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ABSTRACT

This study investigates the questions of why male and female college students tend to chosse different fields of study. Subjects were recruited by mail from the list of incoming Freshmen of the University of California at Riverside and sampled randomly to represent one fifth of the Freshman class. Since subjects were paid for their participation there was a high response rate to this form of solicitation for a total sample size of 256. The results show that males and females differ significantly in attitudes. The discriminant function coefficients indicated that mechanical curiosity has the greatest discriminating power, with males showing greater curiosity. The comparison among major field groups yielded a highly significant difference among groups, as well as a significant interaction between sex and major field. The study concludes that attitudes differ between males and females and among major fields. The results have an implication for the use of attitude inventories for the academic counseling of women. A conclusion is that the use of a common norm for the counseling of men and women might actually be detrimental to both groups. (Author/WSK)

SEX DIFFERENCES IN THE RELATIONSHIP OF ATTITUDE-TOWARD-TECHNOLOGY TO CHOICE OF FIELD OF STUDY

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Sex Differences in the Relationship of Attitude-Toward-Technology to Choice of Field of Study

Why do male and female college students tend to choose different fields of study? One answer is provided by Hawley (1971, 1972) who identified an important attitudinal variable in career selection by women. This variable was the attitude toward femininity believed to be held by significant men in the subject's lives. Women preparing for such occupations as housekeeper or teacher (e.g., traditional women's occupations) believed that significant men in their lives held "traditional" beliefs concerning sex roles (sharply defined male and female behaviors). On the other hand, women preparing for careers in science believed that significant men in their lives showed little disparity between their conception of male and female roles.

Another attitudinal domain which might be an important influence on one's selection of a career is attitude toward technology. Students who have the greatest interest in mechanical objects or who are appreciative of technology, may aim toward the science-oriented fields, while others may aim toward the humanities. In fact, a recent investigation by Goldman, Platt and Kaplan (in press) demonstrated that there are differences in attitudes toward technology among students majoring in Physical Science, Biological Science, Social Science, and Fine Arts. The primary locus of the differences among these groups was in mechanical curiosity. As one might expect, these groups formed a science-nonscience continuum on this trait.

Perhaps there are differences between the sexes in attitudes toward technology. Goldman and Warren (1972) have reported that male and female college students choose specific major fields with differing frequencies. Males are much more likely than females to major in Physical or Biological Sciences, while females are more likely to major in Humanities. It is reasonable to expect that differing choices of a field of study by males and females may be due, in part, to differences in attitudes toward technology between the sexes. The investigation reported here concerned the relationship between attitudes toward technology and choice of a college major for men as compared to women.

There is a cogent reason why this study should not be considered to be "hypothesis testing" in the formal sense. The difficulty concerns the direction of causality in the relationship of attitudes to choice of a college major. While it is likely that one's attitudes influence one's choice of a major, it is also reasonable that as a result of exposure to a field of study, students may develop an interest in mechanical principles and objects. Therefore, this investigation is a "heuristic" investigation in which complex data are simplified to generate hypotheses.

In a practical sense, though, this investigation can also be considered as a methodological prototype, a search for test bias in an instance where a criterion variable is nominal rather than continuous. Test bias exists when some predictor bears a different relationship to a criterion for each of two or more groups. Since the choice of a major field is nominal rather than continuous, the present investigation could not simply compare obtained regression equations of major field on attitude for men and women. Similarly, since attitude-toward-technology is complex, a univariate analysis of variance (sex-by-major field) would not do justice to the topic. Therefore, the present study employed multivariate analysis of variance (Rao, 1952) to investigate the existence of a Sex-by-Major Field interaction on attitude-toward-technology group "centroids;" it also employed discriminant function analysis to determine the loci of group differences, and "mapping" of group centroids (Cooley and Lohnes, 1971; Kaplan and Goldman, 1973) to provide a visual summary of complex group differences. These techniques, then, are used to determine if attitude toward technology bears a different relationship to career selection for men than it does for women.

A limited number of possible outcomes regarding the issue of sex difference in the relationship of attitudes to choice of major field would indicate test bias. Two possible outcomes are described below, along with some of their implications.

Possible Outcomes Which Might Indicate Test Bias

1. Differences among major fields, differences between the sexes, and interaction. This finding could be equivalent to test bias in that a given attitude level would lead to a different prediction of major field for males than for females. If this outcome occurs, a discriminatory map could be used with great profit. Simply, this outcome would mean that the attitude differences among major fields were different for the two sexes.

2. Differences among major fields and between sexes, no interaction but little or no overlap between male and female centroids regardless of major field. This type of finding would imply a similar relationship among major fields within the sexes, but a wide difference between the sexes. This finding would be roughly equivalent to the continuous case of parallel regression planes but different intercepts. In a multivariate analysis,

such a finding would be very difficult to detect without a discriminant function "map." Without a map of group centroids, the investigator would be left with a welter of different arrays of groups, one array for each dependent variable. The usefulness of discriminant function mapping is that it allows portrayal of group differences simultaneously along a small number of discriminating dimensions. These dimensions are defined by the proportion of variability in the data accounted for by specific variables. The mapping procedure clearly shows the relationships between centroids of groups holding different attitudes, and displays these relationships in the space created by the dependent variables from which group differences arise.

Method

Subjects and Procedure

Subjects were recruited by mail from the University of California, Riverside registrar's list of incoming Freshmen. They were sampled randomly to represent one fifth of the Freshman class. Since Ss were paid for their participation there was a high response rate (approximately 70%) to this form of solicitation for a total sample size of 256.

The mechanization scale (Goldman, Platt, & Kaplan, in press) was administered to groups of 15 to 20 Ss. Other paper and pencil measures concerned with scholastic abilities were administered at that time. Subjects were classified in a 5 x 2 x 3 (major-by-sex-by GPA) design to permit the assessment of attitude differences between the sexes among high, medium, and low thirds of GPA, and among students in Physical Science, Biological Science, Social Science, Humanities, and undecided majors. (Table 1) GPA was included as a third independent variable in the analysis in order to determine if the degree of student success bears a different relationship to male or female attitudes toward technology.

Description of the Mechanization Scales

The scales employed represent a revised and shortened version of the Mechanization Scale (Goldman, Platt, and Kaplan, 1972). Each of the five subscales was suggested by a factor analysis of the original 80 item version. Each scale contains eight items which reflect the conceptual content of the scale.

Global attitude contains items which reveal a positive or negative global attitude toward technology. Included are items which indicate the stressful nature of technology (e.g., "Technological change is occurring so fast people are becoming second to machines."), items which express lack of confidence in technological cures (e.g., "In order to stop the problems of environmental pollution, mankind should stop using machines that pollute, rather than attempt to develop new machines that purportedly will be cleaner."), as well as items which express a low valuation for the products of technology (e.g., "The greatest reason the dollar is worth so little today is that most goods are produced by machines.").

Mechanical Curiosity contains items that express interest in the mechanisms of technology (e.g., "Computers are so foreign to me that I have little understanding of them"), as well as items which express curiosity for machines (e.g., "I have never had any desire to learn how a car engine operates.": "I would prefer reading Popular Mechanics to reading Life."). Other items on this scale express a relative preference for technical rather than humanistic events (e.g., "I prefer building models to reading books". . . "If I were in a recording studio I would probably be more interested in the equipment used in making a record than in listening to the music.")

Preference for Handmade Goods is defined by items reflecting preference for handmade products over those produced by machines (e.g., "The only real quality items on the market are handmade.")

Spiritual Benefits of Technology contains items which describe man's aesthetic benefits resulting from technological advances (e.g., "A true machine age will enable man to achieve the promise of a rich and rewarding spiritual life.")

Human Vitalism contains items that allude to a "human element" which cannot be duplicated by machine (e.g., "Poets and composers can contribute to understanding this world more than high speed computers...").

Reliabilities and intercorrelations of these scales (based upon the present sample of 256 Ss) are shown in Table 2.

Results

Since the cell sizes shown in Table 1 are unequal, the design was non-orthogonal. In particular, as noted by Goldman and Warren (1972), sex and major field are not independent. Since the relationship of sex with major field was the primary interest, it was necessary to employ a technique to unbias the series of F contrasts. To accomplish this, each F contrast was obtained by subtracting the sums of square and cross products for all other contrasts from the between groups sum of squares and cross-products matrix (SSCP). Thus, each F ratio was conservative and unbiased. (Goldman, 1972).

Males and females differed significantly in attitudes. Rao's (1952) approximation to the *F* ratio yielded a value of 11.39 (*df*=5,222; p<.0001). The discriminant function coefficients (Table 3) indicated that Mechanical Curiosity had the greatest discriminating power, with males showing greater curiosity. The comparison among major field groups (Table 4) also yielded a highly significant difference among group centroids (*F*[20,737]=2.38; *p*<.001). The differences among major fields could be represented along a single dimension, as only the largest discriminant function was significant at beyond the .01 level. The difference among GPA groups was not statistically significant.

There was a significant interaction between sex and major field (*F*[20,737]=1.90;*p*<.01). This interaction is displayed in Table 5. No other interactions were significant. It is rather difficult to interpret an interaction obtained by multivariate analysis of variance. Clearly, the differences in attitudes among the major fields differ for males and females, but in what way? To fully explore the nature of this interaction, a discriminant function analysis was performed on the ten major field-x-sex groups arrayed in a one-way design. GPA groups were pooled since no significant main effects were attributable to GPA nor were any interactions of GPA with the other factors significant. This technique was employed because it permits the investigator to "map" the groups under study. The resulting map of group centroids has considerable heuristic power for it graphically displays the configuration of groups in a space composed of a much reduced set of variables (Cooley and Lohnes, 1971). The configuration of groups can suggest how the groups are similar and how they are different.

Group centroids for this discriminant function analysis differed significantly (Rao's approximation to $\underline{F}[45,1085]=3.16; p<.0001$). Since the first two roots of $W^{-1}A$ (where W^{-1} = the inverse of the within groups SSCP matrix and A= the between groups SSCP matrix) were each significant at beyond the .01 level, the differences among groups could be represented along two orthogonal dimensions. The χ^2 values for these two discriminant functions were $\chi^2[45]=176.24; \underline{p}<.0001$; and $\chi^2[32]=64.29; \underline{p}<.001$, respectively. The remaining discriminant functions were not significant at the .01 level.

The meanings of the discriminant functions can be ascertained best by an examination of the loadings of the dependent variables upon these functions. Table 6 shows that Function I is defined largely by Mechanical Curiosity (in a negative direction) while Function II is defined largely by Global Attitude (negative direction) and to a lesser extent by Mechanical Curiosity. Group centroids of the ten major field-x-sex groups are presented graphically in Figure 1. The configuration of group centroids indicates no male-female overlap on Function I regardless of major field. Furthermore, within sexes major fields are quite transitive on Function I; that is, science students have more Mechanical Curiosity than nonscience students (a low score on Function I indicates high Mechanical Curiosity). The configuration of groups with regard to Function II is less clear. Among males only Biological Science majors hold a less favorable global attitude than do the other fields. Among females, however, science students are more favorable. The most intriguing information resulting from the discriminant map is that males and females differ so uniformly on Mechanical Curiosity.

Discussion

Attitudes differ between males and females (Table 3) and among major fields (Table 4). Furthermore, mechanical curiosity is a locus of such differences for both contrasts. There is also an interaction between sex and major field (Table 5). A detailed graphical presentation of this interaction (Figure 1) reveals this striking finding, no overlap between the sexes on Function I (which represents mechanical curiosity)! Despite the fact that there is no overlap on Function I, the major field groups within each sex are ordered in approximately the same way. That is, science majors indicate more mechanical curiosity than nonscience majors. This finding is analogous to a comparison of regression equations for two groups in which one group has a higher intercept. Since females were equally successful as males as science majors (GPA was quite similar), they simply have a lower "intercept" in mechanical curiosity. If students choose major fields partly as a result of their mechanical curiosity then women "need" less of this attitude than do men. Apparently successful female science majors (and nonscience majors as well) proclaim less mechanical curiosity than their male counterparts but perform as well. Thus, sex appears to moderate the relationship of mechanical curiosity to the choice of a major field. We do not know why this occurs but a plausible explanation may lie in sex-role typing during early socialization. Clearly, the difference between males and females is not due simply to different fields of study, as the obtained sex differences occurred within each major field. If this male-female difference were largely due to choice of major field of study then it would reasonably be expected that the centroids for males and females in the same major field would be closer than they are. For example, male and female Physical Science students would be expected to be closer than male Physical Science students and male Humanities students.

These results have an implication for the use of attitude inventories for the academic counseling of women. If women were to be counseled on the basis of male norms then none would be advised to major in science. Clearly, a separate set of norms would need to be applied in the present case to avoid test bias.

The interpretation of the results along Function II is less clear. This is actually the major locus of the multivariate interaction (Table 5) as the configuration among major fields differs for the two sexes. This function, which largely represents "Global" attitude, shows a reversal of the science-nonscience configuration for the two sexes. For males, science groups are somewhat less favorably disposed toward technology while, for females, science groups are more favorable. The meaning of this finding is unclear to us. Perhaps women who major in science need a greater dedication to technology than do males since the sciences are still "male" fields.

In addition to the substantive findings presented, the method of analysis is quite useful for both theoretical and pragmatic purposes. Pragmatically, it presents a technique for exploring test bias where the criterion is categorical rather than continuous. Theoretically, it provides a starkly clear picture of the multivariate configuration of numerous groups. While some important personality and interest inventories have separate male and female scales (e.g., SVIB) these separate scales probably originated from clearly defined sex-roles. As new attitudinal scales are constructed, they may not make separate male and female norms in light of the growing sentiment for greater equality of the sexes. However, the use of a common norm for counseling men and women may actually be detrimental to both groups.

A direction for future studies might be to investigate the etiology of attitudes-toward-technology; this may help clarify the reasons males and females differ on these attitudes.

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Table 1

Cell Sizes for Sex-by-Major-by-GPA Classification

Males

Major	GPA Low	Middle	High
1. Physical Science	10	11	8
2. Biological Science	14	6	13
3. Social Science	5	13	8
4. Humanities	2	5	2
5. Undecided	4	3	2

Females

Major	GPA Low	Middle	High
1. Physical Science	4	3	9
2. Biological Science	13	13	13
3. Social Science	8	13	15
4. Humanities	13	12	24
5. Undecided	6	4	2

Table 2

Reliabilities and Intercorrelations

Among Mechanization Scales

(N = 256)

Scale	Reliability	2	3	4	5
1. Global	.79	.30	.34	.45	.39
2. Curious	.70		.03	.14	.35
3. Handmade	.40			.25	.29
4. Spirit	.61				.25
5. Hum. Vit.	.72				

Table 3

Comparison of Males and Females

on the Mechanization Scale

Variable	Means: Male (N = 106) M	Male S.D.	Female (N = 150) M	Female S.D.	Univariate F	p	Discriminant Function Coefficients
1. Global	21.57	5.44	24.67	5.10	9.98	.001	-.19
2. Curiosity	21.66	3.75	26.97	4.36	49.56	.0001	-.95
3. Handmade	25.98	3.63	27.40	3.88	4.03	.04	-.30
4. Spirit	25.18	4.58	23.79	3.90	<1	NS	.09
5. Hum. Vit.	24.72	4.70	26.67	4.18	<1	NS	.23

Multivariate $F(5,222) = 11.39$; $p < .0001$

Table 4

Comparison Among Major Fields on

Mechanization Scale

	Variable	Means										Univariate		Discriminant
		Phys. (N=45)		Bio. (N=70)		Soc. (N=62)		Hum. (N=58)		Und. (N=21)		F	p	Function Coefficient
		M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.			
1.	Global	20.69	5.44	22.69	5.65	23.68	5.02	25.64	5.58	24.38	6.53	1.95	.1	-.02
2.	Curiosity	22.71	4.62	23.11	5.12	25.58	4.20	27.00	4.70	26.19	4.71	5.97	.001	.64
3.	Handmade	25.49	3.78	27.04	3.66	26.15	4.14	28.10	3.90	27.29	3.49	2.32	.05	-.15
4.	Spirit	25.36	4.47	24.99	4.12	24.45	4.67	22.83	3.75	24.19	4.00	1.14	.33	.20
5.	Hum. Vit.	23.91	3.75	24.60	4.71	26.21	4.72	28.12	4.26	27.00	4.21	5.03	.001	.58

Table 5

Sex x Major Field Interaction on

Mechanization Scale*

	Variable	Univariate F	p	Discriminant Function Coefficient
1.	Global	4.65	.001	.86
2.	Curiosity	1.43	.22	-.51
3.	Handmade	3.03	.01	.35
4.	Spirit	<1	NS	-.13
5.	Hum. Vit.	<1	NS	-.19

Means and Standard Deviation**

Males

	Variable	Phys.		Bio.		Soc.		Hum.		Und.	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.
1.	Global	19.79	5.80	24.00	5.52	20.76	4.54	21.55	6.34	20.66	5.78
2.	Curiosity	20.68	2.37	19.87	4.29	23.57	3.89	24.66	3.08	22.77	2.94
3.	Handmade	25.48	3.97	27.42	3.81	24.42	3.53	25.44	2.65	27.33	3.12
4.	Spirit	25.82	5.09	24.75	4.58	25.19	5.05	24.77	2.38	25.10	3.80
5.	Hum. Vit.	23.96	4.18	24.15	5.13	24.76	5.16	27.44	4.95	26.33	3.24

Females

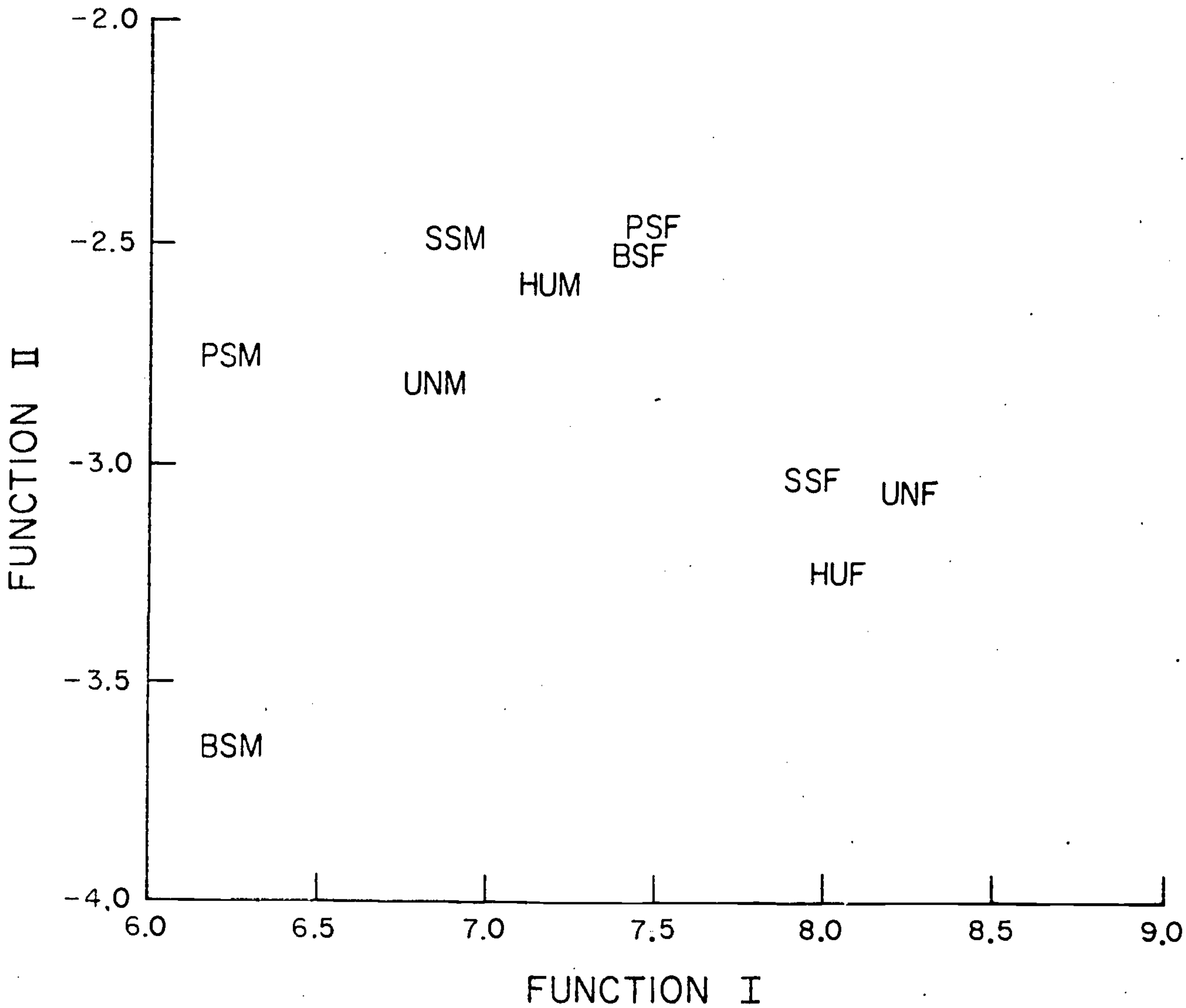
	Variable	Phys.		Bio.		Soc.		Hum.		Und.	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.
1.	Global	22.31	4.45	21.51	5.58	25.77	4.28	26.38	5.15	27.16	5.79
2.	Curiosity	26.37	4.22	26.00	3.97	27.02	3.85	27.42	4.84	28.75	4.69
3.	Handmade	25.50	3.52	26.70	3.55	27.38	4.15	28.59	3.91	27.25	3.88
4.	Spirit	24.50	2.48	25.18	3.71	23.91	4.37	22.46	3.86	23.58	3.80
5.	Hum. Vit.	23.81	2.92	25.00	4.34	27.25	4.14	28.24	4.17	27.50	4.90

*Multivariate F (20,737) = 1.90; p < .01

**Cell sizes are shown in Table 1

	Variables	Univariate	p	Discriminant Function Coefficients I	II
1.	Global	6.60	.0001	-.11	-.80
2.	Curiosity	14.31	.0001	-.88	.51
3.	Handmade	3.34	.001	-.21	-.32
4.	Spiritual	1.84	.05	.06	.01
5.	Hum. Vit.	4.16	.0001	-.10	-.07

Multivariate $F(45,1085)=4.16; p<.0001$



* FIRST TWO LETTERS INDICATE MAJOR FIELD, THIRD INDICATES SEX.
MAJOR FIELDS ARE: PHYSICAL SCIENCE PS, BIOLOGICAL SCIENCE BS, SOCIAL SCIENCE SS, HUMANITIES HU, AND UNDECIDED UN.
SEX: MALE M, FEMALE F

Caption for Figure 1

Major Field-By-Sex Group

Centroids in Two Dimensional

Discriminant Space