# MULTIVARIATE EXPERIMENTAL CLINICAL RESEARCH

VOLUME 8 NUMBER 3
1986



**A Journal for Basic Behavioral Research into Personality Dynamics and Clinical Psychology**



Published Three Times a Year by the Psychology Press, from the Department of Psychology, Wichita State University, Wichita, Kansas, U.S.A.

POLICY STATEMENT

The primary aim of *Multivariate Experimental Clinical Research* is to provide a publication outlet for research in the areas covered and indicated currently by the terms personality study, clinical diagnosis and therapy, extending into the learning, social, physiological, applied and developmental aspects of these. Although due representation is given to theoretical articles which may have a methodological basis, the journal is not one of multivariate statistical methods. Although multivariate in outlook, both manipulative and non-manipulative research is accepted. In fact preference is given to dynamic, manipulative and time-sequential studies. Particular encouragement is provided for pioneer experimental attacks on what is designated personality dynamics and motivation, as well as the natural expansion thereof into structured learning theory.

*Multivariate Experimental Clinical Research,* Volume 8, No. 1, 1986, 147.

# A Note From The Editor

*Multivariate Experimental Clinical Research* is entirely supported by subscription and page charges. It is hoped that in the not too distant future subscriptions will generate sufficient income to allow the elimination of page charges entirely.

The Wichita State University has been quite supportive in the operation of this journal (especially the Graduate School). The Dean of the College of Liberal Arts and Sciences (Dr. Phillip Thomas) has offered to cover the page charges on one exceptional manuscript per issue of the journal.

The first invited article so subsidized (a quite interesting work by Dr. Sam Krug) follows:

C. Burdsal, ed.

*Multivariate Experimental Clinical Research,* Volume 8, No. 1, 1986, 149-159.

# PERSONALITY CHARACTERISTICS OF WIVES AND HUSBANDS PARTICIPATING IN MARRIAGE ENRICHMENT

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## ABSTRACT

The last 25 years have seen widespread growth in the availability of marriage enrichment programs throughout the United States. The working assumption of these programs is that participants have satisfying, well-functioning marriages and seek only to strengthen their present relationships and prevent possible disruption. Some research would suggest, however, that this assumption may not be entirely correct. Although participants may not be as dissatisfied with their marriages as couples who seek counseling, neither do they appear as satisfied with their marriages as non-participants (Powell & Wampler, 1982). The present research attempted to discover whether there were distinctive personality characteristics of marriage enrichment program participants which might be reflective of corresponding strengths or weaknesses in their relationships. Findings from the Adult Personality Inventory (API) indicated that participants in one program tend to appear more like couples who have problem marriages than those who have well-functioning marriages. Additionally, the API appears to be a sensitive indicator of relevant areas of interpersonal conflict and can be expected to become an increasingly important tool in relationship counseling.

## PERSONALITY CHARACTERISTICS OF WIVES AND HUSBANDS PARTICIPATING IN MARRIAGE ENRICHMENT

The alarming frequency with which marriages dissolve has been a very significant factor in the growth of marriage enrichment programs. The basic philosophy of such programs is preventative and the emphasis is on strengthening well-functioning marriages, rather than restructuring dysfunctional relationships. The purpose of this article is to determine whether participants in marriage enrichment programs really have as well-functioning relationships as they are presumed to have or whether they should be recognized as coming from a disturbed relationship and treated accordingly.

A number of diverse approaches and formats have been explored. The Marriage Encounter program, which began in the Roman Catholic church in

Spain in 1958 and has subsequently been promoted by various church groups, normally takes the form of an intensive retreat during which couples participate in a variety of exercises designed to improve communication and understanding. Marriage Encounter is only one of more than 50 programs that are currently available for marriage enrichment (Hof & Miller, 1980). A 1976 survey estimated that nearly 1 million couples had by that time participated in some programmatic form of marriage enrichment (Otto, 1976).

A number of independent research studies have concluded that personality factors play a significant role in marital satisfaction (Buss, 1984; Cattell & Nesselroade, 1967; Eysenck, 1980; Meck & LeUnes, 1977; Moody & Lederer, 1983; Zaleski & Galkowska, 1978). But, what do we know about the personality of people who are attracted to programs designed to increase marital satisfaction? The manner in which they are normally promoted would suggest that participants are in some sense the cream of the crop. They are people who have recognized the importance of a good relationship and have taken the time to improve on a good thing. On the other hand, an increasing number of practitioners are using marriage enrichment programs as adjuncts to marital therapy with troubled relationships (Hof & Miller, 1980). Recent research findings have suggested that these couples are less satisfied with their marriages than nonparticipants, but not as dissatisfied as couples who directly seek counseling (Powell & Wampler, 1982).

Assuming the correctness of Powell and Wampler's conclusions, a logical next step is to ask whether there is something in the personality makeup of participant couples that might represent one source of such discontent. Our research was designed to provide some evidence regarding the personality characteristics of spouses who were participants in one marriage enrichment program. Specific hypotheses we explored were:

(1) when viewed individually, do these men and women display personality characteristics that distinguish them from the general population?

(2) do the characteristics of husbands and wives as couples combine in ways that suggest corresponding areas of strength or weakness in the relationship as a whole?

## METHOD

The instrument used in the present study was the Adult Personality Inventory (API: Krug, 1984). The API is the most recent development in a psychometric tradition that began nearly a half century ago with research that led to the development of Cattell's 16 Personality Factor Questionnaire (16PF). The 16PF has served as the wellspring for a large number of instruments designed for a broad spectrum of specific applications. These include a paper-and-pencil inventory for the diagnosis of anxiety-based disorders in adults (Krug, Cattell & Scheier, 1976), multidimensional questionnaires for measuring personality traits in young children (Cattell & Cattell, 1969; Cattell & Porter, 1975), and computer-based instruments for career development, marriage counseling, police selection, and therapeutic intervention (see Krug [1986] for a summary).

The API is a computer-based instrument that uses three sets of scales to measure personality characteristics, interpersonal style, and career interests. The seven personal characteristic scales include some of the broadest and best replicated factor-analytically defined trait dimensions. The circumplex structure of the next eight scales reflects models of interpersonal behavior described by Leary (1957), Foa (1961), Wiggins (1979), and others. Six empirically derived career scales represent major axes of personality differences among people in various occupations. Four validity scales complete the profile.

Each set of scales may be thought to represent a different template for specific decision needs. The API design called for an instrument directly oriented to user concerns rather than measurement constructs. The test user is free to select whichever template is most relevant, whether the decision relates primarily to personality description, to interpersonal dynamics, or to career preference and job satisfaction.

The interpersonal scales of the API (Caring-Hostile, Adapting-Rebellious, Sociable-Withdrawn, Assertive-Submissive) provided the theoretical model for a recently introduced marriage enrichment program called GROW (Henry, Henry & Krug, 1984). GROW consists of a series of four "lessons," each of which combines individualized personality feedback with a series of structured learning experiences. The emphasis in each unit is on learning about and practicing skills related to one axis of the interpersonal model. For example, the goal of the first unit ("Growing Closer Together") is to enhance caring behaviors. The individualized feedback portion emphasizes related personality characteristics including warmth, sensitivity, and trust. Related learning activities present different techniques to strengthening the bond between spouses. Other units in the program are built on the Sociable-Withdrawn axis ("Talking and Listening"), the Assertive-Submissive axis ("Growing in Decision Making"), and the Adapting-Rebellious axis ("Adapting to New Roles").

## DESCRIPTION OF THE SAMPLE

The data used in the present study was provided by a number of practitioners throughout the United States. From the answer sheets they returned for processing into GROW lessons, we drew a sample of 100 couples who ranged in age from 20 to 64. Some had been married only six months and others as long as 40 years with an average of 12 years.

A contrast group was selected from among adult men and women tested during the API standardization. Each person in this group was matched in terms of age (to the nearest year) and sex to one of the individuals in the experimental group. These 100 men and 100 women were subsequently paired on the basis of age patterns in the married couples. One such "pseudo couple" was matched to each real couple. This approach permitted us to compare personality patterns in naturally occurring relationships with those that might be expected on the basis of chance pairing of two individuals equivalent in age, but not married to each other. Contradictory explanations have been offered both in the folk literature ("opposites attract," "birds of a feather flock together") and the scientific literature (theories of complementariness and similarity) to explain the role of personality in marriage. The existence of a set of randomly paired profiles,

matched only for age, provides an intriguing basis against which to determine whether greater or less similarity was in fact the norm. We shall subsequently refer to the experimental subjects as GROW husbands, GROW wives, and GROW couples. The other groups will be referred to as control men, control women, and pseudo couples.

## PROCEDURE

The analysis began with a test of the generalized null hypothesis of no personality differences among the four groups. Multiple discriminant analysis simultaneously answered this question and identified dimensions of significant between-groups covariation. Since the discriminant model controls for correlations among the variables, we used all 21 personality scales of the API.

Three subsequent analyses were undertaken, each of which focused on the dyad rather than the individual as the earlier analysis had done. In the first case, we analyzed the vector of difference scores that resulted by subtracting the GROW wives' scores from their husbands' scores. By using the algebraic (signed) differences, we were able to determine whether there were tendencies for wives in the GROW sample to exceed their husbands consistently on any characteristics. For example, was there a tendency for GROW women to be more submissive than their husbands, as stereotypes might suggest?

The second analysis focused on the vector that resulted by summing the scores of GROW husbands and wives. This analysis was designed to tell whether there was a tendency for cumulative personality strengths or weaknesses to appear in the relationship as a whole.

The third approach considered the degree of similarity between spouses by analyzing the vector that resulted from taking the absolute values of differences between the profiles.

In each case we formed parallel variables for the sample of 100 pseudo couples. This allowed us to determine whether patterns of significant differences and similarities in the GROW couples were greater or less than what would be expected as a result of random pairing of two people.

## RESULTS

Means and standard deviations of the four groups are shown in Table 1. API scores are reported on a standard scale that has a range of 1 to 10, a mean of 5.5, and a standard deviation of 2.0 in an unselected population.

**Table 1**

DESCRIPTIVE STATISTICS OF THE STUDY SAMPLE

| | GROW Couples | | | | Pseudo Couples | | | |
|---|---|---|---|---|---|---|---|---|
| | Men | | Women | | Men | | Women | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Extraverted | 5.89 | 1.71 | 5.95 | 1.77 | 5.82 | 1.70 | 5.97 | 1.74 |
| Adjusted | 4.53 | 1.68 | 4.35 | 1.78 | 5.36 | 1.60 | 5.39 | 1.76 |
| Tough-minded | 6.24 | 2.01 | 5.75 | 1.62 | 6.22 | 1.80 | 6.31 | 1.77 |
| Independent | 6.90 | 1.80 | 6.14 | 1.77 | 6.80 | 1.62 | 6.41 | 1.87 |
| Disciplined | 4.67 | 2.16 | 5.66 | 1.72 | 5.66 | 2.08 | 5.56 | 2.03 |
| Creative | 7.16 | 1.97 | 6.66 | 2.01 | 6.95 | 1.83 | 6.35 | 1.77 |
| Enterprising | 6.65 | 1.99 | 6.96 | 2.18 | 7.10 | 2.22 | 6.42 | 2.15 |
| Caring | 4.45 | 2.13 | 5.37 | 2.24 | 5.29 | 2.47 | 5.75 | 2.26 |
| Adapting | 4.08 | 2.02 | 5.15 | 1.98 | 4.89 | 2.00 | 5.13 | 2.24 |
| Withdrawn | 5.60 | 1.74 | 5.97 | 1.64 | 5.42 | 1.50 | 5.49 | 1.79 |
| Submissive | 5.92 | 1.94 | 6.19 | 1.83 | 5.16 | 1.73 | 5.43 | 1.80 |
| Hostile | 6.28 | 2.01 | 5.97 | 2.07 | 5.49 | 2.13 | 5.61 | 2.16 |
| Rebellious | 5.83 | 2.15 | 4.76 | 1.77 | 5.08 | 2.06 | 5.20 | 2.45 |
| Sociable | 6.02 | 1.92 | 5.41 | 1.70 | 5.36 | 1.81 | 5.54 | 2.12 |
| Assertive | 4.83 | 1.86 | 5.22 | 1.72 | 5.21 | 1.97 | 5.59 | 1.79 |
| Practical | 4.88 | 1.93 | 4.75 | 2.32 | 5.46 | 1.76 | 5.63 | 1.94 |
| Scientific | 6.61 | 1.85 | 6.10 | 1.78 | 6.39 | 1.64 | 6.42 | 1.98 |
| Aesthetic | 6.98 | 1.99 | 7.42 | 2.05 | 6.54 | 1.79 | 6.50 | 1.87 |
| Social | 5.94 | 1.92 | 5.75 | 1.98 | 5.62 | 1.79 | 5.37 | 1.69 |
| Competitive | 7.02 | 1.84 | 6.76 | 1.92 | 6.93 | 1.87 | 6.74 | 1.92 |
| Structured | 4.20 | 2.35 | 5.71 | 2.15 | 4.92 | 2.36 | 5.64 | 2.27 |
| Good Impression | 4.98 | 1.78 | 5.12 | 1.78 | 5.54 | 1.92 | 5.09 | 1.74 |
| Bad Impression | 5.92 | 2.16 | 5.83 | 2.05 | 5.40 | 1.67 | 5.67 | 2.01 |
| Infrequency | 4.42 | 2.99 | 3.72 | 2.55 | 3.92 | 2.44 | 3.38 | 2.32 |
| Uncertainty | 5.39 | 1.81 | 5.14 | 1.45 | 5.63 | 2.09 | 5.47 | 1.97 |

Considering the sizes of the samples there are some reasonably significant departures from expectation in these results. For example, the GROW men averaged three quarters of a standard deviation below the population mean on Adapting (4.08) and the GROW women averaged almost a full standard deviation above the population mean on Aesthetic (7.42). Profile deviations among the control groups were generally less extreme.

Results of the first discriminant analysis are reported in Table 2. All three functions were found to be statistically significant far beyond conventional levels.

**Table 2**
**RESULTS OF THE MULTIPLE DISCRIMINANT ANALYSIS AMONG FOUR GROUPS**

| A: Discriminant Structure Coefficients | 1 | 2 | 3 |
|---|---|---|---|
| Extraverted | .05 | .02 | -.06 |
| Adjusted | .09 | -.66 | .17 |
| Tough-minded | -.08 | -.27 | -.15 |
| Independent | -.30 | -.19 | -.05 |
| Disciplined | .29 | -.08 | .46 |
| Creative | -.30 | .09 | .06 |
| Enterprising | -.07 | .09 | .38 |
| Caring | .36 | -.18 | .19 |
| Adapting | .36 | -.05 | .31 |
| Withdrawn | .08 | .31 | .01 |
| Submissive | .03 | .52 | -.23 |
| Hostile | -.12 | .27 | -.28 |
| Rebellious | -.26 | -.09 | -.40 |
| Sociable | -.16 | .05 | -.35 |
| Assertive | .25 | -.18 | .04 |
| Practical | .10 | -.45 | .05 |
| Scientific | -.13 | -.13 | -.18 |
| Aesthetic | .01 | .49 | .00 |
| Social | -.16 | .19 | -.03 |
| Competitive | -.12 | -.01 | .00 |
| Structured | .50 | .04 | .19 |
| **B: Means of the Groups on the Discriminant Functions** | | | |
| GROW men | -.78 | .16 | -.33 |
| GROW women | .46 | .62 | .15 |
| Control men | -.35 | -.35 | .44 |
| Control women | .67 | -.43 | -.26 |

Coefficients of the discriminant structure matrix are shown first. These values represent the correlations between the API test scales and each discriminant function. The means of the four groups on the discriminant functions are presented next. As they show, the first function primarily explains differences between men and women and the second explains differences between GROW participants and the control groups. The third function contrasts GROW women and control men, at the one pole, with GROW men and control women at the other.

Function 1 has its highest correlations with the Structured (.50), Adapting (.36), Caring (.36), Creative (-.30), and Independent (-.30) scales. This suggests a general dimension of cooperative, undemanding behavior with some overtones of warmth and sensitivity. Since women in the study scored higher than men on this function, this might at first glance be dismissed as a factor reflecting general sex differences on the API scales. However, the scales that play a major role here show no significant differences between men and women in an unselected population (Krug, 1984).

Function 2 has its highest correlations with the Adjusted (-.66), Submissive (.52), Aesthetic (.49), Practical (-.45), and Withdrawn (.31) scales. On this dimension, husbands and wives in the GROW sample scored higher than the control groups. The combination of scales involved in this pattern immediately suggests a dimension of maladjustment in which anxiety is the most prominent characteristic. The positive correlation with the Aesthetic scale and the negative correlation with the Practical scale suggests some absorption in fantasy and possibly some lack of reality contact.

Function 3 has its strongest correlations with the Disciplined (.46), Rebellious (-.40), Enterprising (.38), Sociable (-.35), and Adapting (.31) scales. In terms of group positioning on this dimension, the highest average score was obtained by men in the control sample, followed by GROW women. Women in the control sample and GROW men fell at the opposite end of the continuum. Three of these scales (Disciplined, Rebellious, and Adapting) suggest an underlying dimension of control. The negative relationship with the Sociable scale is not inconsistent with this pattern, but the positive relationship with the Enterprising scale might seem out of place at first glance. However, some of the adjectives that have been found to correlate with higher scores on the Enterprising scale include self-disciplined and assertive, which would be considered consistent with the concept of control.

The next set of results shifted us from the individual perspective to comparisons of these people as couples.

A discriminant analysis of the signed (algebraic) difference scores between the GROW couples and the pseudo couples resulted in overall significance beyond the .05 level. The results of this analysis are reported in Table 3.

**Table 3**

**DISCRIMINANT ANALYSIS OF THE DIFFERENCE SCORES**
**(Husbands minus Wives)**

| | Means | | Discriminant |
|---|---|---|---|
| | GROW Couples | Pseudo Couples | Structure Coefficients |
| Extraverted | -.06 | -.15 | -.04 |
| Adjusted | .18 | -.03 | -.09 |
| Tough-minded | .48 | -.09 | -.27 |
| Independent | .76 | .38 | -.19 |
| Disciplined | -.99 | .10 | .45 |
| Creative | .50 | .60 | .05 |
| Enterprising | -.31 | .68 | .40 |
| Caring | -.92 | -.46 | .17 |
| Adapting | -1.07 | -.24 | .34 |
| Withdrawn | -.37 | -.06 | .16 |
| Submissive | -.27 | -.27 | .00 |
| Hostile | .31 | -.12 | -.17 |
| Rebellious | 1.07 | -.11 | -.47 |
| Sociable | .61 | -.17 | -.34 |
| Assertive | -.39 | -.38 | .00 |
| Practical | .14 | -.18 | -.13 |
| Scientific | .51 | -.03 | -.26 |
| Aesthetic | -.43 | .04 | .21 |
| Social | .19 | .25 | .03 |
| Competitive | .26 | .20 | -.03 |
| Structured | -1.51 | -.72 | .30 |

Column 1 of this table gives the mean differences for the GROW couples. The largest difference was found on the Structured scale with GROW wives scoring about three quarters of a standard deviation above their husbands. Differences of approximately a one-half standard deviation magnitude were found on Rebellious (husbands higher), Adapting (wives higher), Disciplined (wives higher), and Caring (wives higher).

Column 2 shows comparable values for the pseudo couples. Within this group of randomly "mated" couples, the differences between men and women are much smaller. For about half the scales the sign of the difference is consistent across the two groups, suggesting perhaps that some general sex differences are

operating. However, a few of the discrepancies are noteworthy. In particular, the large differences on the Disciplined and Rebellious scales noted earlier among the GROW couples appear to be even greater when they are compared to the values in column 2.

Column 3 presents the coefficients of the discriminant structure matrix. The magnitude of these correlations largely confirms the patterns already seen in the profiles of mean differences between the groups.

A discriminant analysis of the summed profiles resulted in overall differences between the GROW couples and pseudo couples that were significant beyond the .0001 level. These results are shown in Table 4 in a format that parallels results of the previous analysis.

**Table 4**

DISCRIMINANT ANALYSIS OF THE SUMMED PROFILES

| | Means | | Discriminant |
|---|---|---|---|
| | GROW Couples | Pseudo Couples | Structure Coefficients |
| Extraverted | 11.83 | 11.79 | -.02 |
| Adjusted | 8.88 | 10.75 | .71 |
| Tough-minded | 11.99 | 12.53 | .19 |
| Independent | 13.04 | 13.21 | .06 |
| Disciplined | 10.34 | 11.21 | .29 |
| Creative | 13.82 | 13.30 | -.17 |
| Enterprising | 13.60 | 13.51 | -.03 |
| Caring | 9.81 | 11.04 | .35 |
| Adapting | 9.22 | 10.02 | .25 |
| Withdrawn | 11.57 | 10.91 | -.26 |
| Submissive | 12.12 | 10.59 | -.53 |
| Hostile | 12.24 | 11.09 | -.37 |
| Rebellious | 10.60 | 10.28 | -.10 |
| Sociable | 11.43 | 10.90 | -.19 |
| Assertive | 10.05 | 10.80 | .27 |
| Practical | 9.63 | 11.08 | .46 |
| Scientific | 12.71 | 12.81 | .04 |
| Aesthetic | 14.40 | 13.04 | -.44 |
| Social | 11.68 | 10.99 | -.24 |
| Competitive | 13.78 | 13.67 | -.04 |
| Structured | 9.91 | 10.56 | .18 |

Again, this analysis is quite revealing. As the first two columns of means show, among the couples who participated in this enrichment program, the overall levels on Adjusted, Disciplined, Caring, Assertive, and Practical are less than is found in the control group. Conversely, the overall levels on Submissive, Hostile, and Aesthetic are higher than was found in the control group.

The discriminant analysis of unsigned profile differences between the real and pseudo couples did not yield significant results.

## DISCUSSION

When we compared men and women participating together in marital enrichment with control subjects matched for age, consistent patterns of personality differences emerged. Both GROW participants were less adjusted, less caring, and more hostile than non-participant controls. In addition, the men in the GROW sample showed higher tendencies toward irresponsibility as evidenced by generally lower scores on the Disciplined scale and higher scores on the Rebellious scale.

Over and above the adjustment area, a large portion of the differences between participant and control couples appears to be explained by the interpersonal scales of the API. Participant couples' combined totals on Caring and Adapting were substantially below corresponding values for control subjects. At the same time, their totals on Hostile were substantially higher than those for controls.

Differences on two of the career scales — Practical and Aesthetic — were also substantial. These could be a function of socioeconomic differences between the groups, since it was not possible to match for occupation.

From these results we conclude that there are some important ways in which men and women who participate in marriage enrichment differ from the general population, both individually and as couples. They appear to be generally less well adjusted and more dysfunctional in their interpersonal relationships.

We have no direct measure of satisfaction or marital stability for the couples we have studied. However, based on many past studies which have linked personality and degree of spouse similarity to satisfaction, we can reasonably speculate that things aren't all that rosy for participant couples. It is not possible to generalize beyond the present sample because it may be that some practitioners who administered the GROW program saw it as an adjunct to traditional therapy for problem relationships. It may be prudent, however, for program leaders to assume that problems may exist that require resolution before true enrichment is possible.

Regardless of whether such selection factors operated, it is heartening to note that the theoretical design of the GROW program seems correctly oriented to some of the most important personal needs participant couples display.

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*Multivariate Experimental Clinical Research,* Volume 8, No. 1, 1986, 161-163.

# HETEROGENEOUS CORRELATIONS AND ESTIMATES OF REQUIRED SAMPLE SIZE IN FACTOR ANALYSIS

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## ABSTRACT

Factor matrices with various patterns of loadings were constructed to study the effect of heterogeneous correlations on estimates of the minimal number of subjects in factor analysis. The tabled values of appropriate ratios of number of subjects to number of variables presented in a previous article were shown to furnish rather accurate estimates over the range of factorial patterns studied.

## INTRODUCTION

Using Bartlett's test of the hypothesis that the population correlation matrix is an identity matrix, Baggaley (1982) derived a formula for the minimal value of the ratio of number of subjects to number of variables in factor analysis for the .05 level of significance. He presented a table in which these values of $N/p$ had been calculated for various values of the number of variables and a quantity called $Q$, which was defined as (the negative natural logarithm of the determinant of the correlation matrix) divided by the number of variables. This logarithmic function is involved in Bartlett's formula. By examining seven correlation matrices based on real data, he had concluded that the average absolute off-diagonal correlation (which could hopefully be estimated by an investigator from his knowledge of the domain of inquiry) would furnish a good approximation of $Q$.

Reddon and Jackson (1984) ingeniously tested this approximation by computing the exact value of the determinant of equi-correlation matrices, using the same correlations that Baggaley had used; the calculations are relatively simple when there is a constant correlation value. They proceeded to compute corresponding values of $N/p$ from their own values of $Q$; $N/p$ varies inversely with $Q$. When one compares the tabled values of $N/p$ computed by Baggaley with those by Reddon and Jackson, one finds that for high levels of intercorrelation Reddon and Jackson's $Q$s tend to exceed Baggaley's $Q$s, especially for high $p$, but that for low levels of intercorrelation Reddon and Jackson's $Q$s are lower, especially with low $p$. For example, with 20 variables and an average correlation of .10, Reddon and Jackson obtained a $Q$ value of .05 (instead of .10). In this case, whereas Baggaley advises a minimal $N/p$ of 6.00, Reddon and Jackson suggest a cutoff of 12.35.

Since the average intercorrelation among personality and attitude items is usually closer to .10 than it is to .50 (the highest value used in the two tables), if

Reddon and Jackson's hypothesized situation were representative, some of Baggaley's values would involve rather serious underestimates of $N/p$ with such variables. The critical question is, do correlation matrices with a given average level of intercorrelation give values of $Q$ when the correlations vary about this value (heterogeneous correlations) similar to those with a constant correlation throughout the matrix. The practical difficulty in answering this question involves the fact that many patterns of $r$s will produce the same average $r$. Nevertheless I tried various patterns of correlation to study their effect on $Q$. To generate the correlation matrices and their determinants, I used PROC MATRIX of the SAS computer "package." For example, for factor matrix A (see Table 1) the statements were

RA=A*A′-DIAG (A*A′)+I(12) and DA=DET(RA).

Table 1

CONSTRUCTED FACTOR MATRICES AND THEIR VALUES OF $\bar{r}$ AND $Q$

| Matrix A | | Matrix B | | Matrix C | |
|---|---|---|---|---|---|
| .6 | .0 | .6 | .0 | .6 | .2 |
| .6 | .0 | .6 | .0 | .6 | .0 |
| .6 | .0 | .4 | .0 | .6 | .2 |
| .6 | .0 | .4 | .0 | .6 | .0 |
| .6 | .0 | .2 | .0 | .6 | .2 |
| .6 | .0 | .2 | .0 | .6 | .0 |
| .0 | .6 | .0 | .6 | .2 | .6 |
| .0 | .6 | .0 | .6 | .0 | .6 |
| .0 | .6 | .0 | .4 | .2 | .6 |
| .0 | .6 | .0 | .4 | .0 | .6 |
| .0 | .6 | .0 | .2 | .2 | .6 |
| .0 | .6 | .0 | .2 | .0 | .6 |
| $\bar{r}$ = .1636 | | $\bar{r}$ = .0703 | | $\bar{r}$ = .2327 | |
| $Q$ = .2003 | | $Q$ = .0619 | | $Q$ = .2267 | |

| Matrix D | | Matrix E | | Matrix F | |
|---|---|---|---|---|---|
| .6 | .4 | .6 | -.2 | .4 | -.4 |
| .6 | .0 | .6 | .0 | .4 | .0 |
| .6 | .4 | -.6 | .2 | -.4 | .4 |
| .6 | .0 | -.6 | .0 | -.4 | .0 |
| .6 | .4 | -.6 | -.2 | -.4 | -.4 |
| .6 | .0 | .6 | .2 | .4 | .4 |
| .4 | .6 | -.2 | .6 | -.4 | .4 |
| .0 | .6 | .0 | .6 | .0 | .4 |
| .4 | .6 | .2 | -.6 | .4 | -.4 |
| .0 | .6 | .0 | -.6 | .0 | -.4 |
| .4 | .6 | -.2 | -.6 | -.4 | -.4 |
| .0 | .6 | .2 | .6 | .4 | .4 |
| $\bar{r}$ = .3091 | | $\bar{r}$ = .2194 | | $\bar{r}$ = .1406 | |
| $Q$ = .3178 | | $Q$ = .2282 | | $Q$ = .1181 | |

Along with each factor matrix is given the average absolute correlation ($\bar{r}$) and the calculated value of $Q$. Matrices B and F represent low levels of average correlation, while Matrices C and D involve relatively high levels; the other two matrices are intermediate. Matrices E and F contain some negative loadings, but the other four involve all positive loadings. Matrices A and B give factors with "nonoverlapping" loadings, whereas the other four represent more complex factors. Thus these six factor matrices are rather varied in nature. The largest absolute discrepancy between $\bar{r}$ and $Q$ is .0367, while the smallest is .0060. Notice that there are as many overestimates of $Q$ as underestimates. Thus it seems that the estimates of the minimal value of $N/p$ for statistical significance given in Baggaley's (1982) Table 1 are rather accurate when $\bar{r}$ is used to estimate $Q$.

These calculations are based only on matrices involving 12 variables and two factors. I did try a few matrices with three and four factors, of various patterns, and the approximations were not as close. However, I claim that a researcher who uses the cutoffs in the table of my previous article would be fairly well protected from obtaining chance results from a factor analysis.

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*Multivariate Experimental Clinical Research,* Volume 8, No. 1, 1986, 165-173.

# PATTERNS OF RELATIONSHIP BETWEEN THE 16PF AND ZUCKERMAN'S SENSATION SEEKING SCALE

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## ABSTRACT

The relationship between personality and sensation-seeking factors was investigated in a large sample of applicants for jobs where sensation seeking was of special relevance.

Four distinct patterns of relationship between the two domains were found. The first reflected an association between the Thrill and Adventure Seeking (TAS) component of the Sensation Seeking Scale (SSS) and a personality profile of emotional adjustment, independence and unconventionality. The second pattern related the Experience Seeking (ES) component of SSS with a personality profile of sensitivity, nonconformity and low superego. The third pattern comprised the Boredom Susceptibility (BS) component of the SSS and personality traits that represent a tense person who constantly seeks change. The fourth pattern reflected the relationships between the Disinhibition (Dis) component of the SSS and certain aspects of extraversion, especially those of impulsivity and group dependence.

The findings were discussed in light of Zuckerman's theoretical framework concerning the nature of the sensation-seeking construct and its components.

## INTRODUCTION

The sensation seeking construct developed by Zuckerman and his associates during the past two decades has been considered a major contribution to the area of personality (see for example Izard, 1979). The assumption underlying the development of the Sensation Seeking Scale (SSS) was that people differ in their optimal levels of stimulation and arousal and these differences influence their choices of life activity. Four different aspects of stimulation seeking were empirically identified by Zuckerman and his associates. "Thrill and Adventure Seeking" (TAS) refers to enjoyment of internal arousal produced by physical risk taking. This aspect mainly involves risky activities of the socially accepted type. "Experience Seeking" (ES) involves seeking of arousal through the mind and senses. It mainly expresses an anti-establishment self-fulfillment pattern.

"Disinhibition" (Dis) reflects the more traditional pattern of nonconformity through rebellion against strict codes concerning acceptable social behavior. "Boredom Susceptibility" (BS) refers to aversion to repetitive experience of any kind, expressing extreme tension and restlessness under conditions where such constancy is unavoidable.

These four aspects of the sensation seeking construct constitute the four subscales of the fifth version of the SSS. (Zuckerman, 1979).

The sensation seeking construct has been investigated in the domains of clinical, vocational and social psychology. The four sensation seeking subscales were found to be differentially related to personality traits (see for example: Gorman, 1970; Bone, 1972; Jacobs, 1975; Eysenck & Eysenck, 1977; Eysenck & Zuckerman, 1978), to psychopathological factors (see Zuckerman & Link, 1968; Blackburn, 1969; Zuckerman, 1978, 1979; Montag & Birenbaum, 1984), to vocational choices (see Levin & Brown, 1975; Musolino & Hershenson, 1977; Biernsner & LaRocco, 1983).

Most of the above mentioned studies in the area of personality were done with earlier versions of the SSS. Moreover, they used relatively small sample sizes, which mainly consisted of college students or psychiatric patients. Most of these studies report zero-order correlations between the SSS and the various personality variables or criteria. Only a few report results based on factor analytic techniques. The purpose of the current study was to find patterns of relationship between primary personality factors and the four components of the SSS. Following Zuckerman's contention that the SSS is a multidimensional construct, it was hypothesized that the four sensation seeking components will be differentially related to personality factors. The present study differs from previous work in this area with respect to its sample size, the method of analysis and the version of the SSS being used. Furthermore, the setting in which the study was carried out was a real-life one, of the selection type. The subjects were applicants for jobs involving a high degree of risk taking. Thus, the SSS seemed to be especially relevant to the situation. In order to reduce the subjects' tendency to falsify their responses, as is expected under such circumstances, a special technique which has been proposed for reducing such tendencies (Montag, 1978; Montag & Comrey, 1982) was used.

## METHOD

### SUBJECTS

The sample consisted of 765 Israeli male applicants for security related jobs. The mean age of the subjects was 22.23 years, with a standard deviation of 1.6. Their mean of education was 12.4 years of schooling. Ninety three percent of the subjects were born in Israel.

### INSTRUMENTS

Form V of the Sensation Seeking Scale (SSS) (Zuckerman, 1979) is a 40 item forced-choice questionnaire which yields 4 subscale scores and a total score. The 4 subscales are: TAS (Thrill and Adventure Seeking); ES (Experience Seeking); Dis (Disinhibition); and BS (Boredom Susceptibility). The subscales are based on

factors found in American and British males and females (Zuckerman et al., 1978). The intercorrelations among the subscales are relatively small (Zuckerman & Neeb, 1980).

The Hebrew version of the questionnaire was developed and validated by the authors. (See Birenbaum & Montag, 1984; Birenbaum, 1984; Montag & Birenbaum, 1984).

Form A of the 16PF (Cattell, 1970) is a 187-item questionnaire with a trichotomous response-format, which yields 16 subscale scores. This instrument was developed through extensive factor analytic studies. The questionnaire measures the following primary personality factors: A (warmth); B (intelligence); C (emotional stability); E (dominance); F (impulsivity); G (conformity); H (boldness); I (sensitivity); L (suspiciousness); M (imagination); N (shrewdness); O (apprehension); Q1 (radicalism); Q2 (self-sufficiency); Q3 (self-discipline); Q4 (tension); (see Krug, 1981.)

The Hebrew version of the questionnaire was developed by Montag (1973) and validated by Zak (1976), Montag (1977), and Birenbaum & Zak (1982).

## THE ADMINISTRATION OF THE QUESTIONNAIRES

In order to reduce the applicants' tendency to falsify responses on the tests in the context in which the data were collected, a technique developed by one of the authors was used (Montag, 1978). According to this technique subjects are given a test of very transparent social desirability items prior to answering the personality questionnaire. The scores on this pretest are given back to the examinees so they can be aware of the extent of their apparent "faking good." In earlier studies, it was found that this technique helps to retain the underlying basic factor structure of questionnaires which are affected by social desirability, when administered to job applicant populations (see Montag & Comrey, 1982).

## ANALYSIS

To study the relations between the set of the four sensation seeking subscales and the set of 16 primary personality factors, canonical analysis was used. The relative magnitude of the correlations of the observed variables with the latent trait (the canonical variate) was assessed. In addition, the amount of overlap between the two sets was estimated by the redundancy index suggested by Stewart and Love (1968). The computer Program 6M from the BMDP package (Dixon & Brown, 1979) was used for the computations. The canonical variates were rotated using the Varimax rotation procedure of program FACTOR from the SPSS package (Nie et al., 1975).

## RESULTS

The results of the canonical analysis between the four sensation seeking subscales and the 16PF are presented in Table 1. As can be seen in the table, the results of the overall test of significance, as well as those of the sequential tests, are significant, indicating that all four canonical variates are significant.

**Table 1**

Canonical Correlation Results: The Relations Between the sets of 4 Sensation Seeking Scales and 16 Personality Factors (N = 765)

| Root | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Rc | .54 | .32 | .26 | .21 |
| $\lambda$ | .29 | .10 | .07 | .05 |
| $\chi^2$ (1) | 429.59 | 170.97 | 88.54 | 34.68 |
| df | 64 | 45 | 28 | 13 |
| P< | .001 | .001 | .001 | .001 |
| $\overline{Rd}_{x \cdot y}$ (2) | .03 | .01 | .01 | .01 |
| $\overline{Rd}_{y \cdot x}$ | .11 | .02 | .02 | .01 |

STRUCTURE COEFFICIENTS

| | Unrotated | | | | Varimax Rotated | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Root 1 | Root 2 | Root 3 | Root 4 | Root 1 | Root 2 | Root 3 | Root 4 |
| A | -.17 | .37 | -.12 | -.08 | -.19 | -.12 | -.19 | .32 |
| C | .02 | -.31 | -.25 | .37 | *.52* | -.09 | -.05 | -.13 |
| E | *.57* | -.03 | -.14 | .31 | *.45* | .22 | .37 | .22 |
| F | .39 | *.70* | -.35 | .23 | .17 | .02 | .14 | *.88* |
| G | *-.55* | -.08 | -.18 | *.49* | .30 | *-.62* | -.30 | -.10 |
| H | .15 | .02 | -.30 | *.45* | *.49* | -.12 | .05 | .22 |
| I | .12 | -.22 | -.18 | *-.56* | -.14 | *.54* | -.27 | -.14 |
| L | .26 | .15 | .36 | .06 | -.15 | .00 | *.44* | .07 |
| M | .39 | -.33 | *-.41* | .03 | *.49* | *.43* | -.05 | -.01 |
| N | *-.41* | .18 | .33 | -.16 | *-.48* | -.29 | -.08 | -.10 |
| O | -.16 | *.40* | .32 | -.30 | *-.59* | -.09 | .04 | .15 |
| Q1 | *.46* | -.08 | .36 | *.46* | .26 | -.07 | *.69* | -.04 |
| Q2 | .07 | *-.48* | *.40* | .04 | .02 | .05 | .30 | *-.55* |
| Q3 | -.37 | -.17 | -.12 | *.50* | .36 | *-.51* | -.15 | -.16 |
| Q4 | .12 | .31 | *.42* | *-.55* | *-.69* | .26 | .19 | .09 |
| B | .29 | .00 | -.02 | -.04 | .07 | .22 | .15 | .09 |
| TAS | .37 | -.28 | *-.44* | *.77* | *.97* | -.08 | .19 | .11 |
| ES | *.69* | *-.45* | -.36 | *-.44* | .30 | *.95* | .00 | -.10 |
| Dis | *.71* | *.69* | -.17 | -.05 | -.03 | .37 | .36 | *.85* |
| BS | *.66* | -.11 | *.73* | .13 | -.09 | .20 | *.96* | -.18 |

Notes: (1) Bartletts' chi-square approximations

(2) $\overline{Rd}$ = Redundancy index (the average squared correlations of a variable in one set with the canonical variable from the other set).

Coefficients $\geqslant$ .40 are italicized.

The total redundancy of the sensation seeking subscales, given all the linear combinations of the 16PF, amounts to $\overline{Rd}$ = 15.6%. In order to simplify the interpretation of the correlations between the original variables and the canonical variate scores (i.e., the structure coefficients) a varimax rotation was employed to the original solution. The structure coefficients before and after rotation are presented in Table 1. The interpretation to follow refers to the rotated canonical variates. As can be seen in the table, the "latent trait" that is predicted by the first canonical variate is represented in the sensation seeking set by the TAS (Thrill and Adventure Seeking) subscale. In the personality set that trait is characterized by four components from the negative pole of the second-order factor of anxiety: Q4- (low tension), C+ (emotional stability), O- (self confidence) and H+ (boldness). Three other personality primaries yielded meaningful coefficients on this variate: M+ (imagination), E+ (dominance), both of which contribute to the second-order factor of independence, and N- (low shrewdness). According to Krug (1981), a high scorer on scale M tends to be unconventional and unconcerned about everyday matters. A high E scorer is described by Krug as a self-assertive, competitive person who enjoys having things his own way. Occupationally, athletes have been found to score significantly above average on this scale. A low scorer on N is described as a straight forward person, less constrained by rules and standards. The second canonical variate relates the ES (Experience Seeking) component of sensation seeking to two of the personality primaries that contribute to Cattell's super-ego second-order factor: G- (nonconformity) and Q3-(low self-discipline), a pattern that indicates lack of confirmity, a desire for freedom from rules and lack of restraints (Karson & O'Dell, 1976, p. 94). The two other personality factors that are represented in this variate are I+ (sensitivity) and M+ (imagination), which are the main contributors to Cattell's Cortertia vs. Pathemia second-order factor. According to Karson & O'Dell (1976), this pattern characterizes persons who are easily swayed by their feelings.

The third canonical variate relates BS (Boredom Susceptibility) to two personality factors: L (suspiciousness) and Q1 (radicalism), which contribute to the second-order factor of independence. According to Krug (1981), high scorers on scale L are irritable and exhibit inner tension in their interpersonal relations, as well as a lack of composure. A person who scores high on Q1, according to Krug (1981), feels that society should throw away tradition and established norms.

In the fourth canonical variate Dis (Disinhibition) is related to two aspects of extroversion: F+ (impulsivity) and Q2- (group dependence). A high scorer on F is, according to Krug (1981), a person who has a need for exhibition, enjoys parties and shows. A low scorer on Q2 is described as a person who seeks and enjoys company.

## DISCUSSION

The analysis of the relations between the set of the four sensation seeking components and the 16 personality primaries yielded a clear picture in which each of the sensation seeking subscales was differentially related to scales of the 16PF. According to Zuckerman (1974), "the general picture defines sensation seeking as an uninhibited, nonconforming, impulsive, dominant type of extraversion" (p. 103). The results of the present study help to clarify this general

picture by distinctly relating those factors to the different components of the Sensation Seeking Scale. The first variate relates the TAS (Thrill and Adventure Seeking) component of the SSS to a personality profile of an independent, emotionally adjusted person who tends to be unconventional in his activities. The second variate, which is represented in the sensation seeking set by the ES (Experience Seeking) component, depicts a personality pattern of a sensitive, nonconforming person with a low superego, who tends to seek unusual emotional experiences. The third variate relates the BS (Boredom Susceptibility) component of the SSS to a personality pattern that represents a tense person who constantly seeks change. The fourth variate relates Dis (Disinhibition) to a personality pattern that represents certain aspects of extraversion, especially impulsiveness and group dependence.

Unlike Zuckerman's conclusion that sensation seeking is unrelated to general trait anxiety of the neurotic type (Zuckerman, 1979, p.182), our results indicate a negative relation between general (neurotic) anxiety and the TAS component of sensation seeking. It should, however, be noted that Zuckerman distinguishes between the general type of free-floating, ambiguous anxiety, which is generally operationalized by neurotic-anxiety scales, and situation-specific anxiety, which he refers to as fearfulness. According to his findings only the latter is related to SSS-TAS. A second point of dispute relates to the personality correlates of the Disinhibition component of the SSS. According to Zuckerman (1978), the Dis is particularly sensitive to psychopathic aspects, especially to impulsiveness and nonconformity. Our findings indicate a relationship between inpulsiveness and Dis, whereas the nonconformity aspect seems to be more related to the ES component of sensation seeking.

Taken together, the results of the canonical analysis which yielded four distinct patterns of relations between each of the four SSS components and the primary personality factors validate the multidimensional structure of the sensation seeking construct. Furthermore, the results lend support to Cattell's claim that one can not solely rely on second-order factors in personality research due to their frequent decomposition in relation to various criteria (Cattell et al., 1970). The results of the investigation conducted by Eysenck and Zuckerman (1978) concerning the relationship between the SSS and the three superfactors of the Eysenck Personality Questionnaire lend support to this claim. Eysenck and Zuckerman failed to precisely locate the sensation seeking construct in the personality sphere and had to conclude that it is located somewhere in the quadrant between E (Extraversion) and P (Psychoticism). The results of the present study, which used primary personality factors rather than second-order ones, yielded, therefore, a clearer picture of the relationships between the two domains.

It is worth noting that the magnitude of the overall relations between sensation seeking and personality traits in the present study, as well as in previous ones, were relatively moderate. There are at least two reasons by which this might be explained. One reason refers to the content of the two measures and the other to their format. Sensation seeking, being a motivational personality factor, contains items which mainly tap motivational rather than temperamental aspects; whereas the 16PF consists of items which especially tap temperamental and characterological aspects. It may therefore be recommended that further

research on the location of the sensation seeking construct in the broader personality domain include also motivational measures (e.g., the Motivational Analysis Test, Cattell et al., 1964).

Formatwise, the Sensation Seeking Scale and the 16PF differ in the amount of transparency which characterize their items. Presumably, the SSS, being composed of high face validity type of items, elicits responses which are close to the subjects' "self-schemata" (Markus, 1977). The 16PF, on the other hand, includes items "which do not obviously refer to the trait but which correlationally are known to measure it" (IPAT, 1972, p. 8). Thus, the 16PF elicits less of the self-schema information. It therefore seems that by adjusting the two measures with respect to their capability to tap personality related type of information on the same level of self-knowledge, the relationship between the two domains may be further clarified and enhanced.

NOTE: The order of the authors' names was determined arbitrarily and it is not indicative of disproportionate contributions to the overall research.

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*Multivariate Experimental Clinical Research,* Volume 8, No. 1, 1986, 175-182.

# APPLICATION OF FACTOR ANALYSIS IN PSYCHOLOGICAL RESEARCH: IMPROVEMENT OF SIMPLE STRUCTURE BY COMPUTER-ASSISTED GRAPHIC OBLIQUE TRANSFORMATION: A BRIEF NOTE

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## ABSTRACT

Several studies have suggested the efficacy of topological rotation as an adjunct to oblique analytical rotation in attaining improved approximation to *maximum* simple structure of the factor pattern matrix. Recently, using a higher-order scale factoring of the Motivation Analysis Test (MAT), and the Eight State Questionnaire (8SQ), Boyle (1983) reported a 6.17% increase in the ±.10 hyperplane count after only 5 Rotoplot cycles. Four of the 11 extracted factors were simplified. The present brief note examines the issue of topological rotation in regard to its usefulness and ease of application by investigators untrained in the procedure.

## INTRODUCTION

An important decision point in exploratory factor analysis is the choice of rotation technique and the concomitant approximation of the final factor pattern solution to *maximum* simple structure (cf. Boyle, 1985a,b; 1986; Cattell, 1978, 1985; Cureton & D'Agostino, 1983; Dunn-Rankin, 1983; Gorsuch, 1983; Humphreys, 1982; McArdle, 1984; Wainer & Messick, 1983). Several studies have suggested that superior approximation to simple structure can be achieved by using computer-assisted graphic oblique rotation in addition to an oblique analytical rotation (such as direct Oblimin in the SPSS package). Specifically, use of the topological Rotoplot program (Cattell, 1978, pp. 140-154) has been shown in a number of studies to enhance the quality of the factor pattern, resulting in improved psychological interpretation of the derived factors (e.g., Dielman, Cattell & Wagner, 1972; Cattell & Nesselroade, 1976; Cattell, 1978; Cattell, McGill, Lawlis & McGraw, 1979; Burdsal & Bolton, 1979; Gillis & Cattell, 1979; Price, Cattell & Patrick, 1981). For example, Burdsal and Bolton (1979) reported that topological rotation by Rotoplot typically resulted in an average

eight percent increase in the ±.10 hyperplane count (an index of the degree of approximation to simple structure) over that obtained with analytical Oblimin alone. Using questionnaire data, Burdsal and Bolton (1979) reported ±.10 hyperplane counts for Varimax (71.7%), Quartimax (72.0%), Oblimin (72.9%), Quartimin (14.3%), Covarimin (28.1%), Biquartimin (43.6%), and Rotoplot (80.8%). Previously, Dielman et al., (1972) had reported that the best simple structure approximations were obtained with Rotoplot-finished Maxplane, Promax, and the Harris-Kaiser methods in that order, with Oblimax and Varimax giving poorer solutions. Other studies (e.g., Cattell et al., 1979) have reported increases of up to 15 percent in the ±.10 hyperplane count after 12 Rotoplot cycles.

Ideally it would be desirable to do an extensive empirical examination of the efficacy of Rotoplot with widely varying data sets, differing in the clarity of hyperplanes, inherent factorial complexity and so on, comparing the obtained results with the efficacy of say Maxplane (Eber, 1966, 1968) and Functionplane procedures (Katz & Rohlf, 1974, 1975), and also with Oblimin and Harris-Kaiser methods. Functionplane criteria accomplish via a continuous analytical function the maximization of hyperplane counts directly on the primary pattern. While direct Oblimin is not the best analytical oblique rotation method, it is among the best and is a reasonable criterion against which to compare Rotoplot (Eber, Note 1). Nevertheless, as a precursor to a thoroughgoing empirical investigation, it would be informative to examine the ease with which Rotoplot can be used, and the enhancement to simple structure approximation of the factor pattern obtainable by an investigator inexperienced in using the procedure.

The present paper reports the findings of a case study, wherein an investigator inexperienced in using Rotoplot, applied the procedure after having performed a scale factoring of the Motivation Analysis Test (MAT), and the Eight State Questionnaire (8SQ). While the substantive psychological interpretation of the final factor pattern solution was discussed in Boyle (1983), the present paper examines only the usefulness of Rotoplot to factor analysts untrained in the method.

In this study, the person who employed Rotoplot had not used the method before. However, he had previously conducted numerous analytical rotations using statistical packages such as SPSS. In the present study, the pre-Rotoplot analyses were conducted in this fashion by the person who subsequently employed the Rotoplot procedure. No training or coaching in the Rotoplot technique had been undertaken, although it would undoubtedly help the factor analyst to use the technique even more effectively than in the present instance. Even minimal training in the procedure, over say three or four factor analytic outputs would be desirable.

## PROCEDURE

The Rotoplot procedure was instigated using the direct Oblimin solution as the starting point for the topological rotation (the eleven factor Oblimin solution was obtained using the procedures specified in Boyle, 1983). The iterated but unrotated 28 x 11 factor matrix and the derived transformation matrix were used in performing the Rotoplot transformations. Since the SPSS output failed to include the transformation matrix associated with the Oblimin solution, it was

derived by "pseudo-inverting" the unrotated factor matrix (Vo), and pre-multiplying the factor pattern matrix (Vr) by the 11 x 28 pseudo-inverted matrix ($Vo^{-1}$)[1]. In the Rotoplot procedure, the plotting of graphs and the calculation of the new transformation matrix from the visual decision shifts of the investigator were made by computer (see Cattell, 1978, Ch. 7). Basically, a shift matrix which shifts particular reference vectors to the degree thought desirable by the investigator, operates on the existing transformation matrix, so that a new transformation matrix is produced which can produce an improved factor pattern as indexed via the ±.10 hyperplane count. The strategy for the Rotoplot rotations was that advocated by Burdsal and Bolton (1979), except that Rotoplot was used in isolation, and not in conjunction with Maxplane. According to Burdsal and Bolton (p. 105), the procedure they used was, "(a) all rotations that would increase the .10 hyperplane count were given first priority and carried out regardless of other considerations, (b) any rotation that would increase a loading of an item on its associated scale was done if and only if it did not lower the hyperplane count, and (c) after no improvement in either hyperplane count or 16PF-E structure could be obtained, a Maxplane clean-up rotation which limits shifts on any factor to 2° was performed. The entire process required 16 graphical rotations."

To make a valid comparison of direct Oblimin rotation with Rotoplot, the full power of the SPSS Oblimin routine must be used ($\delta$ must be varied from high negative to maximum positive obliquity such that collapse of the solution space is barely avoided). Monitoring the ± .10 hyperplane counts, it was clear that maximum approximation to simple structure was obtained with $\delta$ set at zero. For the eleven factor Oblimin solution, the ± .10 hyperplane count was 65.91%, and this served as the point of departure for the subsequent 'visual polishing' via Rotoplot. Interestingly, the Varimax solution gave a ± .10 hyperplane count of 64.29%, while Quartimax, Quartimin, Oblimax, Covarimin and Biquartimin all gave lower counts again. These findings supported those of Burdsal and Bolton (1979).

[1]In the rotation equation $Vo\,L = Vr$ —(1), Vo was a 28 x 11 matrix, L was an 11 x 11 square transformation matrix, and Vr was also a 28 x 11 matrix. Both Vo and Vr were known and it was necessary to derive L, in order to use the Rotoplot procedure (cf. Cattell, 1978, p. 151). Hence, Equation 1 was pre-multiplied by the "inverse" of Vo such that $Vo^{-1}Vo\,L = Vo^{-1}Vr$ —(2). As $Vo^{-1}Vo = I_1$ (identity matrix), $L = Vo^{-1}Vr$ —(3). Since $Vo^{-1}$ was an 11 x 28 matrix it was not possible to derive the classical inverse, which is defined only for square matrices. However, a "pseudo-inverse" was found using a special computer sub-routine for inverting non-square matrices. By post-multiplying Vo by $Vo^{-1}$, the equation $Vo\,Vo^{-1} = I_2$ —(4) was obtained, such that $I_2$ was not an identity matrix, and $Vo^{-1}Vo \neq Vo\,Vo^{-1}$ since the order of $I_1$ was not the same as the order of $I_2$. Thus $_{Vo}$-1 was not a classical inverse of Vo.

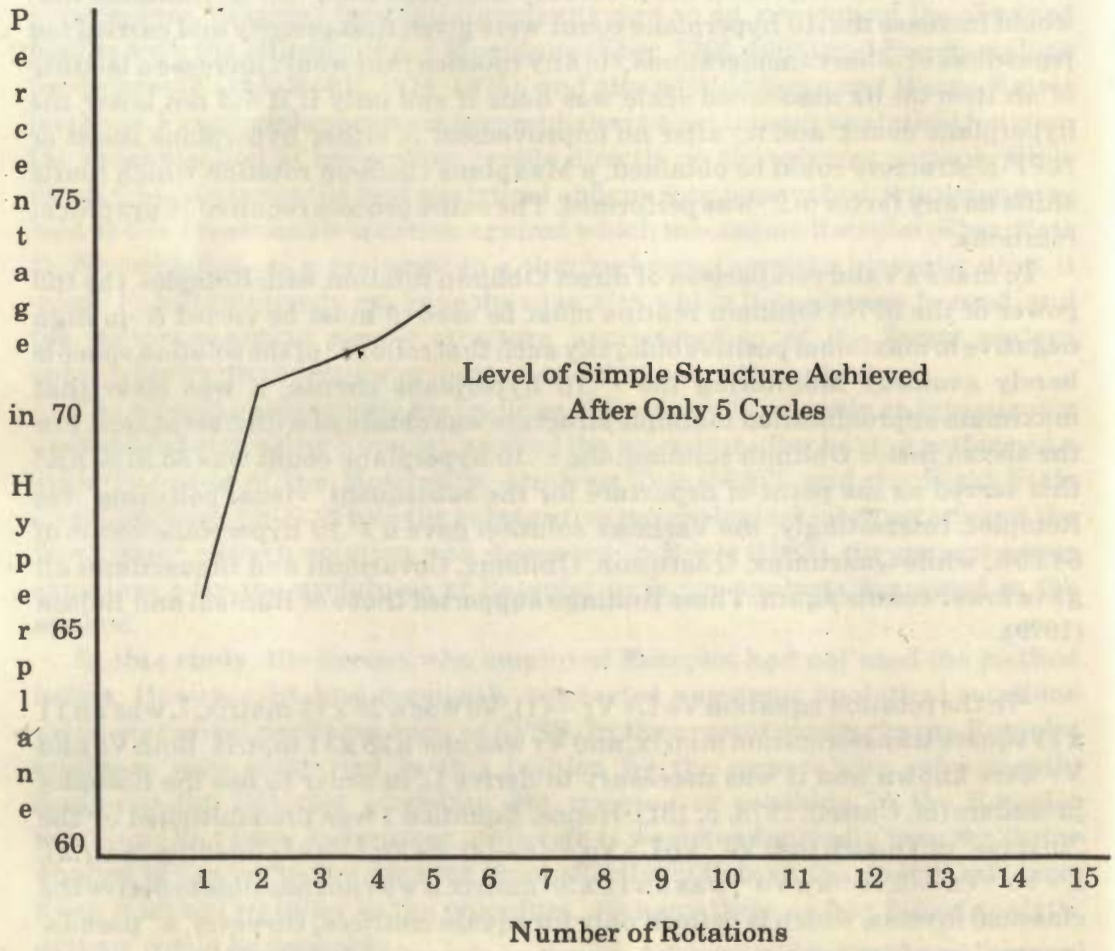
## RESULTS AND DISCUSSION

The topological Rotoplot rotation improved the ± .10 hyperplane count by 6.17% over the direct Oblimin solution, taking the total count up to 72.08% after

only five Rotoplot cycles (cf. Price et al., 1981, p. 85). Cattell (1978, p. 150) indicated that when starting with an oblique analytical output such as Oblimin, up to 24 Rotoplot cycles may be needed to reach the best approximation to simple structure. However, even with only the five Rotoplot cycles in the present case, the hyperplane count increased significantly (Figure 1).

**Figure 1**

HISTORY OF HYPERPLANE COUNTS (± .10)



While the 6.17% increase in the hyperplane count was not large in absolute terms, nevertheless, comparison of the oblique analytical and Rotoplot solutions indicated that the latter was more readily interpretable (see Boyle, 1983, p. 124). The Rotoplot solution was less complex and contained less overlap between the higher-order factors. The change of loading patterns is shown in Table 1.

Examination of Table 1 indicates that Rotoplot reduced practically all factor loadings, including the larger ones. The Rotoplot procedure forced several coefficients from marginally above to marginally below the cut-off point (≥ .20), so that the small reductions in coefficient size appeared as discrete changes. However, in view of the greater factorial complexity of the direct Oblimin solution, the validity of the Rotoplot solution was almost certainly higher, even if only very moderately so. Improvement to the quality of the factor pattern with each Rotoplot cycle suggests that 20-30 cycles should significantly enhance many final factor pattern solutions. This clarification of the factor pattern could be crucial in deciding between opposing theoretical arguments, in some instances. Kline (1979, p. 37) stated that the criteria for simple structure include, " . . . the demonstration that further rotations produce a drop in the hyperplane count, the application of Bargmann's . . . statistical test for simple structure and the fact that the percentage of variables in the hyperplane lies between 55% and 85% . . . generally topological programmes by these criteria of simple structure do seem more efficient than others."

Presentation of only one set of data is not sufficient to provide a definitive answer to the question investigated, but it is hoped that this research note will stimulate academically curious readers to explore more fully the merits or otherwise of topological rotation. In this regard, Eber (Note 1) reported that the revised automatic topological Maxplane program, " . . . produced higher hyperplane counts than even Rotoplot with Cattell guiding the rotations."[2] However, Maxplane applied to Vo while maximizing the hyperplane count beyond what one can do by hand if starting from Vo, often appears not to meet other criteria of simple structure (from a Thurstone model). Eber's conclusion seems based on the premise that the hyperplane count is the *sole* criterion of simple structure. However, other aspects of simple structure, such as having at least two linearly independent variables load each factor when using topological rotations, need to be considered. While Rotoplot does allow for these other criteria, Maxplane essentially relies solely on the hyperplane count.

Experimenters have often asked if the small increase in quality of the factor pattern solution resulting from use of Rotoplot is really worth all the trouble. On Eber's statement it would seem doubtful. It may be that use of the most effective version of Maxplane should now supersede all analytical rotation methods. A more useful strategy, however, might be to start with Promax, followed by Rotoplot with a Maxplane finish (limiting the amount of rotation of each factor to two degrees as recommended by Burdsal & Bolton, 1979). This should yield excellent approximation of the final factor pattern to simple structure without either rotating essentially all loadings into oblivion as does a full Maxplane (especially when aplied to item data) or producing excessive factor correlations. There are many decision points in conducting a successful exploratory factor analytic study, and what is needed is a full and open debate of these issues. The

**Table 1**

DIRECT OBLIMIN AND ROTOPLOT SOLUTIONS COMPARED

| | Variable | FACTOR NUMBER 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8SQ | Ax | *85* (*69*) | 02 (03) | -01 (01) | -06 (-07) | -01 (01) | 06 (06) | -19 (16) | 06 (05) | 00 (01) | 02 (03) | -01 (-05) |
| | St | *69* (*56*) | 06 (07) | 08 (09) | -09 (-10) | -12 (-09) | 04 (04) | -17 (-14) | 06 (05) | 00 (00) | 11 (12) | 09 (03) |
| | De | *55* (*44*) | -05 (-05) | -07 (-07) | -09 (-09) | 03 (03) | 01 (01) | *-45* (*-38*) | 03 (03) | 13 (12) | -15 (-14) | 09 (04) |
| | Rg | *54* (*44*) | -07 (-06) | 06 (05) | 10 (10) | 10 (10) | 01 (00) | *-35* (*-29*) | 03 (03) | 11 (10) | -15 (-14) | 03 (02) |
| | Fa | *23* (18) | 05 (04) | 05 (01) | 08 (08) | 02 (00) | -07 (-07) | *-76* (*-63*) | -02 (-01) | -07 (-06) | 06 (04) | -09 (-10) |
| | Gi | *81* (*66*) | -16 (-15) | 02 (03) | 16 (15) | 01 (03) | -10 (-09) | -03 (-02) | 00 (01) | 05 (06) | -17 (-15) | 00 (-08) |
| | Ex | *-21* (-17) | 04 (02) | 14 (14) | 02 (02) | -05 (-04) | -10 (-09) | *64* (*54*) | 03 (03) | 01 (01) | 19 (19) | -15 (-15) |
| | Ar | -10 (-08) | -07 (-06) | 08 (09) | -09 (-09) | -02 (01) | -04 (-03) | *77* (*64*) | 03 (03) | -10 (-10) | 04 (05) | 01 (00) |
| MAT | U-Ca | -01 (-01) | 02 (00) | -03 (-03) | *-38* (*-35*) | 12 (10) | -12 (-11) | 14 (11) | -01 (-01) | 06 (05) | -02 (-02) | -03 (01) |
| | U-Ho | -12 (-09) | *53* (*48*) | 04 (06) | 06 (05) | 09 (12) | 07 (07) | 12 (10) | 06 (05) | -08 (-08) | *-23* (*-20*) | 05 (00) |
| | U-Fr | 03 (03) | -01 (01) | 01 (04) | 09 (08) | *-63* (*-60*) | -02 (-02) | 07 (06) | 01 (01) | 05 (05) | 01 (03) | 00 (-01) |
| | U-Na | -07 (-06) | *-35* (*-30*) | 14 (12) | -10 (-09) | -07 (-07) | 01 (00) | -04 (-03) | 15 (16) | *-20* (-18) | 07 (06) | -12 (-08) |
| | U-Se | 18 (15) | 19 (19) | -02 (-01) | 03 (02) | 00 (03) | 07 (06) | 15 (13) | *-23* (*-22*) | -10 (-10) | -14 (-12) | 12 (07) |
| | U-Ss | 02 (02) | 00 (02) | -09 (-09) | -04 (-05) | -01 (02) | 09 (08) | 09 (08) | *-20* (-19) | *-38* (*-35*) | 05 (06) | 05 (00) |
| | U-Ma | -06 (-06) | -11 (-10) | 17 (16) | *44* (*41*) | *26* (*25*) | 07 (06) | 03 (02) | 04 (03) | 08 (07) | 13 (11) | 05 (01) |
| | U-Pg | 11 (10) | 02 (03) | -04 (01) | 09 (07) | -13 (-10) | *24* (*24*) | 03 (02) | *42* (*39*) | 04 (04) | -02 (00) | 00 (-01) |
| | U-As | 04 (03) | 02 (00) | -08 (-06) | -07 (-06) | -05 (-07) | -02 (-01) | 04 (02) | -09 (-10) | *56* (*52*) | 04 (03) | -01 (04) |
| | U-Sw | -05 (-05) | -03 (-03) | -01 (-01) | 02 (02) | 00 (-01) | 02 (02) | 04 (03) | -01 (-01) | 01 (00) | *54* (*51*) | 04 (-03) |
| | I-Ca | 01 (-01) | 00 (-03) | 07 (03) | 02 (04) | -02 (-07) | *-48* (*-45*) | 02 (02) | -01 (01) | 07 (08) | -01 (-03) | 02 (02) |
| | I-Ho | -04 (-02) | *79* (*69*) | -01 (01) | -15 (-14) | -02 (-01) | -08 (-07) | -13 (-10) | 05 (05) | 01 (01) | 05 (07) | -12 (-17) |
| | I-Fr | -14 (-11) | -06 (-02) | *36* (*33*) | -11 (-11) | -17 (-17) | 00 (-01) | -09 (-08) | 03 (02) | -04 (-05) | -16 (-16) | *21* (18) |
| | I-Na | -04 (-03) | -01 (03) | *21* (*20*) | *-55* (*-53*) | 12 (13) | 19 (18) | -01 (-01) | -04 (-05) | 05 (03) | 01 (07) | 03 (06) |
| | I-Se | 00 (-01) | -14 (-10) | 01 (-01) | -01 (00) | -01 (-03) | -05 (-05) | 00 (-01) | 06 (05) | -02 (-04) | 01 (-02) | *68* (*56*) |
| | I-Ss | -11 (-08) | -18 (-10) | *33* (*32*) | 00 (-02) | -14 (-10) | *34* (*31*) | -14 (-12) | *-53* (*-52*) | 09 (08) | -06 (-05) | -13 (-10) |
| | I-Ma | 11 (10) | -07 (-05) | 10 (12) | 06 (05) | 02 (05) | *21* (*20*) | 08 (06) | 18 (17) | 05 (05) | 08 (10) | *-22* (*-19*) |
| | I-Pg | -10 (-09) | -03 (-07) | *-66* (*-61*) | 00 (01) | -04 (-05) | 07 (08) | -10 (-09) | 06 (05) | 05 (05) | -06 (-05) | 02 (08) |
| | I-As | -02 (-02) | -18 (-19) | -01 (-02) | -06 (-05) | -03 (-04) | -05 (-04) | -05 (-04) | 06 (06) | 07 (08) | -03 (-03) | *-33* (*-23*) |
| | I-Sw | 10 (08) | *23* (*22*) | 14 (12) | 12 (12) | 07 (07) | -03 (-03) | -07 (-06) | -02 (-02) | -12 (-12) | 18 (16) | *25* (12) |
| Hyperplane Count | ±.10 | 12 (19) | 18 (21) | 20 (19) | 20 (21) | 20 (21) | 21 (22) | 15 (17) | 22 (22) | 20 (22) | 17 (17) | 18 (21) |

NOTES: (i) Factor loadings rounded to two decimal places.
(ii) Significant > .20) loadings italicized.

decision to use or not to use topological rotation is but one of these dilemmas, although as indicated above, the best simple structure approximation is most likely obtained by using a combination of graphical and automatic rotations. This is especially important if factor scores are to be estimated.

[2]Eber also pointed out that the simple structure criterion is not always appropriate. According to him (Note 1), "It turned out that Thurstone's factorial invariance example was not factorially invariant. In fact, Maxplane quickly found a 'better' solution than the 'correct' one, and suggested that a lifetime of study of a domain might be a better criterion than even the highest hyperplane count (in one study)."

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*Multivariate Experimental Clinical Research*, Volume 8, No. 1, 1986, 183.

# BOOK REVIEW

by
Fred H. Wallbrown
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## INTERPRETING 16 PF PROFILE PATTERNS

Samuel E. Krug
Institute for Personality and Ability Testing
1981 193 pages $14.95 paper

Publication of *Interpreting 16 PF Profile Patterns* marks a third milestone in the development of a body of knowledge concerned with the clinical interpretation of the 16 PF. The first milestone consisted of publication of the *Handbook for the 16 PF* (Cattell, Eber, & Tatsuoka, 1970). This provided a comprehensive summary of the research literature available at that time as well as a convenient summary of the theoretical constructs measured by the test. The second milestone consisted of the publication of *A Guide to the Clinical Use of the 16 PF* (Karson & O'Dell, 1976) which recast many ideas and insights from Cattell's theory and research so they are more intelligible to clinicians.

Several considerations figure in my assertion that *Interpreting 16 PF Profile Patterns* constitutes a third milestone in the evolution of literature concerning the clinical interpretation of the 16 PF. First and foremost, however, the author has succeeded in producing a simple, straightforward method summarizing the salient information in a 16 PF profile. Krug takes the four most important secondaries (extraversion, anxiety, tough-poise, and independence) and assigns numerical codes of 3 (high for stens > 7), 2 (average for stens 4-7), and 1 (low for stens 1-3). Thus we have eighty-one distinct four-point codes which can be used to designate 16 PF profile patterns. This procedure is compelling because it takes into account the whole 16 PF profile.

Another advantage of Krug's method is that it provides a means of making actuarial interpretations based on the information in the whole 16 PF profile. Both of the earlier books base most interpretations on examination of single scales, or, at most, configurations of two or three scales. The new approach does not negate the earlier approach that most of us are already familiar with but rather goes beyond it to provide additional information. A third advantage of Krug's actuarial approach is that it provides a direct link to a vast array of research data that is already available about the 16 PF. For each of the eighty-one code types, a general interpretive statement is provided with incidence data by sex for normal and clinical populations. Sten scores are also provided for five clinical scales, four additional scales, Holland's six career-themes, and a large number of specific occupations.

Professionals using the 16 PF in their clinical work can be encouraged by what appears to be a consistent trend toward the production of texts which provide the basis for increasing refinement in interpretation of that text.

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