DOCUMENT RESUME

ED 253 493 SO 016 234

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TITLE Self-Image, Science and Math: Does the Image of the "Scientist" Keep Girls and Minorities from Pursuing Science and Math?
SPONS AGENCY National Inst. of Education (ED), Washington, DC.
PUB DATE Aug 84
GRANT NIE-G-79-0111
NOTE 29p.; Paper presented at the Annual Meeting of the American Sociological Association (79th, San Antonio, TX, August 27-31, 1984).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Career Choice; Educational Research; *Females; *Hispanic Americans; Males; *Mathematics; Minority Groups; *Science Curriculum; Secondary Education; *Self Concept; Self Evaluation (Individuals); *Sex Differences; Sex Role; Sex Stereotypes; Student Interests

ABSTRACT

Interest in the relationship between self-image and occupational choice and concern over the low representation of women and minorities in science provided the impetus for this study of 2,442 high school and junior high school students. Self-image ratings were examined with respect to the student's interest in taking science courses. Particular attention was paid to male/female differences and Mexican-American/Anglo-American differences. Results indicated that the commonly held image of the scientist corresponds to the self-image of students with an interest in science insofar as intelligence, self-confidence, independence, and creativity are concerned. Girls also include competetiveness in the image. Variation by gender and ethnic background were found significant in how students evaluated themselves and what additional characteristics were seen as part of the image of scientists. Boys and Anglo-Americans were more likely to see themselves as intelligent and creative. They were also more likely to be interested in science. Contrary to expectations, Mexican-Americans were more interested in taking math than Anglo-Americans. Feedback to girls and minorities about their intelligence may be crucial in raising their interest in science, but it may be difficult to do so because students' self-perceptions develop over many years. (IS)

Self-Image, Science and Math:

Does the image of the "scientist" keep girls and minorities from pursuing science and math?

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Presented at the American Sociological Association, August, 1984, San Antonio, Texas.

This research was supported by a grant from the National Institute of Education (NIE-G-79-0111). The ideas and opinions presented in this paper are those of the author and do not represent the positions or policies of the National Institute of Education.

ABSTRACT

Theories of reference groups and occupational choice suggest that perceived consonance between self image and the image of a typical occupational incumbent increases interest in that career. Self image ratings from 2442 high school and junior high school students are examined with respect to interest in taking science, a behavioral intention measure. Particular attention is directed to differences between boys and girls and Mexican Americans and Anglos in the association between self image and science. The results indicate that self confidence, independence, creativity, responsiveness to others and comfortable with others are associated with interest in science. The effects of competitiveness and likeability vary by gender. Intelligence, which is related to interest in both science and math, is particularly important because of its salience to academic and scientific roles.

The word "scientist" evokes a common, widely held image. The image of an extremely intelligent, independent, energetic, yet shy man in a white lab coat surrounded by test tubes and laboratory equipment emerges in every day discussions of science and in depictions of scientists in cartoons, magazines, textbooks, and television. The content of this image has consequences for the selection of individuals into science. The similarity principle of reference group theory proposes that people select reference groups on the basis of perceived congruence between the group members' attitudes, values, and traits and those of the individual (Newcomb, 1961). Perceived consonance between the self and the reference group results in self-satisfaction for the individual and may facilitate social support (Singer, 1981). Congruence is also predicted by the self-concept implementation theory of occupational choice (Super, 1953). According to this theory, when making occupational choices, the individual tries to coordinate self-image and the image of the typical occupational incumbent. Both of these theories view self-image as a social force, in Rosenberg's terms (1981), insofar as self-image has consequences both for selection into various occupational categories and for the composition of the occupational system.

The increasing entry of women into science has begun to challenge this image of the scientist and to raise questions as to whether the characteristics that contribute to careers in science vary by gender. Rossi, (1965) noted four characteristics of eminent scientists: high intellectual abilities, intense channeling of energy in one direction, extreme independence and apartness from others socially. She noted that the conflict between these characteristics and the traditional sex role ideology, which emphasizes interpersonal skills and family roles for women,

keeps women from entering science, engineering and medicine. In addition to difficulties combining nontraditional careers and family roles, respondents in her study felt that women did not enter engineering because of reflected appraisals, i.e., they felt discouraged by parents, resented by male colleagues, and fearful of being considered "unfeminine." Thus, there seems to be an inherent conflict between the female sex role and the role of scientist.

Self-Image of Scientists and Mathematicians

Empirical evidence suggests that the common stereotype of the "scientist" is similar to the actual personalities of scientists and mathematicians. Women who have succeeded in these fields or who are pursuing advanced study in these fields tend to resemble their male counterparts. Insofar as many of the traits associated with science and mathematics are male sex-typed, women may be discouraged from entering or continuing in these fields. Thus, the popular image of the scientist affects self-selection in mathematical and scientific careers.

Four questions of interest remain to be answered. First, is the self-image of high school students associated with interest in science and math in the same way as found for university students and persons employed in these fields? If self-image is associated with interest in science and math among high school students, intervention programs can be designed for use early in the educational process. Difference between the traits associated with interest in science at the high school and college level would help differentiate those students who discontinue their studies in these areas from those who lack initial interest. Programs to encourage these interested high school students might be particularly successful in increasing participation in scientific and technical careers. Second, are there personality characteristics whose association with interest in

science and math vary by gender? For example, female scientists and science students describe themselves as tough minded while male scientists choose sensitive. An understanding of such gender differences would help to identify barriers to women's entry into these nontraditional fields and aid in the development of programs to encourage their participation. Third, do scientists and science students see themselves as exhibiting female sex-typed characteristics? Insofar as these more "feminine" characteristics can be identified, the perceived conflict between the image of scientists and mathematicians and the female sex role may be reduced. For example, female scientists' and science students' self-perception as tough minded may be due to a rejection of what they perceive as "feminine" because they feel that these traits are inappropriate in their professions. Information on the more "feminine" side of the personality of scientists and mathematicians would encourage perserverance among those students who are interested in these fields but also see themselves as having "feminine" characteristics and interests. Fourth, empirical research has neglected the additional barrier due to the conflict between the image of scientist or mathematician and culturally desirable traits among ethnic groups. If the ethnic group members are not expected to be competitive or assertive, for example, they may not consider careers in science or mathematics where these traits seem necessary.

The following study examines student's interest in science and math and self-image. Comparisons across sex and ethnic groups will be made to test the following hypotheses.

A greater likelihood of interest in science and math is expected among:

1. students who rate themselves higher on the "masculine" traits

intelligence, self-confidence, and independence.

2. girls who rate themselves higher in creativity.

3. Anglo girls who rate themselves higher on competitiveness.

4. students who rate themselves lower on the "feminine" social characteristics, comfortable with others and responsive to others.

No significant associations of interest in science and math with the traits of likeable and strong are expected.

Methods

The data utilized in this paper were collected as part of a larger project on "Social Influences on the Participation of Mexican-American Women in Science." Bilingual questionnaires were distributed to high school and junior high students in southern Arizona during required classes in the Spring of 1980. A total of 2,442 questionnaires were completed. The response rates were quite high; at one school, less than one percent refused to participate and the highest rate of nonparticipation was thirteen percent. The questionnaire included questions about educational and occupational aspirations, attitudes toward adult roles and school subjects, social support for education, family and background characteristics, and self-image.

The six schools included in the study were selected on the basis of the proportion of minority students. Students who identified themselves as Mexican or Mexican American were the modal ethnic group in each school. For the purposes of this paper, students who characterized themselves as Mexican or Mexican American (treated together) (N=1589) are contrasted with

students who identified themselves as Anglo (N=476). Students of other ethnicities are excluded from the present analysis.

The research sites represent variation in urban or rural location and in socio-economic class. The first site utilized the only high school and junior high in a small town which borders on Mexico. Because there is only one high school and one junior high for this community, the entire range of socio-economic background is represented. The other schools were drawn from the largest school district in Arizona and were chosen on the basis of minority enrollment. The socio-economic background of these students tends to overrepresent the lower end of the distribution for parents' education and occupation.

Interest in science and math were measured by asking students whether they would take courses in these areas if they had a choice. The answer categories were yes, probably and no. Self-image was assessed using a five point semantic differential format (Osgood, Suci, and Tannenbaum, 1957). Students rated themselves on the characteristics of self-confident, likeable, competitive, strong, intelligent, creative, comfortable with others, independent, and responsive to others.[1]

The data on interest in science and math and self-image were analyzed using log-linear techniques for cross-classified data (Fienberg, 1980). Each characteristic of the self was cross-classified with sex, ethnicity, and interest in science or math. Partitioning was used to reduce the number of categories of self-image. For each characteristic, an attempt was made to partition adjacent categories.[2] If the differences between the categories were not significant in any of the sex and ethnic groups,

the categories were combined. The partitioned tables were then analyzed and a preferred model selected (Fienberg, 1980).[3] For the purposes of this paper, details about partitioning and model selection are not presented but are available from the author.

Results.

Interest in science is associated with both gender and ethnicity (MacCorquodale, 1983). Males and Anglos are more likely to answer yes; females and Mexican Americans are more likely to answer probably or no when asked whether they would be interested in taking science if they had a choice. Interest in taking math is associated with ethnicity but not sex (MacCorquodale, 1982). However, contrary to what might be expected, Mexican Americans are more interested in taking math than are Anglo students.

Three characteristics, intelligence, self-confidence, and independence, are expected to be related to interest in science and math for all students. Turning first to intelligence and science, the preferred model includes independent effects of sex, ethnicity and intelligence.[4] The relationship is monotonic with those who described themselves as highly intelligent most likely to be interested in science, followed by those who chose moderate scores (2 and 3), then those who chose the lower scores (4 and 5). The association of perceived intelligence and interest in math varies by ethnicity. As can be seen in Figure 1, among Anglos higher ratings of intelligence are associated with greater interest in math. For Mexican Americans the pattern of association is curvilinear. Both those who see themselves as moderately high in intelligence (2) and very

low in intelligence (5) are likely to be interested in math. Self-confidence and independence are associated with students' interest in taking science, but are not associated with interest in taking math. Under the preferred model of association, in addition to separate effects of sex and ethnicity, students with the highest perception of self confidence are more likely to be interested in science.[5] The pattern of association for independence, illustrated in Figure 2, is curvilinear. Along with effects of sex and ethnicity, those who are very independent or very dependent are more likely to be interested in science.

The results for the characteristic creativity do not vary by gender as expected. The preferred model for interest in taking science is presented in Figure 3. In addition to the effect of gender, creativity has an effect which varies by ethnicity. The general trend is that the more creative students describe themselves, the greater their interest in taking science. Among Mexican Americans, the effect drops markedly at low creativity (category 4) while among Anglos there is little difference in the middle categories (2 and 3 or 4). The results for interest in taking math yield a curvilinear pattern.[6] Although those who describe themselves as very creative (category 1) are more likely to be interested in taking math than those who see themselves as uncreative (category 5), those in the middle categories have the greatest likelihood of being interested in math. Ethnicity has an independent effect but sex is not significantly associated with interest in taking math.

Ratings of competitiveness are associated with interest in taking science but independent of interest in taking math. The association of

competitiveness with interest in taking science varies by gender but not ethnicity. As can be seen in Figure 4, girls of both ethnicities who describe themselves as highly competitive are interested in taking science. Girls who describe themselves as less competitive (categories 2, 3, 4 and 5) are markedly less interested in taking science. Among males, competitiveness has virtually no effect on interest in taking science. Although ethnicity continues to have an effect such that Anglos are more likely to be interested in science than Mexican Americans, at the highest rating of competitiveness, girls are more likely to be interested in science than are boys.

The results contradict the fourth hypothesis, that students who rated themselves lower on social characteristics would be more likely to be interested in science. Two social characteristics, comfortable with others and responsive to others, were examined. Both are independent of interest in taking math. With respect to interest in taking science, the preferred model includes separate effects for sex, ethnicity, and the social characteristic. Those students who describe themselves as more responsive to others or more comfortable with others are more likely to be interested in science. Thus, the traditional "feminine", social orientation does not reduce interest in science, as expected.

The expectation that ratings of likeable and strong would not be significantly associated with interest in science and math was found in three of the four cases. Students' perceptions of their strength are independent of their interest in either subject and how likeable they are is not associated with interest in taking math. The association of likeable and

interest in science includes two interactions. As can be seen in Figure 5, the effect of likeable varies by sex and by ethnicity. Ratings on likability have a more pronounced effect on Anglo males than on Mexican-American males and on Mexican-American females compared to Anglo females. The overall trend indicates that girls who are more likeable (categories 1 or 2 and 3) are more likely to be interested in taking science. Among boys, the less likeable they see themselves, the greater the interest in taking science.

Discussion

Several characteristics associated with the image of the scientist are related to interest in taking science among all students. Self-confidence, creativity, and intelligence are associated with interest in taking science in a linear pattern. Although these characteristics affect all sex and ethnic groups similarly, there are sex and ethnic differences in the distribution of these components of self-image. Thus, although all students who describe themselves as more self-confident are more likely to be interested in taking science, girls (and Anglos) are less likely to think of themselves as self-confident. Similarly, girls and Mexican Americans are less likely to describe themselves as high on creativity or intelligence. Thus, sex and ethnicity not only affect interest in taking science directly, but also reduce students' participation in science by influencing self-perception as self-confident, intelligent or creative.

The association of independence with interest in science is curvilinear. Those who describe themselves as highly dependent or highly independent are more likely to be interested in science. In terms of sex

and ethnic differences, Anglos are more likely to describe themselves as independent and girls are overrepresented at the high and low ends of the scale. The curvilinear pattern of association is interesting since studies of adult scientists indicate that independence is related to science. The discrepancy in the results may be due to differences in the measures of independence. For example, a checklist of adjectives might include independent but not in a way that contrasted it with dependence. The use of the semantic differential format in this research and the curvilinear association suggest that dependence and independence may not fall on a single continuum. Students who chose independent may have used cognitive style as their referent in that they were responding that they were "independent thinkers" or independent in their intellectual pursuits. Students who chose dependent may have been referr - to a social orientation, i.e. that they are dependent upon their friends or their families. This interpretation is supported by the research on science students previously cited which found that they are both more independent and more group dependent. Thus, the differences between studies which have used adults and those which have used students may be due to the frame of reference which the respondents use in responding to measures of "independence".

The findings with respect to competitiveness provide a partial explanation of the sex differences in science participation. Competitiveness is not related to interest in science among boys, probably because competitiveness is a taken-for-granted dimension of the male sex role. For girls, those who describe themselves as highly competitive are much more likely to be interested in science. Since girls are less likely than boys

to describe themselves as competitive, self-perception along this dimension is a barrier to participation in science for girls. Efforts to encourage girls to see themselves as more competitive would increase the likelihood of their being interested in taking science and eventually might increase the number of women entering scientific occupations.

The results of this research contradict the stereotype of the scientist as a socially distant individual and past research which has supported the "person/thing dimension."[7] The characteristics "responsive to others" and "comfortable with others" are associated with interest in science in a linear pattern for all groups. Thus, a social orientation, which is often proposed as an explanation of the paucity of women in science does not reduce students' interests. It may be that those who are successful in science differ from science students on these social characteristics. This interpretation receives some support from the findings with respect to likability. Boys who describe themselves as less likeable are more interested in science while those girls who describe themselves as more likeable are interested. Since science has been primarily a male domain in the past, the association of science with social isolation may be due to the particular characteristics of males who have been successful in science. As more women enter science, this image may change to incorporate a greater emphasis on "feminine" social characteristics. One strategy for encouraging more students to be interested in science would be to emphasize the opportunities to work with others that are available in science.[8] Information about the diversity of employment settings and social interaction possibilities might be particularly appealing to girls who see

themselves as more responsive to others than boys and to Mexican Americans who are more likely than Anglos to rate themselves comfortable with others.

Fewer characteristics are related to interest in math, and the results often do not conform to the hypotheses. Intelligence is related to interest in taking math in a linear pattern for Anglos, as expected, but in a curvilinear form among Mexican Americans. The curvilinear pattern for Mexican Americans suggests that although some of these students may be getting feedback that they are not very intelligent, their interest in math is not reduced. One interpretation may be gleaned from prior research. Evans and Anderson (1973) found that math grades corresponded to achievement test scores more for Anglo students than for Mexican Americans. Thus, Mexican-American students may discount the feedback that they get from teachers, peers, and parents insofar as they may get low grades but still have an aptitude for and an interest in math. These results suggest that further research is needed to determine factors in the social system that may mediate the effects of self-image on academic interest for minority students.

Creativity is related to math in a curvilinear pattern which accounts for the initial ethnic difference in interest. Those students who see themselves as moderately creative are more likely to be interested in math. Since Anglos and boys rate themselves higher on creativity, one reason that Mexican Americans are more likely to be interested in math is that they give themselves moderate ratings on creativity. Because creativity has been consistently identified as a characteristic of successful mathematicians, those students identified in this research with moderate scores on

creativity may not be able to perservere in their studies of mathematics.

Self-confidence, independence, and competitiveness are independent of interest in taking math as are the more social characteristics, responsive to others and comfortable with others. The finding that fewer characteristics are associated with interest in taking math may indicate that high school students do not share a clearly defined image of the "mathematician" and therefore, their self-image is less consistently related to interest in math than to interest in science.

Conclusions

Two concerns have been voiced with respect to recruitment of students into science. First, there is an interest in increasing the total number of science students and, second, a desire to encourage female and minority students who are currently underrepresented. This research has identified several aspects of self-image which are associated with interest in science and math. The commonly held image of the scientist corresponds to the self-image of students with an interest in science insofar as intelligence, self-confidence, independence, creativity, and competitiveness (for girls) are concerned. The self-image of students interested in science departs from the stereotype of the scientist by including dependence, responsiveness to others, comfortableness with others, and effects of likability, which vary by gender.

The implications of these findings for increasing participation in science are that alteration of self-image may affect science enrollments, but that these changes may be difficult to achieve. Emphasizing the social

interaction possibilities in science, providing social support and acceptance of competitiveness for girls, and reducing the degree to which characteristics of the self are sex-typed would be the most feasible ways of increasing the representation of female and minority students in science. Although the patterns of association vary, creativity is associated with both an interest in science and math. The more creative students are interested in science but disinterested in math. Because creativity has been found to be a key characteristic of successful mathematicians, information on the creative processes in aspects of mathematics might encourage those students who see themselves as creative to consider educational and occupational options in mathematics. Efforts to reduce the sex and ethnic differences in students' self-perception of creativity would augment the participation of girls and Mexican Americans in mathematics and science.

Ratings of intelligence may be particularly important insofar as this characteristic is highly salient in self-image, relevant to academic decision making, and associated with interest in both science and math. Although the curvilinear association for math merits further exploration, the pattern of association with science is clear. Since boys and Anglos perceive themselves as more intelligent, feedback to girls and minorities about their intelligence may be crucial. Because of the variety of sources of feedback and experiences which contribute to this component of self-image and the connection to supposedly "objective" indicators, perceptions of intelligence develop over a long period of time and may be difficult to alter. Therefore, students' perceptions of their intelligence may be the

most important factor in educational decisions and, therefore, may continue

FOOTNOTES

1. The characteristics were presented in the order listed but some of the scales were reversed so that the more socially desirable end did not always appear on the same side of the page.

2. First, the second highest and middle categories (2 and 3 where 1 is the high end) were considered and then the lower two categories (4 and 5). If the second highest and middle could be combined, they were contrasted to the next to lowest (4). If this contrast was not significant, the combined categories (2, 3 and 4) were contrasted with the lowest (5).

3. The following hierarchial models were considered:

Model	Marginals fitted
(1)	{SGE} {I}
(2)	{SGE} {EI}
(3)	{SGE} {GI}
(4)	{SGE} {SI}
(5)	{SGE} {EI} {GI}
(6)	{SGE} {EI} {SI}
(7)	{SGE} {GI} {SI}
(8)	{SGE} {EI} {GI} {SI}
(9)	{SGE} {EGI}
(10)	{SGE} {ESI}
(11)	{SGE} {GSI}
(12)	{SGE} {EGI} {SI}
(13)	{SGE} {ESI} {GI}
(14)	{SGE} {GSI} {EI}
(15)	{SGE} {EGI} {ESI}
(16)	{SGE} {EGI} {GSI}
(17)	{SGE} {ESI} {GSI}
(18)	{SGE} {EGI} {ESI} {GSI}

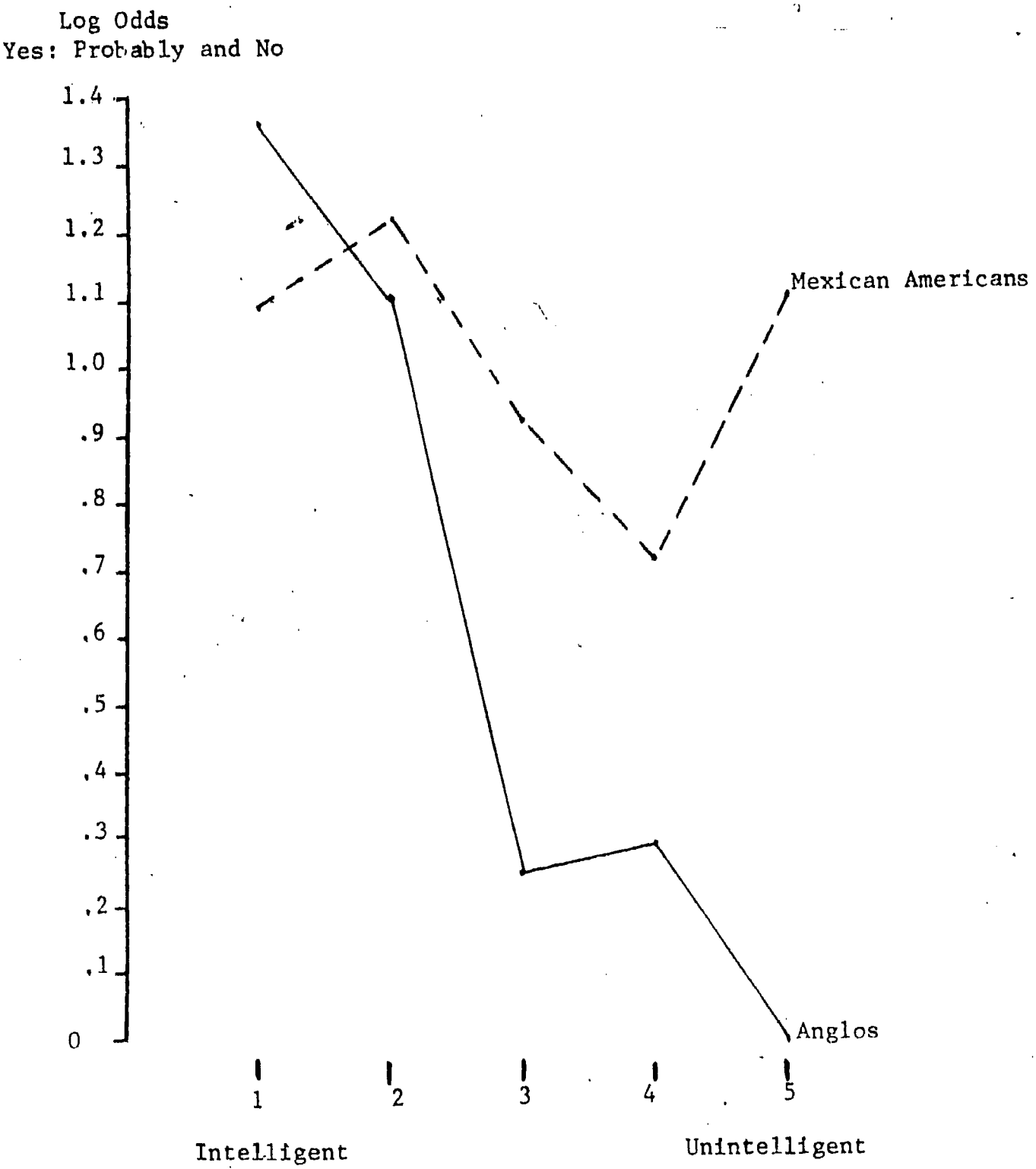
Where I = interest in science or math
S = self-image
G = gender
E = ethnicity

The .05 level of significance was used in comparing models in order to determine which fit better.

4. L^2 = 16.86 with 14 degrees of freedom, p = .2637. The table was partitioned into three categories. Rows 2 and 3 were combined as were 4 and 5.
5. L^2 = 4.76 with 8 degrees of freedom, p = .4724. Partitioning yielded one significant contrast. Therefore, category 1 was retained and the others (2 through 5) were collapsed.
6. L^2 = 28.86 with 24 degrees of freedom, p = .2259.
7. Meredith and Bradley (1976) also found that science students were not more interested in things than art students.
8. Stamp (1979) proposed emphasizing the usefulness of math in service-oriented occupations since the female students in her study who were interested in math were more nurturant and had more feminine activities than other students.

Figure 1

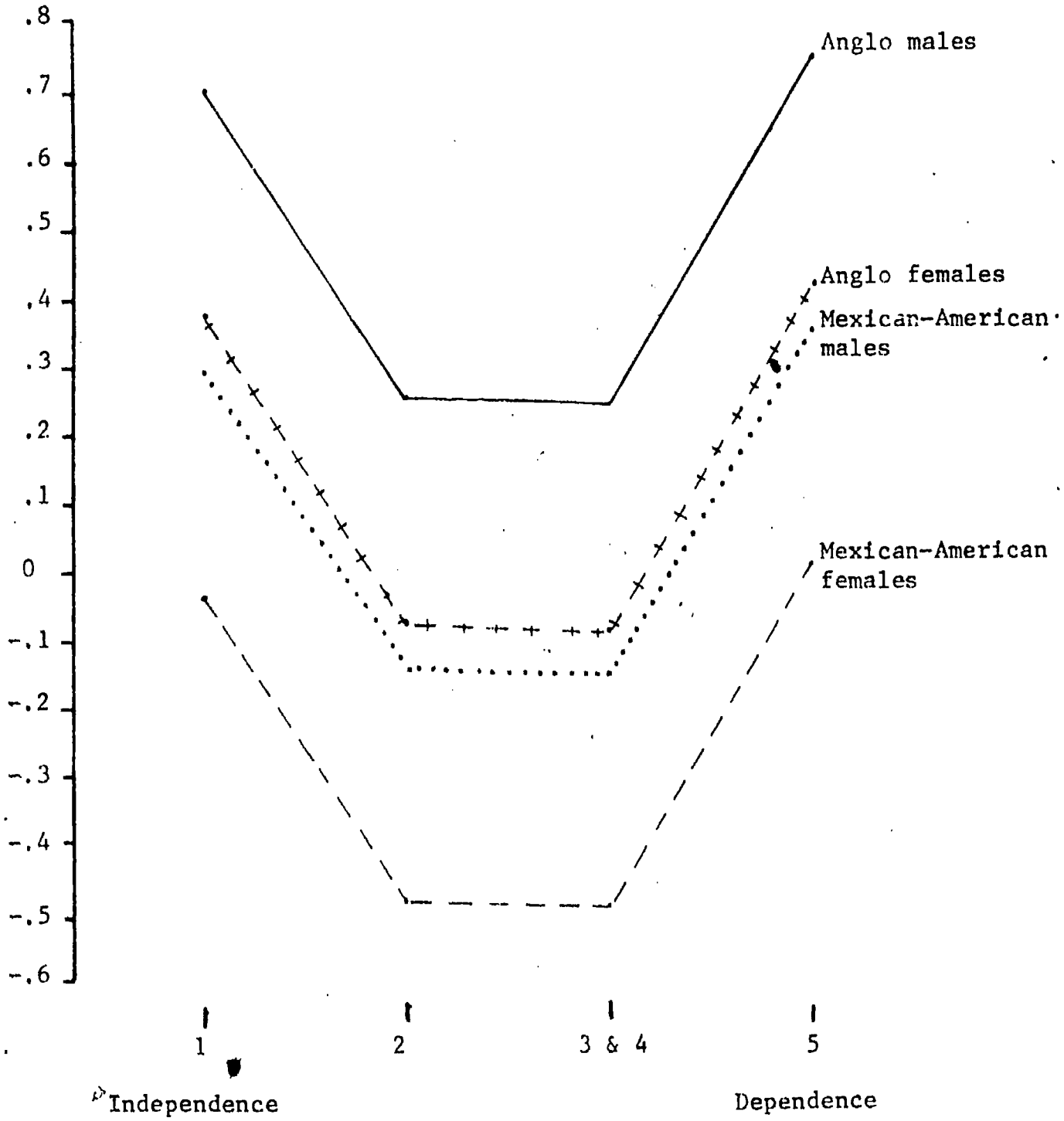
Log Odds on Interest in Taking Math, Yes: Probably and No, by Perceived Intelligence and Ethnicity



L^2 = 21.15 with 20 degrees of freedom, p = .3883

Figure 2

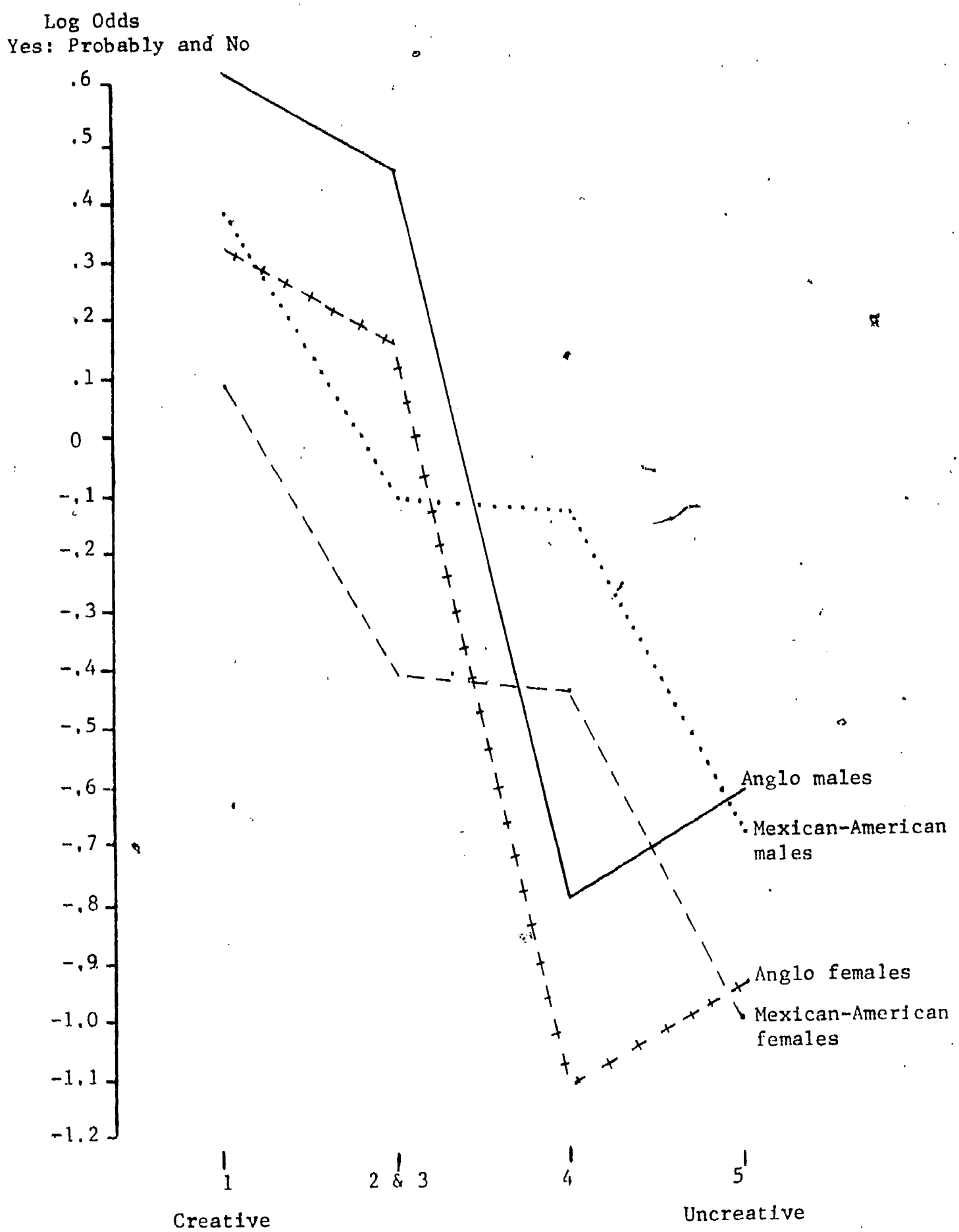
Log Odds on Interest in Taking Science, Yes: Probably and No, by Perceived Independence, Sex, and Ethnicity



L^2 = 19.11 with 20 degrees of freedom, p = .5150

Figure 3

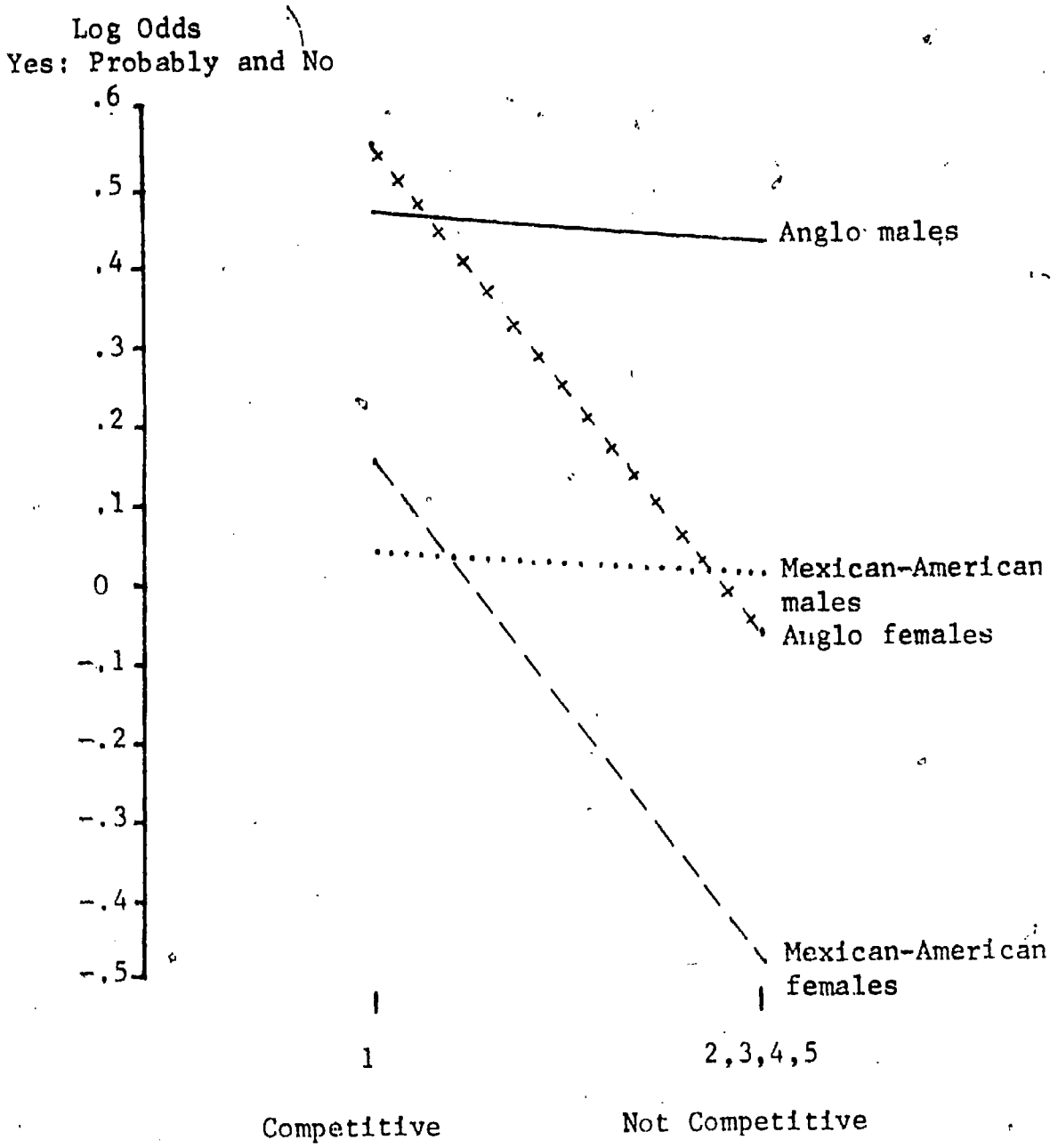
Log Odds on Interest in Taking Science, Yes: Probably and No, by Perceived Creativity, Sex, and Ethnicity



L^2 = 12.42 with 14 degrees of freedom, p = .5723

Figure 4

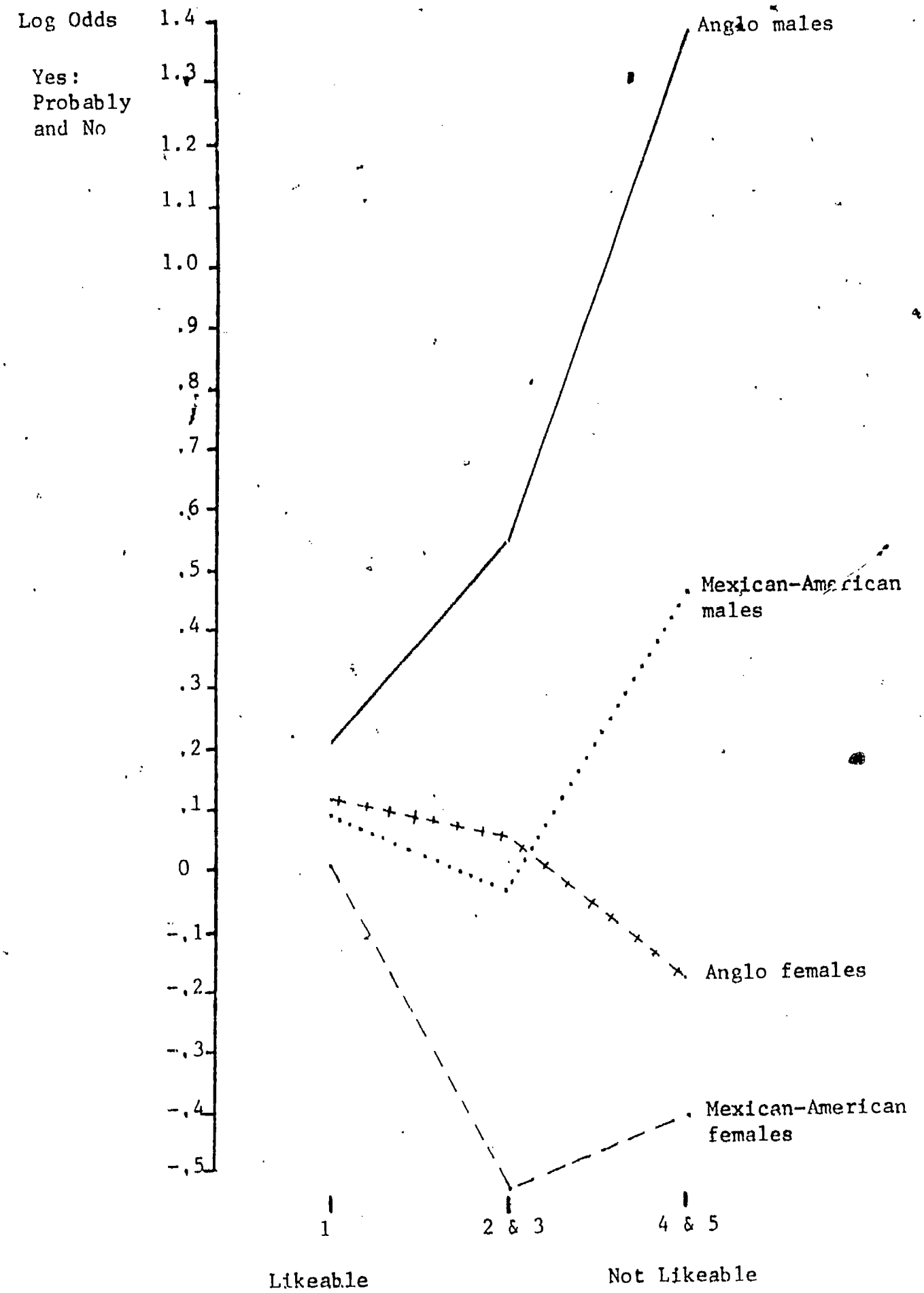
Log Odds on Interest in Taking Science, Yes: Probably and No, by Perceived Competitiveness, Sex and Ethnicity



L^2 = 3.19 with 6 degrees of freedom, p = .7849

Figure 5

Log Odds on Interest in Taking Science, Yes: Probably and No, by Perceived Likeability, Sex, and Ethnicity



L^2 = 9,44 with 6 degrees of freedom, p = .1501

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