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ABSTRACT

Investigated were the reasons for low participation rates of women and minorities in college science curricula. The data base for the study came from the National Longitudinal Study, a study of over 20,000 high school seniors of the Class of 1972. Three follow-up surveys of the class were conducted in order to analyze the educational and vocational background of these graduates. The survey involved a sample of 1,200 schools with 18 seniors per school. Data collecting instruments included a test battery, a student record information form, and a student questionnaire. The primary tool used for analysis of the data was multiple regression analysis in a path analysis framework. Analysis of the data indicated that sex differences were more important than differences between blacks and whites in the probability of selecting a major in science. Black males were less likely to select a science major or to obtain a degree in science than were white males. When results were adjusted for difference between males and females in interviewing variables, blacks had a higher probability of selecting a science major than whites. Females showed negative impacts on the selection of a college science major. (Author/DS)

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RACE AND SEX DIFFERENCES IN COLLEGE SCIENCE PROGRAM PARTICIPATION

by

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I. INTRODUCTION

The primary purpose of this study is to explain the relatively low entry rate of females and blacks into college science curricula. A subsidiary and related purpose of the study is to explain the relatively low science degree attainment on the part of females and blacks. The findings from the explanatory models, hopefully, will be useful in identifying means to increase the participation of females and blacks in college academic science programs. The data base to be used in modeling sex and race effects on choosing a science major and science degree attainment is the National Longitudinal Study of the High School Class of 1972 (NLS). The NLS involved a two-stage probability sample of over 20,000 students from about 1,300 schools who were contacted as high school seniors in 1972 and recontacted in 1973, 1974, and 1976. The in-school and subsequent three follow-up surveys cover some of the critical periods in science career development: the transition from high school to college and the completion of college.

That women and minority groups are seriously underrepresented in both science and engineering careers is a clearly established fact. Although equal proportions of women and men are now entering postsecondary educational institutions (Peng, 1977) and an increasing number of women are obtaining advanced degrees and entering careers, the careers they enter continue to be those traditionally dominated by females, such as education and nursin[illegible]achek, 1977). In 1973, more than two-thirds of the employed professional women in the United States were elementary or secondary school teachers or health workers, while but a fraction chose careers in the natural sciences or technology (Monthly Labor Review, 1974). In fact, only seven percent of all women who graduated from college in 1972 were science majors, compared to 24 percent of the male graduates (Scientific Engineering Technical Manpower Comments, 1974). As evidence of this trend, NSF reports that in 1973 women constituted only 7.6 percent of the employed doctoral scientists and engineers (NSF Report 77-304, 1977).

Similarly, blacks represent 11.1 percent of the United States population (1970 census data) but a much smaller percent are trained for or actually employed in careers in science and technology. For example, Porter et al. (1974) reported that, in 1973, only 0.6 percent of United States physicists were black, and Alden (1974) reported that only 1.2 percent of those employed in engineering occupations were black. Educational enrollment data show similar results. For example, enrollment of graduate students in 1973 indicates that only 1.2 percent of those in engineering were black. In the physical sciences the figure was 1.3 percent, and in the life sciences it was 1.5 percent. Finally, Henderson (1974) reported that blacks received only 29 (0.5%) of the 5,696 geoscience degrees granted in 1972.

This disproportionate distribution of the sexes and minority groups across scientific occupations has far-reaching implications since, as Goldman and Hewitt (1976) point out, "scientists and engineers exert considerable influence on United States society, (and) any group that contributes few scientists and engineers is at least partly disenfranchised."

II. LITERATURE REVIEW

A. Introduction

We shall see that the data from the National Longitudinal Study on a cohort of over 20,000 high school seniors of the Class of 1972 indicates that the gap in science participation in college between males and females and between blacks and whites has narrowed in recent years. Nevertheless, the problem still remains. The purpose of this section is to review theoretical arguments and empirical evidence that shed some light on the mechanisms underlying the generally lower science participation rates on the part of females and blacks. The general focus is on the underlying processes involved in the selection of a science major in college. Without a science degree, it is virtually impossible to subsequently pursue a career in science. Although a science degree is necessary for pursuing a science career it is not sufficient since many barriers may arise to hinder the participation of females and blacks (e.g. job discrimination, family formation in the case of women, etc.).

B. Sex Differences in Science Participation

Various sets of factors or influences have been proposed to account for sex differences in the selection of a college science major. Among them are ability, personality and interest patterns, and lack of high school preparation.

1. Ability

Maccoby (1970) contends that women think less analytically than men, and so are less capable at mathematical and scientific subjects.

She suggests that from an early age, females develop a different way of dealing with incoming information. Consequently their thinking is "less analytic, more global, and more perseverative...and that this kind of thinking may serve them very well for many kinds of functioning but that it is not the kind of thinking most conductive to high-level intellectual productivity, especially in science."

What brings about this dissimilarity in types of thinking? Maccoby concurs with the work of Bing (1963) and Witkin (1962) which indicates that children who display analytic perceptions have been encouraged by their mothers to establish independence of thought by freely exploring their environment and solving problems without "motherly" intrusion. An earlier study by Levy (1943), which also cites maternal behavior as a potentially important element in intellectual development, found that "overprotected" boys possessed high verbal ability, but their performance in mathematics was significantly inferior. These findings are consistent with data which reveals that girls (the traditionally protected sex) exhibit proficiency in languages but low levels of performance in science and mathematics (Herman, 1976).

Rossi (1965) cites evidence that indicates that the parental action that fosters analytic thinking could differ according to the sex of the child. She notes that the four characteristics typical of outstanding scientists (as outlined by Roe, 1952) are more likely to be recognized as characteristics of boys rather than girls in American society. These characteristics, (1) high intellectual ability, (2) persistence in work, (3) extreme independence, and (4) "apartness" from others, are capable of manifestation early in a child's development. That these characteristics show up predominantly in boys at an early age lends support to the thesis that social molding discourages girls from developing qualities of assertiveness, self-reliance, and independence of thought which, in turn, may lead to scientific modes of thought.

It is a common supposition that boys consistently score higher than girls on tests of mathematical ability, but this tendency does not appear until secondary school where boys forge ahead of girls (Maccoby, 1970). It is interesting to note that during the early and middle school years, the sexes do not consistently differ in mathematical abilities. However, throughout the grade school years, boys perform better on tests of spatial ability (Maccoby, 1970). The earlier references to the intellectual development of females attempts to "explain" this lack of spatial ability which is closely associated with analytic thinking. Tyler (1965) presents an excellent summarization of sex differences in ability and achievement. Girls, in general, obtain higher grades than boys and do better on verbal tests. Boys do better on mathematics, spatial relations, mechanical comprehension, and maze tests.

While mathematics ability is important in the selection of a science career, it does not completely explain sex differences in the selection of a science major. Goldman and Hewitt (1976) found that the association between sex and the selection of a college major was reduced when SAT Math scores were used as a control variable. The authors contended however that differential mathematics ability between the sexes just about completely explained sex differences in the selection of a science major. They seemed to overstate the importance of mathematics ability, however, since a significant partial association between sex and science major status still remained after partialling out the influence of mathematics ability. Gilmartin et al. (1976) also found that sex differences in selecting a college major were not completely mediated by mathematics ability.

2. Personality and Interest

Although there have been psychological studies of male scientists (Roe, 1952 and Clifford, 1958), less attention has been paid to the personality characteristics of women scientists. However, one study of female biologists and chemists (Bachtold and Werner, 1972) utilizing the Sixteen Personality Factor Questionnaire (16 PF) found that as a group, women scientists were "more serious, radical, confident, dominant, intelligent, and adventurous than women in the general population, and less sociable, group-dependent, and sensitive." The study also showed a strong similarity of personality profiles (16 PF) for men and women scientists. In measurements of self-esteem of professional women, McBee, Murray, and Suddick (1976) discovered that women in "masculine" professions had higher self-esteem scores than those in feminine professions.

Astin's (1968) analysis of high school girls disclosed that science career-bound girls are least like the girls who either plan to become housewives or enter a career which does not require a college degree. Another study (Tangri, 1972), found personality differences between senior college women who chose non-sextypical occupational choices (Role Innovation) and those who chose traditional female occupations. The Role Innovators were more autonomous, individualistic, and motivated by internally imposed demands to perform to capacity.

Another facet of personality associated with scientific patterns of thought and interest is orientation towards things as contrasted to people, a tendency found more often in males than in females. Both Lovett (1971) and Rezler (1967) found that women in atypical (male dominated) occupations place less value on helping others and interest in people as opposed to things, than do women in traditional occupations.

Women score higher on vocational interest scales for occupations involving art, social service, and writing. Men score higher on scales for science and business. However, men and women within a particular profession are highly similar in interests (Tyler, 1965).

Kirk (1975), in her study of 500 academically superior high school senior girls, found that the girls attributed the greatest influence in their career direction to their own interests and abilities. She noted that concern over courses, grades, and abilities were important factors in discouraging interest in science.

McClure's (1978) study of college bound girls noted a lack of personal interest in science and technology that was further compounded by inadequate academic preparation. Hansen and Neujahr (1974) found that, even in a select group of males and females gifted in science, interest patterns differed on the basis of sex. Males were more likely to be involved in scientific hobbies and to have labs in their homes.

Males also chose the physical sciences and published scientific papers more often than did females. The conclusion drawn from this research is that the "major difference between males and females...would seem to be the depth of interest in science and that the relative levels of interest manifest in high school seem to persist."

Erlick and LeBold (1977) conducted a large survey of over 8,000 high school students that concerned science career plans and the factors that influenced them. The survey indicated that males exceeded females in reporting that mathematics and science courses were very interesting and enjoyable. Females were also more likely to prefer serving others and teaching while males were more likely to prefer making, building, or growing things, and servicing, maintaining, or repairing things.

3. High School Preparation

McLure (1978) claims that girls lack the necessary math and science preparation in high school. This is empirically supported by a number of studies. For example, Erlick and LeBold (1977) found that males outnumbered females in taking advanced mathematics and science courses in high school and a survey conducted at Berkley in 1972 by Ernest (1976) found that only 8 percent of freshman women compared to 57 percent of freshman men had completed four years of high school mathematics.

4. Other Sex Related Influences

McLure (1978) claims that neither parents nor teachers encourage the development of scientific interests in girls and that, in addition, there are few role models of successful women in science. Goldman and

Hewitt (1976) also contend that sex role development may depress the development of motivation to develop mathematical skills.

McLure (1978) and Trigg and Perlman (1976) emphasize the problems women have in combining marriage and family formation with a science career. Astin and Myint (1971) using Project Talent data found that marital-familial status was a good predictor of whether women would pursue careers in the sciences and professions or become housewives or office workers. Rossi (1965) reported that while four out of five employed men scientists are married, only two out of five employed women scientists are married. Perrucci (1970) reports that career women are more likely to be childless than their non-career peers. Erlick and LeBold (1977) found that women planning careers in science are more likely to plan to marry later and to combine marriage and career than are women not planning science careers. However, they found that marriage plans per se were not perceived as important deterents in pursuing a science career.

There are other sex related influences such as job discrimination that have probably played a key role in the past if not the present. Lewin and Duchan (1971) reported conspicuous disparities between salaries of men and women along with documented inequalities in awards of research grants in order to illustrate discriminatory practices operating in the highest levels of the academic structure. Rosenfeld (1978) suggests that men stereotype women as less serious workers, possibly due to the common assumption that women will not work continuously throughout their lives, regardless of the actual behavior of a specific female employee.

The situation for females is best summarized in a recent National Science Foundation Study (1977) which contends that there is a strong focus in our society that is unfavorable to the development of science potential, interests, and professional activities among women (and minorities). These influences have been particularly strong.

C. Race Differences in Science Participation

The statistics discussed earlier that cite the striking lack of participation of blacks in the sciences has only recently come to be viewed as a matter of concern. Employers attempting to meet affirmative action standards experience difficulty locating qualified scientists in the black population. For example, in December of 1972 some 300 companies planned to visit and interview the 30 engineering school students in the graduating class at Tennessee State, a predominantly black college (Habarth, 1974). Despite the existing programs designed to increase the number of blacks in specific scientific areas (e.g., engineering and health-related professions), blacks continue to be underrepresented among students in those fields. There is little information available to explain why the recruitment of blacks into science has accomplished little; even the blacks who are successfully recruited as science students have a high dropout rate (Rowe, 1977).

The reasons for the scarcity of black scientists are far from completely understood although various reasons have been put forth in the literature (e.g. stereotyping, aptitude deficiencies, absence of role models, parental and social factors). There are repeated calls in the literature for improved and more comprehensive studies to explore the factors which may mitigate against the participation of blacks in science (Rowe, 1977; Dillon and James, 1977).

The discussion in this section will be primarily focused on the influences of ability, personality and interests, high school preparation, socioeconomic status, and other factors in accounting for differences between blacks and whites in choosing a college science major and pursuing a science career. The number of hispanics and other minorities in the NLS data base is too small on which to develop empirically based models so that the discussion will not consider these other minority groups unless findings or speculations apply to minority groups in general.

1. Ability

The generally lower ability of blacks for both sexes and at all age levels has been well documented in the literature. For example, Sie et al. (1978) found that mathematics background, an important prerequisite to a science career, was especially lacking among black females. Also, Sie's data showed that black males had the lowest level of high school academic performance of all student groups including black females. Gilmartin et al. (1976) noted large differences among four major ethnic groups in mean scientific potential, with blacks and Spanish surname students scoring one standard deviation below whites and orientals. In general, these ability differences between blacks and whites remain even after adjusting for socioeconomic status and education (Tyler, 1965). Gilmartin et al. (1976) reported that minority differences in high school science plans were mediated by ability. The

NLS data, as will be seen, indicates that black-white differences in initially selecting a college science major in the freshman year and being a science major four years thereafter are not explained simply by ability differences. Gilmartin, however, is modeling plans while the goal of the present study is to model the actual selection of a college science major.

2. Personality and Interests

Data collected by Sewell and Martin (1976) on a sample of black inner city high school students revealed a pattern of occupational choice that was substantially different from a normative sample of 2,000 predominantly white, middle class students. In particular, the black adolescents demonstrated more interest in artistic, health and welfare, and business-clerical fields than the white sample. Although the black students were chosen as having potential for college education, their interest in technical-scientific fields was very low. In agreement, Hager and Elton (1971) compared black and white male college freshman of similar socioeconomic status. They found that whites more frequently aspired to scientific occupations, while black students aspired to social service vocations and concluded that race may therefore be a more powerful determinant of vocational choice than SES. Rowe (1977) speculates that possibly blacks have more of an external locus of control than whites. That is, blacks emphasize the importance of luck and external environmental influences beyond their control as determining their life outcomes. Rowe further speculates that since successful scientists have an internal locus of control, blacks would be less likely to choose a scientific career. Overall, the evidence suggests that there are substantial personality and interest differences between blacks and whites.

3. High School Preparation

Erlick and LeBold (1977) found that even those minority group members who were considering science as a career often lacked the high school mathematics and science courses and experiences which the majority of their white counterparts had in school and at home. Data from the present study, as will be seen in the chapter on descriptive statistics indicates that blacks, in general, have less overall high school math and science preparation than whites.

4. Socioeconomic Status

Socioeconomic status (SES) is traditionally defined as a weighted linear composite of parental income, occupation, education, and, in some instances, household possessions. Along with ability, it has been consistently used as a predictor variable in educational and vocational outcome studies.

There has been considerable speculation as to whether or not the relative low SES of blacks compared to whites explains, at least in part, the relative scarcity of blacks in science. An examination of the literature reveals that the impact of SES, after controlling for ability, and other variables, is less important than other forces which can affect one's career choice. In a study by Sie et al. (1978), SES differences among black students did not predict career choice. Gilmartin et al. (1976) reported that the correlations between SES and tendency towards selecting a science career were very low. Similarly, Carter and Picou (1975) and Allen (1978) concluded that lower social origins are less of a handicap to blacks than to whites in regard to vocational aspirations and occupational choice.

5. Other Race Related Influences

Sloan and Peden (1974) as well as Vetter (1975) noted the lack of black role models in science which they felt might contribute to the apparent reluctance of blacks to choose a career such as science in which minorities are not clearly visible. The nebulous concept of parental influence in the black family on children's vocational and educational aspirations has been cause of considerable debate. According to Allen (1978), the thesis that links lower rates of occupational and educational attainment among blacks to deficiencies in the family, rather than deficiencies in the society and its institutions, is suspect. The thesis is that black parents have low educational and occupational aspirations for their children.

On the contrary, Allen (1978) found that black parents placed greater stress on college attendance than white parents, though the white parents expected higher levels of school performance. Among blacks, the mother was the central figure in the determination of adolescent level of mobility aspirations, while among whites it was the father. In addition, Rodman and Voydanoff (1975), in a study of 436 black parents, found that there were a wide range of educational aspirations in their relatively low SES group. These findings suggest that educational aspiration levels among blacks might not be a major factor in explaining the lower rate of black participation in science.

III. METHODOLOGY

A. Introduction

The data base for this study comes from the National Longitudinal Study (NLS). The NLS is a longitudinal study of over 20,000 high school seniors of the Class of 1972 whose primary objective is the observation of the educational and vocational activities, plans, aspirations, and attitudes of young people after they leave high school. The ultimate purpose of the NLS is to better understand the educational and vocational development of a cohort of young high school graduates.

B. Data Base

Following an extensive period of planning and field testing, the full scale survey was initiated in the spring of 1972. The sample design involved a deeply stratified sample of 1,200 schools with 18 seniors per school, school size permitting. The resulting base-year sample of 18,143 students from 1,044 high schools provided base-year data on up to three data collection instruments: a test battery, a student record information form, and a student questionnaire. The key form, the student questionnaire was completed by 16,683 seniors.

The first followup survey began in October 1973 and ended in April 1974. Added to the base-year sample were 4,450 seniors from the Class of 1972 in 256 additional schools that had been unable to participate earlier, as well as more than 1,000 students who had been classified as base-year nonparticipants. This brought the total first followup sample to 23,451 potential respondents. First followup forms were mailed to 22,654 students. Of these 22,654 students, 21,350 of them completed a first followup questionnaire. Sixty-nine (69) percent of the completed questionnaires were obtained by mail and 31 percent by personal interview. Of the 16,683 seniors who completed a student questionnaire, 15,635 took part in the first followup survey - a sample retention rate of 93.7 percent.

The second followup survey began in October 1974 and ended in April 1975. Of the forms sent to 22,364 potential respondents, 20,872 completed a second followup questionnaire, 72 percent by mail and 28 percent by personal interview. Of the 21,350 persons who completed a first followup questionnaire, 20,144 (94.6%) also participated in the second followup survey.

The third followup survey began in October 1976 and ended in May 1977. Some 20,092 members completed a third followup questionnaire, 80 percent by mail and 20 percent by personal interview. The sample retention rate from the second to the third followup survey was 94 percent. The retention rate over the four and one-half years between the base year and third followup surveys was 88 percent. Current planning calls for at least one more followup survey in the next few years.

C. Instrumentation

The present study is concerned with modeling the selection of a freshman science major and modeling the probability of either completing a science degree in the spring of 1976 or still working towards the completion of a science degree in the fall of 1976. For these purposes, data is needed from the test booklet, the student record information form, the base-year questionnaire, the first followup questionnaire, the second followup questionnaire and the third followup questionnaire.

The test booklet was administered in school and 69 minutes was allowed for it's completion. The test booklet consisted of six tests and measured both verbal and nonverbal ability. The items for the tests were selected to avoid academic or collegiate bias and to be of an appropriate difficulty level for twelfth grade students. The six tests are briefly described below.

1. Vocabulary was a brief test (15 items, 5 minutes) using a synonym format.

2. Picture Number was a test (30 items, 10 minutes) of associative memory consisting of a series of drawings of familiar objects, each paired with a number. The student, after studying the picture number pairs, was asked to recall the number associated with each object.

3. Reading was a test (20 items, 15 minutes) based upon short passages (100-200 words) with several related questions concerning a variety of reading skills (e.g. analysis, and interpretation) but primarily focused on straightforward comprehension.

4. Letter Groups was a test (25 items, 15 minutes) of inductive reasoning requiring the student to draw general concepts from sets of data. The items consisted of five groups of letters among which four groups shared a common characteristic while the fifth group was different. The student indicated which group differed from the others.

5. Mathematics was a test (25 items, 15 minutes) comprised of quantitative comparisons in which the student indicated which of two quantities was greater, equal, or could not be determined because of insufficient data.

6. Mosaic Comparisons was a highly speeded test (116 items, 9 minutes) which measured perceptual speed and accuracy through items which required that small differences be detected between each component of a pair of otherwise identical mosaics or tile-like patterns.

The student record information form contained primarily information pertaining to the student's high school coursework and grades. It was completed from school records by a survey specialist.

The base year questionnaire contained 104 questions distributed over 11 major sections. The questions related to the student's personal-family background, education and work experiences, plans, aspirations, attitudes, and opinions.

Two forms (A and B) of a first followup questionnaire were developed for self-administration by the student. Form A was mailed to each sample member who responded to the base-year student questionnaire. Seniors from the high school class of 1972 who were unable to participate in the base-year survey (usually because of time and scheduling considerations) were mailed Form B of the questionnaire. Questions one through 85 were identical on both forms. Each form was organized into sections. Form A contained five sections: general, education and training, work experience, military service, and background information. These questions dealt with the respondent's activity state (education, work, etc.) in October 1972 and October 1973; his or her socioeconomic status; work and educational experiences since leaving high school; and future educational and career plans, aspirations, and expectations. Form B contained an additional 14 questions to supplement missing base-year information.

The second followup questionnaire was similar in format to the first followup. It contained 153 questions arranged into seven sections: general; education and training; work; family; military; activities and opinions; and background information. The activity state data (education, work, etc.) referred to October 1974.

The third followup questionnaire followed the format of the previous followup surveys and contained 158 questions organized into seven sections similar to the second followup. In addition to repeating major measures of past questionnaires, the third followup instrument collected information on activity states for October 1976.

D. Variable Definitions

From all of the above instruments a number of variables had to be constructed for use in the descriptive and analytical statistics presented in subsequent chapters of this report. The rationale for the selection of the variables will be discussed later on in conjunction with the particular statistical models to be estimated. The intent of this section is to briefly describe the variables that are used and referred to throughout the remainder of this report.

One set of variables that plays a prominent role in the analyses for this report are the six ability measures described above. Each test was scaled to have a mean score of 50 and a standard deviation of ten.

Another central variable was socioeconomic status (SES) which was an equally weighted linear composite of standardized scores for father's education, mother's education, parents' income, occupational prestige of father's job, and an index measuring the prevalence of household items. Values of non-missing components were summed and the resultant sum was divided by the number of items summed. The SES distribution was then standardized to a mean of 0 and standard deviation of one. The rationale for forming this linear composite was based upon the factor analyses of the five components (see Dunteman et al, 1974, for more details).

Measures of sex and race were based upon information from the base year and first followup questionnaire. They represent the most consistent values obtained from the several data sources.

Perceived mother's and father's educational aspirations reflected the highest level of education that the mother (or father) desired for the respondent as reported by the respondent in the base year questionnaire. Responses to this item for both the mother and the father were scored on a six point scale ranging from "wants me to quit high school without graduating" (scored 1) to "wants me to go on to a graduate or professional school after graduating from a four-year college or university" (scored 6). For the analytic purposes, responses of "don't know" were treated as missing data and the associated observation was deleted from all analyses.

High school grades were based upon the subject's estimates in response to item five of the base year questionnaire. Response options ranged from "Mostly A" (with a scale value of 1) to "Mostly below D" (with a scale value of 8). In most analyses, the scaling of this variable has been reflected so that higher values represent higher grades.

Two personality variables, self concept and locus of control, were constructed on the basis of a factor analysis of a set of eight questionnaire items in the base year questionnaire (see Dunteman et al, 1974). Self concept was an equally weighted linear composite of four items each rated on a 1 (strongly agree) to 4 (strongly disagree) scale. Low scores on the self concept scale indicated that the respondent had a positive attitude towards his or her self, felt equal in worth to other people, felt as competent as other people, and overall was satisfied with his or her self.

Locus of control was also defined as an equally weighted composite of four items each rated on a 1 to 4 scale. High scores on the scale indicated that the respondent had an internal locus of control and low scores indicated an external locus. High scores or an internal locus of control was indicated for a respondent by disagreeing with statements such as "good luck is more important than work in getting ahead" and "planning only makes a person unhappy since plans hardly ever work out anyway."

Three general orientation towards life scales were also developed on the basis of factor analyses (Dunteman et al, 1974) of a ten item set. Each item had a three point scale associated with it ranging from 1 (not important) to 3 (very important). Work orientation was defined as an equally weighted linear composite of three items reflecting importance of being successful in work, being able to find steady work, and having lots of money. Community orientation was similarly defined by three items reflecting the importance of being a community leader, working to correct social and economic inequalities, and giving their children a better opportunity. Family orientation was defined by three items reflecting the importance of having a happy family life, living close to parents and relatives, and staying near home.

Four composites were developed on the basis of factor analyses that measured various orientations in selecting a job or career. Each item contributing to a composite was also based upon a 1 (not important) to 3 (very important) scale. People orientation was a two item composite indicating an interest in being helpful to others, and having an opportunity to work with people rather than things. For some of the analytical models the scale values were reflected so that a high score on this composite indicates an orientation towards working with things. Creativity orientation was similarly measured by three items which reflected the importance of opportunities to be original and creative, living and working in the world of ideas, and freedom from supervision. Job prestige orientation was measured by three items which reflected the importance of making a lot of money, the chance to be a leader, and having a position that is looked up to by others. The final job orientation composite was labelled avoiding pressure orientation. High scores on this dimension resulted from endorsing two items as very important: "avoiding a high pressure job that takes too much out of you"; and "opportunities for moderate but steady progress rather than the chance of extreme success or failure."

Both the number of terms of high school science and mathematics were determined from a set of items in the student's school record information form collected in the base year of the study. Data which indicated that more than 10 terms of either high school science or mathematics was taken were considered invalid and deleted from the analysis file.

Values for the two key outcome variables, 1972 college major and 1976 college major, were determined by examining responses to questions concerning the respondent's educational activity state in the first and third followup questionnaires, respectively. For the purposes of this study, only students in two or four year academic programs were considered; vocational-technical students were excluded.

College majors for both 1972 and 1976 were classified into the following six categories: life sciences (zoology, physiology, anatomy, etc.); engineering sciences (civil, electrical, mechanical, etc.); mathematical sciences; physical sciences (physics, geology, chemistry, etc.); social sciences (psychology, sociology, economics, history, etc.); and non-sciences (business, education, agriculture, nursing, home economics, etc.). The 1972 major corresponded to that major selected in October of the respondent's freshman year. The 1976 major was defined as the major in which a degree was obtained in spring 1976, the senior year for most sample members, or the college major declared in October 1976 if the respondent was still enrolled in college in the pursuit of a Bachelor's degree. Sample members who were not enrolled in an academic program in October 1976 and had not previously obtained a Bachelor's degree (e.g. withdrawal) were placed into a residual category which for most analyses were combined with the non-science category since most of the models in this study focus on the prediction of entering or being in an academic science program versus not entering or not being in an academic science program.

Other variables were used in some of the preliminary analyses, but were found not to be important in explaining the selection of an academic science for either females or blacks. Consequently, they will not be discussed in detail at this point, but will be referred to when appropriate in subsequent chapters.

E. Descriptive Analyses

The NLS data is based upon a complex probability sample that may be described as a deeply stratified two-stage probability sample with schools as first stage sampling units and students as second-stage units. Each student in the target population had a positive probability of being selected in the sample. In order to obtain unbiased estimates for descriptive statistics and model parameters each sample student's data was weighted by the inverse of his or her sample inclusion probability adjusted for overall instrument non-response. A weighting class method was used to adjust the student weights for instrument non-response.

The basic idea behind weighting is that of appropriately allocating the contribution of each student's data to the unbiased estimation of the population parameter of interest. For example, if some students were undersampled then their inclusion probabilities would be relatively small but their sample weights would be relatively large since they are the inverses of the small inclusion probabilities. Conversely, if some students were oversampled then their inclusion probabilities would be relatively large and, hence, their weights would be relatively small. The weighting class procedure adjusts for instrument non-response by distributing the weights of non-respondents across respondents who are similar in important respects to the non-respondents.

Most of the descriptive analyses presented in this report are based upon weighted analyses. For the purposes of this study, descriptive analyses refer to the tabular presentation of estimated means and proportions for various subgroups of respondents (e.g. black females). In one instance, discriminant analyses was used to simplify and summarize the differences and similarities among the science and non-science major categories on the important variables defined earlier in this chapter. The purpose of discriminant analysis is to find a few basic dimensions derived from a large number of variables that best characterize the major differences and similarities between groups. This technique will be discussed in more detail in conjunction with it's use in the next chapter.

F. Analytical Models

The basic statistical tool used in developing the analytical models discussed in Chapter V was multiple regression analysis. Multiple regression analysis is a powerful statistical tool that is most appropriately used to model the relationship between a set of independent variables, whether categorical or continuous, and a single continuous dependent variable. It can also be used in modelling a binary dependent variable (i.e. a categorical dependent variable with two values), but there are some problems involved in this case. The major problem is that the regression parameter estimates, although still unbiased, are not minimum variance estimates. A related problem is that it is difficult when using weighted data to estimate the variances of the regression parameter estimates from the sample data. The ordinary least squares estimate of the variance of the regression parameter estimates is usually biased downward so that the researcher is more likely to claim significance than is actually the case.

Multiple regression analysis results in a linear combination of the independent variables that maximizes the predictability of the dependent variable. As long as the model is linear in the regression parameters, it is completely general in nature and can accommodate interactions, nonlinearly, categorical variables, and nonconstant error variances across the observations in the sample. In other words, it is a rather robust technique which can be applied to a variety of situations. It probably suffices as well as any technique for exploratory analyses or preliminary model development with fallible data.

Most of the models explored in Chapter V are simultaneous equation models. That is, more than one regression equation is needed to portray the relationship between the variables in a particular model. Under the simplifying assumption that the error in each equation is independent of all of the independent variables in that particular equation, the regression parameters of each regression equation can be independently estimated by weighted least squares. Most of the simultaneous equation models involve eight regression equations and either nine or ten variables. The large number of equations and variables makes it extremely difficult to use analytic models that may be more appropriate for modeling relationships with some of the categorical dependent variables (e.g. science major versus non-science major) in these simultaneous equation models.

A model for analyzing the relationships among a set of categorical variables that has recently gained attention in the statistical and social science literature is the log linear model. The log linear model parallels the analysis of variance approach by partitioning the log of the number of sample numbers in a particular cell of a k way table into a number of main effects and interaction effects. Since the log linear model is a relatively recent development, a simple example might help in understanding this approach. Let us suppose that we have a probability sample in which we can categorize each sample member with respect to race (black, white), sex (male, female) and college graduate (yes, no). There are two levels for each of the three categorical variables and a total of eight cells (2 x 2 x 2) if the three variables are crossed. Let n_{ijk} be the number of sample members in the ijkth cell where i is the level of the first variable (race), j the level of the second variable (sex), and k the level of the third variable (college status), then $\log_e n_{ijk}$ can be expressed

$$\log_e n_{ijk} = \mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{3(k)} + \mu_{12(ij)} + \mu_{13(ik)} + \mu_{23(ik)}$$

$$+ \mu_{123(ijk)}.$$

where μ is the overall effect; $\mu_{1(i)}$ is the main effect parameter associated with the ith level of race; $\mu_{2(j)}$ is the main effect parameter associated with the j level of sex; $\mu_{3(k)}$ is the main effect parameter associated with the kth level of college status; $\mu_{12(ij)}$ is the first order interaction parameter associated with level i of race and level j of sex; $\mu_{13(ik)}$ is the first order interaction parameter associated with the ith level of race and the kth level of college status; $\mu_{23}(jk)$ is the first order interaction parameter associated with the jth level of sex and the kth level of college status; and $\mu_{123(ijk)}$ is the second order interaction associated with the ith level of race, jth level of sex, and kth level of college status. For the present example, i, j, and k take the values 1 and 2 since there are only 2 levels for each variable.

The main effect parameters reflect the properties of the marginal distributions for each of the three variables and are usually not of interest. The first order interaction parameters represent the relationship between each pair of variables adjusting for levels of the remaining variable. The second order interaction parameters represent the variation in the first order interactions across the levels of the remaining variable. Interest is generally focused upon the interaction parameters. If one variable, say college status, is to be considered the dependent variable, then interest focuses primarily upon the interaction parameters reflecting the relationship between the dependent variable and the other variables which would be considered as independent variables.

The model presented above is called a saturated model because it includes every possible parameter and fits the cell data perfectly. The objective of log linear modelling is to remove as many higher order parameters as possible in order to simplify the model such that it still adequately fits the contingency table data. The fit of the simplified or reduced model is tested by a chi-squared statistic. In the above example, one might want to test the hypothesis that sex and race are unrelated to college status. This is done by setting $\mu_{13(ik)} = \mu_{23(jk)} = \mu_{123(ijk)} = 0$ for all i, j, and k.

In addition we would probably not expect race and sex to be associated so that the parameters $\mu_{12(ij)}$ would also be set to zero. Thus, the simplified model becomes

$$\log_e n_{ijk} = \mu + \mu_{1(i)} + \mu_{2(j)} + \mu_{3(k)}$$

This model can be tested for goodness of fit. If the chi-square is significant, then it can be concluded that some or all of the parameters that were set to zero need to be included in the model.

While this model is useful for analyzing the relationships among a small set of categorical variables, the number of possible hypotheses to test with a large set of categorical variables and the problems of empty cells make this model more cumbersome to apply than, say, multiple regression. Nevertheless, it is used to substantiate some of the results obtained by multiple regression analysis where problems in using a binary categorical dependent variable were previously pointed out.

IV. DESCRIPTIVE RESULTS

A. Introduction

This section summarizes college science participation characteristics of subpopulations based upon sex and ethnicity. It describes the distribution across college major in 1972 and degree status in 1976 for each population. In addition various transition matrices are presented and described. The transitions include major field selected in 1972 versus degree status in 1976 and degree status in 1976 versus graduate school participation.

B. Intended Major in Fall 1972

Table IV.1 presents the distribution of college major for six subpopulations defined on the basis of sex and ethnicity. Cursory examination of the table indicates that females are considerably less likely to major in the physical, engineering and life sciences and just about as likely as males to major in mathematics and the social sciences. Males are three times more likely to major in the physical sciences and thirty-six times more likely to major in the engineering sciences. These are the most extreme sex differences in the choice of a college major.

The picture is quite different when black and white distributions across science majors are compared within sex groups. Black and white females have roughly the same proportion majoring in the engineering, mathematics, and the life sciences. Black females are about twice as likely to select a freshman major in the physical and social sciences.

Table IV.1

Intended Major - Freshman Year (Fall 1972)

Subpopulations	(N)	Science: Physical	Engineering	Math	Life	Social	Total All Sciences	Other Fields	No Intended Major	Unknown
Females	3334	2.0	.3	1.9	9.2	14.6	28.0	58.3	6.2	7.5
Black	433	3.0	0	1.9	9.1	22.5	36.5	54.2	2.3	6.9
White	2666	1.6	.3	1.9	9.2	13.7	26.7	59.3	6.5	7.4
Hispanic	98	3.1	.7	0	10.4	11.5	25.7	57.0	3.2	14.1
Males	3539	6.1	11.0	1.9	14.0	13.7	46.7	38.7	7.3	7.2
Black	278	5.4	9.0	1.7	8.7	12.3	37.1	49.0	4.8	9.1
White	2988	6.0	11.3	1.9	14.4	13.9	47.5	38.2	7.2	7.0
Hispanic	122	7.9	5.1	0	10.0	13.3	36.3	39.4	11.3	12.9
TOTAL	6873	4.1	6.0	1.9	11.8	14.2	38.0	47.9	6.8	7.4

*Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. The cell entries in a row are the conditional probability that a member of the appropriate subpopulation has a specific intended major in the fall of 1972. All estimates are based upon weighting the data according to the sample design.

Overall, black females are more highly represented than white females in the sciences. The higher overall percentage for blacks is due, however, primarily to their overrepresentation in the social sciences.

Both black males and white males are about as likely to select a freshman major in the physical, engineering, mathematical and social sciences. Black males are less likely than white males to select a life sciences major. The higher overall proportion of white males in the sciences is due primarily to their higher representation in the life sciences although they have slightly higher participation rates in science across the board. The distributions of Hispanic males and females across the fields of study are presented but not interpreted because of the small sample sizes.

The table clearly indicates that females are in general considerably more underrepresented than males in the sciences. On the other hand, compared to the sex differences, the gaps between the blacks and whites are not nearly as large.

In interpreting Table IV.1 as well as interpreting subsequent tables and analyses in this report, a number of factors should be kept in mind. First, the target population of concern is students enrolled in an academic program in either a two year or a four year college. Students in vocation-technical programs, whether majoring in science or not, are not considered a part of the target population. Second, although blacks do not appear to be at a great overall disadvantage when compared to whites, it could very well be that they are more likely than whites to be attending two year colleges and/or enrolled in low quality science programs (e.g. small black colleges). This question is not pursued in the report, but would certainly be worthy of future research efforts.

C. Undergraduate Degree Status in Fall 1976

Table IV.2 indicates that by the fall of 1976, 31.5 percent of the students had withdrawn from school. Withdrawal is defined as a former student who was not enrolled in an academic program in October 1976 and did not receive a bachelors degree by that time. By this definition, withdrawals could have completed a degree program at a two year college. The withdrawal rates for males and females were highly similar, 31.1 and 31.9 percent, respectively. Both black males and black females had higher than average withdrawal rates, 35.7 and 42 percent, respectively.

While a substantial percentage of students initially choose a science major (38% including the social sciences), the percentage of freshman who obtained a science degree by October 1976 was only 13.7, although 12.3 percent were still enrolled in a science program.

Except for the mathematical sciences, males were more likely than females to obtain a degree in the sciences. The odds ratio in favor of males remained highest for the physical and engineering sciences. Black females were more likely than white females to obtain a bachelors degree in the social sciences (10.4 versus 7.4%) although both groups were about equally likely to obtain degrees in the remaining sciences. Overall, black females were more likely than white females to obtain a science degree by October 1976. The overall difference was primarily due to the higher percentage of black females obtaining social science degrees.

Table IV.2

Undergraduate Degree Status (Fall 1976)

Subpopulations	(N)	Science Degree: Physical	Engineering	Math	Life	Social	Total All Sciences	Non-Science Degree	Undetermined Degree	Still in School: Science Major	Non-Science Major	Withdrew
Females	3334	.7	.1	.8	2.2	7.6	11.4	30.6	.4	7.9	17.8	31.9
Black	433	1.0	0	.8	2.4	10.4	14.6	17.4	0	8.7	17.3	42.0
White	2666	.7	.1	.8	2.2	7.4	11.2	32.8	.5	7.4	17.6	30.5
Hispanic	98	0	0	0	2.4	.7	3.1	11.8	0	16.1	19.2	49.8
Males	3539	1.7	2.4	.5	3.7	7.7	16.0	16.8	.5	15.9	19.7	31.1
Black	278	.9	.2	.3	1.3	6.5	9.2	14.0	.2	16.6	24.3	35.7
White	2988	1.8	2.7	.5	4.0	7.7	16.7	17.8	.5	15.4	19.3	30.3
Hispanic	122	0	0	0	1.8	4.4	6.2	3.2	.5	18.9	22.0	49.2
TOTAL	6873	1.2	1.3	.6	3.0	7.6	13.7	23.3	.4	12.3	18.8	31.5

Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. The cell entries in a row are the conditional probability that a member of the appropriate subpopulation has a specific major. All estimates are based upon weighting the data according to the sample design.

On the other hand, white males received a substantially higher percentage of science degrees than black males (16.7 versus 9.2%). The odds ratio was in favor of white males for each of the five science categories. White males were twice as likely as black males to have obtained a physical science degree, three times as likely to have obtained a life science degree, and over ten times as likely to have obtained an engineering degree. Black males seemed to fare less favorably compared to white males in respect to science degree attainment than they did in respect to choosing a science major in their freshman year. In fact, black males were less likely to obtain a science degree than either black or white females. Black females kept pace with their white counterparts while black males lost considerable ground. It should be noted that a substantially greater percentage of males (both black and white), compared to females, were still enrolled in a college science program. One might expect that a significant proportion of these will eventually receive a science degree. Table IV.2 indicates that a large proportion of all subpopulations do not complete their undergraduate degree within four years of matriculation. Consequently, our inferences regarding science degree attainment only apply to those students who completed their degree requirements in the traditional four year manner. The data clearly indicate that it is quite common to take more than four years in calendar time to complete a four year degree.

In summary, the situation for black females in regard to completing a science degree is more favorable than it is for black males and white females. Race and sex interact; race differences for females are different from race differences for males. They are smaller and opposite in effect for females as compared to males. In spite of the interaction between race and sex on science degree attainment, sex differences are greater than race differences. It should be noted, however, that black males are approximately twice as likely as black females to be still enrolled in a science program in October 1976. In the end, black males may have an equal or greater science degree attainment rate than black females.

D. Transitions from Fall 1972 Status to Fall 1976 Status

The next two tables (Tables IV.3 and IV.4) present separately for males and females the transition probabilities of moving from a freshman major choice state in the fall of 1972 to a particular degree state or major choice state, if still enrolled, by the fall of 1976. Corresponding tables for black males and black females are not presented separately because of the small sample sizes and the consequent imprecision of the transition probabilities.

Table IV.3 indicates that for males only a relatively small proportion of those who chose a particular major in the fall of 1972 had obtained a degree corresponding to that major by the fall of 1976. The probabilities ranged from .15 for mathematics to .31 for the social sciences. However, in most instances, a substantial proportion of those who chose a particular science major in 1972 still indicated the same major in 1976 if they had not already completed their degree. The probabilities ranged from a low of .025 for mathematics to a high of

Table IV.3

Transitions from Fall 1972 Status to Spring 1976 Status (Males)

Major 1972	State 1976							
	Field of Degree							Total Science
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Non-Sciences	Unknown	
Physical Sciences (210)	17.8	2.2	1.3	1.6	2.9	8.2	.4	25.8
ngineering (389)	.9	18.6	.4	1.4	2.5	6.2	.0	23.8
athematics (66)	2.8	.0	15.0	.8	10.1	26.9	.0	28.7
ife Sciences (498)	2.1	.3	.5	20.2	5.9	10.9	.7	29.0
ocial Sciences (483)	.2	.3	.0	.8	[illegible]0.8	9.3	.7	32.1
on-Sciences (1389)	.1	.3	.0	.3	2.6	27.0	.4	3.3
ndecided (251)	1.5	.0	.4	3.1	6.8	15.4	1.2	11.8
nknown (253)	.0	1.1	.0	2.8	6.3	10.7	.7	10.2

(Continued)

Major 1972	State 1976									
	No Degree - Field of Study									
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Undecided	Non-Sciences	Unknown	Withdraw
Physical Sciences	8.5	3.1	1.7	3.7	2.6	5.2	.4	9.6	3.9	27.1
Engineering	1.0	16.6	.0	.0	.5	1.6	.6	19.6	2.9	27.3
Mathematics	6	.8	2.5	.0	1.4	2.1	.0	15.7	1.4	20.5
Life Sciences	2.1	1.0	.0	7.9	1.6	6.6	.2	12.5	2.4	24.5
Social Sciences	.1	1.0	.0	.6	14.7	1.8	.7	13.1	1.4	24.7
Non-Sciences	.3	1.2	.0	.4	2.7	2.0	.6	27.3	.9	33.9
Undecided	2.8	1.6	.0	1.5	3.7	2.2	2.9	16.9	2.9	37.0
Unknown	1.7	1.3	.0	2.0	5.2	1.5	.0	18.0	2.1	47.4

*The numbers enclosed in parentheses are sample sizes. Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. All estimates are based upon weighting the data according to the sample design.

.166 for engineering. The relatively high proportion of male freshman engineering majors still enrolled in an engineering program is probably due to the widespread prevalence of five year engineering programs. A substantial proportion of freshman science majors ended up with a non-science degree. The proportions ranged from .06 for engineering to .27 for mathematics. There was a small likelihood for male freshman science majors to switch to another science. "Hard" science freshman majors (i.e. science excluding social science) had small probabilities of being in a different "hard" science state in 1976, while social science freshman majors had much smaller probabilities of shifting to a "hard" science state by 1976. Presumably, this is because social science majors in general lack both the high school and the college science preparation necessary for transferring into a "hard" science curriculum. On the other hand, switches from "hard" sciences to the social sciences were more common.

Table IV.4 presents the same transition table for females. In general, the results for females are similar to those for males. The number of females in the physical, engineering, and mathematical sciences freshman major groups are relatively small and hence the probabilities for these groups are less precise. The relatively large sample sizes for the life science and social science freshman major groups for both sexes, however, allows us to make comparisons across the sexes for those two groups. Male freshman life science majors had a slightly higher probability of completing a life sciences degree program than female life science majors (.20 versus .17). More significantly, female

Transitions from Fall 1972 Status to Spring 1976 Status (Females)

Major 1972	State 1976							
	Field of Degree							Total Science
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Non-Sciences	Unknown	
Physical Sciences (63)	13.5	.0	8.1	5.6	2.7	18.0	.0	29.9
Engineering (10)	.0	27.4	.0	.0	.0	6.0	.0	27.4
Mathematics (64)	4.0	.0	28.7	1.4	3.9	25.5	.0	38.0
Life Sciences (297)	2.5	.0	.0	17.4	5.9	21.5	.2	25.8
Social Sciences (488)	.0	.0	.0	.9	27.8	14.1	1.1	28.7
Non-Sciences (1953)	.1	.1	.0	.3	3.6	39.5	.2	4.1
Undecided (197)	.6	.0	.9	1.0	6.5	16.7	.9	9.0
Unknown (262)	1.0	.0	.0	.8	4.9	21.3	.3	6.7

(Continued)

Table IV.4 (Continued)

Major 1972	State 1976									
	No Degree - Field of Study									
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Undecided	Non-Sciences	Unknown	Withdra
Physical Sciences	3.3	3.4	.0	.0	2.0	3.8	.0	20.3	2.9	16.2
Engineering	.0	.0	.0	.0	.0	13.4	.0	10.6	.0	41.8
Mathematics	1.4	.0	2.7	.3	5.2	.0	.0	11.9	.8	14.2
Life Sciences	1.3	.2	.0	5.6	2.0	3.9	.4	13.7	1.2	24.2
Social Sciences	.5	.0	.0	.7	9.0	.9	.5	11.8	1.3	31.3
Non-Sciences	.1	.1	.0	.5	1.0	.9	.5	19.1	2.1	32.0
Undecided	.5	.0	.0	.7	4.7	.8	.6	28.8	2.1	35.3
Unknown	.0	.6	.0	.0	1.5	2.1	.0	16.6	3.9	47.0

*The numbers enclosed in parentheses are sample sizes. Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. All estimates are based upon weighting the data according to the sample design.

freshman life science majors were twice as likely as their male counterparts to end up with a non-science degree. The same trends were present for the freshman social science majors. Summarizing, both male and female freshman science majors had a relatively low probability of completing a degree in their originally chosen field. Significant proportions in all freshman science major groups completed requirements for a non-science degree. Many, as we have previously seen, withdrew. Some were still in school enrolled in a science or non-science degree program and an even smaller percentage received science degrees in a field different from their freshman choice.

E. Transitions to Graduate School

The next set of data to be examined involves the graduate school participation for students who received an undergraduate degree prior to the fall of 1976. Tables IV.5 and IV.6 present the results for males and females, respectively. The reader should be cautioned about the small numbers involved in various science degree categories. The numbers are especially small for women. For example, there are only three women who can be identified in the total NLS sample of over 20,000 that received an undergraduate degree in engineering by the fall of 1976. Certainly, the transition probabilities to graduate school for this group are too unstable for making generalizations to the population of women engineering graduates in 1976. The best that one can do under these conditions is to make some rather gross generalizations concerning sex differences in graduate school participation.

Table IV.5

Transitions to Graduate School (Males)

Major Program	Not in School	Graduate Curriculum 1976: Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Other Non-Sciences	Unknown
Physical Sciences (55)	52.8	39.0	.0	.0	.0	.0	6.2	.0	.0
Engineering (86)	76.5	.0	21.9	.0	.0	.0	.0	.0	.0
Mathematics (17)	23.6	.0	.0	49.1	.0	.0	5.9	21.4	.0
Life Sciences (130)	40.0	1.5	.0	.0	33.1	.0	16.8	1.5	1.2
Social Sciences (263)	63.3	.2	.0	.0	.0	20.8	5.5	3.3	1.1
Non-Sciences (592)	83.0	.0	.4	.0	.4	.6	2.2	10.7	.2

(Continued)

Table IV.5 (Continued)

Major Program	Undergraduate Curriculum 1976								
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Undecided	Non-Sciences	Unknown
Physical Sciences	1.9	.0	.0	.0	.0	.0	.0	.0	.0
Engineering	.0	1.6	.0	.0	.0	.0	.0	.0	.0
Mathematics	.0	.0	.0	.0	.0	.0	.0	.0	.0
Life Sciences	2.1	.0	.0	1.3	.8	2.5	.0	.0	.0
Social Sciences	.0	.0	.0	.0	2.0	1.7	.0	.0	.0
Non-Sciences	.0	.3	.0	.4	.3	.2	.0	1.5	.0

* The numbers enclosed in parentheses are sample sizes. Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. all estimates are based upon weighting all data according to the sample design.

Table IV.6

Transitions to Graduate School (Females)

Major Program	Not in School	Graduate Curriculum 1976: Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Other Non-Sciences	Unknown
Physical Sciences (22)	52.4	33.7	.0	3.7	.0	.0	4.3	5.9	.0
Engineering (3)	52.0	.0	48.0	.0	.0	.0	.0	.0	.0
Mathematics (24)	87.3	.0	.0	6.8	.0	.0	.0	.0	5.8
Life Sciences (71)	58.4	2.3	.0	.0	20.7	.0	11.8	4.3	.0
Social Sciences (256)	74.4	.0	.0	.0	.0	19.1	3.2	1.2	.0
Non-Sciences (989)	83.4	.0	.0	.0	.0	.4	1.1	11.9	.7

(Continued)

Table IV.6 (Continued)

Major Program	Undergraduate Curriculum 1976								
	Physical Sciences	Engineering	Mathematics	Life Sciences	Social Sciences	Professional Program	Undecided	Non-Sciences	Unknown
Physical Sciences	.0	.0	.0	.0	.0	.0	.0	.0	.0
Engineering	.0	.0	.0	.0	.0	.0	.0	.0	.0
Mathematics	.0	.0	.0	.0	.0	.0	.0	.0	.0
Life Sciences	.0	.0	.0	.0	.0	2.5	.0	.0	.0
Social Sciences	.7	.0	[illegible]	.0	1.4	.0	.0	.0	.0
Non-Sciences	.0	.0	.0	.1	.1	.2	.0	1.8	.2

*The numbers enclosed in parentheses are sample sizes. Each row is a conditional probability distribution whose probabilities sum to one. For the readers convenience, the probabilities have been converted to percentages. All estimates are based upon weighting the data according to the sample design.

Referring to the first column of Table IV.5, it can be seen that the rate of graduate school participation for males varied considerably with the type of undergraduate degree. Only 24 percent of the male mathematics degree recipients were not enrolled in school in the fall of 1976 while 77 percent of the engineering graduates were not enrolled in school. Eighty-three percent of the non-science graduates were not attending school in the fall of 19.6. Of those male degree recipients attending school, the large majority were attending graduate school: relatively few remained in an undergraduate curriculum. As would be expected, the graduate school curriculum chosen, in most instances, corresponded to their undergraduate science major. A significant percentage (17%) of the males with life science degrees were in professional schools, presumably in the medical sciences. The majority of engineers went directly to work (77%) and all of those who entered graduate school (22%) were in engineering. Engineering is a professionally oriented curricula which provides the skills necessary for immediate job entry as a practicing engineer. The other undergraduate curricula are not professionally oriented and result in more options for the degree recipient. For example, it was seen that a considerable percentage of life science graduates enter a professional school.

The corresponding data for females is presented in Table IV.6. Except for women with physical science degrees, women in all other science degree categories were more likely not to be enrolled in graduate school. No inferences will be made from the three women graduate engineers. Like men, most women who did enroll in a graduate curriculum chose a field corresponding to their undergraduate degree.

F. Multiple Discriminant Analysis of Intended Major in Fall of 1972

For both males and females in a 2 or 4 year college academic program the sample was divided into six groups on the basis of their freshman major: physical sciences, engineering, mathematics, life sciences, social sciences and non-sciences. A multiple discriminant function analysis was conducted separately for males and females. Each discriminant analysis was based upon the same comprehensive set of variables.

The variables are presented in Table IV.7 along with the standardized discriminant function coefficients of the two largest discriminant functions for each group. In both cases, two discriminant functions accounted for a high percentage of the between group variation. Multiple discriminant function analysis is a statistical technique for finding independent linear combinations of a set of variables that successively maximize the between group variation on the derived variables, the discriminant functions. The first discriminant function accounts for the largest proportion of between group variance and each succeeding discriminant function is independent of the preceding ones but successively accounts for less between group variation.

The examination of Table IV.7 indicates that the variables cover the major domains in which between group differences might be expected to exist, i.e. abilities, personal orientations, socioeconomic status, and high school background factors. They were selected on the basis of the conceptual models and previous research presented in Chapter II.

For males, the first and largest discriminant function had the largest weight for number of high school science courses (.61). The

Table IV.7

Discriminant Analysis of Five Science Freshman Major Groups (Fall 1972) and Non-Science Majors Separately by Sex

	Males (N = 1749) Standardized Discriminant Functions Weights		Females (N = 1634) Standardized Discriminant Functions Weights	
	1	2	1	2
1. Self concept	.051	-.001	-.079	-.112
2. Locus of control (external)	.129	.095	.036	-.189
3. Work orientation	.090	-.155	-.079	-.354
4. Community orientation	-.010	.045	-.094	-.133
5. Family orientation	-.069	-.056	-.082	.205
6. Father's educational aspirations for child	.008	-.008	.120	.020
7. Mother's educational aspirations for child	.302	.498	.193	-.203
8. Vocabulary score	-.141	.096	-.153	-.070
9. Reading score	.138	-.043	.028	-.135
10. Mathematics score	.212	-.310	.265	.092
11. Socioeconomic status	.053	.202	.003	-.112
12. Number of high school science courses	.611	.156	.577	-.375
13. Number of high school math courses	.044	-.397	.048	.338
14. Self estimated high school grades	.108	-.108	.078	.327
15. Job prestige orientation	-.144	-.202	.203	.093
16. Creativity orientation	.227	-.252	-.094	-.457
17. Orientation towards things	.076	-.590	.443	.120
18. Orientation towards avoiding pressure	.024	-.050	-.047	.496
% Between group variation	48%	33%	66%	19%

next largest weight was for mother's educational aspirations for child (.30) followed by creativity orientation (.23) and mathematics ability (.21). (For purposes of interpretation, only weights equal or greater than .20 will be considered.) The second discriminant function for males had the highest weight for orientation towards things (-.59) closely followed by mother's educational aspiration for child (.50), number of high school math courses (-.40) and mathematics ability (-.31). The first discriminant function will be interpreted as "science orientation" and the second discriminant function will be interpreted as "orientation towards people versus things." These two discriminant functions are not easily interpretable singly but together reflect the contributions of mathematics ability, number of math courses, number of science courses, mother's educational aspirations for child, and orientation towards things in discriminating among the various science and the non-science groups.

As in factor analysis, the two discriminant functions might become more interpretable under an orthogonal or non-orthogonal rotation. But, in any case, considering the two dimensions jointly results in a pretty clear picture of the pattern of variables that are important discriminators among the groups. Another advantage of multiple discriminant function analysis is that we can plot the group centroids in a lower order space of, say, two dimensions so that we can see how close in the discriminant space the various groups are. The plotting of the group centroids can also help in the interpretation of the discriminant functions themselves.

The group centroids for males are presented in Figure IV.1. The first discriminant function ranks the groups from left tc right in the order non-science, social science, and the "hard" sciences. Thus, the first discriminant function does seem to rank the groups on a science continuum. The second discriminant function has the social sciences lying at one end of the continuum and engineering at the other end. The groups seem to order themselves in respect to concern with people versus things. Engineers are the most thing oriented and use math as a tool for modeling physical phenomenon while students in the social sciences are more people oriented and apply, in general, less quantitative techniques to people oriented-problems. Physical science majors and mathematics majors closely resemble one another, but aside from that the other groups are fairly well separated from one another.

As in the case of males, the first discriminant function for females had the highest weight for number of high school science semesters. It differed somewhat, however, from the corresponding male dimension in the high weight accorded to orientation towards things. Like the male dimension, this dimension separated the non-sciences and social sciences from the "hard sciences" (see Figure IV.2). The second discriminant function for females is more difficult to interpret. It primarily contrasts mathematics majors with the remaining groups. (Since the engineering major centroid is only based upon five observations, its positio- in the discriminant space is too unstable and, hence, will be disregarded in the ensuing discussion.) It differs from the second male dimension in respect to both the weights of the

Figure IV.1

Group Centroids for Females on First Two Discriminant Functions (Ma

N = 1634

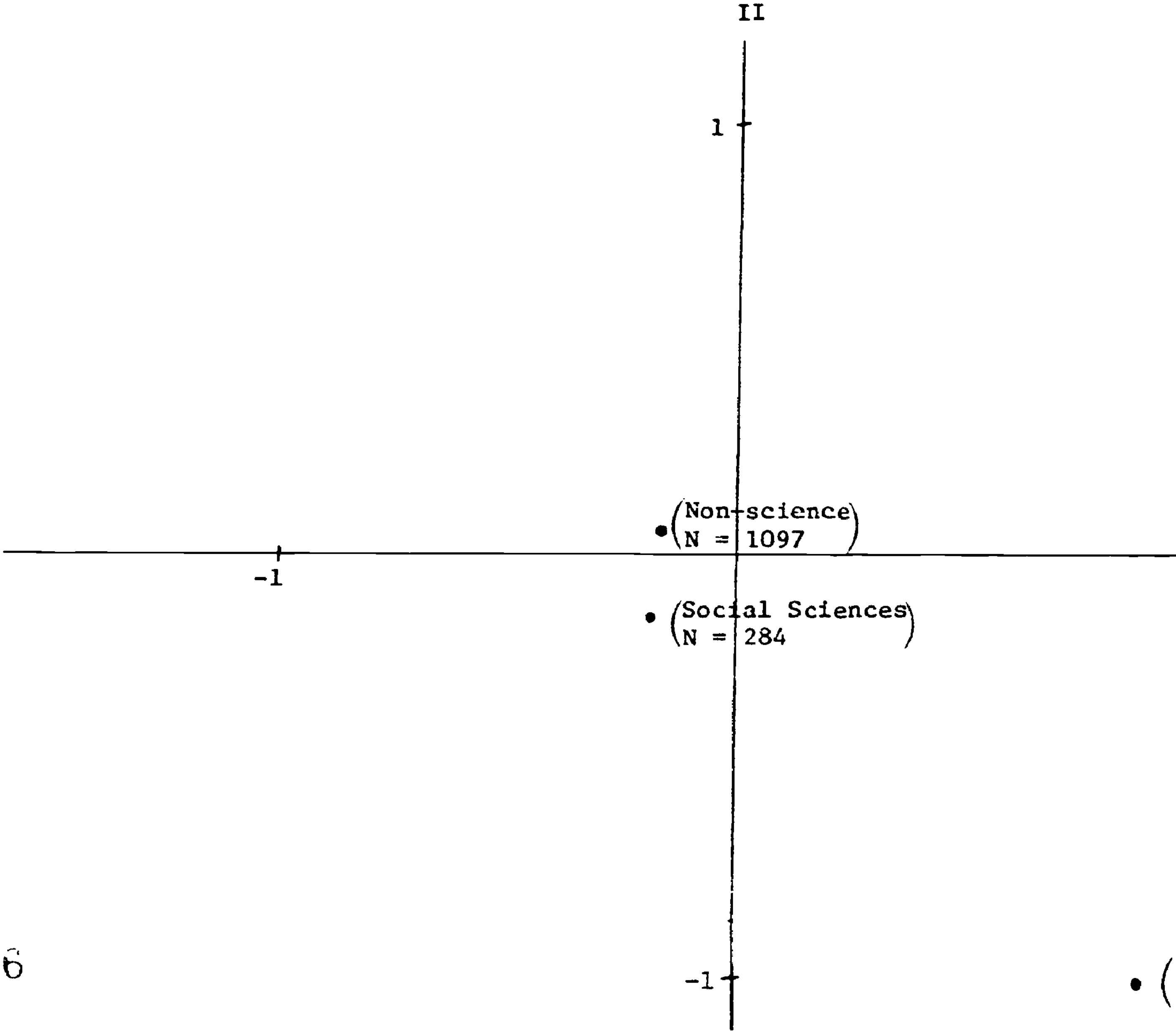
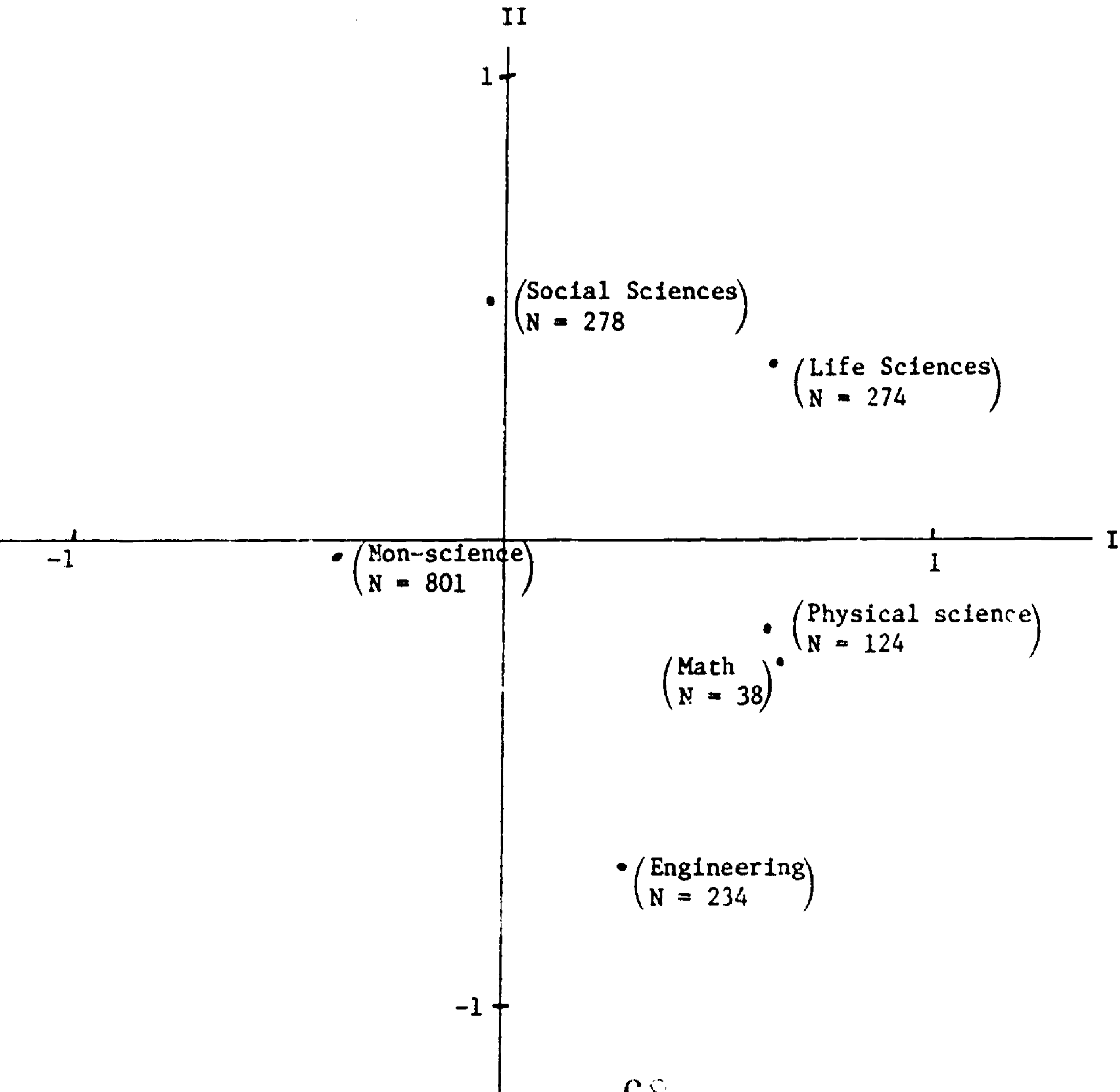


Figure IV.2

roup Centroids for Males on First Two Discriminant Functions (Major 1972)

N = 1749



variables defining the dimension and the ordering and spacing of the groups on the dimension. In general, however, the same variables differentiate the major 1972 groups and the hard sciences are discriminated from the social sciences and non-sciences for both sexes. It would still be reasonable to label the first dimension for females as "Science Orientation."

Since the first discriminant function accounts for roughly one-half of the between group variation for males and two-thirds for females and since they are similar to one another in respect to both the weighting of the variables and the ordering and spacing of the groups, more attention will be focused upon the implications of the first discriminant function. The first discriminant function for both males and females reflects degree of science orientation and effectively clusters the social sciences with the non-sciences and contrasts them with four tightly clustered (on the first dimension) "hard" science groups. One of the implications of this is that it would be conceptually appealing to treat the hard sciences as one group and develop a model for explaining the probability of choosing a hard science major, per se. Of course, modeling the probability of selecting a particular science major will also be of interest and will be pursued subsequently in this report. Since the discriminant analyses indicated some differences between the sexes in the pattern of between group variation for the college major categories, some models will be developed separately for males and females and the model parameter values will be compared.

G. Differences Between Males and Females Within Science Major

In general, the differences between males and females on seventeen attributes are relatively small within each of four science major 1972 groups (see Table IV.8). The number of female engineering majors (n = 5) is too small for stable estimates of the means of the 17 attributes and, hence, sex differences will not be presented for engineering majors. Except for the deletion of perceived father's educational aspirations for the child, the attributes were the same ones as used for the discriminant analyses. Father's educational aspirations was deleted because of its high correlation with mother's educational aspirations and it's lack of independent discriminatory power.

For physical science majors, males and females are highly similar. This is especially true of ability, mother's educational aspirations for child, and high school science and mathematics preparation. Women have higher high school grades and are less likely to be oriented towards things.

For mathematics, a similar picture emerges. Males and females have virtually identical mean ability scores. Females have a little less high school science and math preparation, and a little lower mean on parental educational aspirations for child. Female mathematics majors tend to be more homogenious than their male counterparts in respect to mathematics ability and self estimated high school grades as can be seen from comparing the male and female standard deviations on these variables.

Female life science majors are similar to their male counterparts in terms of ability, and orientation towards things. They tend to have less high school preparation in math and science, but have higher high school grades.

Female social science majors tend to be slightly lower than males in ability and differ somewhat from them in their personal orientations. Like the other science groups, females have higher self estimated high school grades.

In summary, the same general pattern of sex differences and similarities is found for physical science, mathematics, life science and social science majors. Males and females within a particular science major have similar abilities, interests, and personality patterns. Females, however, have less high school math and science preparation, but have higher high school grades. In addition, their perception of their mother's educational aspirations for them are lower (except for the physical sciences) and they tend to be more person oriented (except for mathematics).

Many of these attributes, as will be seen, play important roles in predicting entry into a science curriculum. Since females as a whole have less of these attributes, the analytical models demonstrate that females are considerably less likely to choose a science major. However, as we have seen, women who select a science major appear to be highly similar to their male counterparts. If we use male science majors as a "quasi" normative group, then as a whole the "right" type of females are choosing science. However, subsequent analytical models will demonstrate that the sex differences in these attributes alone cannot adequately explain why females are considerably less likely than males to choose or complete a science major. In other words, the magnitude of the sex differences in attributes are not important enough to completely explain the difference between males and females in the probability of choosing or completing a science major. Even after statistically adjusting for the most important of these attributes, it will be seen that females still have a significantly lower probability of choosing or completing a science major. There are other factors (e.g. sex role modeling, job discrimination, etc.) that our models do not incorporate that contribute to sex differences in choosing a science major.

The sample sizes for blacks were too small within a particular science major group to make reliable contrasts with whites and, hence, will not be presented here.

Table IV.8

Weighted Means and Standard Deviations for Seventeen Variables for Males and Females by Intended Science Major in the Fall of 1972

	Social Sciences				Life Sciences			
	Females (N = 284)		Males (N = 278)		Females (N = 179)		Males (N = 274)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1. Self Concept	1.99	.64	1.93	.62	1.94	.66	1.94	.61
2. Locus of Control[1]	4.10	.62	4.00	.56	4.19	.62	4.05	.62
3. Work	2.37	.3[illegible]	2.48	.41	2.41	.35	2.56	.35
4. Community	2.21	.44	2.20	.51	2.03	.51	2.11	.47
5. Family	.95	.42	.90	.42	.87	.41	.92	.37
6. Mother's Educational Aspirations	2.10	.59	2.36	.57	2.33	.55	2.55	.54
7. Vocabulary	57.19	8.92	58.55	9.03	59.05	9.05	57.52	8.83
8. Reading	56.65	7.75	57.28	7.91	58.92	7.99	57.51	7.26
9. Mathematics	55.41	8.24	58.12	7.47	58.67	6.70	60.11	6.06
10. SES	.43	.75	.49	.72	.55	.70	.53	.64
11. Science Courses	3.76	1.64	4.52	1.87	5.24	1.82	5.78	1.65
12. Math Courses	4.24	1.72	4.91	1.80	5.02	1.65	5.54	1.72
13. High School Grades[2]	2.48	1.18	2.85	1.22	2.11	1.23	2.68	1.26
14. Job Prestige	5.45	1.47	5.96	1.65	5.53	1.56	5.98	1.51
15. Creativity	6.77	1.50	6.60	1.41	6.31	1.44	6.57	1.48
16. Person versus Thing[3]	5.52	.79	5.03	1.13	4.91	1.13	4.80	1.15
17. Avoiding Pressure	4.23	1.07	3.99	1.11	3.83	1.12	4.10	1.06

[1] High score indicates internal locus.

[2] High score reflects low grades.

[3] High score reflects person orientation.

Table IV.8 (Continued)

	Mathematics				Physical Scientists			
	Females (N = 35)		Males (N = 38)		Females (N = 34)		Males (N = 124)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1. Self Concept	1.89	.63	1.99	.53	1.94	.60	1.91	.56
2. Locus of Control[1]	4.10	.56	4.01	.66	4.13	.60	4.02	.57
3. Work	2.27	.33	2.46	.39	2.36	.38	2.54	.33
4. Community	1.88	.48	2.11	.47	2.06	.51	2.03	.51
5. Family	1.08	.32	.90	.41	.90	.42	.87	.42
6. Mother's Educational Aspirations	2.20	.40	2.35	.63	2.31	.59	2.36	.57
7. Vocabulary	59.14	7.66	58.85	8.96	57.77	8.09	57.95	9.33
8. Reading	60.51	6.89	59.11	6.50	59.72	8.24	59.07	7.25
9. Mathematics	63.98	3.0[illegible]	62.80	5.92	60.74	6.41	61.85	6.34
10. SES	.44	.66	.43	.66	.34	.69	.44	.69
11. Science Courses	5.10	1.63	5.21	1.72	5.77	1.95	5.87	1.76
12. Math Courses	5.98	.34	6.28	1.39	5.99	1.29	5.81	1.23
13. High School Grades[2]	1.42	.62	2.18	1.16	1.87	.96	2.42	1.24
14. Job Prestige	5.55	1.30	5.75	1.23	5.42	1.39	6.03	1.45
15. Creativity	5.35	1.56	6.55	1.50	6.68	1.24	6.59	1.50
16. Person versus Thing[3]	4.63	1.12	4.59	1.02	4.97	1.24	4.50	1.11
17. Avoiding Pressure	4.59	1.09	4.11	.99	3.93	1.13	4.12	1.02

V. ANALYTICAL MODELS

A. Introduction

We have previously seen that both race and sex have an effect on choosing a science major while in college. Females are considerably less likely to select a physical science, engineering, or life sciences major. Black males are less likely than white males to select any science area whatever and black females are less likely than white females to select an engineering major. The sex effect appears substantially greater than the race effect and there is an interaction between race and sex in the selection of a science major. That is, black females tend to select a "hard" science major about as frequently as white females whereas black males lag behind white males in each of the five science areas.

The purpose of this section is to develop some models that can explain race and sex differences in the selection of a college science major. The models are based upon theoretical propositions from the literature, previous empirical studies and preliminary explorations of variable relationships within the NLS data base.

B. Overall Science Model

The basic model finally adopted is portrayed in Figures V.1 and V.2. Both sex and race are exogenous variables in the model whose effects on both the selection of a freshman science major in 1972 and science major status in 1976 are to be estimated. The two figures represent one model which, for the sake of clarity, has been separated

Figure V.1

Overall Science Path Analysis Model (Part I)
Sex Model
N = 3877

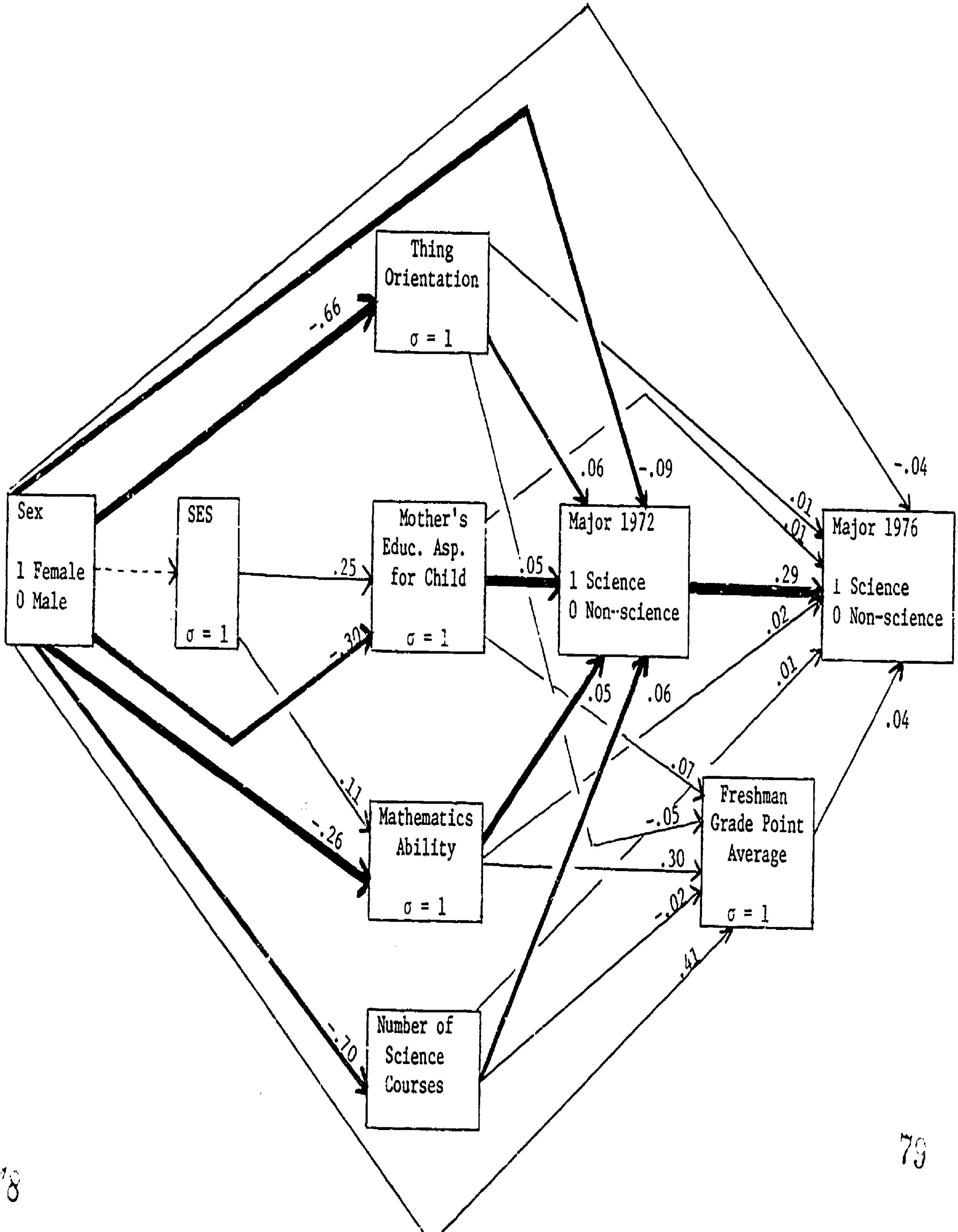
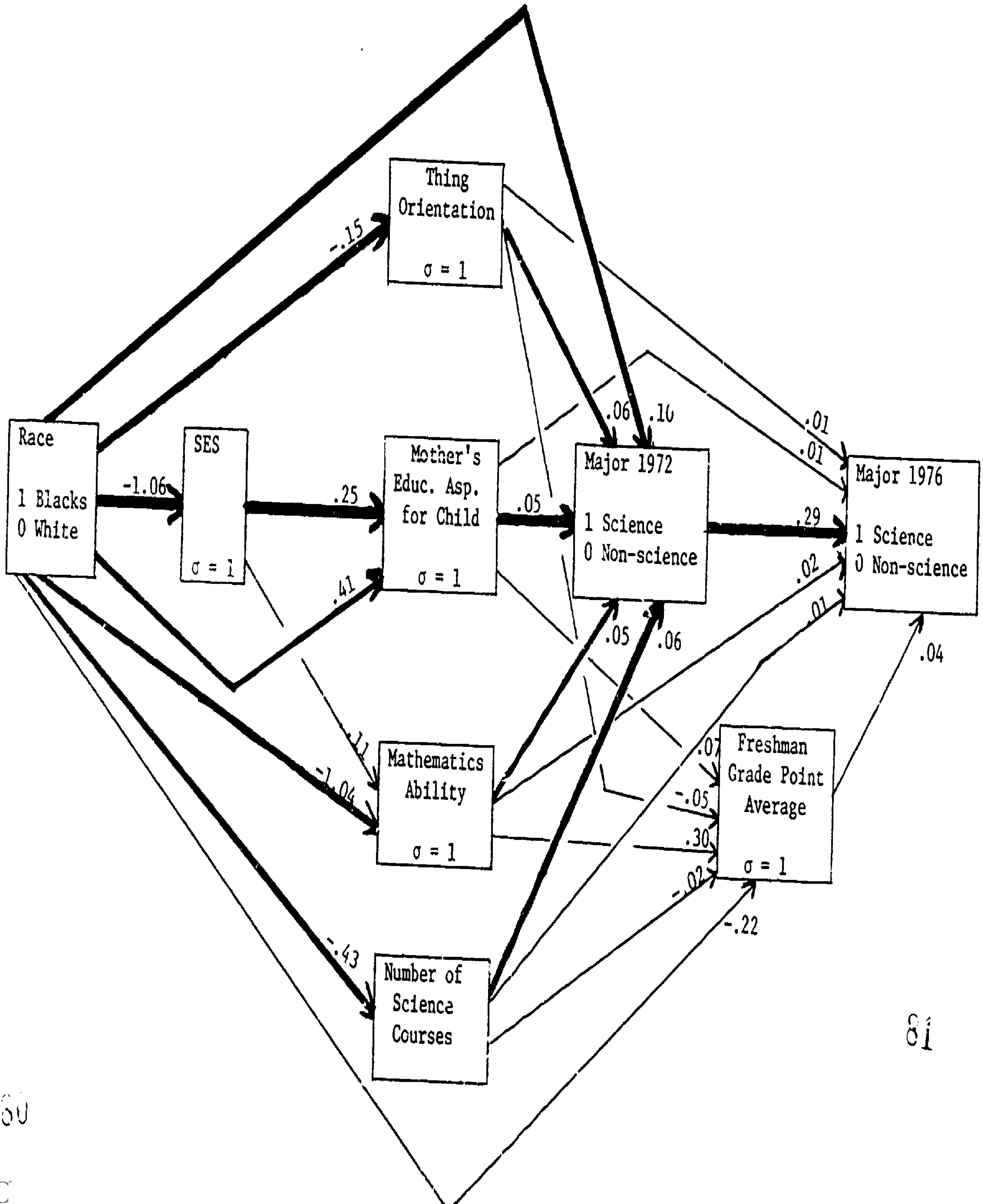


Figure V.2

Overall Science Path Analysis Model (Part II)
Ethnicity Model
N = 3877



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to show the effects of sex in Figure V.1 and the effects of race in Figure V.2. The numbers corresponding to the arrows in each figure represent the regression coefficients associated with the effect. The model represented in Figures V.1 and V.2 involves explaining the selection of a "hard" science major versus some other major. A hard science major is defined as physical sciences, engineering, mathematics, or life sciences. Only regression coefficients significant at the .05 level are presented. The heavy arrows represent the major network of causal influences operating within the model. There are eight regression equations associated with this model and they are presented in Table V.1. The correlations among the ten variables utilized in the system of regression equations are presented in Table V.2.

Figures V.1 and V.2 or equivalently Table V.1 indicates that the exogenous variables, sex and race, affect SES. Sex, race, and SES effect Thing Orientation, Mother's Educational Aspirations for Child, Mathematics Ability, and Number of High School Science Courses. These variables as well as sex, race, and SES affect the choosing of a "hard" science major in 1972 and so on.

Sex and race are the exogeneous variables in this model. They are the variables whose effects on the selection of a science major in 1972 and 1976 we want to understand. SES and the four variables immediately to the right of SES are considered intervening variables (or intermediate endogenous variables) that attempt to explain or mediate the effects of sex and race on major 1972. If this set of five intervening variables completely mediated the effects of race and sex on 1972 major, then we

Table V.1

Overall Model
Regression Parameter Estimates for System of Regression Equations
N = 3877

Dependent Variables	Independent Variables									
	Race (1=Black) (0=White)	Sex (1=Female) (0=Male)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.06**	-.04								1
Thing Orientation	-.15*	-.66**	.00							2
Mother's Educational Aspirations	.41**	-.30**	.25**							3
Math Ability	-1.04**	-.26**	.11**							4
Number of Science Semesters	-.43**	-.70**	.06							5
Major 1972	.10**	-.09**	.01	.06**	.05**	.05**	.06**			6
Freshman GPA	-.22**	.41**	.01	-.05**	.07**	.30**	-.02*	.05		7
Major 1976 (1=Science) (0=Non-Science)	.03	-.04**	.01	.01**	.01*	.02**	.01**	.29**	.04**	8

* = p < .05
** = p < .01

84

83

Table V.2

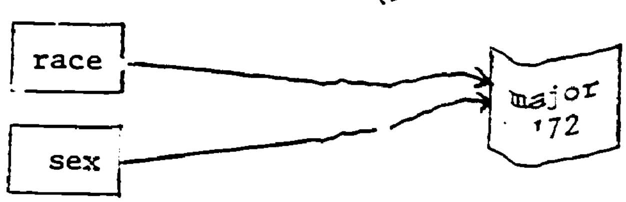
Correlations Among the Regression System Variables
N = 3877

Variables	Correlations									
	1	2	3	4	5	6	7	8	9	10
1. Race	1.00	.07	-.27	-.06	.02	-.31	-.08	-.02	-.12	-.04
2. Sex		1.00	-.04	-.33	-.15	-.16	-.19	-.23	.16	-.18
3. Socioeconomic Status			1.00	.02	.22	.19	.05	.07	.09	.08
4. Thing Orientation				1.00	-.03	.11	.09	.20	-.09	.14
5. Mother's Educational Aspirations					1.00	.23	.15	.20	.11	.16
6. Math Ability						1.00	.34	.25	.28	.22
7. Number of Science Semesters							1.00	.34	.04	.23
8. Science Major 1972								1.00	.04	.46
9. Freshman GPA									1.00	.15
10. Science Major 1976										1.00

would have one reasonable explanation of how these four intervening variables mediate the relationship of sex and race with major 1972. Likewise, the seven variables lying between sex, race, and 1976 major are hypothesized to mediate the effects of race and sex on the 1976 major. The model attempts to explain the known relationship between sex and major field choice and race and major field choice. If these intervening variables are not completely successful in mediating race and sex effects, then the model must allow direct effects to come into play. Direct effects are represented by arrows that bypass the intervening variables and lead directly to the endogenous variables of interest. They indicate that other variables are needed to explain the effects of race and sex. This doesn't mean that the model is a failure; the mediating variables could still explain a significant proportion of variation in the endogenous variables.

In short, the problem is to explain the associations in the models presented below by incorporating a set of mediating variables between race, sex and major 1972 and between race, sex, and major 1976.

(1)



(2)

Let us now examine how well the path model presented in Figures V.1 and V.2 does in explaining the probability of selecting a science major in the freshman year and the probability of being a science major in the spring of 1976. The effects of being black will be examined first and then attention will be turned to the effects of being female.

1. Race Effects

SES is a weak mediator of the race effect even though blacks and whites differ over 1 standard deviat : in SES. It does not effectively explain the differences between blacks and whites on Thing Orientation, Mother's Educational Aspirations for Child, Mathematics Ability, or Number of High School Science Courses. Adjusting for SES, we still find blacks scoring over one standard deviation below whites in mathematics ability, taking fewer high school science courses, and having a lower mean on Thing Orientation. An interesting finding is that SES mediates a negative relationship between race and Mother's Educational Aspirations for Child (i.e. blacks perceive their Mother's Educational Aspirations for them to be lower than whites because of the mediating influence of SES) while at the same time there is a positive direct effect of being black on Mother's Educational Aspirations. A 'usting for SES, blacks have higher perceived Mother's Educational Aspirations than whites.

The four basic intervening variables following SES all have similar and substantial direct effects on choosing a 1972 science major. Adjusting for all of the variables, a standard deviation change in each results roughly in a probability increase of .05 or .06 in choosing a science major. Being black has strong negative effects on mathematics ability, number of science courses taken in high school and thing orientation. Since the effects of these three variables is positive on 1972 science major, race has a strong aggregate negative indirect effect operating through these variables. On the other hand, SES contributes to a negative impact of Mother's Aspirations for Child while at the same time there is a strong positive direct effect of being black on mother's aspirations. The net effect of being black on mother's aspirations is positive and, hence, mother's aspirations indirectly enhances the probability of selecting a science major for blacks. Overall, the intervening variables contribute a negative indirect effect of being black on choosing a 1972 science major.

There is a strong direct positive effect of being black on choosing a science major. Hence the intervening variables do not completely explain the relationship between being black and the selection of a science major in 1972. That is, blacks have a higher probability than whites of selecting a 1972 science major after statistically equating the two races on the intervening variables.

There are some factors operating that give blacks an advantage in regard to selecting a science major when sex and all of the intervening variables are controlled. One of these factors might be affirmative action programs: another factor may be strong motivation on the part of blacks to select science as a means of enhancing their status.

It should be remembered that the overall relationship between race and the selection of a science major was not nearly as strong as the relationship between sex and the selection of a college science major. The model results are interesting because they show that there are some strong negative influences operating as suspected but there are some strong positive influences also operating that cancel out to some extent these negative indirect effects.

The probability of being a science major or science graduate in the spring of 1976 is primarily a function of major status in 1972. The four basic intervening variables that were important in explaining the selection of a 1972 science major are relatively unimportant, though significant, in explaining the 1976 science status. The four intervening variables have important effects on 1976 major but they are primarily indirect effects operating through the selection of a 1972 major. In addition, the substantial direct effect of race on 1972 major has virtually diappeared for 1976 major. The probability of being in science in 1976 if a student was in science in 1972 is only .29 higher than if the student was in non-science in 1972. This is because a substantial proportion of the students withdrew from school by 1976 or switched from a science to a non-science major.

2. Sex Effects

As would be expected, the partial association of sex with SES controlling for race is close to zero and nonsignificant. Males and females enrolled in college academic programs have about the same SES level. As a result, SES does not mediate or explain the association of sex with the four basic intervening variables. The model assumes that the four intervening variables have the same direct effects on major

1972 for sex as for race. The indirect effects of sex, then, are a result of the relationship between sex and the four intervening variables. Sex has an extremely high negative association with orientation towards things. Females are approximately two-thirds of a standard deviation below males. Females, in general, tend to be more people oriented while males tend to be more oriented towards things. This is consistent with previous research with interest differences between males and females. Females report lower mother's educational aspirations than males scoring about three tenths of a standard deviation below males on this dimension. Females also score about a quarter of a standard deviation below males on mathematics ability. It is a well established fact that females, in general, score lower on math achievement and ability tests. Finally, females, on the average, take considerably fewer science courses than males.

Since the four intervening variables are substantially and positively related to choosing a science major and since females score substantially below males on these variables, these variables explain, in part, the lower probability of women choosing a science major. Even in the presence of these strong negative indirect effects of being female, there still remains a strong negative direct effect of -.09 for females. The mediating variables do not completely account for the lower probability of women choosing a science major. That is, females have a lower probability of choosing a science major after statistically equating the two sexes on the intervening variables.

There are substantial negative influences operating for females that the model has not explained. Some preliminary modeling activities considered a host of additional mediating variables such as other interest characteristics (e.g. community orientation, family orientation, locus of control, and self concept) and future plans for family formation. But regardless of the substance and number of variables brought into the model, the strong direct sex effect could not be substantially reduced.

One can speculate on what variables might explain this large negative direct effect. First, there are, of course, strong cultural influences in our society that would discourage females from pursuing science as a career. Second, there are strong sex role influences within the family itself; girls are not encouraged to show scientific interests and are mostly rewarded for feminine behavior. Third, the schools have not been overly supportive to science oriented females and have traditionally counseled them in the direction of adopting feminine careers (e.g. teacher, nurse, social worker, etc,). Fourth, there certainly has been discrimination in the job market place. Female salaries, advancements, and responsibilities have always been less than those of their male counterparts.

The picture changes considerably when the model is extended to explain the probability of being a science major in the spring of 1976 or having obtained a science degree by the spring of 1976. In this case, the direct effect of being female is only -.04 which means that adjusting for all the mediating variables between sex and major 1976, the female probability of being in science in 1976 is only roughly four percentage points lower than for males.

The important mediating variable here, as in the case of race, is the student's major status in the fall of 1972. That is, the best predictor of being in science in 1976 is whether or not they were majoring in science in 1972. Once the freshman major is chosen, the other variables have relatively little impact on predicting status in the spring of 1976.

3. Comparison of Race and Sex Effects

The problems encountered by blacks and females in choosing a science major are of a completely different nature. More specifically, the relative influence of the mediating variables is quite different for race and sex.

SES plays no mediating role whatsoever in explaining sex differences, but plays a limited role in explaining black versus white differences. Mathematics has more of a negative impact for blacks than for females. On the other hand, females are more handicapped than blacks in regard to Thing Orientation and science preparation in high school.

The most interesting finding is that the direct effect of being black in choosing a freshman science major is positive while the direct effect of being female is about the same magnitude as the black effect but is negative. The path analysis model decomposed the negative simple association between being black and choosing a science major into two components: a sum of strong negative indirect effects and a strong positive direct effect. The sum of the negative indirect effects slightly outweighs the single positive direct effect since the total effect of being black is negative. The implication is that blacks have some positive factors operating that partially cancel out the strong debilitating negative indirect effects.

On the other hand, both the direct and indirect effects of being female are strongly negative and equivalent in magnitude. The total effect of being female is strongly negative and the model only explains a portion of this total negative effect.

The implications of the model for decreasing sex differences are decidedly different from those concerned with decreasing race differences. The strongest negative indirect effect for blacks is due to their low mathematics ability followed by their lack of high school science preparation. For females, the strongest negative indirect effects are due to their person orientation and their lack of high school science preparation. Mother's Educational Aspirations mediates a positive indirect effect for blacks and a negative indirect effect for females.

The model suggests that the mathematics ability and high school science preparation of blacks needs to be significantly improved. It also suggests that the high school science preparation of females needs to be improved along with a shift from person to thing orientation.

Overall, parents expect less for girls than for boys as can be seen from the negative sex effect on perceived educational aspirations. Parents should be encouraged to promote the development of each child in regard to their abilities regardless of sex.

C. Overall Model By Sex

Because of the possibility of differences in the parameters of the model for males and females, the model parameters were estimated separately for both groups. The model for females is presented in Figure V.3 and for males in Figure V.4. The regression equation corresponding to these path models are presented in Tables V.3 and V.4 for females and males, respectively. The correlations among the nine variables utilized in the system of regression equations are presented in Tables V.5 and V.6 for females and males respectively.

The parameters of the male and female models are similar except for these instances:

- Black and white females do not significantly differ on Thing Orientation while black and white males differ significantly. In other words the regression parameter for race in predicting Thing Orientation is zero for females and significantly and substantially negative for males.

- The regression parameter for race in predicting mother's educational aspirations for females is significantly and substantially positive while the corresponding parameter for males is not significantly different from zero.

- Mathematics ability has a somewhat larger direct effect for males than females and, hence, race has a larger indirect negative effect through mathematics for males than for females.

For both males and females, race differences in choosing a science major are strongly mediated by mathematics ability and high school

Figure V.3

Overall Science Path Analysis Model for Females
N = 1917

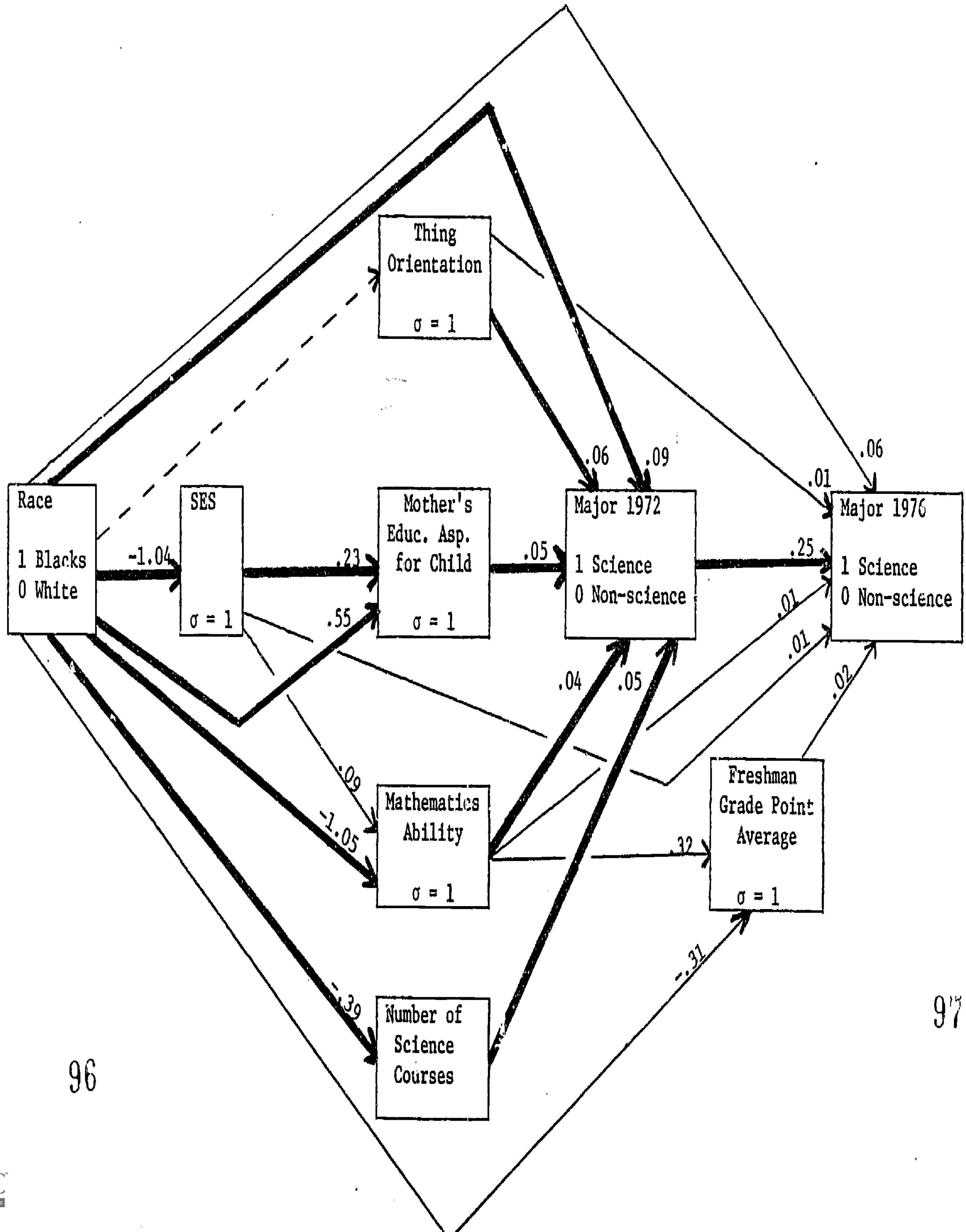


Figure V.4

Overall Science Path Analysis Model for Males
N = 1960

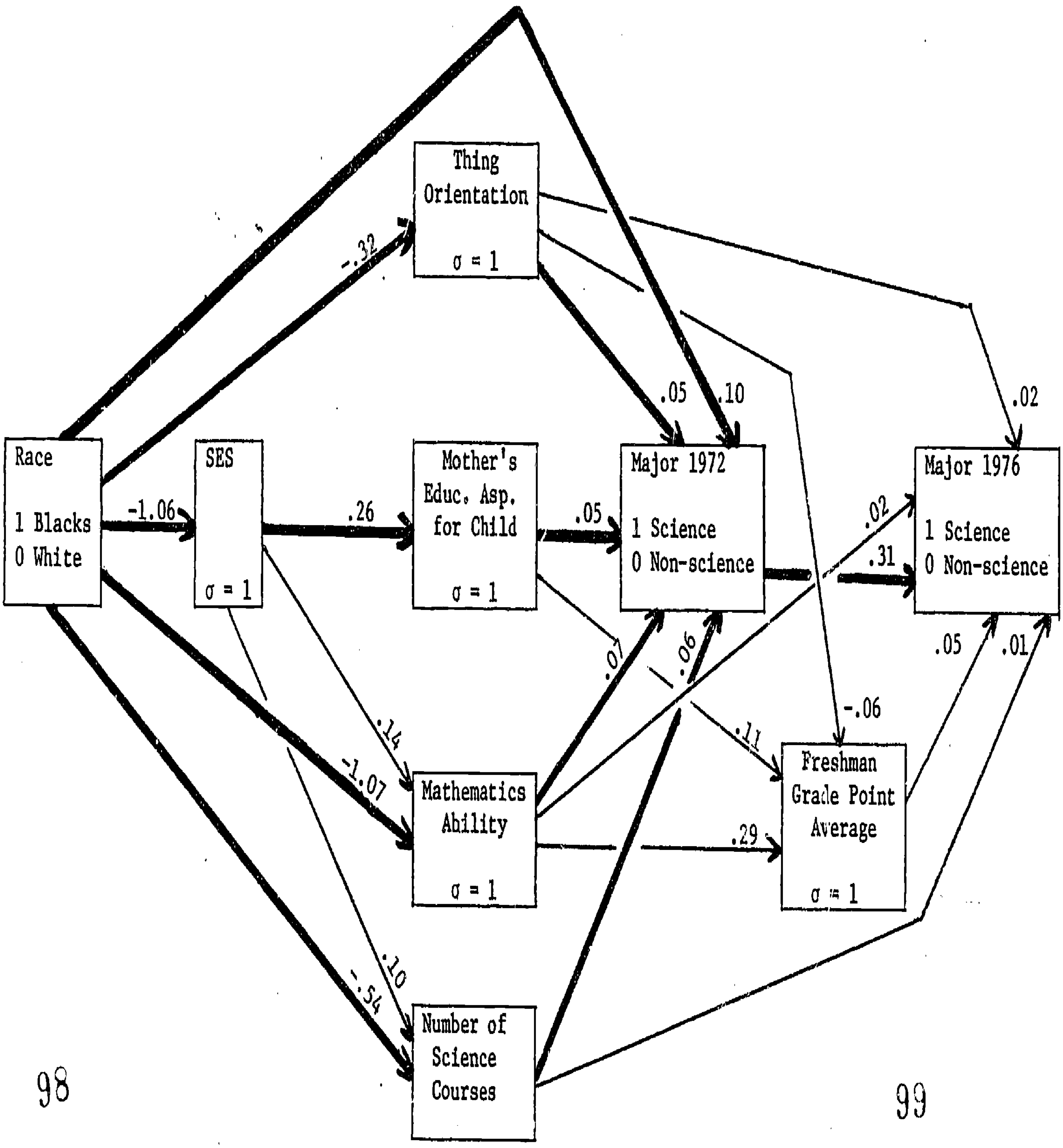


Table V.3

Overall Model (Female)
Regression Parameter Estimates for System of Regression Equations
N = 1917

Dependent Variables	Race (1=Black) (0=White)	Socio-ecoromic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.04**								1
Thing Orientation	-.02	.03							2
Mother's Educational Aspirations	.55**	.23**							3
Math Ability	-1.05**	.09**							4
Number of Science Semesters	-.39**	.01							5
Major 1972	.09*	.02	.06**	.05**	.04**	.05**			6
Freshman GPA	-.31**	.01	-.02	.04	.32**	-.02	-.02		7
Major 1976 (1=Science) (0=Non-Science)	.06**	.01**	.01**	.01	.01*	.00	.25**	.02**	8

(Independent Variables: Race through Freshman GPA)

* = $p < .05$
** = $p < .01$

Table V.4

Overall Model (Male)
Regression Parameter Estimates for System of Regression Equations
N = 1960

Dependent Variables	Independent Variables: Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.06**								1
Thing Orientation	-.32**	-.03							2
Mother's Educational Aspirations	.18	.26**							3
Math Ability	-1.07**	.14**							4
Number of Science Semesters	-.54**	.10*							5
Major 1972	.10*	.00	.05**	.05**	.07**	.06**			6
Freshman GPA	-.06	.01	-.06**	.11**	.29**	-.02	.08		7
Major 1976 (1=Science) (0=Non-Science)	-.03	.00	.02*	.01	.02*	.01*	.31**	.05**	8

* = $p < .05$
** = $p < .01$

Table V.5

Correlations Among the Regression System Variables for Females
N = 1917

Variables	Correlations 1	2	3	4	5	6	7	8	9
1. Race	1.00	-.30	-.01	.09	-.33	-.06	.02	-.19	.02
2. Socioeconomic Status		1.00	.03	.18	.18	.02	.07	.10	.10
3. Thing Orientation			1.00	.00	.06	.01	.19	-.01	.13
4. Mother's Educational Aspirations				1.00	.19	.09	.19	.08	.15
5. Math Ability					1.00	.28	.19	.33	.18
6. Number of Science Semesters						1.00	.32	.05	.18
7. Science Major 1972							1.00	.04	.43
8. Freshman GPA								1.00	.14
9. Science Major 1976									1.00

Table V.6

Correlations Among the Regression System Variables for Males
N = 1960

Variables	Correlations								
	1	2	3	4	5	6	7	8	9
1. Race	1.00	-.23	-.06	-.02	-.27	-.07	-.02	-.09	-.06
2. Socioeconomic Status		1.00	-.01	.24	.19	.07	.06	.10	.07
3. Thing Orientation			1.00	.15	.07	.04	.10	-.06	.08
4. Mother's Educational Aspirations				1.00	.24	.16	.16	.19	.14
5. Math Ability					1.00	.36	.25	.31	.23
6. Number of Science Semesters						1.00	.32	.09	.22
7. Science Major 1972							1.00	.11	.45
8. Freshman GPA								1.00	.21
9. Science Major 1976									1.00

science preparation. However, Thing Orientation is a significant mediator only for males and race has a significant positive direct effect on mother's aspirations only for females. The aggregate overall indirect negative effects of being black are smaller for females than for males. In other words, female blacks are less disadvantaged compared to female whites on the mediating variables relative to the disadvantage of black males compared to white males.

D. Specific Science Models

The models presented in this section attempt to explain the probability of selecting a particular science major (i.e. physical sciences) versus a non-science major. As in the overall science model, each series of equations will be fit to the total sample, and then separately by sex. The overall science model will be used as a standard for comparing the science specific models. Since the number of female engineering majors in the sample was extremely small, no attempt will be made to develop models for engineering majors. In addition, no attempt will be made to model the selection of a mathematics major since there were no overall sex differences. Overall models and models by sex are presented for life sciences, physical sciences, and the social sciences. The total sample for each science model is the sample of students who are majoring in that particular science plus those students who choose a non-science major. Taking the physical sciences as an example, major 1972 would be coded 1 if the student was majoring in physical science and 0 if he was majoring in a non-science. The remaining science majors have been excluded from the physical sciences model sample. Defining the sample in this manner results in the probabilities of selecting a particular science major being interpreted as the conditional probability of selecting a particular science major (versus a non-science major) given that no other science major was selected. In effect, these models contrast those students majoring in a particular science with those students pursuing a non-science major.

1. Life Sciences

The sign and magnitude of the parameters for the first five equations of the Life Sciences Model (Table V.7) were similar in size and magnitude to the overall science model. The direct effects of race and sex on major 1972 were similar in sign to the overall model but were smaller in magnitude and non-significant. While all four intervening variables (Thing Orientation, Mother's Educational Aspirations for Child, Mathematics Ability, and Number of Science Courses) where equally important in the overall science model, math ability and Thing Orientation are not particularly important in choosing a freshman life sciences major. As in the overall model, the most important predictor of life science major status in 1976 is life science major status in 1972. The direct race and sex effects on life sciences major 1976 were about identical to those for the overall model - an insignificant positive direct effect for race and a significant negative direct effect for sex.

When the life science model parameters are estimated separately for males and females some important differences from the overall model emerge (see Tables V.8 and V.9, respectively). Race has a positive and significant direct effect on life sciences major 1972 for females and a

Table V.7

Overall Model (Life Sciences)
Regression Parameter Estimates for System of Regression Equations
N = 2830

		Independent Variables									
		Race (1=Black) (0=White)	Sex (1=Female) (0=Male)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
DEPENDENT VARIABLES	Socioeconomic Status	-1.05**	-.01								1
	Thing Orientation	-.12	-.65**	.00							2
	Mother's Educational Aspirations	.41**	-.29**	.25**							3
	Math Ability	-1.04**	-.17**	.11**							4
	Number of Science Semesters	-.35*	-.58**	.04							5
	Major 1972	.04	-.02	.02**	.02**	.08**	.01	.05**			6
	Freshman GPA	-.26**	.43**	.01	-.07**	.06**	.29**	-.02	.09		7
	Major 1976 (1=Science) (0=Non-Science)	.06*	-.05**	.02**	.01*	.02**	.02**	.00	.27**	.03**	8

* = $p < .05$
** = $p < .01$

Table 7.?

Life Sciences Model (Male)
Regression Parameter Estimates for System of Regression Equations
N = 1284

DEPENDENT VARIABLES	Independent Variables: Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.13**								1
Thing Orientation	-.28*	-.02							2
Mother's Educational Aspirations	.16	.27**							3
Math Ability	-.94**	.15**							4
Number of Science Semesters	-.23	.10							5
Major 1972	.01	.02	-.01	.10**	.00	.06**			6
Freshman GPA	-.04	.02	-.09**	.11**	.28**	-.03	.15*		7
Major 1976 (1=Science) (0=Non-Science)	.01	.02	.01	-.02*	.02	.00	.29**	.03**	8

* = p < .05
** = p < .01

Table V.9

Life Sciences Model (Female)
Regression Parameter Estimates for System of Regression Equations
N = 1546

DEPENDENT VARIABLES	Independent Variables: Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.00**								1
Thing Orientation	-.03	.01							2
Mother's Educational Aspirations	.57**	.23**							3
Math Ability	-1.11**	.07**							4
Number of Science Semesters	-.43*	-.01							5
Major 1972	.07*	.03**	.05**	.05**	.02	.05**			6
Freshman GPA	-.39**	.01	-.03	.03	.31**	-.02	-.02		7
Major 1976 (1=Science) (0=Non-Science)	.08**	.02*	.02*	.02**	.02*	.01	.25**	.02**	8

* = $p < .05$
** = $p < .01$

small and insignificant positive direct effect for males. For females, Thing Orientation has a positive and significant direct effect on major 1972 while for males it is insignificant. For life sciences major 1976, the direct effect parameters are similar. The best predictor of life science major status in 1976 is life science major status in 1972.

The most significant difference from the overall science model is the insignificant role mathematics plays in choosing a life sciences major for both males and females. In addition, the direct positive effects of race on selecting a life sciences major in 1972 for both males and females tend to be smaller, although they are still statistically significant for females.

2. Physical Sciences

The overall physical sciences model is quite similar to the overall science model (see Table V.10). Sex and race have the same pattern of direct effects on physical sciences major 1972 and 1976. The four basic intervening variables all play a highly significant role contributing to the negative indirect effects of sex and race as in the overall science major. Math ability plays a significant role, as expected, in the selection of a physical sciences major. The same basic processes are in evidence for both males and females (see Tables V.11, and V.12, respectively). Math is an important intervening variable for both sexes. As in the other models, Mother's Educational Aspirations for Child is significantly higher for black females compared to white females while no significant race differences exist for males. Black females who do not differ from white females in Thing Orientation

Table V.10

Overall Model (Physical Science)
Regression Parameter Estimates for System of Regression Equations
N = 2528

Dependent Variables	Race (1=Black) (0=White)	Sex (1=Female) (0=Male)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
	Independent Variables									
Socioeconomic Status	-1.00**	-.02								1
Thing Orientation	-.11	-.74**	-.02							2
Mother's Educational Aspirations	.37**	-.23**	.25**							3
Math Ability	-1.03**	-.19**	.11**							4
Number of Science Semesters	-.30*	-.55**	.02							5
Major 1972	.06**	-.05**	.00	.01*	.02**	.03**	.03**			6
Freshman GPA	-.21**	.45**	.01	-.05**	.06**	.29**	-.02	.07		7
Major 1976 (1=Science) (0=Non-Science)	.01	-.04**	.02**	.01*	.02**	.01	.00	.35**	.02*	8

* = p < .05
** = p < .01

Table V.11

Physical Sciences Model (Male)
Regression Parameter Estimates for System of Regression Equations
N = 1130

Dependent Variables	Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
	Independent Variables								
Socioeconomic Status	-1.04**								1
Thing Orientation	-.26	-.02							2
Mother's Educational Aspirations	.16	.28**							3
Math Ability	-.93**	.16**							4
Number of Science Semesters	-.14	.09							5
Major 1972	.04	.00	.01	.02**	.04**	.04**			6
Freshman GPA	.06	.01	-.06*	.12**	.25**	-.02	.17		7
Major 1976 (1=Science) (0=Non-Science)	-.05	.02*	.01	.02*	.00	.00	.36**	.02	8

* = p < .05
** = p < .01

Table V.12

Physical Science Model (Female)
Regression Parameter Estimates for System of Regression Equations
N = 1398

Dependent Variables	Independent Variables: Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-.98**								1
Thing Orientation	-.01	-.03							2
Mother's Educational Aspirations	.50**	.22**							3
Math Ability	-1.12**	.06*							4
Number of Science Semesters	-.41*	-.04							5
Major 1972	.06**	.00	.01**	.01**	.01**	.02**			6
Freshman GPA	-.35**	.01	-.02	.01	.32**	-.02	-.24		7
Major 1976 (1=Science) (0=Non-Science)	.05	.02*	.02*	.01	.01	.00	.35**	.01	8

* = $p < .05$
** = $p < .01$

(adjusted for socioeconomic status) while the opposite is true for males. Thus, males manifest indirect negative race effects through thing orientation while females do not.

3. Social Sciences

Since the discriminant analyses indicated that non-science majors are similar to social science majors for both males and females, it would be expected that the social sciences model would be quite different from the overall science model and any of the particular "hard" science models examined thus far. Tables V.13, V.14, and V.15 present the results for the social sciences. There is no significant direct effect for race for either choosing a social science major in 1972 or 1976. There is, however, a significant negative effect for sex on choosing a social science major in 1972 which declines in size in its influence in choosing a social science major in 1976 but is still statistically significant. Since females are more people oriented than males (see equation 2, Table V.13) and People Orientation is directly related to selecting a major in the social sciences, being female has a positive indirect effect on selecting a social science major in 1972. Mathematics ability, as expected, has no significant effect on choosing a social sciences major in 1972, and hence neither sex nor race have any indirect effects on selecting a social sciences major in 1972 through mathematics ability. The same is true of number of science semesters in high school.

Thing Orientation mediates a positive indirect effect for females in choosing a social science major in 1972 while the higher mother's

Table V.13

Overall Model (Social Sciences)
Regression Parameter Estimates for System of Regression Equations
N = 2945

	Independent Variables									
Dependent Variables	Race (1=Black) (0=White)	Sex (1=Female) (0=Male)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.09**	-.03								1
Thing Orientation	-.11	-.68**	-.02							2
Mother's Educational Aspirations	.35**	-.26**	.24**							3
Math Ability	-1.01**	-.17**	.13**							4
Number of Science Semesters	-.40**	-.51**	.04							5
Major 1972	.05	-.07**	.02**	-.05**	.04**	.01	.00			6
Freshman GPA	-.19*	.44**	.01	-.05**	.06**	.28**	-.02	.10*		7
Major 1976 (1=Science) (0=Non-Science)	.03	-.05**	.02**	.01	.03**	.01	.00	.35**	.02**	8

* = p < .05
** = p < .01

Table V.14

Social Sciences Model (Male)
Regression Parameter Estimates for System of Regression Equations
N = 1293

	Independent Variables								
DEPENDENT VARIABLES	Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
Socioeconomic Status	-1.14								1
Thing Orientation	-.30*	-.03							2
Mother's Educational Aspirations	.21	.27**							3
Math Ability	-.89**	.18**							4
Number of Science Semesters	-.19	.13*							5
Major 1972	-.01	.03*	-.06**	.06**	.01	.01			6
Freshman GPA	.06	.02	-.06*	.10**	.25**	-.01	.17*		7
Major 1976 (1=Science) (0=Non-Science)	-.02	.03**	-.00	.03*	.00	.00	.36**	.03*	8

* = p < .05
** = p < .01

Table V.15

Social Science Model (Female)
Regression Parameter Estimates for System of Regression Equations
N = 1652

Dependent Variables	Race (1=Black) (0=White)	Socio-economic Status σ=1	Thing Orientation σ=1	Mother's Educational Aspirations σ=1	Math Ability σ=1	Number of Science Semesters (High School)	Major 1972 (1=Science) (0=Non-Science)	Freshman GPA σ=1	Equation
	Independent Variables								
Socioeconomic Status	-1.06								1
Thing Orientation	.01	-.02							2
Mother's Educational Aspirations	.42**	.22**							3
Math Ability	-1.10**	.09**							4
Number of Science Semesters	-.54**	-.03							5
Major 1972	.07*	.01	-.03**	.03**	.01	-.01			6
Freshman GPA	-.31**	.00	-.03	.02	.31**	-.02	.03		7
Major 1976 (1=Science) (0=Non-Science)	.06	.02	.02**	.03**	.02*	.01	.33**	.01*	8

* = p < .05
** = p < .01

educational aspirations for males mediates a positive indirect effect for males.

Examining the model parameters estimated separately for males and females, it can be seen that race has insignificant direct effects for males on choosing a social science major in either 1972 or 1976. The positive direct effect of race for females was, however, significant.

Like the other models, the most important predictor of social science major status in 1976 was social science major status in 1972.

E. Probabilities of Science Entry for Four Subpopulations

In order to appreciate the joint magnitude of the effects of mathematical ability, amount of high school science, and Thing Orientation on the probability of choosing a science major in the freshman year the reader is referred to Table V.16. This table presents the estimated proportion of students majoring in "hard" sciences for four subpopulations: white males with below median scores on these three variables; white males with above median scores; white females with below median scores; and white females with above median scores. The splits could not be made exactly at the median because of the relatively small number of integer values. The corresponding black subpopulations had sample sizes that were too small to make reliable estimates of the proportions. Also, the white subgroups that had extreme perceived mother's educational aspirations were too small so mother's aspirations was held constant at the middle level for all four groups.

The percentages of both men and women choosing science is extremely small for both men and women that fell below the median on the three

Table V.16

Probabilities of Choosing a Freshman Science Major

Subpopulation	Sex	Race	Sciences Semesters	Math Score	Thing Orientation	Mother's Educational Aspirations	Sample Size	Estimated Proportion
1	Male	White	Low	Low	Low	Medium	79	.0506
2	Female	White	Low	Low	Low	Medium	280	.0214
3	Male	White	High	High	High	Medium	352	.5341
4	Female	White	High	High	High	Medium	119	.4286

independent variables. There was, however, a small tendency for males to have a higher probability than females for choosing a science major. On the other hand, a large proportion of the "qualified" females and more than half of the "qualified" males choose a freshman science major.

Again, males had an advantage over females in this regard. The differences in the percentages of males and females choosing a science major are still substantial when the important factors that predict the selection of a science major are held constant. The probability of "qualified" females entering the "hard" sciences is about .10 lower than the probability of "qualified" males entering the "hard" sciences. However, one major problem for females is that they are less likely to be qualified than males. This can be seen from the relative sample sizes of qualified men (N = 352) and qualified women (N = 119), a ratio of approximately 3 to 1 in favor of males. These tabular results correspond closely, as they should, with the results of the previous regression analyses where there was a decided advantage for males in choosing the "hard" sciences after adjustment for the four major intervening variables. That is, the direct effect of being female is approximately -.10 based upon either the previous regression analyses or the simple tabulations presented here.

F. Log Linear Models for Predicting the Selection of a Freshman Science Major

It was previously shown in the overall regression analysis predicting freshman entry into the "hard" sciences that race, sex, Thing

Orientation, Perceived Mother's Educational Aspirations for Child, mathematics ability, and number of high school science courses all had substantial and significant multiple regression weights. When the regression model was estimated separately for males and females it was found that there were some indications that sex interacted with some of the other independent variables although there were general similarities in the pattern of relationships among the variables for both sexes.

The purpose of this section is to determine whether a log linear model containing only first order interaction terms reflecting the relationship between the six independent variables and science major adequately fits the data or whether second order interaction terms involving sex and race with the independent variables are needed to adequately fit the data. Other interaction terms representing the relationships among the independent variables themselves have to be included in the log linear model for predicting cell values but these parameters are of no substantive interest.

In order to fit a log linear model to these seven variables, four of the continuous variables have to be converted into categorical varibles.

In order to avoid having too many cells with low frequencies, it was decided to categorize the mathematics ability scores into two levels (high, low); number of high school science courses into two levels (high, low), Thing Orientation into two levels (high, low); and perceived parental educational aspirations for child into three levels (graduate school, college, and no college). Combined with two levels for sex, race, and science major, the result was a seven way table with 192 cells

(2 x 2 x 2 x 2 x 2 x 2 x 3). The two level splits were made as close to the medians as possible given the distributions of the variables. The sample size for this analysis was 4,000.

For our purposes, the first order interaction log linear model can be written as

$$\log_e \text{cell } n = \begin{bmatrix} \text{overall effect} \\ + \text{ all main effects} \\ + \text{ higher order} \\ \text{interaction effects} \\ \text{among the inde-} \\ \text{pendent variables} \end{bmatrix} + \begin{bmatrix} \text{all first order inter-} \\ \text{actions between the six} \\ \text{independent variables} \\ \text{and science entry} \end{bmatrix}$$

The main interest lies in the second set of parameters in the above model. The above model did not adequately fit the data (probability of $X^2 < .01$). This indicated that certain higher order interaction terms needed to be added to the model to provide an adequate fit. Following the results of the regression analyses, it made sense to augment the model with second order interaction terms representing the interaction of sex and race with each of the six independent variables and science entry.

When these second order interaction parameters were added to the previous model, an acceptable fit was obtained (probability of $X^2 > .05$).

While other possible models may fit the data as well, the last model seems reasonable since it indicates that in order to fit the 192 cell contingency table, parameters reflecting the relationship of each of the six independent variables with the dependent variable, science entry, needed to be included among the terms of the log linear model. These results strongly agreed with the regression analyses which indicated that all six variables had significant regression parameters.

VI. SUMMARY

The purposes of this study were (1) to explain the relatively low entry rates of females and blacks into college science curricula and (2) to explain the relatively low science degree attainment on the part of females and blacks. The data used for modeling sex and race effects on choosing a science major and science degree attainment came from the National Longitudinal Study of the High School Class of 1972 (NLS), a longitudinal data base containing data on over 20,000 students. The primary analytical tool employed in this study was multiple regression analysis in a path analysis framework. Discriminant analysis and log linear modeling were used to augment these analyses.

The data indicated that there were greater sex differences than differences between blacks and whites in the probability of selecting a freshman science major. Black females had about the same probability as white females in selecting a hard science major. On the other hand, black males compared to white males had a consistently lower probability of entering each specific science major group. In terms of science degree attainment, black females kept pace with white females, but the gap between black males and white males widened. Black males even had a lower probability of obtaining a degree in a particular science area than black females. Males and females within a particular science major group were highly similar to one another on 17 attributes spanning the ability, interest, high school background, and socioeconomic background domains.

Discriminant analyses for both males and females indicated that the non-science and social science majors were similar to one another and could be discriminated from the "hard" science majors on the basis of 18 relevant attributes spanning the domains previously mentioned. On the basis of the discriminant analyses, it was concluded that some models could be developed to explain the race and sex effects of choosing a "hard" science major. Path analysis models were developed which had four key intervening variables: mathematics ability, thing orientation, perceived mother's educational aspirations for child, and number of high school science semesters. These four intervening variables explained some of the negative indirect effects of race and sex on the selection of a college science major. The most significant finding was a substantial positive direct effect of being black and substantial negative effect of being female on selecting a college science major.

These results indicated that after adjusting for differences between males and females in respect to these four intervening variables, females still had a lower probability of choosing a science major. On the other hand, similar adjustments for differences between blacks and whites indicated that blacks had a higher probability of selecting a college science major than whites. The models indicated that there are some remaining negative impacts of being female on the selection of a college science major that are not explained by the models. Similarly, there are some postitive impacts of being black that are not explained by the models. All the effects of being female are negative while there is some evidence that being black has some positive effects to compensate, to a large extent, for the built in negative effects. Some speculations concerning the nature of these impacts are presented in the report.

Path analysis models were also developed separately for males and females and for specific science major groups. There were some differences in the parameters of these more specific models from the parameters of the overall "hard" science path analysis model. Log linear models, which are especially appropriate for categorical dependent variables, were used to verify the results of the regression based path analysis models.

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