses about the nature of the relationship between "selectivity" and changes in educational plans. The theory of "relative deprivation" (Davis, 1966) predicts that, assuming the student's educational plans generally tend to rise, they will rise less at the highly selective colleges than they will at the unselective colleges; whereas the "environmental press" theory (Thistlethwaite & Wheeler, 1966) predicts just the opposite. One cannot, strictly speaking, infer from our correlations that any rise in aspiration takes place. However, because the mean SLOA is greater than the mean FLOA, and because Wallace's (1965) results indicated a rapid rise in aspiration during the freshman year, we will talk as if this were the case.

Although Davis studied career decisions, his results should apply to educational plans also, since career preferences are associated closely with decisions to attend graduate school. The coding of educational plans here (including M.D., LL.B., Ph.D., B.D., and D.D.S. in the highest category) should sort people into a category much like Davis' "high academic-performance career fields," which comprises the physical sciences, biological sciences, social sciences, humanities and fine arts, and law and medicine. Davis (1956) reasoned as follows:

> The theory of relative deprivation suggests the following interpretation of our data: (a) In making career decisions regarding the high-performance fields (which generally require graduate training), the student's judgment of his own academic ability plays an important role. (b) In the absence of any objective evidence, students tend to evaluate their academic abilities by comparison with other students. (c) Most of the other students one knows are those on one's own campus, and since GPA's (Grade Point Averages) are reasonably public information, they become the accepted yardstick. (d) Comparisons across campuses are relatively rare, and where they take place it is difficult to arrive at an unambiguous conclusion because institutional differences are not well publicized; even when these differences are known, there is no convenient scale comparable to GPA for drawing conclusions. (e) Since more conclusions are drawn on the basis of GPA standing on the local campus than by comparison with students on other campuses, GPA is a more important variable in influencing self-evaluations and, consequently, career decisions (p. 25).

Davis' study overlaps ours considerably, in both the logic and the types of variables used. His School Quality is identical with "selectivity," his GPA corresponds to CG (since grade point average is a linear function of grades), and, as noted before, his coding of Career Aspiration sorts people in much the same way as the FLOA and SLOA educational plans codes do here. Davis' theory implies the developmental sequence: SELECT→CG→subjective feeling of academic success→SLOA (where SLOA actually means changes in plans with FLOA controlled). This sequence suggests that students who attend highly selective colleges will obtain lower grades than they would have at less selective colleges (SELECT→CG); and that their subjective reaction to lower grades (CG→subjective feeling) will be one of relative academic failure, causing them to lower their aspirations (subjective feeling→SLOA). When each variable in a developmental sequence is influenced only by the variable immediately preceding it in the chain (Blalock, 1961), controls for any one of the intervening variables will reduce the association between the initial and the final variable to zero. Consequently, when studying the association of "selectivity" with SLOA, controls for CG: (a) will remove the influence of "relative deprivation" because the mechanism for its effect (viz. the intervening variable, CG) is controlled, and (b) will not remove the influence of "environmental press" because the influence, as noted below, is not mediated through CG.

The "environmental press" theory implies that the student will be influenced by the demands, expectations, and activities most characteristic of teachers and other students at his college. The theory suggests a trend towards homogeneity, with deviants tending to become more like the majority in their aspirations. Because "intellectual" atmosphere is associated closely with "selectivity" (Astin, 1964), the hypothesis is that the more intellectual atmosphere of the more selective college will produce a relatively greater rise in the educational plans of its students. In the absence of compelling evidence from the literature, it is possible to suggest many hypotheses other than those presented above: for example, perhaps there is a ceiling effect on educational plans, or perhaps in the more selective colleges only the inferior students are affected by "relative deprivation," the more able students being "pressed" towards the majority position.

Method

The set of six simultaneous equations constructed from theoretical considerations usually is referred to as a recursive system. The characteristic of a recursive system is that the regression coefficients, a_{ij} (where $i > j$), appear in the set, but the corresponding coefficients, a_{ji}, do not. A useful property of a recursive system is that least squares analysis can be used to obtain unbiased estimates of the regression coefficients. Therefore an ordinary regression program can be used to calculate the regression coefficients by computer. Since this analysis was based on standardized regression coefficients, which are easier to interpret than unstandardized coefficients, the "normal" equations (Walker & Lev, 1953, pp. 324-326) were used to obtain the standardized regression coefficients directly from the correlation coefficients in Table 1. The "normal" equations then were solved by using a standard computer program for the solution of simultaneous equations. Some inexactness resulted from the use of correlations computed from incomplete data; however, the error appeared trivial. The standardized, partial regression coefficients are given in Table 2. The causal model represented by equations 1 through 6 is a special case of path analysis (Duncan, 1966); its distinctive features are that there are no unmeasured variables--other than the residual or "implicit" factors--and that each variable is directly related to all variables preceding it. Under these circumstances path analysis amounts to conventional regression analysis, and the standardized, partial regression coefficients are identical with the path coefficients of path analysis. Consequently, the term, "path coefficients" (denoted p_{ij}), will be used interchangeably with the term, "standardized, partial regression coefficients," in the remainder of the discussion.

Standardized, partial regression coefficients may be compared directly with each other: that is, if one is twice the size of another, it is twice as important in predicting (estimating) the dependent variable (Steel & Torrie, 1960, p. 284). In a recursive system where the residual (implicit) factors are uncorrelated, Boudon (1965) proved a further theorem: the standardized, partial regression coefficient is a measure of the direct influence of one variable on another.[3] "Direct" in this sense is defined as that influence which remains after all other independent variables in the causal equation have been controlled. Therefore the direct will be equal to the total influence of one variable on another only when there are no intervening variables.

In order to clarify the rationale for regression analysis in terms of the relationships postulated previously, equations 1 through 3 will be

---

3. This interpretation of "importance in prediction" should not be confused with "percentage of variance accounted for." It is more like (but not identical with) the sense in which partial correlations are interpreted.

Table 2

Calculated Path Coefficients for all Relationships

Independent Variable	Dependent Variable	Symbol	Standardized Partial Regression Weights (path coefficients) Males	Females
FaEd	SLOA	p_{71}	.084	.018
NMSQT	SLOA	p_{72}	-.025	.019
HSG	SLOA	p_{73}	.068	.037
FLOA	SLOA	p_{74}	.552	.499
SELECT	SLOA	p_{75}	-.010	.037
CG	SLOA	p_{76}	.174	.134
FaEd	CG	p_{61}	.028	.041
NMSQT	CG	p_{62}	.248	.243
HSG	CG	p_{63}	.413	.456
FLOA	CG	p_{64}	.081	.007
SELECT	CG	p_{65}	-.210	-.208
FaEd	SELECT	p_{51}	.189	.207
NMSQT	SELECT	p_{52}	.341	.422
HSG	SELECT	p_{53}	.206	.009
FLOA	SELECT	p_{54}	.092	.068
FaEd	FLOA	p_{41}	.151	.069
NMSQT	FLOA	p_{42}	.219	.182
HSG	FLOA	p_{43}	.210	.141
FaEd	HSG	p_{31}	-.061	-.068
NMSQT	HSG	p_{32}	.526	.485
FaEd	NMSQT	p_{21}	.202	.250

Note.--The abbreviations are: FaEd = Father's Education, NMSQT = National Merit Scholarship Qualifying Test Score, HSG = High School Grade Average, CG = Freshman College Grade Average, FLOA = Freshman Educational Plans, SLOA = Sophomore Educational Plans, and SELECT = "Selectivity" of College.

analyzed in detail. This analysis is presented only for didactic purposes for the reasons noted earlier. Figure 1 shows the complete net of causal relationships postulated for equations 1, 2, and 3. In least squares analysis the error term, corresponding to the residual factors in equations 1 through 6, is assumed to be uncorrelated with the independent variables in the regression equations. As Blalock (1960) pointed out, this is a weaker assumption than that used for many partial correlation studies where it is assumed that all relevant variables have been controlled. Ideally one should bring as many of the outside, disturbing influences as possible into the analysis as explicit (i.e. not residual) variables in order to minimize interpretational distortions resulting from non-independence of the residual factor.

The causal network in Fig. 1 is an explicit representation of equations 1, 2, and 3, and amounts to saying that these relationships will account completely for the observed correlations between all variables. The correlation of HSG (X_3) with FLOA (X_4) will be the result of a variety of influences, viz.: (a) The direct influence of X_3 on X_4 ($X_3 \rightarrow X_4$) will create an association between X_3 and X_4. (b) The antecedent variable, FaEd (X_1), may contribute some spurious association between X_3 and X_4 ($X_4 \leftarrow X_1 \rightarrow X_3$). (c) The antecedent variable, NMSQT (X_2), likewise may contribute some spurious association between X_3 and X_4 because of its direct influence on both these variables ($X_3 \leftarrow X_2 \rightarrow X_4$). (d) Since X_1 influences X_4 through the intervening variable, X_2, ($X_1 \rightarrow X_2 \rightarrow X_4$), this mediated influence could combine with the direct influence of X_1 on X_3 ($X_1 \rightarrow X_3$) to create an additional, spurious association between X_3 and X_4 ($X_3 \leftarrow X_1 \rightarrow X_2 \rightarrow X_4$). And (e) since

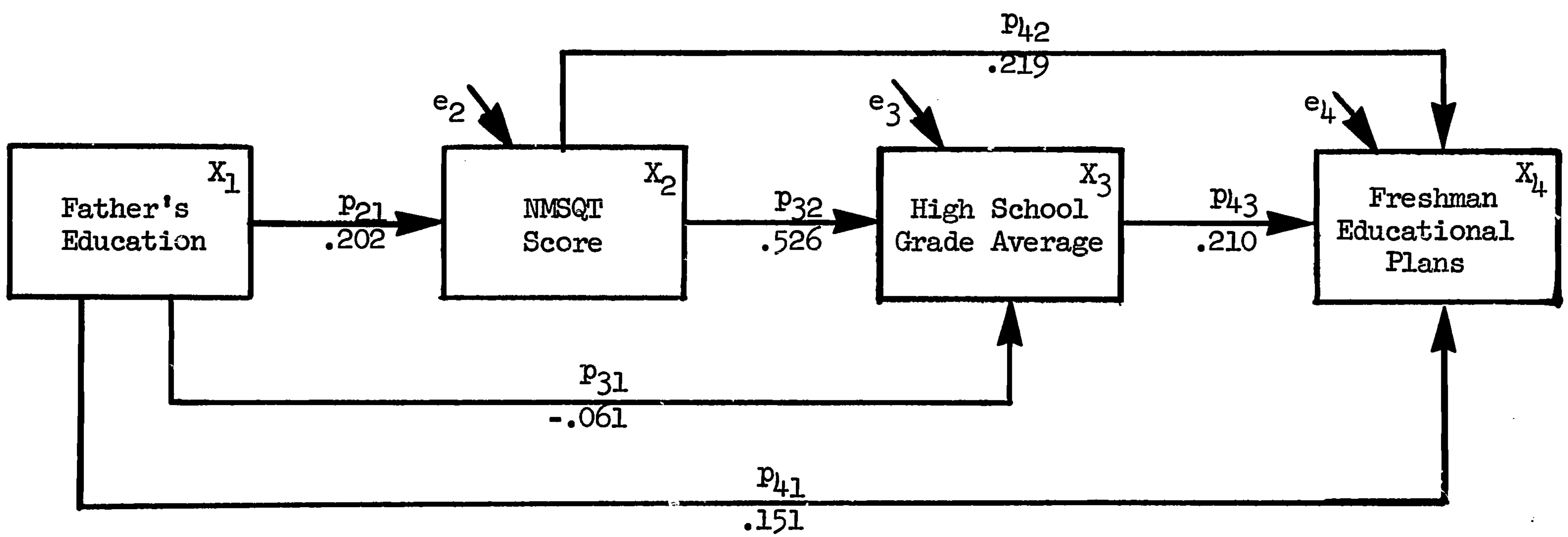


Fig. 1. Causal diagram representing equations 1, 2, and 3 for males.

X_1 influences X_3 through the intervening variable, X_2, $(X_1 \rightarrow X_2 \rightarrow X_3)$, this mediated influence might combine with the direct influence of X_1 on X_4 $(X_1 \rightarrow X_4)$ to create additional, spurious association between X_3 and X_4 $(X_4 \leftarrow X_1 \rightarrow X_2 \rightarrow X_3)$.

Because the role of intervening and antecedent factors has been commonly discussed in the literature, it may not be too difficult to understand sources (a), (b), and (c) $(X_4 \leftarrow X_1 \rightarrow X_3$; $X_4 \leftarrow X_2 \rightarrow X_3$; and $X_3 \rightarrow X_4)$ of association between X_3 and X_4 implied in Fig. 1. However, the more indirect sources of spuriousness $(X_3 \leftarrow X_1 \rightarrow X_2 \rightarrow X_4$ and $X_4 \leftarrow X_1 \rightarrow X_2 \rightarrow X_3)$ are less obvious. Sources of association between any pair of variables in equations 1 through 6 can be detailed by using the normal equations of regression analysis, in which the standardized, partial regression coefficients are stated in terms of the known correlation coefficients between variables. The normal equations corresponding to equations 1, 2, and 3 above (p_{ij} are the standardized version of the corresponding regression coefficients, a_{ij}, in equations 1, 2, and 3) are:

$$r_{12} = p_{21}$$

$$r_{13} = p_{31} + r_{12}p_{32}$$

$$r_{23} = r_{12}p_{31} + p_{32}$$

$$r_{14} = p_{41} + r_{12}p_{42} + r_{13}p_{43}$$

$$r_{24} = r_{12}p_{41} + p_{42} + r_{23}p_{43}$$

$$r_{34} = r_{13}p_{41} + r_{23}p_{42} + p_{43}$$

First, note that the p_{ij} are unknowns in these equations, but can be solved for since there are as many equations as unknowns. Strictly speaking, the normal equations have additional terms, including the residual factors. These terms drop out because each residual factor has been specifically assumed to be uncorrelated with the independent variables in the least squares analysis. To determine the sources of association between X_3 and X_4, the procedure is:

Step 1. Start with the equation for r_{34}: $r_{34} = r_{13}p_{41} + r_{23}p_{42} + p_{43}$

Step 2. Substitute the equations for $r_{13} = p_{31} + r_{12}p_{32}$ and $r_{23} = r_{12}p_{31} + p_{32}$ to obtain:

$$r_{34} = p_{41}(p_{31} + r_{12}p_{32}) + p_{42}(r_{12}p_{31} + p_{32}) + p_{43}$$

$$= p_{31}p_{41} + r_{12}p_{32}p_{41} + r_{12}p_{31}p_{42} + p_{32}p_{42} + p_{43}$$

Step 3. Substitute the equation for $r_{12} = p_{21}$ to obtain:

$$r_{34} = p_{31}p_{41} + p_{21}p_{32}p_{41} + p_{21}p_{31}p_{42} + p_{32}p_{42} + p_{43}$$

In examining the terms on the right-hand side of the equation relating r_{34} to the p_{ij}, several analogies can be drawn: (a) the p_{43} represents the direct influence of X_3 on X_4 ($X_3 \rightarrow X_4$), (b) the $p_{31}p_{41}$ represents the spurious association contributed by the antecedent factor, X_1, because of its direct influence on X_3 (p_{31}) and on X_4 (p_{41}) or symbolically, $X_4 \leftarrow X_1 \rightarrow X_3$, (c) the $p_{32}p_{42}$ represents the spurious association contributed by the antecedent factor, X_2, because of its direct influence on X_3 (p_{32}) and on X_4 (p_{42}) or symbolically, $X_4 \leftarrow X_2 \rightarrow X_3$, (d) the $p_{21}p_{31}p_{42}$

represents the spurious association due to the direct influence of X_1 on X_3 (p_{31}), combined with the influence of X_1 on X_4 mediated through X_2, i.e. $X_3 \leftarrow X_1 \rightarrow X_2 \rightarrow X_4$, and (e) the $p_{21}p_{32}p_{41}$ represents the spurious association due to the direct influence of X_1 on X_4 (p_{41}), combined with the mediated influence of X_1 on X_3 through the intervening variable, X_2. Each term in the equation for r_{34} corresponds to another source of association, which allows one to specify precisely the sources of association between two variables (the sources implied by the use of regression analysis).

Although the investigator can specify all sources of association between two variables, he usually is interested only in certain kinds. The sources resulting in spuriousness often are of little interest, but the sources of association due to the direct or mediated influence of one variable on another are of considerable interest, since neither is spuriousness in the interpretive sense. In the analysis of r_{34}, all sources of association except $X_3 \rightarrow X_4$ (measured by p_{43}) are considered to be sources of spuriousness, simply because there are no variables in the model intervening between X_3 and X_4. To understand mediated sources of association, let us solve for r_{14} in terms of p_{ij}, employing the procedure used previously to solve for r_{34}:

Step 1. $r_{14} = p_{41} + r_{12}p_{42} + r_{13}p_{43}$

Step 2. Substituting $r_{13} = p_{31} + r_{12}p_{32}$

$$r_{14} = p_{41} + r_{12}p_{42} + p_{43}(p_{31} + r_{12}p_{32})$$

$$= p_{41} + r_{12}p_{42} + p_{31}p_{43} + r_{12}p_{32}p_{43}$$

Step 3. Substituting $r_{12} = p_{21}$

$$r_{14} = p_{41} + p_{21}p_{42} + p_{31}p_{43} + p_{21}p_{32}p_{43}$$

Interpreting each term of this equation: (a) p_{41} measures the direct influence of X_1 on X_4 ($X_1 \rightarrow X_4$), (b) $p_{21}p_{42}$ is the association due to the influence of X_1 on X_4, mediated through X_2 (i.e. $X_1 \rightarrow X_2 \rightarrow X_4$), (c) $p_{31}p_{43}$ is the association due to the influence of X_1 on X_4, mediated through X_3 (i.e. $X_1 \rightarrow X_3 \rightarrow X_4$), and (d) $p_{21}p_{32}p_{43}$ is the association due to the influence of X_1 on X_4, mediated through the intervening variables, X_2 and X_3 (i.e. $X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow X_4$). One can see that the presence of intervening variable(s) means that the total influence--direct and mediated--of one variable on another is measured not only by the path coefficient between them but also must include all the mediated influences. Thus if an investigator is interested only in the direct and mediated influences of one variable on another, he need only specify all possible mediating influences, and he can calculate the association contributed by each one of these by multiplying the path coefficients corresponding to each pair of variables in the mediating chain: for example, as indicated above, $X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow X_4$ contributes an association, $p_{21}p_{32}p_{43}$, between X_1 and X_4.

To reiterate, let us examine the correlation of NMSQT (X_2) scores with freshman educational plans (FLOA = X_4). In this case HSG (X_3) intervenes between NMSQT and FLOA, and FaEd (X_1) is a common, antecedent factor. Solving the normal equations for r_{24}, we obtain:

$$r_{24} = p_{41}p_{21} + p_{42} + p_{43}p_{21}p_{31} + p_{32}p_{43}$$

Using the path coefficients for males (shown in Table 2), one may deduce that r_{24} (.357) has four components due to: (a) the direct influence of X_2 on X_4 ($X_2 \rightarrow X_4$) or p_{42} = .219, (b) the mediated influence of X_2 on X_4 through X_3 ($X_2 \rightarrow X_3 \rightarrow X_4$) or $p_{32}p_{43}$ = .526(.210) = .110, (c) the antecedent variable, X_1 ($X_4 \leftarrow X_1 \rightarrow X_2$), or $p_{41}p_{21}$ = .151(.202) = .031, and (d) the chain, $X_4 \leftarrow X_3 \leftarrow X_1 \rightarrow X_2$, accounts for the remainder, i.e. $p_{43}p_{21}p_{31}$ = .210(.202)(-.061) = -.003. Accordingly, the interpretation of these data is that: (a) NMSQT (X_2) seems to have a direct influence (independent of both X_1 and X_3) on freshman educational plans (X_4) as measured by the path coefficient p_{42} = .219, (b) NMSQT has an additional, mediated influence on FLOA (NMSQT → HSG → FLOA) which is about one half as potent (.219 vs. .110) as the direct influence, and (c) the total influence of NMSQT on FLOA, direct and mediated, accounts for .329 (i.e. .219 + .110) of the .357 correlation of X_2 with X_4. The remainder (.357 - .329 = .028) is accounted for by the algebraic sum (.031 - .003 = .028) of the two spurious or antecedent components. It is worth noting that the inclusion of high school grades (HSG = X_3) in the causal model allows us not only to measure separately the mediated influence, NMSQT → HSG → FLOA, as distinct from NMSQT → FLOA, but also to specify the indirect sources of spuriousness, NMSQT ← FaEd → HSG → FLOA.

Results

This study was originally intended to interpret only three correlations: SELECT with CG, CG with SLOA, and SELECT with SLOA. SELECT has been treated as antecedent to both CG and SLOA, because SELECT is determined on college entrance before CG and SLOA have been determined. The assumption that CG is antecedent to SLOA is not as easy to defend, because there may be little or no time lapse between these variables. In order to interpret the correlations between SELECT, CG, and SLOA, we must consider the association remaining between these variables after FaEd, NMSQT, HSG, and FLOA have been controlled. When these latter four variables are controlled, no assumptions need be made about the causal ordering among them--in other words, equations 1, 2, and 3 are unnecessary. Equation 4, in essence, states that before we can study the influence of SELECT on CG or on SLOA we must control for FaEd, NMSQT, HSG, and FLOA. Since we did not originally intend to examine the factors influencing SELECT, equation 4 need not have been constructed. The causal model corresponding to equations 4, 5, and 6 is shown in Fig. 2. Curved lines with arrows at either end were drawn between FaEd, NMSQT, HSG, and FLOA to indicate that equations 4, 5, and 6 do not assume any causal ordering among these variables. Where the path coefficients are less than .10, no arrows were drawn.

The sources of the correlations between SELECT (X_5), CG (X_6), and SLOA (X_7) may be derived from the normal equations in the following manner:

Step 1. The normal equation corresponding to equation 6 which involves r_{57} is:

$$r_{57} = r_{15}p_{71} + r_{25}p_{72} + r_{35}p_{73} + r_{45}p_{74} + p_{75} + r_{56}p_{76}$$

Step 2. The normal equation for r_{56} is (corresponding to equation 5):

$$r_{56} = r_{15}p_{61} + r_{25}p_{62} + r_{35}p_{63} + r_{45}p_{64} + p_{65}$$

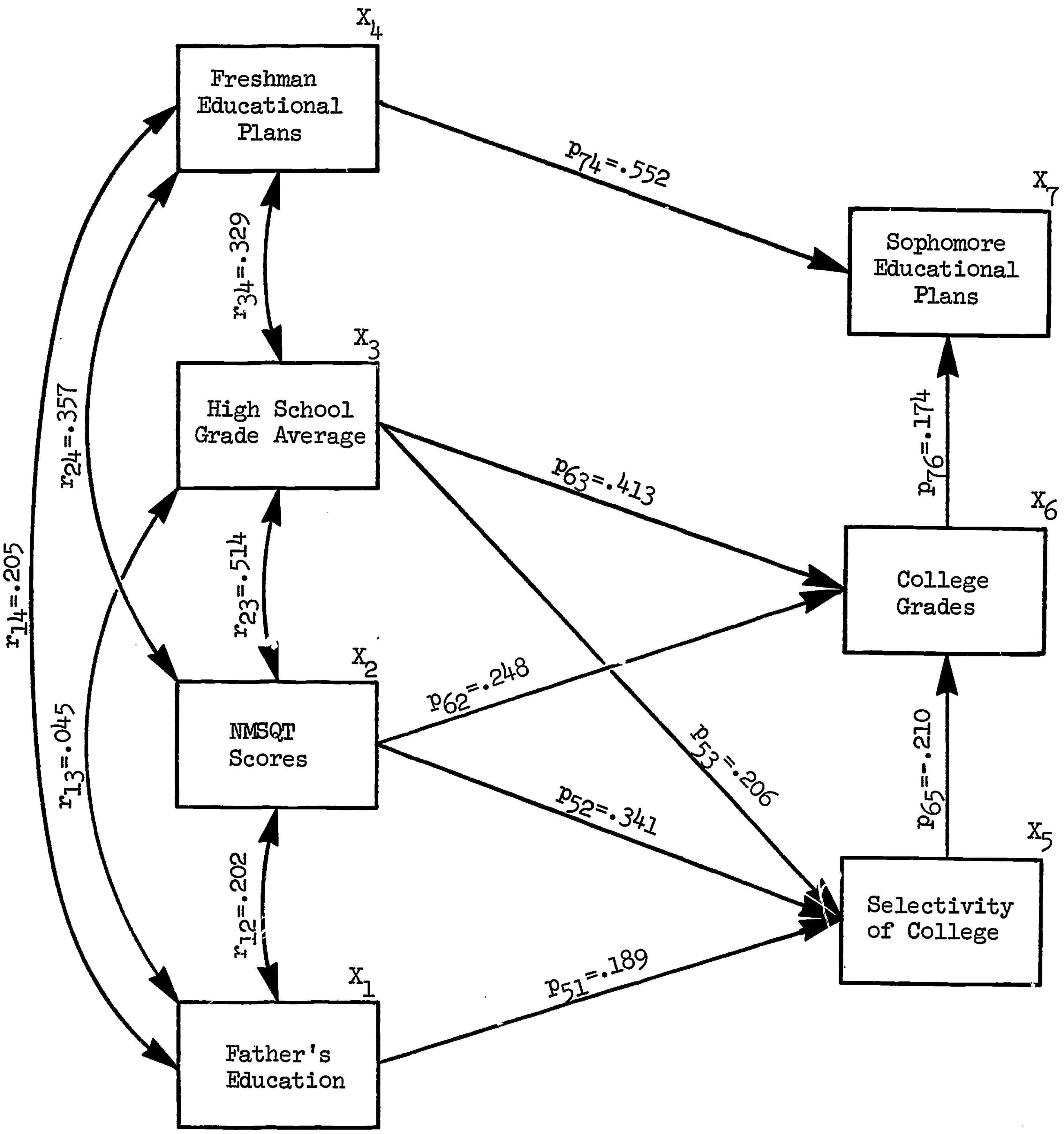


Fig. 2. Causal model representing equations 4, 5, and 6 for males. Double-headed, curved arrows represent unanalyzed correlations among the four background variables, FaEd, NMSQT, HSG, and FLOA. Straight single arrows represent causal influences in the direction indicated. To emphasize the main findings, no arrow was drawn where the path coefficient representing the strength of a relationship was less than .10 in absolute magnitude.

Step 3. Substituting r_{56} into r_{57}:

$$r_{57} = r_{15}p_{71} + r_{25}p_{72} + r_{35}p_{73} + r_{45}p_{74} + p_{75} + r_{15}p_{76}p_{61} + r_{25}p_{76}p_{62} + r_{35}p_{76}p_{63} + r_{45}p_{76}p_{64} + p_{76}p_{65}$$

$$r_{57} = r_{15}(p_{71} + p_{76}p_{61}) + r_{25}(p_{72} + p_{76}p_{62}) + r_{35}(p_{73} + p_{76}p_{63}) + r_{45}(p_{74} + p_{76}p_{64}) + p_{75} + p_{76}p_{65}$$

This equation can be rewritten as $r_{57} = p_{75} + p_{76}p_{65}$ + spuriousness, since we have accounted for the direct effect of X_5 on X_7 by p_{75} and the indirect effect of X_5 on X_7 through X_6 by $p_{76}p_{65}$. This equation removes the spurious effects of the background variables. Following the principles laid down earlier, since there are no intervening variables between X_6 and X_7 the influence of X_6 on X_7 is measured by p_{76}, the difference, r_{67} minus p_{76}, representing spuriousness. Likewise, the influence of X_5 on X_6 is measured by p_{65}, the difference, r_{56} minus p_{65}, representing spuriousness. It follows that the .228 (for males) correlation of SELECT with SLOA is due to the direct influence of SELECT $\rightarrow$ SLOA measured by p_{75} = -.010, the mediated influence of SELECT $\rightarrow$ CG $\rightarrow$ SLOA measured by $p_{65}p_{76}$ = -.210(.174) = -.037, and the spurious association caused by antecedent variables, X_1, X_2, X_3, and X_4, amounting to .275 (since r_{57} = .228 = -.010 -.037 + spuriousness). The contribution of both the direct (-.010) and the indirect (-.037) influences of SELECT actually is quite small, as therefore is the total influence (-.047) of SELECT on SLOA. The sign of the mediated influence, SELECT $\rightarrow$ CG $\rightarrow$ SLOA, is negative just as Davis (1966) predicted, but its size is trivial. The data for women also show the indirect influence to be negative and small, i.e. $p_{65}p_{76}$ = -.208(.134) = -.029, whereas the direct influence is small and positive: p_{75} = +.037. The direct influence of "selectivity" (SELECT = X_5) on college grades (CG = X_6) is negative as measured by p_{65} = -.210 for males and -.208 for females. Davis' assertion that a student attending a more selective college would have obtained somewhat higher grades at a less selective college is supported. The direct, positive influence of college grades on sophomore educational plans is measured by p_{76} = .174 for males and .134 for females. Thus to the extent that a student obtains better grades than one would predict (from FaEd, FLOA, HSG, NMSQT, and SELECT), his educational plans will rise more than will the plans of students who do only as well as predicted.

It is interesting to note in Fig. 2 that the direct influences on SLOA of FaEd (p_{71} = .084 for males and .018 for females), of NMSQT (p_{72} = -.025 for males and .019 for females), and of HSG (p_{73} = .068 for males and .037 for females), are small, which suggests that background factors tend to have little direct influence on changes in educational plans during college. As in most studies, HSG is the major predictor of college grades (p_{63} = .413 for males and .456 for females), followed by test scores like the NMSQT (p_{62} = .248 for males, .243 for females), and only slightly by FLOA (p_{64} = .081 for males, .007 for females) or FaEd (p_{61} = .028 for males, .041 for females).

Equation 4 might be interpreted as one kind of description of students attending the more selective colleges. Thus the path coefficient on SELECT of FaEd (p_{51} = .189 for males, .207 for females) suggests that these students have more highly educated fathers (HSG, NMSQT, and SLOA controlled), higher (p_{53} = .206 for males, .009 for females) high school grades (even with NMSQT, FaEd, and SLOA controlled), higher (p_{52} = .341 for males, .422 for females) NMSQT scores (with HSG, SLOA, and FaEd controlled), and only slightly higher freshman aspirations (p_{54} = .092 for males, .068 for females) than do other students of comparable background (FaEd, NMSQT, and HSG). It is not clear why the path coefficient of HSG on SELECT should be negligible for girls but significant for boys.

Discussion

The problem here was to interpret the correlations between a college characteristic ("selectivity"), a student experience characteristic (college grades), and changes in educational plans during the freshman year of college. It was necessary as a first step to assume a causal ordering among these variables. College "selectivity" was assumed to be antecedent to college grades and changes in educational plans, because the type of college attended is determined on entry to college, whereas college grades and changes in educational plans are ascertained later (i.e. an effect should not precede a cause in time). College grade average was treated as antecedent to changes in educational plans, because: (a) the theory under test--Davis' "relative deprivation"--considers college grades to be an intervening variable between college "selectivity" and changes in educational plans; and (b) it was found that high school grade average correlates higher with sophomore educational plans than freshman educational plans correlates with college grades, which in cross-lag analysis is interpreted to mean that grades probably cause educational plans (i.e. an effect should correlate higher with an a priori cause than with a subsequent cause). With this causal ordering and utilizing the usual assumptions of regression analysis, it was possible to interpret the correlations between "selectivity," college grades, and educational plans. Logically one had to consider the characteristics of students at different colleges as antecedent factors to be controlled, although no assumptions needed to be made about the causal ordering among the background variables. Path analysis, which makes explicit the rationale behind regression analysis, was used.

The results suggested that changes in educational plans are a positive function of the degree to which a student's academic performance--as measured by grades--differs from that predicted from his background and the college he attends. If he does better than expected, he will be more likely to raise (during the freshman year) his educational sights. The direct influence of college "selectivity" on educational plans appears to be small or nonexistent. "Selectivity" does seem to influence college grades, apparently causing a student at a more selective college to get lower grades than he would have received at a less selective college. It follows that only to the extent that a student gets lower grades because he goes to a more selective college, his sophomore educational plans will not be as high as they would have been at a less selective college. The results suggested, however, that this indirect influence of "selectivity" on educational plans, mediated by college grades, is small and perhaps trivial, especially when compared with the more general influence on educational plans of academic performance. Because of all the theoretical and statistical assumptions necessary to any interpretation, one may reasonably doubt the validity of these assertions. As Stanley (1966b) and Campbell and Stanley (1963) indicated, problems arising from the study of existent college populations make any interpretations very speculative. On the other hand, it would be even harder to defend a finding that "selectivity" positively influences aspiration, because of the plausible, alternate hypothesis that such a finding is due to incomplete control for input.

Whether the present analysis really is an adequate test of either the "relative deprivation" or the "environmental press" theory, the processes involved in both are assumed to act upon only a minority of persons--the poor achievers at highly selective colleges and those deviating from local norms respectively. The use of Pearson product moment correlations therefore may be misleading, because the small correlations simply may reflect the small number of persons affected. Another problem posed by this analysis is our assumption that all the independent variables have been measured without error. Had the appropriate reliability and validity coefficients been available, they could have been incorporated in the path analysis. However, since the data indicate no college effect on educational aspirations, it seems probable that this conclusion would not be modified by correcting for unreliability of measurement.

Summary

The goal of this study was to demonstrate that path analysis is a valuable tool when one wishes to interpret correlations in a causal sense. As Duncan (1966) has said:

> The great merit of the path scheme, then, is that is makes the assumptions explicit, and tends to force the discussion to be at least internally consistent, so that mutually incompatible assumptions are not introduced surreptitiously into different parts of an argument extending over scores of pages. With the causal scheme made explicit, moreover, it is in a form that enables criticism to be sharply focussed and hence potentially relevant not only to the interpretation at hand but also, perchance, to the conduct of future inquiry (p. 7).

To provide a concrete example, the technique was applied to a non-experimental, panel survey in an effort to determine if the more selective compared with the less selective colleges had a differential impact on the educational plans of their students. In order to test this hypothesis, it was necessary to make assumptions, including: (a) the usual assumptions of regression analysis (linearity, additivity, normality, homoscedasticity, and error terms uncorrelated with independent variables); (b) assumption of a definite causal sequence for the variables studied, such that any given variable could be "caused" only by variables causally prior to it, and could itself be a "cause" only of variables subsequent to it; (c) no measurement error for any variable, i.e. perfectly valid indicators; and (d) inclusion of all relevant, antecedent factors that would distort interpretation of any association. The weight of these assumptions was such that failure to reject the null hypothesis (that "selectivity" of the college does not influence educational plans) is not convincing evidence that no such relationship exists, especially in light of the short time interval (one year) studied. It seems better to risk making these assumptions and to draw qualified conclusions from the data than to draw no conclusions about causality.

If anything, this study demonstrates that it is extremely difficult to put theories about college environments into testable form because of the enormous variety of hidden assumptions in the published studies. One value of path analysis is that many of these assumptions are exposed in the process of setting up the causal equations. It should be noted that the assumptions used in our analysis are not necessary to all path analyses. In a given situation, it may be possible to study problems that contain correlated error terms, reciprocal causation, or unmeasured variables (like the "true" test score). It is almost impossible to test the assumptions implicit in a given theoretical model, unless one makes from that model an a priori prediction which may be contradicted by reality. No such prediction was made here. Instead, we tried--post hoc--to account for the total pattern of observed corre. ations.

References

Astin, A. W. A re-examination of college productivity. Journal of Educational Psychology, 1961, 52(3), 173-178.

Astin, A. W. "Productivity" of undergraduate institutions. Science, April 13, 1962, 136(3511), 129-135.

Astin, A. W. Distribution of students among higher educational institutions. Journal of Educational Psychology, 1964, 55(5), 276-287.

Astin, A. W. College preferences of very able students. College and University, 1965, 41, 282-297. (a)

Astin, A. W. Recent studies of college environments. Paper read at American Personnel and Guidance Association annual meeting, Minneapolis, 1965. (b)

Astin, A. W. Who goes where to college? Chicago: Science Research Associates, 1965. (c)

Blalock, H. M. Correlational analysis and causal inferences. American Anthropologist, 1960, 62, 624-631.

Blalock, H. M. Causal inferences in nonexperimental research. Chapel Hill: The University of North Carolina Press, 1961.

Blalock, H. M. Four-variable causal models and partial correlations. The American Journal of Sociology, September 1962, 68, 182-194.

Blalock, H. M. Controlling for background factors: Spuriousness versus developmental sequences. Sociological Inquiry, Winter 1964, 34(1), 28-40.

Boudon, R. A method of linear causal analysis: Dependence analysis. American Sociological Review, 1965, 30(3), 365-374.

Boyle, R. P. The effect of the high school on students' aspirations. The American Journal of Sociology, May 1966, 71, 628-639.

Campbell, D. T., & Stanley, J. S. Experimental and quasi-experimental designs for research on teaching. In N. L. Gage (Ed.), Handbook of research on teaching. Chicago: Rand McNally, 1963. Pp. 171-246.

Coleman, J. S. The adolescent society. Glencoe, Ill.: The Free Press, 1961.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. Equality of educational opportunity. Washington, D. C.: U. S. Department of Health, Education, and Welfare, Office of Education, National Center for Educational Statistics, 1966.

College Entrance Examination Board. Manual of freshman class profiles: 1961 edition. Princeton, N. J.: Educational Testing Service, 1961.

Davidsen, O. M. Reliability of self-reported high school grades. Unpublished manuscript. American College Testing Program, 1963.

Davis, J. A. The campus as a frog pond: An application of the theory of relative deprivation to career decisions of college men. The American Journal of Sociology, July 1966, 72(1), 17-31.

Duncan, O. D. Path analysis: Sociological examples. The American Journal of Sociology, July 1966, 72(1), 1-16.

Eckland, B. K. Project Talent's predictors of school outcomes: A critique. Unpublished manuscript, 1966.

Lavin, D. E. The prediction of academic performance: A theoretical analysis and review of research. New York: Russell Sage Foundation, 1965.

Nichols, R. C., & Holland, J. L. Prediction of the first year college performance of high aptitude students. Psychological Monographs, 1963, 77(7, Whole No. 570).

Rozelle, R. M., & Campbell, D. T. More plausible rival hypotheses in the cross-lagged panel correlation technique. Unpublished manuscript, 1967.

Science Research Associates, Inc. National Merit Scholarship Qualifying Test, Spring 1966, interpretive manual. Chicago: Author, 1966.

Sewell, W. H., & Armer, J. M. Neighborhood context and college plans. American Sociological Review, April 1966, 31, 159-168.

Simon, H. A. Spurious correlation: A causal interpretation. Journal of the American Statistical Association, 1954, 49, 467-479.

Stanley, J. C. Common-applicant groups in collegiate research. Paper read at American Psychological Association, New York, September 1966. (a)

Stanley, J. C. A common class of pseudo-experiments. American Educational Research Journal, March 1966, 3(2), 79-87. (b)

Steel, R. G. D., & Torrie, J. H. Principles and procedures of statistics. New York: McGraw-Hill, 1960.

Thistlethwaite, D. L., & Wheeler, N. Effects of teacher and peer subcultures upon student aspirations. Journal of Educational Psychology, 1966, 57(1), 35-47.

Walker, H. M., & Lev, J. Statistical inference. New York: Holt, Rinehart & Winston, 1953.

Wallace, W. L. Peer influences and undergraduates' aspirations for graduate study. Sociology of Education, Fall 1965, 38(5), 375-392.

Wold, H. O. A., & Jureen, L. Demand analysis. New York: John Wiley & Sons, 1953.

Wright, S. The method of path coefficients. Annals of Mathematical Statistics, September 1934, 5, 161-215.

Wright, S. The treatment of reciprocal interaction, with or without lag, in path analysis. Biometrics, September 1960, 16, 423-445.

PREVIOUS NMSC RESEARCH REPORTS

Volume 1, 1965

Number

1. The Inheritance of General and Specific Ability, by R. C. Nichols (also in Manosevitz, M., Lindzey, G., and Thiessen, D. (Eds.), Behavioral Genetics: Method and Research, Appleton-Century-Crofts, in press).
2. Personality Change and the College, by R. C. Nichols (also in American Educational Research Journal, 1967, 4, 173-190).
3. The Financial Status of Able Students, by R. C. Nichols (also in Science, 1965, 149, 1071-1074).
4. Progress of the Merit Scholars: An Eight-Year Followup, by R. C. Nichols and A. W. Astin (also in Personnel and Guidance Journal, 1966, 44, 673-686).
5. Prediction of College Performance of Superior Students, by R. J. Roberts.
6. Non-intellective Predictors of Achievement in College, by R. C. Nichols (also in Educational and Psychological Measurement, 1966, 26, 899-915).
7. Ninth Annual Review of Research by the NMSC Research Staff (superseded by the Tenth Annual Review).
8. Social Class and Career Choice of College Freshmen, by C. E. Werts (also in Sociology of Education, 1966, 39, 74-85).

Volume 2, 1966

1. Participants in the 1965 NMSQT, by R. C. Nichols.
2. Participants in the National Achievement Scholarship Program for Negroes, by R. J. Roberts and R. C. Nichols.
3. Career Choice Patterns: Ability and Social Class, by C. E. Werts.
4. Some Characteristics of Finalists in the 1966 National Achievement Scholarship Program, by W. S. Blumenfeld.
5. The Many Faces of Intelligence, by C. E. Werts (also in Journal of Educational Psychology, in press).
6. Sex Differences in College Attendance, by C. E. Werts.
7. Career Changes in College, by C. E. Werts (also in Sociology of Education, 1967, 40, 90-95).

Number

8. The Resemblance of Twins in Personality and Interests, by R. C. Nichols (also in Manosevitz, M., Lindzey, G., and Thiessen, D. (Eds.), Behavioral Genetics: Method and Research, Appleton-Century-Crofts, in press).
9. College Preferences of Eleventh Grade Students, by R. C. Nichols (also in College and University, in press).
10. The Origin and Development of Talent, by R. C. Nichols (also in Phi Delta Kappan, 1967, 48, 492-496).
11. Tenth Annual Review of Research, by the NMSC Research Staff (includes abstracts of all previous NMSC studies).

Volume 3, 1967

1. Do Counselors Know When to Use Their Heads Instead of the Formula?, by D. J. Watley (also in Journal of Counseling Psychology, in press).
2. Paternal Influence on Career Choice, by C. E. Werts (also in Journal of Counseling Psychology, in press).
3. The Effect of Feedback Training on Accuracy of Judgments, by D. J. Watley (also in Journal of Counseling Psychology, in press).

NMSC research is supported by grants from the National Science Foundation, the Carnegie Corporation of New York, and the Ford Foundation