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The purpose of the present study was to determine if occupational interest measures could discriminate between research and development (R & D) managers and technical specialists. The demand for R & D personnel and the need to create and develop new knowledge and products is expected to be strong through the 1980s (U.S. Department of Labor, 1982). The issue of staffing, counseling and allocating individuals into different roles in technically based organizations is thus receiving renewed attention from organizational policy makers as well as behavioral scientists (Badawy, 1982; Mossholder, Dewhirst and Arvey, 1981; Roberts and Fusfeld, 1981). Public opinion has also apparently changed in recent years, and now an estimated 68 percent of the American public believes government funds for research and development should be sizeably increased (Norman, 1983).

For the organization, the economic costs of misallocation while difficult to quantify, are estimated to be high. At the individual level Zaleznik, Dalton and Barnes (1970) documented the dysfunctions which obtain to R & D personnel whose ego interests (values as measured by the Allport-Vernon Lindzey Study of Values) were incongruent with their work role. In their study of an R & D organization, they note:

> In today's knowledge-oriented organizations it is commonplace for the trained specialist...to confront the choice of continuing a career as a specialist or shifting into management. For some, the choice is clear-cut. For others the

> choice may be difficult, and once made, a source of continuing ambivalence (Zaleznik, Dalton and Barnes, p. 3).

There were two types of ambivalence and associated personal difficulties for the subjects of their study. One was the technical specialist who was more dominated by economic rather than theoretical values, and the other was the R & D manager whose theoretical values overshadowed the economic values. Tagiuri (1965), however, found that both scientists and science managers had high theoretical value orientations, but the science managers had stronger economic and political values compared to scientists. Only one study (Rosen, Billings and Turney, 1976) pertained directly to the occupational interests of R & D managers and technical specialists. They found managers to be higher than specialists on a composite managerial interest scale constructed by summing the production manager, army officer and air force officer occupational scales of the Strong Vocational Interest Blank. This particular measure is heavily saturated with an interest in realistic, pragmatic, and mechanical activities, however, and does not reflect a heavy interest in economic or enterprising activities. In the same study, the authors found specialists to be higher than managers on a composite science interest scale constructed by summing the mathematician, chemist, engineer, physicist and architect occupational scales.

A variety of other authors have examined personality differences between managers and technical specialists. Some of these have mixed scientists and engineers, and others have studied

them separately as has been recommended by Kerr, Von Glinow and Schriesheim (1977) and Badawy (1975). The comments below will attempt to note the studies which are most pertinent to the measures used in the present research, but can by no means be viewed as a comprehensive review of all the studies relevant to personality differences between specialists and managers in R & D settings.

Relative to engineers, engineering managers have been found to be higher on a dominance and social ascendance dimension (Brown, Grant and Patton, 1981; Harlow, 1973). Life history research indicates engineering managers are higher than engineers on an athletic interest factor and that managers see themselves as more forceful, aggressive, gregarious and confident in social settings (Klimoski, 1973; Chaney and Owens, 1964). Albright and Glennon (1961) found a similar pattern for physical scientists with technical versus managerial aspirations.

Schein, McKelvey, Peters and Thomas (1965) studied scientists and engineers in a research section of NASA, and found those with a managerial orientation to be more interested in responsibility, influence and interpersonal relations. Those with a technical orientation were more task oriented and socially passive. In this particular study, however, not all those who were classified as having a managerial orientation were actually doing supervisory or managerial work. Managerial orientation was associated with a development job, whereas a technical orientation correlated with a research job. In a somewhat related vein, Mossholder et. al (1981)

found development personnel scored significantly higher than research personnel on the Strong Vocational Interest Blank scales pertaining to technical supervision, recreational leadership, and medical service, and were also significantly higher on the Adjective Check List dominance scale. In the present study we therefore attempted to equalize the proportions of researchers and developers in the two comparison groups.

Before proceeding to the research methods section, some background comments should be made on the Strong Campbell Interest Inventory (SCII) form T325 which was used in this study since it has undergone significant change in comparison to its predecessor, the Strong Vocational Interest Blank (SVIB). Campbell and Holland (1972) and Hansen and Johansson (1972) in a major innovation merged Holland's (1973) personality theory with the SVIB (which had largely been atheoretical since its inception in the 1920s). By scaling the six general occupational themes postulated by Holland (1973) to simultaneously represent the occupational world and the psychological structure of the individual, the SCII was significantly advanced in terms of its surplus meaning and power as an occupational counseling device. It was not until the middle 1970s and early 1980s that these scales were routinely available on the scored output, and the name of the instrument was changed to coincide with the appearance of this new output organization. No studies could be found in the literature which assessed R & D personnel with the revised SCII, but as noted earlier, some used

the earlier SVIB.

The six generic occupational themes are listed and defined in Table 1. In addition, the six areas are broken into finer components, the twenty-three basic interest scales. That is, there are different ways to express an artistic motive, or the general enterprising motive. For instance, an individual may be high on public speaking and business management, but lower on law/politics and merchandising. Thus equal scores on a generic occupational theme may break into rather different patterns at the basic interest scale level. A basic tenent of Holland's model is that the themes are arranged in a hexagonal structure as shown in Figure 1. An associated postulate is the idea that neighbors are reinforcing domains, whereas themes across any of the three possible diagonals represent somewhat opposing states. Themes which skip one neighbor are moderately opposing. The investigative individual enjoys spending long periods of time thinking about the same problem, is somewhat introverted, does not enjoy exercising social power, etc. The enterprising individual, on the other hand, enjoys persuasion and social power, likes action rather than reflection, is extroverted, and enjoys running from one activity to another without getting deeply involved in details. An individual's personality or motive pattern is some combination of high, medium, or low scores on these scales. Although it is theoretically possible to score high on all six scales, most people are usually high on some and low on others.

The hexagonal model could be bifurcated as shown by the dotted line in Figure 1. Persons in the upper right half of the hexagon would generally be viewed as endorsing the world of things, ideas and symbols. Persons whose interests fall in the lower left half would generally be viewed as endorsing the world of people, management and organizations. Most of the engineering and scientific occupations are inhabited by persons scoring high in the reinforcing and neighboring themes in the domain of things, ideas and symbols. As one comes around the hexagonal structure into the domain of organizations, management and people, most occupational roles involve accounting, banking, selling, administration, teaching, social work, etc.

Another premise of the framework is that occupations can be described as requiring a certain blend of two or three highly dominant themes. Engineering for instance is usually Investigative-Realistic, whereas scientific occupations are usually straight Investigative, or Investigative-Artistic. This leads to the principle of congruence which posits that an individual's personality type must be matched to the occupation type for optimal satisfaction and performance in the occupational role. The framework is a typological, interactive scheme for assessing occupational fit, and has demonstrated reasonable validity across a large range of occupations (Holland, 1973). It is often referred to as the RIASEC model, which is an acronym based on the theme labels starting with Realistic and moving clockwise around the

hexagon to conventional.

While no formal hypotheses were formed for this study, two general organizing propositions guided our data exploration.

Proposition_1. R & D managers will differ from technical specialists by exhibiting a stronger interest in the domain of people, management and organizations.

Proposition_2. The two groups will be essentially the same in the degree to which they endorse the world of things, ideas and symbols. In short, R & D managers will be more likely than technical specialists to incorporate opposing themes into their motive pattern since this psychological polarity is likely to be required for adaptation to the occupational role of R & D manager.

METHOD

The_Sample

The data for the study were developed by creating a sample of R & D managers which matched a sample of technical specialists. This involved a two step process as explained below. Managers will be referred to as MGRs and technical specialists as TSs. First data were collected on both MGRs and TSs from the R & D departments of two firms (high energy physics and telecommunications firms). This resulted in a much larger number of TSs than MGRs, since the sampling was generally in proportion to the size of the work force in each category. The MGRs were also approximately ten years older on average than the TSs.

In the second step, the MGR sample was expanded by selecting additional MGRs from a larger data base. (This larger data base was recently collected by the authors exclusively on MGRs from a large variety of settings and is being used to construct an occupational interest scale.) The expansion of the MGR sample for this study was done so that the final group would match the TS sample with respect to average age, research versus development proportions, educational level and area of training. The TS sample was modified by deleting all individuals under age 30. In short, an attempt was made to construct comparable samples for analysis purposes. All members of each sample were male.

With respect to age, the final MGR sample averaged 39.1 years and the TS sample averaged 38.4. Both samples were approximately 60 percent scientists or Ph.D. engineers, and 40 percent engineers with less than Ph.D. training. The average MGR educational level was 18.8 years, and for TSs, it was 18.0. All persons in each sample had at least a bachelor's degree in science or engineering. Educational background was segmented into four broad categories with respective MGR and TS percentages as follows: category 1, physicists and chemists - 32%, 35% (physicists and chemists were combined since they score very similarly on occupational interest scales); category 2, electrical, mechanical and chemical engineers - 40%, 40%; category 3, mathematics and computer science - 10%, 14%; category 4, miscellaneous (i.e, materials science, biology, geology) - 18%, 11%. Approximately 70 percent of both samples were

classed as doing development work, and 30 percent as research. Finally, the total occupational tenure of the groups was 15 years for MGRs and 14.3 for TSs. Of the 15 years for MGRs, the average was 6.9 in managerial roles.

Analytic Procedures. The analysis consisted essentially of two linear discriminant function analyses, one on the general occupational themes, and a second on the basic interest scales. First, the six general occupational theme scores for each group were averaged and compared using Hotelling's T statistic. Since there were significant correlations among variables, it was appropriate to test for the degree of profile separation using the multivariate extension of the univariate t test. This was followed by linear discriminant analysis in an effort to interpret the underlying data structure in the tradition of Cooley and Lohnes (1971), and Borgen and Seling (1978).

Second, since the general occupational themes demonstrated significant departure for the two groups, all twenty-three basic interest scales were entered in a stepwise discriminant analysis where the significance level for retaining a variable was set at .05.

An overall test of profile separation was not performed on the twenty-three basic interest scales since the second analysis was aimed more specifically at identifying the unique subscales on which the two groups differed. For each discriminant analysis, the function was applied to the original data to examine how well it

classified the original respondents. While this is hardly as useful as extending the function to new samples, it gives another concurrent representation of discrimination power which is more graphic than the eigen value and canonical correlation.

RESULTS

Table 2 shows the means, standard deviations, discriminant analysis for the RIASEC variables. In the two group case, the discriminant weights are proportional to regression coefficients and can be used for interpretation along with the loadings (although not in the same precise sense as regression coefficients). The elements in the loadings vector are correlations between each variable and the linear discriminant compound, and can be interpreted much like a "factor" in factor analysis. The weights are sensitive to collinearity in the predictor variables, whereas the loadings are less sensitive to these intercorrelations. Thus somewhat more importance will be attached to the loadings than the discriminant weights in interpreting the data structure.

In reference to Table 2, the RIASEC means were significantly different ($T^2 = 32.5$, $p < .001$), the eigen value was .20 ($\chi^2_6 = 29.1$, $p < .001$) and the squared canonical correlation (W^2) was .17. This indicates a significant amount of variation is being carried forward from the predictor variables into the group membership variable. The group centroids were -.63 for the TS group and .31

Table 2

Means, Standard Deviations, and Discriminant Analysis for General Occupational Themes

General Occupational Theme	Technical Specialists N = 55 Mean	SD	R & D Managers N = 110 Mean	SD	Discriminant Weights	Loadings Vector
Realistic	57.2	10.4	58.5	8.5	-.29	.16
Investigative	57.2	6.8	58.7	5.9	.15	.28
Artistic	47.2	10.5	45.5	10.2	-.47	-.19
Social	38.6	10.1	44.8	8.3	.74	.76
Enterprising	44.5	9.5	49.6	8.2	.18	.66
Conventional	45.7	9.4	51.0	7.4	.45	.73
	Hotelling T^2 = 32.5, $p < .001$				Eigen values = .20	
					x^2 = 29.1, $p < .001$	
					W^2, Canonical correlation = .17	

for the MGRs ($t_{163} = 5.69$, $p < .001$). The group membership variable was represented as 1 for TSs and 2 for MGRs. The loadings vector in concert with the discriminant weights, indicate that the social, and conventional variables count heavily in discriminating between the two groups. The loadings and weights do not give as consistent a picture for the enterprising theme. The enterprising (E) variable is correlated with the conventional (C) and social (S) variables ($r_{EC} = .62$; $r_{ES} = .51$, $p < .001$), and makes interpretation of the enterprising weight difficult; the high loading of the enterprising variable suggests it is more important than its weight would

indicate in interpreting the function, and hence it should be viewed as influential in the discriminant scheme. The negative weight on the realistic variable combined with a positive loading, suggests a potential suppressor effect. Inspection of the simple correlations among the group membership (GM), conventional (C) and realistic (R) variables indicated the classic suppressor situation wherein R was enhancing C's effect by suppressing irrelevant variance in C ($r_{GM,R}$ = .07; $r_{GM,C}$ = .30; $r_{C,R}$ = .41 where r > .20, p < .01). Inspection of the partial correlations did not clearly support this suppressor view, however ($r_{GM,C \cdot R}$ = .30, $r_{GM,R \cdot C}$ = -.06). One would have expected the partialed relation between GM and R to be larger in absolute value than the simple correlation if the suppressor condition obtained.

The artistic variable consistently reflects a negative sign, which indicates it is more related to membership in the TS group than the MGR group. The investigative theme had a low positive inpact by being somewhat related to MGR group membership. In summary, then, the discriminant function could be labeled as an "artistic versus managerial" interest factor. The coefficients in the loadings vector clearly indicae the CES area is more important than the RIA variables, and thus lends support to proposition 1 and 2.

Table 3 shows the results of the stepwise discriminant analysis using the basic interest scales. The variables were retained if their significance level reached the .05 level.

Table 3

Means, Standard Deviations, and Discriminant Analysis for Basic Interest Scales

Basic Interest Scale	Technical Specialists N = 55 Mean	SD	R & D Managers N = 110 Mean	SD	Discriminant Weights	Loadings Vector
Agriculture	49.2	10.2	52.1	9.3	.27	.24
Art	47.4	10.5	43.8	9.5	-.46	-.30
Athletics	44.6	10.5	50.9	9.6	.28	.50
Public Speaking	44.1	8.2	50.4	8.8	.19	.57
Business Management	43.6	9.6	52.7	8.1	1.01	.78
Office Practice	43.8	7.4	44.1	5.6	-.51	.05
	Hotelling T^2 = 100.3, $p < .0001$				Eigen value = .49, $x^2 = 63.7$, $p < .0001$ W^2, canonical correlation = .33	

Interestingly, a subscale from each general occupational theme area except investigative was retained, with two from the enterprising domain being retained. The eigen value was .49 (approximated x = 63.7, $p < .0001$), and W^2 was .33. The discriminant centroids were -.98 and .49 for TS and MGR respectively ($t_{163} = 8.9$, $p < .0001$), and indicates considerably more discrimination power is contained in this function than in the previous analysis. When the weights and loadings are taken in concert, the clear and consistent

discriminators are art (A) and business management (BSM). Again these two are predicting in opposing directions as was indicated with the RIASEC variables. Agriculture (AG), athletics (ATH) and public speaking (PSK) have moderate influences in discriminating the groups, with the loadings suggesting more importance than the weights for PSK and ATH. With office practice (OPR), the suppressor variable influence is again indicated, this time by the large negative weight but near zero loading. In addition, inspection of the simple correlations revealed overlap between office practice and business management, but only business management was correlated with group membership ($r_{GM,OPR} = .03$, $r_{GM,BSM} = .44$, $r_{BSM,OPR} = .46$). When the effects of office practice were partialed out of business management, the correlation, increased slightly ($r_{GM,BSM \cdot OPR} = .48$). And the correlation between group membership and office practice became significantly negative with business management controlled ($r_{GM,OPR \cdot BSM} = -.22$, $p < .01$). This more clearly reflects that office practice is suppressing irrelevant variance in business management and thereby enhancing its size in the discriminant function. More will be said about this suppressor effect in the discussion. It is a curious phenomenon in social science research, and whether one uses partial correlations or step-down F ratios, the interpretation is not easy.

Overall, this discriminant function has particularly high loadings on athletics, public speaking and business management

while retaining the negative loading on Art. It could tentatively be labeled an "artistic versus ascendance and management" factor, where the art component is again associated with membership in the TS group. The highest loadings come from variables in the enterprising and social area, and again reinforce propositions 1 and 2 in terms of where discrimination will occur in Holland's scheme.

Finally, each discriminant function was applied to the samples to see how well it could classify the original respondents. These results are shown in Table 4. The diagonal elements indicate correctly predicted group membership, whereas the off diagonal numbers represent errors. A x^2 statistic for each set of scales was calculated, and indicated prediction was better than chance

Table 4

Cross Tabulation of True and Predicted Group Membership Using Discriminant Function

		Predicted	
		Technical	Managerial
	RIASEC scales		
	Technical	37	18 (n=55)
Actual	Managerial	35	75 (n=110)
		x^2_1 = 18.74, p < .001	
	Basic Interest Scales		
	Technical	45	10 (n=55)
Actual	Managerial	22	88 (n=110)
		x^2_1 = 58.1, p < .0001	

beyond the .001 level in each case. Inspection of Table 4 reveals the basic interest scales from the stepwise analysis were considerably more accurate predictors of group membership than the RIASEC variables. For the RIASEC scales, the total percentage of accurate classifications was 68 percent (sum of diagonal elements divided by N = 165). For the basic interest scale, the comparable figure was 81 percent. In addition, the percentage of correct classification for TSs and MGRs were virtually identical to the total percentage in each analysis.

DISCUSSION

It is not surprising on an intuitive level that the managerial domain variables were consistent discriminators of the two groups. For example, the large difference on the means for the business management basic interest scale (approximately 9 units) is dramatic indeed since 9 units is roughly one standard deviation unit for these data. The managers have a "business mind set" relative to the specialists who are notably disinterested in this area. The consistent negative signs on the artistic scales across both analyses suggests the technical specialists are more stereotypically independent, somewhat anti-organization, and more concerned about originality and creativity relative to the managerial group. The RIASEC analysis indicated the managers on the other hand were likely to be more responsive to authority, to be more comfortable in an organizational hierarchy (higher on the

conventional scale), and to be somewhat more socially oriented. This pattern is reminiscent of Badawy's (1982) professional versus bureaucratic tension in the career transition of technical specialists into management.

The stepwise discriminant analysis refined the shape of the differences between the groups which was generically suggested by the RIASEC scales. The social area difference for instance is more specifically driven by differences in athletic interest (note that athletics is a subset of the social area). This is consistent with Klimoski's (1973) autobiographical work on the origins of engineering and engineering management interests wherein the manager group reported more childhood participation in athletics. The athletic area is apparently bound up with a more gregarious, confident psychological posture. The realistic scale in the RIASEC analysis was difficult to interpret, and given the small mean difference should probably not be given much weight. However, the agriculture basic interest scale which is in the realistic theme entered the stepwise analysis with more consistency and clarity. The inference which strikes the authors here is that it could be a proxy for the work ethic, and a need for short term reinforcement. While we do not have background information on our respondents, agricultural backgrounds and interests are commonly intertwined with the protestant work ethic. Public speaking is part of the enterprising domain, and has been associated with progression into management in other research (Bray, Campbell and Grant, 1974).

Particularly important is the ability to make presentations, which is often an exercise in management assessment centers. Office practice did not show large mean differences, but apparently operates through a suppressor effect. When stripped of its business management component through partial correlation, office practice is more indicative of technical specialist group membership. The "office practice residue" suggests careful observation and systematic exploration which are consistent with the work of the technical specialist.

In general this research is supportive of the proposition that interests in the people, organizations and management domain are stronger for the managers than technical specialists. Furthermore, these general areas contribute most to discrimination between the groups. However, at the more specific level of the basic interest scales, both realistic and artistically oriented variables took on some importance. R & D managers appear to embroider their basic scientific and technical identity with a managerial interest pattern, whereas technical specialists are more delineated and consistent in Holland's theoretical framework. That is they accept the scientific, technical area, but are more rejecting of managerial interests. R & D managers, however, incorporate the technical/managerial polarity into their interest structure and psychological functioning.

The variables under study here are considered to have remarkable stability over time, particularly after age twenty five

(Campbell and Hansen, 1981). Thus a practical implication for the management of technical personnel is the assessment and career counseling of individuals faced with the technical/managerial choice point. Holland's framework and the associated SCII scales also have great potential for raising an individual's awareness of the inherent conflict in R & D management. In this sense assessment and feedback can serve a developmental and educative function for R & D personnel, and assist both organizations and individuals in conceptualizing, clarifying and coping with the difficulties inherent in staffing job roles in the R & D function. Also, psychological questionnaires today are being used increasingly as a basis for assigning persons to training programs. That is, scientists and engineers with a managerial interest pattern may not make good managers immediately, but rather would benefit more from management training than persons with lower interest levels. Lastly, inasmuch as stable psychological differences are demonstrated and valid for managers and technical specialists, the issue of creating a pluralistic career systems (Bailyn, 1980) becomes more important in the management of the R & D function.

Table 1.

Basic Interest Scales Associated with Holland's Six Occupational Themes

General Occupational Themes	Basic Interest Scales
Realistic--rugged, robust, practical, prefer to deal with things rather than people, mechanical interests	Agriculture, nature, adventure mechanical activities, military activities
Investigative--scientific, task oriented, prefer abstract problems, prefer to think through problems rather than act on them, not person oriented, enjoy ambiguous puzzles	Science, mathematics, medical science, medical service
Artistic--enjoy creative self expression, dislike highly structured situations, sensitive, emotional, independent, original	Music/dramatics, art, writing
Social--concerned with the welfare of others, enjoy developing, teaching others, good in group settings, extroverted, cheerful, popular	Teaching, social service, athletics, domestic arts, religious activities
Enterprising--good facility with words, especially selling, leading, are energetic, extroverted, adventurous, enjoy persuasion	Public speaking, law/politics, merchandising, sales, business management
Conventional--prefer ordered, numerical, verbal work, enjoy large organizations, respond to authority, dislike ambiguous situations, stable, dependable	Office practices

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