Research and Development Division

Professional DynaMetric Programs, Inc.

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Independent Studies of the Reliability and Validity of Responses to the Professional DynaMetric Programs® ProScan Survey

THE PROSCAN® SURVEY: DEVELOPMENT AND STANDARDIZATION

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Table of Contents

The ProScan® Survey: Development and Standardization

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Introduction

This monograph was written to document the reliability and validity of responses of individuals to a survey that has been carefully prepared by Professional DynaMetric Programs® (ProScan®), Inc.

The ProScan® Survey, originally designated as the PDP® Survey, is a simple, objective device designed to measure important behavioral traits that are possessed in different amounts by every human being. The items of the Survey include 60 carefully selected, self-descriptive adjectives presented on two sides of a single card, 30 adjectives on Part 1 and 30 adjectives on Part 2. The selection of each adjective was made by Hubby, Houston and Solomon (1977a, 1977b, 1978a, 1978b), following the analysis of carefully conducted field trials and extensive case study reports.

The response to each adjective is recorded on a five-point Likert (1932) scale with 1 being least and 5 being most.

The ProScan® Survey purports to measure four primary behavioral traits (1-4) and one secondary trait (5), as follows:

Factors of Behavior Measured by the ProScan® Survey

(1) Dominance, the control trait

(2) Extroversion, the social and fluency trait

(3) Pace/Patience, the rate of motion trait (often referred to as Patience)

(4) Conformity/Structure, the structure and detail trait

(5) Logic/Rationale, the type of reasoning trait

The Survey also measures certain "dynamic features" of the personality that are derived from special formulas applied to the available data. Those features are identified in the list that follows:

Dynamic Features of Behavior Measured by the ProScan® Survey

(1) Energy level

(2) Environmental stress

(3) Direction of stress in behavioral changes, e.g., "...feel the need to be less (or more) dominant"

(4) Energy lost due to stress

(5) Morale/satisfaction

(6) Rationale for decisions, fact or feeling

(7) Primary and back-up management styles

(8) Primary and back-up communication styles

(9) Primary and back-up approaches to tasks or goals

(10) Environmental preferences

(11) Motivators, demotivators

(12) Prime needs, those being met and those not being met

The entire Survey typically is completed within 5 minutes when administered to individuals and within 10 minutes when administered to groups. However, the instrument is not timed and must be used without time restrictions; each respondent may use as much time as he/she requires to complete the Survey.

The next several pages provide the theoretical foundation on which the instrument was built and technical information about its development and standardization.

Theoretical Assumptions

The development of the ProScan® Survey was based on the following primary assumptions:

(1) Human behavior is comprised of different factors.

(2) Factors of behavior can be measured by appropriate sets of self-descriptive word lists.

(3) Knowledge of behavioral traits is useful for describing, understanding and predicting individual behavior.

(4) The ability to describe, understand and predict behavior can make important differences in many real-life situations.

Self description is a common means by which human behavior is measured. Indeed, self-

descriptive word lists have been used extensively to identify and measure important behavioral traits by both early and recent investigators: Cattell, (1945 and 1950); Daniels, (1973); Eysenck, (1947); Fiske, (1949); Guilford, (1954); Horst, (1968); Hubby, Houston and Solomon (1977-1983); Jung, (1933); and Thurstone, (1934).

Carl Jung (1933), a Swiss physician and psychologist, was first to observe the behavioral construct referred to in bipolar terms as "Introversion-Extroversion." Later, Cattell (1950) and Eysenck (1947) independently demonstrated that variations among individuals on this trait can be arrayed at various positions on a continuum. When the sample is large, continuous data of this type usually are distributed in a Gaussian (bell-shaped or normal) curve within a definable range that includes the lowest and highest scores. The normal distribution of scores is an important prerequisite for the appropriate application of a sophisticated statistical tool called factor analysis. Cattell used that procedure to identify 16 potential "factor" dimensions.

Factor analysis is effective in the reduction of large amounts of information, such as a long list of self-descriptive words, to one or more scales that are much more manageable than the original information but still retain their power for measuring important constructs. In addition to the normal distribution of raw scores, factor analysis requires scores to be consistent with repeated administrations of the instrument. A third requirement is that scores reveal certain commonalities in the response patterns. The scores from responses to word lists from which the ProScan® Survey was developed met these conditions, and factor analysis was used as the analytical tool for identifying the behavioral traits.

All self-descriptive techniques are subject to the possibility that respondents guess, make selections at random, deliberately distort responses and/or choose responses that contain erroneous perceptions of the facts. In the present situation, individuals in the normative sample had the same opportunity to make those errors as did subsequent respondents and individuals who will take the Survey in the future. If such errors occurred frequently in the normative sample, the norms of the Survey are flawed and those flaws will be reflected in low coefficients of reliability and validity, perhaps to levels that are unacceptable. On the other hand, if reliability and validity coefficients are

high, then errors from the above sources could not have occurred often in the normative sample and, therefore, they also may be assumed to be rare among respondents, generally. (Results reported in Tables 1 through 19 show that coefficients of reliability and validity with few exceptions were substantial to very high in studies conducted to date.)

Despite the potential sources of error from chance, deliberate distortion or poor judgment, there were three reasons for thinking that, in fact, their effect would be negligible. First, observations clearly show that respondents react without hesitation or difficulty to positive stimuli. For this reason the instrument was specifically designed to include non-threatening descriptors, diminishing the need for distortion. Second, each factor measured by the Survey was developed from not more than eight adjectives all of which were randomly distributed in the two lists of 30 words. The ability to correctly associate every adjective with its appropriate factor is highly unlikely, thereby lowering the probability that respondents are able to bias their choices on several adjectives for any one factor. Third, the Survey was designed to utilize differences between actual and perceived behaviors.

Thus, theoretical assumptions provided an important basis for the definition of human behavior in terms of multiple trait-dimensions within which individuals locate themselves at particular points and which together define the behavior space. Factor analysis was relied upon as the statistical tool for translating theoretical constructs into scales of measurement. The use of that statistical procedure assumed that scores on self-descriptive word lists are distributed normally when samples are large, that consistencies occur in repeated measurements, and that commonalities among responses exist. It was with those understandings that the development of the ProScan® Survey proceeded.

Factor Analytic Methodology

Briefly, the steps involved in the factor analysis were as follows (Houston and Solomon, 1977):

1. A matrix of Pearson product moment correlation coefficients was computed. When a datum was missing, the mean value for that variable was inserted. The amount of missing data was less than one percent.

2. Squared multiple correlations were entered as initial commonality estimates. Iteration for commonalities proceeded until the maximum absolute deviation between iterations dropped below .001.
3. Kaiser's criterion was used to determine the number of factors to be rotated.
4. A rotation to the varimax criterion was performed.
5. The orthogonal varimax solution was rotated to oblique simple structure, using the maxplane and promax criteria (hyperplane width is .10).
6. The matrix of regression weights of the variables of the factors V(fe) was computed using V(fe)=(Rv)-1V(fs), where Rv-1 is the matrix of correlations among the variables and V(fs) is the oblique factor structure matrix.

Development of the Item Pool

A five-point Likert scale was chosen as the medium for responses to self-descriptive adjectives in preference to the Q Sort, interview, or picture alternatives. That decision proved to have many benefits. It ensured quick and effective administration and precise scoring of the instrument, even for a group. It helped simplify the reporting of results, and all of these qualities contributed to the important objective of producing an instrument that is both "user" and "management" friendly.

An original pool of 185 adjectives was drawn from the works of Thurstone (1934), Cattell (1950), Guilford (1954), Fiske (1949), Daniels (1973), Horst (1968) and the designers of ProScan®, Hubby, Houston and Solomon (1978). An experimental survey was administered to several hundred individuals whose responses were factor analyzed. That analysis reduced the list of adjectives from 185 to the 60 adjectives that constitute the present instrument

The terms were arranged on the Survey Card so that measurements of behavioral traits could be obtained from three different perspectives, the Basic/Natural Self, Priority Environment(s) and the Predictor/Outward Self.

The Basic/Natural Self refers to how the individual functions when there is freedom to respond in a completely natural way. The first 30 terms listed on the Survey measure the behavior from this perspective and the responses to these terms are made in reference to the statement:

"How you feel you really are."

Priority Environment(s) refer to environments that are important to the respondent and the responses are to people within those environments. It is a fact of life that individuals either feel the need or are forced to make adjustments to their environment in order to reach goals that are perceived to be necessary for success or survival. Case studies reveal that those adjustments nearly always are in reference to one or more of the six environments. Those environments have been observed to include: the work world (employment or lack thereof); the domestic scene including all aspects of the family and mate (or lack thereof); health, both mental and physical; finances or economic considerations; social relationships and perhaps matters that pertain to one's religious beliefs. This perspective, then, represents the self as perceived through the eyes of "others" who are associated with some environment that predominates in the mind or even in the unconscious thinking of the respondent at the moment the item is scored. Information that pertains to Priority Environment(s) is from the directed responses to "How you feel others expect you to be or act."

The Predictor/Outward Self is a synthesis of responses to the Basic/Natural Self and the Priority Environment(s). Normative data were prepared independently and confirmed by feedback from a large number of case studies.

The Survey also includes a Respondent Information Record (RIR), completed partially by the respondent and partially by the Survey administrator. The RIR contains space for recording date, name, occupation, organization, age, and sex, although the only mandatory information on the list is a name or identifier (initials or an alpha-numeric code).

The Norming Procedure

Standardization procedures provided separate norms for each trait within each of the three perspectives. A major step in those procedures was the administration of the final list of self-descriptive adjectives to the normative sample. That sample consisted of 1024 individuals who were carefully selected to represent a cross section of the adult population in the United States. The factor analysis of scores from the normative sample clearly identified the five behavioral traits. Indices for other important dynamic features also were derived by applying certain proprietary formulas to

normative sample scores. Finally, exhaustive case studies were employed to establish the meaning of a score at any given location on the continuum of its normative distribution.

The raw scores for each individual in the normative sample were converted to standard scores to form standard score distributions each of which had a base of seven sigmas. Also, mean standard scores for the four primary factors provided a standard score "variable norm" within each of the three perspectives, Basic/Natural Self, Priority Environment(s) and Predictor/Outward Self. Thus, the extent of the deviation from the individuals own "central tendency norm" on a given trait provided an index of the intensity of that trait. This unique concept made it possible to measure the strength of individual behavioral traits not only with reference to other traits of the individual, but also with reference to the population norms.

Narrative descriptions of the factors and "variable norm" values are presented for individuals. Each factor is labeled in a positive manner with high scores being most characteristic of the label. For example, references to the two extremes on the continuum of scores on the Dominance scale are "High Dominance" and "Low Dominance," as opposed to common references of "Dominant" and "Submissive," respectively.

The five behavioral traits measured by the ProScan® Survey and for which separate norms are provided within each of the three "perspectives" are described below:

Factor D: Dominance

Individuals with high scores on this factor consider themselves to be concerned about getting things done, very competitive, decisive, calculating and risk takers. Those with low scores consider themselves to be non-confrontive, submissive, cautious, and risk avoiders.

Factor E: Extroversion

Individuals with high scores on this factor consider themselves to be outgoing, friendly, optimistic and persuasive. Those with low scores consider themselves to be bashful, quiet, introspective and awkward or uncomfortable in social situations.

Factor P: Pace/Patience

Individuals with high pace/patience scores consider themselves to be relaxed, stable, likeable,

and at ease or cooperative with their environment. Those with low pace/patience scores consider themselves to be urgent, intense, action-oriented, pressing and receptive to change.

Factor C: Conformity/Structure

Individuals with high scores on this factor consider themselves to be very precise, dedicated, careful and concerned about what is "right." Those with low scores on this factor consider themselves to be very independent, free thinkers, non-traditional, not concerned about the "establishment" and more interested in the "end" as opposed to the "means."

Factor L: Logic/Rationale

Individuals with high scores on logic/rationale consider themselves to be fact-oriented and objective. Those with low scores consider themselves to be feeling-oriented, ruled by the heart, and subjective.

Unique Features

There are eight features of the ProScan® Survey that distinguish it from most other instruments that purport to measure behavioral traits. They are listed below:

(1) The adjectives selected for use by the Survey are unique—no other instrument is composed of the identical word list and, consequently, no other instrument contains exactly the same data on which the specific behavioral traits are based.

(2) Behavioral traits are measured from different perspectives the "Basic/Natural Self" and the "Priority Environment(s)" are measured by direct responses to the Survey; the "Predictor/Outward Self" is an indirect measurement of behavioral traits and is produced from a synthesis between raw scores for the first two perspectives. Separate norms were derived for each trait within each of the three perspectives.

(3) The Survey measures important "dynamic features" of the behavior. Those features are derived from special proprietary formulas applied to the available data.

(4) The Survey was standardized separately on the adult and pre-adult population for the purpose of describing normal behaviors in contrast to instruments designed to identify aberrant or abnormal behaviors.

(5) The four primary factors of behavior produce a "variable norm" that permits measurement of the relative intensity of each individual trait.

(6) The instrument is computerized—scores and results are compiled and reported in both narrative and graphic form entirely by computer.

(7) The software programs, data entry procedures, computer-compiled reports and interpretation of reports were all planned and designed for use by laymen so that mastery could be achieved by thorough but relatively simple training. This means the product accommodates both administrative and managerial issues so the system is both "user friendly" and "management friendly."

(8) The user is able to score, retain, and has complete control over, all information associated with every Survey. No individuals or agencies except those directly involved need to see or have access to the information.

Factor Correlations

Factor analysis attempts to identify factors that are independent and therefore do not correlate significantly with other factors. However, that kind of purity is rare in practice. Correlations among the factors derived from Survey data are presented in Tables 1 and 2. As the results in the two tables indicate, the patterns of intercorrelations among the factors for the Basic/ Natural Self and Priority Environment(s) are quite similar. In general, the correlations among the factors are low to moderate.

Reliability

Estimates of the reliability of responses to the Survey were obtained by test-retest and split-half correlations. Table 3 reports coefficients of reliability for those analyses. The test-retest coefficients are for Surveys administered three months apart.

Test-retest coefficients of reliability for 101 adults ranged in the 0.70's and 0.80's. Split-half coefficients of reliability for a sample of 332 individuals were in the high 0.80's and low 0.90's, except for one factor, Logic/Rationale under Priority Environment(s) that was 0.80. Overall, the

coefficients compare very favorably with the reliability of scores earned on many achievement tests and are somewhat higher than other nationally normed measures in the affective domain.

Intrinsic Validity

Structural integrity is a generic term formulated by Nesselroade and Bates (1970) that incorporates systematic factor analysis procedures for establishing desirable characteristics of a psychological measure. A scale cannot be a valid predictor of outside (extrinsic) criteria unless it predicts itself. The ability to predict itself requires consistency of scores under varying conditions. These qualities include, replicability, invariance, constancy and stability and determine the internal soundness of an instrument, its "intrinsic validity." Each of the four concepts is described briefly below.

Replicability—The extent to which a pattern, regularity, or configuration appears in essentially the same form in random samples or occasions, for example, random replicates of individuals.

Invariance—The similarity of the configuration of the structure across selected groups with varying characteristics, e.g., configurational similarity across race, sex, occupation, age, etc.

Constancy—The degree to which a pattern or configuration appears in essentially the same form in each quartile of the range of a measure or instrument, e.g., do individuals scoring low on Dominance evidence the same configuration of items as do individuals scoring high on that factor?

Table 1. Coefficients of Correlation Among Factors in Basic/Natural Self
(N=1024)

	Dom.	Ext.	Pac.	Con.	Log.
Dominance	1.00	.40	.08	.06	.51
Extroversion	.40	1.00	.21	.20	.41
Pace	.08	.21	1.00	.54	.28
Conformity	.06	.20	.54	1.00	.39
Logic/Rationale	.51	.41	.28	.39	1.00

Table 2. Coefficients of Correlation Among Factors in Priority Environment(s)
(N=1024)

	Dom.	Ext.	Pac.	Con.	Log.
Dominance	1.00	.63	.02	.06	.39
Extroversion	.63	1.00	.12	.13	.33
Pace	.02	.12	1.00	.55	.20
Conformity	.06	.13	.55	1.00	.36
Logic/Rationale	.39	.33	.20	.36	1.00

Table 3. Coefficients of Reliability

	Three-Month Test-Retest (N=101)	Split-Half* (N=332)
Basic/Natural Self:		
Dominance	.83	.91
Extroversion	.81	.90
Pace	.78	.89
Conformity	.85	.92
Logic/Rationale	.76	.86
Priority Environment(s)		
Dominance	.82	.89
Extroversion	.80	.89
Pace	.77	.87
Conformity	.86	.90
Logic/Rationale		

*Internal Consistency

Stability—The similarity of the pattern across two or more administrations of the instrument to the same subjects.

Studies performed by Houston and Solomon (1977) considered two of the four above characteristics, the replicability of the instrument and its invariance across sex, occupation, and race where factor analysis was the statistical procedure employed. Those studies were conducted as part of the initial validation of the instrument and were carried out on the normative sample. The methods they used and the results of their analyses are reported below.

To determine the replicability of the factors, four random subsamples (n=250) were drawn from the total validation samples. The factor analytic procedure previously outlined was applied to

each of the four replicates. Each factor estimation matrix was used to calculate factor scores for each member of the total sample thus yielding four separate estimates of an individual's score on each factor. Correlation coefficients between factor score estimates from each replicate pair were computed, producing six estimates of the coefficient of replicability for each factor. Fisher's r to Z transformation was performed on each of the six coefficients of replicability for each factor. The means and standard deviations of Fisher Z values were obtained and r equivalents of the mean Fisher Z values were computed.

The instruments of the ProScan® system were highly replicable with coefficients of replicability above 0.94 for all factors.

Since replicability across random subsamples was demonstrated, the next concern was to investigate the invariance of the factors across race, sex, and occupation. A procedure identical to the one outlined above was applied to groups selected according to race, sex, and occupation. There were four occupations, nurses, lawyers, ministers, and military, two race categories, white and non-white, and two sex categories, males and females. As a result, 32 coefficients of invariance were calculated.

Each of the factors was highly invariant across race, sex, and occupation with coefficients above 0.87 in all cases.

Validity

Jung's (1933) theory of type provided a model of behavioral traits for the ProScan® Survey. Thus, one appropriate test of the Survey's validity was the strength of coefficients of correlation between Survey scores and scores earned on scales that purport to measure the same or similar constructs when both instruments are administered at the same time and under similar conditions. Such coefficients are examples of concurrent validity.

One practical reason for measuring behavioral traits is that those measurements have a potential for providing information about the future performance or behavior of individuals. Procedures that, in fact, estimate how effective an instrument measures performance in advance deals with its predictive validity.

Whereas, in the previous section the focus was on criteria that were "intrinsic," or internal, the next section assesses the ProScan® Survey with reference to its effectiveness as a measure of "extrinsic" criteria. Both concurrent and predictive validity coefficients are indices of extrinsic validity.

Extrinsic Validity

The validation of the ProScan® Survey with reference to extrinsic criteria was done by studies that correlated scores on the Survey with those obtained concurrently on other comparable instruments (concurrent validity) and by other studies that correlated ProScan® Survey scores with various criteria of performance or success (predictive validity).

In Table 4 are presented concurrent validity estimates in which selected factor scores on the ProScan® Survey are correlated with selected factor scores on the Predictive Index (Daniels, 1973), selected scales (Adjective Rating Scales) from Veldman and Parker (1970), and selected factors from the Self Index (Solomon and Houston, 1982).

Ultimately, the criterion for any method of measuring behavior is its relevance to the goals of the investigators. While it is impossible to assess the extrinsic validity of an instrument for all the potential uses to which it might be applied, a few studies are presented in Table 5 which show that Survey factors can be used to increase understanding of the behavioral differences among predefined groups. A multiple linear regression procedure was employed in which the ten factors of the ProScan® (Basic/Natural Self and Priority Environment(s)) served as the set of independent variables and each of the dependent variables was as specified in Table 5.

In Table 5 a square of the multiple correlation coefficient (R2) is reported for each of the seven empirical studies. That coefficient indicates the percentage of total variance that is common between the independent variables and the criterion (dependent variable). If the coefficient was 1.00, for example, there would be perfect agreement between what was being measured by the set of independent variables and the criterion variable. In that situation, when any set of values for the independent variables was known, the value for the dependent variable also would be known (predicted) without error.

The ProScan® Survey was developed from a sound theoretical base, a carefully selected normative sample and appropriate statistical procedures. Evidence from initial experiments showed high coefficients of reliability and validity. That evidence has been confirmed further by feedback from more than 600,000 individual case study reports.

Table 4. Coefficients of Concurrent Validity

ProScan® Factors	Predictive Index (N=117)	Adjective Rating Scales (N=46)	Self Index (N=87)
Basic/Natural Self:			
Factor D	Factor A (.75)	Factor 2 (.72) (Soc. Abrasiveness)	Factor B (.58) (Personal Style)
Factor E	Factor B (.81)	Factor 4 (.69) (Int. RD/Ext. RD)	Factor A (.45) (Int. Pers. Beh.)
Factor P	Factor C (.63)		Factor C (.61) (Social Attitude)
Factor C	Factor D (.87)	Factor 6 (.64) Individualism	Factor D (.39) (Ego Behavior)
Factor L	Factor E (.86)		
Priority Environment(s)			
Factor D	Factor A (.56)		
Factor E	Factor B (.75)		
Factor P	Factor C (.73)		
Factor C	Factor D (.74)		
Factor L	Factor E (.83)		

Table 5. Coefficients of Predictive Validity

Group	Sample Size (N)	Dependent Variable	Multiple R^2
Ministers	68	Number of Members	.63
Stock Brokers	21	Volume of Sales	.50
Doctoral Students in Administration	31	Graduate GPA	.60
Undergraduate Nursing Students	53	Undergraduate GPA	.61
Attorneys	15	Rank in Law School	.51
Teachers	58	Undergraduate GPA	.54
Military Officers	34	Grade in Graduate Course in Administration	.55

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